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ANTENNA STRUCTURE.
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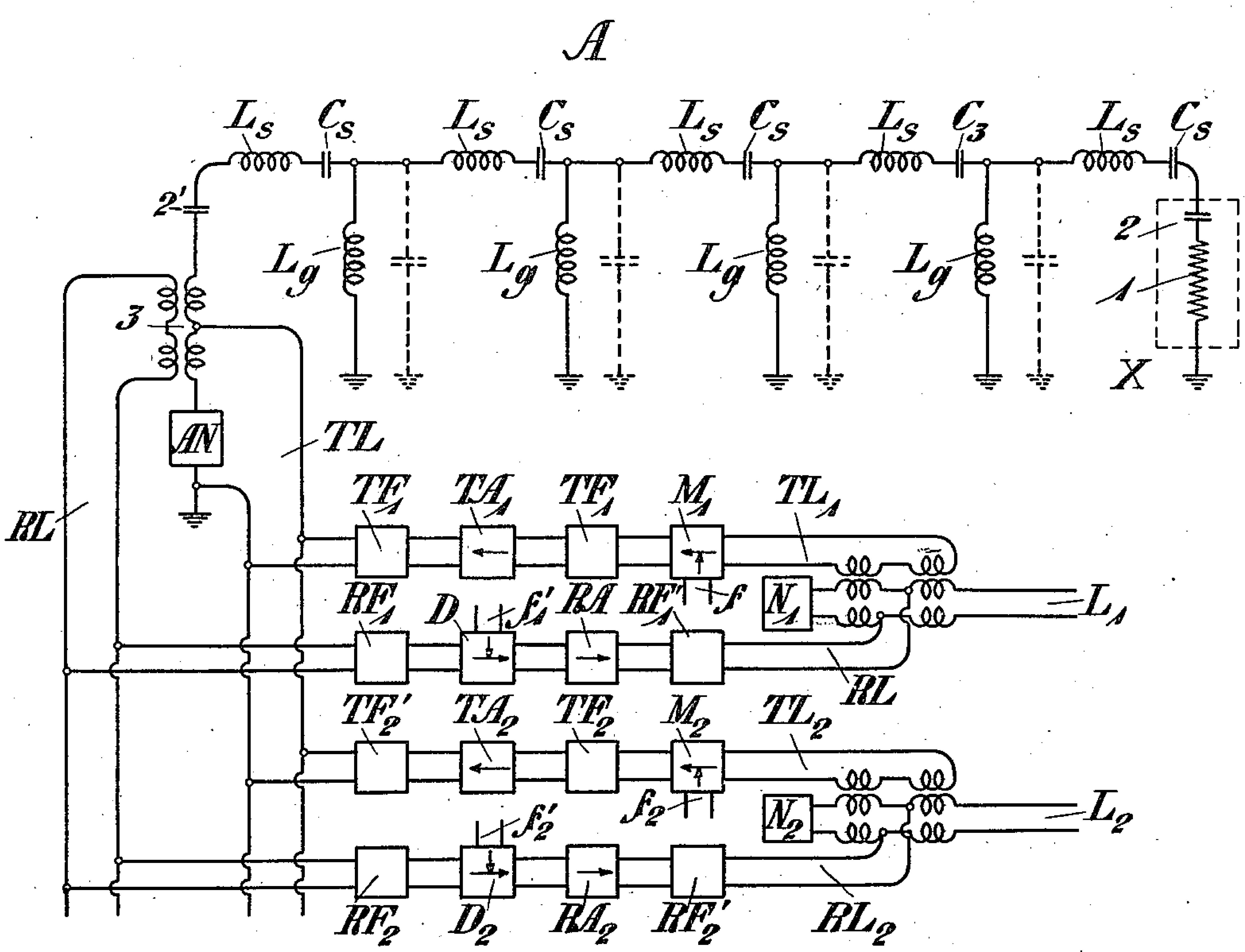
1,353,735. Patented Sept. 21, 1920.



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ANTENNA STRUCTURE.

1,353,735. Specification of Letters Patent. Patented Sept. 21, 1920.

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To all whom it may concern:

Be it known that I, LLOYD ESPENSCHIED, residing at Hollis, in the county of Queens and State of New York, have invented certain Improvements in Antenna Structures, of which the following is a specification.

This invention relates to radio transmission and more particularly to antenna arrangements for radio systems.

One of the principal features of the invention resides in the provision of an antenna arrangement having the characteristics of a broad band filter, that is a filter which will freely transmit a wide band of frequencies with uniform attenuation, while substantially extinguishing frequencies lying without the band.

A further feature of the invention resides in the provision of a terminating impedance associated with the end section of a series of sections of an antenna having a broad band characteristic, said impedance being for the purpose of substantially preventing reflection losses due to the fact that the number of sections is less than infinite.

These features, together with other features of the invention more fully appearing hereinafter, are realized in an antenna structure made up of a plurality of similar sections, each section comprising a series impedance element which is preferably an inductance and capacity in series with each other and a shunt impedance element connected to ground and constituting with the normal capacity to ground of the section, a shunt element comprising parallel inductance and capacity.

In accordance with the principles set forth in the United States Patents, Nos. 1,227,113 and 1,227,114, issued to George A. Campbell, under date of May 22, 1917, such a structure when composed of an infinite number of sections may, by proper design of the elements constituting each section, freely transmit a band of frequencies with uniform attenuation, while substantially suppressing frequencies lying without the band. Since in practice it is not feasible to provide an infinite number of filter sections, a lesser number may be used with substantially the same result, provided the end sections of the series are related to terminal lines or other elements having the proper impedance values. In the construction of an antenna, however, since the aerial member of an antenna is open-circuited at one end, the last section of an antenna structure, such as above described, would not be connected with a proper impedance, so that reflection losses would result. It is therefore proposed to associate with the last section of the series a terminal impedance element so related to a small number of sections that the effect of reflection losses will be substantially eliminated.

The invention may now be more fully understood from the following description when read in connection with the accompanying drawing, the figure of which illustrates the general embodiment of the invention.

Referring to the drawing, A designates generally an antenna arrangement comprising a plurality of sections of similar construction. Each section comprises series inductances L_s and series capacities C_s in series with each other and a shunt inductance L_g connected to ground. The normal capacity of the section to ground may be considered to be in parallel with the inductance L_g, as indicated in dotted lines. It will thus be seen that the antenna arrangement constitutes one of the types of band filters disclosed in the patents to Campbell, above mentioned, and if the four elements of each section were properly proportioned and if the number of sections were infinite, the arrangement would readily transmit with uniform attenuation a band of frequencies, while substantially suppressing frequencies lying without the band. Since it is impractical to provide an infinite number of sections, it is necessary to provide a terminating impedance for the end sections of the series, in order to prevent reflection effects which would tend to distort the broad band characteristic. Accordingly, the right hand section has associated therewith an impedance element X, which comprises a resistance 1 and a capacity 2, so proportioned as to give the proper terminating impedance. In actual practice the capacity C_s and the capacity 2 may be combined in one condenser, but are separately illustrated, in order that the relation of the parts may be more clear. The left hand section of this series should also be provided with a similar terminating impedance and for this purpose a capacity 2' is provided, the resistance corresponding to the resistance 1 being taken as the resistance of the transformer 3 and other apparatus whereby the multiplex circuits may be associated with the antenna.

The multiplex circuits are associated with the antenna through a common transmitting circuit TL and a common receiving circuit RL. The latter is connected to the secondary winding of the balanced transformer 3. The circuit TL has one conductor grounded, while the other conductor is connected to the midpoint of the split winding of the transformer 3. In order that the circuits TL and RL may be rendered substantially conjugate, an artificial line or network AN is provided to balance the antenna structure A over the range of frequencies to be transmitted.

L_1 and L_2 designate a plurality of low frequency signaling lines adapted to transmit signals through the medium of the antenna structure A. The line L_1 is associated with the circuits TL and RL through transmitting channel TL_1 and receiving channel RL_1 respectively. The line L_2 is similarly associated with the circuits TL and RL through the channels TL_2 and RL_2, respectively. The transmitting channel TL_1 includes a modulator M_1, a band filter TF_1, an amplifier TA_1 and a band filter TF_1'. The modulator M_1 is of any well-known character but is preferably a vacuum tube modulator such as is disclosed in the U. S. application of John R. Carson, Serial No. 157,413, filed March 26, 1917. This modulator is adapted to modulate a radio frequency f_1 applied thereto in accordance with signals incoming from the line L_1.

The filters TF_1 and TF_1' are preferably band filters of the type illustrated in the patents to Campbell above referred to. The filter TF_1 is designed in accordance with the principles of said Campbell patents, to transmit a band of frequencies above a desired lower limit, while suppressing frequencies below this limit and also to suppress frequencies above a desired upper limit. The lower limit of the filter should be so chosen as to pass the modulated carrier frequencies, while suppressing low frequency components, while the upper limit should be so chosen as to suppress harmonics of the carrier frequency. The filter TF_1' is designed to transmit a relatively narrow band of frequencies in the neighborhood of the frequency f_1, the band being sufficiently wide, however, to accommodate the frequency variation due to the modulation of the frequency f_1 by the signaling currents. This function may be performed by filter TF_1 and the filter TF_1' used merely to selectively combine the outputs from circuits TL_1 and TL_2.

The amplifier TA_1, which is included in the channel TL_1 between the two filters, may be of any well-known type. It is, however, preferably a vacuum tube amplifier of the well-known push and pull type, since this type of amplifier tends to distort high frequencies to a lesser extent than the ordinary vacuum tube amplifier.

The receiving channel RL_1 includes a band filter RF_1, a demodulator or detector D_1, an amplifier RA_1 and a band filter RF_1'. The band filter RF_1 is of the general type disclosed in the patents to Campbell, above referred to, and is so designed as to transmit a band of frequencies in the neighborhood of the basic frequency assigned to this receiving channel. Where transmission and reception take place at the same frequency, the filter RF_1 may therefore be identical in construction with the filter TF_1'. In radio systems, however, it is desirable that reception take place at a different frequency from transmission, in order to suppress the transmitted energy absorbed by the receiving circuit, due to unbalance. If therefore the basic carrier frequency assigned to the channel RL_1 be f_1', the filter RF_1 should pass a band of frequencies in the neighborhood of the frequency f_1', sufficiently wide to accommodate the frequency variation due to modulation.

The detector D_1 may be any well-known type of detector, but is preferably a duplex vacuum tube detector of the type illustrated in the U. S. application of John R. Carson, Serial No. 157,414, filed March 26, 1917. This type of detector operates upon the so-called homodyne principle of reception and is therefore supplied with oscillations of carrier frequency f_1', which react with the received modulated carrier frequency to produce in the output of the detector the low frequency currents in accordance with which the carrier frequency was modulated at the distant transmitting station.

The amplifier RA_1 may be of any desired type, but is preferably an ordinary vacuum tube amplifier adapted to amplify low frequency currents. The filter RF_1' is arranged in the output circuit of the amplifier and is so designed as to suppress high frequency components while freely transmitting the detected low frequency currents.

The transmitting channel TL_2 associated with the line L_2 includes a modulator M_2, filter TF_2, amplifier TA_2 and filter TF_2', all of these pieces of apparatus being in general similar to those described in connection with the line TL_1. The modulator M_2 is supplied with a carrier frequency f_2, however, instead of f_1, in order that the proper frequency separation between the channels be maintained. The filter TF_2' will therefore be accordingly designed to transmit a band of frequencies of substantially the same width as that transmitted by the filter TF_1', but said band in this instance will lie in the neighborhood of the frequency f_2, instead of the frequency f_1.

The receiving channel RL_2 likewise includes a filter RF_2, a detector D^2, an amplifier RA_2 and a filter RF_2'. The detector D_2 is supplied with homodyne currents having a frequency f_2', corresponding to the carrier frequency assigned to the channel. The filter RF_2 is accordingly designed to transmit a band of frequencies in the neighborhood of the frequency f_2'. The several pieces of apparatus are otherwise similar to those described in connection with the channel RL_1.

The operation is as follows: Low frequency signals incoming from lines L_1 and L_2 are impressed upon the modulators M_1 and M_2 to modulate the carrier frequencies f_1 and f_2, in a well-known manner. The modulated currents are then passed through the filters TF_1 and TF_2, amplified by the amplifiers TA_1 and TA_2 and then passed through the filter TF_1' and TF_2' to the common transmitting circuit TL. The several modulated carrier frequencies are now impressed upon the midpoint of the antenna winding of the transformer 3, so that part of the energy passes through the balancing network AN to ground and part of the energy is transmitted to the network comprising the antenna A, for radiation to a distant receiving station. Owing to the broad band characteristic of the antenna structure A, the several modulated carrier frequencies will be radiated with substantially the same amplitude, the terminal network X and its electrical equivalent, the condenser 2′ and the transformer 3 functioning to prevent reflection effects which might otherwise disturb the filtering action of the antenna structure.

Since the energy transmitted from the circuit TL flows in opposite directions through the two halves of the primary winding of the transformer 3, only a small amount of energy due to unbalance will be impressed upon the circuit RL and this energy will be suppressed by the filters RF_1 and RF_2, since the frequencies of the transmitted energy are different from the frequencies used in reception.

A plurality of modulated radio frequencies received from a distant sending station are absorbed by the antenna A and due to its broad band characteristics, these frequencies are impressed through the transformer 3 upon the common receiving circuit RL, with substantially equal amplitude. The several frequencies are now selected into the proper receiving channels RL_1 and RL_2, by means of the filters RF_1 and RF_2 and the low frequency currents in accordance with which the radio frequencies were modulated at the distant station are detected by means of the detectors D_1 and D_2. The low frequency currents are then amplified by the amplifiers RA_1 and RA_2 and passed through the filters RF_1' and RF_2' to the lines L_1 and L_2.

It will be understood that while but two low frequency lines L_1 and L_2 are illustrated, additional lines may be connected for signaling over the antenna structure A, by connecting them through suitable transmitting and receiving channels to the common circuits TL and RL.

It will also 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. An antenna structure for multiplex transmission comprising a plurality of sections, each section including a series impedance element and a shunt impedance element connected to ground, and a terminating impedance associated with the end section of the series, the impedance elements of each section being so proportioned and related to each other that the combination will freely transmit with substantially equal attenuation a broad band of frequencies, while substantially suppressing frequencies lying outside the band, and said terminating impedance being so proportioned as to substantially prevent reflection losses due to the fact that the number of sections is not infinite.

2. An antenna arrangement for multiplex radio transmission, comprising a plurality of sections, each section including an inductance and capacity in series and a shunt inductance connected to ground, and a terminal impedance element associated with the end section of the series, the elements of each section being so proportioned and related to each other than the combination will freely transmit with uniform attenuation a band of frequencies, while substantially extinguishing frequencies lying without said band and said terminal impedance being so proportioned as to substantially prevent reflection losses due to the fact that the number of sections in the series is not infinite.

3. An antenna structure for a multiplex radio system, comprising a plurality of sections, each section including an inductance and capacity in series and a shunt inductance connected to ground and comprising with the normal capacity to ground of the section, a parallel combination of inductance and capacity, and a terminal impedance element associated with the last section of the series, the inductance and capacity elements of each section being so proportioned and related to each other and to the normal capacity to ground of the section that the combination of sections will

freely transmit with uniform attenuation a band of frequencies while substantially suppressing frequencies lying without the band, and said terminal impedance element being so proportioned as to substantially prevent reflection effects due to the fact that the number of sections is less than infinite.

4. An antenna structure for radio transmission comprising a plurality of sections, each section including a series impedance element, the impedance elements of each section being so proportioned and related to each other and to the antenna capacity of each section that the combination will freely transmit with substantially equal attenuation a broad band of frequencies, while substantially suppressing frequencies lying outside the band.

In testimony whereof I have signed my name to this specification this 25th day of September, 1919.

LLOYD ESPENSCHIED.