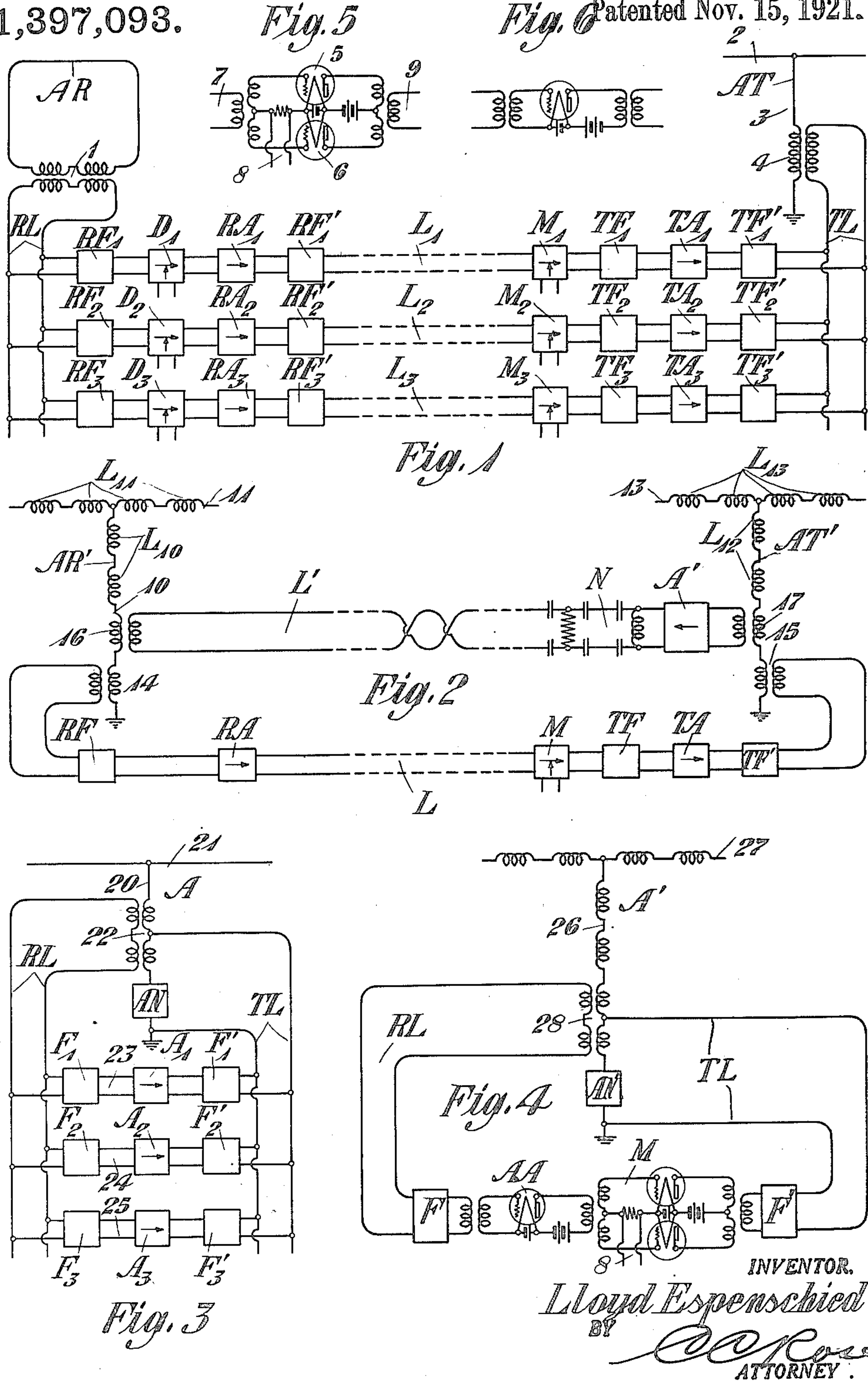


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RADIOREPEATING SYSTEM.
APPLICATION FILED SEPT. 27, 1919.

1,397,093.

Patented Nov. 15, 1921.



INVENTOR.
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BY *[Signature]*
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UNITED STATES PATENT OFFICE.

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RADIOREPEATING SYSTEM.

1,397,093.

Specification of Letters Patent.

Patented Nov. 15, 1921.

Application filed September 27, 1919. Serial No. 326,736.

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 Radiorepeating Systems, of which the following is a specification.

This invention relates to radio signaling, and more particularly to repeating stations for amplifying at intermediate points the signals transmitted between two radio terminal stations.

One of the features of the invention resides in the provision of apparatus for amplifying a plurality of radio signals, said apparatus being related to an antenna arrangement of such character that the reaction of the amplified radio signals upon the input side of the amplifying arrangement will be reduced to a minimum.

Another feature of the invention relates to a repeater apparatus for a radio system so arranged as to not only amplify received radio signals, but to translate the received signals into a different frequency range for further transmission, the resultant difference in frequency being utilized to prevent reaction of the outgoing energy upon the input side of the amplifying arrangement.

Another feature of the invention relates to the use of a loaded antenna arrangement, the loading being so distributed and related to the distributed capacity of the antenna as to impart to it a broad transmission characteristic, so that the antenna may be more efficiently used for multiplex radio transmission.

The means whereby the above features, as well as the other features more fully herein-after appearing are realized, may be understood from the following detailed description of the invention, when read in connection with the accompanying drawing, Figures 1, 2, 3 and 4 of which constitute simplified circuit diagrams of a number of embodiments of the invention, while Figs. 5 and 6 constitute diagrams of details of the apparatus involved.

Referring to Fig. 1, AR designates a receiving antenna, which is here illustrated as comprising a closed loop having no ground connection, the loop being inductively associated with the common receiving circuit RL through a transformer 1, said transformer being balanced with respect to the two halves

of the loop lying on either side of a vertical line drawn through its center. The transmitting antenna of the repeater system is indicated at AT and comprises an aerial member 2 and a vertical member 3, the latter being coupled through a transformer 4 with a common transmitting circuit TL. In order to reduce the reaction of the transmitted energy from the antenna AT upon the receiving antenna AR, the loop constituting the receiving antenna should be preferably arranged in a plane at right angles to a line drawn between the transmitting and receiving antennæ and the two antennæ should also be located some distance apart. Waves radiated from the antenna AT will consequently produce equal effects upon the two halves of the loop, so that substantially equal and opposite potentials will be applied to the two halves of the primary winding of the transformer 1. Consequently a relatively small amount of energy radiated from the antennæ AT will be impressed upon the receiving circuit RL.

The repeating apparatus interconnecting the receiving antenna AR and the transmitting antenna AT includes a plurality of lines L_1 , L_2 and L_3 for transmitting the several signals which may be simultaneously received by the receiving antenna. In order to separate into their proper channels the several frequencies received by the receiving antenna and impressed upon the common receiving circuit RL, filters RF_1 , RF_2 and RF_3 are provided in the lines L_1 , L_2 and L_3 . These filters may be tuned circuits, or they may be broad band filters of the general type disclosed in the United States patents of George A. Campbell, Nos. 1,227,113 and 1,227,114, dated May 22, 1917. Where it is desired to amplify the received signals at low frequency before transmitting them over the lines L_1 , L_2 and L_3 to the transmitting antenna, detectors or demodulators D_1 , D_2 and D_3 will be provided. These detectors may be of any well known type, but are preferably duplex vacuum tube detectors or demodulators of the general type illustrated in the United States patent of John R. Carson, No. 1,343,308, dated June 15, 1920. The circuit details of a detector of this type are indicated in Fig. 5, in which the vacuum tubes are designated as 5 and 6 respectively, while 7 indicates the circuit through which the modulated high frequency oscillations to be

detected are applied to the detector circuit. Since a detector of this character preferably operates upon the so-called homodyne principle, oscillations of the basic carrier frequencies are supplied to the detector over a circuit 8, the low frequency detected currents being impressed upon an outgoing circuit 9.

In order to amplify the currents appearing in the outgoing circuits of the several detectors, amplifiers RA_1 , RA_2 and RA_3 are provided. These amplifiers may be of any well-known type, but are preferably vacuum tube amplifiers such as illustrated in Fig. 6.

In order to suppress the higher frequency components and transmit only the detected low frequency signaling currents, filters RF_1' , RF_2' and RF_3' are included in the outgoing circuits of the amplifiers. These filters may be resonant circuits, tuned to the frequency of the low frequency signaling currents, or they may be suitably constructed band filters of the general type disclosed in the patents to Campbell above referred to. Where it is desired to amplify and transmit the several multiplex signals to the transmitting antenna AT in their high frequency state, the detectors D_1 , D_2 and D_3 , and the low frequency filters RF_1' , RF_2' and RF_3' , may be omitted, and the amplifiers RA_1 , RA_2 and RA_3 will then function as high frequency amplifiers.

Whether the multiplex signals be detected before amplification, or whether they be amplified in their high frequency state, it is desirable that a translation in frequency occur before impressing the signals upon the transmitting antenna in order to reduce the reaction of the radiated energy upon the receiving antenna, which would otherwise tend to set up singing in the repeater circuit. For this purpose, modulators M_1 , M_2 and M_3 are provided. These modulators may be of any well-known type, but are preferably duplex vacuum tube modulators of the type illustrated and described in the United States patent of John R. Carson, No. 1,343,307, dated June 15, 1920. The duplex modulator of said Carson application is identical in construction with the demodulator already referred to, and hence the embodiment illustrated in Fig. 5 applies equally well to the modulator. The carrier frequency is applied to the modulator over the circuit 8, while the modulating frequency, whether it be the detected low frequency signals, or the received signal in its high frequency state, is applied to the incoming circuit 7. In either case, two frequencies will appear in the circuit 9, a frequency equal to the sum of the frequencies applied to circuits 7 and 8 and a frequency equal to the difference of the frequencies applied to circuits 7 and 8. One or the other of these frequencies may be suppressed by means of

a filter, as hereinafter described, so that the signaling frequency applied to the modulator over the circuit 7 may be translated either up or down in frequency by an amount equal to the frequency applied over the circuit 8.

Filters TF_1 , TF_2 and TF_3 are provided in the output circuits of the modulators. These filters may be either tuned circuits or band filters such as described in the Campbell patents above referred to, and should be so designed as to suppress all undesired frequency components, such as the frequencies applied to the circuit 7, while freely transmitting the desired translated frequencies. Amplifiers TA_1 , TA_2 and TA_3 are provided for the purpose of amplifying the translated frequencies. These amplifiers may be of any type, but are preferably vacuum tube amplifiers of the general character illustrated in Fig. 6, and of relatively large power capacity.

Filters TF_1' , TF_2' and TF_3' are provided in the outgoing circuits of the amplifiers. These filters may also be either tuned circuits or band filters of the Campbell type, and are preferably so designed as to suppress one or the other of the side bands resulting from the modulating action of the modulators M_1 , M_2 and M_3 . These filters also function to preserve the frequency separation between the frequencies corresponding to the several multiplex signals applied to the transmitting circuit TL.

The operation is as follows: Multiplex radio signals received from a distant transmitting station are impressed upon the receiving antenna AR which is preferably arranged in a plane passing through the distant signaling station. Consequently the oscillations absorbed by the antenna AR are not balanced out with respect to the transformer 1, but are impressed upon the receiving circuit RL, and the frequencies corresponding to the several signals are selected out by means of the filters RF_1 , RF_2 and RF_3 , and impressed upon the detectors D_1 , D_2 , D_3 . The detectors operate to detect from the radio frequencies the low frequency signals in accordance with which the radio frequencies were modulated, and these low frequencies are amplified by the amplifiers RA_1 , RA_2 and RA_3 . The low frequency filters RF_1' , RF_2' and RF_3' function to suppress the higher frequency components so that the low frequency signaling currents are now transmitted over the lines L_1 , L_2 and L_3 to the modulators M_1 , M_2 and M_3 . The carrier frequencies assigned to these modulators should be different from the received radio frequencies corresponding to the filters RF_1 , RF_2 and RF_3 , and should preferably lie in a group of frequencies outside of the received group. The frequencies assigned to the modulators M_1 , M_2 and M_3 are modu-

lated by the low frequency signaling currents transmitted over the lines L_1 , L_2 and L_3 , and the modulated carrier currents after passing through the filters TF_1 , TF_2 and TF_3 are amplified by the amplifiers TA_1 , TA_2 and TA_3 . The amplified carrier frequencies are now passed through the filters TF_1' , TF_2' and TF_3' and impressed upon the common circuit TL, from which they are transmitted through the transformer 4 to the transmitting antenna AT for radiation to a distant receiving station.

The energy radiated by the antenna AT is also radiated in the direction of the receiving antenna AR as well as in the direction of the distant receiving station, but owing to the balanced relation already described of the antenna AR with respect to the transmitting antenna, the energy absorbed by the antenna AR from the antenna AT is very largely balanced out. Furthermore, since the multiplex signals are being radiated from the antenna AT at frequencies different from those at which they were received by the antenna AR, such energy as is impressed from the receiving antenna AR upon the circuit RL will not be reamplified, since it will be suppressed by the filters RF_1 , RF_2 and RF_3 .

If the feature of translating the radio frequencies to low frequency signaling currents before transmission over the lines L_1 , L_2 and L_3 is eliminated by omitting the detectors D_1 , D_2 and D_3 , and the filters RF_1' , RF_2' and RF_3' , the operation will be as follows: The received radio frequencies after passing through the filters RF_1 , RF_2 and RF_3 will be amplified by the amplifiers RA_1 , RA_2 and RA_3 and transmitted over the lines L_1 , L_2 and L_3 . The action of the modulators M_1 , M_2 and M_3 will now merely be to step up or down each of the radio frequencies by some definite amount in order to prevent the reaction of the outgoing energy upon the input sides of the amplifiers. Either the same frequency or different frequencies may be supplied to the circuit 8 of each of the modulators M_1 , M_2 and M_3 , so that the several radio frequencies will be stepped up or down by frequency intervals which may be or may not be the same for all of the channels. The resultant frequencies then pass through the filters TF_1 , TF_2 and TF_3 and are amplified by the amplifiers TA_1 , TA_2 and TA_3 . The filters TF_1' , TF_2' and TF_3' will now determine whether the final frequencies impressed upon the transmitting antenna AT will be stepped up or stepped down in frequency. If it is desired to step the radio frequencies up, these filters will be so designed as to suppress the difference frequency of modulation while if it is desired to step the frequency down, the filters will be designed to suppress the sum frequency.

In either case, the several frequencies passed by the filters will be impressed upon the common circuit TL and transmitted to the antenna AT for radiation to a distant station. One of the two sets of filters, TF_1 , etc., and TF_1' , etc., may be omitted by suitably designing the remaining set to assume the frequency discriminating functions of the others.

Where the radio frequencies are not translated into low frequency signaling currents before transmission over the repeater lines, a single line will ordinarily be sufficient for the transmission of all of the frequencies, and the frequencies may also be amplified by a common amplifier. An arrangement of this character is illustrated in Fig. 2. In this figure, AR' designates a receiving antenna, and AT' a transmitting antenna of a repeater station. The antenna AR' includes a vertical member 10 and an aerial member 11. Inductances L_{10} and L_{11} may be included in the vertical aerial member at intervals as indicated, these inductances being so related to the distributed capacity between the antenna and ground as to constitute a broad band filter similar in principle to the filters described in the Campbell patents above referred to. Each inductance element constitutes a series inductance of a filter section, the shunt capacity of which is the distributed capacity between that section and the ground. An antenna thus constructed is capable of receiving a wide range of radio frequencies without undue attenuation.

The transmitting antenna AT' may be constructed in a similar manner, its vertical member 12 including distributed inductances L_{12} and its aerial member 13 including distributed inductances L_{13} , these inductances being proportioned with respect to the distributed capacity in the manner described in connection with the receiving antenna AR'. The repeater line L is associated with the receiving antenna through a transformer 14, and with the transmitting antenna through a transformer 15; said receiving line includes a band filter RF of the general type disclosed in the patents to Campbell above mentioned, said filter being designed to transmit a band of frequencies covering the range of radio frequencies to be received in multiplex signaling. An amplifier RA is provided, said amplifier being preferably of the vacuum tube type illustrated in Fig. 6, and being designed to amplify the several radio frequencies received. In order to step up or step down the received frequencies to reduce the reaction of the output energy upon the input side of the amplifier, the modulator M is provided, which may be of the type illustrated in Fig. 5. This modulator will be supplied over its circuit 8 with a

frequency corresponding to the amount by which the received radio frequencies are to be stepped up or down. A filter TF may be provided for the purpose of eliminating all components appearing in the output circuit of the modulator which are not to be transmitted, such as the frequency applied over the circuit 8 and frequencies passed by filter RF. This filter is adapted to freely transmit a range of frequencies corresponding to one side band of the multiplex frequencies after being stepped up or down, as the case may be and preferably to suppress the opposite side band. An additional amplifier TA, similar to the amplifier RA except for its being a power amplifier may also be provided for further amplification of the several multiplex frequencies after translation.

In order to balance out the component of the energy radiated by the antenna AT' and absorbed by the receiving antenna AR', these two antennae may be connected by a balancing line L'. The line L' includes a network N for adjusting the transmission efficiency of the circuit and for determining the phase relation between the currents transmitted over line L' and the oscillations radiated from the antenna AT' to the antenna AR'. The line L' also includes an amplifier A' for adjusting the transmission efficiency of the circuit, said amplifier being of any well-known type, but preferably of the character illustrated in Fig. 6. The circuit L' is associated with the antennae AR' and AT' through transformers 16 and 17 respectively.

The operation is as follows: A plurality of radio frequencies radiated from a distant sending station and absorbed by the antenna AR' are transmitted through the transformer 14 to the line L through the filter RF, and after amplification by the amplifier RA are transmitted over the line L to the modulator M. The modulator M is supplied with a carrier frequency over its circuit 8, and upon impressing the several radio frequencies upon said modulator, frequencies appear in the outgoing circuit corresponding to the radio frequencies plus the carrier frequencies applied to the modulator M, and the radio frequencies minus the carrier frequency applied to the modulator M. Both or either of the resultant frequency bands may be passed through the filter TF and amplified by the amplifier TA. If it is desired that radio frequencies are to be stepped up before radiation, the filter TF will be so designed as to transmit a band of frequencies corresponding to the modulated components corresponding to the received radio frequencies plus the carrier frequencies of the modulator M, and these frequencies will be transmitted through the transformer 15 and radiated by the antenna AT'. If, however, the

received radio frequencies are to be stepped down the filter TF will be designed to transmit only the modulated components corresponding to the received radio frequencies minus the carrier frequency of the modulator M.

A certain proportion of the energy radiated by the antenna AT' will be absorbed by the antenna AR', but this energy may be balanced with respect to the line L by transmitting an equal amount of energy over the line L' to the antenna AR'. For this purpose the amplifier A' and the phase adjustment elements N should be so set that the energy transmitted over the line L' will be impressed upon the antenna AR' equal in value and opposite in phase to that radiated from the antenna AT'. By this means a relatively small portion of the received energy will actually be transmitted to the line L due to the unbalance of the antenna structure. Even this energy, however, will be largely eliminated due to the suppressing action of the filter RF to the translated frequencies at which the received radio currents were transmitted by the antenna AT'.

Fig. 3 discloses an arrangement in which a common antenna is used both for sending and receiving. In this figure A designates an antenna structure comprising a vertical member 20 and an aerial member 21. The common receiving circuit RL is associated with the antenna A through a balanced transformer arrangement 22, said transformer arrangement having one winding divided so that one-half of said winding is included in the vertical member 20 of the antenna and the other half is included in circuit with an antenna balancing network AN. The common transmitting circuit TL has one conductor thereof connected to ground and the other conductor connected to the midpoint of the split winding of the transformer 22. A plurality of bridge connections 23, 24 and 25 are provided, serving to interconnect the receiving circuit RL and the transmitting circuit TL, these bridge connections including amplifiers A₁, A₂ and A₃. These amplifiers may be of any well-known type, but are preferably vacuum tube amplifiers of the general character illustrated in Fig. 6 and adapted to amplify radio frequencies. In order to provide for frequency selection between the bridge circuits, filters F₁, F₂ and F₃ are inserted in the bridges on one side of the amplifiers and filters F₁', F₂' and F₃' are inserted in the bridges on the opposite sides of the amplifier. These filters may be either tuned circuits or band filters of the type disclosed in the patents to Campbell hereinbefore mentioned.

The operation is as follows: A plurality of radio frequencies transmitted from a distant station are absorbed by the antenna ar-

rangement A and are impressed through the
 transformer 22 upon the receiving circuit
 RL. The several radio frequencies are
 selected into the circuits 23, 24 and 25 re-
 spectively, by means of the filters F_1 , F_2 and
 F_3 . The radio frequencies are then ampli-
 fied by the amplifiers A_1 , A_2 and A_3 and are
 then passed through the filters F_1' , F_2' and
 F_3' to the common transmission circuit TL.
 The energy from this circuit is impressed
 upon midpoint of the transformer 22, so that
 one-half of the energy is radiated by means
 of the antenna A and the other half is trans-
 mitted through the balancing network AN,
 to ground. If the balance between the cir-
 cuits TL and RL is sufficiently good, sub-
 stantially no energy will react upon the re-
 ceiving circuit RL to cause singing of the
 amplifiers. It will be understood, of course,
 that where the degree of balance obtainable
 is insufficient to prevent singing that reac-
 tion between the transmitting and receiving
 circuit may be further reduced by stepping
 the radio frequencies up or down, in the
 manner described in connection with Figs. 1
 and 2, so that the energy due to unbalance
 may be suppressed by means of filters.

Instead of using separate repeaters for
 each radio frequency, as shown in Fig. 3,
 a common amplifier may be used, as illus-
 trated in Fig. 4. In this figure A' designates
 an antenna arrangement comprising a ver-
 tical member 26 and an aerial 27, the antenna
 being associated with the common receiving
 circuit RL through a transformer 28. The
 antenna is balanced by means of a network
 AN'. The common transmitting circuit TL
 is so arranged that one conductor is con-
 nected to ground and the other conductor
 is connected to the midpoint of the split
 winding of the transformer 28. A common
 amplifier AA is provided for amplifying
 the several radio frequencies. This amplifier
 may be of any well-known type, but is pref-
 erably a vacuum tube amplifier as indicated.
 A band filter F of the Campbell type is in-
 cluded in the circuit RL, this filter being
 designed to transmit a range of frequencies
 sufficiently extensive to accommodate the
 several received radio frequencies.

The relation between the circuits TL and
 RL is such that a minimum degree of un-
 balance exists between these circuits and con-
 sequently the transmitted energy absorbed
 by the receiving circuit RL is comparatively
 small. As even this small amount of energy
 may be large as compared with the greatly
 attenuated waves received from a distant
 transmitting station, it is desirable to
 further suppress the transmitted energy ap-
 pearing in the circuit RL, due to unbalance.
 This may be done by stepping the frequency
 up or down, by means of the modulator M.
 This modulator may be of any well-known
 type, but as illustrated is a duplex vacuum

tube modulator of the general type illus-
 trated in the application of John R. Carson,
 above identified. Oscillations whose fre-
 quency is equal to the amount by which the
 several radio frequencies are to be stepped
 up or down, are supplied to the modulator M
 over the circuit 8. A band filter F' is in-
 cluded in the transmitting circuit TL, this
 filter being of the general type illustrated
 and described in the patents to Campbell,
 already referred to, and being designed to
 transmit a range of frequencies equal either
 to the received radio frequencies plus the
 carrier frequency supplied to the circuit 8,
 or the received radio frequencies minus the
 frequency supplied to the circuit 8, depend-
 ing on whether it is desired to step the re-
 ceived frequencies up or down. The an-
 tenna A' may be loaded in the manner de-
 scribed in connection with Fig. 2, in order
 to give to the antenna a transmission char-
 acteristic somewhat similar to a band filter.

The operation is as follows: A plurality
 of radio frequencies transmitted from a dis-
 tant station, upon being absorbed by the
 antenna A' are impressed through a trans-
 former 28 upon the circuit RL and after
 passing through the filter F are amplified
 by the amplifier AA. The several radio
 frequencies are now impressed upon the
 modulator M, in which they react with the
 frequency supplied to the circuit 8 to pro-
 duce in the output circuit of the modulator
 M frequencies equal to the initial radio fre-
 quencies, plus the frequency supplied to the
 circuit 8, or frequencies equal to the initial
 radio frequencies minus the frequency sup-
 plied to the circuit 8. The band filter F'
 transmits one of these sets of frequencies
 and suppresses the other, depending upon
 whether it is designed for a step up or step
 down transformation in frequency. The
 changed frequencies are now impressed upon
 the midpoint of the windings of the trans-
 former 28 and part of the energy is radiated
 by the antenna to a distant receiving station
 and part of the energy flows through the
 balancing network AN' to ground. The
 small amount of energy absorbed by the re-
 ceiving circuit RL, due to unbalance, is
 substantially prevented from reacting upon
 the amplifier AA by the filter F, which is
 designed to suppress the translated fre-
 quencies.

In arrangements hereinbefore described it
 will be understood, of course, that any de-
 sired number of repeating channels may be
 provided in order to accommodate as many
 multiplex radio frequencies as are to be em-
 ployed. Furthermore it will be understood
 that the antenna arrangement may be either
 loaded in the manner illustrated in Figs. 2
 and 4, or non-loaded, as desired.

In general while the invention has been
 illustrated as being embodied in certain cir-

cuit arrangements, it will be obvious that the 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. A multiplex radio repeating station comprising a receiving antenna for absorbing energy transmitted at a plurality of frequencies from a plurality of signaling channels, a transmitting antenna for radiating amplified received energy to a distance, and a circuit arrangement interconnecting said receiving and transmitting antenna, comprising means for amplifying a plurality of radio frequencies corresponding to different channels.

2. A multiplex radio repeating station comprising a receiving antenna for absorbing energy transmitted at a plurality of frequencies from a plurality of signaling channels, a transmitting antenna for radiating amplified received energy to a distance, and a circuit arrangement interconnecting said receiving and transmitting antenna, comprising means for amplifying a plurality of radio frequencies, corresponding to different signaling channels, said receiving and transmitting antenna being so arranged that energy radiated by the transmitting antenna will produce a negligible effect upon the receiving antenna.

3. A multiplex radio repeating station comprising an antenna arrangement, an amplifying means for amplifying a plurality of radio frequencies corresponding to different signaling channels, means to associate the input side of said amplifying means with said antenna arrangement, means to associate the output side of said amplifying means with said antenna arrangement, and connections whereby amplified energy impressed by said amplifying means upon said antenna arrangement will not react through the antenna arrangement upon the input side of said amplifying means.

4. A multiplex radio repeating station comprising an antenna arrangement, a repeating circuit associated therewith, means in said repeating circuit for absorbing from said antenna arrangement energy of a plurality of frequencies corresponding to different signaling channels and for translating said received high frequency energy into amplified high frequency energy of frequencies different from those at which it was received, means to impress said translated and amplified high frequency energy upon said antenna arrangement, and means to prevent the amplified and translated energy from being impressed through said antenna arrangement upon said repeating circuit.

5. A multiplex radio repeating station

comprising an antenna arrangement, a plurality of repeating circuits associated therewith, each repeating circuit including means for amplifying energy of a different frequency absorbed from said antenna arrangement, and selective means to separate the different frequencies into the proper repeating circuits, means to simultaneously impress the several amplified frequencies upon said antenna arrangement, and means to prevent the reaction of the amplified frequencies through said antenna arrangement upon said repeating circuits.

6. A multiplex radio repeating station, comprising an antenna arrangement including a plurality of sections, each section having series inductances therein, said inductance being so proportioned with respect to the shunt capacity to ground of the section that the antenna arrangement as a whole freely transmits a band of frequencies of sufficient width to include the frequencies of a plurality of signaling channels, while substantially suppressing frequencies lying without said range; an amplifying means for amplifying a plurality of radio frequencies corresponding to different signaling channels; means to associate the input side of said amplifying means with said antenna arrangement, and means to associate the output side of said amplifying means with said antenna arrangement.

7. A multiplex radio repeating station, comprising a receiving antenna for absorbing energy transmitted at a plurality of frequencies from a plurality of signaling channels; a transmitting antenna for radiating amplified received energy to a distance; each of said antennae including a plurality of sections, each section having series inductance therein, said series inductance being so proportioned with respect to the shunt capacity to ground of the section that the network comprising the sections of the receiving antenna functions to transmit a band of frequencies of sufficient width to include the several frequencies received from different signaling channels while substantially suppressing frequencies lying without the range, and the network comprising all of the sections of the transmitting antenna will transmit a band of frequencies of sufficient width to include the frequencies of a number of channels equal to those associated with the receiving antenna, while substantially suppressing frequencies lying without said range, and a circuit arrangement interconnecting said receiving and transmitting antenna, comprising means for amplifying a plurality of radio frequencies corresponding to different channels.

8. A multiplex radio repeating station comprising a receiving antenna for absorbing energy transmitted at a plurality of frequencies from a plurality of signaling chan-

nels, a transmitting antenna for radiating amplified received energy to a distance, and a circuit arrangement interconnecting said receiving and transmitting antennæ, said circuit comprising means to modulate the locally supplied carrier in accordance with said received frequencies, thereby producing a carrier frequency, and two side bands each including translated frequencies corresponding to the received frequencies, said circuit arrangement including also means for suppressing said carrier component to prevent its transmission by said transmitting antenna.

9. A multiplex radio repeating station comprising a receiving antenna for absorbing energy transmitted at a plurality of frequencies from a plurality of signaling channels, a transmitting antenna for radiating amplified received energy to a distance, and a circuit arrangement interconnecting said receiving and transmitting antennæ, said circuit comprising means to modulate the locally supplied carrier in accordance with said received frequencies, thereby producing a carrier frequency and two side bands each including translated frequencies corresponding to the received frequencies, said circuit arrangement also including means for suppressing one of said side bands to prevent its transmission by said transmitting antenna.

10. A multiplex radio repeating station comprising a receiving antenna for absorbing energy transmitted at a plurality of frequencies from a plurality of signaling channels, a transmitting antenna for radiating amplified received energy to a distance, a

circuit arrangement interconnecting said receiving and transmitting antennæ, said circuit arrangement comprising means for absorbing from said receiving antenna energy of a plurality of frequencies corresponding to different signaling channels and for translating said received high frequency energy into amplified high frequency energy of frequencies different from those at which it was received, and means to impress said translated and amplified high frequency energy upon said transmitting antenna.

11. A multiplex radio repeating station comprising a receiving antenna for absorbing energy transmitted at a plurality of frequencies from a plurality of signaling channels, a transmitting antenna for radiating amplified received energy to a distance, a circuit arrangement interconnecting said receiving and transmitting antennæ, said circuit arrangement comprising means for absorbing from said receiving antenna energy of a plurality of frequencies corresponding to different signaling channels and for translating said received high frequency energy into amplified high frequency energy of frequencies different from those at which it was received, means to impress said translated and amplified high frequency energy upon said transmitting antenna, and means to prevent the amplified and translated energy from being impressed through said antenna arrangement upon said repeating circuit.

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

LLOYD ESPENSCHIED.