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2,018,356

TRANSMISSION OF RELATED RADIANT FREQUENCIES

Original Filed Nov. 9, 1929 3 Sheets-Sheet 1

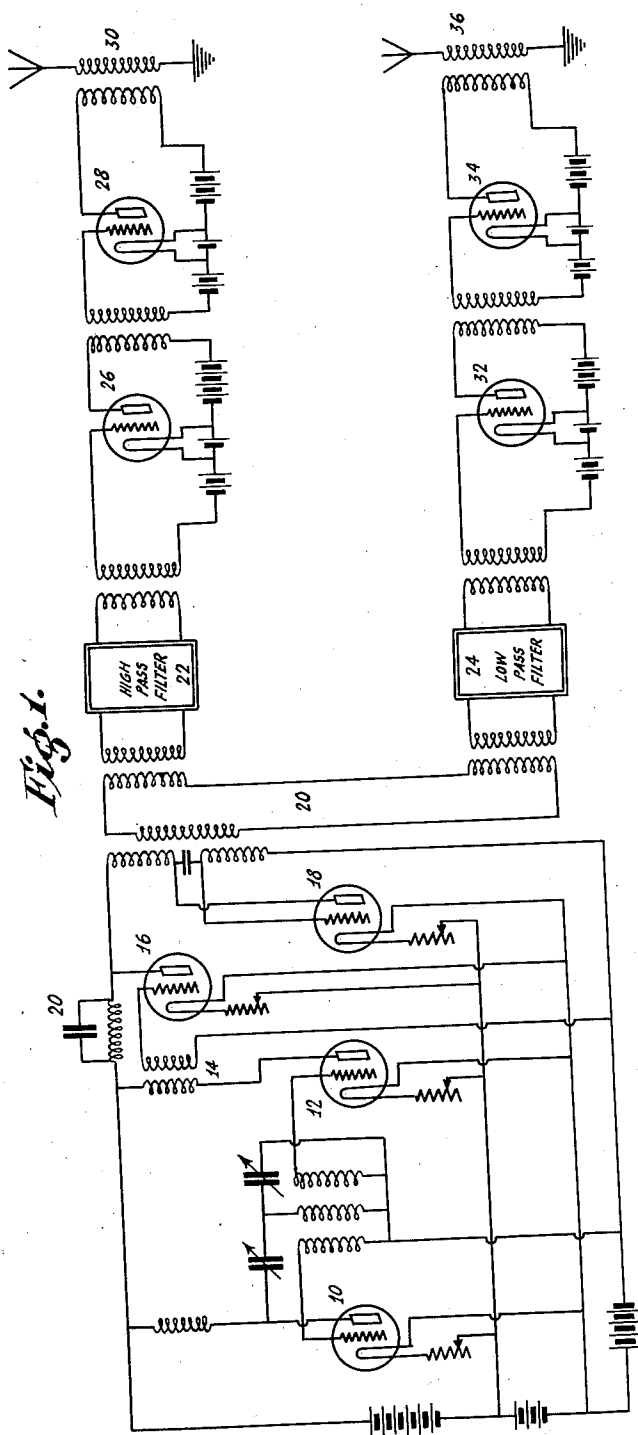


Fig. 1.

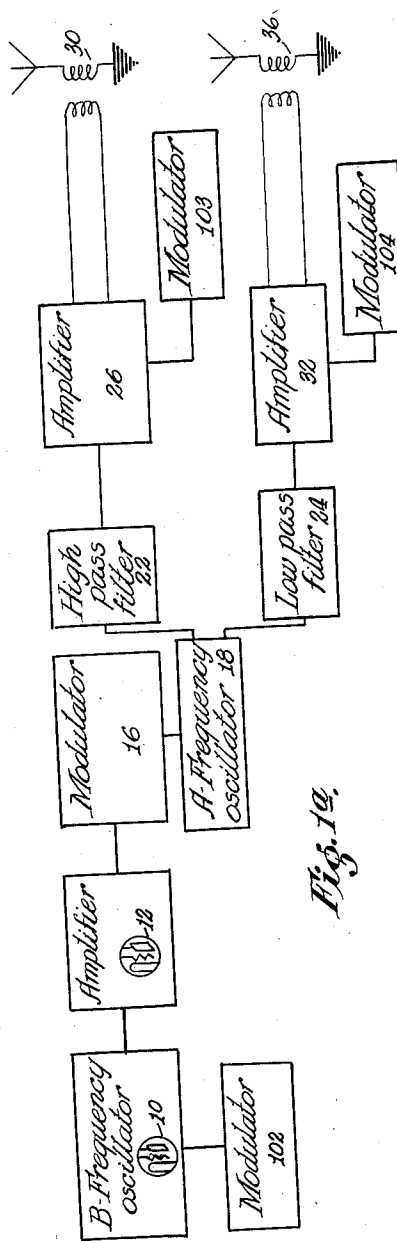


Fig. 1A.

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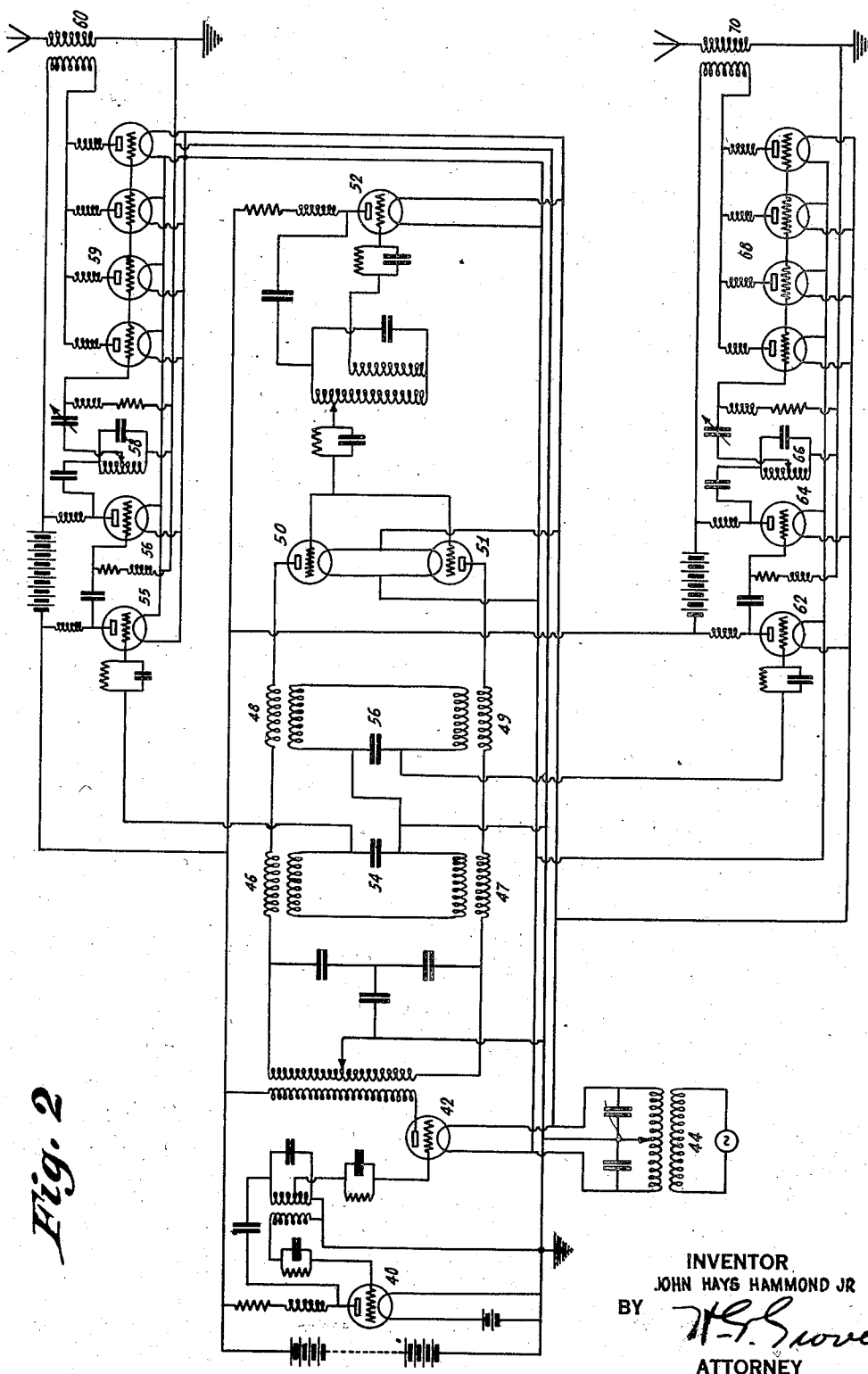
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TRANSMISSION OF RELATED RADIANT FREQUENCIES

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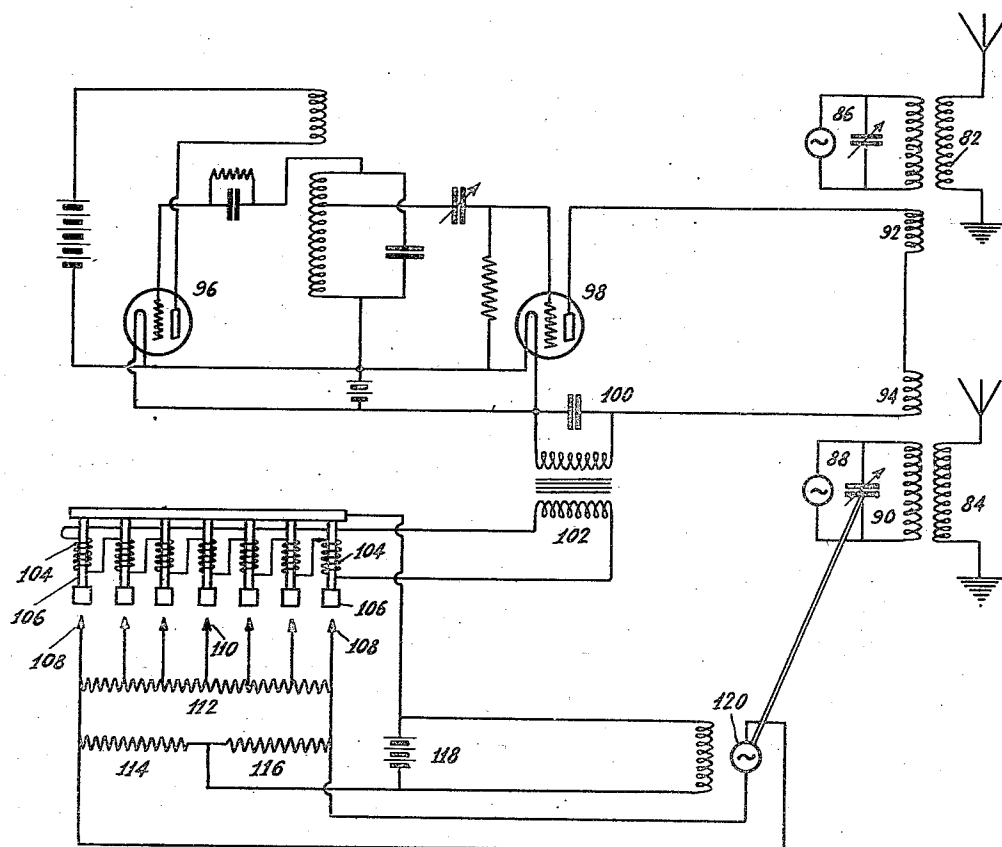
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TRANSMISSION OF RELATED RADIANT FREQUENCIES

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Fig. 3



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TRANSMISSION OF RELATED RADIANT
FREQUENCIES

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16 Claims. (Cl. 250—10)

The object common to all forms of the present invention is the production of radio frequency energy in the form of two or more separate radiant frequencies having accurately determined frequency differences at all times.

More specifically, it is the object of this invention to provide a means and apparatus for producing and radiating currents of two or more radio frequencies a definite and constant difference apart, with respect to the frequency spectrum.

A further object of this invention is to monitor the frequencies of a plurality of radio transmitters in an accurate manner.

A still further object of this invention is to provide a large number of frequencies to be radiated independently and at will by the simple combining of two constant radio frequencies.

These and further objects of my invention will become apparent from the following specification taken in connection with the appended drawings.

It is frequently necessary to radiate energy of various radio frequencies when the difference between the two frequencies is of great importance, such a use would be required for instance, in the control of apparatus by two radio frequencies. Such a control of the frequency allocation of a plurality of radio transmitters is also desirable in radio broadcasting. The fundamental object of the present invention is to enable each of these requirements to be fulfilled.

In accomplishing my invention, with respect to control of remote apparatus, a current of a carrier or "A" frequency, and a secondary or "B" frequency, which may be of a frequency of half the desired separation of the two frequencies that it is desired to produce, are generated. The "B" frequency is used to modulate the "A" frequency and thus produce two side band frequencies. The side band frequencies are amplified and radiated as carrier frequencies. The two frequencies thus radiated may be modulated in any desired manner to send separate messages as required under the circumstances of the case. In any case the original "A" or carrier frequency is suppressed.

For the production of a plurality of accurately allocated frequencies, it is obvious that the "B" frequency may again be used to modulate either or both of the side bands, and will produce additional side bands which may be amplified and radiated as independent frequencies. On the other hand, the harmonics of the "B" frequencies may be utilized to modulate the "A" frequency

and the side bands produced by said modulation may be independently radiated.

Thus the production of currents of two carefully controlled radio frequencies may be used to produce any given number of constant frequencies accurately allocated with respect to each other. Each of the frequencies thus produced may be modulated as desired in the usual manner which, per se, constitutes no part of the present invention.

As a further feature of my invention, when it is desired to generate a current of a frequency which shall at all times have a given frequency difference between it and another frequency, and this latter frequency is subject to slight variations, I provide a generator of a current of a frequency a few hundred cycles different from the desired difference frequency, and modulate the actual difference frequency by this frequency, I then by mechanically vibrating filter means, operated by the fluctuations in the frequency thus produced, control the frequency of the controllable radiant frequency.

Having thus briefly described my invention, I will now describe it in detail with the use of the accompanying drawings in which:

Fig. 1 is an elementary circuit diagram showing the production of two radiant frequencies in accordance with my invention,

Figure 1a is a diagrammatic showing of the elementary circuit diagram shown in Figure 1 and including certain modulator systems,

Fig. 2 is a practical circuit diagram for a transmitter adapted to produce two radiant frequencies in accordance with my invention, and

Fig. 3 is a circuit illustrating a method for controlling the frequency of one of two frequencies between which it is desired to maintain a constant frequency difference.

Attention is now particularly invited to Fig. 1 in which 10 represents an oscillator of any well known type including its associated circuits. This oscillator is adapted to produce a current of the low or "B" frequency which corresponds to one half of the desired difference frequency. The energy produced by the oscillator 10 is amplified in the amplifier 12 and fed through the transformer 14 to the modulator 16.

For the production of the high or "A" frequency, there is provided the thermionic oscillator 18 with its associated circuits. For producing modulation, there is provided in the outputs of the modulator 16 and the oscillator 18 the usual choke and condenser circuit 20.

The modulated high frequency is conveyed

from the output of the oscillator 18 through the circuit 20 to the inputs of the high pass filter 22 and the low pass filter 24. The high pass filter 22 is adapted to exclude all frequencies except the upper side band, and the low pass filter 24 is adapted to exclude all frequencies except the lower side band.

The energy transmitted by the filter 22 is amplified in the amplifier devices 26 and 28 in the usual manner and radiated through the antenna system 30. The energy radiated by the antenna 30 may be modulated in any well known or appropriate manner to send a signal which, however, constitutes no part of the present invention. Such a modulation scheme is shown diagrammatically in Figure 1a by the modulator 103 working in conjunction with the amplifier 26.

The energy transmitted by the low pass filter 24 is amplified in a similar manner by the amplifiers 32 and 34, and is transmitted similarly by the antenna circuit 36. Similarly the energy radiated by the antenna 36 may be modulated to send a message. The energy transmitted by the antenna 36 may be modulated by voice currents or the like as desired by the modulator 104 shown diagrammatically in Figure 1a.

It is to be understood that the modulation of the energy transmitted by either of the antennas 30 or 36 can in no way affect the difference frequency which is dependent entirely upon the "A" and "B" frequencies.

Attention is now particularly invited to Fig. 2 which shows, as before said, a practical circuit arrangement for carrying out the transmission, shown more generally in Fig. 1. The low or "B" frequency corresponding to that of Fig. 1 is produced by the oscillator 40 and its associated circuits, in the usual and well known manner. The energy produced by the oscillator 40 is amplified in the power amplifier 42 and is supplied to the plates of the push-pull modulator comprising the thermionic devices 50 and 51, which will be described in more detail hereinafter.

In that branch of the input for supplying the plate of the device 50, there are included the inductances 46 and 48. In that branch of the input for supplying the plate voltage of the device 51, there are included the inductances 47 and 49.

For producing the high or "A" frequency, there is provided the oscillator 52 and its associated circuits. The energy produced by the oscillator 52 is fed to the grids of the push-pull modulator 50 and 51. The output of the modulator is fed through the tuned circuits 54 and 56, inductively related to the inductances 46 and 47, and 48 and 49 respectively.

It can be seen that with respect to these tuned circuits, the high frequency produced by the oscillator 52 and the frequency produced by the oscillator 40 is balanced out. However, the circuits 54 and 56 are tuned to the upper and lower side bands of the resultant modulation and the energy of these side bands is available and is supplied through the connections shown to the grids of the amplifier devices 55 and 62 respectively.

The side band energy supplied through the amplifier 55 may be amplified in any desired manner by impedance or resistance coupled amplifiers, such as the amplifier 56. The energy thus amplified may be filtered in the tuned circuit 58 and supplied in any appropriate manner to the power amplifier 59, the output of which is so inductively related to the antenna 60 as to enable the side band thus amplified to be radiated by said antenna circuit.

The energy of the other side band is similarly supplied to the grid of the amplifier 62 and is amplified in the amplifier 64 and selectively passed through the circuit 66 to the power amplifier 68 to be amplified and radiated by the antenna circuit 70.

For supplying the filament current to the various thermionic devices any appropriate arrangement may be used, that shown being a direct current source for the low frequency oscillator 40, and an alternating current source 44 for the remaining thermionic devices. This arrangement, however, is merely illustrative and may be varied to meet the varying requirements in practice without departing from the spirit of the present invention.

It can be understood that Fig. 2 is fundamentally similar to Fig. 1, the chief difference being that the two frequencies which are not desired to transmit, are balanced out in Fig. 2 by a push-pull modulator instead of being filtered out as shown in Fig. 1.

Attention is now particularly invited to Fig. 3, which shows that part of my invention which relates to the control of the frequency produced by one transmitting device to maintain it at all times a constant frequency difference from the radiations of a second device. The antenna system 82 is adapted to radiate high frequency energy produced by the transmitter shown generally at 86. Similarly, the antenna 84 is adapted to radiate the energy produced by the transmitter indicated generally at 88. The frequency of the last mentioned transmitter 88 is adapted to be controlled by the condenser 90 which latter is adapted to be automatically varied to maintain the desired frequency difference at all times as will now be described. The frequency transmitted by the antenna 82 is picked up by the inductance 92 and the frequency radiated by the antenna 84 is picked up by the inductance 94 both of which inductances are included in the plate circuit of the demodulating device 98, the function of which will now be described.

The oscillator 96 with its associated circuits is adapted to produce a "B" frequency which differs from the desired frequency difference between the two radiations by a small number of cycles. This frequency is supplied to the grid of the plate demodulator 98, the plate voltage of which is supplied as above stated. The demodulator 98 performs the functions of first demodulation to produce the difference frequency, and second demodulation by heterodyne methods to produce low frequency. This has been found an efficient method of using one tube for double purpose when plenty of radio frequency energy is available. Thus the difference frequency existing in the plate circuit will be modulated by the "B" frequency produced by the oscillator 96. In the plate circuit of the modulator 98, there is included an output circuit 100 which is provided with a bypass condenser for high and intermediate frequencies. The whole output is so adjusted as to transmit over a broad band to cover the frequencies it may be called upon to transmit.

The energy existing in the circuit 100 is picked up by the secondary 102 and supplied to the coils 104 which surround vibration type reeds 106. These reeds are adapted to vibrate at frequencies of the normal frequency which will exist in circuit 100 and frequencies slightly above and slightly below that frequency.

A plurality of contacts 108 are adapted to be closed by the vibration of the reeds 106 and are

adapted to short circuit various variations of the resistor 112. Resistors 114 and 116 are so arranged with respect to the source 118 that a varying potential will be impressed upon the armature of the motor 120 in accordance with which the contacts 108 are closed. The motor is connected to the condenser 90 in any appropriate manner as through gearing so that rotation of the motor will serve to vary the frequency produced by the oscillator 88. Thus, for instance, if the central contact 110 is closed by the reed 104, which will vibrate to the normal frequency which will exist in this circuit with respect to the armature 102, a perfect bridge will be formed and no potential from the source 118 will be impressed upon the said armature. If, however, other of the contacts are closed, a potential will be impressed upon the armature of the motor 120 which will cause it to rotate in one direction or the other and thus vary the setting of the condenser 90 to control the frequency of the transmitter 88.

Having thus described my invention, I will now describe its operation. The oscillator 10 of Fig. 1 may be adapted to produce a "B" frequency of 5,000 cycles and the "A" frequency oscillator may be adapted to produce a frequency of 150,000 cycles. The side bands produced by the modulation of the latter named frequency by the "B" frequency will thus be 145,000 cycles and 155,000.

In this instance the high pass filter 22 will be adapted to transmit only frequencies in the immediate vicinity of 155,000 cycles whereas the low pass filter 24 will be adapted to transmit only frequencies in the immediate vicinity of 145,000 cycles. These frequencies only are then impressed upon the amplifiers and radiated through the antenna circuits 30 and 36.

The oscillator 40 of Fig. 2 similarly is adapted to produce a "B" frequency of 5,000 cycles and to have a five watt output. The amplifier 42 is adapted to increase the output to say 50 watts, and the master or "A" frequency oscillator 52 is adapted to supply a frequency of 150,000 cycles at five watts. The energy of the power amplifier 42 supplies the plate voltage of the push-pull modulator 50 and 51, the grids of which are controlled by the "A" frequency. Thus it can be seen that with respect to tuned circuits 54 and 56, no energy of the "A" frequency will exist. That is, the effect of the winding 46 will neutralize the effect of the winding 47 with respect to these frequencies, as the effect of the winding 48 will be neutralized with respect to the winding 49 of these frequencies. The circuit 54 may be tuned to the side band of 155,000 cycles, and with respect to this circuit, the side band frequency is additive. This permits the frequency to be impressed upon the amplifier device 55 and after the intermediate amplifications, to be transmitted by the antenna system 60. Similarly, the circuit 56 may be tuned to 145,000 cycles or the lower side band with respect to which frequency this circuit is additive, and the lower side band will thus be amplified and radiated by the antenna system 70.

The generator 86 of Fig. 3 is adapted to produce, and the antenna 82 is adapted to radiate a current of one of two frequencies, the difference between which it is desired to accurately control. A current of the second frequency is produced by the transmitter 88 and is controlled by the condenser 90. Say that the antenna system 82 radiates a current of a frequency of 165,000 cycles and the antenna 84 radiates a current of a frequency of 155,000 cycles, the differ-

ence between this frequency is 10,000 cycles which frequency will exist in the plate circuit of the device 98. In this case the oscillator 96 would be arranged to generate a current of a frequency of 9,500 cycles or a frequency which would differ from the beat frequency by a very low frequency of 500 cycles, from the difference frequency between the main radiations. The circuit 100 would be broadly tuned to pass frequencies of the order of 500 cycles which frequency would be actually controlled by the difference between the frequency of antenna 82 and antenna 84. The reeds 106 would be tuned to vibrate at, say, from 460 to 540 cycles, the central reed, which is adapted to close contact 110, being adapted to vibrate at 500 cycles which is normally the frequency which will exist in the reed actuating circuit. When the contact 110 is closed, which indicates that the frequency difference of the two transmitters is exactly correct, there will be a balance of the resistance in the bridge arrangement so that no energy from the battery 118 will be impressed upon the armature of motor 120. If, however, the difference is incorrect, other of the reeds will be vibrating and other contacts will be closed and the bridge will be thrown out of balance. Then a voltage will be impressed by the battery 118 upon the armature of the motor 120 which will cause it to rotate in a direction to appropriately adjust the frequency of the transmitter 88. When the adjustment of the transmitter 88 has caused it to generate a frequency differing from the frequency transmitted by the transmitter 86 by the proper amount, the frequency of 500 cycles will again exist in the windings 104 and the contact 110 will be closed, which will cause the motor 120 to stop rotating until the frequency difference is again varied, at which time the correction will be again accomplished in a similar manner.

It is obvious of course that either the system shown in Fig. 1 or that shown in Fig. 2 may be modified to radiate the carrier frequency as well as the side frequencies. In this case the three frequencies or such of them as are radiated may be independently modulated to send separate messages and the "B" frequency would be properly adjusted to give the desired separation between the various frequencies radiated. For modulating the frequency produced by the oscillator 10 there is provided a modulator circuit of any suitable type 102 (see Figure 1a). It can be seen that signals may be sent out in three different ways, namely, by modulating the energy radiated by the antenna 30 through the medium of modulator 103 by modulating the energy radiated by the antenna 36 through the modulator 104 and also by modulating the B-frequency energy through the medium of modulator 102.

Having thus described my invention, attention is invited to the fact that various embodiments might be devised differing from those shown and described for the purpose of illustration, and that I am not to be limited by the specific form shown and described, but by the scope of my invention as set forth in the appended claims.

What I claim is:

1. The method of producing a plurality of accurately related frequencies which comprises producing a main frequency and a modulating frequency, said modulating frequency having a value equal to the difference between any two successive frequencies to be produced, combining said two generated frequencies and producing from said combination a frequency equal to the sum of said

two frequencies and a frequency equal to the difference between said two frequencies, combining at least one of said last two produced frequencies with said modulating frequency and producing
 5 from said combination a frequency equal to the sum of the two last combined frequencies and a frequency equal to the difference between the two last combined frequencies.

2. The steps in a method of producing a plurality of electrical waves having accurately related frequencies which comprise producing a main frequency wave and a modulating frequency wave, said latter having a value equal to the difference between the frequencies of any two successive
 10 waves desired to be produced, combining said two waves and producing from said combination waves having a frequency equal to the sum of the frequency of said two waves and also waves of a frequency equal to the difference of the frequency
 15 of said two waves, combining at least one of said last two produced waves with the modulating frequency wave and producing from said combination a wave resulting from a beat note of said combination.

3. The method of producing a plurality of related frequencies which comprises producing two frequencies, modulating one of said frequencies by the other of said frequencies, and thus producing a plurality of related frequencies, suppressing the originally produced frequencies and
 20 independently radiating the related frequencies thus produced.

4. The method of producing a plurality of related frequencies which comprises producing two frequencies, and modulating one of said frequencies by the other of said frequencies and thus producing a plurality of related frequencies, suppressing the originally produced frequencies and
 35 independently modulating and radiating the frequencies thus produced to send a plurality of messages.

5. The method of producing a plurality of related frequencies which comprises generating a high continuous frequency, generating a second
 40 but lower continuous frequency, modulating the said high frequency by said lower frequency, and filtering out, independently amplifying and independently transmitting the side bands produced by said modulation.

6. The method of producing a plurality of related frequencies which comprises generating a high continuous frequency, generating a second but lower continuous frequency, modulating the said high frequency by said lower frequency without the original frequencies appearing in the output of said modulation, independently amplifying
 50 and independently transmitting the side bands produced by said modulation.

7. The method of controlling the frequency allocation of a plurality of radio broadcasting stations which comprises generating a high continuous frequency, generating a second but lower continuous frequency, modulating the said high frequency by said lower frequency without the original frequencies appearing in the product of said modulation, and independently modulating and transmitting the side bands produced by said modulation to broadcast a plurality of programs.

8. The method of radio transmission by a plurality of related frequencies which comprises generating two continuous frequencies, modulating one of said frequencies by the other of said frequencies without either of said frequencies appearing in the product of said modulation, and
 70 amplifying, modulating, and transmitting the

side bands produced by said modulation to send a plurality of messages.

9. Apparatus for the production and radiation of related radio frequencies which comprises means for generating a constant frequency wave,
 5 means for generating a different constant frequency wave, push-pull means for modulating said first wave by said second wave, whereby only the side bands of said modulation will be present and independent means for amplifying and radiating each of the two said side bands produced by said modulation.

10. Apparatus for the transmission of a plurality of messages by related radio frequencies which comprises means for generating a high
 15 constant and continuous frequency, means for generating a low constant and continuous frequency, means including a modulator circuit for the high continuous frequency with said low frequency including its harmonics, for producing
 20 upper and lower beat note frequencies, and means for independently amplifying, modulating and radiating each of the several beat note frequencies produced by said modulation to transmit desired signals.

11. Apparatus for the production and transmission of a plurality of accurately related radio frequencies for transmitting a plurality of different signals which comprises means for producing a high radio frequency, means for producing a low
 30 radio frequency, including its harmonics, means for modulating said first named frequency by said second named frequency, a plurality of transmitting means each of which comprises a means for filtering from the resultant of said modulation
 35 all except one of the plurality of the side bands produced by said modulation, means for amplifying said side band, and means for modulating said side band to send a message, whereby a plurality of accurately allocated radio frequencies is transmitted.

12. Apparatus for the production and transmission of a plurality of related radio frequencies which comprises means for generating a high continuous frequency, means for generating a low
 45 continuous frequency including a plurality of harmonics, push-pull means for modulating the high continuous frequency by the low frequency, whereby only the side bands resulting from said modulation will exist, and independent means for amplifying, modulating, and radiating each of the plurality of side bands thus produced.

13. The method of signalling which comprises producing a main frequency and an auxiliary frequency, modulating said main frequency with said
 55 auxiliary frequency and producing therefrom at least two other frequencies, separately modulating the produced frequencies with the signal energy desired to be transmitted and transmitting each of the resulting modulated waves.

14. The steps in a method of signalling which comprise producing a main frequency and an auxiliary frequency, modulating one of said frequencies with signal energy, modulating the resultant energy with the other frequency, and separating, individually amplifying and radiating the various constituent frequency bands resulting from said last modulation.

15. In a system for producing a plurality of electrical waves of different but accurately related
 70 frequencies, means for producing a main frequency wave and a modulating frequency wave said latter wave having a value equal to the difference between the frequencies of any two successive waves desired to be produced, means com- 75

prising a combining circuit for combining said two waves and producing from said combination waves having a frequency equal to the sum of the frequency of said two waves and also waves of a frequency equal to the difference of the frequency of said two waves and means for combining at least one of said two produced waves with the modulating frequency wave, said last named means acting to produce from said combination a beat frequency wave.

10 16. In a system for producing a plurality of accurately related frequencies, means for producing a main frequency and a modulating frequency, said modulating frequency having a value equal to

the difference between any two successive frequencies to be produced, means for combining said two generated frequencies and producing from said combination a frequency which is equal to the sum of said two frequencies and also a frequency which is equal to the difference between the said two frequencies, means for combining at least one of said last two produced frequencies with the modulating frequency and producing from said combination a frequency equal to the sum of the two last combined frequencies and a frequency equal to the difference between the two last combined frequencies.

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