Feb. 6, 1951 W. H. HUGGINS ET AL 2,540,734

HIGH-FREQUENCY FILTER

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FIG. 1

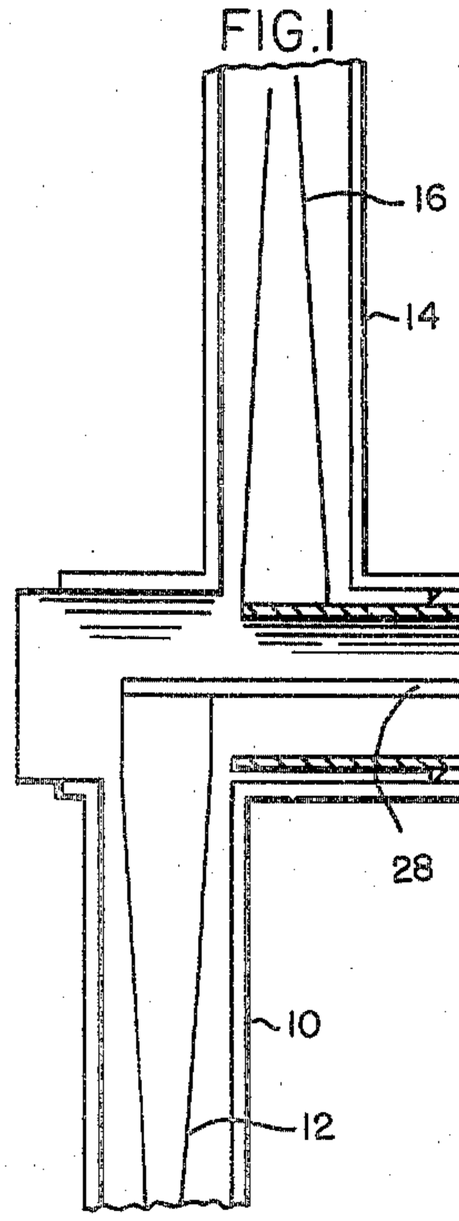


FIG. 2

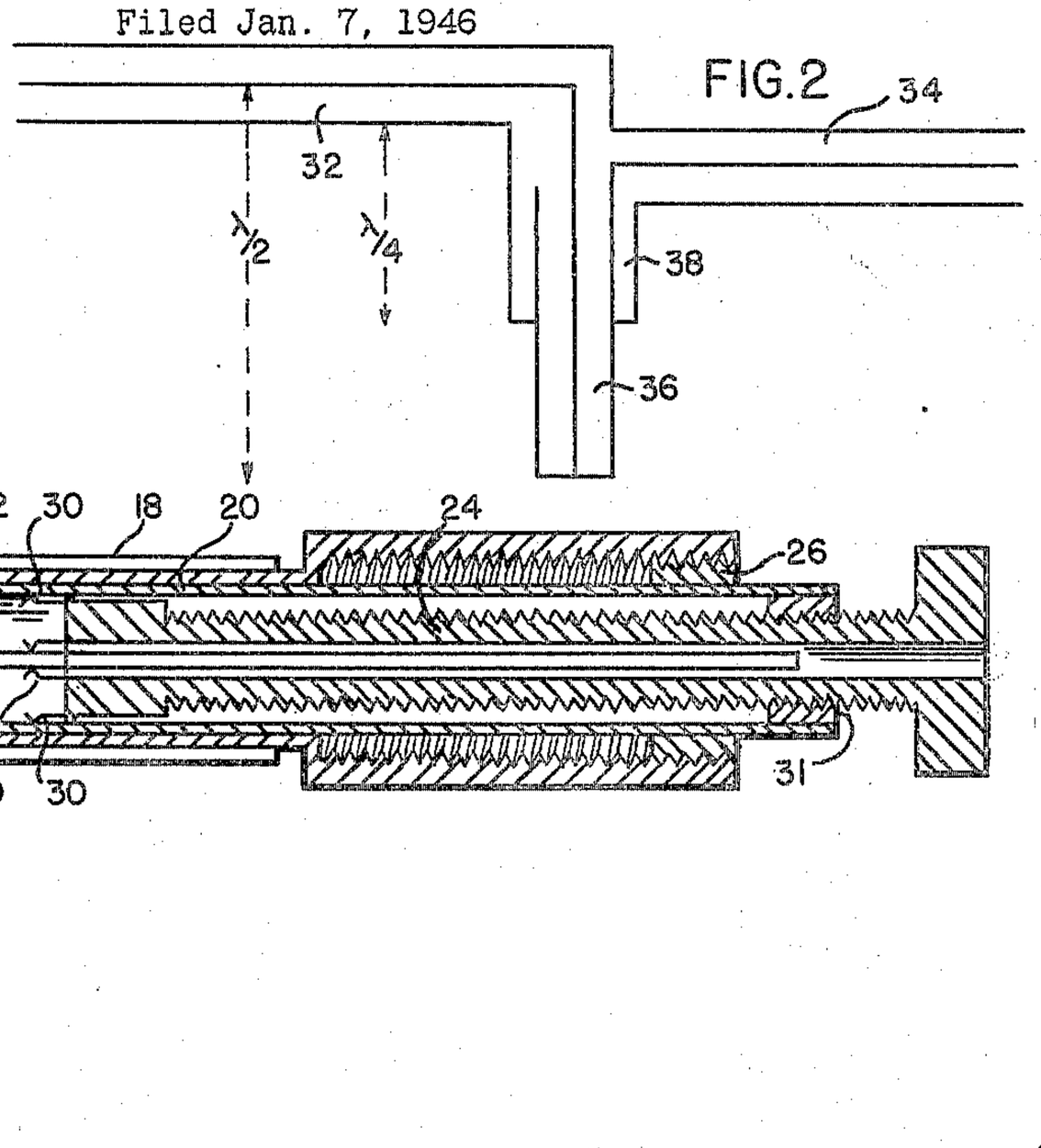
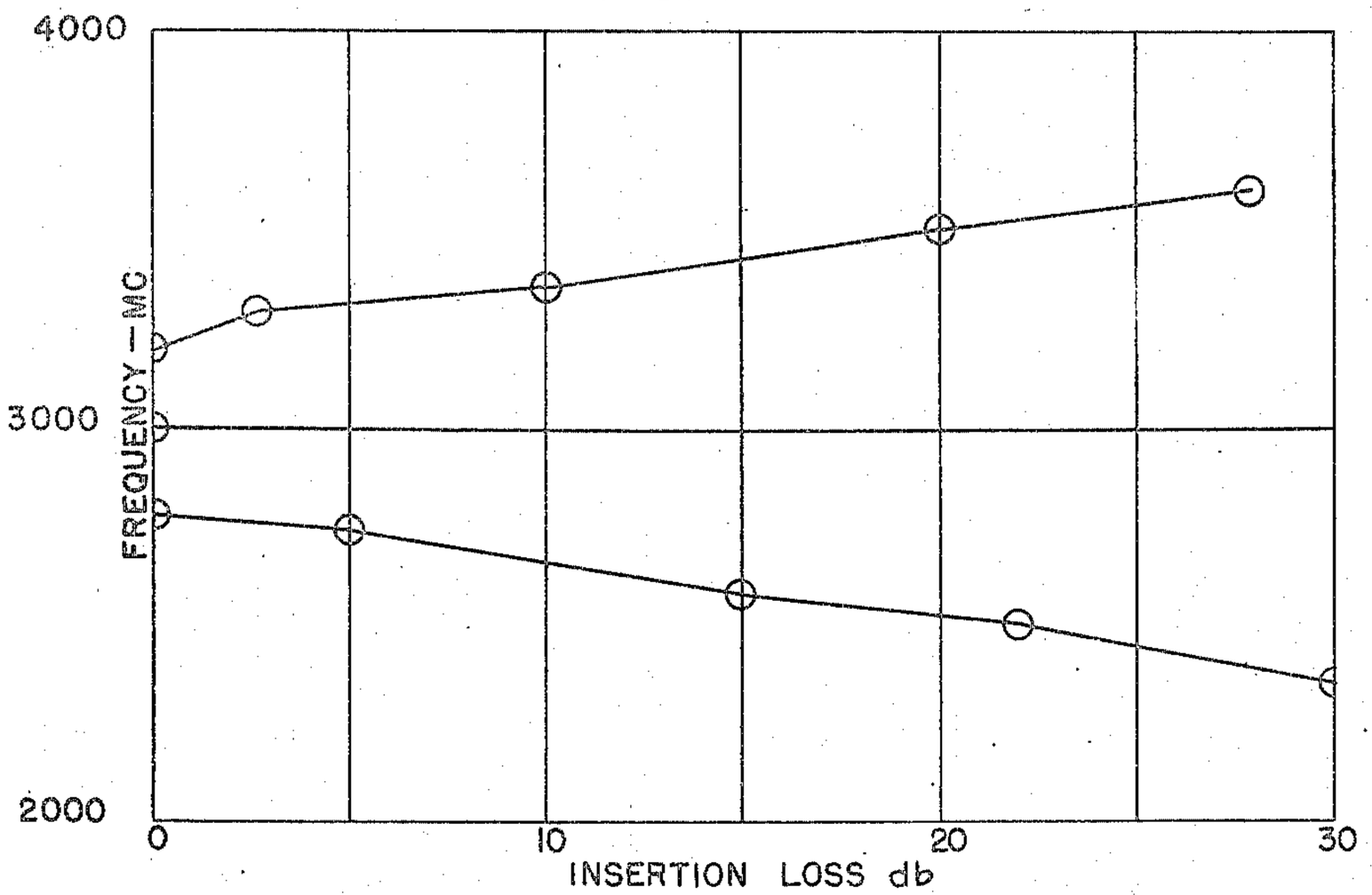


FIG. 4



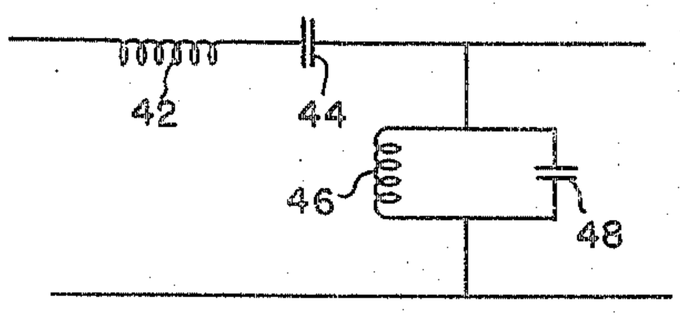


FIG. 3

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HIGH-FREQUENCY FILTER

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4 Claims. (Cl. 178—44)

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This invention relates generally to electrical apparatus and more particularly to an "L-section" coaxial high frequency band-pass filter.

At high frequencies filter networks composed of conventional inductances or capacitances become impractical, and equivalent inductances or capacitances supplied by suitably chosen lengths of coaxial transmission lines are frequently used to form a filter having desired characteristics. Coaxial filters may simulate networks such as the "L-section," "Π section," "T-section," or "M-derived" filters which are commonly employed at lower frequencies.

It is an object of the present invention, therefore, to provide a novel coaxial "L-section" band-pass filter. It is a further object to design this filter in such a manner that the center frequency of the pass band may be varied over a desired range of frequencies. It is another object to design said filter so as to have a narrow bandwidth, a sharp cutoff, and high off-band attenuation.

Other objects, features and advantages of this invention will suggest themselves to those skilled in the art and will become apparent from the following description of the invention taken in connection with the accompanying drawing in which:

Fig. 1 is a cross-sectional diagram of a coaxial filter embodying the principles of this invention:

Fig. 2 is a schematic diagram of the filter of Fig. 1;

Fig. 3 is a diagram of the equivalent circuit formed by the coaxial lines included in the filter of Figs. 1 and 2; and

Fig. 4 is a curve showing a typical frequency response for a filter as contemplated by the invention.

Reference is now made more particularly to the filter shown in Fig. 1 which includes an input section of transmission line composed of an outer conductor 10 and a tapered inner conductor 12, and an output section of transmission line composed of an outer conductor 14 and a similarly tapered inner conductor 16. These sections of line communicate with a lateral section which includes coaxial conducting cylindrical sleeves 18 and 20, conducting plungers 22 and 24 and central conductor 28. Plunger 22 has a section of small diameter which fits between cylinders 18 and 20 and a section of larger diameter which extends beyond cylinder 18 and is threaded on its inner surface. These threads engage similar threads on a collar 26 which is part of the cylindrical sleeve 20. Plunger 24 fits between

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cylindrical sleeve 20 and central conductor 28, making contact with both by means of sliding contacts 30. The body of plunger 24 is threaded on its outer surface, these threads engaging a threaded collar 31 mounted on the inside of sleeve 20. Conductor 12 is connected to central conductor 28, while conductor 16 is connected to cylindrical sleeve 20. Conductors 10 and 14 are joined to the outermost cylindrical sleeve 18.

Fig. 2 shows schematically the coaxial lines formed by the device of Fig. 1. The input section 32 of Fig. 2 corresponds to the transmission line formed by conductors 10 and 12 of Fig. 1 while the output section 34 of Fig. 2 corresponds to the line formed by conductors 14 and 16 of Fig. 1. The series section 36 of Fig. 2 corresponds to the line formed by conductors 20 and 28 of Fig. 1, and the shunt section 38 of Fig. 2 corresponds to the line formed by conductors 18 and 20 of Fig. 1. As indicated in Fig. 2, line 36 should be one-half wave length long and line 38 should be one-fourth wave length at the center frequency of the pass band. These lengths are adjusted by plungers 24 and 22, respectively.

The principle of operation of the filter may be clearly seen from the conventional "L-section" filter of Fig. 3. Line section 36 of Fig. 2 is a short-circuited line connected in series with the input and output sections 32 and 34. It may therefore be represented by the series tuned circuit of Fig. 3 composed of inductance 42 and capacitor 44, since its operation over the frequency band is analogous to that of a series resonant circuit. At frequencies below the center frequency of the pass band, this line section is between one-fourth wave length and one-half wave length in electrical length, and hence presents a capacitive reactance. At the center frequency it is exactly one-half wave length and acts as a short circuit, while at higher frequencies it is between one-half and three-fourths wave length and presents an inductive reactance. Similarly, line section 38 of Fig. 2 may be represented by the parallel tuned circuit of Fig. 3 composed of inductance 46 and capacitor 48 and connected in shunt with the input and output lines. At frequencies below the center frequency it presents an inductive short-circuited line of less than one-fourth wave length, while at the center frequency it presents a very high impedance and at higher frequencies a capacitive impedance.

It can be seen that at the center frequency the series circuit will offer little opposition to the passage of R.-F. signals and the parallel circuit will bypass only a small amount, so that

a maximum signal is passed. At other frequencies the series circuit will offer greater opposition to signals and the parallel circuit will bypass a larger percentage, so that the resultant output will be decreased. To obtain a narrow bandwidth the sections of line making up the filter are so constituted that the characteristic impedance of line section **36** (Fig. 2) is high while that of section **38** is low. To allow the filter to be used in a standard transmission line the total input characteristic impedance must be low, hence the center conductors of the input and output sections have been tapered, thus avoiding the production of undesirable reflections due to a sudden change of impedance at the points of connection.

The mid-frequency of the pass band may be varied by simultaneously varying the lengths of the component line sections. Referring to Fig. 1, this would be accomplished by rotating plungers **22** and **24** simultaneously. If desired, these plungers may be connected by a mechanism which will enable them to move longitudinally with respect to each other while rotating in unison. The plungers are threaded in a ratio of 2:1 so that the proper ratio is maintained between the lengths of the line sections being adjusted. Tapered conductors **12** and **16** may be terminated by standard coaxial transmission line connectors, so that the assembly may be readily inserted in a standard transmission line. The band-pass filter as described has a very sharp cutoff and high off-band attenuation, as may be seen by reference to the typical curve of Fig. 4. There are no undesirable pass bands at frequencies lower than 2½ times the mid-frequency of the pass band.

While there has been described what is at present considered to be the preferred embodiment of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the scope of the invention.

The invention claimed is:

1. A coaxial high frequency band-pass filter including an input section of coaxial transmission line having a tapered inner conductor; an output section of coaxial transmission line having a tapered inner conductor; a first cylindrical conductor connecting with the outer conductors of said input and output lines; a second cylindrical conductor connecting with one of said tapered inner conductors, said second conductor being coaxial with said first cylindrical conductor and fitting within said first cylindrical conductor for a portion of its length, two threaded collars respectively disposed on the inner and outer surfaces of said second conductor; a central conductor within and coaxial with said first and second conducting cylinders and connecting with the other of said tapered inner conductors; a first conducting plunger having a cylindrical portion fitting between said first and second cylindrical conductors and a threaded portion engaging the outer of said threaded collars; and a second conducting plunger fitting between said second conducting cylinder and said central conductor and making electrical contact with both, said second plunger being threaded on its outer surface so as to engage the inner of said threaded collars, both of said plungers being rotatable so as to vary their positions relative to said first and second cylindrical conductors and said central conductor.

2. A coaxial high frequency band-pass filter comprising an input section and an output section of coaxial transmission line, said sections having tapered inner conductors, a one-fourth wave length shorted transmission line connected in shunt with said input and output sections, and a one-half wave length shorted transmission line connected in series with said input and output sections, the characteristic impedance of said one-half wave length line being larger than that of said one-fourth wave length line, said two shorted transmission lines being adjustable in length so as to vary the mid-frequency of the pass band of said filter.

3. A narrow high frequency band pass filter of the coaxial line type comprising a main coaxial transmission line, a first coaxial transmission line section forming effectively a series tuned circuit connected in series in the inner conductor of said main line, said inner conductor of said main line being tapered to a larger diameter at its points of connection to said first line section than at its ends remote from said points of connection, and a second coaxial transmission line section forming effectively a parallel tuned circuit connected in shunt to said main line, the characteristic impedance of said first line section being larger than that of said second line section.

4. A narrow high frequency band pass filter of the coaxial line type comprising a main coaxial transmission line, a half wavelength coaxial transmission line section connected in series in the inner conductor of said main line, a first plunger shorting said half wavelength section, said inner conductor of said main line being tapered to a larger diameter at its points of connection to said half wavelength section than at its ends remote from said points of connection, a quarter wavelength coaxial transmission line section connected in shunt across said main line, a second plunger shorting said quarter wavelength section, the characteristic impedance of said half wavelength line section being larger than that of said quarter wavelength line section, and mechanical means coupled between said plungers for simultaneously moving said first plunger at twice the rate of said second plunger to vary the mid-frequency of said high frequency band pass.

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