July 7, 1925. 1,544,622

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ELIMINATION OF INTERFERENCE IN CARRIER SYSTEMS

Filed May 10, 1924 2 Sheets-Sheet 1

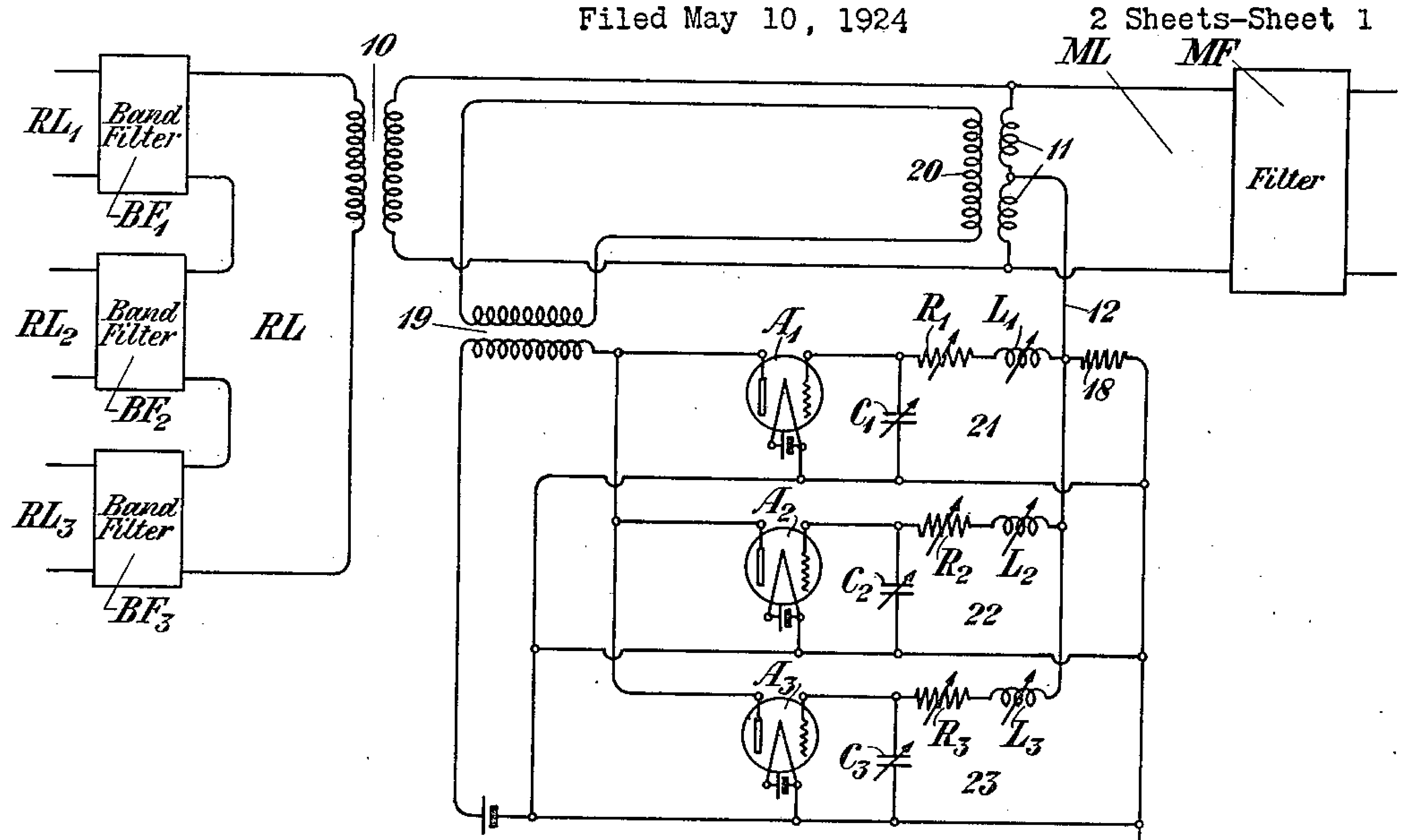

Fig. 1

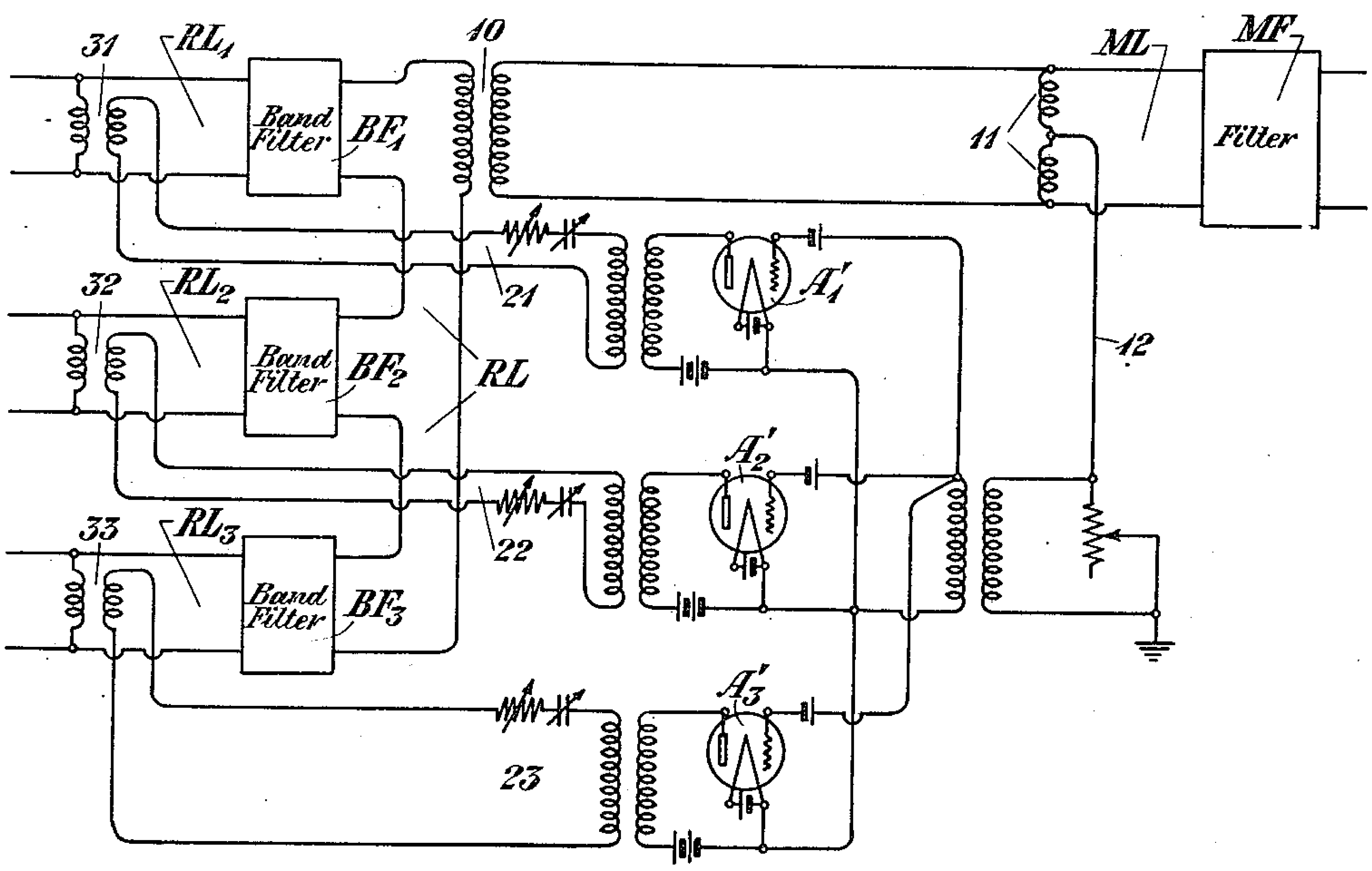

Fig. 2

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2 Sheets-Sheet 2

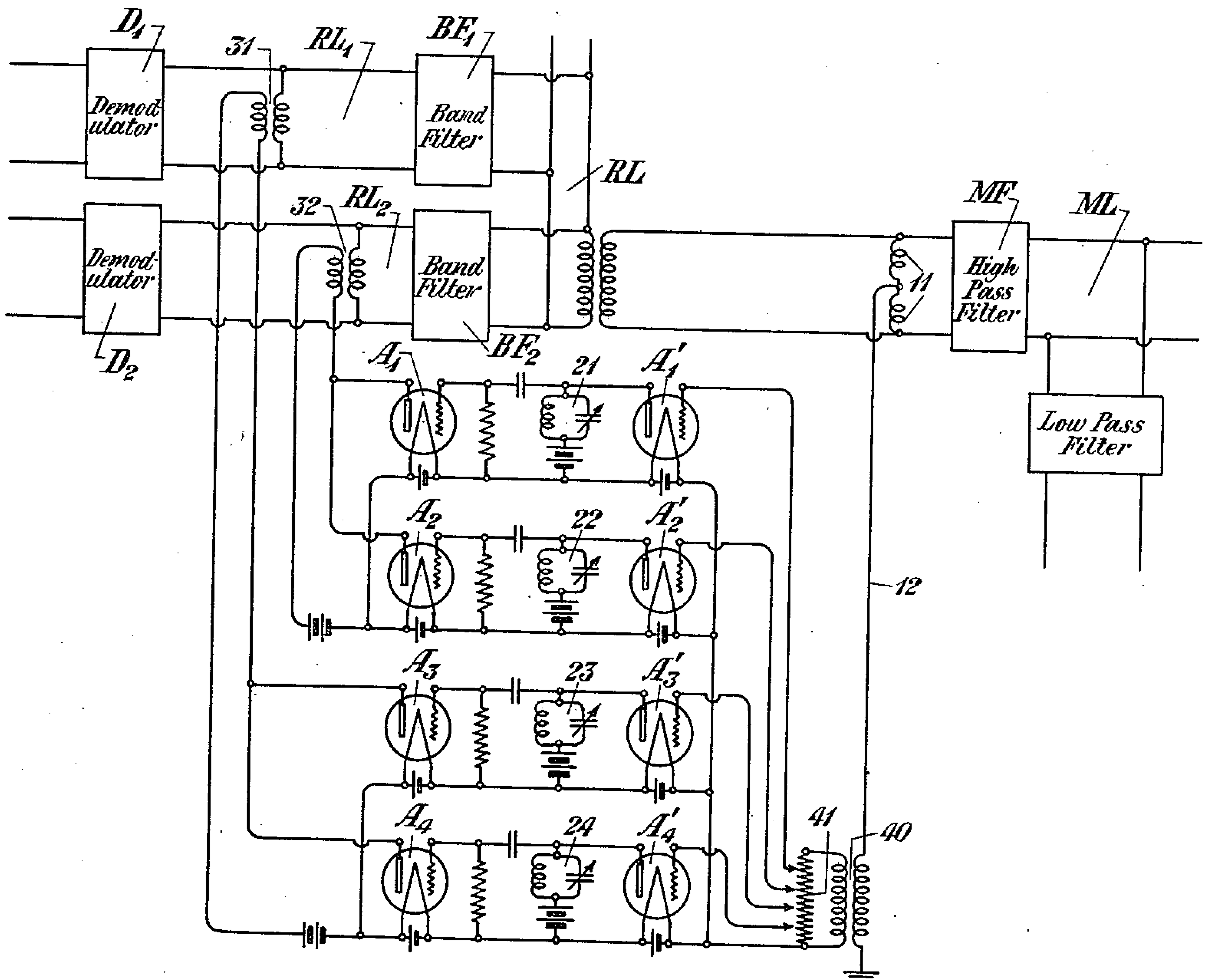

Fig. 3

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UNITED STATES PATENT OFFICE.

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ELIMINATION OF INTERFERENCE IN CARRIER SYSTEMS.

Application filed May 10, 1924. Serial No. 712,447.

To all whom it may concern:

Be it known that I, HERMAN A. AFFEL, residing at Brooklyn, in the county of Kings and State of New York, have invented certain Improvements in Elimination of Interference in Carrier Systems, of which the following is a specification.

This invention relates to carrier systems and more particularly to the elimination of external interference in such systems.

In systems employing carrier frequencies for the transmission of signals, one of the principal sources of external interference is due to radio transmitters employing frequencies lying within the range transmitted by a carrier channel. Such interference is produced by the line wires acting as an antenna to pick up the radiated wave and transmit it to the receiving carrier apparatus.

It has heretofore been proposed to overcome interference of this sort by picking up a component corresponding to the interfering wave and impressing it upon the circuit at some point common to all of the carrier channels with such phase and amplitude as to neutralize the interfering component transmitted over the line wires. While this method is satisfactory where only one interfering frequency is involved, some difficulty has been experienced where more than one interfering frequency is involved due to the fact that each interfering frequency must be treated separately by selecting into tuned circuits components of each frequency and separately adjusting the phase of the component in each tuned circuit. Any adjustment made in one of the tuned circuits, either for the purpose of changing the phase or rendering the circuit selective of a desired frequency, results in some change in the characteristics of the other tuned circuits associated with it, so that it becomes a very difficult matter to make the adjustment.

In accordance with the present invention this difficulty is overcome by arranging the source of balancing voltage so that it works into a substantially constant impedance. This may be done by inserting a resistance or interposing one or more vacuum tubes at a proper point in the circuit.

The invention may now be more fully understood from the following description when read in connection with the accompanying drawing, Figures 1, 2 and 3 of which illustrate three different embodiments of the invention.

Referring to Fig. 1, ML designates a main transmission line of a carrier system, which is associated through a transformer 10 with the common circuit RL of a carrier terminal. Individual carrier channels RL_1, RL_2 and RL_3 are connected to the common circuit RL through filters such as BF_1, BF_2 and BF_3, the band filters being designed to pass to each individual carrier channel the range of frequencies assigned to it.

One of the principal sources of interferences in a circuit of this kind is that due to radio transmitting stations transmitting at frequencies which lie within the range or ranges of one or more receiving channels of the carrier system. The main line of the carrier system will act somewhat as an antenna to pick up the waves transmitted by the radio stations and transmit them to the receiving terminal. In this connection, the transmission takes place over the two sides of the main line in parallel but as the two conductors of the line are not exactly alike, so that the main line is not exactly balanced with respect to the ground, there would be a resultant component of the interfering frequency, flowing serially over the two sides of the line, and it is this component that causes interference in the carrier terminal.

In order to neutralize this component, a local antenna may be employed to intercept the radio energy, or as has been found desirable, an inductance 11 may be bridged across the line and a connection 12 is tapped to the midpoint of the inductance 11 so that the components flowing over the two sides of the line in parallel may be taken off. The components thus taken off may be changed in phase and amplitude and then reapplied to the circuit in such a manner as to neutralize the series interfering components flowing over the line. Branch circuits 21, 22 and 23 are connected in parallel to the common tap 12 and these branch circuits include suitable inductances, resistances and capacities, such as L_1, R_1 and C_1. The inductance L_1 and the capacity C_1, for example, may be adjusted to tune the circuit to a particular interfering component and the resistance R_1 may be used to give the component the desired amplitude. When the circuit is tuned to a particular frequency, a very slight adjustment of the condenser C_1, for example, will produce a large change in the phase without materially detuning the circuit, so that the phase angle of the selected component will be under control. The three circuits 21, 22 and 23 may then be connected through a transformer winding 20 to apply the several individual frequencies selected to the main line ML with the same amplitude and in opposite phase relation to the corresponding series interfering components, due to the radio stations.

The circuit, so far as above described, is not entirely satisfactory, for the shifting of phase and amplitude required for the proper balancing of one frequency, changes the impedance of the circuit into which the balancing voltages work and, hence, the tuning for one frequency affects any balance already obtained by adjustment of another circuit for another frequency. It is, therefore, necessary to render the several tuned circuits independent. This is done, so far as the output side of the tuned circuits is concerned, by connecting them to the transformer 20 through one-way devices, such as vacuum tube amplifiers A_1, A_2 and A_3, the input circuits of the amplifiers being bridged across the condensers C_1, C_2 and C_3 respectively and their output circuits being connected together through the transformer 19 to the transformer winding 20.

It will be apparent that the output side of circuit 22 can produce no effect in the circuit 21 because the effect must be transmitted through the one-way device A_1 and this device does not transmit in a direction to permit of transmission from 22 through the amplifier A_2 to 21. It now remains to effectively segregate the input sides of the circuits 21, 22 and 23, and this is accomplished by providing a small resistance 18 in the circuit 12 and so arranging the branches 21, 22 and 23 that they are in parallel with respect to this resistance. The impedance of the resistance 18 is small as compared with the impedance through any one of the tuned branches, such as 21, 22 and 23, so that any change in the impedance of one of the branches due to the adjustment of its tuning will produce little effect in the total impedance across the terminals of the resistance 18, this impedance being largely determined by said resistance 18. The tuning of one of the branches will, therefore, produce very little effect in the impedance of the other branches. This favorable relation of impedances is, of course, permitted by the use of the vacuum tube because of the amplifying properties of the device. The amount of energy which each of the balancing circuits takes from the common source of balancing components is therefore very small as compared to the total available energy and this may in a sense be regarded as an essential principle of the invention.

A modified arrangement is shown in Fig. 2. In this case, the tuned circuits 21, 22 and 23 are prevented from reacting, one upon the other, at their input sides, by interpolating one-way amplifiers A'_1, A'_2 and A'_3 between said circuits and the ground tap 12. Upon their output sides the circuits 21, 22 and 23 are connected to the receiving channels LR_1, LR_2 and LR_3 through transformers 31, 32 and 33, bridged across the receiving channels beyond the band filters BF_1, BF_2 and BF_3. The output sides of the three tuned circuits are therefore connected together through the common carrier terminal circuit RL so that between each tuned circuit and the common branch there is a band filter, such as BF_1, BF_2 and BF_3. Any change in the tuning of the circuit 21, for example, can produce practically no change in the circuit 22 for the change in the impedance of the circuit 21 must be seen from the circuit 22 to the impedance of the band filters BF_2 and BF_1 in tandem, and the bands of free transmission of these two filters do not overlap. For all practical purposes, therefore, the several tuned circuits are electrically segregated at both ends.

A modified arrangement is shown in Fig. 3, in which the electrical segregation of the tuned circuits is obtained by providing one-way devices on each side of each individual tuned circuit. The system, as shown in Fig. 3, is also designed to take care of the situation where more than one interfering frequency may fall within the range of the same carrier channel. As shown in Fig. 3 there are four tuned circuits 21, 22, 23 and 24, each tuned to a different interfering frequency and arranged so that by adjusting the capacity element of the tuned circuit the phase angle of the wave may be adjusted without material change in the tuning of the circuit. Upon their input sides the several tuned circuits are segregated by being connected through one-way amplifiers A'_1, A'_2, etc., to a transformer 40 associated with the ground tap 12. The amplitudes of the neutralizing components are controlled by connecting the grid circuits of the several amplifiers to proper points of a potentiometer 41.

In the case illustrated it is assumed that the frequencies to which circuits 21 and 22 are tuned will fall within the range of the channel RL_2. Therefore, it is necessary to connect these circuits together at the transformer 32, whereby the neutralizing electromotive forces are impressed upon the receiving channel. To prevent reaction between the tuned circuits at this common point, amplifiers A_1 and A_2 are interpolated, as shown, on the output sides of the tuned circuits. In a similar manner, the circuits

23 and 24 are tuned to interfering frequencies falling within the free range of the channel RL_1 and these two circuits are separated by means of the amplifiers A_3 and A_4 upon their output sides.

It will also be noted that reaction of the tuned circuits 23 and 24 upon the tuned circuits 21 and 22 is prevented not only by the amplifiers A_1, A_2, A_3 and A_4 but by the fact that the two pairs of circuits are connected to the receiving channels RL_1 and RL_2 beyond the band filters BF_1 and BF_2 so that the impedance of one of the tuned circuits, as 21, must be viewed from another of the tuned circuits, as 24, through the band filters BF_1 and BF_2 in tandem. It will be obvious, therefore, that the tuning and adjustment of the phase of each tuned circuit may be made quite independent of the adjustment of any of the other tuned circuits.

It will be obvious that the general principles herein disclosed may be embodied in many other organizations widely different from those illustrated without departing from the spirit of the invention as defined in the following claims.

What is claimed is:

1. In a multiplex carrier system comprising a main transmission line and a plurality of carrier terminal channels, an arrangement for reducing interference from external sources comprising means for picking up voltages from said interfering sources, a plurality of selective circuits for selecting different interfering components, means to impress the selected components upon the carrier system with such amplitude and in such phase relation as to neutralize interfering currents transmitted over said system, and means to substantially prevent the reaction of any circuit upon the tuning of any other comprising a substantially constant impedance through which said selective circuits are interconnected.

2. In a multiplex carrier system comprising a main transmission line and a plurality of carrier terminal channels, an arrangement for reducing interference from external sources comprising means for picking up voltages from said interfering sources, a plurality of selective circuits for selecting different interfering components, means to impress the selected components upon the carrier system with such amplitude and in such phase relation as to neutralize interfering currents transmitted over said system, and means for preventing interaction between said selective circuits comprising one-way devices included in each circuit to provide a constant impedance at their point of interconnection.

3. In a multiplex carrier system comprising a main transmission line and a plurality of carrier terminal channels, interconnected with said main line through filters for passing into each channel the band of frequencies assigned thereto, an arrangement for reducing interference from external sources comprising means for picking up voltages from said interfering sources, a plurality of selective circuits for selecting different interfering components, means to impress the selected components upon the carrier system with such amplitude and in such phase relation as to neutralize interfering currents transmitted over said system, and means for preventing interaction between said circuits comprising one-way devices connected to the input sides of said circuit and their output sides being connected to the individual channels beyond the filters so that the interconnection between the output sides of two selective circuits will include at least two filters passing different bands.

4. In a multiplex carrier system comprising a main transmission line and a plurality of carrier terminal channels interconnected with said main line through filters for passing into each channel the band of frequencies assigned thereto, an arrangement for reducing interference from external sources comprising means for picking up voltages from said interfering sources, a plurality of selective circuits for selecting different interfering components, certain of which components fall within the range assigned to one terminal channel, the others of which fall within the ranges assigned to other terminal channels, means to interconnect the selective circuits corresponding to interfering frequencies of one channel and associate said circuits with said channel at a point beyond the filter therein so that groups of selective circuits connected to one channel will be connected to groups of selective circuits connected to another channel through two filters, having different transmission ranges, one-way devices included in each of the selective circuits connected to a given channel between said circuits and their point of interconnection, and a one-way device on the input side of each selective circuit.

In testimony whereof I have signed my name to this specification this 7th day of May 1924.

HERMAN A. AFFEL.