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2,297,451

METHOD OF SELECTIVE FILTERING OF FREQUENCY BAND RANGES.

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2 Sheets-Sheet 1

Fig. 1

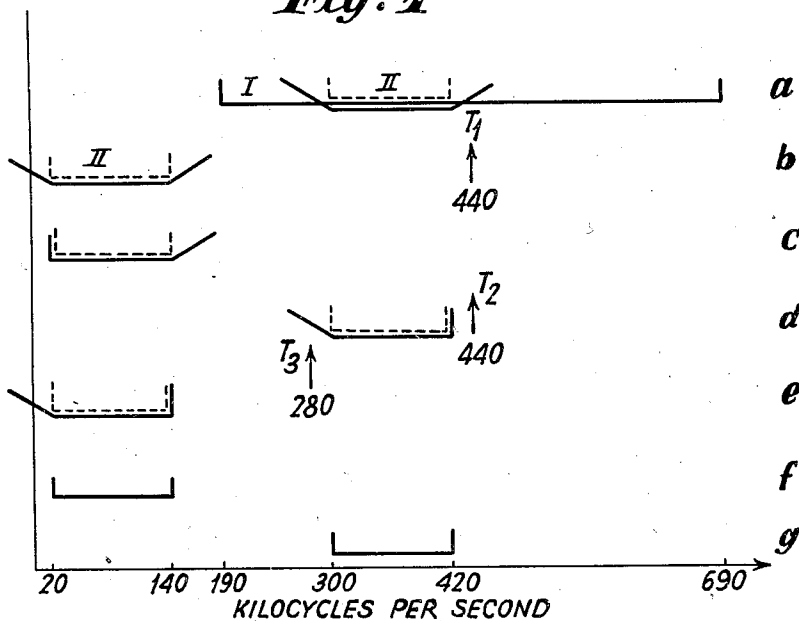
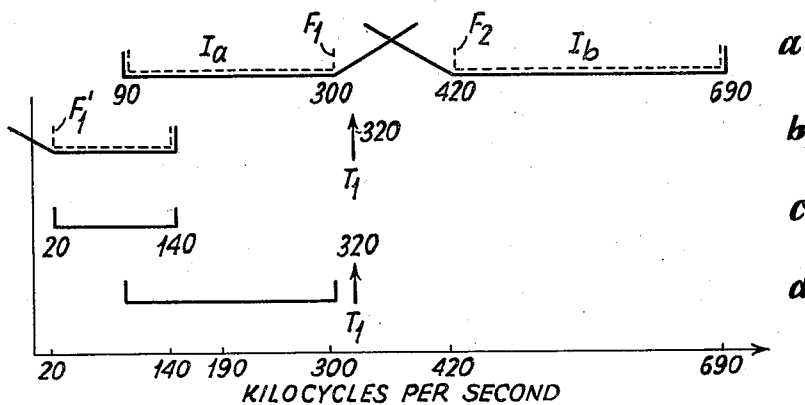


Fig. 2



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Fig. 3

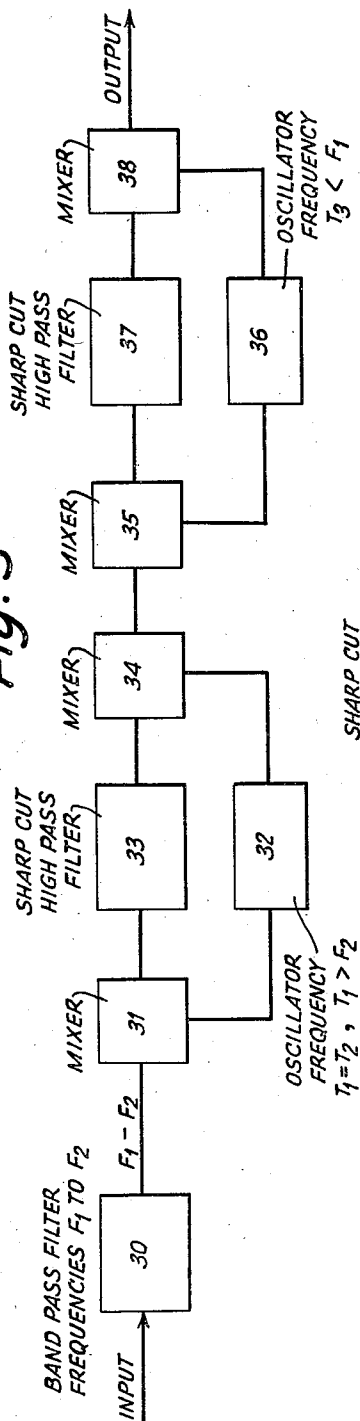
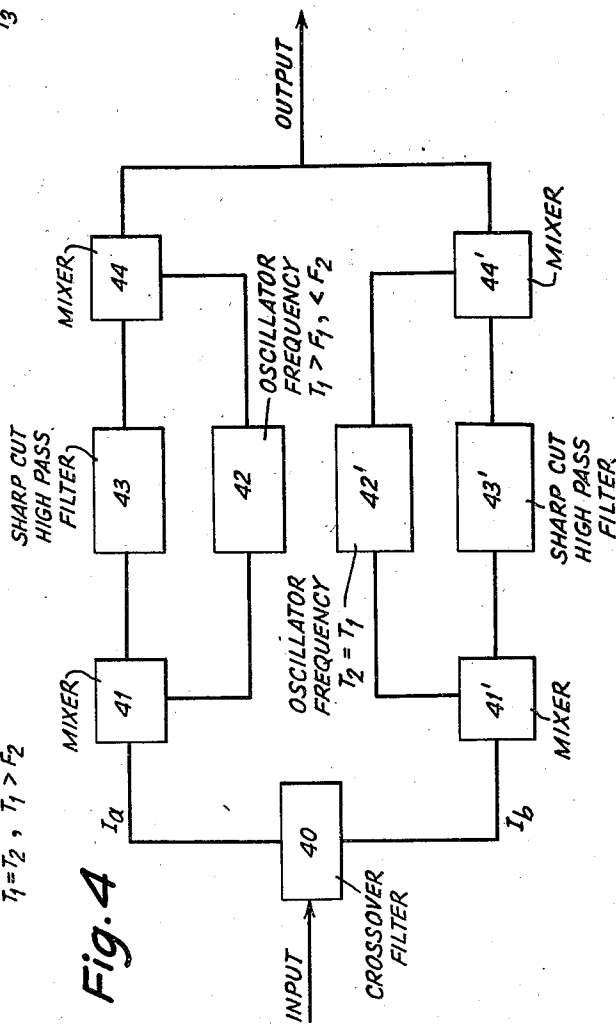


Fig. 4



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METHOD OF SELECTIVE FILTERING OF FREQUENCY BAND RANGES

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8 Claims. (Cl. 178—44)

It is often necessary to filter out selectively a partial band from a frequency band and to block it selectively. As long as this is done in a range having a comparatively low frequency and as long as the partial band is comparatively narrow, the provision of the required filter means causes no particular difficulties. The steepness of the flanks of the admission curve and blocking curve of the necessary filter means can be attained without undue complexity of circuit arrangement. In the case of higher frequencies a very considerable amount of filter means is required. If, furthermore, a particularly sharp cutoff of the flanks of the curves is necessary, this can no longer be attained by means of coils and condensers or even with the use of crystal filters. In multiple carrier frequency systems comparatively wide unused frequency gaps are, therefore, required between the message bands or groups of message bands.

In order to achieve an unbroken continuity of message bands in carrier frequency message communication systems, methods are already known and systems constructed according to which, with the utilization of a multiple modulation, shift the required selectivity substantially into a range of lower frequency in order thus to permit the realization of required filters. However, the known methods are not directly suited for filtering out of a frequency band a wide partial band, such as for instance a television band, or one group or several groups of adjacent message bands such as will be necessary for instance in the case of a transmission system having more than two terminal exchanges. For instance, at an exchange it is necessary to filter out a television band, or one or several groups of message bands in a selective manner and then to fill out again the open frequency ranges which were occupied by the removed bands. When resorting to the known measures for this purpose, an excessively large amount of apparatus is required for filtering out a wide partial band, such a partial band which may consist of, for instance, one or more groups, each having ten message bands, must be partitioned to form a multiplicity of part channels after the conversion into the low frequency range, in order that through selective means in the audio-frequency range a sufficiently sharp separation from the adjacent frequencies can be obtained. The same amount of equipment is necessary with a frequency conversion into a higher frequency range where the filtered out partial band is used again, for instance, to fill out a second wide band cable.

However, with this large amount of structure, which is practically that needed in the terminal exchanges for transmission and filtering of a partial band of same width, it has not been possible, as far as we are aware, to again render the frequency band range completely available by the filtering out of the partial band. The liberated range cannot be made completely available for re-use simply through customary means utilized for the blocking of a frequency band range, so that larger frequency gaps must be taken into account.

The method according to the present invention offers a substantial reduction in means required as well as the possibility of covering a frequency band having practically no gaps.

For the selective filtering and for the selective blocking of a wide band contained within the said portion of the frequency spectrum, the invention contemplates the shifting of each edge of the partial band, to be filtered out and to be blocked, individually through conversion into a sufficiently low frequency range and the carrying out of the exact separation therein. The conversion of the frequency edges is, by our invention, carried out through modulator arrangements such that for one edge separation, the frequency sequence is retained and for the other the sequence is reversed whereby the region of sharp cutoff to be attained always lies at the bottom in the frequency range.

When filtering a wide partial band it is seen that the latter is obtained with a simple selective filter and that for obtaining an exact separation or cut-off, of the undesirable neighboring frequencies said band is converted into a sufficiently low frequency range while retaining the frequency sequence for cutting off one edge and reversing the frequency sequence for cutting the other edge, whereby after each conversion an exact separation is carried out at the lower frequency edge of the converted band.

For the selective blocking of a wide partial band, the adjacent frequency band ranges are separated with a simple selective filter and each partial band thus obtained is converted into a sufficiently low frequency range, the lower one with reversing of the frequency sequence and the upper one without such reversal. At the lower frequency edge of the two converted partial bands an exact separation or cut off is carried out and thereafter the two partial bands are brought back into their initial position.

The invention will be elucidated in the following description with reference to the Figures 1

and 2 representing schematically examples of application of the method according to the invention, while Figures 3 and 4 illustrate in block diagram form circuit arrangements which may be used for practicing the examples illustrated in Figures 1 and 2.

In Figure 1 the various steps of the method are shown in the portions of the figure labeled *a* to *f* inclusive. From the frequency band I extending, for instance, from 190 kilocycles per second up to 690 kilocycles per second, the message band group II indicated in dash line and which is to reach from 300 kilocycles per second up to 420 kilocycles per second is to be filtered out. In accordance with the invention this is done in the following manner:

(a) The group is filtered out with a band-pass filter having a less sharp cut-off than finally required.

(b) There is carried out with a carrier frequency T_1 a frequency conversion into a convenient low frequency range, for instance, extending from 20 kilocycles per second to 140 kilocycles per second.

(c) There is carried out through selective filtering means an accurate separation of the undesirable neighboring frequencies at the lower frequency edge.

(d) The carrier or conversion oscillator frequency T_2 , which may be chosen equal to the carrier frequency T_1 , is employed to carry out a frequency conversion to a higher frequency range, which may or may not be the same as the original range.

(e) With the conversion oscillator frequency T_3 a renewed frequency conversion to the low frequency range is carried out. The carrier frequency T_3 is to be chosen in such a manner that the frequency sequence of the group is reversed relative to that of the first frequency conversion (b). The choice of T_3 is such to advantage that the position in the frequency spectrum, after the frequency conversion, is the same as in the case of the first frequency conversion (b).

(f) The exact separation of the undesirable neighboring frequencies which are now situated at the bottom is carried out, as explained in step c.

The frequency band group thus obtained shows sharp frequency edges and through renewed conversion, step (g), with a conversion frequency may be shifted to a desired range. For instance, it can be shifted to a range covered by another wide band cable.

For again utilizing the liberated frequency band it is necessary to provide a sharply selective blocking for this range. Figure 2 shows the way in which this can be done in accordance with the invention:

(a) The entire frequency range is divided up into two parts Ia and Ib by means of a coil and condenser connection, or other cross over filter whose cross point is situated in the range II which is to be blocked.

(b) The lower part Ia of the frequency band is converted by means of the conversion frequency T_1 for narrow blocking ranges this may lie substantially exactly in the center of the range to be blocked. The conversion may be such that the frequency edge F_1 is shifted into a conveniently low range as shown by F_1' .

(c) The undesired neighboring frequencies at the lower frequency edge are accurately separated.

(d) The partial band Ia is converted into the original frequency range by means of the conversion frequency T_1 .

The upper part Ib of the frequency band is dealt with in the same way, i. e. this part is converted with a conversion frequency T_2 which may be identical to the conversion frequency T_1 , said conversion being such that the frequency edge F_2 is shifted into a conveniently low range. After completing the accurate separation of the undesirable neighboring frequencies at the lower frequency edge of this band, the conversion into the original position is carried out with the same conversion frequency. Then a frequency band is obtained which is utilized to the frequency F_1 , is free from the frequency F_1 to F_2 and again utilized above the frequency F_2 .

In Figure 3 is shown in block diagram form an organization for practicing the method of Figure 1. The input signal, as indicated by the arrow labeled "input," is applied to band pass filter 30 wherein step *a* of Figure 1 takes place. The selective frequency band F_1 , F_2 is then applied to mixer 31 wherein it is mixed with oscillations generated at oscillator 32 thus performing step *b* of Figure 1. Sharp cut high pass filter 33 accurately separates the lower edge frequencies of the converted band as at step *c* of Figure 1 and then in mixer 34 the band is again converted to its original position as in step *d* of Figure 1. Then, in mixer 35 the band of frequencies F_1 , F_2 , now accurately cut at one edge, is mixed with oscillations from oscillator 36 of such frequency that inversion of the band takes place, thus performing step *e* of the method of Figure 1. The converted inverted band is passed through sharp cut high pass filter 37 and then applied to mixer 38, thus reconverting the band to its original position in the frequency spectrum. The band now has both edges accurately defined and may be used in the manner required.

Figure 4 is similar to Figure 3, but illustrates an organization for practicing the method of Figure 2 wherein a sharply selective cutting of a predetermined range in a frequency spectrum is accomplished. The input is applied to crossover filter 40 where the spectrum is divided into two bands of frequencies Ia, Ib, thus performing step A of Figure 2. The frequency band Ia is applied to mixer 41 where it is mixed with oscillations from oscillator 42, thus performing step *b* of Figure 2.

It will be noted that the frequency band is converted to a lower frequency and inverted. An accurate separation of the lower edge of the band at F_1' is then accomplished in sharp cut high pass filter 43, as indicated in step *c* of Figure 2. The converted band of frequencies Ia with the lower edge accurately defined is then applied to the mixer 44 where it is reinverted and converted to its original position in the frequency spectrum, as indicated in step *d* of Figure 2. The frequency band Ib is similarly dealt with in the lower portion of Figure 4, the mixers 41' and 44' and the high pass filter 43' acting similarly as just above described. The oscillator 42' generates a frequency such that inversion does not take place in the conversion in mixers 41' and 44'. The combined output from mixers 44 and 44' provides a frequency band which is utilized up to frequency F_1 of Figure 2, is free from the frequency F_1 to F_2 and again utilized above the frequency F_2 .

We claim:

1. The method of separating a desired band

from a range of frequencies which comprises filtering out a band wider than and including said desired band, converting said wider band to a low frequency range, inverting and converting said wider band to said low frequency range, sharply discriminating in each of said converted bands against the undesired low frequency portion thereof and reconverting said converted bands to a predetermined single position in said range of frequencies.

2. The method of separating a desired band from a range of frequencies which comprises filtering out a band wider than the desired band converting said wider band to a low frequency range, sharply discriminating against the undesired portion of the low frequency end of said wider band, converting and inverting said wider band to said low frequency range whereby the remaining undesired portion of said band is at the low frequency end discriminating sharply against said remaining portion and converting said desired band to a predetermined position in said range of frequencies.

3. Method of filtering out selectively a wide partial band of a frequency band, characterized in that the partial band is filtered out and that for separating accurately the undesirable neighboring frequencies said band is converted into a sufficiently low frequency range on the one hand, with retaining of the frequency sequence and on the other hand with reversal of the frequency sequence, whereby after each conversion there is carried out an accurate separating of the respective lower frequency edge of the converted band.

4. Method of blocking selectively a wide partial band in a frequency band, characterized in that the adjacent frequency band ranges are separated and that each partial band thus obtained is converted into a sufficiently low frequency range, the lower one with reversal of the frequency sequence and the upper one without reversal of the frequency sequence and that a sharp discrimination is carried out at the lower frequency edge only of each of the two converted partial bands whereafter the two partial bands are returned again into their initial position.

5. A method according to claim 4 characterized in that identical carrier frequencies are employed respectively for the conversion into the

low frequency range and for the conversion into the higher frequency range.

6. Method according to claim 3, characterized in that identical carrier frequencies are employed respectively for the conversion into the low frequency range and for the conversion into the higher frequency range.

7. In a communication system, the method of substituting one wide frequency band of signals for another in a transmitted spectrum comprising the steps of selectively blocking said band from said spectrum by separating said spectrum into two partial bands, one above and one below said blocked band, each partial band including a portion of said blocked band, converting each partial band into a low frequency range, the lower of said partial bands with frequency inversion, sharply discriminating against frequencies below the low frequency edge of each of said converted partial bands, reconverting said partial bands to their initial position in said spectrum, sharply defining the edges of said band to be substituted by filtering from a range of signal frequencies a band wider than and including said band to be substituted, converting said wider band to a low frequency range, inverting and converting said wider band to said low frequency range, sharply discriminating in each of said converted bands against the undesired low frequency portion thereof reconverting said converted bands to the original position in said spectrum and inserting said sharply defined band in said transmitted spectrum in the position of said blocked band.

8. The method of selectively blocking a wide partial band in a spectrum of frequencies including the steps of separating said spectrum into two partial bands, one above and one below said band to be blocked, each partial band including a portion of said blocked band, converting each partial band into a low frequency range, the lower of said partial bands with frequency inversion, sharply discriminating against frequencies below the low frequency edge of each of said converted partial bands and reconverting said partial bands to their initial position in said spectrum.

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