

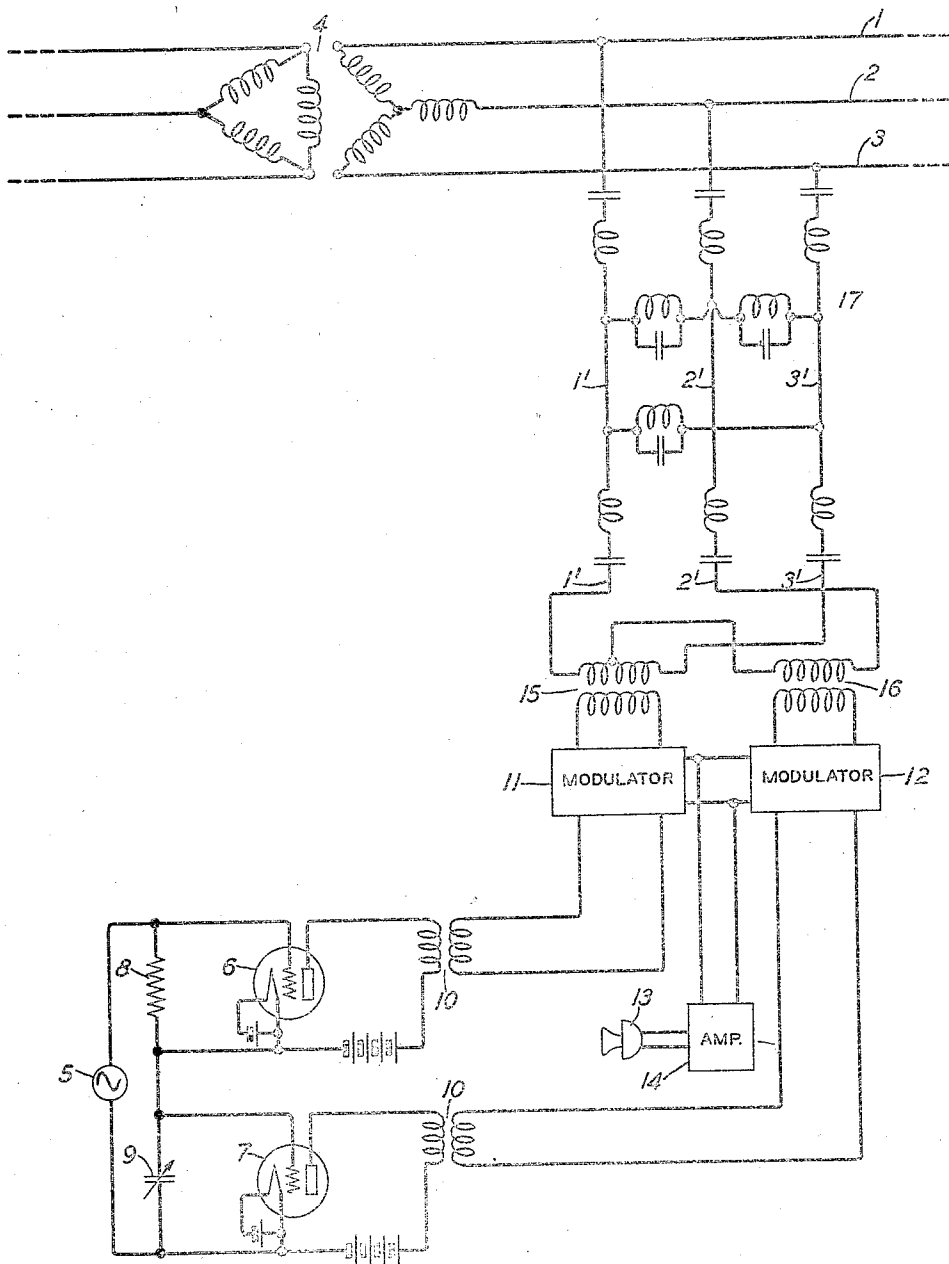
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ELECTRIC WAVE FILTER

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ELECTRIC WAVE FILTER

Original application filed November 21, 1925, Serial No. 70,529. Patent No. 1,804,952, dated May 12, 1931. Divided and this application filed March 2, 1931. Serial No. 519,408.

This invention relates to electric wave filters and particularly to polyphase filters for the selective transmission of a polyphase system of currents having frequencies within a preassigned broad band.

This application is a division of application Serial No. 70,529, filed November 21, 1925, (Patent 1,804,952, May 12, 1931), for wave signaling systems.

The wave filters of this invention operate in accordance with the principles set forth in U. S. patent to Campbell 1,227,113 issued May 22, 1917 but in accordance with the invention they are adapted for insertion in polyphase transmission lines, particularly in three-wire, three-phase lines.

The nature of the invention and the mode of its operation will be fully understood by reference to the following detailed description and the accompanying drawing which forms a part thereof, the single figure of which shows the embodiment of the invention in a power line carrier signaling system.

In the figure 1, 2 and 3, are the three conductors of a three-phase power line which is connected to a three-phase power generator through transformer 4. A single phase source of carrier waves is shown at 5, waves from which are impressed in quadrature upon the input terminals of vacuum tube amplifiers 6 and 7, the quadrature relationship being secured by the series connection of resistance 8 and condenser 9 in the input circuits of amplifiers 6 and 7 respectively.

The output waves from amplifiers 6 and 7 are transmitted through similar transformers 10 to separate modulating amplifiers 11 and 12 which are shown conventionally and in which the carrier waves are modulated in accordance with speech waves from microphone 13 which are impressed upon the two modulators jointly after amplification in amplifier 14.

The modulation process in each case is merely the modulation of a simple carrier wave, and the modulating devices 11 and 12 may be of the customary space discharge type using three-electrode vacuum tubes. A suitable type, for example, is the simplex modulator disclosed in the U. S. Patent

1,343,307, issued June 15, 1920, to J. R. Carson, the input circuits preferably being arranged so that the low frequency waves are impressed on the balanced system in parallel and are suppressed in the output circuit.

In order that the quadrature of the two-phase waves may be maintained right through to the output of the modulating devices it is desirable that the apparatus in the channel of each phase be closely matched with the corresponding apparatus in the other channel.

Amplifier 14 serves merely to strengthen the speech signals, and may be of any well-known type.

As the result of modulation there are produced in the output circuit of each of modulators 11 and 12, an unmodulated component of carrier frequency components accompanied by two side band components. The carrier components are in quadrature, and the side bands are in quadrature with the corresponding side bands in the other channel.

For conversion from two-phase to three-phase the output waves from modulators 11 and 12 are impressed upon the primary windings of transformers 15 and 16, respectively, in which the conversion is accomplished in accordance with the Scott system. Transformer 15 has a secondary winding which is tapped at its mid-point, and which is connected at its outer terminals through two of the line wires of the three-phase filter 17, to power line conductors 1 and 3. The secondary winding of 16 is connected at one end to the mid-point of the secondary winding of 15, and at the other end it is connected through the third line wire of filter 17 to power conductor 2. The transformation ratios of 15 and 16 should have the relative values 1 and 0.867 respectively.

The modulated three-phase waves produced by the Scott transformation are transmitted to the lines 1, 2, 3, through the three-phase broad band filter 17 which serves, not only to select the proper frequencies from the output of the modulators, but also to prevent the high voltage power currents from entering the carrier apparatus.

The filter is similar to the broad band filters described in U. S. Patent No. 1,227,113 issued May 22, 1917 to G. A. Campbell, but differs therefrom in that it is adapted to the transmission of a three-phase wave. The particular example of the filter shown is characterized by the combination of simple resonant circuits in series with the lines and simple anti-resonant circuits in shunt between the lines, the line and the shunt circuits being resonant at the same frequency. The individual series circuits are all exactly alike in their electrical constants and the shunt circuits are also uniform. This type is adapted to transmit freely a band of frequencies centered around the common resonance frequency and determined in width by the ratio of the series to the shunt inductances.

The filter illustrated contains only one complete section, of symmetrical form and series terminated. Additional sections may be added if desired.

The method of designing the three-phase filter may be understood very readily by considering the transmission therethrough of the two-phase waves from modulators 11 and 12. By means of the Scott system of transformation these waves combine in three-phase relationship in the three-phase conductors, but it is nevertheless permissible, and for the present purpose, more convenient, to regard them as retaining their separate existences in the three-wire system.

The waves from modulator 11 are impressed through transformer 15 upon the two lines 1' and 3' of the filter and thereafter on conductors 1 and 3 of the power line. Since the system is balanced the current waves from source 11 are confined to the circuits mentioned and do not traverse the third power conductor 2 of the third filter line 2'. Filter 17 must therefore act as a simple two-wire filter with reference to these waves. The effective elements are the four series resonant circuits in lines 1' and 3', the sum of the impedances of which constitutes the full series impedance of the effective filter section, and the three shunt anti-resonant circuits, these being disposed in two parallel shunt circuits, one having two of the circuits in series. The effective shunt circuit is therefore equivalent to a single anti-resonant circuit having an impedance equal to two-thirds of that of the individual circuits.

This effective filter section may be proportioned to have the desired transmission range and to match the impedance of the wave channel in which it is effective. For detail design formulæ to determine the impedance elements in terms of the band limiting frequencies and the impedance, reference should be made to the patent to Campbell already mentioned, and to a paper in the Bell System Technical Journal, Volume II, No. 1, January 1923, entitled, "Theory and design

of uniform and composite electric wave filters" by Otto J. Zobel.

The formulæ in the latter of these references are explicit for the full series and the full shunt values of the impedance elements. Since four of the individual series circuits of filter 17 are combined to give the full series impedance of the effective filter, the inductances determined by the formulæ must be divided by four and the capacities multiplied by four to get the values for the individual circuits. Similarly, the shunt inductances computed from the formulæ must be multiplied by 1.5 and the capacities divided by 1.5. The procedure described enables the coefficients of the individual circuits to be determined and hence, by virtue of the symmetry of the structure, gives the design of the complete filter.

The waves from transformer 16 traverse line 2' of the filter and return by lines 1' and 3' in parallel. In this case the effective filter section comprises a total series impedance equal to three times that of the individual series circuits, and a total shunt impedance equal to one-half that of the individual shunt circuits. This filter section so comprised is found to have an iterative impedance three-quarters of that of the filter effective to waves from transformer 15, but this is just as it should be, since the different transformation ratios of transformers 11 and 12 cause the impedances looking back into the two modulators to be in ratio of 1 to 0.75.

As explained above, the design of the three-phase filter may be accomplished in accordance with the rules for the design of simple two-wire filters. It follows, then, that a three-phase filter can be constructed to correspond to each type of simple filter, and consequently that many other types than that shown may be used in the three-phase system.

What is claimed is:

1. In a three-phase wave transmitting system, a broad band wave filter comprising equal reactive impedances connected in series in each phase and equal reactive impedances connected between the phases, said impedances being substantially free from resistance and having values such that the structure freely transmits a wave lying within a pre-assigned band of frequencies and attenuates waves lying outside of said frequency band.

2. In a three-phase wave transmitting system, a three-phase wave source, a polyphase line and a wave filter connected between said source and said line, said wave filter comprising equal reactive impedance elements connected in series in each phase and equal reactive impedance elements connected in shunt between phases, said impedance elements having values precomputed in terms of two limiting frequencies and of the impedance of said source, whereby waves from said

source having frequencies between said limiting frequencies are transmitted with small attenuation through the filter and waves of other frequencies are strongly attenuated.

5 3. A three-phase broad band wave filter comprising three line circuits including reactive elements in series, shunt circuits interconnecting said line circuits and including reactive elements, said series reactive
10 elements being equal and similarly disposed in each of said lines, said shunt circuits being connected to like points in said line circuits and said series and said shunt impedances being so proportioned that the structure transmits freely waves within a pre-
15 signed band of frequencies and attenuates waves of other frequencies.

4. A three-phase wave filter section comprising three line circuits, a pair of equal
20 series resonant circuits included in series relation in each line circuit, the resonant circuits in each line being of like impedance to those in the other lines, and equal anti-resonant circuits connected in shunt between
25 said line circuits at the interconnecting point between said series circuits, said series resonant circuits and said anti-resonant circuits being proportioned to resonate at the same frequency.

30 In witness whereof, I hereunto subscribe my name this 25th day of February, 1931.

FRANCIS X. RETTENMEYER.

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