

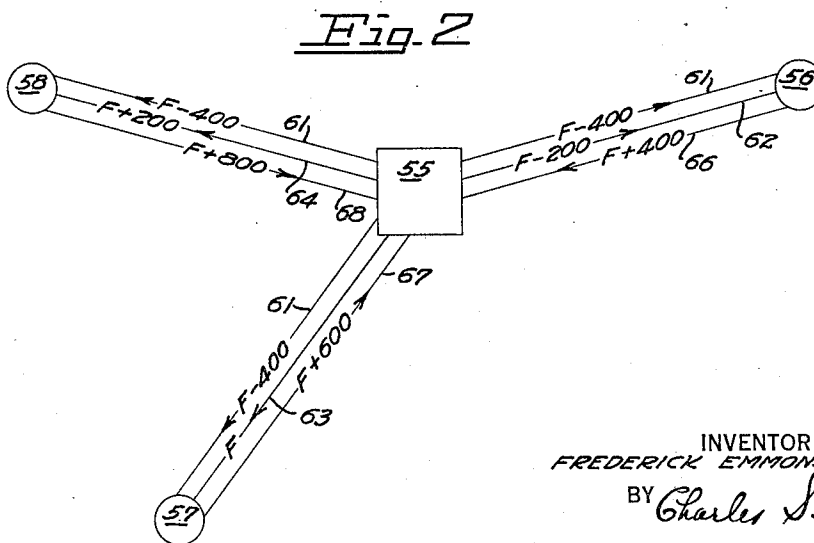
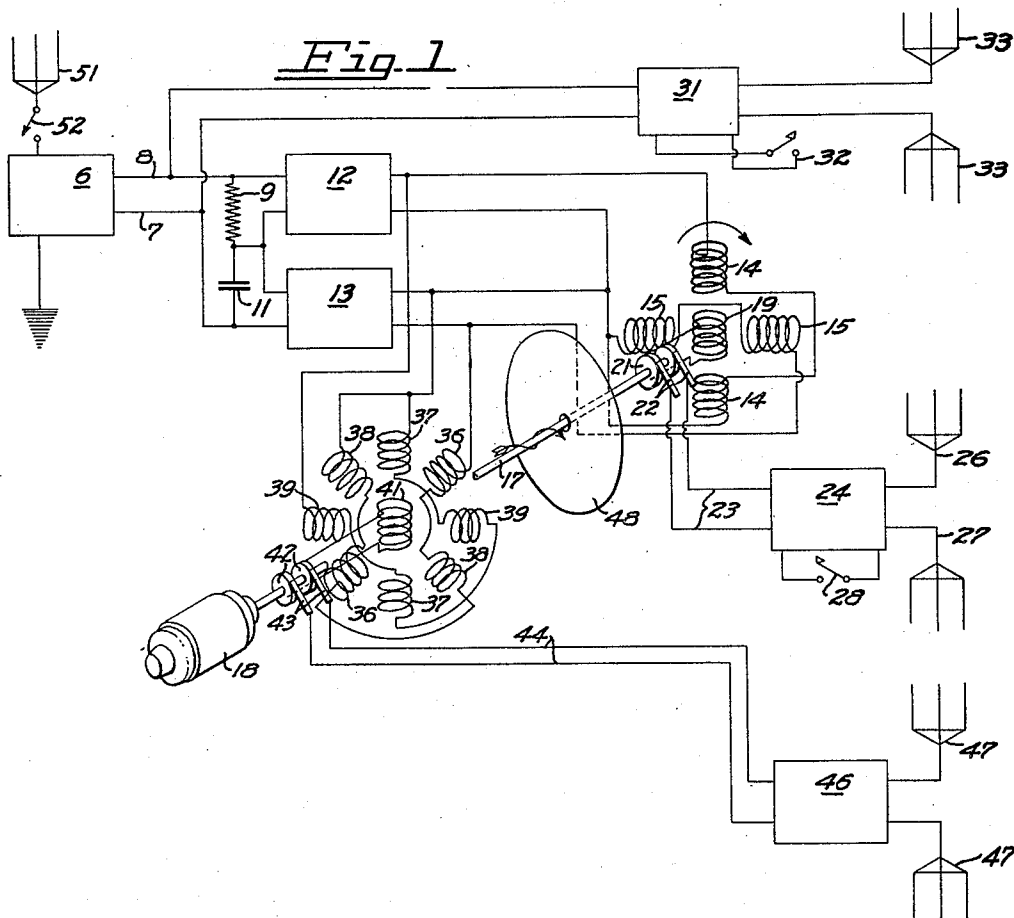
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SIGNALING SYSTEM

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## UNITED STATES PATENT OFFICE

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## SIGNALING SYSTEM

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My invention relates to signaling systems in which the signal to be transmitted is modulated upon a carrier current or oscillation of high frequency, and particularly to radio communication systems; and its broad object is to increase the numbers of messages which can be carried by a limited band of frequencies.

An object of my invention is to provide a means of generating a plurality of carriers in closely adjacent communication channels without interference between these channels.

Another object of my invention is to provide means of generating a plurality of electrical oscillations having a constant frequency difference.

Still another object of my invention is to provide a means of operating an extensive radio net with a single unified frequency control.

A further object of my invention is to provide a means whereby communication channels may be spaced more closely than is possible by even the best of the present laboratory methods of frequency control.

My invention possesses other objects and valuable features, some of which will be set forth in the following description of my invention which is illustrated in the drawings forming part of the specification. It is to be understood that I do not limit myself to the showing made by the said description and drawings, as I may adopt varying forms of my invention within the scope of the claims.

Radio communication channels are now assigned on a basis which has for one of its factors the precision with which the carrier frequency can be controlled. This precision of control expressed in cycles or kilocycles is proportional to the nominal frequency of the carrier channel itself and therefore as the frequency of the channel becomes higher, the channels are more widely spaced.

The actual frequencies or "side bands" which are used in transmitting a message are independent of the modulated frequencies. For telegraph service this side band varies from 200 cycles wide to about 35 cycles wide, depending upon the code used and the method of reception. Thus, for high frequency radio

telegraphy, that is, for communication at frequencies in the neighborhood of ten thousand kilocycles, the assigned channels are several thousand cycles wide, of which only a few hundred cycles are actually used, since closer spacing would result in overlapping of adjacent channels and confusion of signals due to frequency instability of the transmitters.

Broadly considered, my invention comprises the generation of a master oscillation, whose frequency is, of course, preferably held as stable as possible. From this oscillation are derived a plurality of other oscillations whose frequencies differ from the master frequency by fixed amounts, and these derived frequencies are independently keyed or otherwise modulated. The result is that if the master frequency varies, the others vary in the same direction and to the same degree, so that there is no overlapping of channels or garbling of messages. One oscillation of the series thus generated may be transmitted unmodulated, and used to control the frequency of a generator at the receiving station. Here, the same method may be used to generate a frequency of a constant difference from the master frequency, which the receiving station may, in turn, use for transmission. The preferred method of deriving the secondary frequencies from the master frequency is to use the master frequency oscillation to generate a rotating magnetic field within which an inductor or coil is mechanically rotated. There will then be generated within the coil a frequency proportional to the algebraic difference between the frequency of rotation of the magnetic field and the product of the frequency of rotation of the coil and the number of pairs of field poles.

Referring to the drawings:

Figure 1 is a diagram illustrating the method of generating the series of carrier waves.

Figure 2 is a schematic diagram showing a radio net whose frequencies are controlled by a single master station and embodying this invention.

In more detailed terms the embodiment of my invention which I have chosen for de-

tailed description comprises an oscillator 6, which may be of any well known type, and which generates electrical oscillations of a frequency which preferably lies within the communication band which it is desired to use. Across the output leads 7 and 8 of the oscillator is connected a phase splitter, comprising a resistor 9 and a condenser 11, across which are connected the vacuum tube amplifiers 12 and 13. The impedances of the resistor and condenser are so chosen as to make the voltage drop across the two substantially equal, but differing in phase by ninety degrees.

The output circuits of the two amplifiers are connected across the coils 14, 14 and 15, 15 respectively, and these coils are placed at substantially right angles so as to provide a magnetic field of uniform strength and rotating in space at the frequency generated by the oscillator 6.

Rotatably mounted upon the shaft 17 within the rotating field, and driven by a constant speed motor 18, is an inductor 19 whose terminals are brought to the slip-rings or other collector device 21. Brushes 22, bearing upon the slip-rings, connect thru the leads 23 to the input of an amplifier 24 which is connected to an antenna 26 and counterpoise 27 or other suitable radiating system. A key 28 or other suitable device is used in the customary manner for modulating the output of the amplifier 24.

If both the rotating field and the inductor 19 rotate in the same direction there will be generated in the inductor a current whose frequency is equal to the difference of the two frequencies of rotation. If the directions of rotation of field and inductor are opposite, the frequency of the generated current will be the sum of the two frequencies of rotation. If the speed of rotation of the motor be one hundred revolutions per second, the frequency generated in the inductor 19 will differ from that of the oscillator 6 by exactly this amount. The speed of the motor may easily be controlled to within one per cent of its required value, that is, to within one revolution per second, plus or minus; but to control a separate oscillator operating in the short wave telegraph band to this accuracy, i. e., to one cycle per second, the precision of control would have to be not to one per cent, but to within one-hundred-thousandth of one per cent, and such stability of control is as yet impossible of commercial attainment.

It is of course possible to hold the inductor stationary and rotate the field coils mechanically. This method, although identical in principle with that described, offers mechanical difficulties which make the described method preferable. Electrostatic fields may also be used in place of the magnetic fields here described.

A potential derived from the oscillator 6 is applied directly across the input terminals of an amplifier 31, which is also provided with a modulator 32 and a radiating system 33.

A second rotating field is derived from the amplifiers 12 and 13 by means of the coils 36, 37, 38 and 39. This is a four pole field and when the inductor 41 is rotated within it, the frequency generated within its windings differs from that of the oscillator by twice the speed of rotation of the shaft 17 upon which the inductor is mounted, for reasons well understood in electrical art. In the present case, under the assumptions made above, this frequency would differ from that of the oscillator 6 by two hundred cycles per second, and from that generated in the inductor 19 by one hundred cycles per second. The current generated in the inductor 41 is shown as brought out thru the collector rings 42 and brushes 43 and the leads 44 to the amplifier 46, thence to be radiated by the antenna system 47 without modulation. The reason for this will be discussed later.

By mounting a plurality of coils upon the shaft 17, each provided with its own field coils, some of which are arranged to produce clockwise rotational fields while others produce counter-clockwise fields, the series of oscillations, each differing from the adjacent oscillation by a fixed amount, may be extended as far as desired. It is moreover unnecessary to increase the number of poles in order to extend the series, as a portion of the output of each inductor may be used to excite the succeeding field.

Succeeding field coils should be separated by electrostatic shielding 48.

It will be noted that the oscillator 6 is shown as being provided with an antenna system 51 to which it may be connected by a switch 52. The oscillator 6 may therefore be used either as a self-excited oscillator controlling the entire communication system, or its frequency of oscillation may be controlled by a received radiation, which is transmitted by some other station of the network. Such a network is shown in Figure 2, where a master station 55 radiates a plurality of waves of closely adjacent frequencies generated as shown in Figure 1.

One of these frequencies, preferably an end frequency in the series radiated, is transmitted unmodulated, and is picked up by the secondary stations 56, 57 and 58 and used to control their own master oscillators. This frequency is here assumed to be the master frequency minus four hundred cycles, and is indicated by the lines 61 which are marked  $F-400$ . The frequency  $F-200$  is modulated and used to transmit to station 56, as indicated by the line 62, while the frequency  $F$  is used to transmit to station 57 and  $F+200$  to station 58, indicated by lines 63 and 64

respectively. The secondary stations use the received unmodulated frequency  $F-400$  to heterodyne the received waves from station 55, the particular signal corresponding to their own communication channel being separated by electrical acoustic or mechanical filters.

The secondary stations control the frequency of their master oscillators by means of the received unmodulated waves  $F-400$ , and derive their all transmitting frequencies therefrom in the same manner that the master station derives its transmitting frequencies from the frequency  $F$ . Station 56 transmits on the frequency  $F-400$ , as is indicated by the line 66. Station 57 transmits on the frequency  $F+600$ , as indicated by the line 67, and station 58 on the frequency  $F+800$ , as indicated by the line 68. Additional stations or additional communication channels for the stations shown, may be added as desired.

The use of an end frequency of the series as the heterodyning or controlling frequency is advisable because the use of a frequency in the middle of the bands would give the same beat frequency with stations both above and below it in the bands, and their separation from each other would therefore be extremely difficult.

This system is capable of almost indefinite extension. If the separation desired between the communication channels is greater than can conveniently be supplied mechanically, it is possible to derive the transmitting frequencies from a master frequency which is integrally divisible into a frequency in the transmitting band. A difference frequency having the same ratio to the desired frequency difference as the master frequency has to the transmission frequency selected is mechanically generated, and both master and difference frequencies are multiplied by means of harmonic amplifiers.

It is also possible to generate one series of difference frequencies as described, and by heterodyning this series by a frequency within the series, to produce a second series founded upon a sum frequency. In the system described above, the frequency  $F$  could be used as a heterodyne frequency to produce a series comprising the frequencies  $2F-400$ ,  $2F-200$ , etc.

It is also possible to heterodyne the frequency series with some frequency lying outside of the band, but in this case the frequency instability of the new series, thus obtained, will depend upon the frequency shift of both oscillators, and therefore will not follow exactly in step with the series directly generated, as in the other cases here mentioned. The difference between successive frequencies of the series will remain constant, however.

The use of the method here outlined enables a single communication channel to be

used much more effectively than has heretofore been possible. The method may be extended into adjacent frequency channels with a still further gain in utilization. Thus it is theoretically possible to make a channel, which now carries but a single message, to carry as many as two hundred without interference. Such utilization is impossible at the present time, and increased frequency stability does not, at the present time, offer the possibilities of the method here described.

It is to be noted that the system here described involves no problems that have not already been successfully met in other radio fields, and it has therefore been considered unnecessary to describe the component parts in detail. Thus, the coils for establishing the rotating field and the rotating inductor form what is essentially a radiogoniometer, such as is familiar in radio beacon and direction finding work, the only difference being that the phases in the coils differ, and the inductor is continuously rotated instead of set to a desired azimuth. Speed controlled motors have been developed for picture transmission, electric clocks, and other uses, and suitable oscillators and amplifiers of many suitable types are well known.

Methods of modulation or keying may vary from the hand operated key to printer telegraph or voice modulation without affecting the principles of the system. If key modulation is used, however, it is advisable to make the modulating wave rounded instead of rectangular, in order to limit the width of the sidebands and reduce "key thump" on adjacent bands. This is also a well known expedient which need not be described in detail here.

I claim:

1. The method of signaling which comprises generating a master oscillation, generating a rotating field with said oscillation, rotating an element in said field to produce a second oscillation of different frequency, and transmitting both of said oscillations.

2. The method of signaling which comprises generating a master oscillation, generating a rotating field with said oscillation, rotating an element in said field to produce a second oscillation of different frequency, modulating one of said oscillations and transmitting both of said oscillations.

3. The method of signaling which comprises generating a master oscillation, generating a rotating field with said oscillation, rotating an element in said field to produce a second oscillation of different frequency, keying one of said oscillations, and transmitting both of said oscillations.

4. The method of signaling which comprises generating a master oscillation, generating a rotating field with said oscillation, rotating an element in said field to produce a second oscillation whose frequency is the

algebraic difference of the frequencies of rotation of said field and said element and transmitting both of said oscillations.

5. The method of signaling which comprises generating a master oscillation, generating a rotating field with said oscillation, rotating an element in said field to produce a second oscillation of different frequency, and using each of said oscillations to control the frequency of an electric wave transmitter.

6. The method of signaling which comprises generating a master oscillation, generating a rotating field with said oscillation, rotating an element in said field to produce a second oscillation whose frequency is the algebraic difference of the frequencies of rotation of said field and said element, and using each of said oscillations to control the frequency of an electric wave transmitter.

7. The method of signaling which comprises generating a master oscillation, inducing a series of oscillations of different frequency therefrom by rotational difference, and using each oscillation of said series to control the frequency of an electric wave transmitter.

8. The method of signaling which comprises generating a master oscillation, inducing a series of oscillations of different frequency therefrom by rotational difference, modulating certain of said oscillations, and transmitting said oscillations.

9. The method of signaling which comprises generating a master oscillation, inducing a series of oscillations of different frequency therefrom by rotational difference, modulating all but one of said series, and transmitting said series.

10. The method of signaling which comprises generating a master oscillation, inducing a series of oscillations of different frequency therefrom by rotational difference, modulating all but an end frequency oscillation of said series, and transmitting said series.

11. The method of signaling which comprises generating a master oscillation, generating an electrically rotating field with said oscillation, causing a relative mechanical rotation between said field and an inductor element to generate an oscillation of different frequency, and using each of said oscillations to control the frequency of an electric wave transmitter.

12. A radio transmitter comprising means for generating an electrical oscillation of a master frequency, means for producing an electrically rotating field excited by said oscillation, an inductor mounted within said field, means for causing a relative rotation between said field producing means and said inductor to produce an oscillation of different frequency, and means controlled by said sec-

ond oscillation for radiating an electromagnetic wave.

13. A radio transmitter comprising means for generating an electrical oscillation of a master frequency, means for producing an electrically rotating field excited by said oscillation, an inductor mounted within said field, means for causing a relative rotation between said field producing means and said inductor to produce an oscillation of different frequency, and means controlled by each of said oscillations for radiating electromagnetic waves.

In testimony whereof, I have hereunto set my hand.

FREDERICK EMMONS TERMAN.