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SEARCH ROOM

July 5, 1960 A. FONG 2,944,233

CAVITY RESONATOR AND OSCILLATION GENERATOR

Original Filed July 27, 1953 3 Sheets-Sheet 1

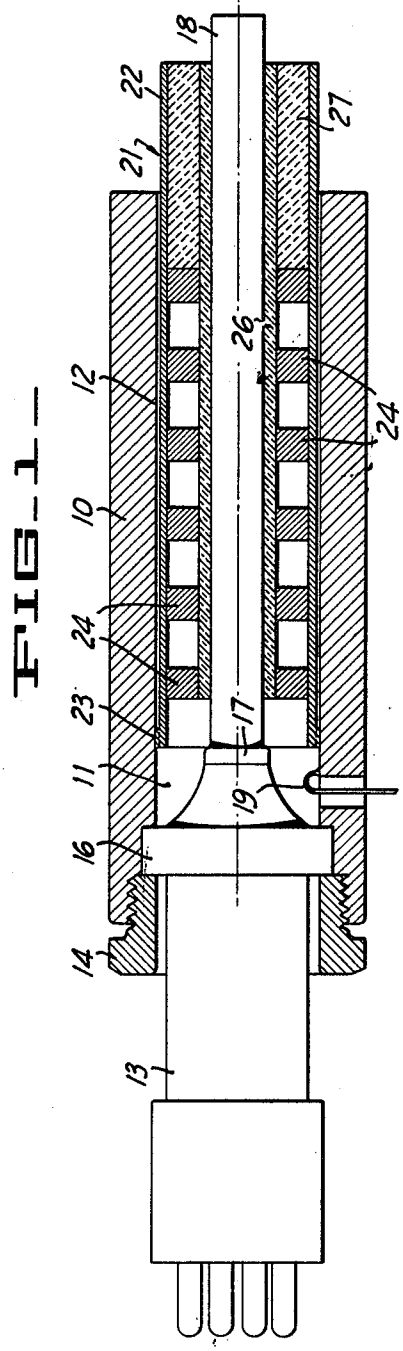


FIG-1

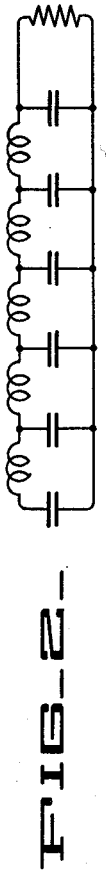


FIG-2

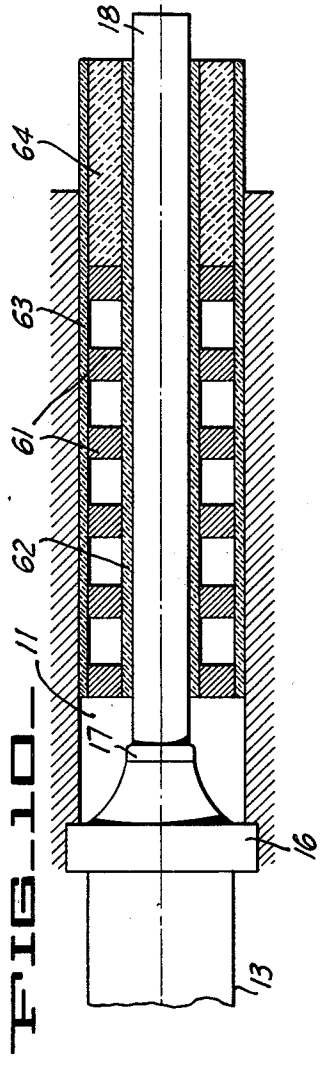


FIG-10

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FIG-3-

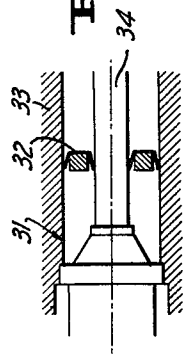


FIG-4-

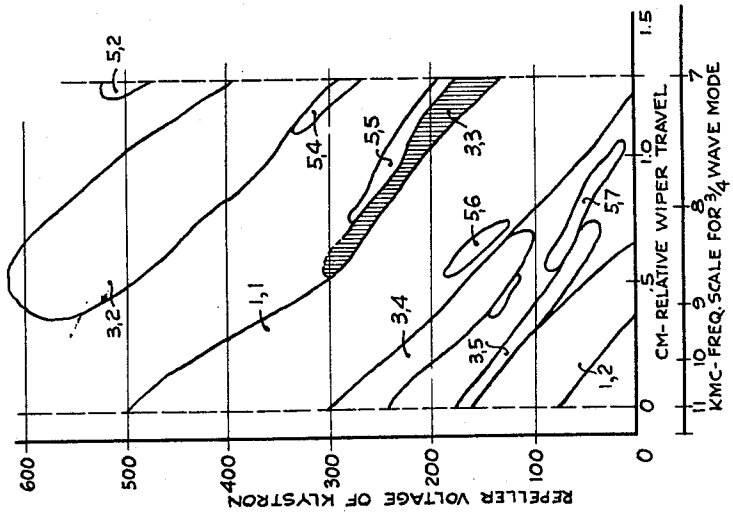
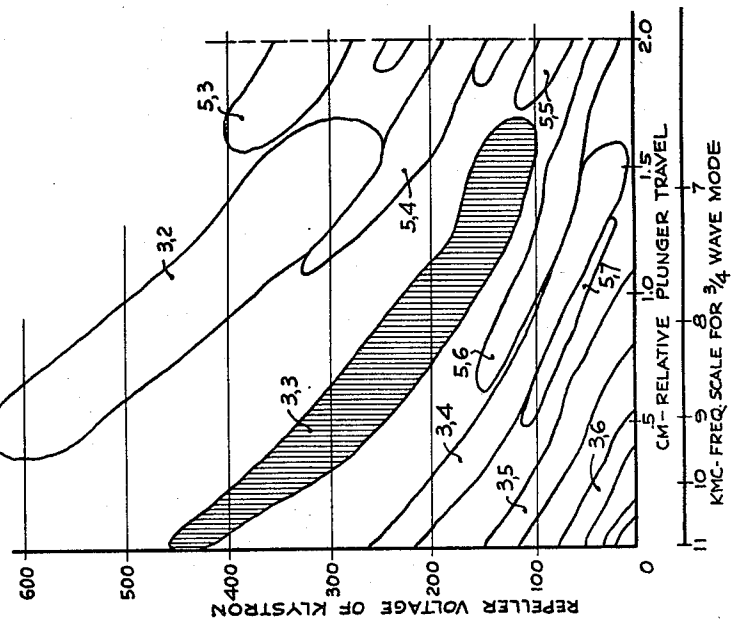


FIG-5-



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CAVITY RESONATOR AND OSCILLATION GENERATOR

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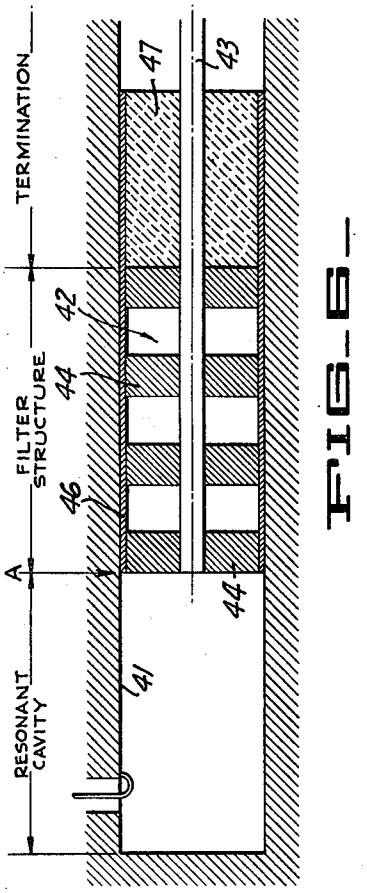


FIG-6

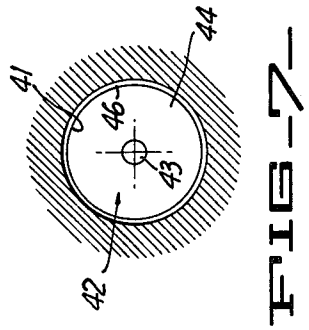


FIG-7

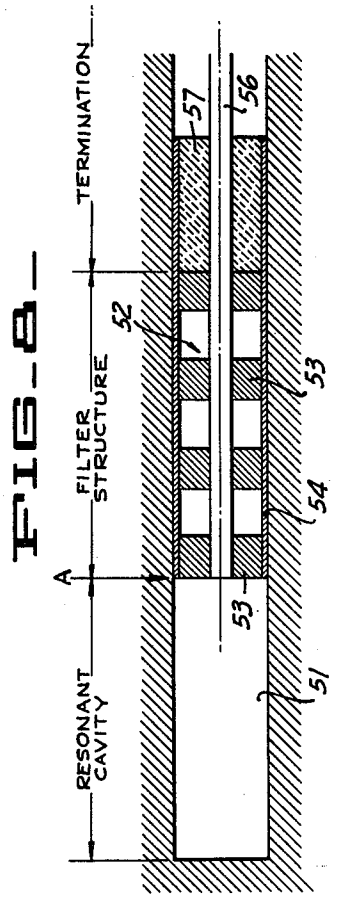


FIG-8

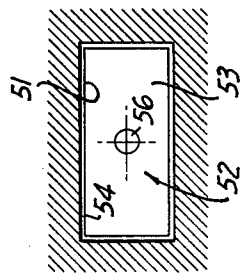


FIG-9

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2,944,233

CAVITY RESONATOR AND OSCILLATION GENERATOR

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Continuation of application Ser. No. 370,553, July 27, 1953. This application Oct. 16, 1958, Ser. No. 768,530

4 Claims. (Cl. 333—82)

This application is a continuation of U.S. Patent application, Serial No. 370,553, filed July 27, 1953.

This invention relates generally to high frequency electrical apparatus of the microwave type, and particularly to cavity resonators and oscillators making use of the same.

Broadband microwave resonant circuits generally utilize a cavity which is adjustable with respect to its effective volume to meet the conditions of oscillation. For a cavity of a given shape and volume there can exist numerous modes of resonance. In many instances it is desirable to design a microwave circuit for the lowest frequency mode of resonance. However, this is not always possible nor practical, because as the operating frequencies become higher, the cavity diminishes in size. Also the design size requirements may be such that the node of the lowest mode of resonance may fall inside of another structure, such as an oscillator tube. When because of such limitations higher order modes are utilized, resonance will at times coincide with lower order modes. Under such conditions the lower order modes generally override the higher modes, with resulting discontinuity in the tuning curve. Still higher modes of resonance will at times occur simultaneously with the desired resonance, with resulting simultaneous operation of the system on two different frequencies. In order to avoid such difficulties it has been proposed to provide means which will prevent operation on an undesired mode. One means which has been used for this purpose is the provision of a probe of lossy material which is introduced into the cavity in such a manner as to suppress the undesired mode. This means has the disadvantage that a mechanical arrangement must be employed to change the position of the probe for various selected frequencies of operation. Another means for this purpose is disclosed in U.S. Patent 2,747,098 to Myers and Zeidler which involves use of a special arrangement of slots in the walls of the cavity. In many instances such special slotting of the cavity walls is not desirable, particularly since it involves accurate milling operations.

In general it is an object of the present invention to provide apparatus of the above character in which novel means is provided to prevent oscillation on an undesired mode.

Another object of the invention is to provide apparatus of the above character in which the means that prevents oscillation on an undesired mode is incorporated in an adjustable plunger which forms one wall of the cavity.

Further objects and features of the invention will appear from the following description in which the preferred embodiment of the invention has been set forth in detail in conjunction with the accompanying drawings.

Referring to the drawings:

Figure 1 is a side elevational view in section illustrating a microwave oscillator incorporating the present invention.

Figure 2 is a circuit diagram illustrating the equivalent

circuit for the filter incorporated in the apparatus of Figure 1.

Figure 3 is a schematic view illustrating a coaxial cavity resonator and adjustable plunger of conventional construction.

Figure 4 is a mode plot of the cavity shown in Figure 3.

Figure 5 is a mode plot of the coaxial cavity shown in Figure 1.

Figure 6 is a side elevational view schematically illustrating a circular wave guide resonator incorporating the present invention.

Figure 7 is an end view of the resonator shown in Figure 6.

Figure 8 is a side elevational view schematically illustrating a rectangular wave guide resonator utilizing the present invention.

Figure 9 is an end view of the resonator shown in Figure 8.

Figure 10 is a view like Figure 2 but showing another embodiment.

In accordance with the present invention I provide a cavity resonator with one wall which is movable to adjust the cavity volume. The movable wall is in the form of a plunger that incorporates a filter and a termination, and which prevents oscillation on an undesired mode. More specifically any energy of the undesired frequency would be passed by the filter and absorbed in the termination. The net result is that the cavity resonates only over the desired range of frequencies, and no interruptions can occur due to modes of resonance outside the designed range.

In Figure 1 the invention has been incorporated in a resonator of the coaxial type which is combined with a velocity modulation tube such as a klystron. Thus the metal body **10** provides conducting walls which form the cavity **11**. It is assumed that the shaping is such that the cavity is circular in section, and that the bore **12** which extends from the cavity is likewise circular in section. A klystron tube **13** is mounted within one end of the body, and is held in place by the removable retaining nut **14**. The lower grid ring **16** of the tube is directly connected to the body. The upper grid ring **17** is directly connected to the conductor **18**, which extends axially through the cavity **11** and the bore **12**. A coupling loop **19** is shown for coupling the cavity to an external circuit.

The plunger assembly designated generally at **21** is fitted within the bore **12**, and forms an adjustable wall for the cavity. This plunger consists of a tubular conducting shell **22** which is provided with wiper contact fingers **23**, or a like means for making good electrical contact with the adjacent walls of the body **10**, at the forward end of the plunger.

A plurality of annular conducting members **24** are disposed within the shell **12** and spaced axially of the plunger. The outer peripheries of members **24** are fixed to and in good conductive contact with the shell **22**, while their inner peripheral faces are spaced with respect to the center conductor **18**. In order to maintain such spacing, a tube **26** of suitable dielectric material is fitted within the members **24**, and serves to maintain a definite spacing between these members and the center conductor **18**. Beyond the last one of the members **24** there is an annular body **27** of lossy material, which forms a termination, and can be made of Polyiron.

The capacitive relation between the inner faces of the members **24** and the center conductor **18** forms a plurality of capacitive components. These capacitive components are connected by a plurality of inductive components, formed by the conductive paths between members **24**. Therefore the capacitive and inductive components form the elements of a filter as shown in Figure

2, with the termination 27 forming a resistive energy absorbing load.

In accordance with the present invention the parts of the plunger are so designed that the filter passes high frequency energy of a frequency corresponding to the undesired mode, whereby such energy is absorbed by the termination 27. The net result is that the cavity does not resonate on the undesired modes.

For the desired operation at any selected frequency over a broad band the repeller voltage of the klystron tube is adjusted in accordance with changes in the positioning of the plungers. It is desirable for this purpose to employ suitable mechanical means operated by a single control for moving the plunger and simultaneously track the repeller voltage.

To more adequately explain my invention I have shown a conventional coaxial resonator in Figure 3, and in Figure 4 its corresponding mode plot. In Figure 3 one wall of the coaxial resonator 31 is formed by the conventional contact plunger 32, which has wiper contacts making connection with the outer conducting walls 33, and the center conductor 34. By reference to the mode plot of Figure 4 drawn for the particular cavity under observation, it will be evident that oscillation due to the quarter wave mode (about 5,000 mc.) completely overrides the three-quarter wave cavity mode at frequencies above 8,800 mc. Thus with this arrangement it was impossible to secure stable operation on the desired three-quarter wave mode. When this resonator was equipped with a plunger of the type described in Figure 1, the mode plot obtained was as shown in Figure 5. Note that oscillation due to the undesired quarter wave cavity mode was completely eliminated. The desired mode was thus permitted to oscillate without interference. The filter carried by the plunger was in this instance arranged to pass frequencies below about 6,500 mc.

By way of example, the particular apparatus for which the mode plot of Figure 5 was made, was constructed as follows: The cavity 11 was circular and had a diameter of 0.765 inch. The klystron employed was known by manufacturers' specifications as No. 5721 and the center conductor 18, connected to the upper grid ring 17 had a diameter of 0.407 inch. The conducting tube 22 had an internal diameter of 0.740 inch, and a total length of about 5 inches. Each of the conducting members 24 was annular, with external and internal diameters respectively of 0.740 and 0.522 inch, and a thickness or width between faces of 0.181 inch. These members were spaced .250 inch apart, and were bonded to the tube 22. The body 27 was made of compressed Polyiron, with an axial length of about 2 inches. The zero plunger position indicated in Figure 5 correspond to a position in which the ends of the wiping contacts 23 were substantially in contact with the coupling loop 19.

As illustrated in Figures 6 to 9 inclusive, my invention can be used with a wave guide resonator, as well as resonators of the coaxial type. As schematically illustrated in Figures 6 and 7, the cavity 41 is circular in section, and is provided with the adjustable plunger 42. The plunger consists of a central rod 43, formed of a metal, and which carries the several spaced conducting members 44. These members are annular in form, and have their outer peripheral surfaces spaced by an annular gap from the adjacent metal walls forming the cavity 41. Suitable means such as the insulating sleeve 46, can be positioned about the members 44, and slidably fitted in the cavity, to maintain the members 44 generally centered. Adjacent the most remote one of the members 44, there is a body 47 formed of lossy material like Polyiron, to form a filter termination.

The apparatus of Figures 8 and 9 is similar to Figures 6 and 7. The cavity 51 is rectangular in section, and the

plunger 52 is formed by the elements 53, which are rectangularly contoured, and which have their outer peripheral faces spaced from the adjacent conducting walls of the cavity, by suitable means such as the insulating sleeve 54. Members 53 are likewise carried by the central rod 56, and a filter termination is provided by the body 57 of the lossy material, such as Polyiron.

In both Figures 6 and 8 the plunger is designed to have the desired filter characteristics, whereby the cavity is prevented from oscillating on an undesired cavity mode.

Figure 10 illustrates another embodiment which in effect is a modification of Figure 1. The plunger assembly in this instance consists of the axially spaced annular metal members 61 together with the inner and outer insulating tubes 62 and 63 to which members 61 are fixed. The annular body 64 of lossy material forms a termination for the filter. The equivalent diagram for Figure 10 is the same as Figure 2, except that two series capacities are provided in place of the single capacities. With proper proportioning and spacing the arrangement of Figure 10 can be made to have the same characteristics as described in connection with the mode plot of Figure 5.

I claim:

1. In high frequency electrical apparatus designed to oscillate at the three-quarter wave mode, means defining a high frequency resonant cavity, a velocity modulation tube forming at least part of one end wall of said cavity and a low-pass filter forming another end wall of the cavity, said filter serving to pass high frequency energy of the quarter-wave mode and reject high frequency energy of the three-quarter wave mode.

2. Apparatus as in claim 1 in which the filter is in the form of a plunger which is adjustable to vary the volume and resonance frequency of the cavity.

3. In high frequency apparatus designed to oscillate at the three-quarter wave mode, means defining a high frequency resonant cavity, a velocity modulation tube forming one end wall of said cavity, a plunger fitted into said means and movable axially in opposite directions to adjust the volume and resonance frequency of the cavity, said plunger comprising a plurality of capacitive and inductive elements distributed along said axis to form a reactive low-pass filter, said filter serving to pass high frequency energy of frequency corresponding to the quarter-wave mode and reject high frequency energy of the three-quarter wave mode, and filter termination means of lossy material, said means serving to absorb the high frequency energy passed by the filter.

4. In high frequency electrical apparatus designed to oscillate at the three-quarter wave mode, means defining a high frequency resonant cavity, a velocity modulation tube forming one end wall of the cavity and a low-pass filter forming another end wall of the cavity, said filter being formed with a plurality of filter sections and serving to pass the energy of the quarter-wave mode and reject high frequency energy of the three-quarter wave mode, and filter termination means of lossy material serving to absorb the energy passed by the filter.

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