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orig 4430m 12V. 175,838 exp 180
Fig 2 is Fig 7 of French 549,901

J. R. CARSON.

FREQUENCY CONTROL SYSTEM.

APPLICATION FILED SEPT. 30, 1919. RENEWED APR. 19, 1920.

1,403,841.

Patented Jan. 17, 1922.

2 SHEETS—SHEET 1.

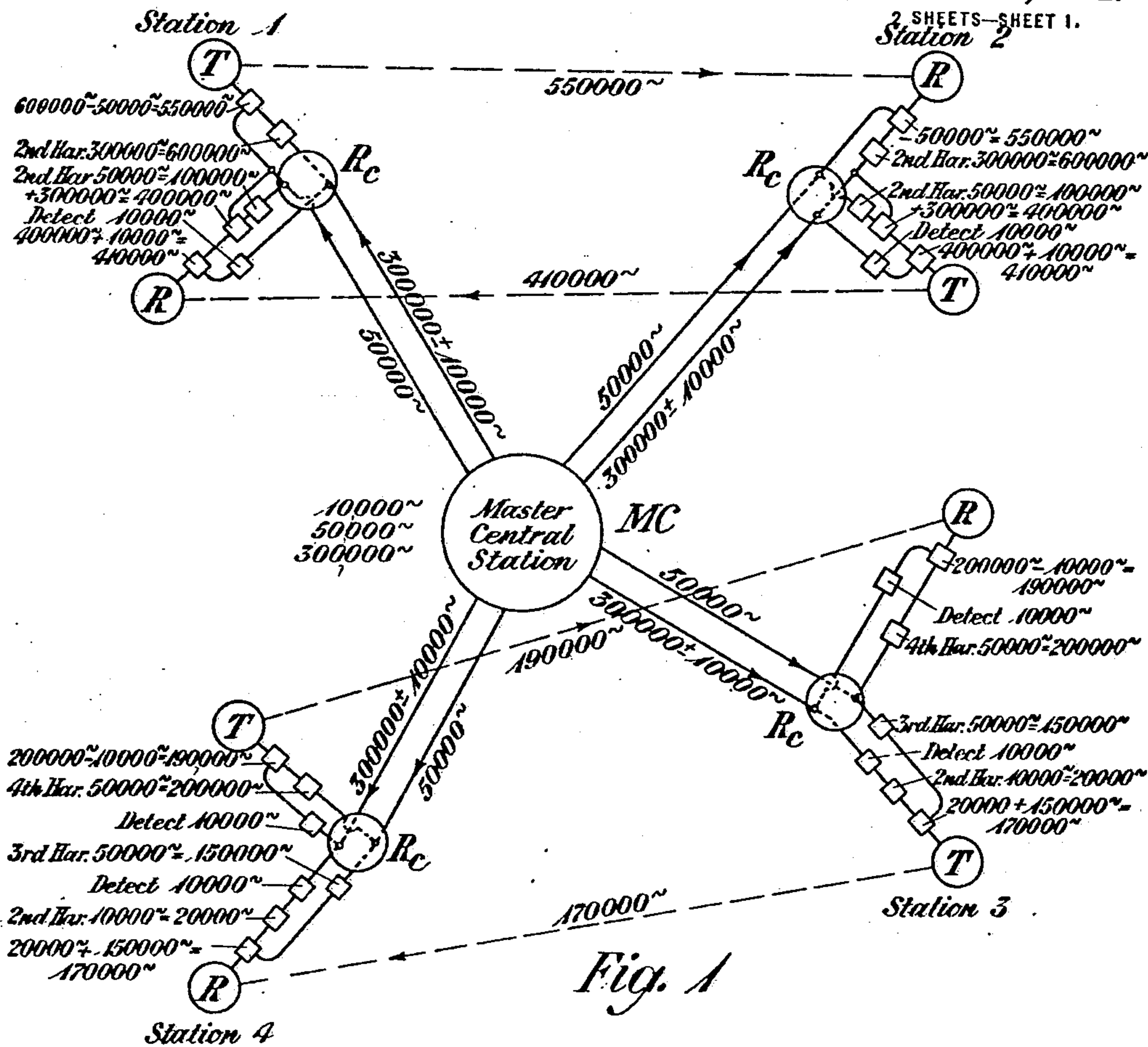


Fig. 1

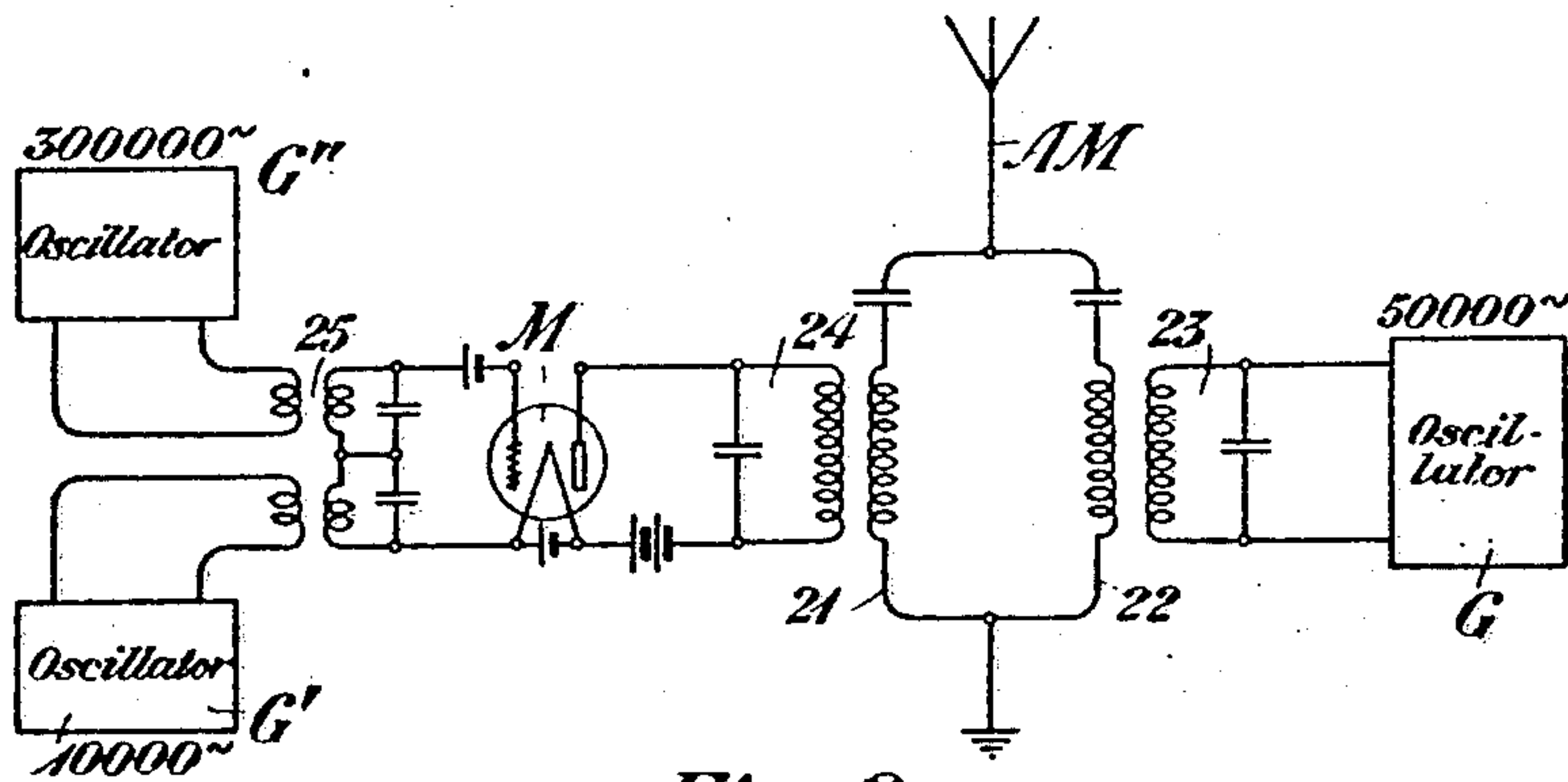


Fig. 2

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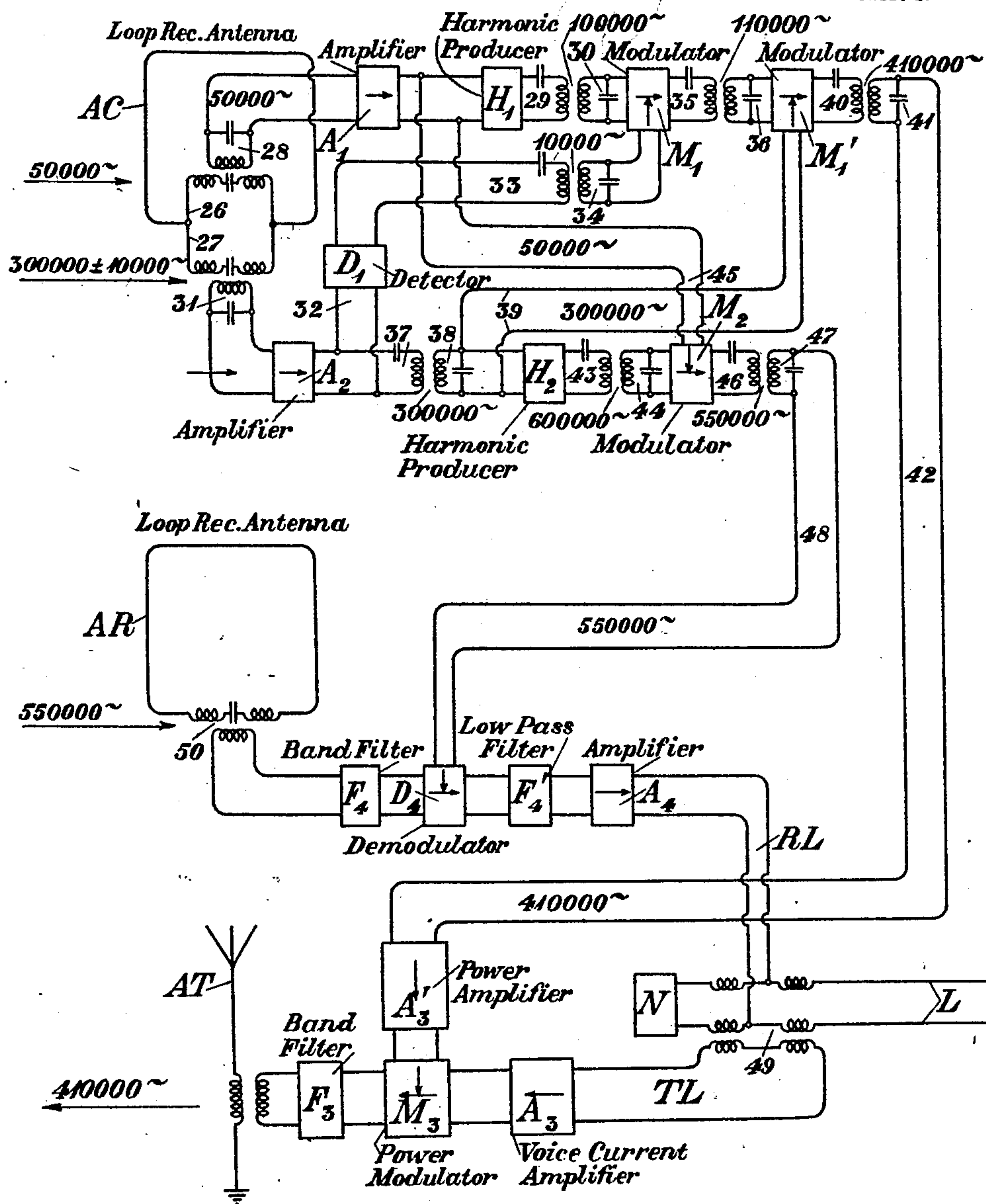


Fig. 3

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UNITED STATES PATENT OFFICE.

JOHN R. CARSON, OF MONTCLAIR, NEW JERSEY, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

FREQUENCY-CONTROL SYSTEM.

1,403,841.

Specification of Letters Patent. Patented Jan. 17, 1922.

Application filed September 30, 1919, Serial No. 327,554. Renewed April 19, 1920. Serial No. 375,148.

To all whom it may concern:

Be it known that I, JOHN R. CARSON, residing at Montclair, in the county of Essex and State of New Jersey, have invented certain Improvements in Frequency-Control Systems, of which the following is a specification.

This invention relates to radio signaling and more particularly to arrangements for controlling the signaling frequency used by different stations.

In radio signaling where a large number of signaling stations are to signal simultaneously, it is necessary, in order to avoid interference, that each pair of communicating stations signal at one or more radio frequencies differing from the frequencies used by all other pairs of communicating stations. Furthermore, the various signaling stations may be divided up into groups or systems, depending upon the corporation or other interest controlling the system or group. Since but one frequency spectrum is available to all of the parties interested, it is desirable that the spectrum be divided up and certain ranges of frequencies be assigned to each group. The organization operating a given group of stations will then have available for signaling as many channels as can be included within the range assigned and these channels may be individual channels for individual signaling stations or a plurality of channels may be assigned to a station for multiplex signaling.

In order to prevent the stations of one group from overlapping in their operation the range of frequencies assigned to another group, it is desirable that some means or method be provided for definitely relating the frequencies of the various groups with reference to each other, so that a shifting of the band of frequencies utilized by one group will cause a corresponding shifting of the frequencies utilized by other groups.

In accordance with the present invention the above results may be obtained by generating at a master station one or more fundamental radio frequencies which may be radiated to the various signaling stations of the various groups and there translated into carrier frequencies to be used for transmission between the various intercommunicating stations. At the signaling stations the received fundamental frequencies may be

translated into the desired frequencies by combining the fundamental frequencies directly, if more than one fundamental is provided, or by combining harmonics of the fundamental frequencies to produce frequencies corresponding either to the sums or the differences of the combined frequencies, in accordance with the well known principles of modulation. Since the controlling frequencies radiated must be relatively high and since it is desirable to produce at the signaling stations frequencies for other signaling channels which will lie in the frequency spectrum in between the principal carrier frequencies assigned to an intercommunicating group of stations, the invention further contemplates providing a low frequency for the signaling stations, which low frequency, or one of its harmonics, may be combined with the higher radio frequencies to produce other radio frequencies. As this low frequency will be too low to be radiated directly from the master controlling station, the invention contemplates modulating at the master station one or more of the fundamental frequencies radiated by means of this low frequency, thereby producing frequencies corresponding to the unmodulated fundamental and to the sum and difference of the fundamental and the modulating frequency. At the signaling stations the low frequency may be reproduced by the ordinary methods of detection, while the fundamental frequency may be selected by means of a tuned circuit.

The invention may be more fully understood by reference to the following description when read in connection with the accompanying drawing, Figure 1 of which constitutes a schematic diagram illustrating the method of the invention, Figure 2 of which illustrates the apparatus at a master controlling station, and Figure 3 of which illustrates the apparatus at one of the signaling stations.

Referring to Figure 1, MC designates a master controlling station at which frequencies of say 10,000 cycles, 50,000 cycles and 300,000 cycles are produced. By modulating the 300,000 frequency with the lower frequency of 10,000 cycles, frequencies corresponding to 300,000 cycles, 310,000 and 290,000 cycles may be produced and radiated. A frequency of 50,000 cycles may

also be radiated from the master controlling station.

Two intercommunicating stations, 1 and 2, are indicated as comprising controlling receiving apparatus R_c , transmitting apparatus T and receiving apparatus R. If transmission is to take place from station 1 to station 2 at a frequency of 550,000 cycles and from station 2 to station 1 at 410,000 cycles, these carrier frequencies may be produced as follows: At station 2, for example, the frequency of 50,000 cycles will be selected and its second harmonic corresponding to 100,000 cycles will be produced. This frequency will then be combined by modulation with the fundamental frequency of 300,000 cycles, thereby producing a frequency of 400,000 cycles. The low frequency of 10,000 cycles will also be detected and by combining this low frequency with 400,000 cycles, the carrier frequency of 410,000 cycles, to be used for transmission between station 2 and station 1, will be produced. In order to produce the carrier frequency for transmission in the opposite direction, the fundamental frequency of 300,000 cycles may be selected and its second harmonic, corresponding to 600,000 cycles, produced therefrom. By combining 600,000 cycles with the fundamental of 50,000 cycles, a frequency of 550,000 cycles may be produced by selecting the lower side frequency resulting from modulation. The carrier frequencies (410,000 and 550,000 cycles) may be produced at station 1 in the same manner as at station 2, but in this instance the carrier frequencies supplied to the apparatus T and R will be reversed with regard to the frequencies supplied to the corresponding apparatus at station 2.

A pair of intercommunicating stations 3 and 4 are also illustrated, these stations being typical of a larger number of stations comprising a group. If it be assumed that transmission is to take place from station 4 to station 3 at 190,000 cycles and from station 3 to station 4 at 170,000 cycles, these frequencies may be produced as follows: At station 3, for example, the frequency of 190,000 cycles may be produced by selecting the fundamental frequency of 50,000 cycles, producing the fourth harmonic of said frequency, which corresponds to 200,000 cycles, detecting a frequency of 10,000 cycles from the modulated radio frequency and then combining 200,000 cycles and 10,000 cycles, in accordance with the principles of modulation, to produce a lower side frequency of 190,000 cycles, which may be selected to the exclusion of the upper side frequency. This frequency will be supplied to the receiving apparatus R at station 3. In order to provide the carrier frequency of 170,000 cycles, the frequency of 50,000 cycles may be selected and its third harmonic, corresponding to

150,000 cycles, is produced therefrom. The low frequency of 10,000 cycles is detected as before, and the second harmonic of this frequency is produced, so that a frequency of 20,000 cycles is available. By combining this frequency with a frequency of 150,000 cycles and selecting the upper side frequency resulting from modulation, the frequency of 170,000 cycles is secured. The same frequencies may be produced at station 4, in a similar manner, except that in this instance the frequencies supplied to the apparatus T and R will be reversed with regard to that supplied at station 3.

The manner in which the fundamental frequencies may be produced at the master control station MC is illustrated in Figure 2. In this figure AM designates a radiating antenna having two tuned branches 21 and 22. The branch 22 may be tuned to one of the fundamental frequencies, for instance 50,000 cycles, and is coupled to a similarly tuned circuit 23, associated with an apparatus G for generating the desired fundamental frequency, which is illustrated as being 50,000 cycles. The generator G may be of any well known type, such as an alternator, Poulsen arc, or vacuum tube oscillator.

The circuit 21 may be tuned to another fundamental frequency, for instance 300,000 cycles, and is coupled to a similarly tuned circuit 24 on the output side of a modulator M. The generators G' and G'' , which may be similar to the generator G, are coupled to the input circuit of the modulator M, through a transformer arrangement 25. If the generator G' supplies 10,000 cycles and the generator G'' supplies 300,000 cycles to the modulator M, frequencies will be impressed upon the antenna AM, corresponding to the unmodulated fundamental of 300,000 cycles and to the upper and lower side frequencies, which in this instance will be 310,000 cycles and 290,000 cycles.

The apparatus for translating the frequencies at the signaling stations may be understood from Figure 3, which illustrates the apparatus at station 2. In Figure 3 AT designates a transmitting antenna of ordinary construction and AR designates a receiving antenna in the form of a loop which is balanced with respect to the transmitting antenna, since the latter is located in a direction normal to the plane of the loop and oscillations radiated from the transmitting antenna therefore produce equal and opposite effects in the two sides of the loop, so that no resultant effect is produced upon the associated receiving apparatus. AC designates a second receiving loop similar in construction to the loop AR and similarly related to the transmitting antenna AT. The loop AC is adapted to receive the fundamental frequencies, and for this purpose is provided

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with two parallel tuned branches 26 and 27, the former being tuned to the fundamental frequency of 50,000 cycles and the latter to the fundamental frequency of 300,000 cycles.

5 The tuned branch 26 is associated with a similarly tuned circuit 28, connected to the input side of an amplifier A_1 . This amplifier may be of any well known type, but is preferably an amplifier of the well known vacuum tube type. The output circuit of the amplifier A_1 is connected to a harmonic producer H_1 , which is an apparatus of well known construction and is preferably a distorting tube apparatus of the character illustrated in the U. S. application of B. W. Kendall, Serial No. 139,530, filed December 29, 1916. The harmonic producer is adapted to produce various harmonics of the fundamental frequency of 50,000 cycles. A tuned circuit 29, in the output of the harmonic producer is tuned to select the second harmonic of the fundamental frequency, which corresponds to 100,000 cycles. The tuned circuit 29 is coupled to a similarly tuned circuit 30, associated with the input side of a modulator M_1 . This modulator may be of any well known type, such, for instance, as the vacuum tube modulator.

The branch 27 of the circuit AC is coupled to a circuit 31, tuned to a frequency of 300,000 cycles and this frequency, together with side frequencies resulting from modulation at the master station, are impressed upon an amplifier A_2 , which may be similar to the amplifier A_1 . A branch 32 from the output of the amplifier A_2 leads to a detector D_1 , whereby the low frequency of 10,000 cycles, in accordance with which the 300,000 cycle fundamental was modulated, may be detected. This detector may be of any well known type, such, for instance, as a vacuum tube detector. A tuned circuit 33 in the output of the detector D_1 selects the low frequency of 10,000 cycles and this tuned circuit is coupled with a similarly tuned circuit 34 associated with the input of the modulator M_1 . The modulator M_1 is therefore supplied with frequencies corresponding to 100,000 cycles and 10,000 cycles. In accordance with the well understood principles of modulation, these two frequencies will be modulated, with the result that frequencies of 90,000, 100,000 and 110,000 cycles will appear in the output circuit of the modulator. The circuit 35 is tuned to the upper side frequency, which is 110,000 cycles and this circuit is associated with the second tuned circuit 36 on the input side of the modulator M_1' .

Returning to the amplifier A_2 , another branch 37, tuned to the fundamental frequency of 300,000 cycles, is included in the input circuit of said amplifier and this tuned circuit is associated with a second tuned circuit 38, whereby the fundamental frequency of 300,000 cycles may be impressed upon a

branch circuit 39, leading to the modulator M_1' and upon another branch leading to the harmonic producer H_2 . The frequencies 300,000 cycles and 110,000 cycles are impressed upon the modulator M_1' and are modulated, and the resultant side frequency corresponding to 410,000 cycles is selected by means of the tuned circuit 40. The tuned circuit 40 is coupled to a similarly tuned circuit 41, associated with the supply circuit 42, leading to the transmitting apparatus.

The harmonic producer H_2 , hereinbefore referred to, may be similar to the harmonic producer H_1 , already described, and when supplied with a fundamental frequency of 300,000 cycles, produces harmonics of said frequency. The second harmonic, corresponding to 600,000 cycles, may be selected by the tuned circuit 43, which is coupled to a similarly tuned circuit 44 upon the input side of the modulator M_2 . The modulator M_2 is also supplied with the fundamental frequency of 50,000 cycles over a circuit 45, connected to the output side of the amplifier A_1 . The lower side frequency resulting from the modulation of 600,000 cycles by 50,000 cycles may be selected by means of a tuned circuit 46, tuned to a frequency of 550,000 cycles, this circuit being coupled to a similarly tuned circuit 47 associated with the supply circuit 48 leading to the receiving apparatus.

L designates a low frequency transmission line which is balanced by an artificial line N and is coupled through a balanced transformer arrangement 49 to a transmitting circuit TL, while a receiving circuit RL is connected to the midpoints of the line windings of the transformer 40. The transmitting channel TL includes an amplifier A_3 , which may be of any well known type, such, for instance, as the well known vacuum tube amplifier. The output circuit of the amplifier A_3 is connected to a power modulator M_3 , which may be a modulator of any well known type, such, for instance, as a vacuum tube modulator. The modulator M_3 is supplied with the carrier frequency assigned for transmission purposes, which, in this instance, is 410,000 cycles, over the circuit 42, which may include a power amplifier A_3' for amplifying the carrier frequency. A band filter F_3 may be included upon the output side of the power modulator. This filter is preferably a filter of the type disclosed in the U. S. patents to George A. Campbell, Nos. 1,227,113, and 1,227,114, issued May 22, 1917, and is so designed as to transmit a band of frequencies in the neighborhood of 410,000 cycles, said band being of sufficient width to accommodate the frequency variation due to modulation.

The receiving channel RL is coupled to the receiving antenna AR, through a trans-

former arrangement 50, and includes a band filter F_4 of the Campbell type. This filter is designed to transmit a band of frequencies in the neighborhood of 550,000 cycles, said band being of sufficient width to accommodate the frequency variation due to modulation at the distant transmitting station. A sharply tuned circuit may be used where the frequency range of the signaling band is very small compared with the frequency of radio transmission. The circuit TL also includes a demodulator D_4 , which may be of any well known type, such, for instance, as a vacuum tube detector. This modulator preferably operates upon the homodyne principle and is therefore supplied with unmodulated oscillations of carrier frequency, over the circuit 48. A low pass filter F_4' , preferably of the Campbell type, may be provided for suppressing the higher frequencies and passing the detected signaling currents. The signaling currents may be amplified by an amplifier A_4 , which may be of the vacuum tube type.

The operation is as follows: The fundamental frequency of 50,000 cycles absorbed by the antenna AC is impressed through the tuned circuit 26 upon the tuned circuit 28 and is then transmitted to the amplifier A_1 for amplification. The amplified frequency is then impressed upon the harmonic producer H_1 , which produces harmonics of the fundamental. The second harmonic corresponding to 100,000 cycles, is selected by means of the tuned circuit 29 and impressed through the tuned circuit 30 upon the modulator M_1 . In a similar manner the fundamental frequency of 300,000 cycles, together with the two side frequencies resulting from modulation at the master station, are selected by the tuned branch 27 and impressed through the tuned circuit 31 upon the amplifier A_2 . These frequencies are then impressed through the branch 32 upon a detector D_1 which detects the low frequency of 10,000 cycles. This frequency is selected by means of the tuned circuit 33 and impressed through the tuned circuit 34 upon the modulator M_1 .

The modulator M_1 is now supplied with frequencies of 10,000 cycles and 100,000 cycles, which react in the modulator in a well known manner, to produce two side frequencies of 90,000 and 110,000 cycles, respectively. The circuit 35 is tuned to the latter frequency and this frequency is therefore impressed through the tuned circuit 36 upon the modulator M_1' .

Returning to the amplifier A_2 , the tuned circuit 37 selects the fundamental frequency of 300,000 cycles from the output circuit of the amplifier and this frequency is impressed through the tuned circuit 38 upon a circuit 39, leading to the modulator M_1' . The frequencies 300,000 and 110,000 cycles, im-

pressed upon the modulator M_1' , react to produce side frequencies in the output circuit of the modulator. The upper side frequency of 410,000 cycles is selected by means of the circuit 40 and impressed, through the circuit 41 upon the transmitting carrier supply circuit 42.

The fundamental frequency of 300,000 cycles, selected by the circuit 37, is also impressed through the tuned circuit 38 upon a harmonic producer H_2 . The second harmonic is then selected by the tuned circuit 43 and impressed through the circuit 44 upon the modulator M_2 . This modulator is also supplied, over the circuit 45, with oscillations of the other fundamental frequency (50,000 cycles) from the amplifier A_1 . The frequencies 600,000 cycles and 50,000 cycles, applied to the modulator M_2 , produce side frequencies in the output circuit of the modulator and the lower side frequency of 550,000 cycles is selected by means of the tuned circuit 46 and impressed through the tuned circuit 47 upon the receiving carrier circuit 48.

Low frequency signals received from the line L are impressed through the transformer 49 upon the transmitting channel TL and after being amplified by the amplifier A_3 , are impressed upon the power modulator M_3 , which is also supplied with amplified carrier currents of 410,000 cycles frequency from the circuit 42. These carrier currents are modulated by the low frequency signaling currents and the modulated carrier currents are then transmitted through the band filter F_3 to the antenna AT, for radiation to a distant receiving station. The energy radiated from the antenna AT is substantially without effect upon the apparatus associated with the receiving loops AR and AC, owing to the balanced arrangement of these loops, already referred to, and because of the sending and receiving circuits being designed to operate on different frequencies.

Modulated carrier currents of 550,000 cycles radiated from a distant transmitting station, are received by the loop AR and transmitted through the transformer 50 and the band filter F_4 to the demodulator D_4 . The modulated receiving frequency reacts with the unmodulated carrier frequency of 550,000 cycles, supplied from the circuit 48, so that the low frequency signaling currents are detected by the detector D_4 and passed through the filter F_4' to the amplifier A_4 . After being amplified, the low frequency currents are transmitted to the line L, in a well known manner.

It will be understood that the frequencies hereinbefore referred to are given for purposes of illustration only and that these frequencies may be varied as practical conditions may require. It will further be

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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 radio system in which a plurality of radio stations are divided into groups of intercommunicating stations, each group having assigned to it a definite frequency range which shall not interfere with the frequency range assigned to any other group, the method of controlling the frequencies used for signaling in the various groups, which consists in generating at a master station a radio frequency and a relatively low frequency (too low to radiate) modulating the radio frequency by the low frequency, radiating the resultant frequencies to the stations of the groups, detecting the low frequency and selecting the radio frequency and producing frequencies within the range assigned to the group, by various combinations of the two frequencies.

2. In a radio system in which a plurality of radio stations are divided into groups of intercommunicating stations, each group having assigned to it a definite frequency range which shall not interfere with the frequency range assigned to any other group, the method of controlling the frequencies used for signaling in the various groups, which consists in generating at a master station a plurality of fundamental frequencies, certain of which are radio frequencies and at least one of which is a frequency too low to radiate, modulating one of the radio frequencies by the low frequency, radiating said radio frequencies and modulated frequencies to the stations of the various groups, detecting at said stations said low frequency and selecting the radio frequencies and producing frequencies within the range assigned to each group by various combinations of said frequencies.

3. In a radio system in which a plurality of radio stations are divided into groups of intercommunicating stations, each group having assigned to it a definite frequency range which shall not interfere with the frequency range assigned to any other group, the method of controlling the frequencies used for signaling in the various groups, which consists in generating at a master station a plurality of fundamental frequencies, certain of which are radio frequencies and at least one of which is a frequency too low to radiate, modulating one of the radio frequencies by the low frequency, radiating said radio frequencies and modulated frequencies to the stations of the various groups, detecting at said stations said low frequency and selecting the radio frequencies and producing frequencies within the

range assigned to each group, by various combinations of said frequencies and harmonics of said frequencies.

4. In a radio system in which a plurality of radio stations are divided into groups of intercommunicating stations, each group having assigned to it a definite frequency range which shall not interfere with the frequency range assigned to any other group, the method of controlling the frequencies used for signaling in the various groups, which consists in producing at a radio station fundamental radio frequencies, at least two of which differ from each other by a relatively small frequency difference, radiating said frequencies to the stations of the various groups, detecting at said stations said relatively small frequency difference, thereby producing a low frequency, selecting at least one radio frequency and producing frequencies within the range assigned to each group, by variously combining the high and low frequencies.

5. In a radio system in which a plurality of radio stations are divided into groups of intercommunicating stations, each group having assigned to it a definite frequency range which shall not interfere with the frequency range assigned to any other group, the method of controlling the frequencies used for signaling in the various groups, which consists in producing at a radio station fundamental radio frequencies, at least two of which differ from each other by a relatively small frequency difference, radiating said frequencies to the stations of the various groups, detecting at said stations said relatively small frequency difference, thereby producing a low frequency, selecting at least one radio frequency and producing frequencies within the range assigned to each group, by variously combining the high and low frequencies and harmonics of said frequencies.

6. In a radio system in which a plurality of radio stations are divided into groups of intercommunicating stations, each group having assigned to it a definite frequency range which shall not interfere with the frequency range assigned to any other group, the method of controlling the frequencies used for signaling in the various groups, which consists in producing at a master station a plurality of radio frequencies, at least two of which differ from each other by a relatively small frequency difference, radiating said frequencies to the stations of the various groups, detecting at said stations said frequency difference, thereby producing a relatively low frequency and producing said stations frequencies within the range assigned to the corresponding group, by variously combining said low frequency and said radio frequency.

7. In a radio system in which a plurality

of radio stations are divided into groups of intercommunicating stations, each group having assigned to it a definite frequency range which shall not interfere with the frequency range assigned to any other group, the method of controlling the frequencies used for signaling in the various groups, which consists in producing at a master station a plurality of radio frequencies, at least two of which differ from each other by a relatively small frequency difference, radiating said frequencies to the stations of the various groups, detecting at said stations said frequency difference, thereby producing a relatively low frequency and producing at said stations frequencies within the range assigned to the corresponding group, by variously combining said low frequency and said radio frequency, and harmonics of said frequency.

8. The method of preventing relative frequency changes between a plurality of separate radio channels of communication involving a plurality of radio stations, which consists in modulating a radio frequency by a frequency too low to radiate, transmitting the resultant frequencies to each of said radio stations, and deriving from said frequencies at each of said stations the carrier frequencies employed in transmission.

9. The method of fixing the frequency relation between a plurality of non-intercommunicating radio stations, which consists in modulating a radio frequency by a frequency too low to radiate, transmitting the resultant frequencies for each of said radio stations and translating said frequencies into frequencies employed for radio transmission.

10. The method of fixing the frequency relation between a plurality of non-intercommunicating radio stations, which consists in modulating a radio frequency by a frequency too low to radiate, transmitting the resultant frequencies to each of said radio stations, and translating said resultant frequencies at each of said stations into frequencies employed for radio transmission.

11. The method of preventing interference between non-intercommunicating radio channels, which consists in modulating at a master station a radio frequency with a frequency too low to radiate, transmitting the resultant frequencies to each of the radio signaling stations involved, and translating at said stations the radiated frequencies into the frequencies of transmission.

12. The method of fixing the frequency relation between a plurality of radio systems, which consists in modulating a radio frequency with a frequency too low to radiate, transmitting the resultant frequencies to the terminals of the various radio communication systems, translating at said terminals the transmitted frequencies into frequencies of transmission to be employed in

connection with the communicating channels of the systems.

13. In a wave length control system, a plurality of radio stations, some of which are non-intercommunicating, a source of non-signaling radio frequency, means to modulate currents from said source in accordance with a non-signaling frequency too low to radiate, means to transmit the resultant frequencies to said radio stations, and means at said radio stations for translating the frequency control thus transmitted into transmission frequencies for signaling purposes.

14. In a radio wave length control system, a master station and a plurality of radio stations, means at said master station for modulating a radio frequency with a frequency too low to radiate, means for transmitting the resultant frequencies to each of said radio stations, and means at the various radio stations for combining the currents of the waves thus transmitted and harmonic multiples thereof to produce transmission wave lengths for the various stations.

15. A radio system comprising a plurality of radio stations, means at one of said stations for modulating a non-signaling radio frequency with a non-signaling frequency too low to radiate, means to transmit the resultant frequencies to each of the other stations, and means at each of said stations to translate the received frequencies into other frequencies for signal transmission.

16. A radio system comprising a plurality of radio stations, means at one of said stations for modulating a non-signaling radio frequency with a non-signaling frequency too low to radiate, means for transmitting the resultant frequencies to each of the other stations, and means at said other stations for translating the received frequencies into higher frequencies for signal transmission.

17. A radio system comprising a master station and a plurality of radio signaling stations, some of which are non-intercommunicating, means at said master station for modulating a non-signaling radio frequency with a non-signaling frequency too low to radiate, means to transmit the resultant frequency to said radio signaling stations, and means at said stations to translate the received frequencies into higher frequencies for signal transmission.

18. In a radio system in which a plurality of radio stations are divided into groups of intercommunicating stations, each group having assigned to it a definite frequency range which shall not interfere with the frequency range assigned to any other group, the method of controlling the frequency used for signaling in the various groups, which consists in generating at a master station a radio frequency and a relatively low frequency (too low to radiate), modulating

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the radio frequency by the low frequency, radiating the resultant frequencies to the stations of the groups, detecting the low frequency and controlling by means of said low frequency the frequency of signaling energy produced for signaling within the frequency range assigned to the group.

19. The method of preventing relative frequency changes between a plurality of separate radio channels of communication involving a plurality of radio stations, which consists in modulating a radio frequency by a frequency too low to radiate, transmitting the resultant frequencies to each of said radio stations, and controlling by means of said frequencies at each of said stations the frequency of energy produced for carrier frequencies employed in transmission.

20. The method of fixing the frequency relation between a plurality of non-inter-

communicating radio stations, which consists in modulating a radio frequency by a frequency too low to radiate, transmitting the resultant frequencies to each of said radio stations, and determining by said frequencies the frequencies of the energy employed for radio transmission.

21. The method of fixing the frequency relation between a plurality of non-inter-communicating radio stations, which consists in modulating a radio frequency by a frequency too low to radiate, transmitting the resultant frequencies to each of said radio stations, and determining by said resultant frequencies at said stations the frequencies of the energy employed for radio transmission.

In testimony whereof, I have signed my name to this specification this 29th day of September, 1919.

JOHN R. CARSON.

Hewitt

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