

April 6, 1937.

H. H. BEVERAGE

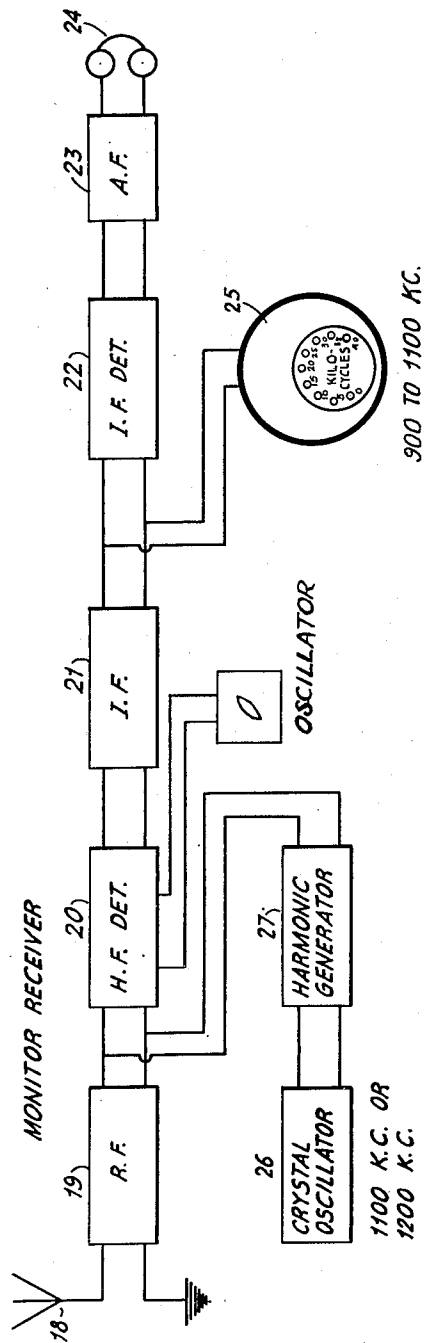
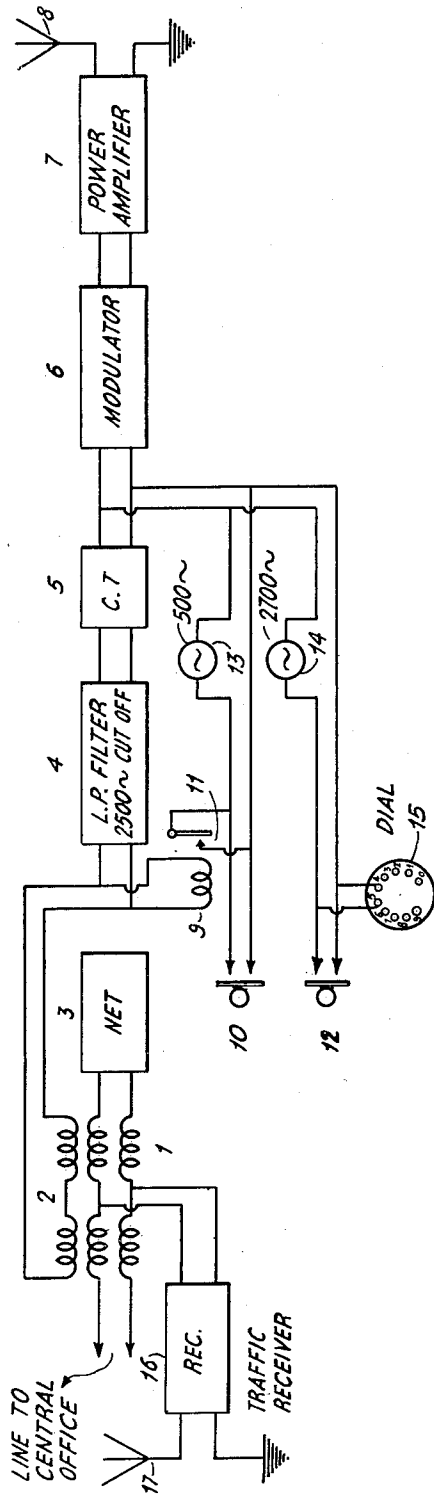
2,076,361

CRYSTAL OSCILLATOR MONITOR AND CENTRALIZED CONTROL

Filed April 21, 1933

3 Sheets-Sheet 1

Fig. 1



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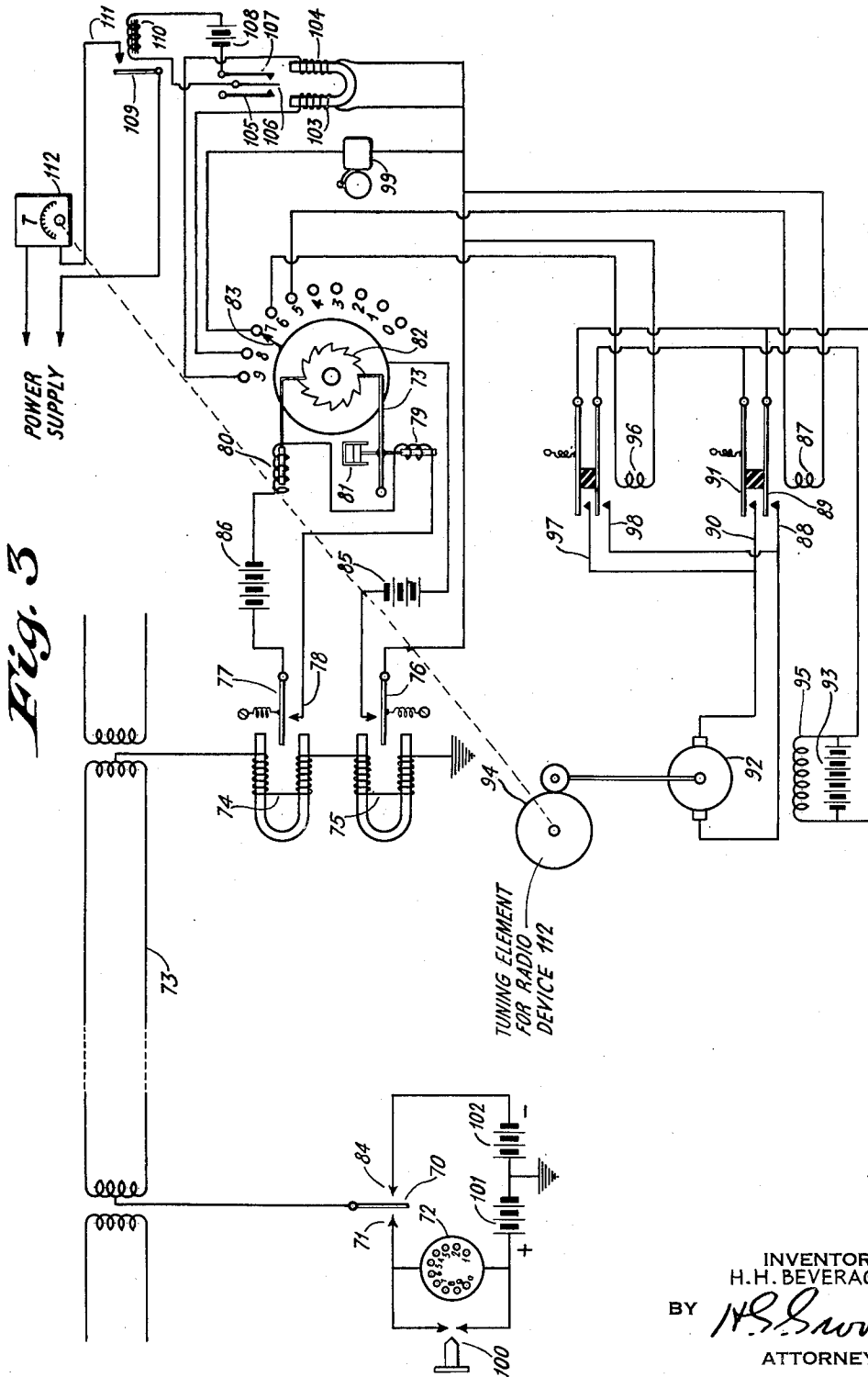
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CRYSTAL OSCILLATOR MONITOR AND CENTRALIZED CONTROL

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3 Sheets-Sheet 3



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CRYSTAL OSCILLATOR MONITOR AND
CENTRALIZED CONTROLHarold H. Beverage, Riverhead, N. Y., assignor to
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Application April 21, 1933, Serial No. 667,253

10 Claims. (Cl. 250—17)

The present invention relates to a novel method of and circuit arrangement for producing oscillations by means of a quartz crystal oscillator, and utilizing said oscillations as a frequency standard to produce harmonics as markers throughout the radio frequency spectrum covering the different frequencies used in the signaling system. The standard frequencies and the harmonics thereof are utilized in accordance with the present method and circuit for checking the frequency of any or all of the transmitters of the system and for producing indications of the amount by which the transmitters have deviated from their assigned frequency. This determining of the frequency of the transmitters is accomplished by a novel and simplified method and circuit which eliminates the necessity of interpolations between harmonics.

The invention also involves a method of and circuit for controlling from a remote point any of the transmitters of the system. The object of the remote control is to eliminate the necessity of attendance at some of the transmitters. By means of the method of remote control and circuit therefor of the present invention the circuit at the remote control may be turned on or off, the attendant at the transmitter may be called, or any central station may send ring calls over the control circuits to any other central station.

A particular feature of the present invention is a novel method of and circuit for tuning any or all of the transmitters of the system back to their assigned frequency if my method of and circuit for checking the frequency of said transmitters, as described in the second preceding paragraph, shows that such transmitter or transmitters are off their assigned frequency.

In connection with the ultra short wave inter-island telephone system which the Mutual Telephone Company has installed in the Hawaiian Islands, I have suggested certain equipment and certain ideas for the purpose of facilitating the adjustment and the maintenance of the entire radiotelephone network from a common station. The Mutual Telephone Company was anxious to obtain a system which could be left relatively unattended at the outlying islands; they desired means for quickly checking the frequency of all of the transmitters in the system to see that they were on their proper frequencies.

I proposed obtaining frequency assignments from the Federal Radio Commission which corresponded with the harmonics of a single quartz crystal oscillator. By the use of such a device, the harmonics of the oscillator would light ex-

actly on the assigned frequencies of the transmitters and if the transmitters were on frequency, they should beat with the proper crystal harmonic at the control station. If it should then be found that the transmitter did not beat with the crystal harmonic, it would be an indication that the transmitter was off frequency and it would then be desirable to obtain an approximate measure of how much the transmitter was off frequency and to further have some means by which the transmitters could be put back on frequency by remote control from the control station.

I propose to put the transmitters back on frequency by remote control through a system of step by step dial selectors and an on-off relay control. In order to accomplish these two functions, I propose to use two separate audio tone frequencies which may be sent out over the radio circuit by modulating one of the local transmitters. One of these tones will be used to operate the dial selector at the distant point, while the second tone would be used to operate a simple on-off relay after the proper point had been selected on the dial, thereby operating a motor, for example, which would tune the transmitter back on to its proper frequency.

In the prior art, it has been customary to use a quartz crystal oscillator as a frequency standard and to use the harmonics of this oscillator as markers throughout the radio frequency spectrum over which it was desired to make measurements. A comparatively complicated arrangement was required to interpolate between these harmonics in order to accurately determine the frequency of a station which lay between a particular pair of harmonics. A universal method of making this interpolation has been described in Peterson United States application Serial No. 535,910, filed May 8, 1931. In the present invention, it is not necessary to interpolate between harmonics and the only requirement is, that a simple means be provided for approximately determining a small frequency change close to one of the harmonics. A means for accomplishing this result is quite simple and will be described in more detail later.

In regard to the second feature of this invention, that is, the remote control idea, it has been the usual practice to have an attendant at each of the transmitting stations to maintain the transmitter in proper adjustment on its assigned frequency. By means of the invention described herewith, continuous attendance at the transmitter is not required since the adjustments

which must be most frequently made, can be made from a remote control center.

The novel features of my invention as required by law have been pointed out with particularity in the claims appended hereto.

The method of determining the frequencies and of controlling the stations of the system from any one of a plurality of remote points, and circuits for carrying out the same, will be understood by the following detailed description thereof and therefrom when read in connection with the attached drawings, in which:

Figure 1 shows diagrammatically a control station including the regular traffic receiver, a transmitter connected therewith, and the frequency checking receiver and crystal oscillator which forms a feature of the present invention;

Figure 2 shows a controlled station at a remote point; while,

Figure 3 shows a modification of the prior arrangements.

In Figure 1, I have shown the equipment required at the central control station. A monitor receiver including an aerial 18, radio frequency amplifier 19, demodulator 20 of the heterodyne type, oscillator O, intermediate frequency amplifier 21, etc., is shown. The receiver may be tuned to the frequency of any of the transmitters in the radiotelephone network. The transmitters in this network are set up with a uniform frequency spacing, such that their frequencies correspond with the harmonics of a crystal oscillator 26. The output of the crystal oscillator is amplified and applied to a negatively biased tube in the harmonic generator 27. I need not describe this harmonic generator in detail, as it has already been described in United States application No. 535,910, filed May 8, 1931, referred to above.

The harmonics from the harmonic generator 27 are applied to the high frequency detector or first detector, of the monitor receiver 20. Now if the monitor receiver 18, 19, etc., is tuned to one of the transmitters of the network, the transmitter frequency and the crystal harmonic frequency corresponding to this transmitter frequency should both be practically the same and both are applied to the high frequency detector 20, where they are combined to produce a lower frequency, i. e., the difference frequency, and are amplified by the intermediate frequency amplifier 21, which may, for example, be tuned to 1000 kilocycles. If the transmitter frequency and the crystal harmonic are close together, they will be detected in the intermediate frequency detector 22, and will be amplified by audio frequency amplifier 23, and the beat note between them will be audible in telephone 24. In the statement of operation given above it is assumed that the transmitter is on a frequency sufficiently close to its assigned frequency to produce an audible beat note in the telephone 24. If, however, the transmitter has drifted off frequency more than 10 or 15 kilocycles, no beat will be heard in telephone 24, and it will be necessary to put oscillator 25 into operation. This oscillator is calibrated over a range of say 900 to 1100 kilocycles. If the oscillator 25 is set at 1000 kilocycles, and the oscillations in the output of the high frequency detector 20 are adjusted until the proper harmonic from crystal oscillator 26 is heard at zero beat in telephone 24, then a simple adjustment of oscillator 25, will give an approximate measure of the difference in frequency between the crystal harmonic and the transmitter

frequency. This adjustment merely consists in raising or lowering the frequency of oscillator 25 until it is at zero beat with the intermediate frequency produced in the receiver intermediate frequency amplifier by the transmitter. If, for example, the transmitter zero beat occurred, on setting 25, at 980 kilocycles, then we would know that the transmitter was 1000 minus 980, or 20 kilocycles below its assigned frequency. Conversely, if the oscillator 25 had indicated 1020 kilocycles to produce zero beat with the transmitter, then the transmitter would have been 20 kilocycles above its assigned frequency.

The operation of the monitoring system will now be set forth more fully. Suppose the operator wishes to check a transmitter which is supposed to operate on a frequency F, but actually is on a frequency F+. The operator tunes 20 to a frequency F (19 is not operating) and then introduces into 20 the harmonic of crystal 26 which is equal to this frequency F. The high frequency oscillator O is now adjusted to about a frequency X which, when beat with the frequency F, produces a beat note of frequency Y to which the intermediate frequency amplifier 21 is tuned. Now, if the calibrated oscillator 25 is turned on and set at a frequency Y, a zero beat note should be produced in 23. If the beat note is not zero frequency it indicates that the high frequency oscillator O is not tuned exactly to the frequency X. The operator accordingly tunes O until the beat note frequency is reduced to zero. The tune of O is now known because the oscillator 25 is calibrated and the harmonic F of 26 is known. Now the radio frequency amplifier 19 is turned on and tuned to the wave of the transmitter to be checked whose frequency is F+, but should be F. This wave of a frequency F+ beats with the wave of a frequency X produced in O to produce in 21 a wave of frequency Y+. This wave beats with Y (say 1000 kc. wave) produced by 25 and a beat note equal to Y+ — Y is heard in the phones. 25 is now adjusted until zero beat is produced and the setting of 25 shows the kilocycle deviation of the transmitter from its assigned harmonic. The oscillator 26 is an accurate precision oscillator. The oscillator 25 measures difference frequencies.

The device described above permits the operator at the control station to ascertain in a simple and novel manner whether the transmitters of the system are on their assigned frequencies.

If a transmitter has shifted from its assigned frequency it may be brought back into tune by the novel device described hereinafter.

In Figure 1, I have also indicated the incoming line from the central office terminating in the hybrid coil 1, with a balancing network 3. The incoming signal from one of the distant stations would be received on antenna 17 and receiver 16 and applied to the midpoint of the hybrid coil where the energy divides between the line to the central office and the network. The output from the receiver then divides equally between the line and the network, so that no energy is induced in winding 2. Winding 2 is the output of the hybrid coil and carries the voice from the line over to the transmitter which is represented as including the essential elements including modulator 6 and power amplifier 7. The voice frequency currents are passed through a low pass filter 4 and coupling tube 5, for reasons which will be described later. There are also two oscillators 13 and 14, the oscillations from which may be applied to the modulator 6 for the purpose of controlling

circuits at the remote station. The oscillator 14 produces a tone which is utilized at the remote station to actuate a circuit selector relay. The oscillator 13 produces a tone which is used at the remote station to actuate a control relay. The invention is not limited to the frequencies selected since, obviously, other frequencies may be used.

If the dial 15 is operated it keys the 2700 cycles oscillator 14 and sends this modulated interrupted tone out over the transmitter 7. At the remote station shown in Figure 2 this modulated signal is picked up on antenna 28 and receiver 29 and the 2700 cycle tone is selected by band pass filter 31, and is further amplified and rectified at 32, and is applied to a quick acting selector control relay 33. The contacts 34 of this relay 33 are held open by a spring S but the relay will close in accordance with the impulses sent out from the control station by means of the dial. Closing the contact 34 of this relay connects two relays 35 and 36 with the energy source B. Thus the relay 33 actuates the two other relays 35 and 36. Relay 36 is a holding relay which actuates the holding pawl 37 and its operation is made slow by means of a dashpot DP. Relay 35 is rapid acting. When an impulse at 2700 cycles comes in the relay 33 closes its contact 34 in response to said impulse resulting from operation of dial 15. Relay 35 is energized and operates and pulls the drag 38 and moves the ratchet wheel RW in a clockwise direction one notch. The ratchet wheel RW is then held in position by the latch or pawl 37. If a second impulse of 2700 cycles is then received, the ratchet wheel switch is notched up one more point. It is obvious that the ratchet wheel switch will be advanced a number of points corresponding with the number of impulses at 2700 cycles sent over the circuit by the dial 15 at the control station, and, that the switch 39 will be held stationary on the final notch by the latch or pawl 37.

Now if the oscillator 13 of Figure 1 is energized by closing switch 10, a 500 cycle tone is sent over the radio circuit where it is selected by band pass filter 40 and is amplified and rectified at 41 and operates control relay 42. This relay is also slow acting on account of dashpot 44. This may not be necessary in some cases, but the slow action of relay 42 is a means of assuring that the relay will not be operated by momentary voice currents which might come through the filter 40 when the circuit is being used for conversations. After the 500 cycle tone has been on for a period sufficient to close the contacts 43 of relay 42, current will flow from battery 46 through the selector switch arm 39 to whatever mechanism may be associated with the particular contact on the selector switch which has previously been dialed. For example, if the operator at the control station dials #1 a single pulse of 2700 cycles would go out from 8, be received at 28, and pass through 31 and 32 to actuate 33 to move the ratchet wheel RW one step so that contact 39 comes to rest on contact #1 to close the circuit including 46 and bell 50 at this point. Then when switch 10 of Figure 1 is operated to send out a 500 cycle pulse long enough to close contact 43, the circuit through 50, 46 will be closed and the bell 50, which might be placed in the living quarters of the attendant, for example, will ring. This serves to call the attendant to the transmitter room in case of necessity. If the control operator wishes to correct the frequency of the transmitter, he may dial #4. This may send out

four 2700 cycle pulses, which will be received by 28. These pulses will advance the wheel RW forward four steps so that 39 would come to rest on contact #4 to close at this point the circuit through source 46 and relay windings 51 and 52. Now, if the operator presses switch 10, a 500 cycle note will be sent out and 42 will be energized to close 43 and current from battery 46 will energize relay windings 51 and 52 to close contacts 55 and 56. When the contacts 55 and 56 of these two relays close, they put the armature of the motor 61 across the battery 59 and the motor then revolves in one direction, such as, for example, the direction necessary to raise the frequency of the transmitter. It should be noted that the field of this motor, shown at 60, is permanently connected across the battery 59.

If the operator at the control station had desired to lower the frequency of the distant transmitter, he would have dialed #5 and then the operation of the on-off relay 42 would have operated relays 53 and 54. This would have closed contacts 57 and 58, putting the armature of the motor 61 across the battery 59 with the polarity reversed so that the motor would operate in the reverse direction and lower the frequency of the transmitter.

It is obvious that the rotation of the motor 60, 61 may produce or cause frequency control in many ways, such as by operating a variable condenser or a variable inductance, etc. The particular arrangement used in the Hawaiian Islands, however, is the long line control method and for the purpose of adjusting the frequency, a trombone tube 67, connected by line 7' to 5', has been connected with a rack 66 and a pinion 65. Rotary motion of wheel 64 will decrease or increase the electrical length of the long line 67 and raise or lower the frequency of the power amplifier 5'. The wheel 64 may be driven by the motor in any manner. I have shown the wheel 64 as being driven by a belt, which in turn is driven by a pulley on the shaft 62 of the motor.

After an operation has been completed, as, for example, adjusting the frequency of the transmitter, or calling the attendant by ringing the bell 50, the selector switch can be returned to the zero point by pressing the switch 12 of Figure 1. This sends out a continuous 2700 cycle tone which energizes 33 continuously and holds relay contact 34 closed. This enables the slow acting relay 36 to operate so that it finally pulls up latch or pawl 37 and allows a spring, not shown, to return the wheel RW and contact arm 39 to the zero point of the selector device. The selector switch is now in readiness for dialing any other combination that may be desired.

Since the operation of the whole system depends upon the position of the selector switch contact arm 39, it would be highly undesirable for this switch to be operated by stray currents. Since the relay 33 must be quick acting, it is not possible to protect it against operation by momentary voice currents with a dashpot as was done in the case of relay 42. To avoid this difficulty, I propose to use a low pass filter 4 at the control station, which cuts off everything above 2500 cycles, so that no voice currents will exist at 2700 cycles, which might get through the band pass filter and operate the selector relay at the remote station.

Incidentally, in connection with the operation of the slow relay 42, of Figure 2, it should be pointed out that the relay is forced to close slowly on account of the dashpot 44, but it must

open quickly in order that it may return to its starting point. This switch is opened by the tension on the spring 45.

I have also shown means which will enable the operator, at one central office, to ring over the radio circuit to the operator at a remote station. The ringing current from the central office, connected with the control station of Figure 1, sends ringing current over the line which operates relay 9 of Figure 1 to close contact 11. This relay is slow opening, so that as long as the winding of relay 9 is energized by ringing current, the contacts 11 will remain closed, thus sending a long continuous dash of 500 cycle modulation out over the air.

At the remote station shown in Figure 2, the ratchet wheel RW will not have been moved and it will be resting in a position such that 39 is on the zero point. The long dash of 500 cycle modulation will energize the winding of the slow acting relay 42 and close 43, thereby completing a circuit through 46 and energizing buzzer 48 with energy from battery 46. The contacts 49 under the magnetic action of 48 will then open and close intermittently as in the case of an ordinary buzzer. The armature of this buzzer should be loaded mechanically so that it will vibrate at a period of, say, 16 cycles per second, corresponding with the normal ringing currents. The output from this buzzer passes through transformer 47 onto the midpoints of the hybrid coil 1 and thence to the central office at the remote station, where it signals the operator in the normal manner. In order to keep this buzzer current from exciting the band pass filters 31 and 40 and thereby causing false operation of the relays, I have shown a coupling tube 30 which isolates the filters from the ringing current. It is obvious that the operator at the control station would have rung long enough for the relays to operate at the remote station, but the relays could be adjusted such that if the operator rings for three or four seconds, the relays will operate and at the same time will still give the desired protection against false operation by momentary voice currents.

At the remote point of Figure 2 four different operations may be carried out, as described hereinbefore in connection with Figure 2.

1. The attendant can be called by sending out a single 2700 cycle impulse and a 500 cycle dash.
2. The circuit for raising the frequency of the transmitter 8' at the remote point may be prepared by sending out four 2700 cycle impulses to actuate the ratchet wheel and close the circuits through 51, 52 so that the 500 cycle tone may be sent out to tune the transmitter.

3. The circuit for lowering the frequency of 8' may be completed by sending out five 2700 cycle impulses before the 500 cycle tuning impulses are sent out.

4. Ringing current may be sent out to all remote stations from the control station by sending from the control station ringing current to close 11.

It is obvious that several other functions could be added. For example, the first operation of calling the attendant could be arranged for starting up the transmitter, while operation two might be arranged for stopping the transmitter. A sixth operation could be used for increasing the gain of the audio frequency energy supplied to the modulator, while a seventh operation could be arranged for decreasing the gain of the audio frequency supplied to the modulator. I have not shown these functions, as the means

for carrying them out is perfectly obvious and it would unnecessarily complicate an understanding of the diagram if these functions were shown in detail.

While I have shown a remote control means applied to a radio circuit, it would be possible to apply the same mechanism for operation over a land line. I have shown such a modification in Figure 3. In this case, instead of using two frequencies, I propose to use currents of two polarities, for example, if the switch 70 is thrown to make contact with contact 71, and the dial 72 is operated, it will send positive impulses over line 73, which will energize relays 74 and 75 at the receiving end. These relays may both be quick acting. Relay 74 must be quick acting. However, these relays are polarized and the positive impulses will not operate the tongue 76 of relay 75, but will operate the tongue 77 of relay 74, thus causing the tongue to make contact with contact 78. This connects battery 86 and energizes both relays 79 and 80, but since relay 79 is slow closing on account of the dashpot 81, only relay 80 will operate on the impulses from the dial 72. These impulses will notch up step by step selector relay ratchet wheel 82 in accordance with the number of impulses dialed at the control end of the line. For example, if the operator dials 5 the selector switch ratchet wheel 82 will rotate and 83 will make contact with point 5. Now, if the switch 70 is swung over to contact 84, a negative impulse will be sent over the line. This negative impulse does not operate polar relay 74, but it will operate polar relay 75, thereby passing current from the battery 85, up through the selector switch and arm 83 to point 5, then down to relay 87. When relay 87 is energized, it closes contacts 88, 89 and 90, 91, thus connecting the armature of motor 92 across the battery 93, causing it to turn dial 94 in one direction. On the other hand, if the operator had dialed #6, the same sequence of events would have operated relay 96, causing the motor to close contacts 97 and 98, and turn the dial 94 in the opposite direction. Motion of the dial 94 may be utilized to tune signalling circuits or for other purposes. When it is desired to return the selector switch to zero the switch 70 will be thrown to contact 71 and a long impulse of positive current will be sent out by operating switch 100, thereby closing polar relay 74 and energizing slow relay 79, pulling down latch 73, and allowing the selector switch and ratchet wheel 82 to be pulled back to its zero position by a spring not shown.

The field winding 95 of the motor at the remote point is energized by the source 93. The positive and negative pulses dialed from the control point dial 72 are supplied from batteries 101 and 102 respectively.

The system, of course, may also be used to control a transmitter, that is, turn the transmitter on and off and tune the same from a remote point. For example, if the operator at the control station dials #9 on dial 72, relay 74 notches the selector switch 82 up nine steps so that the contact 83 comes to rest on point 9. Then when switch 70 is thrown to the right to complete a circuit through the negative battery 102, 75 is energized and the tongue 76 thereof is pulled against its spring biased to close its contact and can complete a circuit through battery 85, selector switch point 9 to polar relay or winding 104. When the winding 104 is energized the tongue 106 connected with the armature of said relay is moved to the right to bear on contact 75

107. This completes a circuit from the power supply not shown to the transmitter 112, which in this manner may be rendered operative. The polar relay including the elements 105, 106 and 107 is so adjusted that the tongue 106 remains on contact 107 until the operator at the control point dials #8 after the switch 70 has again been moved to the left hand position so that positive impulses of current passing over the control line energize the winding or relay 74 to close contact 78 and step the ratchet wheel up to a point at which the contact 83 bears on point #8. This closes a circuit through winding 103 of the polar relay. The armature 106 is drawn to the left to bear on contact 105, thus deenergizing the winding 110 of the power circuit contactor relay. Deenergizing winding 110 permits contact 109 to open, thereby breaking the energizing circuit to the transmitter, which becomes inoperative. The transmitter 112 may be replaced by a receiver. The receiver or transmitter in 112 may be tuned by the element 90 to the desired frequency, as set out hereinbefore.

In conclusion, therefore, it may be noted that I have provided a novel means for checking the frequency of a plurality of transmitting stations. This checking operation may be done with a single monitoring circuit, thus eliminating the necessity of separate frequency checkers at each transmitter. The present invention also provides means which eliminates the necessity of keeping an attendant on duty at many of the stations since the apparatus at said stations may be controlled to the extent indicated above by my novel control scheme.

Having thus described my invention and the operation thereof, what I claim is:

1. A monitoring system to be used with a signaling system including a plurality of transmitters each operating at different harmonically related frequencies comprising, signal receiving means of the heterodyne type including a radio frequency amplifier, a source of local oscillations and a demodulator, an oscillation generator of the constant frequency type including a crystal the frequency of which crystal is equal to the difference or to a sub-multiple of the difference between the frequencies assigned to the wave transmitting stations, a connection between said oscillation generator and the input of the demodulator of said receiving means, an intermediate frequency amplifier coupled to the output of the demodulator of said receiving means, and an indicator coupled to the output of said intermediate frequency amplifier.

2. The method of monitoring a transmitting system including a plurality of transmitting stations each operating at different assigned frequencies which are harmonically related which includes the steps of, producing high frequency local oscillations which may be beat with said transmitter frequencies to produce therewith beat notes, producing oscillations of constant frequency which frequency is equal to the difference or to a sub-multiple of the difference between the frequencies assigned to the various transmitters of said system, producing harmonics of said constant frequency oscillations which harmonics are equal to the frequencies assigned to the different transmitters of said system, combining said harmonics with said locally produced oscillations to produce beat notes of intermediate frequency, and comparing said beat notes of intermediate frequency with

locally produced oscillations of known intermediate frequencies.

3. The method of monitoring a transmitting system including a plurality of transmitters each operating on a different assigned frequency including the steps of, producing local high frequency oscillations, producing local oscillations of constant frequency which is equal to the frequency of operation of the transmitter to be monitored, beating said local oscillations of high frequency with said local oscillations of constant frequency to produce a beat note, producing intermediate frequency oscillations of a frequency of the order of the frequency of said beat note, beating said intermediate frequency oscillations with said beat note to produce a second beat note, adjusting the frequency of said locally produced oscillations of high frequency until said second beat note is zero, beating energy from said transmitter to be monitored with said first named locally produced high frequency oscillations to produce a third beat note, and comparing said third beat note with the frequency of said intermediate frequency oscillations when said zero beat note is obtained.

4. In a monitoring receiver to be used with a signaling system in which a plurality of geographically spaced transmitters are operated at different harmonically related frequencies, an oscillator controlled by a crystal the frequency of which crystal is equal to the difference or to a sub-multiple of the difference between the several harmonically related frequencies of the transmitting station of said system, a demodulator of the superheterodyne type coupled to said oscillator controlled by said crystal, a wave receiving circuit which may receive waves from each of said transmitters, an intermediate frequency oscillator coupled to said receiving means, and an indicator coupled to said intermediate frequency oscillator.

5. The method of checking the tune of a plurality of transmitters operating in a system wherein each transmitter is assigned a frequency which is harmonically related to the frequency of the other transmitters which consists in, producing high frequency oscillations of a constant frequency equal to the frequency assigned to the transmitter to be checked, producing other high frequency oscillations which differ from said first produced oscillations of constant frequency by a beat note of intermediate frequency, beating said oscillations to produce said beat note of said intermediate frequency, producing oscillations of a known intermediate frequency, beating said last produced oscillations of known intermediate frequency with said beat note, and varying the frequency of said second produced high frequency oscillations until zero beat note is obtained between said intermediate frequency beat note and said produced oscillations of known intermediate frequency, resonating energy characteristic of the energy transmitted from the transmitter to be checked, beating said resonated energy with said second produced high frequency oscillations to produce a beat note, and comparing said beat note with said produced oscillations of said known intermediate frequency to determine the deviation of said transmitter from its assigned frequency.

6. In a monitoring receiver to be used with a signaling system in which a plurality of geographically spaced transmitters are operated at different harmonically related frequencies, an oscillator controlled by a crystal the frequency

of which crystal is equal to the difference or to a sub-multiple of the difference between the harmonically related frequencies of the transmitting stations of said system, a harmonic generator coupled to said oscillator, signal receiving means, amplifying means coupled to said signal receiving means, a demodulator coupled to said amplifying means and to said harmonic generator, a source of high frequency oscillations coupled to said demodulator, an intermediate frequency amplifier coupled to said demodulator, an intermediate frequency detector coupled to said intermediate frequency amplifier, indicating means coupled to said intermediate frequency detector, and a source of intermediate frequency oscillations of variable frequency coupled to said intermediate frequency detector.

7. The method of monitoring a plurality of transmitter stations each operating at different harmonically related frequencies which comprises, producing oscillations of a constant frequency which are equal to the difference or to a sub-multiple of the difference between the frequencies of the several transmitter stations, producing harmonics of said frequency, combining said harmonics with energy from said transmitters to produce a beat note, and comparing said beat note with the beat note produced between other high frequency oscillations and said harmonic frequencies.

8. The method of monitoring a transmitting system including a plurality of transmitters each operating at different assigned harmonically related frequencies, which includes the steps of, producing oscillations which are equal to the difference or to a sub-multiple of the difference between the assigned harmonically related frequencies, producing harmonics of said oscillations equal to the assigned frequencies, combining said harmonics with energy from said transmitters to produce beat notes, and comparing said beat notes with

beat notes produced by beating other local oscillations with said harmonics.

9. The method of monitoring a transmitting system comprising a plurality of transmitters each operating at different assigned frequencies which are harmonically related including the steps of, producing oscillations of a constant frequency equal to the difference or a sub-multiple of the difference between the assigned frequencies, producing harmonics of said oscillations, combining said harmonics with signal energy from said transmitters, demodulating said combined energy to produce beat note energy of an intermediate frequency, producing other local oscillations, beating said other local oscillations with said harmonic to produce other beat notes, and comparing the frequency of said beat notes.

10. The method of monitoring a transmitting system comprising a plurality of transmitting stations each operating at different assigned frequencies differing by a constant difference frequency which includes the steps of, producing local oscillations of high frequency, producing constant frequency oscillations equal to the difference or a sub-multiple of the difference between the frequencies assigned to said several transmitting stations, producing harmonics of said constant frequency oscillations, beating said high frequency oscillations with said harmonic frequencies to obtain beat notes, combining said high frequency oscillations with signal energy received from said transmitting stations to produce beat notes equal to the difference between the frequencies transmitted by the several stations and the assigned frequencies, comparing said first beat notes with the last beat notes to determine the amount any of said transmitters have deviated from their assigned frequency, and retuning any of said stations, the frequency of which deviates from the assigned frequency.

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