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H. L. DIETRICH

2,369,542

RECEIVER

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2 Sheets-Sheet 2

Fig. 4

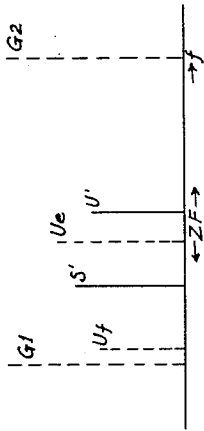


Fig. 6

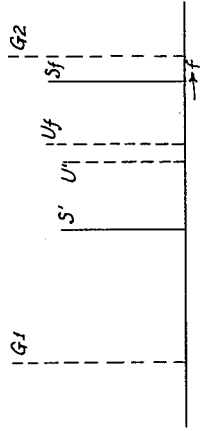
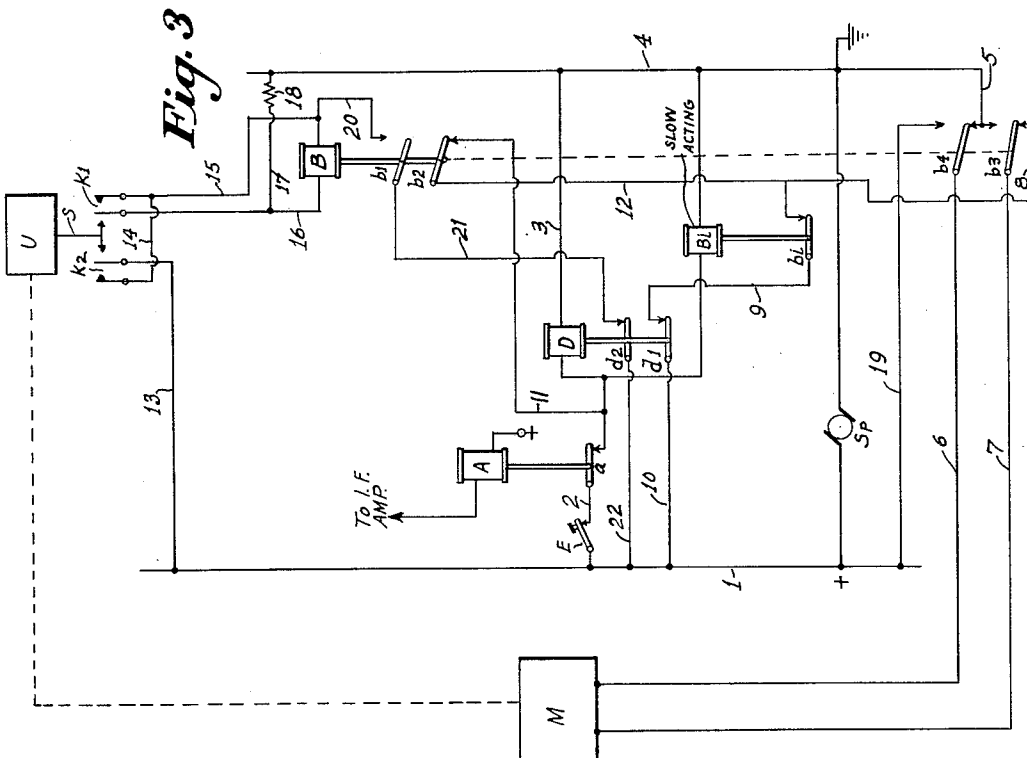
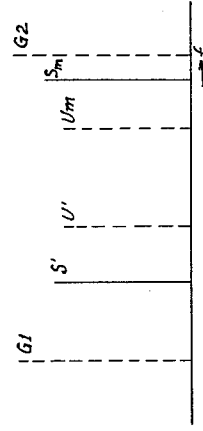


Fig. 5



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UNITED STATES PATENT OFFICE

2,369,542

RECEIVER

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4 Claims. (Cl. 250—40)

The present invention relates to a tuning arrangement for receivers which can be used more especially for ultra-short waves and decimeter waves. It is known that in case of short waves it is not possible to achieve as high a degree of constancy of the frequency as in the case of longer waves, since changes in the relative distances of the tube electrodes caused by temperature variations, for instance, have an essential influence upon the frequency which is not experienced in the case of long waves. Therefore, the frequency of a short wave transmitter inevitably fluctuates beyond the band width of the input circuit of the receiver such that reception stops or when resuming the communication cannot be realized at all. Furthermore, the same drawbacks are inherent in the oscillation generators employed as oscillators in superheterodyne receivers and thus the produced intermediate frequency deviates from the desired value not only on account of the variation of the transmitter wave, but also on account of the variation of the local oscillator frequency. In order to insure a safe operation means must therefore be employed which enable the receiver to receive waves which are unstable within a certain frequency range. Thus it has become known, for instance, to wobble the frequency of the local oscillator of the receiver at a frequency lying beyond the audible limit, about a low value so that also the intermediate frequency fluctuates periodically about an average value. The permissible fluctuation width of the transmitter frequency however, is hereby extremely small with the result that in most cases this arrangement is insufficient for practical purposes. Furthermore, it is known that the receiver can be sharply tuned in an automatic manner to the transmitter wave whereby disturbances caused by the lack of constancy of the transmitter wave, can also be avoided within narrow limits. But since the range of this automatic vernier tuning is very narrow, this arrangement fails also if for instance at the switching-in of the receiver, the transmitter wave lies outside the range of the vernier tuning.

In accordance with the invention an entirely safe reception of the desired transmitter is rendered possible in that a pendulum movement of the tuning device of the receiver, within which a frequency range will be swept which corresponds to the possible fluctuation range of the transmitter frequency, is automatically stopped at resonance of the receiver with the transmitter frequency and at the same time an arrange-

ment for the automatic vernier tuning is switched-in or becomes effective.

This offers the advantage that the range of the automatic vernier tuning can be chosen as small as desired, i. e. its accuracy can be chosen extremely high, while wide fluctuations of the transmitter frequency or local oscillator frequency are still admissible.

The first-mentioned feature of the invention, namely the periodic oscillatory movement of the tuning device will be termed "finding performance" or "searching operation" denoting that the receiver proceeds to find automatically the transmitter wave within a given range and holds on to this wave in this tuning stage at resonance with the transmitter wave. The second feature of the invention, namely, the automatic vernier tuning which can be carried out in any desired manner, serves for enabling the receiver to follow continuously eventual variations of the transmitter frequency.

It is readily seen that with the method of tuning carried out in accordance with the invention, the reception is always accomplished in exactly the same manner as in the case of the normal receiver so that all disturbances caused for instance by the wobbling of the local oscillator are eliminated. It should be remarked at this point that the arrangement according to the invention is equally effective whether the frequency of the transmitted wave to be received or the frequency of the local oscillator in a superheterodyne receiver is incapable of being maintained constant. Since at ultra-short waves superheterodyne receivers are often used and the transmitters can usually be operated at a constant frequency by well-known means, the invention will be applicable more frequently to the case involving fluctuation of the local oscillator frequency.

For a clear understanding of the invention, reference will be had to the accompanying drawings wherein Fig. 1 shows schematically a radio receiver circuit to which the present invention is applied; Fig. 2 shows a practical construction of the motor switch reversing mechanism that is employed in Fig. 1; Fig. 3 is a modified form of the invention; and Figs. 4 to 6 are graphs which will serve to explain the invention under certain conditions of operation.

Referring now to Fig. 1, item H represents the high frequency amplifier and the mixer stage of a superheterodyne receiver to which there is applied in addition to the received frequency the frequency of the local oscillator which is indi-

cated only by an oscillator circuit O for the sake of simplicity. The resultant intermediate frequency is amplified in the intermediate frequency portion Z, then demodulated and applied to the audio-frequency portion N of the receiver. In order to find the transmitter wave that is desired to be received, the variable tuning condenser C of the local oscillator tuned circuit O is caused to be oscillated through a certain frequency range. To this end a motor M is provided which turns the variable condenser of the local oscillator through a certain angle after which the polarity of the motor is reversed by means of a switch reversing mechanism U which actuates the contacts *u*, thereby causing the condenser O to rotate in the other direction. If, for instance, the control switch E which is coupled for example with the main switch of the receiver proper, is closed, the finding performance starts immediately irrespective as to whether or not a transmitter wave is present.

Now, when the desired transmitted signal is being received and the oscillator condenser C assumes its correct position of tuning, the current passing through the intermediate frequency tubes changes at this moment so that the relay A which is included in the plate circuit of one or of all intermediate frequency tubes will be actuated or energized. The movable relay contact pertaining to relay A is shown at *a*, being included in the energizing circuit of the motor M and adapted to close said circuit in the position of rest, that is, when relay A is not energized. As soon as the correct resonance position of the receiver is attained, the relay A will open contact *a* thereby breaking the motor energizing circuit and causing the motor to come to a stop.

The starting of the finding performance at the switching-in of the receiver may be delayed until the receiver has reached the operative state, i. e. until the tubes are heated up. Furthermore, the finding performance may be started only after if it is ascertained in any desired manner that a received signal is present within the intermediate frequency range. In the latter instance, the control switch E will not be coupled to the main receiver switch, as mentioned above, but will be separately actuated and after the presence of a signal is ascertained.

The mode of carrying out the finding performance according to the invention is not limited to the arrangement shown in Fig. 1; the oscillatory movement of the tuning condenser C may also be obtained by purely electrical means, for instance, with the aid of relaxation circuits through which an inductance, or a capacity, has its value varied periodically. Furthermore, the potential which causes the stopping of the oscillatory movement may be derived at any desired place of the receiver, such as at the high frequency portion. In the case of a receiver of the tuned radio frequency type the tuning of the receiver input circuit may, for instance, be varied periodically and this variation may be interrupted directly by the current of the high frequency tube.

In Fig. 2 there is shown by way of example a practical construction of the switch reversing mechanism U shown schematically in Fig. 1. The shaft of the variable condenser C of the oscillator tunable circuit is shown at T and is suitably coupled with the motor M shown in Fig. 1 of the drawings. The shaft has rigidly connected to it a lever S which is provided at its free end with switch actuators J, J. A sta-

tionary ring R is arranged concentrically to the shaft and two levers H₁ and H₂, which are freely mounted on the shaft T, are each adapted to be clamped to said ring in any desired position by means of a clamping screw F. The levers H₁ and H₂ are provided at their outer ends with the contacts K₁ and K₂, respectively. Now, if the shaft T is driven by the motor in such direction to cause the lever S to turn clockwise, for example, the lever S will arrive at the contact K₁ and actuate the latter which in turn will actuate the reversing switch *u* so that the direction of motor operation will be reversed. The lever S will then turn in the other or counter-clockwise direction until it reaches the contact K₂ thereby again reversing the polarity of the motor, etc. The limits and the central position of the frequency range covered by the tuning device C can be set at will through separate adjustments of the contact levers H₁ and H₂. The positions of these levers are fixedly established in advance depending upon the various transmitters to be tuned in. The lever positions may be fixed at suitable points by means of corresponding stop members (not shown) carried by the ring R. Obviously, also for the reversing arrangements various structural solutions can be found all of which are suited for practising the general idea of the invention.

As already pointed out the hitherto described finding performance is switched in simultaneously with the switching-in of the entire receiver, so that until the transmitter wave is found, the tuning device is periodically moved in an oscillatory fashion through a predetermined range. If no transmitter frequency exists within the searching range, the tuning device carries out a continuous pendulum movement so that the absence of a transmitter carrier can be readily verified from the outset. If, however, a transmitter wave is present, the finding performance is stopped when the correct tuning position is reached. But since the transmitter frequency or local oscillator frequency does not remain constant, the receiver would very soon fall out of its correct tuning position entailing failure of reception. In order to avoid this condition there is inserted in accordance with the invention simultaneously with the switching-in of the finding performance, an arrangement for the automatic vernier tuning. This arrangement may be of any desired type and may be constructed in a manner known as such. It will, however, be advisable to employ for the automatic vernier tuning the same means as those employed for finding the transmitter wave as will be described in greater detail in the following. In order to obtain a control voltage through which the receiver is always brought automatically into the correct position of tuning, there may be employed, in a manner known as such, two circuits F₁ and F₂ which are detuned relatively to each other and which are placed for instance in the intermediate frequency circuit of the receiver and whose voltages are detected by the rectifiers D₁ and D₂ and connected in opposition. A detuned circuit arrangement of the type just described is shown in the Round Patent 1,642,173. If the frequency applied to these circuits varies, the control potential also varies in an unequivocal fashion. Since when operating with ultra-short waves, frequency modulation is ordinarily employed, the arrangement for obtaining the control potential can be advantageously used at the same time for the demodulation of the frequency

modulated oscillations, since as is known, two relatively detuned circuits connected in opposition across detectors as shown in the Conrad Patent 2,057,640 are in fact likewise suited to this end.

The control voltage now is applied, for instance, to a tube T' in whose plate circuit a differential relay DR is placed. At the mean frequency which corresponds to the required frequency, the relay contact RC is in its central position, as shown. When the frequency applied to the two circuits increases, the relay contact moves in the one direction, and when the frequency decreases, the said contact moves in the other direction. Now, if the relay is so placed in the circuit of the motor M shown in Fig. 1, that the relay contacts determine different directions of rotation of the motor assigned thereto, the tuning of the oscillator O in Fig. 1, will be affected when a control potential appears. Now, if the dependence of the direction of rotation of the motor on the direction of the variation of the control voltage is chosen in such a sense whereby in the case of an increase of the signal frequency being received a rotation of the motor in the direction of low frequencies takes place, the receiver will place itself always in the desired position of tuning. When the transmitter frequency changes, the receiver tuning follows in the proper sense.

In applying the general idea of the invention there is thus assured the finding of the transmitter frequency lying at any desired place of the given range, and furthermore, always a correct tuning of the receiver in spite of fluctuations of this frequency.

If during reception the frequency of the transmitter carrier or the frequency of the local oscillator changes suddenly over too wide a range which cannot be followed-up by the automatic vernier tuning, the finding performance sets-in anew and continues until the transmitter wave is found again. It is therefore advantageous to have the finding performance switched-in with a certain delay, instead of being initiated instantaneously, since it happens often that the transmitter wave varies its frequency during a brief moment but later resumes its assigned frequency. Thus, the stopping of the finding performance may, after reaching the correct tuning position, take place by means of an immediately responding or quick acting relay, while the next switching-in is carried out by means of a special time delay relay. A circuit of this type is shown in Fig. 3 and will be described hereinafter. The time delay is hereby provided in a manner known as such, for instance, in that a bi-metal strip establishing the contact is passed by the current which initiates the finding performance, such that the contact will be closed only at sufficient heating.

In the operation with ultra-short waves, the distribution of the various transmitters and the ranges thereof across the frequency band are of particular importance. In order to avoid disturbances of the receiver owing to the image frequencies, it is of advantage so to adapt the arrangement that the finding performance is finally stopped only when the frequency of the local oscillator lies at the one predetermined side of the transmitter frequency. This condition will be now elucidated by reference to Fig. 4. In this figure the frequencies are plotted along the abscissa. The vertical solid line S' indicates the normal position of the wave being received

and U' is the desired position of the frequency of the local oscillator of the receiver. Then the intermediate frequency ZF is obtained which would be plotted in the same way if the frequency of the local oscillator were at the place U_r. In order to avoid disturbances due to the reception of image frequencies it is required however that the local oscillator operate at position U'. The vertical dash-lines G₁ and G₂ may represent the limits of the range covered during the finding performance. Now, the correct choice of the frequency of the local oscillator to be obtained automatically can be realized in that, through suitable choice of the initial direction of rotation of the motor, the frequency of the local oscillator which may be at the place U_e, for instance, at the switching-in of the receiver, is always moved in the direction toward the limit G₂ at the switching-in of the receiver and away from this limit, whereby contact arrangements are provided in such a manner that the finding performance can be stopped only when the tuning device has been reversed once at the limit G₂. Therefore, if the tuning device is moved such that U_e moves to the right, it cannot as yet be stopped at the place U' but must first reverse its movement at the limit G₂ in order to enter the correct tuning position at U' in arriving from the right and be fixed in this position.

As can be readily seen, it can then never happen that the finding performance will be interrupted in the tuning position U_r. In fact if U_e is between the limits G₁ and U_r, for instance, and if, as is required, it is caused to move initially to the right, it cannot be stopped either in position U_r or in position U', but must first reverse its movement at the limit G₂ in order to arrive in the final position U' from the direction of higher intermediate frequencies. If, however, U_r is to be the desired position of the local oscillator frequency, while U' is the wrong local oscillator tuning, the initial movement must take place towards the left and the arrangement must be so adapted that the finding performance can be stopped only after a reversal at the limit G₁. The same conditions must then be fulfilled as before.

If the transmitter frequency should have moved such a distance that the correct tuning position cannot be found at all within the range of finding, the receiver cannot stay on a wrong tuning position because the automatic vernier tuning operates in the wrong direction in this case and the receiver moves out of its tuning position again. The prevailing conditions in this instance are shown in Fig. 5. The limits of the finding performance are again designated by G₁ and G₂ while S' represents the normal position of the transmitter frequency and U' is the correct position of the frequency of the local oscillator. Now, if the transmitter frequency moves towards the place S_m, the proper position of the frequency of the local oscillator would lie outside the limits of the finding range, namely, outside the limit G₂ and thus the receiver cannot move into this position.

On the other hand it would be possible to have the receiver remain tuned with the tuning of the local oscillator at the place U_m because with this adjustment the proper intermediate frequency is obtained with the transmitter frequency S_m. This condition however could not be prevented through the described method of adjusting the receiver only after the tuning means has been reversed at a limit of the range. But in this case

the automatic vernier tuning operates in the wrong direction, i. e. when the frequency of the local oscillator approaches the place U_m the control voltage acts in the sense whereby the tuning means is turned beyond the place U_m so that U_m is likewise not suited as the final tuning position. This condition can therefore serve for verifying the fact that the transmitter frequency or the receiver frequency has departed too far from its assigned frequency, i. e. that the range defined by the limits G_1 and G_2 is too narrow.

A circuit fulfilling these conditions is shown in Fig. 3. Herein M is the motor and U is the reversing mechanism just as in the case of Fig. 1 whereby said mechanism acts upon the two contact pairs K_1 and K_2 in accordance with Fig. 2. As in Fig. 1, item A designates the relay which serves to initiate the finding performance of the tuning position. The appertaining contact is designated by a which is closed at an incorrect tuning, or in the absence of the transmitter wave. E corresponds to the similarly labeled switch in Fig. 1. Now it is assumed that the correct tuning position has not yet been reached and that, therefore, the contact a is closed. Consequently, the relay D, which is energized by the circuit from the + side 1 of the source Sp, conductor 2, closed contact a , relay D, conductor 3 to the - side 4 of the source, will be actuated to close its contacts d_1 and d_2 . The relay D has placed in parallel thereto the time delay relay B having the contact b_1 and which, as already stated, serves for causing the finding performance to start with a certain time delay. Otherwise this relay and its contact correspond with the relay D and its contacts.

The motor M is now in operative condition, receiving its energizing voltage across the contacts b_3 and b_4 from the voltage source Sp, the motor circuit being traced from the - side 4 of source Sp, conductor 5, contact b_4 , conductor 6, through motor M to conductor 7, contact b_3 , conductor 8, contact b_1 , conductor 9, contact d_1 and conductor 10 to the + side 1 of the source. As a consequence the lever S of the reversing mechanism U has now moved to the left. If during this motor operation the tuning device passes a place in which a correct intermediate frequency appears, the contact a will be opened. However, rotation of the motor can not as yet be interrupted, since the relay D continues to be energized by reason of the following circuit: negative side of the source, conductor 3, relay D, conductor 11, contact b_2 which is closed in the position of rest, conductor 12, contact b_1 , conductor 9, contact d_1 and conductor 10 to the + side 1 of the source. As a consequence the motor circuit remains energized by the circuit above traced which has not yet been broken. Thus, the tuning arrangement moves beyond this position and the lever S arrives at the contact k_2 which is closed thereby. The relay B will then be energized through the circuit which is completed as follows: from + side 1, conductor 13, contact K_2 , conductors 14 and 15, relay B, conductors 16 and 17, resistor 18 to the negative side 4 of the source. The contact b_1 will then be closed, while the contact b_2 will be opened and the contacts b_3 and b_4 will be moved to their upper positions. Meantime the contact a has closed again since the tuning has moved beyond the correct value of the intermediate frequency. The switching of b_3 and b_4 upwardly has the effect of reversing the direction of rotation of the motor since the conductors 6 and 7 leading to the motor will have their

polarities reversed from what they were previously, conductor 6 being connected through contact b_4 and conductor 19 to the + side and conductor 7 being connected through contact b_3 and conductor 5 to the - side of the source.

With the reversal of the motor as above described the lever S will be moved to the right, opening contact k_2 and closing contact k_1 . However, when the contact k_2 is opened the relay B remains energized by reason of the completed circuit from the negative side 4, resistor 18, conductors 17 and 16, relay B, conductor 20, contact b_1 (which is closed), conductor 21, contact d_2 and conductor 22 to the positive side of the source. Now, if a correct position of tuning is arrived at again, the contact a will be opened and therefore, the motor circuit will be broken because the contacts b_1 and d_1 will be open while b_2 was open in the first place due to the excitation of relay B and thus the relay winding D no longer receives current. As soon as D is deenergized, d_2 will be opened thus deenergizing relay B so that contact b_1 will be opened and contact b_2 will be closed. But the motor cannot start again since d_1 and b_1 are open. Now, then, owing to relay B being inactive, the contacts b_3 and b_4 return to the downward position of rest as shown, and the initial state is again realized thereby permitting repetition of the same performance in exactly the same manner when the transmitter wave is interrupted.

If no transmitter wave can be found within the entire frequency range covered by tuning element C, the lever S moves to and fro between the contacts k_1 and k_2 . A short circuit of k_2 results in a switching of the contacts b_3 and b_4 as already pointed out and these contacts remain in the upward position since d_2 is closed in the position of rest and b_1 will likewise be closed when k_2 is short circuited. It is only when the lever S arrives in the other limit position and short circuits the contact k_1 that the winding B will be short circuited so that b_1 will be released and b_3 as well as b_4 return again to the position of rest. The direction of rotation of the motor will then be reversed.

With the circuit illustrated in Fig. 3 it can be accomplished in fact that only a single one of the possible positions of the frequency of the local oscillator with respect to the transmitter frequency leads to the stopping of the finding arrangement. The automatic vernier tuning will in no ways hereby be effected since the local oscillator is obviously always correctly controlled once it has been given its proper position. As already explained in connection with Fig. 4, in the case of a position of the frequency of the local oscillator at the other side of the transmitter frequency, the initial direction of rotation in Fig. 4 must obviously be upwards and the contacts k_1 and k_2 must be interchanged.

It will be shown with respect to Fig. 6 that in applying the idea of the invention and in employing an additional means a substantial saving in the band width required for any transmitter is realized and that the transmitters can be placed nearer each other without mutual disturbance being encountered. If S' represents again the transmitter frequency being received and if U' designates the correct position of the local oscillator, the initial direction of rotation of the motor is to be such that the frequency of the local oscillator moves to the left at the beginning of the finding performance. Now, if a further transmitter frequency S_r exists within the limits

G_1 and G_2 , the danger exists that after reversing its movement at the limit G_2 the frequency of the local oscillator stops at the place U ; where the same intermediate frequency will be formed as in U' but this with the wrong transmitter so that the wrong transmitter will be received. However, the receiver cannot stop at the wrong transmitter wave, because in this case, as already stated, the control voltage of the automatic vernier tuning acts in the wrong direction and withdraws the tuning again from this position of tuning. The finding performance then starts anew until the wrong position of tuning is found again, etc. But the receiver can in no ways be brought beyond the wrong tuning position and into the range of the correct tuning position. Now, if care is taken that the disconnection of the finding performance occurs only when the frequency of the local oscillator approaches the correct intermediate frequency from the side of the higher intermediate frequencies while on the contrary the interruption of the finding performance is rendered impossible if the correct tuning is obtained from the side of the low intermediate frequencies, also the place U cannot serve for the stopping of the finding arrangement such that the tuning moves beyond the said place and reaches the correct position U' from the side of the higher intermediate frequencies.

This can be done easily, for instance, in that by means of potentials, derived from the one of the two circuits for the automatic vernier tuning, tuned, for instance, to the higher frequency, which circuits are detuned relative each other, relay contacts are prepared in such a manner that they lead to the stopping of the finding performance only when potentials are actually applied to the said circuit, i. e. when the intermediate frequency has been brought to the center position from the side of the tuning of this circuit.

Finally in many cases not further described herein for the sake of simplification, an automatic exclusion of wrong transmitter frequencies lying within the range of finding can already be accomplished solely by the automatic vernier tuning, since at the stopping of the finder arrangement at a wrong tuning position, the vernier tuning acts in the wrong direction as soon as it begins operating, as a result of which the finding performance will be switched-in again whereby the correct transmitter wave will then be found automatically. In order to contribute to this action it is of advantage instead of stopping the finding performance exactly at resonance frequency to have it cease at a place lying at a short distance from said resonance place inside the range of the vernier tuning in order that in any event the automatic vernier tuning will be put in operation. In view of the speed of the entire switching performances this does not involve any appreciable delay of the tuning performance.

I claim:

1. In a radio receiver, means for tuning the receiver to a frequency which is in the vicinity of the frequency of desired signal energy, means for varying the tuning of the receiver back and forth between a frequency which is below the frequency tuned to and a frequency which is above the frequency tuned to, to thereby search for the desired signal energy, operable means

actuated upon receipt of the desired signal energy in the course of said search for stopping the searching means, and auxiliary means also responsive to the desired signal energy effective to stop the searching means only when the tuning position at which the desired signal energy is received is approached from one predetermined direction.

2. In a radio receiver, variable tuning means, means for operating the variable tuning means to tune the receiver to a frequency which is in the vicinity of the frequency of desired signal energy, means including an electric motor acting upon operation to cyclically vary the tuning means over a narrow range of frequencies bounded by a frequency which is below the frequency tuned to and by a frequency which is above the frequency tuned to, to thereby search for the desired signal energy, means operable upon receipt of the desired signal energy in the course of said search for stopping the operation of said motor, and auxiliary means also responsive to the desired signal energy effective to stop the motor only when the correct tuning position is approached from one predetermined direction.

3. In a radio receiver, means for tuning the receiver to a frequency which is in the vicinity of the frequency of the desired signal energy, signal searching means for varying the tuning of the receiver back and forth within a range of frequencies which includes a frequency which is below the frequency tuned to and a frequency which is above the frequency tuned to, operable means actuated upon receipt of the desired signal energy for stopping the searching means, auxiliary means also responsive to the desired signal energy effective to stop the searching means only when the tuning position at which the desired signal energy is received is approached from a predetermined direction, and means so constructed and arranged that said back and forth tuning variation of the searching means is always started in a direction opposite to said predetermined direction.

4. In a radio receiver having a tuning means adapted to tune the receiver over a predetermined wide band of frequencies, a reversible motor for driving said tuning means, a switching device under the control of said motor for determining the direction and extent of travel of said motor, said extent of motor travel corresponding to a limited range of frequencies within said wide band of frequencies, means including a motor reversing switch automatically responsive to the operation of said switching device for energizing said motor and causing the same to vary the tuning of the receiver back and forth over said limited range of frequencies, means acting automatically upon receipt of a signal of a desired frequency for deenergizing the motor to stop the tuning means at a position whereby the receiver is tuned to said desired signal, a frequency discriminator circuit operating upon receipt of energy of a frequency which departs slightly from the desired frequency on either side thereof, to develop a control voltage, and means under the control of said automatic frequency control circuit for effecting a final adjustment of said tuning means by said motor to hold the receiver in tune with the desired signal frequency.

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