

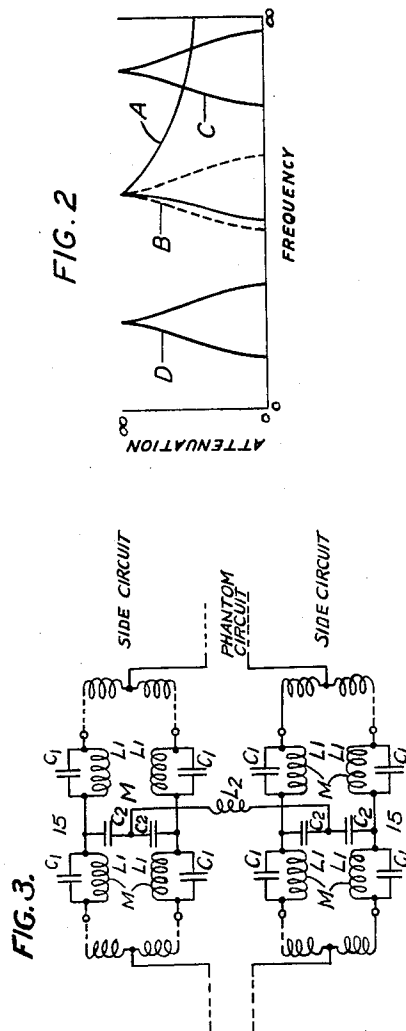
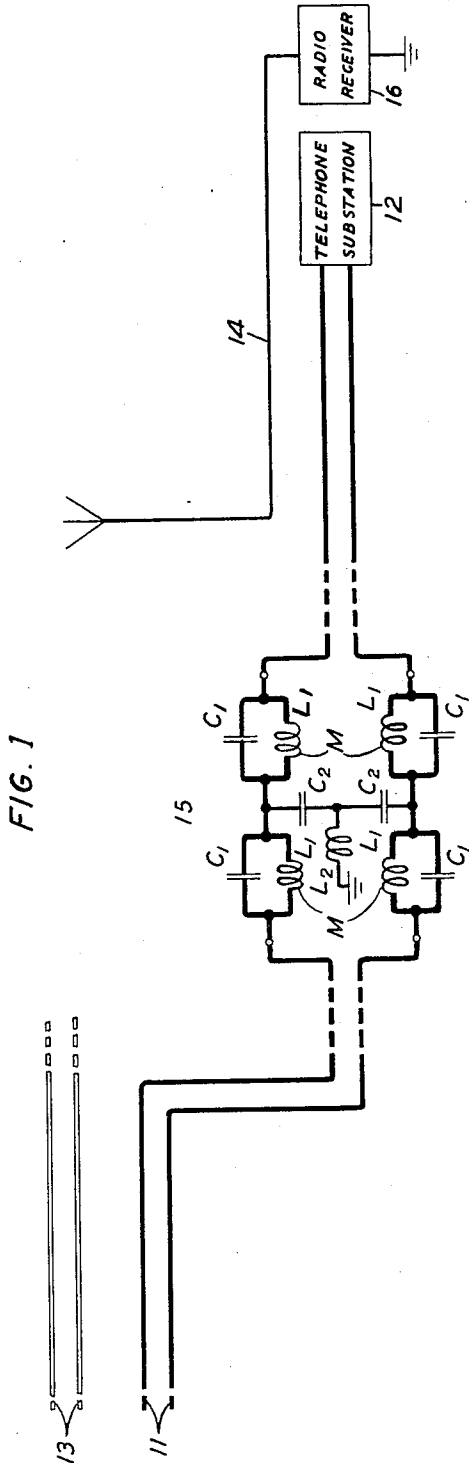
Jan. 9, 1934.

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1,942,488

ELECTRIC WAVE FILTER

Filed Sept. 16, 1931



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1,942,488

ELECTRIC WAVE FILTER

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Application September 16, 1931

Serial No. 563,013

7 Claims. (Cl. 178—44)

This invention relates to wave transmission and more particularly to electric wave filters adapted for use in a loop circuit which also carries longitudinal currents.

5 The principal object is to pass without appreciable distortion a range of frequencies in the loop circuit and at the same time to suppress the longitudinal currents over a range of frequencies.

10 A feature of the invention is a network which introduces into the loop circuit a broad-band filter characteristic and, at the same time, offers to the longitudinal currents an attenuation characteristic of an entirely different type.

15 Another feature of the invention is a filter which includes reactance elements that are effective in the loop circuit but ineffectual, or effective to a different degree, to the longitudinal currents, or vice versa.

20 An aerial telephone line which parallels an aerial power line is exposed to electrostatic and electromagnetic induction which tends to set up longitudinal currents in the telephone line. In this way disturbances in the power line produced by switching, changes of load, grounds, lightning
25 or the like cause corresponding disturbances in the telephone line. These surges on the telephone line may, in turn, be reradiated to other communication systems, such as a nearby radio antenna, causing noise or other undesirable interference. Since the telephone circuit ordinarily transmits voice and carrier frequencies, the problem arises of eliminating the undesirable longitudinal currents without appreciably interfering with the transmission of signals in the loop
30 circuit.

35 In accordance with this invention there is provided in the loop circuit a network which allows the free passage of voice and carrier frequencies in that circuit but attenuates to any desired degree the objectionable longitudinal current. There are contemplated two general methods of accomplishing this. According to one method the mid-point of a shunt arm of the loop circuit filter is grounded through an impedance. The
40 other method makes use of mutual coupling between elements of the filter. By virtue of this coupling the elements offer different impedances to the loop and to the longitudinal currents.

Referring to the drawing, Fig. 1 shows an embodiment of the invention in a telephone circuit;

Fig. 2 shows various attenuation characteristics which can be obtained with the filter structure shown in Fig. 1; and

Fig. 3 illustrates the application of the invention to a phantom circuit.

In Fig. 1 the telephone circuit 11 comprises a pair of wires terminated at one end in receiving apparatus 12. A power line 13 or other disturbing source is shown located in such proximity to a portion of line 11 that electric disturbances in the power line induce longitudinal currents of corresponding frequency in line 11. By carefully balancing the two sides and by transposing the two wires in a well known manner the effect of these disturbances on the loop circuit of line 11 can be largely overcome. There remains, however, the longitudinal current which traverses both wires of line 11 in the same direction, with ground as the return path. A radio receiving antenna 14, terminating in receiving apparatus 16 is shown paralleling a portion of line 11 in such a way that disturbances on the telephone line of the frequency used in the radio channel would be radiated to the antenna, causing interference with the received radio signals, either directly or by modulation. One method of preventing such interference with the radio channel is to provide in line 11 a filter network which will not interfere with the passage of the signaling frequencies over the loop circuit but will offer a high attenuation to longitudinal currents of the frequency used in the radio channel. In one practical instance the loop circuit was used for voice frequency and carrier transmission, requiring the passage over the loop circuit of all frequencies up to 30 kilocycles, and the radio channel was placed at 60 kilocycles, requiring a suppression of longitudinal currents over the frequency range of 58 kilocycles to 62 kilocycles.

The filter designated 15 in Fig. 1 may be made to meet the requirements stated above. The filter is of balanced construction, comprising anti-resonant series arms made up of inductance L_1 and capacitance C_1 in parallel, and in the shunt arm a pair of equal capacitances C_2 . The pair of inductances L_1 in the two sides of the circuit are coupled by mutual inductance M , the purpose of which will be fully explained later in the specification. The mid-point of the shunt arm of the filter is grounded through inductance L_2 . Provided the two sides of the circuit are perfectly balanced with respect to ground, there will be no flow of loop current through L_2 , and L_2 will, therefore, be ineffectual in the loop circuit. The structure will function in the loop circuit as a low-pass, suppression type, broad-band filter, the cut-off frequency of which can be so chosen that the signal currents of the loop circuit are passed without appreciable distortion. The attenuation characteristic with respect to

the loop circuit is shown symbolically as curve A of Fig. 2.

The longitudinal current flows in the same direction along the two conductors of line 11, through the series arm of the filter and thence to ground through condensers C_2 and inductance L_2 . Inductance L_2 and all of the other elements of filter 15 are, therefore, effective in the longitudinal circuit filter, the shunt arm of which comprises capacitance and inductance in series. This configuration of elements can be designed to give for the longitudinal currents a band suppression characteristic with a single attenuation peak. Assuming that there is no coupling between coils L_1 , that is, M equals zero, the attenuation peak for the longitudinal currents, as shown by curve B of Fig. 2, will occur at the same frequency as the peak for the loop circuit characteristic.

If it is desired to move the peak for the longitudinal currents to one side or the other of the loop circuit attenuation peak, this can be done by regulating the coupling M and by properly poling the connections of the two windings of inductance L_1 . For instance, if it is desired to have the longitudinal peak occur at a higher frequency than the loop peak, inductances L_1 are connected series aiding for the loop circuit, and the required coupling factor M is provided. By series aiding is meant a series connection in which the flux produced by the current in one winding is increased by the current flowing in the other winding. Curve C of Fig. 2 indicates how the peak for the longitudinal currents can be moved up by this method. On the other hand, if it is desired to have this peak occur at a lower frequency than the loop circuit peak, the windings of inductances L_1 are connected series opposing for the loop circuit, and the proper value of M is chosen. By series opposing is meant a series connection in which the current produced in one winding is opposed or decreased by the current flowing in the other winding. Curve D of Fig. 2 shows how the peak can be located at a lower frequency in this way.

Filter 15 can, of course, be used in a phantom circuit, each side of which is formed from a side circuit, as is illustrated in Fig. 3. In this case, similar filters are placed in each of the associated side circuits and the mid-points of the shunt arms are connected together through inductance L_2 .

If it is desired to attenuate the longitudinal currents in a way different from that shown by the characteristics of Fig. 2, this can be done by substituting other combinations of reactances in place of L_2 and by making changes in the series and shunt arms of the loop circuit filter in accordance with the well known principles of filter design.

Filter 20 is shown as a single section but if greater attenuation is required it can, of course, be obtained by adding additional sections, either of the same type or of a different type.

What is claimed is:

1. In a signaling circuit comprising conductors forming a loop circuit for the transmission of signal currents, said loop circuit being subject to undesired longitudinal currents from some extraneous source, means for attenuating said longitudinal currents in a certain frequency range while at the same time allowing the free transmission over said loop circuit of a second range of frequencies including the signal cur-

rents, the limits of said second range of frequencies being independent of the limits of said first mentioned range.

2. In a balanced telephone line, a balanced wave filter comprising a series arm and a shunt arm, the mid-point of a shunt arm of said filter being connected to ground through an impedance element having a different kind of impedance-frequency characteristic than the impedance-frequency characteristic of said shunt arm.

3. In a loop circuit comprising a pair of conductors, with a signal current flowing in said loop circuit and an undesired current longitudinally traversing said pair of conductors, means associated with said loop circuit for attenuating said undesired longitudinal current over a frequency band while at the same time allowing the free transmission of said signal currents in said loop circuit, the limits of said band being independent of the range of frequencies transmitted in said loop circuit.

4. In a telephone line comprising metallic conductors, a loop circuit formed of said conductors, said loop circuit carrying signaling currents and also carrying undesired longitudinal currents introduced from some extraneous source, means for freely transmitting in said loop circuit a band of frequencies including said signaling current while at the same time attenuating said longitudinal current which falls within a band of frequencies, the limits of said last-mentioned band being independent of the limits of said first-mentioned band.

5. In a signal transmission system, a signal circuit comprising a pair of line wires balanced with respect to ground, a longitudinal circuit comprising said pair of line wires in parallel as one path and ground as a return path, and a wave filter having a series branch in each of said line wires, a branch in shunt with respect to said line wires and a reactance element connected between the mid-point of said shunt branch and ground, said reactance element having a different type of reactance-frequency characteristic than the reactance-frequency characteristic of said shunt branch, whereby said filter has a different attenuation characteristic in said signal circuit than it has in said longitudinal circuit.

6. In a signal transmission system, two side circuits each comprising a pair of line wires balanced with respect to ground, a phantom circuit comprising one of said side circuits as one path and the other of said side circuits as the other path, a wave filter in each of said side circuits, each of said filters having a series branch and a shunt branch and being balanced with respect to ground, and a reactance element connecting the mid-points of said shunt branches, said reactance element having a different type of reactance-frequency characteristic than the reactance-frequency characteristics of said shunt branches.

7. In a signal transmission system, a signal circuit comprising a pair of line wires balanced with respect to ground, a longitudinal circuit comprising said pair of line wires in parallel as one path and ground as a return path, and a wave filter associated with said signal circuit, said filter including a pair of elements coupled by mutual impedance in such a manner that there is formed in said signal circuit a broad-band wave filter of a certain type and in said longitudinal circuit a broad-band wave filter of a different type.