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VARIABLE SELECTIVE SYSTEM

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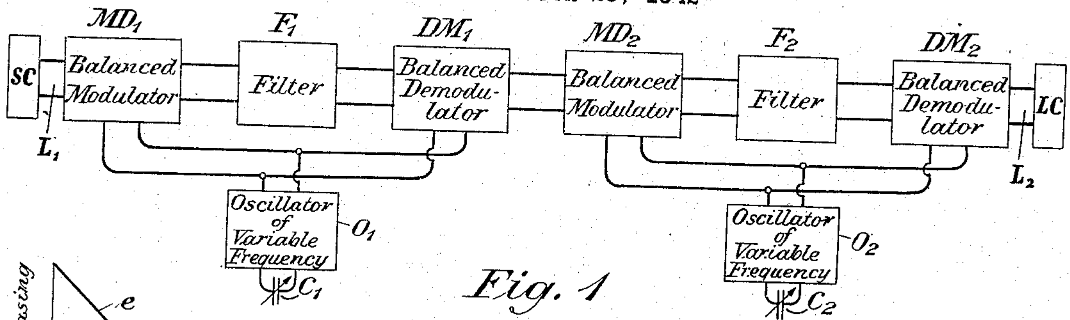

Fig. 1

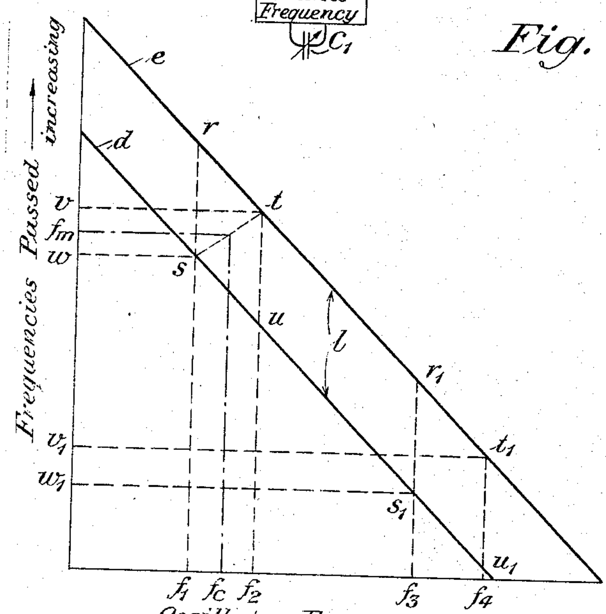

Fig. 2A

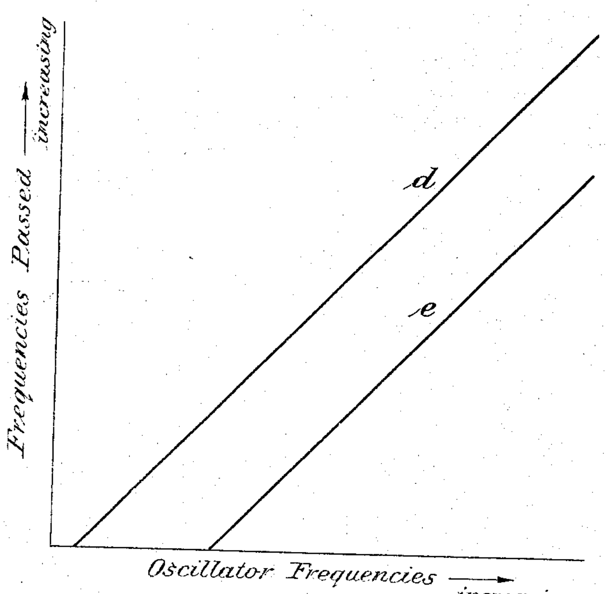

Fig. 2B

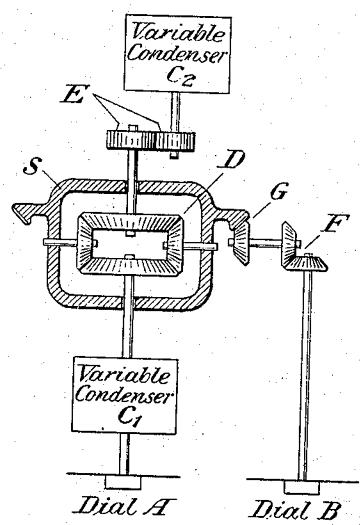

Fig. 3

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VARIABLE SELECTIVE SYSTEM

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6 Claims. (Cl. 178—44)

This invention relates to electrical transmission systems and more particularly to electrical wave filters. Still more particularly this invention relates to transmission or filter apparatus suitable for transmitting currents having any desired band of frequencies and in any portion of the frequency spectrum.

Electrical wave filters usually comprise recurrent networks transmitting with a single structure any desired band width of frequencies in any desired position in the frequency spectrum. In order to change the width of the pass band of the filter or to change the relative position of the pass band in the frequency spectrum it is the usual practice to re-design the circuits of the filter to meet the new requirements. This type of prior art structure is therefore unsuitable for use as an arrangement for freely transmitting with a single structure any desired band of frequencies changed from one position to another in the frequency spectrum.

It is an object of this invention to provide an arrangement which may be quickly adjusted to transmit a band of frequencies of any desired width.

It is another object of this invention to provide an arrangement which may be quickly adjusted to change the desired band from one position to another in the frequency spectrum.

It is still another object of this invention to provide an arrangement suitable for changing quickly both the width of the band of frequencies transmitted and its relative position in the frequency spectrum.

The invention will be better understood from the more detailed description hereinafter following when read in connection with the accompanying drawing in which Fig. 1 shows one form of apparatus for practicing this invention, Fig. 2A illustrates graphs which may be used to explain the operation of the arrangement of Fig. 1, Fig. 2B illustrates graphs similar to those of Fig. 2A which are useful under somewhat different conditions, and Fig. 3 illustrates a structure for varying certain of the elements of Fig. 1.

Referring to Fig. 1 of the drawing, there is shown an input circuit L_1 connected to a source SC which may supply for example, currents having any desired band of frequencies which may be a band of signals having a finite band width, or it may supply currents having frequencies extending from zero to infinity, such as may be obtained from a noise generator of well-known type. The input circuit L_1 is connected to a modulator MD_1 to which an oscillator O_1 is also connected, the modulator MD_1 being preferably but not necessarily a balanced modulator of well-known type which obtains from the oscillator current and the currents of circuit L_1, two side bands of the oscillator current, the oscillator current being suppressed. The output of the modulator MD_1 is supplied to a band filter F_1 having fixed limits, all frequencies beyond the limits of filter F_1 being suppressed. The output of filter F_1 is then supplied to a demodulator DM_1 along with the current of oscillator O_1.

The modulator MD_1 derives two side bands of the current of oscillator O_1, both side bands having the width of the frequencies of the currents flowing over circuit L_1. The filter F_1 passes only a certain band of frequencies of one of these side bands, all other frequencies outside the finite limits of filter F_1 being suppressed. In other words, filter F_1 transmits only a part of one of the side bands while suppressing not only the other parts of the same side band but also all of the other side band. The demodulator DM_1 returns the currents passed by filter F_1 to their original position in the frequency spectrum. The demodulator DM_1 also creates an upper side band, lying in a frequency range above the frequency of oscillator O_1. This upper side band may be eliminated by any simple selective means (not shown) such as an output transformer of suitable characteristics following demodulator DM_1, or a low-pass filter.

The output of demodulator DM_1 is then fed to a second balanced modulator MD_2 together with current from oscillator O_2 whose frequency is different from that of oscillator O_1. The two side bands resulting from modulation, each of which has a frequency width equal to that of filter F_1, are then supplied to a filter F_2 which may be identical to filter F_1. These filters may be of any suitable type, such as the crystal filters disclosed in Patent 2,045,991 granted June 30, 1936, to W. P. Mason. The filter F_2 acts to suppress part of one of the two side bands and all of the other side band while passing only the remaining part of the first-mentioned side band which is within the limits of filter F_2. The currents in the part transmitted by filter F_2 are fed to a demodulator DM_2 along with the current of oscillator O_2 and upon demodulation there appears in the output circuit L_2 leading to a load circuit LC a reduced band of frequencies in its original position in the frequency spectrum. Here again a side band above the O_2 oscillator frequency is created and may be eliminated from the output by a simple filtering means (not shown) such as a suitable output transformer or low-pass filter.

As an example, assume that the frequencies of the currents on line L_1 extend from zero to 100 kilocycles per second. If the oscillator O_1 is adjusted by condenser C_1 to generate current of 134 kilocycles, then the lower side band resulting from modulation in modulator MD_1 would extend from 34 to 134 kilocycles and the upper side band from 134 kilocycles to 234 kilocycles. If filter F_1 passes only those currents of frequencies between 150 and 156 kilocycles, then a portion of the upper side band resulting from modulation will be transmitted by filter F_1 and all other frequencies of the upper side band and all frequencies of the lower side band will be suppressed. The 150–156 kilocycle band will be demodulated in demodulator DM_1 to a band extending from 16 to 22 kilocycles. If oscillator O_2 is adjusted by condenser C_2 to generate a frequency of 136 kilocycles, then the two side bands resulting from modulation in modulator MD_2 will extend from 114 to 120 kilocycles and 152 to 158 kilocycles. The lower of these side bands, being obviously outside the limits of 150–156 kilocycles of filter F_2, will be entirely suppressed. The upper side band is partly within the range of filter F_2. The portion within the filter range extends from 152–156 kilocycles and is freely transmitted while the remaining portion of the upper side band is suppressed. The 152–156 kilocycle band passed by filter F_2 is demodulated in demodulator DM_2 to supply to line L_2 a band of frequencies extending from 16 to 20 kilocycles. A band 4 kilocycles wide is thus selected and transmitted to line L_2 to the exclusion of all other frequencies. By changing the values of the frequencies of oscillators O_1 and O_2, any other band of any desired width up to the width of the narrowest filter may be selected and transmitted as will be explained hereinafter.

The graphs of Fig. 2A may be employed to determine the band to be selected by the circuit of Fig. 1. The band depends upon the characteristics of filters F_1 and F_2 and upon the adjustment of the two oscillator frequencies as will be explained hereinafter.

The two oblique lines d and e are parallel to each other and the vertical distance l $(=r-s)$ between them represents the width of the band passed by filter F_1 which may be, for example, 6 kilocycles. If oscillator O_1 is set at a frequency f_1, then the band of frequencies fed by demodulator DM_1 to modulator MD_2 is represented by the vertical line r—s. If the oscillator O_2 is set at a frequency f_2, then the path between the input to modulator MD_2 and the output of demodulator DM_2 transmits only those frequencies that lie in the range t—u, if we assume that filter F_2 has the same pass limits as filter F_1. Since the output of demodulator DM_1 contains only frequencies lying in the range r—s, the path between lines L_1 and L_2 will now transmit only frequencies lying in the range v—w.

The circuit between modulator MD_1 and demodulator DM_1 of Fig. 1 may be considered to be a filter having a pass band, such as r—s of Fig. 2, the width of the pass band being determined by the constants of filter F_1 and its position in the frequency spectrum being determined by oscillator O_1. The circuit between modulator MD_2 and demodulator DM_2 may likewise be considered as a filter having a pass band, such as t—u of Fig. 2 which is not necessarily equal to r—s, the width of which is determined by the constants of filter F_2 and its position by oscillator O_2. It will be observed that these two filters are connected in tandem and that their pass bands have a common or overlapping range of frequencies as represented by v—w. Only the overlapping range of frequencies v—w will be transmitted by the Fig. 1 circuit.

Suppose it is desired to select from line L_1 and transmit to line L_2 only those frequencies between v_1 and w_1 which may be, for example, a band of frequencies two kilocycles wide extending from 7–9 kilocycles. Horizontal lines through points w_1 and v_1 will intersect lines d and e respectively at points s_1 and t_1 thereby determining the oscillator frequencies f_3 and f_4 which may be, for example, 143 and 147 kilocycles. These are the frequencies of the currents which oscillators O_1 and O_2 are required to supply to the circuit of Fig. 1 to select the required band. The demodulator DM_1 will then supply a band of frequencies r_1—s_1 which may, for instance, lie in the range of 7 to 13 kilocycles. The band t_1—u_1 of, for instance, 3–9 kilocycles which is the range of the second tandem filter, overlaps the r_1—s_1 band in the range 7–9 kilocycles. Only the 7–9 kilocycle band will therefore reach line L_2.

It will be observed that the width of the band of frequencies transmitted to the line L_2 is obtained numerically by subtracting the difference between the oscillator frequencies from the difference between the lower cut-off frequency of filter F_1 and the upper cut-off frequency of filter F_2. For any given networks employing filters F_1 and F_2 the line L_2 will receive a band of increasing width, up to the width of the narrowest filter, by reducing the spacing between the oscillator frequencies, and vice versa. It will also be observed that the position in the frequency spectrum of the band of frequencies transmitted to line L_2 can be obtained numerically by subtracting the frequency of oscillator O_1 from the lower cut-off frequency of filter F_1 and by subtracting the frequency of oscillator O_2 from the upper cut-off frequency of filter F_2.

Fig. 2B is similar to Fig. 2A except for the opposite slopes of the parallel lines d and e. The graphs of Fig. 2A are employed when the pass bands of the filters F_1 and F_2 are in the range of the upper side bands resulting from modulation. The graphs of Fig. 2B are to be used when the pass bands of the filters F_1 and F_2 are in the range of the lower side bands.

It will be observed that the frequency f_0 which is midway between the oscillator frequencies f_1—f_2 shown in Fig. 2A, corresponds, as is shown in the dot-and-dash lines of Fig. 2A, to the mid-frequency f_m of the band of frequencies which the system is capable of transmitting between lines L_1 and L_2. It will be noted that as the frequencies f_1 and f_2 are varied without altering the difference between them, the circuit of Fig. 1 will supply to line L_2 a band of frequencies of constant width v—w, but of varying position in the frequency spectrum. Thus, different portions of the incoming frequencies in line L_1 may be selected and transmitted to line L_2 and there explored or detected.

It will also be noted from Fig. 2A that if the spacing between the oscillator frequencies f_1—f_2 is increased or decreased, the band of frequencies v—w passed to line L_2 will be narrowed or widened respectively by corresponding amounts. The widening of the band, however, is limited by the width of the narrowest pass band of filters F_1 and F_2 which, of course, may have any desired limits. By so varying the width of the selected band and its location in the frequency spectrum, the operator may explore any given range of frequencies no matter how wide or narrow.

Fig. 3 shows the mechanical apparatus which may be used to interconnect the condensers C_1 and C_2 of Fig. 1 to provide a convenient control for varying both the position of the pass band in the frequency spectrum and its width. The control may be exercised by operating two dials, designated A and B, for varying the condensers C_1 and C_2. It is assumed that the plates of the variable condensers C_1 and C_2 are so cut that for each degree of rotation of the rotors of these condensers, the oscillator frequencies f_1 and f_2 will be changed by a fixed and predetermined number of cycles.

In Fig. 3, the condenser C_1 (of oscillator O_1) is adjusted directly by turning the dial A. Any rotation of dial A also adjusts the capacity of condenser C_2 (of oscillator O_2) in the same direction and through the same angle. The simultaneous adjustment of condenser C_2 is accomplished by the gear mechanism of the differential gear box D which is coupled to the gears designated E. The reversing gears E are linked to condenser C_2 as shown. Thus the gear mechanism just referred to serves to impart to condensers C_1 and C_2 simultaneous adjustments in capacity in the same direction, the amount of which is determined by the angular displacement of dial A.

The housing S of the differential gear box D is rotatable about the main shaft of condenser C_1 and dial A as shown in Fig. 3. The dial B is shown coupled by gears F and G to the housing S. By rotating dial B the housing S is rotated in the same direction thereby causing rotation of the rotors of condenser C_2 relative to the rotors of condenser C_1. Thus dial B may be manipulated to vary the width of the band of frequencies $(v—w)$ selected by the circuit of Fig. 1.

After dial B has been operated to effect the selection of the width of the band of frequencies which the system shown in Fig. 1 will be capable of transmitting between lines L_1 and L_2, the selected band width can be readily moved up and down the frequency spectrum by merely operating dial A. As the dials A and B can be operated independently of each other, a band of any desired width up to the width of the narrowest filter can thus be selected and moved up and down the frequency spectrum as desired.

The filters F_1 and F_2 need not have substantially the same fixed limits. Filter F_2 should have an upper cut-off frequency which is a definite band width above the lower cut-off frequency of filter F_1. The filters F_1 and F_2 should be designed to substantially suppress the unwanted products of modulation, such as undesired side bands.

The circuits and mechanism of this invention may be employed, for example, to analyze frequency components of portions of a complex signal. It may also be used to distinguish a set of vibrations or oscillations from any other vibrations or oscillations.

The frequencies referred to hereinabove have been given merely for illustrative purposes and are not to be construed as limitations on the invention.

While this invention has been shown and described in certain particular embodiments merely for the purpose of illustration, it will be understood that the general principles of this invention may be applied to other and widely varied organizations without departing from the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. A variable selective system for selecting and transmitting only a desired band of frequencies to the exclusion of all other frequencies, said system comprising two filter networks connected in tandem, each network including a band filter together with an oscillator and means for changing the position in the frequency spectrum of received currents impressed on the associated filter, said networks being adapted to pass bands of frequencies which overlap in the range of the desired band of frequencies, the frequencies of said oscillators being different and adjustable, a differential gear box for controlling the frequencies of said oscillators for varying both the width and the location in the frequency spectrum of the desired band, and two operating means for operating said gear box, one of said operating means being adapted to change the difference between the oscillator frequencies for changing the width of the band of frequencies transmitted through said networks by an amount corresponding to the change in the difference between said oscillator frequencies, and the other of said operating means being adapted to change the frequencies of both oscillators equally and simultaneously in the same direction for changing the relative position in the frequency spectrum of the band of frequencies transmitted through said networks by an amount corresponding to the change in the oscillator frequencies.

2. A variable selective system comprising means for obtaining two bands of frequencies which partially overlap in the frequency spectrum, means for transmitting only the overlapping portion of said two bands of frequencies to the exclusion of all other frequencies, first control means for selecting and varying the width of the overlapping portion of said two bands of frequencies, and second control means for independently and separately selecting and varying the position in the frequency spectrum of the overlapping portion of said frequencies whose width was selected by said first control means.

3. A selective system for selecting and transmitting any desired band of frequencies from a complex source to the exclusion of all other frequencies, comprising means for changing all of the frequencies of said source to a different position in the frequency spectrum, a first band filter having a pass band of smaller range than the range of said changed frequencies for transmitting only those changed frequencies which come within the limits thereof, means for again changing the position in the frequency spectrum of said transmitted frequencies, and a second band filter for transmitting only those frequencies obtained from said second means which come within the limits of said second filter, said band filters being adapted to transmit bands of frequencies which overlap in the desired band of frequencies.

4. Selective apparatus comprising two oscillators of variable frequency, a pair of filter networks connected in tandem and each having a modulator connected to its input side and a demodulator connected to its output side, and circuit means for connecting one of said oscillators to one of said modulators and its associated demodulator and for connecting the other of said oscillators to the other of said modulators and its associated demodulator for selecting a band of

frequencies whose width and position in the frequency spectrum is determined by the frequencies of the oscillators.

5. A variable band selective system for selecting and transmitting only a desired band of frequencies to the exclusion of all other frequencies, said system including a source of currents, two selective networks connected in tandem, each network comprising a modulator and a filter and a demodulator all connected in tandem, two variable oscillators, first coupling means for coupling one of said oscillators to both the modulator and the demodulator in one of said networks, second coupling means for coupling the other of said oscillators to both the modulator and the demodulator in the other of said networks, means for applying currents from said source to one of said networks, and control means for varying the frequencies of said oscillators.

6. A variable band selective system for selecting and transmitting only a desired band of frequencies to the exclusion of all other frequencies, said system including a source of currents, two selective networks connected in tandem, each network comprising a modulator and a filter and a demodulator all connected in tandem, two variable oscillators, first coupling means for coupling one of said oscillators to both the modulator and the demodulator in one of said networks, said coupling means for coupling the other of said oscillators to both the modulator and the demodulator in the other of said networks, means for applying currents from said source to one of said networks, first control means for simultaneously varying the frequency of each of said oscillators, and second control means for separately varying the frequency of one of said oscillators.

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