Feb. 26, 1929.

1,703,171

E. S. PURINGTON

ELECTRIC WAVE FILTER

Filed May 8, 1924

2 Sheets-Sheet 1

Fig. 1

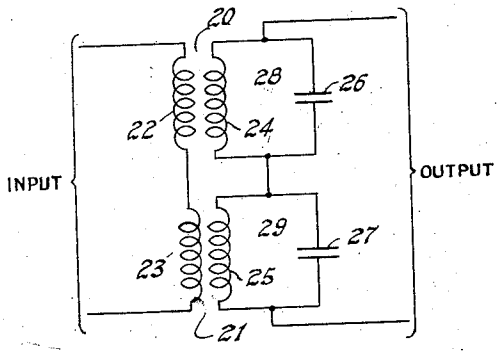


Fig. 2

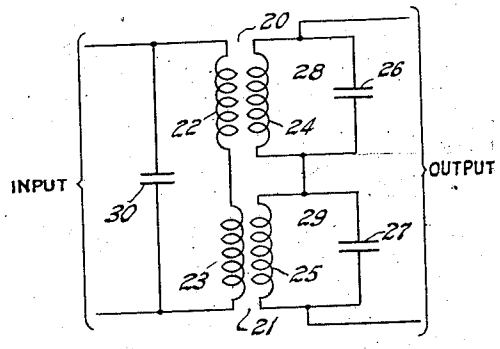
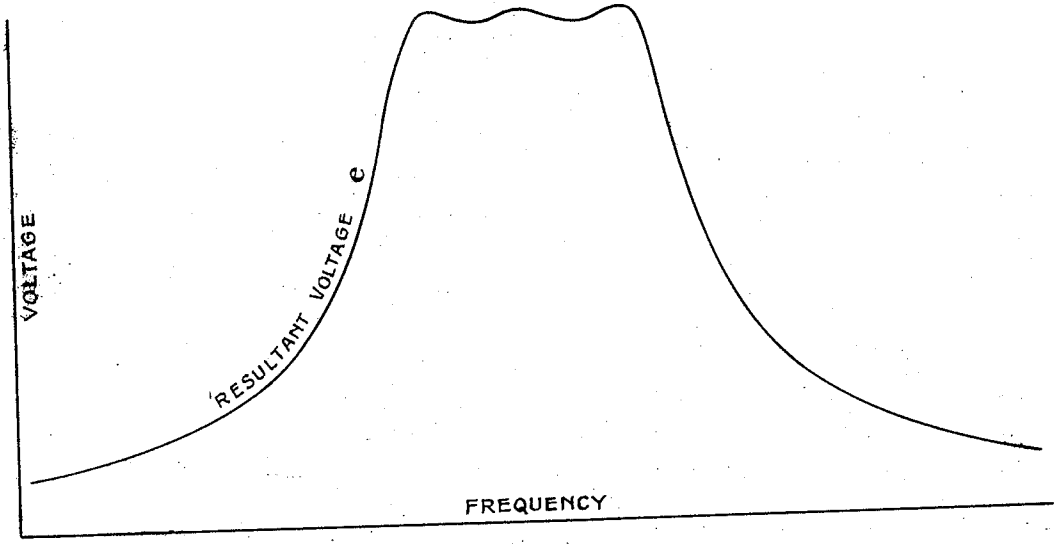


Fig. 3



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Fig. 3

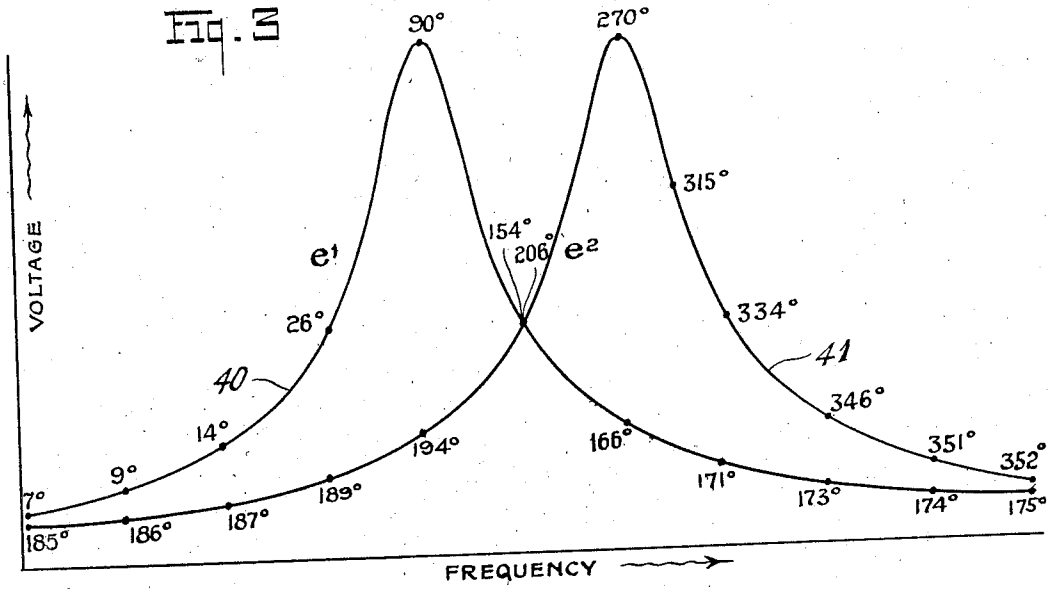
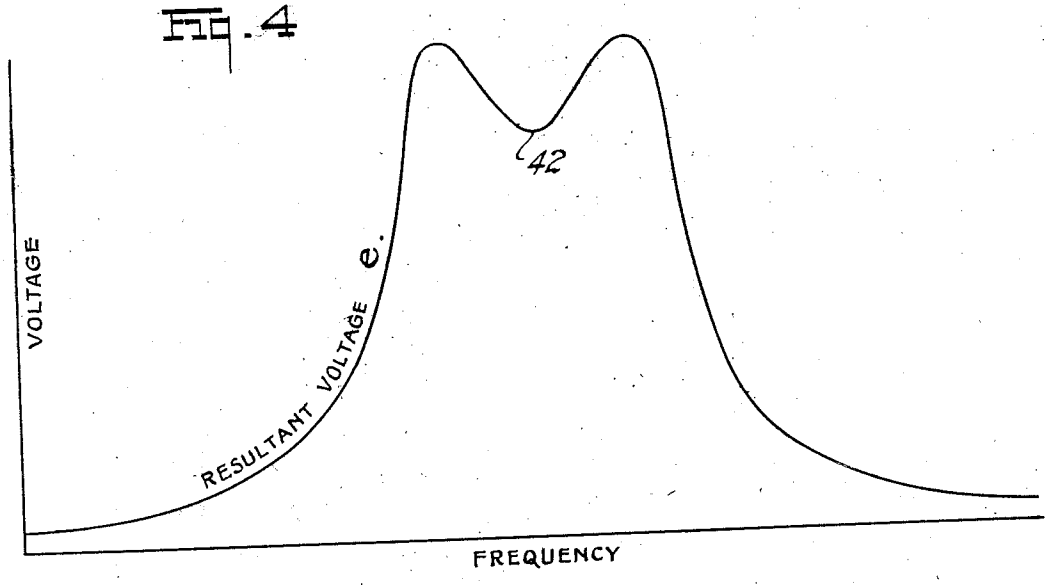


Fig. 4



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UNITED STATES PATENT OFFICE.

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ELECTRIC-WAVE FILTER.

Application filed May 8, 1924. Serial No. 711,770.

This invention relates to resonant circuits used in communication by radiant energy, and more particularly to improvements in band filters conductive to currents of a predetermined band of frequencies, but resistive to or suppressive of currents of other frequencies.

In the reception of radio telephone messages, especially at long wave lengths, the use merely of a single, simple, sharply-tuned circuit does not produce the best results, since if tuned for the best reception of comparatively low audio tones it discriminates against high audio tones. If detuned to produce good speech quality, the circuit becomes relatively weaker against interfering radio telephone or other modulated waves. A coupled circuit receiver may be considered a better receiver for radio telephony because it can be adjusted to have a more or less flat top transmission curve with cutoff properties as good as a single tuned circuit receiver.

The new type of band filter forming the subject matter of this invention has been provided, among other reasons, for the purpose of obtaining better selectivity, with especial reference to circuits which must take in a wider band of wave-length frequencies, than is at present obtained by single or double circuit tuners, either in radio reception or in secondary filtering. It has also, however, application to the reception of continuous waves, either long or short, as will appear hereinafter.

One feature of this new filter device comprises two resonance circuits, differing in frequency from each other, and so connected in a network that off-resonance voltages transmitted through one circuit are substantially balanced by off-resonance voltages transmitted through the other.

In the accompanying drawings:

Fig. 1 is a diagram of a band filter constructed in accordance with this invention;

Fig. 2 is a diagram of a modified form of the same for a band of frequencies relatively wider than that for which the form in Fig. 1 was intended;

Fig. 3 shows voltage curves of the electromotive forces co-existing in different portions of the filter of Fig. 1 at different frequencies;

Fig. 4 shows the vectorial summation of the curves of Fig. 3; and

Fig. 5 shows a curve representing the effective voltages obtained when the system of Fig. 2 is employed.

The filter of the present invention may be employed in a wide variety of utilities. Among other uses, it may be employed as the band filter in the system described in a patent for system of radio communication, No. 1,642,663, granted September 13, 1927, to Emory Leon Chaffee.

The form of the invention shown in Fig. 1 comprises a pair of opposed inductive couplings 20 and 21 having substantially equal resistances, inductances and turns. The couplings have primary coils 22 and 23, and secondary coils 24 and 25. The primary coils 22 and 23 are wound in opposite directions and connected in series in an input circuit extending from another portion of the system in which the filter is to be used. The input may be, for example, from an antenna system, the plate circuit of a three-electrode tube, or the output circuit of a similar filter section. The secondary coils 24 and 25 are wound in the same direction, and in combination with condensers 26 and 27 respectively form two closed oscillatory circuits 28 and 29, which are connected in series with each other and with the output circuit of the filter. This output circuit may, for example, be the grid-filament circuit of a three-electrode tube, or it may be connected to the input of a similar filter section. As thus constructed and arranged the two couplings 20 and 21 act in opposition, one to the other, to oppose or prevent the transmission of oscillations other than those within the selected band of frequencies from the input circuit to the output circuit of the filter.

The constants of the closed circuits 28 and 29 are so selected that the natural period or frequency of oscillation of one circuit, 28 for instance, will be substantially that of the lower frequency of the band of frequencies to which it is desired that the filter shall be conductive, while the natural period of the other circuit 29 will be substantially that of the upper frequency of the desired band. Preferably the upper and lower frequencies of the band selected should not differ by more than a few percent so that incoming oscillations of either of these frequencies will cause both circuits to oscillate but in different amplitudes.

In the operation of the filter of Fig. 1, assuming that an electro-motive force having

a frequency less than the selected range is applied to the input circuit, there will be set up in each of the closed oscillatory circuits 28 and 29 forced oscillations of this frequency, but since these circuits have different natural periods from that of the impressed frequency, the amplitudes of the forced oscillations will be comparatively small.

The curves 40 and 41 of Fig. 3, represent approximately the relative voltages at different frequencies of the electro-motive forces induced in the two circuits 28 and 29, respectively, as a result of the action of currents of different frequencies within the prescribed band applied to the input circuit. The curves 40 and 41 may be taken to represent, approximately, relative voltages e^1 and e^2 measured respectively across the condensers 26 and 27 of Fig. 1 during the operation of the filter under the actions of incoming oscillations of different frequencies.

It is to be understood that the voltage across the coil 24 is 90° out of phase with that in the coil 22, while the voltage across the coil 25 is 90° out of phase with that in the coil 23 in an opposite sense. Therefore, at the point of resonance of the circuit 28 the voltage of the condenser 26 is in phase with that of the coil 24 or 90° from the voltage in the primary winding 22. Similarly, at the resonance frequency for the circuit 29, the voltage across the condenser 27 is in phase with the voltage of the coil 25, and, therefore, 90° behind the voltage of the coil 23 and, consequently, 270° with respect to the coil 22 inasmuch as the coil 23 is 180° out of phase with the coil 22. At frequencies other than the resonance frequencies the current in the oscillatory circuits 28 and 29 will have a lead or a lag with respect to the voltage impressed in the coils 24 and 25 respectively and, consequently, the voltage on the condensers 26 and 27 will have corresponding phase displacements.

Thus in Fig. 3 the numerals "9°", "26°", etc. represent the phase angle of the electromotive force on the condensers 26 and 27 with respect to the input or primary electromotive force.

If the frequency of the applied electromotive force is substantially that of the lower limit of the selected band, the circuit 28 will be in resonance therewith, and oscillations of greatly increased amplitude will be set up therein. In the same way, an applied frequency corresponding to the upper limit will cause oscillations of increased amplitude to be set up in the closed circuit 29. Between these limits the oscillations will be somewhat reduced.

The vectorial summation of the curves of Fig. 3 is given in Fig. 4. In the Fig. 3 the voltages represented are those across the respective condensers and in Fig. 4 the vectorial sum of these voltages is the resultant voltage which is impressed on a work circuit set, for instance, as a grid filament circuit of a thermionic amplifier. The curve of Fig. 4 indicates that electro-motive forces outside the selected band are substantially balanced out, while electro-motive forces within the band are effective for producing manifestations of appreciable strength in the output circuit. The vale 42 is not hurtful provided the range selected, that is the spacing of the limiting frequencies, is not too great.

For frequencies of a wider range than that covered by Fig. 1, this invention provides the filter shown in Fig. 2. This form of filter is the same as that shown in Fig. 1 and hereinbefore described, except that in this case the frequencies to which the closed circuits 28 and 29 are tuned and which are the limiting frequencies of the filter, are more widely separated, and except that a condenser 30 is connected across the windings 22 and 23, and the capacity of the condenser 30 is so selected that the natural frequency of the circuit containing the condenser 30 and the two coils 22 and 23, with the secondary coils 24 and 25 removed, is the mean of the two frequencies of the circuits 28 and 29. The curve of the resulting electro-motive forces ($e = e^1$ plus e^2) is shown in Fig. 5, in which it is to be noted that there is no central vale corresponding to the vale 42 of Fig. 4, but that such a vale has been replaced by a gently undulating line having no deep depressions.

Although only two forms in which this invention may be embodied have been shown herein, it is to be understood that the invention is not limited to any specific construction but might be embodied in various forms without departing from the spirit of the invention or the scope of the appended claims.

I claim:

1. An electric wave filter comprising an input circuit including two primary coils and an output circuit including two secondary coils inductively coupled to said first-mentioned coils respectively to form two inductive couplings, one of said couplings being arranged to act in opposition to the other of said couplings, and two closed oscillatory circuits including respectively said two secondary coils and tuned to respond selectively to two different frequencies respectively.

2. An electric wave filter comprising an input circuit including two primary coils arranged in series and an output circuit including two secondary coils arranged in series and inductively coupled to said first-mentioned coils respectively to form two inductive couplings, one of said couplings being arranged to act in opposition to the other of said couplings, and two closed oscillatory circuits including respectively said two secondary coils and tuned to respond selectively to two different frequencies respectively.

3. An electric wave filter comprising an input circuit including two primary coiled portions and an output circuit including two secondary coiled portions inductively connected to said first-mentioned portions respectively to form therewith two inductive couplings, a condenser in shunt with each of said secondary coiled portions respectively and forming therewith two oscillatory circuits tuned to two different frequencies respectively, said couplings being arranged to act in opposition, one to the other.

4. A filter in accordance with claim 3, in which a condenser connected across said primary coiled portions forms therewith a closed oscillatory circuit tuned to a frequency between said first-mentioned frequencies.

5. An electric wave filter comprising an input circuit including two primary coiled portions and an output circuit including two secondary coiled portions inductively connected to said primary coiled portions respectively and coupled oppositely with respect to them, and means forming with certain of said coiled portions two resonant circuits tuned respectively to different frequencies.

6. An electric wave filter comprising a resonant circuit including two primary coiled portions, a circuit including two secondary coiled portions inductively connected to said primary coiled portions respectively, and means forming with said secondary coiled portions respectively two oscillatory circuits tuned to frequencies different from each other and from the frequency to which the first-mentioned circuit is tuned.

7. An electric wave filter comprising an input circuit including a pair of primary coiled portions and an output circuit including a pair of secondary coiled portions inductively connected to said primary coiled portions respectively, the units of one pair of said coiled portions being wound in the same direction and the units of the other pair of coiled portions being wound in opposite directions and means forming with certain of said coiled portions respectively a plurality of circuits tuned to different frequencies.

8. An electric wave filter comprising an input circuit including two primary coiled portions wound in opposite directions and an output circuit including two secondary coiled portions wound in the same direction inductively connected to said primary coiled portions respectively, means forming with said secondary coiled portions respectively two resonant circuits, and means including said primary coiled portions and forming a resonant circuit.

9. A filter circuit comprising a pair of transformers having their primary windings in series, and their secondary windings in series, each of the secondary windings being included in a closed oscillatory circuit resonant to a predetermined band of frequencies partly overlapping the band to which the other closed oscillatory circuit is resonant, the connections of said transformers, being such that electromotive forces induced in the secondary windings thereof are mutually opposing.

10. An electric wave filter comprising, an input circuit including, two primary coils arranged in series and a condenser shunting both of said coils and an output circuit including, two secondary coils arranged in series and inductively coupled to said first mentioned coils respectively to form two inductive couplings one of said couplings being arranged to act in opposition to the other of said couplings and two closed oscillatory circuits including respectively said two secondary coils and tuned to respond selectively to two different frequencies respectively.

This application signed this 1st day of May, 1924.

ELLISON S. PURINGTON.