March 16, 1926. 1,576,566

H. A. AFFEL

DUPLEX BALANCING ARRANGEMENT

Filed April 1, 1920

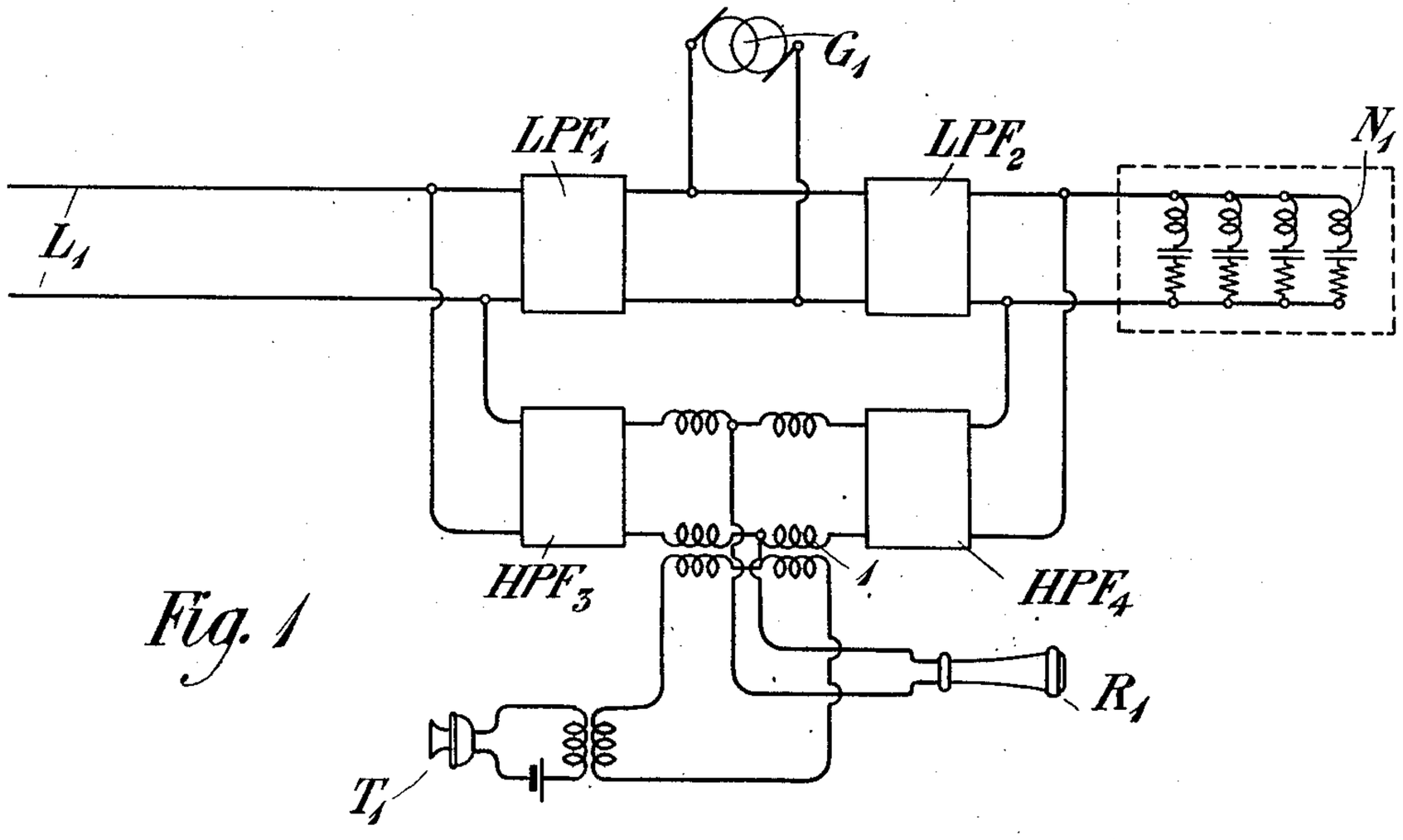

Fig. 1

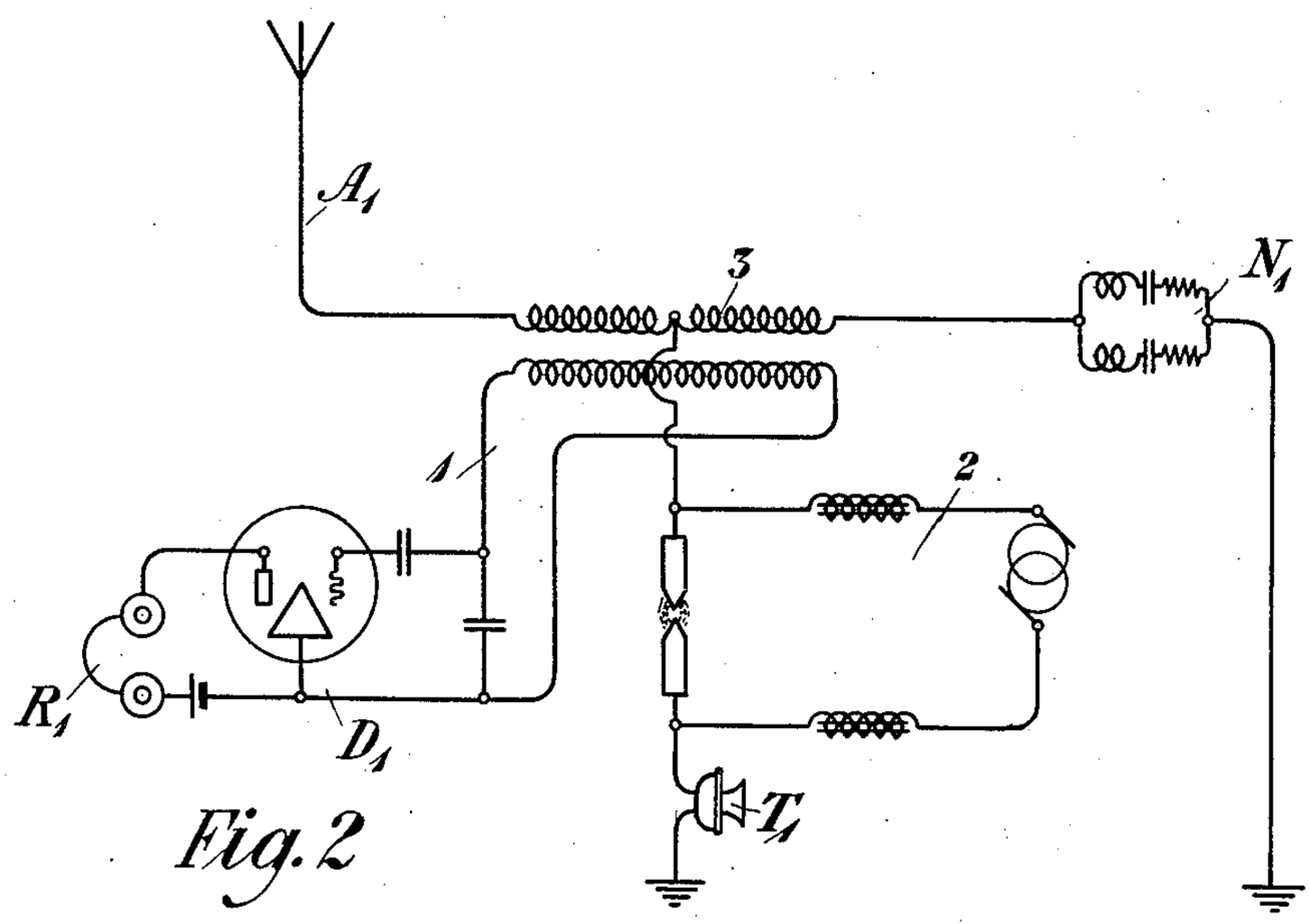

Fig. 2

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Patented Mar. 16, 1926. 1,576,566

UNITED STATES PATENT OFFICE.

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DUPLEX BALANCING ARRANGEMENT.

Application filed April 1, 1920. Serial No. 370,439.

To all whom it may concern:

Be it known that I, HERMAN A. AFFEL, a citizen of the United States, residing at Brooklyn, in the county of Kings and State of New York, have invented certain Improvements in Duplex Balancing Arrangements, of which the following is a specification.

This invention relates to means for the simultaneous transmission of currents of a plurality of channels, and more particularly to a novel combination of selecting networks and balancing networks for preventing interference between the transmitted channels without causing excessive loss of energy in the said interference preventing networks.

In multiplex communication or transmission systems designed for the simultaneous transmission of currents constituting a plurality of bands or channels, each band or channel representing either a single frequency or group of frequencies based upon some fundamental frequency, interference between the fundamental frequencies of the respective channels may be prevented by means of selective networks, but interference may incidentally result if there happen to be present any harmonics of one of the fundamental frequencies which fall within the range of frequencies of the other channel. Investigations of interference between power transmission lines and signaling circuits have revealed in the signaling circuit frequencies as high as the 30th harmonic of the fundamental frequency of the power line so it may readily be seen that it is often difficult to prevent interference in multiplex systems by selective networks alone, particularly where the interference is produced by a powerful transmitting source whose harmonics feed into a local receiving circuit of another channel.

Likewise, systems which are designed to prevent interference between channels by means of balancing networks whose function is to balance the line for one of the fundamental frequencies are objectionable because of the excessive energy absorption which takes place in the balancing network.

It is the object of the present invention to prevent interference between transmission channels by combining in a novel way selective networks and balancing networks, the selective networks functioning to prevent interference between the fundamental frequencies of the channels, and the balancing networks serving to balance the line only for the harmonics of one fundamental which would interfere with the other channel. Such balancing network would offer high impedance to the fundamental of the harmonics for which it serves to balance the line, and therefore no loss of energy of that fundamental frequency would occur.

This invention will be more clearly understood from the following description read in connection with the attached drawing, of which Figure 1 shows the application of the invention to a system for the transmission of current of telephonic frequencies over a power transmission line, and Figure 2 shows the application of the invention to a duplex radio system.

In Fig. 1, L_1 represents a power transmission line which is adapted for the simultaneous transmission of power and signaling currents. G_1 represents an alternating current generator which is connected with the transmission line L_1, the fundamental frequency of which may be assumed for purposes of illustration, to be between 0 and 60 cycles. Connected into the transmission line on each side of the point of connection of the generator thereto are the low-pass filters LPF_1 and LPF_2 respectively, which may be of the well-known type disclosed in the patent to Campbell, No. 1,227,113, dated May 22nd, 1917. Also connected with the transmission line is a balancing network N_1 which is designed to balance the transmission line L_1 with respect to such harmonics of the fundamental power frequency which would be most liable to interfere with the frequencies embraced within the signaling channel transmitted over the said line. Also connected with the line L_1 by means of the triple winding transformer 1 is a telephone circuit represented schematically by the receiver R_1, transmitter T_1 and connecting circuits. Between the transformer 1 and the line L_1, are inserted high-pass filters HPF_3 and HPF_4 which preferably are of the Campbell type heretofore referred to and are designed to transmit therethrough, with minimum attenuation, currents of signaling or telephone frequencies.

Fig. 2, illustrates the application of partial harmonic balancing to a duplex radio system which is intended for the simultaneous transmission and reception of a plurality

of different frequencies. In the drawing A_1 represents an antenna having connected therewith the receiving circuit 1 and the transmitting circuit 2, the latter being represented as a Poulsen type arc circuit which is a type of circuit in which the production of harmonics is notoriously large. The receiving circuit is coupled to the antenna circuit by means of the transformer 3 and the transmitter circuit is directly connected with the midpoint of the antenna winding of the transformer.

Connected with the transformer is a balancing network N_1 which is resonant and whose impedance is adjusted to simulate the corresponding impedance of the antenna to certain predetermined harmonics of the transmitted frequency F_1 which are most liable to interfere with the received frequency F_2. The network N_1 on the other hand, is designed to have high impedance at the fundamental frequency F_1. The circuit 1 which is tuned to reception frequency is connected across the input side of the detector D_1 which in turn is connected with the receiver R_1. Connected with the transmitting circuit 2 may be any well-known form of transmitting device T_1.

Having in mind the foregoing description of the parts of the apparatus set forth in Figures 1 and 2, and the function performed by each part, the invention will be clear from the following description of the mode of operation of each of these circuits.

In the arrangement shown in Fig. 1, the generator G_1 may apply current to the transmission line of a predetermined frequency varying from 0 to 60 cycles and the signaling circuit may simultaneously apply current extending from 200 cycles upward. Interference between the fundamental frequency of the power channel and the band of frequencies of the signaling channel is prevented by means of the arrangement of the low-pass filters and of the high-pass filters. Since it is well-known that high harmonics as far as the thirtieth may be present in power transmission circuits, it is desirable in order to prevent these harmonics from interfering with the signaling channel, to balance by means of a suitable network the transmission line for these frequencies. In the arrangement shown, the low-pass filters LPF_1 and LPF_2 are so arranged in the circuit as to impress the power voltage across both the transmission line and the selective network N_1. Since the network is so designed as to offer relatively high impedance compared with the transmission line itself to the fundamental power frequency and to simulate the transmission line impedance for the higher harmonics, it will be seen that substantially no current of the fundamental power frequency will be lost in the balancing network N_1, but, on the other hand, currents of the higher frequencies which may in a slight degree pass through the low-pass filters due to the large amount of energy in the power circuit will be balanced by the network N_1 and therefore will not interfere with the signaling channel.

Although the principle of this invention has been disclosed in an arrangement for transmitting signaling current of telephonic frequency over a circuit simultaneously with the transmission of power current, it is not limited to such specific structure or to such frequencies but may be applied to other arrangements involving different frequencies. Thus, for example, by means of the balancing transformer 1, which is shown connected through the high-pass filters HPF_1 and HPF_2 on the line and network sides respectively, the line L_1 may be connected to a four-wire telephone, carrier telephone, carrier telegraph or other signaling circuit. Furthermore, if desirable, four-wire operation may be discarded and a two-wire connection substituted by bridging across a through connection between the two high-pass filters.

The arrangement disclosed in Fig. 2 represents the application of this invention to prevent interference in duplex radio systems between the undesirable harmonics of the transmitted frequency and the received frequency. In such systems it is found that when oscillations are being transmitted at a frequency F_1 from the antenna A_1, simultaneously with the reception from a distant station of a frequency F_2, the harmonics or multiples of F_1 may be sufficiently close to the reception frequency F_2 as to cause troublesome interference in receiving even though the fundamental frequencies are sufficiently separated as not to interfere. It is the object of the present invention to minimize or prevent such interference.

If, in transmitting oscillations of the frequency F_1, there are set up in the antenna circuit any harmonics of frequency F_1, current of the frequency of these harmonics will flow in the antenna winding of transformer 3 in both directions from its midpoint, and to substantially the same degree because the network N_1 is adjusted to simulate the impedance of the antenna to these harmonics of frequency F_1. Since the current resulting from the objectionable harmonics of F_1 flows in opposite directions from the midpoint of the antenna winding of transformer 3, substantially no reaction will be set up in the receiving circuit 1, tuned to reception frequency. Furthermore, since the network N_1 has high impedance at the fundamental transmitting frequency F_1 substantially no current at this frequency will flow through the network N_1, consequently there will be no energy lost of the fundamental transmitting frequency. Also, since

the receiving circuit 1 is tuned to a frequency that is fundamentally different from the transmitting frequency F_1 there will be no undesirable reaction between basic frequencies F_1 and F_2 of the transmitting and the receiving channels, respectively.

From the foregoing description of this invention it will be seen that there has been disclosed the novel combination of two well-known means of preventing interferences between transmission channels of a plurality of frequencies, applicable either to wire or wireless transmission systems, which reduces to a minimum the loss incidental to the use of such interference preventing devices.

Although this invention has been disclosed in certain specific forms, it is to be understood that it is not thus limited but is capable of embodiment in other and widely different forms without departing from the spirit and scope of the appended claims.

What is claimed is:

1. In a signaling system adapted for the simultaneous transmission of frequencies constituting a plurality of channels of transmission the combination of a transmission line, means for impressing a plurality of groups of frequencies on the said line, selective networks adapted to discriminate between the fundamental frequencies of the said groups, and a balancing network designed to balance said line for predeterminate harmonics only of one of said groups which are liable to interfere with the frequencies of the other of said groups.

2. In a signaling system adapted for the simultaneous transmission of frequencies constituting a plurality of channels of transmission the combination of a transmitting circuit, means for applying a plurality of groups of frequencies to the said circuit, selective networks adapted to transmit frequencies of the desired group and to attenuate frequencies of the undesired group, and a balancing network simulating the impedance of the said line for harmonics of the frequencies of the first group and having higher impedance for the fundamental frequencies of the said first group.

3. In a signaling system adapted for the simultaneous transmission of power and signaling currents, the combination of a transmission circuit, means for impressing current of power frequency upon the said circuit, means for impressing current of signaling frequency upon said circuit, selecting networks adapted to prevent interference between currents of power frequency and signaling frequency, and a balancing network adapted to simulate the line impedances for such harmonics of the power frequency as are liable to interfere with the said signaling frequency.

4. In a signaling system adapted for the simultaneous transmission of power and signaling currents, the combination of a common transmission circuit, means for impressing current of power frequency upon said circuit, a balancing network connected with said circuit simulating the impedances of the transmission circuit for certain predetermined harmonics of the said fundamental power frequency, low-pass filters connected with the said transmission circuit on the line side and the network side of the point of application of the power current thereto, means for applying current of signaling frequency to the said line circuit comprising signaling apparatus, a triple-winding transformer and high-pass filters inserted between the said transformer and the said line, and balancing network respectively.

5. In a signaling system adapted for the simultaneous transmission of power and signaling currents, the combination of a line circuit, a power circuit for applying current of power frequency to said line circuit, and a signaling circuit for applying high frequency signaling current to said line circuit, selective networks designed to prevent power currents from entering the signaling circuit and likewise to prevent the signaling currents from entering the power circuit, and balancing network designed to have substantially the same impedance as the line circuit for certain predetermined harmonics of the power circuit whereby the said line circuit is balanced and the said harmonics are prevented from interfering with the signaling currents.

6. In a signaling system adapted for the simultaneous transmission of frequencies constituting a plurality of channels of transmission, the method of transmitting the carrier signaling currents over a power transmission line which consists in balancing the said line for those harmonics of the power frequency capable of interfering with the signaling frequency, applying the said power frequency to the said line and suppressing by filtering the harmonics of the said power frequency, and selecting by filtering the said carrier currents, thereby preventing interference between channels.

7. In an electrical transmission system adapted for the simultaneous transmission of frequencies constituting a plurality of distinct channels of transmission, the combination with a transmission circuit of a second circuit having a source of current of definite frequency connected therewith, a balancing network connected with the said transmission circuit whose impedance simulates the transmission circuit for certain harmonics of the frequency impressed on said circuit by said second circuit, and having higher impedance for the fundamental frequency of the said second circuit, and a third circuit having means for the transmis-

sion and reception of currents whose frequencies differ from that produced by the said first circuit.

8. In a system for the simultaneous transmission of signaling currents and power currents over the same transmission line, the method of eliminating interference between the said currents which consists in balancing the said line for the harmonics only of the fundamental frequency of the power currents, and preventing interference between said fundamental power frequency and the signaling frequency by filtering the respective frequencies.

In testimony whereof, I have signed my name to this specification this 30th day of March 1920.

HERMAN A. AFFEL.