

June 24, 1941.

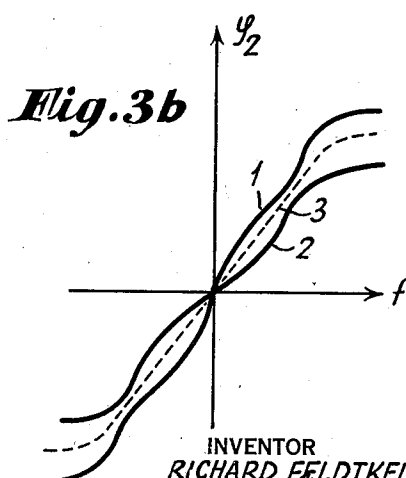
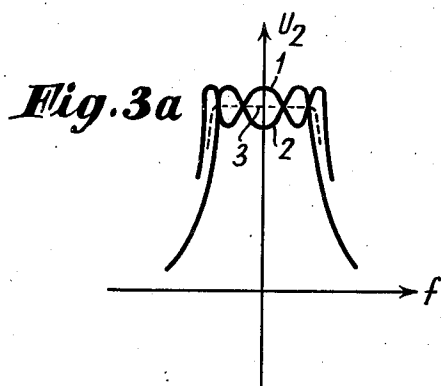
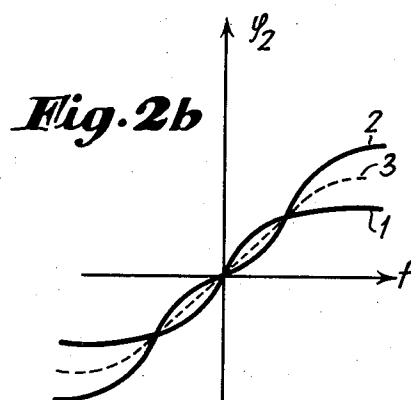
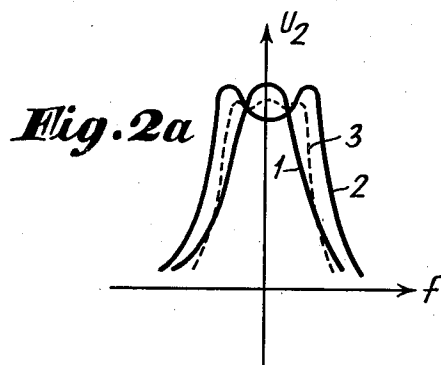
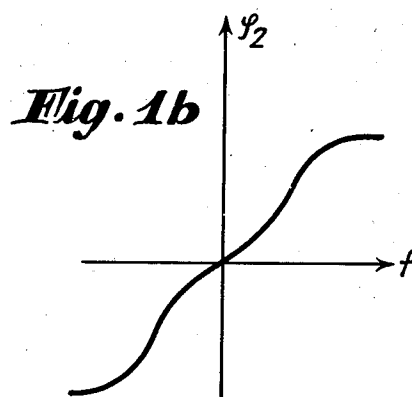
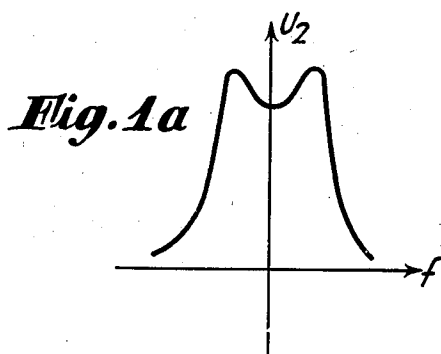
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2,246,935

BAND-PASS FILTER

Filed Nov. 1, 1938

2 Sheets-Sheet 1



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Fig. 4

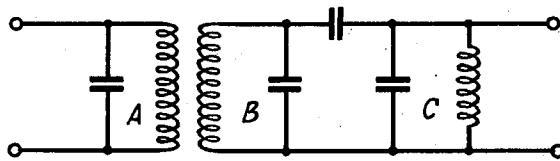
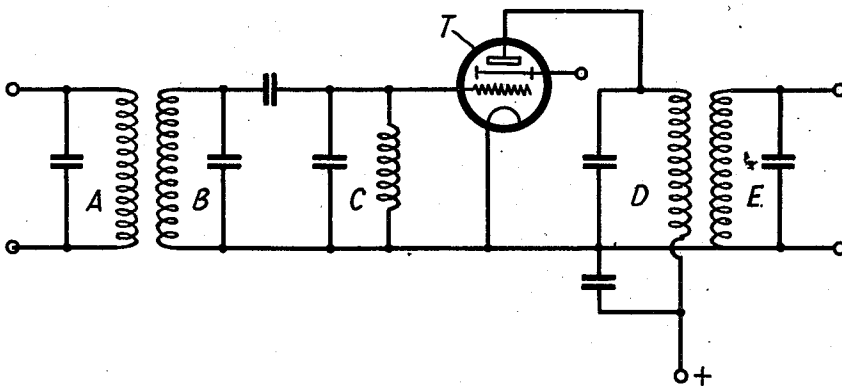


Fig. 5



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BAND-PASS FILTER

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Application November 1, 1933, Serial No. 238,157
In Germany November 16, 1937

1 Claim. (Cl. 178—44)

In the reception of signals and intelligence in the form of a carrier frequency and the two side-bands, particularly for broadcast receivers, it has been found to be necessary to provide symmetric band-pass filters. As a result of rotation of phases of the side-bands, even when adjustments are made most carefully and delicately, non-linear distortions cannot be eliminated with non-symmetric filters. But even in the case of filters with symmetric form of the attenuation curve serious difficulties are often encountered in the attempt to tune the receiver apparatus so exactly that the non-linear distortions disappear.

Figures 1a and 1b represent characteristic curves of well-known band pass circuits.

Figures 2a, 2b, 3a and 3b represent characteristic curves for circuits in accordance with the invention.

Figures 4 and 5 represent band pass filter circuits in accordance with the invention.

In order to insure satisfactory adjustment of the slopes (transition range) of the resonance curve, where two-circuit band-pass filters are employed, it is necessary to make the coupling of the two oscillatory circuits so close that the resonance characteristic presents the well-known double humps shown in Fig. 1a. These humps, basically speaking, are less harmful than the departures from the straight line of the phase constant (curve) which they bring about. Such waviness of this curve is shown, for instance, by the graphs Fig. 1b which illustrates the phase shift of the output potential in reference to the input current against the frequency. If such lack of linearity exists, it is necessary to set the incoming station with great exactitude to band center. Otherwise the two side-bands would be turned dissymmetrically in reference to the carrier, and this results in the well-known non-linear distortions, even where rectification is absolutely linear. It will thus be seen that the slope of the resonance curve and thus the selectivity of the receiver is limited by the lack of linearity or wavy condition of the phase curve since, in the case of high selectivity, requirements regarding accurate adjustment become unduly severe.

In order that the demands regarding sharpness of tuning may be made acceptable and more moderate, in other words, in order that, with adequate selectivity, each receiver of programs may be assured of perfect acoustic quality and faithfulness with normal or average adjustment, band-pass filters with great steepness of slope (narrow interval between transmission and at-

tenuation ranges) and practically linear phase curve would be required. Moreover, the latter should be very symmetric in relation to the center of the pass band in order that non-linear distortions may be avoided as a result of unsymmetric phase rotations in the two side-bands even with correct adjustment and tuning to the carrier frequency.

According to one suggestion that has been made in the prior art a single oscillatory circuit is arranged above a two-circuit band-pass filter with the humps before described and the lack of linearity of the phase. Between the two, an amplifier tube, more particularly a screen-grid tube, is interposed for decoupling. In Fig. 2a are shown the resonance curves of the oscillatory circuit, of the band-pass filter, and the resultant curve. Resonance curve 1 of the oscillatory circuit is so dimensioned that its peak properly fills the dip or crevasse between the two humps of the band-pass filter curve 2. The resultant graph 3 in itself will thus be adapted to insure good proximation to the desired ideal rectangular resonance curve.

Another demand to be fulfilled by the oscillation circuit consists in so dimensioning the phase curve 1, Fig. 2b that it will counterbalance as much as possible the lack of linearity of the phase curve 2 of the band-pass filter. What ensues, for instance, is a resultant curve 3 presenting little waviness (low pulsation factor).

Now, the object of the invention is to create a band-pass filter having a triple-hump symmetric resonance curve. According to the invention, the band-pass filter comprises three oscillation circuits, A, B and C in Fig. 4, the outer ones (A and C) of which are in symmetric detuned relationship to the inner oscillatory circuit (B), and being coupled therewith, one capacitively and the other one inductively. What is obtained with a band-pass filter of such construction is a resonance curve with three real humps. The desired heights of the latter may be secured, as known in the prior art, by choosing different attenuations for the various circuits. In this manner a band-pass filter is obtainable with symmetric attenuation and phase shape. If the dimensions are suitable the form of the resonance curve and of the phase curve will quite measure up to the shape of the resultant curve 3 in Figs. 2a and 2b obtained with the combination disclosed in the earlier art and comprising a two-circuit band-pass filter and one oscillatory circuit isolated or uncoupled by a tube.

According to a further object of the invention,

the three circuit band-pass filter A, B and C is connected together by way of an amplifier tube T decoupled as known in the art, with a two-circuit band-pass filter D, E, as shown in Fig. 5. The attenuations and couplings in this scheme must be so chosen that the attenuation curves and the phase curves will be symmetrical, and the latter also linear. Referring to Fig. 3a, 1 is the resonance curve of the triple-humped band-pass filter. By the steps and means herebefore indicated, conditions can be made so that the middle hump comes to fall in the dip between the two humps of resonance curve 2 of the two-circuit band-pass filter, while the outer humps of curve 1 are so located that there results an expansion of the transmission range width and thereby an improvement of the steepness of the slopes. The resultant curve 3 is practically horizontal and declines (dips) steeply.

At the same time the resultant phase curve 3 in Fig. 3b has a practically linear form and is extremely symmetric in the middle of the band. The lack of linearity of the phase curve 2 of the two-circuit band-pass filter is eliminated with great accuracy by the waviness of phase-curve 1

of the triple-humped band-pass filter. The task of tuning to a transmitter, even for extreme sharpness of tuning, is greatly facilitated since the carrier frequency need no longer coincide with such accuracy with the center of the band-pass filter; in fact, all the accuracy that is required is that the side-bands fall inside the range where the amplifier gives satisfactory amplification.

I claim:

A band-pass filter arrangement comprising three parallel tuned circuits connected in cascade, the first two circuits being inductively coupled and the last two circuits being capacitively coupled and the first and last circuits being symmetrically detuned in reference to the middle circuit, an amplifier tube having its input connected to the output of said three tuned circuits, and a two-circuit band-pass filter connected to the output of said tube, the combined effect of said filters resulting in a substantially flat-topped resonance curve with steep sides and a substantially linear phase curve.

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