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METHOD AND MEANS FOR TESTING RESONANT CIRCUITS

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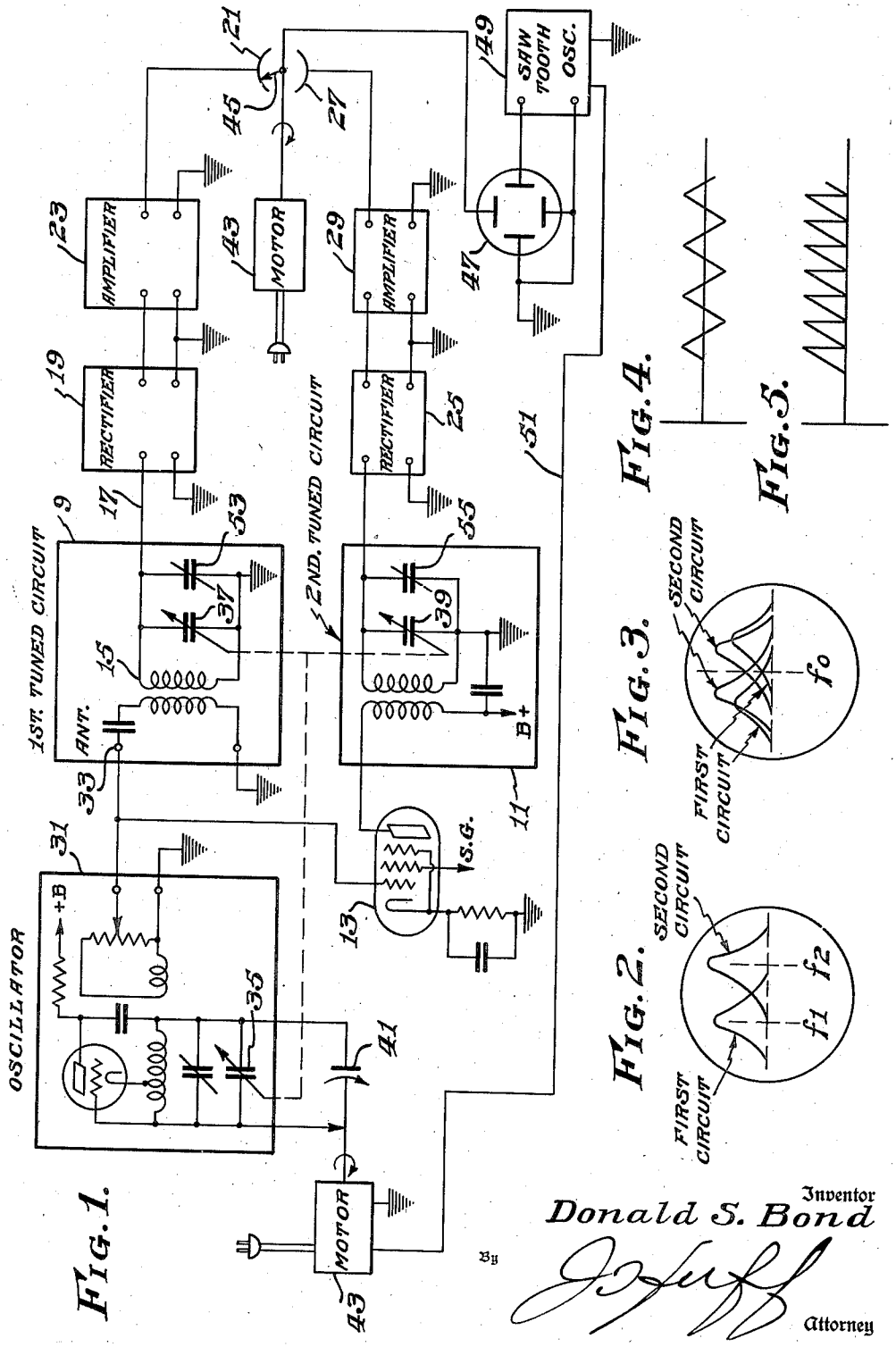


FIG. 1.

FIG. 4.

FIG. 5.

FIG. 3.

FIG. 2.

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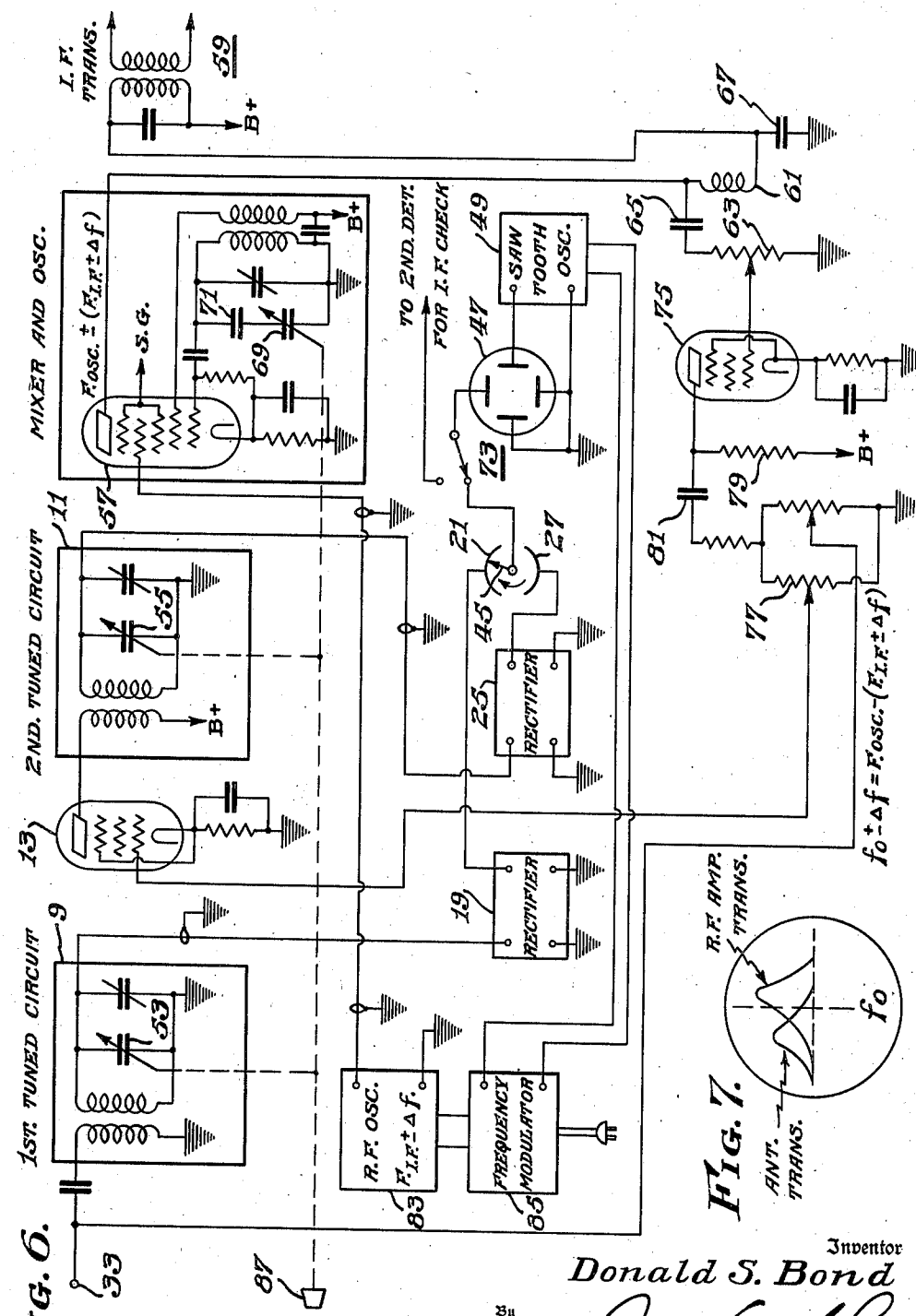


FIG. 6.

FIG. 7.

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METHOD AND MEANS FOR TESTING RESONANT CIRCUITS

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18 Claims. (Cl. 250—20)

This invention relates to a method of and means for visually indicating the tracking of a plurality of tunable circuits with respect to each other, or with respect to the signal frequency which, for any dial setting, combines with the local oscillator of a superheterodyne receiver to produce the desired intermediate frequency.

In a radio receiver having a common tuning or control knob for varying the resonant frequency of a plurality of selector circuits through the operating range of the receiver, it is necessary to adjust the coil inductances and the capacity of the tuning capacitors so that the various tuned circuits each resonate at the same frequency throughout the range of the receiver. This is usually accomplished by means of trimmer capacitors which are connected in parallel with the main tuning condenser. An additional problem is involved in the case of a superheterodyne receiver, since the frequency of the local oscillator, which is generally tuned by a variable capacitor similar to those used to tune the radio frequency circuits, must be maintained at a fixed frequency above or below the resonant frequency of the other circuits, which are herein called the signal frequency circuits.

Theoretically perfect tracking between the signal frequency circuits and the local oscillator is not usually obtained in receivers of commercial design. A compromise is generally made in which the receiver is aligned at two points near the high and low frequency limits of the receiver, respectively, the oscillator circuit being so designed that a third point of alignment is produced near the mid-frequency. Thus the receiver is actually aligned at three points, these points corresponding to the points of intersection of the frequency vs. capacity curves of the oscillator and signal frequency circuits, as is well known.

Assuming that each receiver from a production line is correctly wired and that each component is of the correct value, satisfactory overall performance is obtained when the receiver is aligned at the two points mentioned above. However, the value of one or more components may vary from the desired value. Thus the oscillator coil, the series capacitor, or a section of the tuning condenser may vary from the prescribed value with the result that the receiver may be badly misaligned at frequencies intermediate the frequencies at which it has been adjusted. Such errors are particularly common in the high frequency bands of the receivers, and, in addition, it is possible to adjust the oscillator to a frequency on the wrong side of the signal frequency. The mere fact that the receiver was apparently adjusted properly at one or two points does not guarantee the proper performance throughout the operating range of the receiver.

It is the principal object of this invention to provide a method of and means for observing the tracking of the tuned circuits of a receiver at the points of alignment and also at all intermediate points. Other objects of this invention include the provision of a method of and means for producing signal frequency currents which are automatically maintained at a fixed frequency above or below the oscillator as the receiver is tuned throughout its range; the provision of improved testing apparatus; and the provision of an improved testing method.

In accordance with one embodiment of this invention, the foregoing objects are achieved by applying frequency modulated currents to the signal frequency circuits of a receiver, and visually indicating by means of a cathode ray tube, or the like, the resonance curves of each circuit as the circuits are tuned throughout their operating range. Tracking errors at any particular point in the tuning range are determined by measuring the distance between the peaks of the resonance curves. A modification of this invention which is designed particularly for use with superheterodyne receivers, provides a frequency modulated oscillator the average frequency of which is equal to the intermediate frequency of the receiver under test. By coupling this oscillator to the receiver oscillator, a combination current is produced, the nominal frequency of which is equal to the signal frequency required to produce the given intermediate frequency for all points within the operating range. The deviation of the resonant frequency of the signal frequency circuits from this locally produced signal is indicated by means of a cathode ray tube, and is a measure of the receiver alignment.

This invention will be better understood from the following description when considered in connection with the accompanying drawings. Its scope is indicated by the appended claims.

Referring to the drawings, Figure 1 is the circuit diagram of a device for testing the tracking of two tuned signal frequency circuits; Figure 2 is a sketch representing the cathode ray trace produced by such a device; Figure 3 is a similar sketch of the traces produced by a pair of resonant circuits where the cathode ray employs the double image principle; Figure 4 is a curve representing the saw-tooth deflecting voltage

utilized in the production of the curves illustrated in Fig. 2; Figure 5 is a curve of the scanning voltage used to produce the double image illustrated in Fig. 3; Figure 6 is the circuit diagram of a system for testing the tracking of a superheterodyne receiver, and Figure 7 is a sketch representing the resonance curves of the antenna and amplifier transformers of such a receiver.

Referring to Fig. 1 the tunable resonant circuits included within the blocks 9 and 11 represent the first and second tuned circuits, respectively, of a receiver of the tuned radio frequency type, or the first and second amplifier stages of a superheterodyne receiver. Tube 13 is the tube which is normally used to couple the first and second amplifier stages. Its plate is connected to the second tuned circuit 11. In normal operation its grid would be connected to the secondary 15 of the first tuned circuit 9 by means of a lead 17. In order to test the receiver, however, the grid cap is removed from the tube and connected to a rectifier 19 having similar input impedance characteristics. The rectifier output is connected to a commutator armature 21 through a circuit which may include an amplifier 23. The output of the second tuned circuit 11 is normally connected to the receiver detector tube. Consequently, it is possible to utilize the existing detector by connecting a test prod to a suitable point at which a rectified voltage is available. On the other hand, a separate rectifier 25 may be employed in addition to, or as a substitute for the receiver detector tube. In any case, the rectified output voltage is applied to the second commutator segment 27 through a circuit which may include an amplifier 29.

A frequency modulated oscillator 31 is provided which may be any conventional oscillator, and need not be described in detail. Its output is connected to the receiver antenna binding post 33 and to the grid of the amplifier tube 13. The average frequency of the oscillator 31 is determined by a variable condenser 35 which is preferably operatively connected to variable condensers 37 and 39 which tune the first and second tuned circuits, respectively. The frequency of oscillator 31 is varied above and below this average frequency by a mechanical or an electronic frequency modulator. For example, a rotating condenser 41 may be connected in parallel with tuning condenser 35, and rotated at any desired speed by means of a motor 43.

The commutator arm 45 is rotated at a speed which is suitably related to the speed of rotation of modulating condenser 41 so that the outputs of amplifier 23 and 29 are alternately and successively connected to the vertical deflecting electrode of a cathode ray tube 47. Preferably the speed of rotation of the commutator is one-half that of the modulating condenser so that a complete modulating cycle is completed during the time each amplifier is connected to the cathode ray tube. This may be accomplished by a suitable speed reducing gear connected to the motor 43 or by means of a separate motor 43^1.

The horizontal deflection of the cathode ray tube 47 is provided by means of a conventional saw-tooth oscillator 49 which is synchronized with the modulation frequency by means of a connection 51 which is, for example, connected to a small generator mounted on the shaft of motor 43. The saw-tooth oscillator may produce a symmetrical deflecting voltage of the type illustrated in Fig. 4 or an asymmetrical saw-tooth voltage of the type illustrated in Fig. 5, both of which are well known. The system is adjusted for operation by adjusting the average frequency of the oscillator to the value desired as the low frequency test point on the receiver. Since the oscillator frequency is being swept through this average value, a pair of resonance curves will be produced on the cathode ray tube corresponding to the resonant characteristics of the two circuits under test. While these curves will be drawn alternately, due to the operation of the commutator, they will appear simultaneously on the cathode ray screen and may be visually compared. Two such curves are illustrated in Fig. 2. The actual resonant frequency f_1 of the first resonant circuit does not coincide with the actual resonant frequency f_2 of the second circuit. The distance between the two resonant peaks is, therefore, a measure of the tracking error at the low frequency point in question.

By rotating the tuning knob to increase the frequency response of the tuned circuits and oscillator, a continuous check may be had of the tracking of the two circuits. At the high frequency end the receiver is adjusted by utilizing the trimmer capacitors 53 and 55 to align both circuits to the same frequency. In accordance with conventional practice the circuits may be aligned at the low frequency end by varying the coil inductance, if desired.

The accuracy of the indication is somewhat improved by employing the double image system in which the cathode ray beam is moved horizontally in a given direction as the oscillator frequency increases, and again in the same direction as the oscillator frequency decreases. In order to accomplish this the horizontal deflecting voltage is of the type illustrated in Fig. 5. In such a case, two resonance curves are produced for each resonant circuit, the curves falling on opposite sides of a center line f_0 when the resonant frequency of the circuit differs from the average frequency f of the oscillator. Such a curve is illustrated in Fig. 3. The circuits are aligned when the two resonant peaks coincide. As before, the tracking of the two tuned circuits over their entire operating range may be checked rapidly and accurately by rotating the tuning condenser of the receiver and noting the variation of the two resonance curves.

A modification of this invention is illustrated in Fig. 6 which is particularly suited for use with a superheterodyne receiver. In a receiver of this type the oscillator operates at a frequency above or below the signal frequency by an amount equal to the intermediate frequency. Since the selectivity of the circuit is due primarily to the intermediate frequency circuits, it will be appreciated that the primary consideration in aligning such a receiver is that the amplifier circuits, that is, the antenna transformer and the radio frequency amplifier are tuned to that frequency which combines with the oscillator to produce the intermediate frequency. It is not sufficient, therefore, merely to check the alignment of the signal frequency circuits, that is, the antenna transformer and the amplifier transformer, since such a test does not take into consideration variations in the oscillator frequency. Consequently, I have provided a method of testing a superheterodyne receiver in which the signal utilized to test the alignment of the signal frequency circuits, corresponding to that produced by oscillator 31 of Fig. 1, is a function of the actual oscillator frequency at each point

throughout the operating range. By indicating the deviation of the resonance frequencies of the signal frequency circuits from the frequency of this resultant current, the resultant curves accurately determine the true operating alignment of the receiver.

Referring to Fig. 6, the first tuned circuit 9 is, as before, the antenna transformer which normally couples the antenna terminal 33 to the input of amplifier tube 13. During this test, however, the grid cap of the amplifier tube is removed and the output of the antenna transformer is connected to a rectifier 19. The second tuned circuit 11 includes the radio frequency amplifier coil, the secondary of which is normally connected to the grid of the mixer tube 57, but for this test, the grid cap is removed and connected to the input of a rectifier 25. It is to be understood that the input characteristics of the rectifiers 19 and 25 are preferably made identical to the input characteristics of the tubes which they replace, so that the circuits will not be detuned when the substitution is made.

The plate of the mixer tube 57, in a superheterodyne receiver, is normally connected to the primary of the first intermediate frequency transformer 59. For the purpose of the present test, however, this connection is broken, by means of a socket adapter, by means of which a radio frequency choke 61 is included in the plate circuit, and a connection made to the plate from the ungrounded end of a potentiometer 63 through a blocking capacitor 65. The end of the radio frequency choke coil 61 remote from the plate is bypassed to ground by a capacitor 67.

The local oscillator circuit is connected to the number 1 and number 2 electrodes of the mixer tube 57 in a conventional manner. The frequency of this circuit is determined by a variable capacitor 69 which is connected in series with the usual tracking capacitor 71. The oscillator condenser 69 is operatively coupled to the remaining sections of the tuning condenser 53 and 55, which tune the first and second signal frequency circuits, respectively.

The two rectifiers 19 and 25 are connected to a cathode ray indicator 47 through commutator segments 21 and 27 and the commutator arm 45, as before. For convenience, I have provided a switch 73 by means of which the vertical deflecting electrode of the cathode ray tube may be connected either to the commutator arm 45 or to a suitable point of the audio frequency receiver circuit, the latter connection making possible the use of the cathode ray to check the alignment of the intermediate frequency amplifier in a conventional manner.

The movable arm of potentiometer 63 is connected to the grid electrode of an amplifier tube 75. A pair of potentiometers 77 and 79 are connected in parallel between ground and the anode of amplifier 75 through a blocking capacitor 81. The first potentiometer 77 is connected to the input electrode of the receiver radio frequency amplifier tube 13, while the second potentiometer 79 is connected to the receiver antenna binding post 33.

The frequency modulated oscillator 83 is provided, the average frequency of which is equal to the intermediate frequency of the receiver. It is modulated throughout a range of frequencies by means of a frequency modulator 85. As before, the frequency modulator supplies a synchronizing voltage for the cathode ray saw-tooth oscillator 49, which may be of either type discussed above. The output of the modulated oscillator 83 is connected to the control grid electrode of the mixer tube 57.

It will be noted that the modulated intermediate frequency currents from the oscillator 83 are combined in the mixer tube 57 with the locally generated oscillations of the receiver. The plate circuit of the mixer tube 57, therefore, includes sum and difference components. If the oscillator is operating above the signal frequency to produce the receiver intermediate frequency, then the difference component appearing in the plate circuit will necessarily be equal to the signal frequency to which the receiver will respond for the given setting of the oscillator. If the oscillator is operating below the signal frequency, as is the case in said receivers in high frequency bands, the sum component will then be equal to the signal frequency to which the receiver will respond for the particular oscillator frequency. Thus if the signal frequency circuits of the receiver are adjusted to the signal frequency component produced in the output of the mixer tube, and this throughout the entire operating range of the receiver, the desired alignment and tracking will have been achieved.

The actual alignment of the receiver is conventional, and need not be described in detail. By setting the tuning knob 87 to the desired aligning point, the frequency of the local oscillator is first adjusted and then the signal frequency circuits are adjusted until their resonant peaks, illustrated in Fig. 7, fall upon the vertical line f_0 which corresponds to the signal frequency. For the sake of simplicity, only one curve for each resonant circuit has been indicated in Fig. 7 but it is to be understood that the double system similar to that illustrated in Fig. 3 may also be used.

Having completed the alignment of the receiver in the preselected points, the tracking of the two signal frequency circuits is determined by slowly rotating the tuning knob 87 throughout its entire range. Since the signal frequency itself is varied, since it is derived from the local oscillator, the center line f_0 on the cathode ray screen represents the correct frequency at all points. Consequently, the degree and direction of the deviation of the antenna and amplifier circuits are instantly observed. If the receiver has been improperly aligned this fact may be immediately determined, since in that case the signal frequency circuits will not track properly and will deviate widely from the normal frequency f_0. Normal deviations may be marked directly on the cathode ray screen so that the operator may check the accuracy of the alignment in a minimum of time.

I claim as my invention:

1. In a device having a plurality of circuits tunable over a range of frequencies in response to common control means, the method of indicating the alignment of said circuits throughout their tuning range which includes the steps of generating a radio frequency voltage the nominal frequency of which is variable over said range of frequencies, modulating the frequency of said radio frequency voltage throughout a range less than said range of frequencies, applying said frequency modulated voltage to said resonant circuits, producing separate indications of the resonant rise of voltage in said circuits, and simultaneously varying the nominal frequency of said frequency modulated voltage and the resonant frequency of said circuits, the difference between

said indications being a measure of the alignment of said circuits.

2. In a device having a plurality of resonant circuits tunable over a range of frequencies in response to a common control means, the method of indicating the alignment of said circuits which includes the steps of generating a radio frequency voltage the nominal frequency of which is variable over a range of frequencies, modulating the frequency of said voltage at a constant rate throughout a range less than said range of frequencies, applying said frequency modulated voltage to said resonant circuits, producing separate indications of the resonant rise of voltage in said circuits, and simultaneously varying the resonant frequency of said circuits and the nominal frequency of said radio frequency voltage through similar frequency ranges to indicate the relative alignment of said circuits throughout their operating range.

3. In a radio device having a plurality of resonant circuits tunable over a range of frequencies in response to a common control means, the method of indicating the relative resonant frequencies of said circuits throughout said range which includes the steps of generating an alternating voltage the nominal frequency of which is variable over a range in response to said common control means, modulating the frequency of said voltage above and below said nominal frequency at a constant rate, applying said modulated voltage simultaneously to said resonant circuits, adjusting the nominal frequency of said voltage to a value substantially equal to the resonant frequency of said circuits at a given point in said range, indicating the resonant rise of voltage of said circuits at said point, and operating said control means to tune said circuits throughout said range, while correspondingly varying the nominal frequency of said alternating voltage.

4. In a radio device having a plurality of resonant circuits tunable over a range of frequencies in response to a common control means, the method of indicating the relative resonant frequencies of said circuits throughout said range which includes the steps of generating an alternating voltage the nominal frequency of which is variable over a range corresponding to the range covered by said tunable circuits, cyclically modulating the frequency of said voltage, impressing said modulated voltage simultaneously on said resonant circuits, adjusting the nominal frequency of said voltage to a value substantially equal to the resonant frequency of said circuits at a given point in said range, indicating the resonant rise of voltage of said circuits at said point, and operating said control means to tune said circuits throughout said range while correspondingly varying the nominal frequency of said voltage.

5. In a device having a plurality of circuits tunable over a range of frequencies in response to common control means, the method of indicating the tracking of said circuits which includes the steps of generating an alternating voltage, cyclically varying the frequency of said voltage over a range of frequencies less than the tunable range of said circuits, applying said cyclically varying voltage to said circuits, producing indications of the resonant rise of voltage in said circuits, and simultaneously varying the average frequency of said alternating voltage and the resonant frequency of said circuits throughout said range, the difference between said indications at any point being an indication of the tracking of said circuits.

6. In a device having a plurality of resonant circuits tunable over a range of frequencies in response to common control means, the method of indicating the tracking of said circuits which includes the steps of generating an alternating voltage whose frequency is also variable over said range of frequencies in response to said common control means, cyclically varying the frequency of said voltage over a range of frequencies inclusive of the range covered by the resonance curve of said tunable circuits, applying said voltage to said tunable circuits, visually and separately indicating the resonant rise of voltage vs. frequency characteristic of said tunable circuits, and operating said common control means to vary the resonant frequency of said circuits and the frequency of said voltage throughout said range, the difference between said indications being a measure of the error in tracking of said circuits.

7. In a device having a plurality of resonant circuits tunable over a range of frequencies in response to common control means, the method of indicating the tracking of said circuits which includes the steps of generating an alternating voltage whose average frequency is tunable over said range in response to said common control means, separately varying the frequency of said voltage over a range of frequencies which includes the range covered by the resonance curve of said tunable circuits, applying said voltage to said circuits, deriving output voltages from said resonant circuits, commutating said voltages, producing a beam of electrons, deflecting said beam in a first direction in accordance with said commutated voltages, deflecting said beam in a second direction in synchronism with the cyclic variation of the frequency of said voltage, utilizing said beam to produce luminous traces of the resonance characteristic of said circuits, and simultaneously varying the average frequency of said voltage and the resonant frequencies of said tunable circuits throughout said range, the distance between the peaks of said traces being an indication of the tracking of said circuits.

8. In a device having a plurality of resonant circuits tunable over a first range of frequencies in response to common control means, the method of determining the tracking of said circuits which includes the steps of generating an alternating voltage whose nominal frequency is variable over said first range of frequencies, cyclically modulating the frequency of said voltage throughout a second range smaller than said first range, applying said modulated voltage to said circuits, deriving output voltages from said circuits, producing a beam of electrons, deflecting said beam in a first direction alternately and successively in accordance with said output voltages, deflecting said beam in a second direction in synchronism with the cyclic modulation of said alternating voltage, utilizing said beam to produce traces representing the resonance characteristic of said circuits, tuning said circuits over said first range of frequencies while simultaneously varying the nominal frequency of said alternating voltage over the same range of frequencies, the distance between the peaks of said traces at any point being a measure of the tracking of said circuits at that point.

9. In a superheterodyne receiver having a local oscillator tunable over a first range of frequencies and a resonant circuit simultaneously

tunable over a second range of frequencies displaced from said first range by a fixed intermediate frequency, the method of checking the tracking between said tunable circuit and said oscillator which includes the steps of generating an alternating voltage of said intermediate frequency, combining said voltage with oscillations produced by said local oscillator to produce a signal-frequency voltage, applying said signal-frequency voltage to said resonant circuit, and indicating the deviation of the resonant frequency of said circuit from the frequency of said signal frequency voltage.

10. In a superheterodyne receiver having a variable frequency oscillator, a signal frequency circuit and common means for tuning said oscillator and said circuit throughout frequency ranges which differ by a substantially constant intermediate frequency, the method of checking the tracking of said oscillator and said signal frequency circuit which includes the steps of generating intermediate frequency oscillations, combining said intermediate frequency oscillations with oscillations produced by said local oscillator to produce signal frequency oscillations, applying said signal frequency oscillations to said signal frequency circuit, and indicating the deviation of the resonant frequency of said circuit from said signal frequency.

11. In a superheterodyne receiver having a variable frequency oscillator, a signal frequency circuit, and common means for tuning said oscillator and said circuit throughout frequency ranges which differ by a substantially constant intermediate frequency, the method of checking the tracking of said oscillator and said circuit which includes the steps of generating a current of said intermediate frequency, combining said current with currents of said oscillator frequency to produce signal frequency currents, applying said signal frequency currents to said circuit, and indicating the deviation of the resonant frequency of said circuit from said signal frequency.

12. In a superheterodyne receiver having a variable frequency oscillator, a signal frequency circuit, and common means for tuning said oscillator and said circuit throughout frequency ranges which differ by a substantially constant intermediate frequency, the method of checking the tracking of said oscillator and said circuit which includes the steps of generating a frequency modulated current the average frequency of which is equal to said intermediate frequency, combining said current with currents of said oscillator frequency to produce signal frequency currents, applying said signal frequency currents to a circuit, and visually indicating the deviation of the resonant frequency of said circuit as said oscillator and said circuit are tuned throughout their respective ranges.

13. In a superheterodyne receiver having a variable frequency oscillator, a signal frequency circuit, and common means for tuning said oscillator and said circuit throughout frequency ranges which differ by a substantially constant intermediate frequency, the method of checking the tracking of said oscillator and said circuit which includes the steps of generating a frequency modulated current the average frequency of which is equal to said intermediate frequency, combining said currents with other currents of said oscillator frequency to produce frequency modulated signal frequency currents, applying said signal frequency currents to said circuit, deriving rectified output currents proportional to the resonant rise in voltage in said circuit, and utilizing said output currents to indicate visually the deviation of the resonant frequency of said circuit from said signal frequency as said oscillator and said circuit are tuned throughout their respective ranges.

14. The method of determining the alignment of a superheterodyne receiver having a variable frequency local oscillator, at least one signal frequency circuit and means for simultaneously tuning said oscillator and said circuit throughout frequency ranges which differ by a substantially constant intermediate frequency, which includes the steps of generating a current of said intermediate frequency, modulating the frequency of said current throughout a range of the order of the bandwidth of said circuit, combining said modulated intermediate frequency current with oscillatory currents from said local oscillator to produce frequency modulated signal frequency currents, applying said signal frequency currents to said signal frequency circuit, deriving rectified output currents from said circuit and utilizing said output currents to produce a trace corresponding to the resonance curve of said circuit, the deviation of the resonant frequency of said circuit from the average frequency of said signal frequency currents being a measure of the tracking of said circuit.

15. A device for indicating the alignment of a superheterodyne receiver having a variable frequency local oscillator and at least one tuned signal frequency circuit, said receiver also having common means for tuning said oscillator and said circuit throughout frequency ranges which differ by a substantially constant intermediate frequency, comprising in combination means for producing a frequency modulated current of said intermediate frequency, means for combining said current with current from said local oscillator to produce modulated combination currents of signal frequency, means for applying said signal frequency currents to said circuit, and means for indicating the difference between the average frequency of said modulated signal frequency currents and the resonant frequency of said circuit.

16. A device for indicating the alignment of a receiver having a pair of tunable signal frequency circuits which includes, in combination, means for producing a frequency-modulated current of said signal frequency, means for applying said signal frequency currents to said circuits, means for simultaneously varying the resonant frequency of said tunable circuits and the average frequency of said signal frequency currents, and means for indicating the deviation of the resonant frequency of said circuits from the average frequency of said signal frequency currents.

17. A device for indicating the alignment of a superheterodyne receiver having a pair of tunable signal frequency circuits and a tunable local oscillator which includes, in combination, means including said local oscillator for producing a frequency-modulated signal frequency current, the average frequency of which is determined by the frequency of said local oscillator, means for applying said signal frequency current to said tunable circuits, means for simultaneously varying the resonant frequency of said circuits and the frequency of said oscillator, and means for indicating the deviation of the resonant frequency of said circuits from the average frequency of said signal frequency currents at desired points within the tuning range of said circuits.

18. A device for indicating the alignment of a superheterodyne receiver having a pair of tunable signal frequency circuits and a tunable local oscillator which includes, in combination, an intermediate frequency oscillator, means for periodically varying the frequency of said oscillator, means for combining currents from said intermediate frequency oscillator with currents from said local oscillator to produce a frequency modulated signal frequency current, means for applying said signal frequency current to said tunable circuits, means for simultaneously varying the resonant frequency of said circuits and the frequency of said oscillator, and means for indicating the deviation of the resonant frequency of said circuits from the average frequency of said signal frequency currents at desired points within the tuning range of said circuits.

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