April 22, 1924. 1,490,958

R. BOWN

FREQUENCY CONTROL SYSTEM

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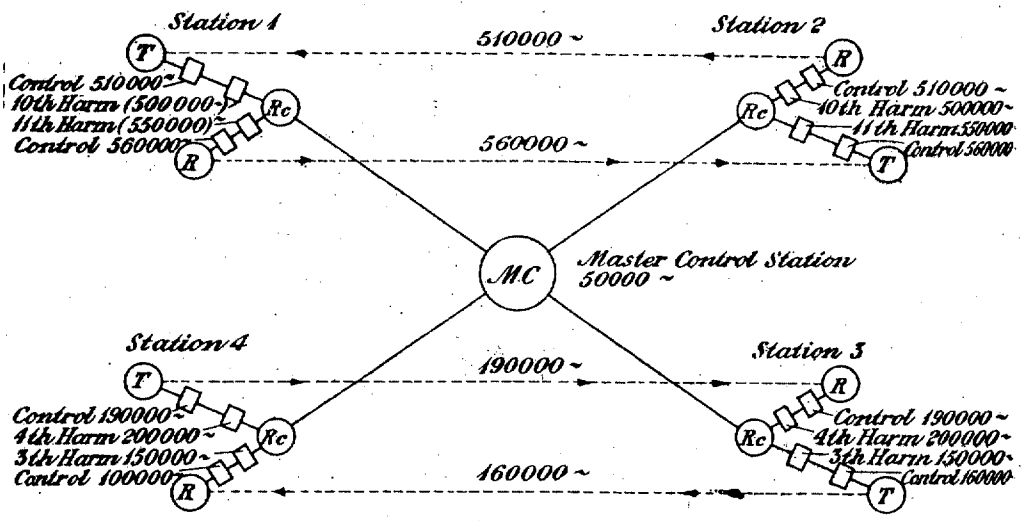

Fig. 1

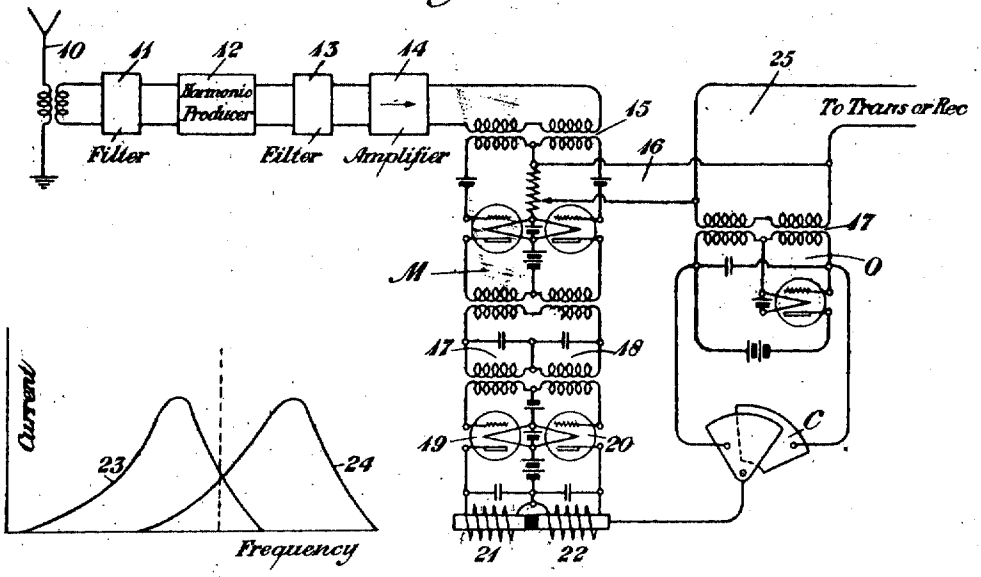

Fig. 3

Fig. 2

INVENTOR
Ralph Bown
BY
ATTORNEY

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RALPH BOWN, OF FREEHOLD, NEW JERSEY, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

FREQUENCY-CONTROL SYSTEM.

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To all whom it may concern:

Be it known that I, RALPH BOWN, residing at Freehold, in the county of Monmouth 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 signaling frequencies used by different stations.

The radio signaling, where a large number of signaling stations are to signal simultaneously, it is desirable 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 in order to avoid interference. Furthermore, the various signaling stations may be divided up into groups or systems, depending upon the cooperation of several interests 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 a 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 be accompanied by a corresponding shifting of the frequencies utilized by other groups. It has heretofore been proposed to accomplish this result by generating at a master station one or more fundamental frequencies which may be radiated to the stations of the various groups or systems, the various signaling frequencies to be used by the individual stations of the groups being derived from the energy of the received fundamental frequency or frequencies by a process of amplification and frequency translation.

This method has the obvious disadvantage that the energy to be used for signaling at the various stations is a function of the energy received from the master controlling station. Consequently at any time the amount of energy to be radiated for signaling purposes by a given station will depend upon the amount of energy radiated from the master station and upon the loss of energy in transmission from the master station to the signaling station. In accordance with the present invention it is proposed to generate the energy to be used for signaling at each signaling station so that the amount of energy to be used for signaling will be independent of the amount of energy radiated at the master station, the frequency of the energy generated, however, being controlled and determined by the frequency radiated from the master station. In other words, the method is such that the control exercised by the master station is one of frequency only and the amplitude of the energy is controlled entirely by the local signaling station.

The invention may now be more fully understood from the following description when read in connection with the accompanying drawings, in which Figure 1 is a schematic diagram illustrating broadly one method of carrying out the invention, Fig. 2 is a diagram of a portion of the apparatus at one of the signaling stations schematically indicated in Fig. 1, and Fig. 3 is a series of curves illustrating the operation of the controlling apparatus.

Referring to Fig. 1, MC designates a master control station at which apparatus may be provided to radiate a fundamental radio frequency of say 50,000 cycles, which is to be picked up by the various signaling stations and translated into the particular radio frequency used for intercommunication between any pair of stations. Two pairs of intercommunicating stations 1—2 and 3—4 are schematically illustrated in Fig. 1, each pair being typical of a larger group and it being further understood that in actual practice more than two stations may intercommunicate at the same frequency. Each station may include an apparatus schematically indicated by R_s for receiving the master controlling frequency, together with suitable apparatus for translating the master controlling frequency into a frequency

or frequencies suitable for the exercise of control over the particular frequency to be locally generated and used for intercommunication. As shown schematically in Fig. 1, separate apparatus may be used in conjunction with the receiving apparatus R_c for controlling the frequency generated for the local transmitter T and the local receiver R. Where a heterodyne or homodyne system is not employed, however, it will be understood that no apparatus is necessary for controlling the frequency of the local receiver R.

Suppose it is desired to transmit from station 1 to station 2 at a radio carrier frequency of 510,000 cycles and to transmit from station 2 to station 1 at a radio carrier frequency of 560,000 cycles. In order to control the local generation of these frequencies at the points T and R, the control frequency of 50,000 cycles received at the point R_c may be impressed upon a harmonic producer. The tenth harmonic of 50,000 cycles is 500,000 cycles. The local generator will be adjusted to generate a frequency of 510,000 cycles and by supplying a portion of the locally generated energy to a suitable modulating device, together with the harmonic frequency of 500,000 cycles, a difference frequency of 10,000 cycles may be obtained. The energy of the difference frequency may be impressed upon a device which is sensitive to frequency changes and this device may be used to govern the frequency of the local generator.

In order to understand more fully the nature of the control mechanism reference may be had to the apparatus illustrated in Fig. 2, the apparatus shown in this figure being typical of the mechanism located at and interconnecting points R_c and T, or points R_c and R, so far as this mechanism is concerned with frequency control. The antenna 10 of Fig. 2 may be any well known type of receiving antenna and has associated therewith a filter 11 of well known type for selecting the control frequency radiated from the distant master station. This filter may be, for example, a tuned circuit or a band filter of the Campbell type.

Where the frequency to be used in signaling differs quite materially from the master frequency it is necessary to produce a harmonic of the master frequency which will be closely related in the frequency spectrum to the frequency which it is desired to generate. For this purpose the selected master frequency is impressed upon a harmonic producer 12 of well known type. For example, it is now well known that the distorting action of a vacuum tube may be used to produce harmonics of a fundamental frequency applied to the tube, and any desired harmonic may be selected by suitable selecting means. Assuming that the apparatus illustrated is to be used for the control of the signaling frequency at the transmitter T of station 1, the harmonic producer 12 will be used to produce harmonics of the fundamental frequency 50,000 and the tenth harmonic corresponding to a frequency of 500,000 cycles will be selected by means of a filter 13, which may be similar in construction to the filter 11.

The selected harmonics may be amplified by means of an amplifier 14 to any desired value and may be impressed upon a modulating apparatus M through a transformer 15. The modulating apparatus as illustrated is of the duplex vacuum tube type disclosed in Carson Patent 1,343,307, issued June 15, 1920. The local generator for supplying the carrier frequency to the transmitter or receiver, as the case may be, may comprise for example an oscillator O of the well known vacuum tube type, whose frequency is controlled by means of a suitable adjustable capacity C. A connection 16 extends from the output transformer 17 of the oscillator O to the common path of the vacuum tube modulator M so that the frequency supplied by the oscillator O may beat with the harmonic frequency derived from the received master frequency.

A special form of tuned circuit arrangement is associated with the output circuit of the modulator M, this tuned circuit arrangement comprising two sharply tuned circuits 17 and 18. One of these tuned circuits is associated with the input circuit of vacuum tube 19 and the other with the input circuit of vacuum tube 20. The vacuum tubes 19 and 20 are of the detector type and each includes in its output circuit a winding 21 or 22 of a solenoid arrangement for adjusting the condenser or capacity C.

In the case assumed, where the harmonic frequency is 500,000 cycles and the frequency generated by the oscillator O is 510,000 cycles, a beat frequency of 10,000 cycles will appear in the output circuit of the modulator M. The tuned circuits 17 and 18 are so adjusted that the resonance peak of the one will correspond to a frequency lower than 10,000 cycles and the resonance peak of the other will correspond to a frequency higher than 10,000 cycles, as illustrated by the curves 23 and 24 of Fig. 3. In these curves the vertical dotted line corresponds to the normal beat frequency of 10,000 cycles and at this frequency the curves of the two tuned circuits 17 and 18 overlap equally so that the same amount of current will be selected into each of these tuned circuits, and by consequence the same amount of direct current will flow in each of the coils 21 and 22. Under these circumstances, the plunger of the solenoid will

occupy an intermediate position and the capacity C will be set so that the desired frequency of 510,000 cycles will be generated by the oscillator and supplied over the circuit 25 to the radio transmitter or receiver, as the case may be.

If, however, the master control frequency varies so that its frequency becomes lower for example, the harmonic frequency supplied by the modulator M will be lower and the beat frequency appearing in the output circuit of the modulator will be greater than 10,000 cycles. This will cause the current flowing through one or the other of the coils 21 or 22 to become greater than the other so that the plunger will be shifted in such a direction as to change the capacity C to correspondingly lower the frequency generated by the oscillator O. Likewise, if the master frequency increases in frequency, the current in the other coil of the solenoid will be increased, thereby changing the capacity so as to increase the frequency of the oscillator O. It will thus be seen that the automatic governing apparatus operates to maintain a frequency difference substantially constant so that the frequency supplied over the circuit 25 will vary up and down as the fundamental frequency varies up and down. If, now, similar apparatus be provided at each station it will be seen that the signaling frequencies generated will vary at all stations in the same direction at the same time, and by proportionate amounts.

It will be noted that the control arrangement described is of such character that the control exercised over the condenser or capacity C is entirely independent of the amount of energy received by the antenna 10 and is proportionate to the variation of the master frequency or harmonic thereof from the predetermined standard. The energy locally generated is therefore at all times quantitatively controllable at the local station.

In the previous description the operation of the apparatus has been described for the case in which the incoming master frequency changes and the frequency generated by the oscillator O is changed correspondingly. It is obvious, however, that if the incoming master frequency remains constant and for any reason the frequency of the oscillator O should vary, the capacity C will be adjusted to bring the frequency of the oscillator back to normal as the changed frequency from the oscillator O will pass through the circuit 16 to beat with the master frequency in the modulator M.

It will be obvious that the general principles here 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 in the various groups for signaling, which consists in generating at a master station a fundamental frequency, transmitting said frequency to the stations of the various groups, generating at said station energy to be used for signaling, and controlling by the fundamental frequency received at each station the frequency of the locally generated energy without controlling the amplitude of the energy.

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 in the various groups for signaling which consists in generating at a master station a fundamental frequency, transmitting said frequency to the stations of the various groups, deriving from the received fundamental frequency other frequencies at the several stations, generating at said stations energy to be used for signaling, and controlling by means of the derived frequencies the frequency of the locally generated energy without controlling the amplitude thereof.

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 in the various groups for signaling which consists in generating at a master station a fundamental frequency, transmitting said frequency to the stations of the various groups, generating locally a frequency to be used for signaling, producing a determining frequency which is a function of the difference between the fundamental frequency and the locally generated frequency, and controlling the frequency of said locally generated frequency in accordance with said determining frequency without controlling the amplitude thereof.

4. 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 transmitting a control frequency to each of the radio stations involved, generating at each station energy to be used in

signaling, and controlling the frequency of the locally generated energy in accordance with the control frequency without controlling the amplitude of the energy.

5. 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 transmitting a control frequency to each of the radio stations involved, deriving at each radio station a frequency from the control frequency, generating at each station local energy to be used for signaling, and controlling the frequency of said local energy in accordance with the derived frequency without controlling the amplitude thereof.

6. 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 transmitting a control frequency to each of the radio stations involved, generating at each radio station a local frequency to be used for signaling, producing a determining frequency which is a function of the difference between the locally generated frequency and the control frequency, and controlling the frequency of said locally generated frequency in accordance with said determining frequency without controlling the amplitude thereof.

7. The method of fixing frequency relation between a plurality of non-intercommunicating radio stations which consists in transmitting to each of said stations a control frequency, generating at each station energy to be used in signaling, and controlling the frequency of the locally generated energy in accordance with the control frequency without controlling the amplitude of the energy.

8. The method of fixing frequency relation between a plurality of non-intercommunicating radio stations which consists in transmitting to each of said stations a control frequency, deriving at each radio station a frequency from the control frequency, generating at each station local energy to be used for signaling, and controlling the frequency of said local energy in accordance with the derived frequency without controlling the amplitude thereof.

9. The method of fixing frequency relation between a plurality of non-intercommunicating radio stations which consists in transmitting to each of said stations a control frequency, generating at each radio station a local frequency to be used for signaling, producing a determining frequency which is a function of the difference between the locally generated frequency and the control frequency, and controlling the frequency of said locally generated frequency in accordance with said determining frequency without controlling the amplitude thereof.

10. The method of fixing the frequency relations between a plurality of non-intercommunicating radio stations which consists in transmitting to each of said stations a control frequency, producing a harmonic of the control frequency at each signaling station, locally generating at each station a frequency to be used for signaling, modulating the harmonic frequency with the locally generated frequency to produce a difference frequency, and controlling by said difference frequency the frequency of said locally generated frequency without controlling the amplitude thereof.

11. 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 in the various groups for signaling, which consists in generating at a master station a fundamental frequency, transmitting said frequency to the stations of the various groups, generating at said station energy to be used for signaling and whose amplitude is independent of the fundamental frequency, and controlling by the fundamental frequency received at each station the frequency of the locally generated energy.

12. 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 in the various groups for signaling which consists in generating at a master station a fundamental frequency, transmitting said frequency to the stations of the various groups, deriving from the received fundamental frequency other frequencies at the several stations, generating at said stations energy to be used for signaling and whose amplitude is independent of the fundamental frequency, and controlling by means of the derived frequencies the frequency of the locally generated energy.

13. 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 in the various groups for signaling which consists in generating at a master station a fundamental frequency, transmitting said frequency to the stations of the various groups, generating locally a

frequency to be used for signaling and whose amplitude is independent of the fundamental frequency, producing a determining frequency which is a function of the difference between the fundamental frequency and the locally generated frequency, and controlling the frequency of said locally generated frequency in accordance with said determining frequency.

14. 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 transmitting a control frequency to each of the radio stations involved, generating at each station energy to be used in signaling and whose amplitude is independent of the control frequency, and controlling the frequency of the locally generated energy in accordance with the control frequency.

15. 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 transmitting a control frequency to each of the radio stations involved, deriving at each radio station a frequency from the control frequency, generating at each station local energy to be used for signaling and whose amplitude is independent of the control frequency, and controlling the frequency of said local energy in accordance with the derived frequency.

16. The method of preventing relative frequency changes between a plurality of separate radio channels of communication involving a plurality or radio stations, which consists in transmitting a control frequency to each of the radio stations involved, generating at each radio station a local frequency to be used for signaling and whose amplitude is independent of the control frequency, producing a determining frequency which is a function of the difference between the locally generated frequency and the control frequency, and controlling the frequency of said locally generated frequency in accordance with said determining frequency.

17. The method of fixing frequency relation between a plurality of non-intercommunicating radio stations which consists in transmitting to each of said stations a control frequency, generating at each station energy to be used in signaling and whose amplitude is independent of the control frequency, and controlling the frequency of the locally generated energy in accordance with the control frequency.

18. The method of fixing frequency relation between a plurality of non-intercommunicating radio stations which consists in transmitting to each of said stations a control frequency, deriving at each radio station a frequency from the control frequency, generating at each station local energy to be used for signaling and whose amplitude is independent of the control frequency, and controlling the frequency of said local energy in accordance with the derived frequency.

19. The method of fixing frequency relation between a plurality of non-intercommunicating radio stations which consists in transmitting to each of said stations a control frequency, generating at each radio station a local frequency to be used for signaling and whose amplitude is independent of the control frequency, producing a determining frequency which is a function of the difference between the locally generated frequency and the control frequency, and controlling the frequency of said locally generated frequency in accordance with said determining frequency.

20. The method of fixing the frequency relations between a plurality of non-intercommunicating radio stations which consists in transmitting to each of said stations a control frequency, producing a harmonic of the control frequency at each signaling station, locally generating at each station a frequency to be used for signaling and whose amplitude is independent of the control frequency, modulating the harmonic frequency with the locally generated frequency to produce a difference frequency, and controlling by said difference frequency the frequency of said locally generated frequency.

In testimony whereof, I have signed my name to this specification this 22nd day of November, 1921.

RALPH BOWN.