

Oct. 26, 1948.

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2,452,114

BALANCED WAVE FILTER

Filed April 26, 1945

FIG. 1

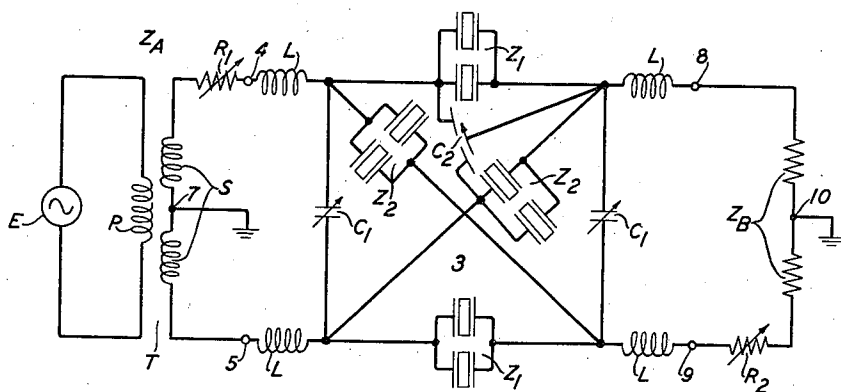
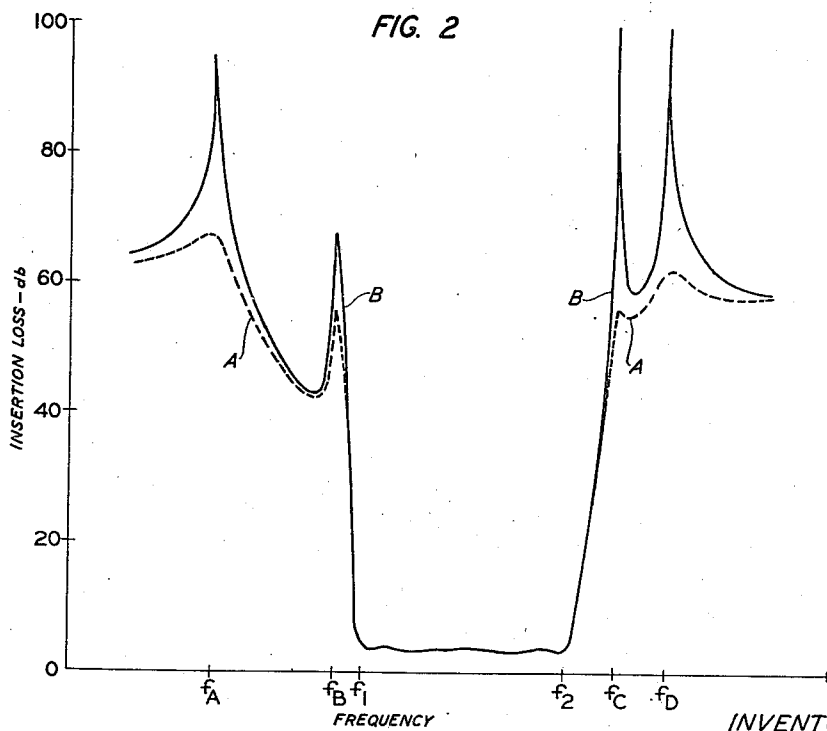


FIG. 2



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2,452,114

BALANCED WAVE FILTER

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Application April 26, 1945, Serial No. 590,366

20 Claims. (Cl. 178-44)

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This invention relates to wave filters and more particularly to filters of the balanced type.

The objects of the invention are to increase the slope along the sides of the transmission band and increase the transmission loss in the suppression ranges in a balanced wave filter.

In order to provide maximum transmission loss in the suppression ranges in a balanced wave filter operating between load impedances grounded at their electrical mid-points it is necessary to reduce to a minimum the admittance dissymmetry of the component impedance branches with respect to ground. Extremely high losses require a high degree of conductive symmetry as well as a high degree of susceptive symmetry. However, even if the component elements are manufactured to the highest standards the assembled filter will generally exhibit some residual conductive dissymmetry, which operates to reduce the loss.

In accordance with the present invention, this residual conductive dissymmetry in a balanced wave filter is substantially eliminated by adding one or more compensating resistances of proper magnitude external to the filter circuit. If only a single resistance is added, it is connected between the filter and one of the load impedances. In some cases a greater improvement may be obtained by adding two resistances, one connected between a filter terminal and one of the load impedances and the other connected between the diagonally opposite filter terminal and the other load impedance. The two resistances are preferably of approximately the same magnitude. As a result the transmission loss is increased in the suppression ranges but the loss in the transmission band is not materially affected.

The nature of the invention will be more fully understood from the following detailed description and by reference to the accompanying drawing in which like reference characters refer to similar or corresponding parts and in which:

Fig. 1 is a schematic circuit of a wave filter in accordance with the invention connected between terminal loads; and

Fig. 2 shows typical insertion loss characteristics for the filter before and after correction of the residual conductive dissymmetry.

Fig. 1 shows a balanced wave filter 3 connected between load impedances Z_A and Z_B which are grounded substantially at their electrical mid-points. The load Z_A comprises a transformer T having a primary winding P across which is connected a wave source E and a secondary winding S connected to the input terminals 4 and 5 of

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the filter 3 and grounded at its electrical mid-point 7. The load Z_B is connected to the output terminals 8 and 9 of the filter 3 and grounded at its electrical mid-point 10.

The filter 3 comprises a lattice section having a pair of series impedance branches Z_1 and a pair of diagonal impedance branches Z_2 , with equal series inductances L and variable shunt capacitances C_1 at the ends. Each impedance branch Z_1 and Z_2 includes two piezoelectric crystal elements. A differential capacitor C_2 is associated with one series branch Z_1 and one diagonal branch Z_2 . For a detailed explanation of how to proportion the elements of the filter 3 to provide a desired transmission characteristic, reference is made to United States Patents 2,045,991 to W. P. Mason issued June 30, 1936, and 2,342,875 to G. H. Lovell issued February 29, 1944.

The component elements of the filter 3 are so designed and mounted as to provide the highest possible degree of admittance symmetry with respect to ground. But even with the most careful design and construction there will be generally a residual admittance dissymmetry, consisting of both susceptive dissymmetry and conductive dissymmetry. The susceptive dissymmetry may be substantially eliminated by a proper adjustment of the differential capacitor C_2 .

In accordance with the present invention, the residual conductive dissymmetry is substantially eliminated by connecting a compensating resistance R_1 between the filter 3 and one of the load impedances, either Z_A or Z_B . As shown, the resistance R_1 is connected between the terminal 4 and the load Z_A . In practice, the proper magnitude for R_1 and side of the line in which it should be connected are determined most conveniently by trial. The resistance R_1 is inserted in one side or the other and adjusted for maximum insertion loss at some frequency in the suppression range, preferably close to a cut-off frequency and at a peak of loss. If a decrease in loss results from the insertion of the resistance R_1 it is moved to the other side and there adjusted for maximum loss. It is generally found that a very material increase in loss in the suppression ranges and a steepening of the slope along the sides of the band are obtainable by inserting the resistance R_1 in the proper side and adjusting it to the optimum value.

Under some circumstances an even greater improvement results from the use of two compensating resistances, associated respectively with diagonally opposite filter terminals. For example, a second resistance R_2 may be connected be-

tween the terminal 9 and the load Z_b , as shown. The resistances R_1 and R_2 are preferably of approximately the same magnitude. For convenience in making the adjustments the resistances R_1 and R_2 may be made variable, as indicated by the arrows.

In Fig. 2 the broken line curve A is a typical insertion loss-frequency characteristic obtainable with the filter 3 adjusted for substantial elimination of the residual susceptive dissymmetry but with the residual conductive dissymmetry uncompensated. The cut-off frequencies are f_1 and f_2 and more or less rudimentary loss peaks appear at the frequencies f_A , f_B , f_C and f_D . The solid line curve B shows the improvement obtainable by inserting the compensating resistance R_1 in the proper side and adjusting its magnitude for substantial elimination of the residual conductive dissymmetry at the frequency f_C of the first loss peak above the transmission band. It is apparent that the slope along the sides of the transmission band has been increased, the peaks have been materially heightened, and the loss considerably increased throughout the suppression ranges.

What is claimed is:

1. In combination, two load impedances grounded substantially at their electrical mid-points, a wave filter interposed between said impedances, and a resistance connected between said filter and one of said impedances, said filter comprising impedance branches which have a high degree of susceptive symmetry but have a residual conductive dissymmetry with respect to ground at a frequency at which transmission through said filter is substantially completely suppressed and said resistance having a magnitude such that said conductive dissymmetry is substantially eliminated at said frequency.
2. The combination in accordance with claim 1 in which said resistance is variable.
3. The combination in accordance with claim 1 in which said filter is of the lattice type.
4. The combination in accordance with claim 1 in which said filter is of the lattice type and includes piezoelectric crystal elements.
5. The combination in accordance with claim 1 in which said filter is of the lattice type and includes piezoelectric crystal elements in each impedance branch.
6. The combination in accordance with claim 1 in which said filter comprises a lattice-type section and equal inductances connected at the ends thereof, said section including crystal elements.
7. The combination in accordance with claim 1 in which said filter comprises a lattice-type section and equal series inductances connected at the ends thereof, said section including crystal elements.
8. The combination in accordance with claim 1 in which said filter comprises a lattice-type section and equal inductances connected at the ends thereof, said section including piezoelectric crystal elements in each impedance branch.

9. The combination in accordance with claim 1 in which said filter comprises a lattice-type section and equal series inductances connected at the ends thereof, said section including piezoelectric crystal elements in each impedance branch.

10. The combination in accordance with claim 1 in which said filter comprises a lattice-type section and said section includes a differential capacitor associated with two adjacent impedance branches for obtaining the high degree of susceptive symmetry.

11. The combination in accordance with claim 1 in which said frequency is close to a cut-off frequency.

12. The combination in accordance with claim 1 in which said frequency falls at a peak of transmission loss.

13. The combination in accordance with claim 1 in which said frequency is close to a cut-off frequency and at a peak of transmission loss.

14. In combination, two load impedances grounded substantially at their electrical mid-points, a wave filter interposed between said impedances, a resistance connected between a terminal of said filter and one of said impedances, and a second resistance connected between the diagonally opposite terminal of said filter and the other of said impedances, said filter comprising impedance branches which have a high degree of susceptive symmetry but have a residual conductive dissymmetry with respect to ground at a frequency at which transmission through said filter is substantially completely suppressed and said resistances having magnitudes such that said conductive dissymmetry is substantially eliminated at said frequency.

15. The combination in accordance with claim 14 in which said filter is of the lattice type.

16. The combination in accordance with claim 14 in which said filter is of the lattice type and includes piezoelectric crystal elements.

17. The combination in accordance with claim 14 in which said frequency is close to a cut-off frequency.

18. The combination in accordance with claim 14 in which said frequency falls at a peak of transmission loss.

19. The combination in accordance with claim 14 in which said frequency is close to a cut-off frequency and at a peak of transmission loss.

20. The combination in accordance with claim 14 in which said resistances are of approximately the same magnitude.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,778,085	Nyquist	Oct. 14, 1930
2,342,875	Lovell	Feb. 29, 1944