Dec. 16, 1941. N. E. LINDENBLAD 2,266,501

ELECTRICAL WAVE FILTER

Filed July 28, 1939

Fig. 1

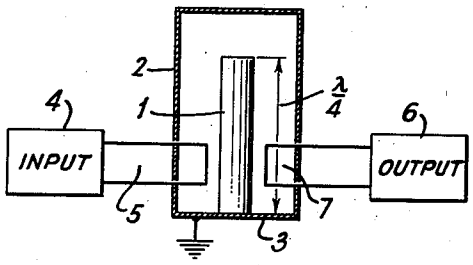


Fig. 4

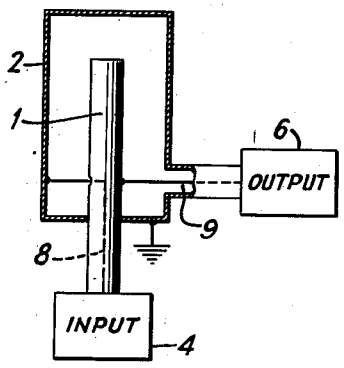


Fig. 2

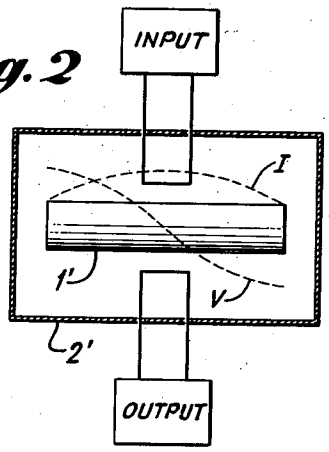


Fig. 5

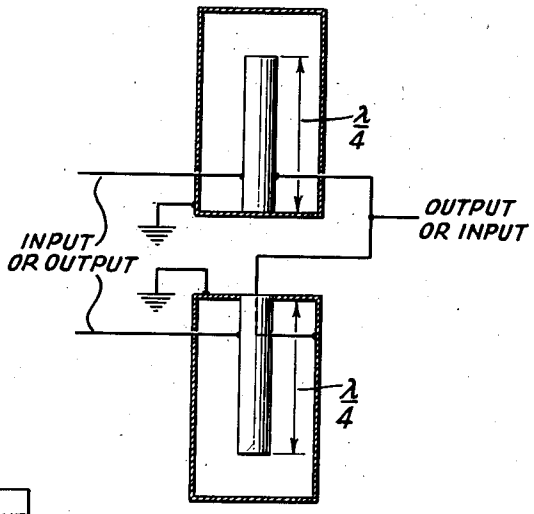
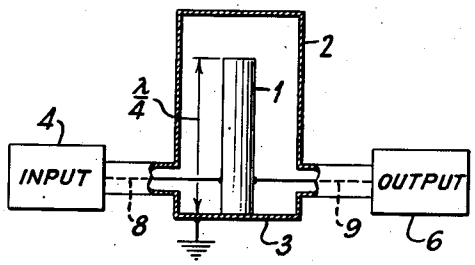


Fig. 3



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ELECTRICAL WAVE FILTER

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6 Claims. (Cl. 178—44)

This invention relates to electrical wave filters. Specifically, the invention is concerned with a filter employing a concentric line resonator for passing frequencies confined within the narrow band obtained by the resonance characteristic of the line resonator.

The invention in general utilizes the well-known type of tuned circuit in the form of a concentric line. Such a concentric line is characterized by low loss and a high Q (low power factor) and consists of a conductor of suitable dimensions surrounded by an outer electrically conducting envelope. The inner conductor may have a length equal to one-quarter of the operating wave coupled at one end in suitable manner to the concentric outer shell. Such concentric line is described in some detail in the article by Clarence W. Hansell entitled "Resonant lines for frequency control," published in "Electrical Engineering," August, 1935, pages 852 et seq. The inner conductor of the concentric line may also have a length equal to one-half the length of the communication wave. A concentric line of this last type is described in my United States Patent No. 2,095,990, granted October 19, 1937.

In brief, the invention contemplates employing a sharply resonant concentric line filter of low loss for eliminating parasitic oscillations or other undesired frequencies between a source and a utilization circuit and for permitting the passage only of the narrow band of frequencies provided by the resonance characteristic of the tuned filter circuit. For this purpose the source of oscillations and the utilization circuit are substantially uncoupled except through the concentric line filter; that is, the source of oscillations and the utilization circuit are uncoupled except at the frequency of resonance of the intermediate concentric line filter.

A more complete description of the invention follows, accompanied by a drawing, wherein Figs. 1, 2, 3 and 4 show four different filter circuits of the present invention for passing an extremely narrow band of frequencies, and Fig. 5 shows a combination of filter circuits, such as shown in Figs. 3 and 4.

In the drawing, Fig. 1 shows a tuned concentric line circuit comprising an inner conductor 1 and an outer conductor 2 suitably coupled together at one end by an end plate 3 which is grounded for radio frequency oscillations. Inner conductor 1 is made to be electrically one-quarter wavelength long for the frequency to be passed. A suitable input circuit 4, shown conventionally in box form, which may be any desired source of oscillations such as an oscillation generator or an amplifier, is shown inductively coupled to the inner conductor 1 by means of a loop 5 at a point of high current and low voltage. Similarly, an output circuit 6, also shown conventionally in box form, which may be another amplifier or a transmission line leading to an antenna, is shown inductively coupled to the inner conductor 1 by a loop 7 also coupled to the concentric line at a point of high current and low voltage. These loops are adjustable to interlink a desired small portion of the total magnetic field existing between the conductors 1 and 2. By means of the arrangement shown, there is very little if any direct coupling between the input and output loops 5 and 7. Since the output loop 7 will not have any consequential energy induced therein until the concentric line 1, 2 has been energized by the source 4, it will be evident that the output circuit will only have induced therein energy at frequencies within the very narrow frequency limits of the low loss, high Q, concentric line resonator. At the resonant frequency of the concentric line the impedance of the input loop 5 rises due to the interlinking field of the resonant circuit, while at frequencies other than the resonant frequency the impedance of the loop 5 will be synonymous with its self-impedance which is very small. In this way the concentric line 1, 2 functions as an extremely efficient filter to eliminate parasitics or other undesired frequencies which may exist in the input circuit 4 and which it is desired to eliminate from passing on to the output circuit 6. Inasmuch as the only frequencies which can pass through the filter are those within the narrow band of frequencies povided by the resonance characteristic of the filter, and since this resonance characteristic can be controlled by the design of the structure, the output circuit will be energized only at the desired frequencies present in the input circuit.

Fig. 2 shows a modification of Fig. 1, wherein the concentric line comprises an inner conductor 1' having a length equal to one-half the length of the wave corresponding to the frequency to be passed, surounded by an outer conductor 2'. The instantaneous voltage and current distributions over the conductor 1' are shown by the curves V and I, respectively. Here also, it will be seen that the input and output circuits are coupled to the line at points of high current and low voltage. The same effect is achieved in this

embodiment as is obtained in the embodiment of Fig. 1.

Fig. 3 shows a method of obtaining the results of the invention by means of direct coupling between the input circuit 4 and the resonant line 1, 2, and the output circuit 6 and the resonant line 1, 2. For this purpose, the input and output circuits are coupled to the resonant line 1, 2 by means of connections 8 and 9, respectively, which directly connect to the inner conductor 1 at a distance a small fraction of a quarter of a wave from the point of coupling to the end plate 3. It should be understood that in this case the concentric resonant line 1, 2 provides a path of extremely low impedance to ground for a frequency other than the resonant frequency of the concentric line.

Fig. 4 shows a modification of the circuit of Fig. 3, wherein the input connection 8 is inversely connected to the concentric line 1, 2 with respect to the output connection 9. The conductor 8 in this figure extends within the interior of the inner conductor 1, in which there exists no field from the currents in the resonant line, and connects to the interior of the outer shell or conductor 2, so that a suitable amount of the total magnetic field is encircled. The conductor 9 extending to the output circuit 6 is joined to the inner conductor 1 so as to encircle either the same or a greater or less amount of the magnetic field than that encircled by conductor 8. By means of these connections, the instantaneous potentials on conductors 8 and 9 will be reversed with respect to each other, a condition which is quite different from that of Fig. 3 wherein the potentials on conductors 8 and 9 in this last figure are not reversed with respect to each other.

The circuits of Figs. 3 and 4 are equivalent in substantially all respects except for the phase reversals of the potentials obtained in conductors 8 and 9 of Fig. 4, which are not obtained in Fig. 3. It will be understood that conditions are encountered in practice where the respective virtues of these two circuits may be used together or separately. As an illustration, they may be used together for purposes of coupling a push-pull circuit to a single ended push-push circuit, or vice versa. Fig. 5 shows one such circuit utilizing the filters of Figs. 3 and 4 together to couple a balanced or push-pull circuit to an unbalanced or single ended circuit.

What is claimed is:

1. An electrical wave filter system comprising a low loss concentric line resonator having hollow inner and outer conductors coupled together at one end by a metallic plate grounded for radio frequency energy, direct connections from said line resonator to suitable input and output circuits, said input circuit being connected to the inner surface of said outer conductor by a connection extending in the interior of said inner conductor and passing through an aperture therein to said outer conductor, said output circuit being connected to the outer surface of said inner conductor by a connection passing through an aperture in said outer conductor, whereby said input and output circuits are uncoupled except at the resonance frequency of said concentric line resonator.

2. A filter system comprising a first low loss concentric line resonator having hollow inner and outer conductors coupled together at one end by a metallic plate grounded for radio frequency energy, and a second low loss concentric line resonator coupled together at one end by a metallic plate grounded for radio frequency energy, an input or output circuit comprising a pair of connections to the inner conductors of said first and second resonators, an output or input circuit comprising another pair of connections one of which connects to the inner conductor of said second resonator and the other of which extends into the interior of the hollow inner conductor of said first line resonator and passes out through an aperture in said hollow inner conductor to connect with the interior surface of the outer conductor of said first resonator, all junction points between said line resonators and said input and output circuits being at locations of relatively large current flow and low voltage.

3. A frequency selective system for coupling together a pair of circuits comprising a concentric line resonator having hollow inner and outer conductors coupled together at one end, said hollow inner conductor extending beyond said end to form the outer conductor of a feeder line, an inner conductor for said feeder line extending into the interior of the hollow inner conductor of said resonator and passing through an aperture therein to the outer conductor of said resonator, one of said pair of circuits being coupled to said feeder line, and a connection from the other of said pair of circuits passing through an aperture in the outer conductor of said resonator to the inner conductor of said resonator.

4. A frequency selective system for coupling together a pair of circuits comprising a concentric line resonator having hollow inner and outer conductors coupled together at one end, connections from said line resonator to said pair of circuits, one of said pair of circuits being connected to the inner surface of said outer conductor by a connection extending in the interior of said inner conductor and passing through an aperture therein to connect with said outer conductor, said other circuit of said pair being connected to the outer surface of said inner conductor by a connection passing through an aperture in said outer conductor, whereby said circuits are coupled substantially solely at the resonance frequency of said resonator.

5. An electrical wave filter comprising a low loss concentric line resonator having a length effectively equal to half the length of the operating wave to be passed thereby, an input circuit comprising a source of oscillations and an output circuit comprising a load, and means coupling both said input and output circuits to the inner conductor of said resonator at points of relatively maximum current and minimum voltage, whereby said circuits are coupled together substantially solely at the resonance frequency of said concentric line resonator.

6. A frequency selective system for coupling together a pair of circuits comprising a concentric line resonator having hollow inner and outer conductors coupled together at one end, said hollow inner conductor extending beyond said end to form the outer conductor of a feeder line, an inner conductor for said feeder line extending into the interior of the hollow inner conductor of said resonator and passing through an aperture therein to the outer conductor of said resonator, one of said pair of circuits being coupled to said feeder line, and a connection from the other of said pair of circuits passing through an aperture in the outer conductor of said resonator intermediate the ends thereof to the inner conductor of said resonator.

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