Oct. 8, 1946. A. M. GUREWITSCH 2,408,927

FILTERING ARRANGEMENT

Filed July 30, 1942

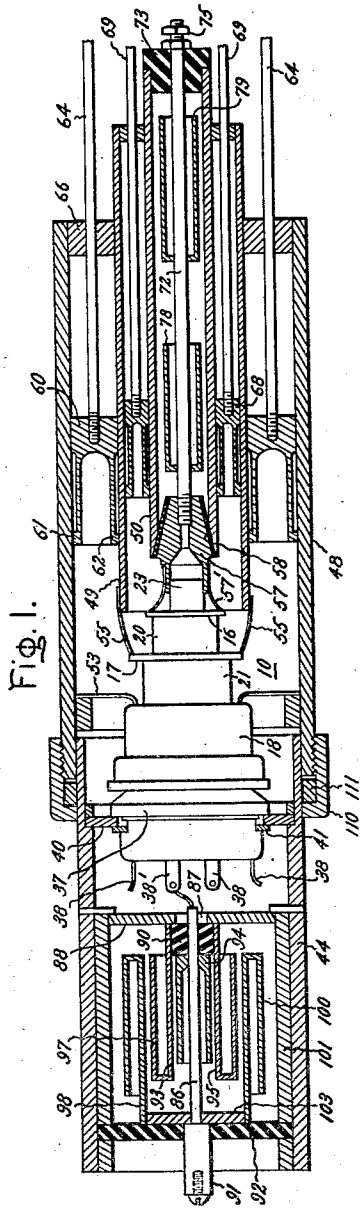


Fig. 1.

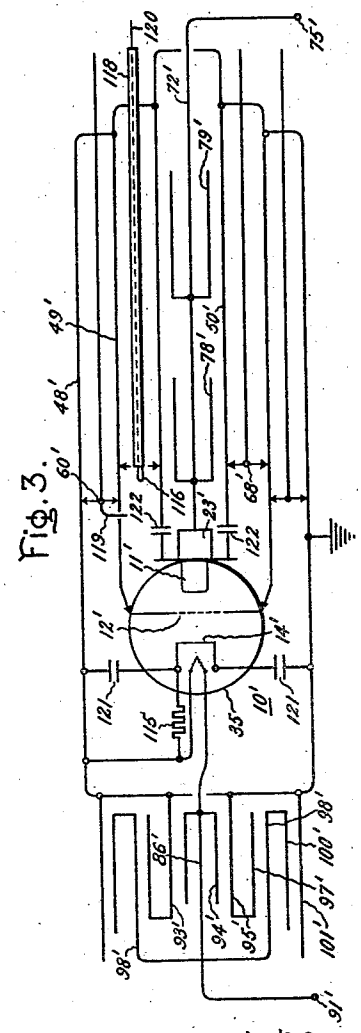


Fig. 3.

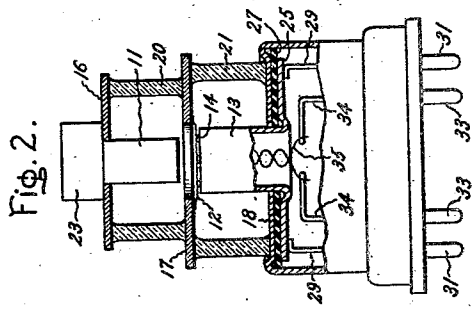


Fig. 2.

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Patented Oct. 8, 1946

2,408,927

UNITED STATES PATENT OFFICE

2,408,927

FILTERING ARRANGEMENT

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Application July 30, 1942, Serial No. 452,946

5 Claims. (Cl. 178—44)

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This invention relates to an electrical filtering arrangement especially adapted for use at ultra high frequencies.

As is well known, it is frequently necessary in the design of radio circuits and like apparatus to provide means for effectively separating the direct current and alternating current paths. At the lower frequencies, such as the frequencies commonly used in radio broadcasting, this separation may be accomplished by the use of choke coils and condensers, properly arranged. However, at higher frequencies, especially at frequencies corresponding to wave lengths on the order of a few centimeters, the conventional arrangements fail to produce the desired results and it is necessary to resort to more complex expedients including specially designed filters.

The present invention is principally concerned with the provision of an improved form of ultra high frequency filter which is characterized by simplicity and compactness of structure and which is well adapted for use at even the shortest wave lengths.

Briefly, the invention makes use of a multiply-folded coaxial transmission line arrangement providing a plurality of quarter wave filter sections in series. In order to obtain a band-block characteristic the various sections may be made of different lengths so that each corresponds to a quarter wave length at some particular frequency within the selected frequency range.

The features of the invention desired to be protected herein are pointed out in the appended claims. The invention itself, together with its further objects and advantages, may best be understood by reference to the following description taken in connection with the drawing in which Fig. 1 is a longitudinal sectional view of a high frequency oscillator embodying one of my improved filter arrangements; Fig. 2 is a partial section of the discharge tube which is represented in less detail in the assembly of Fig. 1, and Fig. 3 is a diagrammatic view useful in explaining the operation of the construction of Fig. 1.

Referring particularly to Fig. 1 there is shown an ultra-high frequency oscillator having a three-electrode discharge tube 10 as its central element. As appears more clearly in Fig. 2, this tube comprises a cylindrical anode 11, a grid 12 and a cylindrical cathode 13 having its emissive part in the form of a flat disk surface 14 which faces the grid 12. The envelope within which these electrodes are enclosed comprises a series of three circular metal parts 16, 17 and 18 which are supported in mutually spaced relation by

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glass cylinders 20 and 21 sealed between them. The part 17 provides a terminal for the grid 12, and a terminal for the anode is provided by a cylindrical enlargement 23 which is welded or soldered against the upper surface of the part 16.

The cathode 13 is provided at its lower extremity with a flange 25 which parallels the under surface of the part 18 but which is separated from that part by an insulating spacer 27 (e. g. a mica washer). With this arrangement the part 18 has a high frequency connection with the cathode through the capacity existing between this part and the flange 25 but is effectively insulated from the cathode as far as direct current is concerned. Separate direct-current connections are made to the cathode by means of lead-in wires 29 secured to the under surface of the part 25 and terminally connected to prongs 31 which depend from the base of the discharge tube. Additional prongs 33 and lead-in wires 34 are provided for the purpose of supplying heating current to a coiled filament 35 arranged within the cathode cylinder 13 so that the emissive part of the filament can be maintained at an elevated temperature by this means.

In the arrangement of Fig. 1 the tube 10 is seated in a socket or adaptor 37 having accessible terminals 38 to which appropriate connections may be made. The socket 37 is itself supported by the combination of a fixed ring 40 and a split locking ring 41, the ring 40 being secured to the inner surface of an elongated cylinder sleeve 44 having certain further functions which will be explained at a later point.

The oscillating circuits employed in connection with the discharge tube 10 are provided by the combination of a series of three concentric tubular conductors 48, 49 and 50. The outer conductor 48 has a high frequency connection with the cathode of the tube 10 through a ring of contact fingers 53 which bear upon the surface of the tube part 18. Similarly, the cylindrical conductor 48 has a symmetrical connection with the grid of the tube through spring contact fingers 55 which bear upon the grid terminal 17. Finally, a high frequency connection between the inner tubular conductor 50 and the anode of the tube 10 is provided by pressing the extremity of the conductor over a tapered adaptor 57 which is fitted snugly onto the anode terminal and which bears contact fingers 57' adapted to engage the disk 16. The tubular conductor 50 is insulated from the adaptor 57 with respect to direct currents by the interposition between

their juxtaposed surfaces of a mica sleeve 58. It will be seen, however, that the capacity which exists through the mica assures that the conductive parts in question are effectively directly connected as far as high frequency currents are concerned.

With the arrangement specified, the space between the conductors 48 and 49 forms in effect a transmission line section which may be adjusted as to length to provide a resonant tank having a resonant frequency appropriately related to the desired frequency of operation of the oscillator. This adjustment may be accomplished by the use of an annular plug or contact ring 60 having two sets of contact fingers 61 and 62 which respectively bear upon the opposed surfaces of the tubular conductors 48 and 49. Actuating rods 64 which extend out through a supporting ring 66 provided in the end of the oscillator structure make it possible to move the ring 60 back and forth to produce the desired tuning.

A similar tunable transmission line section is provided between the grid and anode by the combination of the tubular conductors 49 and 50. The resonant frequency of the tank circuit thus provided between the grid and anode is adjustable, as in the case of the grid-to-cathode circuit, by means of a slidable contact ring or plunger 68 having externally accessible actuating rods 69.

Assuming the application of appropriate direct current potentials to the various electrodes of the tube 10, oscillations may be obtained by properly adjusting the two tunable tank circuits provided and by arranging for a proper feed back coupling between these circuits. The principles which govern the operation of an oscillator of this kind are fully described in application Serial No. 448,206, filed June 24, 1942 in the name of Richard C. Jensen and James E. Keister and assigned to the General Electric Company, a corporation of New York. In general, it is required that the inner and outer lines be tuned to frequencies on opposite sides of the expected operating frequency, such tuning being obtained by adjusting each line so that its length corresponds approximately to an odd number (e. g. 1, 3, 5, etc.) of quarter wave lengths at the frequency to which it is being tuned. Feedback may in some instances be provided solely by the inter-electrode capacity of the tube 10 but in most cases it is found preferable to employ a probe or loop (not shown in Fig. 1) extending between the inner and outer transmission line sections for providing more positive coupling between them.

On the assumption that the concentric conductors 48, 49, 50 and the connected metallic parts provide a complete conductive enclosure, it would appear that high frequency energy developed within the enclosure should be effectively confined and that no high frequency coupling between the oscillating system and external agencies should exist. However, such an assumption ignores the presence of the insulating spacers 27 (Fig. 2) and 58 (Fig. 1). These spacers, which are required to permit the establishment of D.-C. potential differences between the various electrodes of the tube 10, represent leakage gaps in an otherwise continuous metallic structure and may permit uncontrolled radiation of high frequency energy and other disadvantageous effects. For this reason it is necessary to provide filtering means in association with the D.-C. and low frequency A.-C. connections of the tube.

The grid 14 of the tube is connected directly

to the main structure of the oscillator and is operated at ground potential, so that no difficulty exists with reference to the D.-C. connections to this element. On the other hand, mutually insulated connections must be made to both the anode 11 and the cathode 13.

The anode terminal is insulated from the grounded structure by the mica spacer 58, and positive potential is applied to it by the use of a conductor 72 connecting with the adaptor 57 and extending outwardly through an insulating block 73 at the end of the oscillator structure, an externally accessible terminal for this arrangement being indicated at 75. Due to the gap provided between the tubular conductor 50 and the adaptor 57 by the spacer 58 there is some tendency for coupling to exist between the otherwise completely enclosed high frequency system and the direct current conductor 72 and its associated circuits. In order to avoid objectionable effects attributable to this cause, it is expedient to provide filtering means in the form of hollow metal sleeves 78 and 79 fitted on the conductor 72 and each providing a reentrant discontinuity with respect to currents flowing along this conductor.

Filtering means of the type specified are known per se and are not intended to be claimed herein except as embodied in an improved arrangement to be described at a later point. Their usefulness depends in part upon the consideration that the conductor 72 and the surrounding tube 50 form a coaxial transmission line to which the propagation of high frequency energy is necessarily confined. The passage of such energy along the line may be alternatively viewed as attributable to high frequency currents flowing over the opposed surfaces of the coaxial conductors or to the propagation of waves in the space between the conductors. Taking the latter viewpoint, it may be said that the discontinuities provided by the sleeves 78 and 79 tend to block the propagated waves by reflecting them.

For complete blocking or reflection to occur at a particular frequency, the optimum condition is that in which the length of the blocking sleeve is a quarter wave length (or an odd number of quarter wave lengths) at such frequency and in which the impedance "seen" at the right-hand end of the sleeve is infinite. The latter condition is fulfilled by the reentrant sleeve construction illustrated in Fig. 1 since the resonant quarter wave section enclosed by each sleeve actually represents an infinite impedance (at the resonant frequency) in series with the section formed between the outer surface of the sleeve and the surrounding conductor. It is also desirable that the difference in diameter between each sleeve and the conductor 72 be relatively great and that the spacing between the sleeve and the surrounding conductor 51 be small. By making the sleeves 78 and 79 of different lengths and by using as many such sleeves as are needed, a considerable band of frequencies may be blocked so that unwanted coupling is prevented regardless of the particular frequency at which the oscillator is operated.

A generally similar problem with respect to high frequency coupling exists in connection with the means employed for supplying heating current (either D.-C. or 60 cycle A.-C.) to the cathode of the tube 10. These means include the socket terminal 38', which is assumed to be connected to the cathode filament, and a conductor 86 having a connection with this terminal (the other cathode connections do not appear in Fig.

1, but are indicated diagrammatically in Fig. 3). The conductor 86 extends through an opening 87 formed in a transverse wall part 88 which otherwise completely encloses the space within which the socket end of the tube 40 is positioned. At one end it is supported in an insulating bushing 90 and at the other end is provided with an externally accessible terminal 91 mounted in an insulating wall part 92. Objectionable high frequency coupling is to be anticipated in connection with this arrangement because of the possible propagation of high frequency energy through the gap provided by the cathode spacer 27 (Fig. 2), through the glass seals of the tube 10, through the opening 87 and along the conductor 86.

This problem may, of course, be dealt with by a filtering arrangement identical with that employed in connection with the anode, that is, by the use of several reentrant quarter wave filters arranged sequentially in axial alignment. However, while the use of such an arrangement in connection with the anode does not tend materially to increase the space requirements of the oscillator, the same consideration does not apply in connection with the cathode; that is to say, the use of two or more quarter wave filters arranged in end-to-end relation in connection with the cathode terminal would obviously greatly extend the length of the structure as a whole.

In accordance with my invention this difficulty is avoided by the use of a folded conductor arrangement in which a number of quarter wave filter sections are provided in a concentric relationship. This arrangement includes in the first instance a conductive element 93 which surrounds the conductor 86 and which for a short portion of its length forms with the conductor a coaxial transmission line along which high frequency energy passing through the opening 87 tends to be propagated. To block the flow of such energy a reentrant quarter wave discontinuity is provided by mounting upon the conductor 86 a metallic sleeve 94 which is open at one end and which is of materially larger diameter than the conductor. The length of the sleeve 94 is made such as to correspond closely to one or more odd quarter wave lengths at a selected frequency within the expected operating range of the oscillator. In series with this arrangement there is provided a second reentrant quarter wave filtering section provided by a tubular conductor 97, which may be looked upon as a reversely bent extension of the conductor 93. This is surrounded by a tubular conductor 98 which bears a reversely bent part 100 adapted to provide a still further reentrant discontinuity in the path of wave propagation. A sleeve 101 fitted into the cylinder 44 decreases the dimensions of the free space about the conductive part 100. A metallic washer 103 which closely surrounds the extremity of the conductor 86 serves to support the associated tubular elements 98 and 100 and closes one end of the inner conductor. For supporting this structure and for securing it to the remaining structure of the oscillator, use is made of a clamping ring 110 which abuts against a narrow flange 111 provided on the outer surface of the part 44 and which has a screw-threaded engagement with the part 43 as indicated at 112.

As a result of the arrangement described, the only possible path for the escape of high frequency energy through the left hand extremity of the apparatus of Fig. 1 is by series passage through the various filter sections. Where it is

desired to operate the oscillator at one frequency only, all the filter sections may be made of identical length, that is to say, of a length corresponding to a quarter wave length at the frequency in question. On the other hand, where a range of operating frequencies is to be employed, the various filtering sections are preferably made of different lengths as shown, so that the arrangement as a whole provides a band-stop filter.

The operation of the invention may be further explained by reference to the diagrammatic representation of Fig. 3 in which elements which can be readily identified with parts previously described in connection with Figs. 1 and 2 are designated by similar numerals differentiated by priming.

As has been previously explained, the oscillating system is made up of the discharge tube 10' and the two resonant circuits which are respectively provided between the conductors 48' and 49' and the conductors 49' and 50'. Feedback is provided (in part) by means of a conductive probe 119 which is mounted on the tuning ring 60' and which extends through an axial slot cut in the tubular conductor 49'. An output arrangement for the high frequency energy developed is illustrated as comprising a coupling loop 116 which extends into the space between the conductors 49' and 50' and which is made externally accessible by means of a concentric conductor transmission line comprising a metal tube 113 and a coaxial wire 120.

Direct current terminal connections for the electrodes of the tube 10' are indicated at 72' and 86', cathode bias being provided by a resistor 115 connected in series with the cathode. The considerations which require the use of filtering arrangements in association with these connections arise from the presence of the condensers 121 and 122, the first set representing the by-pass capacity provided by the insulating washer 27 (Fig. 2) and the second set representing the capacity provided by the mica insert 58 (Fig. 1). As has been previously indicated, these spacers represent gaps through which undesirable high frequency coupling may occur. As far as the anode conductor 72' is concerned such coupling is prevented by the inclusion of the filtering elements 78' and 79'. In connection with the cathode supply conductor 86' a similar function is performed by the concentrically arranged filters 94' to 101'. Accordingly, no substantial coupling between the high frequency oscillator and the external circuits is permitted.

While the invention has been described by reference to a particular embodiment it will be understood that numerous modifications may be made by those skilled in the art without departing from the invention. I, therefore, aim in the appended claims to cover all such equivalent variations as come within the true spirit and scope of the foregoing disclosure. In the claims, wherever the term "quarter wave" is employed it is to be understood as applying either to a single quarter wave or to any odd number of quarter waves.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A filter comprising a plurality of successively telescoped coaxial conductors connected to provide a plurality of quarter wave discontinuities in series, adjacent ones of said conductors being insulated from each other for unidirectional currents.

2. A band-stop filter for frequencies within a

given range comprising a plurality of successively telescoped concentric conductors connected to provide a number of filtering sections in series, adjacent ones of said conductors being insulated from each other for unidirectional currents, each of said sections having a length corresponding to a quarter wave length at some frequency within the given range, and the various sections being of different diameters whereby each represents a discontinuity with respect to the others.

3. In an arrangement for decoupling the power leads to an ultra high frequency space resonant system, a high frequency filter including a plurality of telescoped conductors of varying diameters connected to provide a number of filtering sections in series, each of said sections comprising a reentrant quarter wave discontinuity in the path of propagation of the waves desired to be filtered, and adjacent ones of said conductors being insulated from each other for unidirectional currents.

4. A device for decoupling the power leads to an ultra high frequency space resonant system

comprising, a high frequency filter including a plurality of telescoped conductors arranged to provide a multiple reversed path for electromagnetic waves tending to pass through the filter, each reversed section of the filter comprising a reentrant discontinuity effective to block passage of waves of a particular wave length, and adjacent ones of said conductors being insulated from each other for unidirectional currents.

5. In combination, a high frequency system, a conductor for supplying current to a part of said system, and a high frequency filter associated with said conductor, said filter comprising a conductive tube surrounding said conductor and defining with it a coaxial transmission line, means on said conductor for providing a quarter wave discontinuity in said line, and further conductive means concentrically surrounding said tube and insulated therefrom at the frequency of said current for providing a second quarter wave discontinuity serially related to the first.

ANATOLE M. GUREWITSCH.