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FREQUENCY MODULATION RECEIVER TUNING INDICATOR

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Fig. 1

Fig. 2

Fig. 4

Fig. 5

Fig. 3

INVENTOR
WALTER VAN B. ROBERTS
BY H. S. Grover
ATTORNEY

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FREQUENCY MODULATION RECEIVER TUNING INDICATOR

Walter van B. Roberts, Princeton, N. J., assignor to Radio Corporation of America, a corporation of Delaware

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My present invention relates to tuning indicators for receivers of the frequency or phase modulated carrier type, and more particularly to a visual tuning indicator of the fluorescent target type adapted to indicate accurately the tuning of receivers of the aforesaid type.

In tuning frequency modulated carrier wave (FM) receivers considerable difficulty is encountered in adjusting the tuning accurately for the reason that during periods of low modulation of the carrier the signals may sound equally well over a considerable range of adjustment. In fact, weakly modulated signals may sound satisfactory when the receiver is adjusted entirely incorrectly to one side or the other of the normal sloping characteristic (which usually is S-shaped) of the discriminator circuit. To insure proper fidelity during periods of wide modulation of the carrier, therefore, it is necessary to be able to adjust the tuning so that the operating point is brought very close to the center of the discriminator characteristic. This usually means that the tuning should be adjusted so that the direct current voltage of the output of the discriminator detector network is substantially zero.

Those skilled in the art are fully aware of the fact that the average value, or direct current voltage output, of the FM signals is zero when the center frequency of the applied FM waves is substantially equal to the predetermined mean frequency of the discriminator circuit. The well known type of 6E5 indicator tube has been used as a tuning indicator. Such tube generally comprises a direct current voltage amplifier section and an indicator section. The indicator section includes a fluorescent target which surrounds a control electrode disposed adjacent a central vertical cathode. Such type of tube can be used as a tuning indicator in the following manner: the shadow produced on the target by virtue of the electron deflection due to the control electrode is adjusted either manually by the operator, or in the factory, to a predetermined magnitude which is intended to be borne in mind by the operator. For example, the shadow could be some sector in the absence of any direct current voltage from the discriminator being applied to the control grid of the amplifier section of the indicator tube.

The control grid of the latter is then connected to the discriminator direct current output voltage circuit, and if the center frequency of the applied FM signals is exactly equal to the predetermined mean frequency of the discriminator circuit the shadow produced on the fluorescent target will be at its pre-set value. This follows from the fact that the direct current voltage output of the discriminator in such case is equal to zero. However, the disadvantage of this method of tuning is that it requires comparing a shadow indication on the target with the operator's recollection of the normal pre-set shadow. When the center frequency of the applied FM waves is different from the discriminator circuit mean frequency, the shadow on the indicator tube target will be different from the normal shadow and the operator of the set may readily be confused as to the relative widths. Furthermore, the normal shadow is subject to variations in factors such as ageing of the indicator tube, variation of the voltage supplies thereto, or variations among tubes. These various factors would tend to confuse the operator of the set who seeks accurately to tune the receiver.

In accordance with my present invention, means are provided for indicating a zero voltage discriminator output in a readily visible manner, and independently of the zero signal adjustment of the shadow. The indicator tube is adjusted to have any convenient shadow sector when the amplifier control grid is grounded, the adjustment being preferably such as to insure a large rate of change of shadow with respect to grid potential at zero grid potential. The grid is then connected to the discriminator output through circuit means arranged to suppress, or filter out, audio frequency variations of the discriminator output, and, furthermore, there is provided a means for periodically varying the fraction of the average direct current voltage output of the discriminator which reaches the input grid of the amplifier section of the indicator tube. Thus, if there is any average voltage either positive or negative at the discriminator output, the shadow on the target will be altered from its normal value, and the amount of alteration will periodically vary. If this periodic variation is chosen to be at a low frequency, 5 cycles per second for example, the edges of the shadow will be observed to be in a state of agitation when there is any mistuning of the receiver, and will only be steady and sharp-edged when the receiver is accurately tuned.

It may, therefore, be stated that it is one of the main objects of my present invention to provide a means for producing a visual indication from the discriminator output of an FM receiver, and, in addition, to provide means for periodically varying said indication.

Another important object of the invention is to provide in an FM receiver having an output

voltage whose direct current component is zero upon accurate adjustment of the tuning to the station being received, indicating means which is responsive to the said component, and means being utilized for interrupting, modulating, or in any way varying the amount of said indication produced per volt of said component whereby said indication is unaffected by the said variation, modulation, interruption or the like only when the said component is zero and the receiver is accurately tuned.

Still other objects of the invention are to improve generally the efficiency and simplicity of visual tuning indicators for FM receivers, and more especially to provide tuning indicators for frequency, or phase, modulated carrier receivers which are reliable in operation, and are economically manufactured and assembled.

The novel features which I believe to be characteristic of my invention are set forth in particularity in the appended claims; the invention itself, however, as to both its organization and method of operation will best be understood by reference to the following description taken in connection with the drawing in which I have indicated diagrammatically several circuit organizations whereby my invention may be carried into effect.

In the drawing:

Fig. 1 shows a circuit diagram embodying one form of the invention,

Fig. 2 shows the appearance of the shadow indication on the target of the indicator tube,

Fig. 3 illustrates a modified form of the invention,

Fig. 4 shows another modification,

Fig. 5 illustrates yet another modification.

Referring now to the accompanying drawing, wherein like reference characters in the different figures designate similar circuit elements, there is shown in Fig. 1 an FM receiver, and it will be noted that all of the networks prior to the tuning indicator tube are schematically represented. Those skilled in the art are fully acquainted with the types of networks employed in an FM receiver. The FM signals are collected by any desired type of signal collector, such as a grounded antenna 1. It is assumed that the FM signals are in the 43–50 megacycle (mc.) range, and that the maximum carrier frequency deviation is 200 kilocycle (kc.). That is, at one hundred percent modulation the carrier frequency is swung 100 kc. on either side thereof. The receiver is of the superheterodyne type, and has its first detector 2 provided with a tunable signal input circuit. The local oscillator 4 has a tunable tank circuit which constantly differs in frequency from the center frequency of the FM waves by a predetermined intermediate frequency (I. F.) value. The I. F. value may be of the order of 2.75 mc., but it is to be kept in mind that any other frequency value may be utilized. The numeral 3 denotes the usual uni-control tuning mechanism which operates the rotors of the variable tuning condensers of the signal and oscillator tank circuits.

Of course, one or more stages of tunable radio frequency amplification can be employed prior to the first detector tube. The FM signals whose carrier has been reduced to the I. F. value are transmitted to an I. F. amplifier 5 through an I. F. transformer 6. The latter may have its primary and secondary circuits each tuned to the I. F. center frequency, and the transformer may be designed to provide a bandpass effect so as to pass the 200 kc. band of the I. F. carrier with substantial uniformity. Of course, one or more stages of I. F. amplification can be provided. Prior to detection of the I. F. signal energy, the latter is transmitted through a further bandpass I. F. transformer 7 to a limiter stage 8. Those skilled in the art are aware of the different types of limiters that may be utilized, and it is believed sufficient for the purpose of this application to show the limiter characteristic within the rectangle designated "Limiter."

It will be noted that the characteristic is such that beyond a predetermined input voltage amplitude the output fails to increase. The limiter functions to eliminate amplitude modulation which exists on the carrier. The amplitude modulation may arise in the frequency modulated carrier wave from various causes, and the limiter prevents such amplitude modulation from reaching the discriminator-second detector stage 9. The stage 9 has as its essential function the conversion of the frequency modulated carrier wave into the audio modulation which was originally imposed on the carrier at the transmitter.

The stage 9 may be of any well known form, and within the rectangle designated by the numeral 9 there is shown a substantially S-shaped characteristic curve which relates carrier frequency deviation as abscissa to rectified output voltage as ordinates. Those skilled in the art are well acquainted with the different types of discriminator-detectors that can be utilized. For example, a pair of rectifiers may be utilized, each of the rectifiers having an input circuit tuned to a predetermined frequency to one side of the center frequency of the FM signals, but the tuned circuits being oppositely mistuned. In such case each rectifier would have its own load resistor, but the load resistors are arranged so that the rectified voltages developed thereacross are in opposition. Hence, the numeral 10 denotes the load resistor of one of the rectifiers. The numeral 11 denotes the load resistor of the other rectifier. By grounding one end of load resistor 11 it is possible to take from the upper end D of resistor 10 a rectified voltage which is the resultant voltage of the voltages developed across load resistors 10 and 11. There may also be used for the stage 9 a discriminator-detector of the type disclosed by S. W. Seeley in U. S. Patent 2,121,103, patented June 21, 1938. In this type of circuit there is also produced across the opposed load resistors of a pair of rectifiers rectified voltages in polarity opposition.

Regardless of the construction of the network 9, it will be understood that when the FM signals applied to the input of stage 9 have a center frequency which is equal to the operating I. F. value, then the rectified voltages across resistors 10 and 11 will be equal and, therefore, the voltage at the upper end D of resistor 10 will be zero. Further, when the carrier wave is unmodulated, but is equal to the operating I. F. value, the direct current voltage output of the detector will be zero. However, when the center frequency of the applied FM signals differs from the operating I. F. value the voltage across one of the load resistors will be greater than that developed across the other load resistor, and, hence, the voltage at the upper end of resistor 10 will be of a polarity and magnitude depending upon the direction and magnitude of the FM center frequency shift. Audio frequency voltage developed across resistors 10 and 11 is tapped off by the adjustable tap 13' on resistor 13, and transmitted through

coupling condenser 13'' to any desired type of audio frequency network which may be followed by the usual reproducer. For the purpose of indicating tuning it is the average value of the direct current voltage developed across resistors 10 and 11 which is important. The audio voltage which corresponds to the carrier frequency swings are taken off by tap 13'. It is, of course, well known in the art that the carrier frequency deviations in the FM signals correspond to the audio modulation. In other words, the amplitude of the audio modulation is represented in the FM signals by the extent of carrier frequency deviation, whereas the frequency of the audio modulation is represented by the frequency of the carrier frequency variations.

The tuning indicator tube may be of any well known type, such as one of the 6U5/6G5 or the 6N5 types. Generally, they comprise an envelope 15 which includes two electrode sections. One of these sections comprises a control grid 16, a cathode 17 and a plate 18. This is the direct current voltage amplifier section. The upper section of the tube comprises a dish-shaped target 19 (whose interior face is coated with a fluorescent material), a cathode, or electron emitter, 20 and a shadow control electrode 21. This type of tube is so well known that it is not believed necessary to describe it in any further detail.

The cathode 17 is connected to ground through a self-biasing resistor 30 which is properly bypassed by condenser 30', while the control grid 16 is connected to the upper end D of resistor 10 through a pair of filter resistors 14, the junction of the resistors being connected to ground through a condenser 14'. The network 14—14' comprises a filter network to remove the audio frequency pulsations from the terminal D. Hence, there is applied to control grid 16 a direct current voltage whose polarity and magnitude depends upon the direction and extent of frequency shift of the FM center frequency with respect to the operating I. F. value.

The plate 18 is connected to a source of positive potential through resistor 31, the control electrode 21 being connected to the plate end of resistor 31. The target 19 is connected to the opposite end of the resistor. It will, therefore, be seen that when the voltage at point D is zero, that is when the receiver is accurately tuned to the center frequency of the collected FM signals, then the control grid 16 will be biased negatively with respect to the cathode 17 by the voltage drop across biasing resistor 30.

In the 6U5/6G5 type of tube the bias developed across resistor 30 may be of the order of —2.5 volts. In this type of tube, and at such a bias, the shadow angle produced on the inner face of target 19, as shown by the spaced solid lines in Fig. 2, is of the order of 60 degrees. In other words, this type of indicator tube has a large shadow angle for a small negative bias on the input grid of the tube. A change of the bias of grid 16 from the normal bias results in a change in the width of the shadow area between the solid lines of Fig. 2. If, for example, point D assumes a positive potential, the value of the FM center frequency being different from the predetermined I. F. value, then the grid 16 will be biased less negatively. Thus there will be a greater drop of potential across resistor 31 thereby producing a widening of the shadow area on the target to the dotted lines 19'. On the other hand, if the FM center frequency shifts in the opposite direction, and point D assumes a negative potential, then the shadow area on target 19 will close down to the area between dotted lines 19''. It will, therefore, be seen that it is only in the case of zero voltage at point D that the shadow area on target 19 will have the normal width.

There is provided a device, in accordance with my invention, wherein the potential applied to grid 16 may be more or less shorted to ground by contact between a point 40 and a metallic button 41 provided on a conductive spring element 42. One end of the spring member 42 is mechanically fixed and electrically grounded, while the opposite end has attached thereto a mass 43 to provide a period of oscillation of the order of five vibrations per second. The mass 43 may be adjustable so as to vary the period of vibration of the spring member 42. The contact 40 is, also, preferably yieldingly supported. Contact 40 is connected to the grid end of resistor 14 through a pair of spark suppression resistors 44, the junction of the resistors being connected to ground through a condenser 45. In this way sparks which may be set up by contact between point 40 and button 41 are suppressed.

When the spring member 42 is not oscillating the contact button 41 does not touch point 40, and the shadow area on target 19 has a width determined by the voltage at point D. However, when the spring member 42 is vibrating the shadow width periodically changes between its normal value and a value determined by the voltage output of the discriminator at point D. By means of a push-button 46, provided with a stem 47 terminated close to the spring member 42, the spring member 42 may be pressed so as to short the grid 16 to ground so long as the button 46 is depressed. If, however, button 46 is given a quick push with immediate release, the spring member 42 will be set into oscillation at its natural period. The damping of the member 42 may readily be made so low that intermittent contacts may continue for sufficient time to permit adjustment of tuning member 43 so as to provide accurate tuning. Any desired type of spring construction 48 may be provided for normally biasing the button 46 away from contact with member 42.

If the operator prefers, he may simply push the button 46 slowly so as to produce the same results as a mere single-pole, single-throw switch. Furthermore, it will be appreciated that the button 46 may be arranged by means of a yielding pawl member to deflect the spring 42 a certain amount, and then slip off so as to make it unnecessary to release the button 46 quickly in order to set the spring into oscillation. Various mechanical expedients will be readily apparent for producing any desired type of contact actuation. Essentially there is provided a device for periodically grounding the grid 16 so that the shadow area on target 19 may be agitated if voltage is produced at point D. Of course, when the shadow area does not agitate upon actuation of the grounding device then it is obvious to the operator that the set is accurately tuned to the desired carrier frequency.

If desired, automatic frequency control bias may be derived from the junction of the resistors 14 and may be applied over lead 12, any well known form of control tube being associated with the local oscillator 4. The aforesaid Seeley patent discloses a method of utilizing such automatic frequency control bias, and the function of the automatic frequency control arrangement is to aid in "pulling" the oscillator towards that fre-

quency which will yield with the applied FM signals the I. F. signal energy whose mean frequency is the predetermined I. F. value.

It is, furthermore, within the scope of the present invention to provide non-mechanical means for varying, or modulating, the direct current voltage impressed upon the grid 16 from the discriminator. For example, electronic variable resistance devices may be employed in series and/or shunt to the connections between the discriminator output resistors and the grid of the indicator tube. Such devices would have their resistance continuously varied in accordance with the 60-cycle power supply current, or by a separately generated alternating control voltage. There may even be employed the audio frequency output of the receiver itself for varying such an electronic variable resistance device. In every case the criterion of accurate tuning is that the edges of the target be sharp rather than blurred or agitated. An obvious advantage of the continuous type of modulation, or variation, of the voltage applied to the grid of the indicator tube is that the operator can tell by a mere glance at any time whether the receiver has drifted off tune or not. It must be remembered that at the ultra-high frequencies employed in FM reception such frequency drift is very likely.

In Fig. 3 there is shown an illustration of an electrical variable resistance device employed between the grid of the indicator tube and the filter resistors 14. The variable resistor device comprises a tube 50 having a pair of diodes arranged in opposed relation within its envelope. Thus, the cathode of one diode is strapped to the anode of the second diode, while the anode of the first diode is strapped to the cathode of the second diode. The input terminal of tube 50 adjacent resistor 14 receives the filtered discriminator output voltage, while the opposite terminal is connected to ground through the resistor 51. A coil 52 is wound around the tube envelope so that its magnetic field will affect the space current path and hence the apparent resistance between the electrodes of tube 50. There is impressed upon the terminals of the coil 52 an interruption voltage, and the latter may be the 60-cycle power supply current since it is immediately available in the receiver itself. In this type of arrangement the resistance within the tube 50 will be very high when the magnetic field due to coil 52 is a maximum and only a small part of the discriminator voltage reaches the indicator tube. During the periods of the interruption voltage corresponding to small current through coil 52 the resistance will be low, and the voltage at point D is readily applied to the input grid 16 of the indicator tube. Thus, the shadow area of target 19 will be agitated if the receiver is not exactly in tune.

In Fig. 4 there is shown still another method of varying, or modulating, the discriminator output voltage applied to grid 16. In this case there is used the type of spring member shown in Fig. 1 at 42. Indeed the entire arrangement shown in Fig. 1 may be the same so far as the interruption device is concerned, except that the spring member 42 will be vibrated by virtue of the magnetized core 60 having wound around it the coil 61 whose terminals may have applied thereto the 60 cycle filament voltage of the receiver. In this case the coil 61 will be connected in parallel with the filament supply line. The spring member 42 will be constantly vibrated, and the operator does not have to actuate the spring member by hand. Of course, the contact point 40 will have associated therewith the spark suppression elements shown in Fig. 1.

In Fig. 5 there is shown an arrangement for utilizing the existing power supply transformer 70 of the radio receiver itself. The numeral 70 schematically designates the power supply transformer of the receiver, and there is secured to one side of the transformer a phosphor-bronze strip 42'. One end of this strip is mechanically affixed to the transformer core, which is grounded, while the opposite end has attached thereto a small mass of magnetic material, or a small permanent magnet. The vibrator comprising 42' is constructed to resonate mechanically at the frequency force acting upon the magnetic mass by virtue of leakage flux from transformer core 70, so that it will continuously vibrate as soon as the receiver switch is actuated to operate the receiver. The contact point 40 will thus have the lead 42' contacted intermittently, and at either a 60 cycle or 120 cycle rate depending on whether the magnetic mass is permanently magnetized or not. This will provide a ready and simple means for informing the receiver operator whether or not he has accurately tuned the receiver.

While I have indicated and described several systems for carrying my invention into effect, it will be apparent to one skilled in the art that my invention is by no means limited to the particular organizations shown and described, but that many modifications may be made without departing from the scope of my invention, as set forth in the appended claims.

What I claim is:

1. In a frequency modulation receiver provided with a discriminator constructed and arranged to produce a direct current voltage in response to a frequency shift of received frequency modulated waves from a predetermined mean frequency, means for producing an indication from said direct current voltage, and means actuated continuously by an alternating current for periodically rendering said direct current voltage ineffective thereby to vary the said indication.

2. In combination with a network provided with an input circuit adapted to have carrier waves applied thereto whose mean frequency is subject to frequency deviations, and an output network adapted to develop direct current voltage whose polarity and magnitude is a function of the direction and extent respectively of such frequency deviation, means responsive to said direct current voltage for producing a visual indication of said deviation, and additional means responsive to an alternating current for intermittently rendering said direct current voltage ineffective.

3. In combination with a network provided with an input circuit adapted to have carrier waves applied thereto whose mean frequency is subject to frequency deviations, and an output network adapted to develop direct current voltage whose polarity and magnitude is a function of the direction and extent respectively of such frequency deviation, means responsive to said direct current voltage for producing a visual indication of said deviation, means for rendering said direct current voltage ineffective and additional means responsive to an alternating current for periodically actuating said last means.

4. In a frequency modulation receiver provided with a discriminator network whose output volt-

age has a direct current voltage component which is zero upon accurate adjustment of the tuning to the station being received, indicating means responsive to said component for providing a visual indication of said accurate tuning, means for varying the amount of said indication produced per volt of said direct current voltage, additional means for intermittently actuating said varying means to render said indication variation intermittent, said indication being unaffected by said intermittent actuation only when said direct current voltage component is zero and said receiver is accurately tuned.

5. In combination with a source of direct current voltage of variable polarity, a visual voltage indicator comprising a tube provided with an electron emitter, a fluorescent target and an electron control electrode, means responsive to said voltage for varying the potential of said electrode thereby to vary the area of luminescence produced on said fluorescent target, and means for periodically rendering ineffective said voltage thereby to agitate said luminescent area on said target.

6. In combination with a source of direct current voltage of variable polarity, a visual voltage indicator comprising a tube provided with an electron emitter, a fluorescent target and an electron control electrode, means responsive to said voltage for varying the potential of said electrode thereby to vary the area of luminescence produced on said fluorescent target, and means for periodically rendering ineffective said voltage thereby to agitate said luminescent area on said target and said last named means comprising a device actuated continuously by an alternating current.

7. In combination with a source of direct current voltage of variable polarity, a visual voltage indicator comprising a tube provided with an electron emitter, a fluorescent target and an electrol control electrode, means responsive to said voltage for varying the potential of said electrode thereby to vary the area of luminescence produced on said fluorescent target, and means for periodically rendering ineffective said voltage thereby to agitate said luminescent area on said target and said last mentioned means comprising a continuously-operated switch mechanism for periodically grounding said direct current voltage.

8. In a frequency modulation receiver provided with a discriminator constructed and arranged to produce a direct current voltage in response to a frequency shift of received frequency modulated waves from a predetermined mean frequency, an indicator of the fluorescent target type for producing a shadow indication from said direct current voltage, and additional means for periodically rendering said direct current voltage ineffective thereby to agitate the said shadow indication.

9. In combination with a detection network provided with an input circuit adapted to have carrier waves applied thereto whose mean frequency is subject to frequency deviation, said detection network having an output network adapted to develop direct current voltage whose polarity and magnitude is a function of the direction and extent respectively of such frequency deviation, means responsive to said direct current voltage for producing a visual indication of said deviation, and additional alternating current-operated means for periodically rendering said direct current voltage ineffective thereby to agitate said indication.

WALTER VAN B. ROBERTS.