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FREQUENCY INDICATOR

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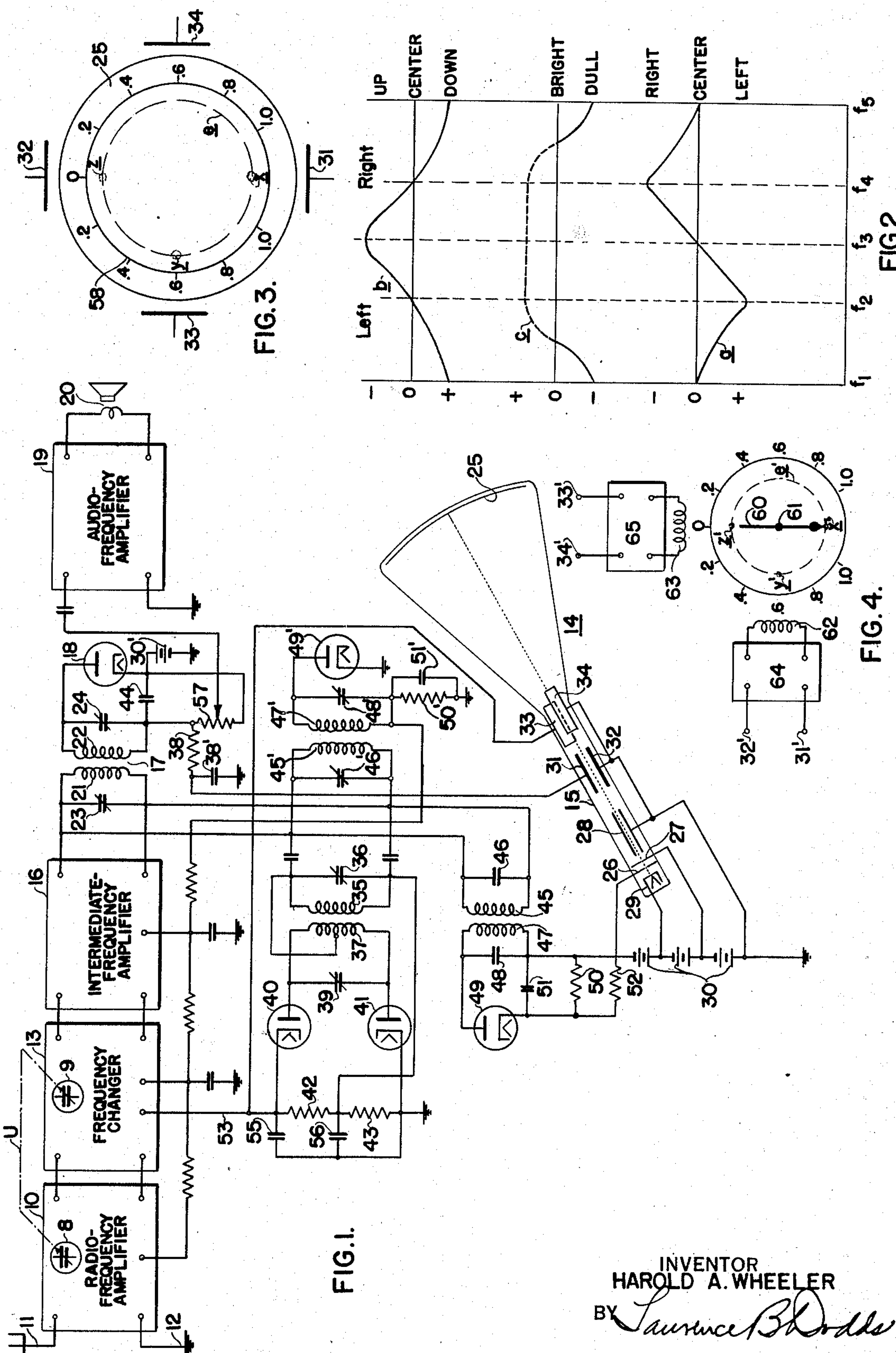

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FREQUENCY INDICATOR

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This invention relates to means for indicating the relation between the frequency of an alternating current source and the resonant frequency of an associated circuit and, more particularly, to tunable modulated-carrier signal-selecting systems including means for indicating when such a system is properly tuned to a desired received signal.

In order that signaling systems, such as radio receivers, may faithfully reproduce a desired signal, it is essential that the tunable circuits of the receiver be precisely adjusted so that the carrier of the desired signal coincides exactly with the mean resonant frequency of the signal-selector networks of the system or bears a predetermined relation thereto. As is well understood, when the receiver is mistuned from the carrier frequency of the desired signal to some other frequency in the vicinity of the carrier frequency, certain of the modulation or sideband frequencies are attenuated or suppressed, while others are accentuated and distortion of the reproduction results. In receivers of the superheterodyne type, the major part of the selectivity of the receiver is obtained in the intermediate-frequency selector circuits. In this case, mistuning of the receiver results in deviations of the intermediate-carrier frequency from the predetermined frequency or the mean resonant frequency of the selector network, resulting in distortion, as mentioned above.

It is usually difficult to determine when a receiver is exactly tuned to the carrier frequency of the signal being received. This is particularly true of receivers provided with automatic amplification control, which is now in general use, since, in such receivers, the control effects substantially uniform volume output for received signals varying over a wide range of amplitude and the volume of the output may not change appreciably for a slight mistuning. It is highly desirable, therefore, that means be provided which will give an indication, preferably a visual indication, of the tuning of the receiver which is independent of received signal amplitude. While certain arrangements have been devised for giving such a visual indication, such arrangements, in general, do not give an indication in which there is a readily apparent relationship between the nature of the indication and the movement of the tuning control member as the tuning is varied. Furthermore, the relative magnitude of mistuning is not, in general, readily apparent in the indicating arrangements of the prior art.

It is an object of the invention to provide a means for indicating the relationship between the frequency of an alternating current source of potential and the resonant frequency of an associated circuit.

It is a further object of the present invention to provide improved means for precisely indicating the resonant condition or tuning of a modulated-carrier signal-selecting system.

It is a further object of the invention to provide means of the type described in which an indicating point moves with a readily apparent predetermined relationship to the movement of the tuning control member.

It is a further object of the invention to provide an indicating means of the type described in which the control potentials required are such as may be present in a modern superheterodyne radio receiver.

In accordance with the present invention, there is provided a modulated-carrier signal-selecting system including a signal-selector network and tuning means for adjusting the relation between the carrier frequency of a desired signal and the mean resonant frequency of the selector network. Furthermore, there is provided means responsive jointly to the relation between the desired carrier frequency and the mean resonant frequency of the selector circuit and to the magnitude of the response of the selector circuit to the carrier frequency, for producing an indication of the relation between the carrier frequency of the desired signal and the mean resonant frequency of the selector network. In addition, there is provided means in which an indicating point moves with a readily apparent predetermined relationship to the movement of the tuning control member.

In the preferred embodiment of the invention, the system is of the superheterodyne type and comprises tunable frequency-changing means for deriving from a selected modulated-carrier signal a second modulated-carrier signal having a carrier normally of a predetermined frequency but subject to deviations upon mistuning of the frequency-changing means. The signal-selector network is coupled to the frequency-changing means and includes a plurality of coupled circuits resonant at the predetermined frequency. For producing the tuning indication there is provided a cathode-ray tube comprising conventional means for developing an electron beam, a fluorescent screen in the path of the electron beam, and means for deflecting the beam in two directions normal to each other and substantially normal to the axis of the tube. Means are provided for coupling the deflecting means to the signal-selector network for deflecting the beam in accordance with the relation between the desired carrier frequency and the resonant frequency of the selector and in accordance with the magnitude of the response of the selector to the carrier frequency, thereby to trace configurations on the screen indicative of the accuracy of the tuning of the receiver.

For a better understanding of this invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawing, and its scope will be pointed out in the appended claims.

In the accompanying drawing, Fig. 1 is a circuit diagram, partly in block form, of a complete superheterodyne radio receiver embodying the present invention; Fig. 2 is a graph of certain operating characteristics of the system of Fig. 1; Fig. 3 is a schematic illustration of the fluorescent screen and the deflecting plates of the cathode-ray tube of Fig. 1; and Fig. 4 is an illustration of an embodiment of the invention which comprises a mechanical indicating means.

Referring now more particularly to Fig. 1, there is shown schematically a complete superheterodyne radio receiver of a conventional design embodying the present invention in a preferred form. In general, the receiver includes a tunable radio-frequency amplifier **10** having its input circuit connected to an antenna **11** and ground **12** and its output circuit connected to a frequency changer **13**. The radio-frequency amplifier **10** and frequency changer **13** may be of conventional types including adjustable tuning condensers indicated generally at **8** and **9**, respectively. The tuning condensers may be interconnected or ganged for unicontrol as indicated by the dotted line U. Connected in cascade with the frequency changer **13**, in the order named, are an intermediate-frequency amplifier **16** of one or more stages, an intermediate-frequency signal selector **17**, a detector **18**, an audio-frequency amplifier **19** of one or more stages, and a sound reproducer **20**. The selector **17** is a double-tuned circuit comprising the coupled circuits **21**, **23** and **22**, **24**, broadly tuned and sharply tuned, respectively, to the normal frequency of the intermediate-frequency carrier. An automatic amplification control bias derived from the load circuit **50′**, **51′** of tube **49′**, coupled to the signal channel through a double-tuned network **45′**, **46′** and **47′**, **48′**, is applied to the grids of one or more of the tubes of the amplifier **10**, frequency changer **13**, and intermediate-frequency amplifier **16** in order to maintain the signal input to the detector **18** within a narrow range for a wide range of received signals.

It will be understood that the various circuits just described may be of conventional construction and operation, the details of which are well-known in the art, rendering further description thereof unnecessary. Considering briefly the operation of the receiver as a whole and neglecting for the moment the visual tuning arrangement of this invention, presently to be described, a desired received signal is selected and amplified by radio-frequency amplifier **10**, converted to a modulated intermediate-frequency carrier in frequency changer **13**, amplified and selected by intermediate-frequency amplifier **16** and selector network **17**, and rectified by the detector **18**, thereby deriving the audio frequencies of modulation, these frequencies, in turn, being amplified in audio-frequency amplifier **19** and reproduced by sound reproducer **20**. The automatic amplification control circuit serves to maintain the volume output of the receiver within a narrow range for a wide range of received signal amplitudes.

Referring now more particularly to the parts of the system embodying the present invention, there is provided, in connection with intermediate-frequency selector network **17**, a cathode-ray tube **14** of the oscilloscope type. This tube is of conventional design and comprises the usual elongated evacuated envelope **15**, having in one end thereof a plurality of electrodes constituting an electron gun and at the other end a fluorescent screen **25**. The electron gun is of the usual design comprising, in the order mentioned, a cathode **29**, control grid **26**, first anode **27**, and focusing anode **28** effective to generate a stream of electrons and focus it into a beam and accelerate it toward the screen **25**. Cathode-ray tube **14** may be of the type commercially known as type 913. Operating potentials for the electrodes of the tube are provided from a suitable source, such as battery **30**. Between the electron gun and the target are disposed two pairs of deflecting plates **31**, **32** and **33**, **34**. Plates **33**, **34** are effectively coupled to the signal selector **17** in such a way as to receive a potential indicative of the relation between the desired carrier frequency and the mean resonant frequency of the selector **17**. Plates **31**, **32** are coupled to the selector network **17** in such a manner as to receive a potential proportional to the response of selector **17** to the carrier frequency of the desired signal carrier.

The means for supplying a potential to electrodes **33**, **34** comprises a circuit **35**, **36** coupled to selector **17** and broadly resonant at a frequency equal to the mean frequency of selector **17** and a circuit **37**, **39** sharply tuned to the same frequency and loosely coupled to circuit **35**, **36**. One terminal of winding **35** is connected to the mid-tap of winding **37**, as shown. The resonant circuits **35**, **36** and **37**, **39** are connected to supply diode rectifiers **40** and **41** having load resistors **42**, **43** by-passed by condensers **55** and **56**, respectively, and provide a circuit such as is commonly used in superheterodyne receivers for obtaining an automatic frequency control potential, variable in magnitude and polarity in accordance with the degree of mistuning.

With the connections as described, the alternating potentials applied to the diodes **40** and **41** comprise the resultants of the potential across the primary circuit **35**, **36** and the sum and difference, respectively, of one-half the potential across the secondary circuit **37**, **39**. It can be readily shown that these resultant potentials vary oppositely in magnitude as the frequency of the impressed potential is varied through the mean resonant frequency of the circuits. If these two potentials are adjusted to equality at the means resonant frequency, the unidirectional difference potential across the load circuits of the diodes **40** and **41** changes polarity as the frequency of the exciting potential varies through resonance. The variation of this difference potential, which is applied to plate **33** as the tuning member U is moved to tune the receiver through a channel containing a desired frequency, is shown in curve *a* of Fig. 2. Tuning member U is moved in a clockwise direction in tuning the receiver from a given frequency to a higher frequency and vice versa. It will be noted that the voltage is small at frequencies, such as f_1 and f_5, which are remote from the resonant frequency of the desired signal, indicated at f_3 in Fig. 2. As the tuning member U is adjusted to tune the receiver to the frequency f_3, it will be seen that the voltage approaches a maximum positive value at f_2 and drops to zero when the receiver is tuned to the desired signal. As the receiver is tuned through the desired signal to the higher frequencies, the voltage reaches a maximum negative value at frequency f_4 and again drops to zero as the receiver is tuned to the higher frequency f_5. It will thus be seen that the voltage represented by curve *a* corresponds in magnitude and polarity to the amount and direction of mistuning of the receiver at points in the vicinity of the correct tuning adjustment, that is, varies inversely with the amount of detuning on either side of the resonant frequency of the system. The potential represented by curve *a* may be applied to an automatic frequency control arrangement of a conventional type incorporated in frequency changer **13** and is shown applied thereto through conductor **53**.

In order to provide an electro-responsive means responsive to the output of the automatic frequency control means of the system, there is applied to the electrodes **31**, **32** a voltage varying in accordance with the response of selector **17** to the desired signal carrier, a control bias derived from the load resistor **57** of detector **18** is applied, through a portion of battery **30'**, between electrodes **31** and **32**. Resistor **38** and condenser **38'** serve to prevent audio signals from being applied between electrodes **31** and **32**. The variation in voltage between electrodes **31**, **32** as the receiver is tuned through a desired signal, is represented by curve *b* of Fig. 2 which is symmetrical on either side of the resonant frequency of the system. It will be seen that the voltage is positive when the receiver is tuned to a frequency f_1 below the frequency of the desired signal and decreases to a maximum negative value when the receiver is correctly tuned at f_3 and again increases in the positive direction as the receiver is tuned to frequencies higher than the correct frequency f_3 and thus varies in magnitude in accordance with the degree of mistuning of the receiver.

For an explanation of the operation of tube **14** as the receiver is tuned toward a desired frequency, reference is made to Fig. 3, in which **25** represents the fluorescent screen of the cathode-ray tube **14** and electrodes **31**, **32**, **33**, and **34** are indicated as being disposed externally to fluorescent screen **25** for clarity of illustration. A calibrated scale **58** is provided on fluorescent screen **25**. It will be seen that zero voltage is applied between electrodes **33** and **34** and that a maximum positive voltage is applied between electrodes **31** and **32** when the receiver is tuned to a frequency f_1. With these voltages applied to the tube, the cathode ray is not deflected by plates **33** and **34**, but is deflected toward plate **31**. As a result, a bright spot will be apparent on the fluorescent screen on the dotted line *e* at a point *x* nearest plate **31**. When the receiver is tuned to the frequency f_2, electrodes **31**, **32** cause no deflection and the cathode spot appears on the dotted line *e* at a point *y* near plate **33**. It will thus be seen that, if tuning mechanism U is adjusted in a clockwise direction, approaching the desired signal from a lower frequency, the cathode spot is shifted in two co-ordinate directions and moves clockwise in a circular path shown by the dotted line *e* to the position *z*, adjacent the plate **32**, as shown in the drawing, presenting an indication that the receiver is tuned exactly to the desired signal. As the receiver is tuned to signals of increasingly higher frequencies, the cathode spot continues to move in the path *e* and again appears at the point nearest electrode **31** as the tuning becomes remote from the desired signal. The movement of the cathode spot is, therefore, related to the movement of the tuning control member U in a manner which is readily apparent and such that tuning of the receiver is greatly facilitated. Stated in another manner, a first unidirectional potential variable in a predetermined relation in accordance with variation of the frequency of the source, for instance, a potential in accordance with curve *b* of Fig. 2, is applied to one set of deflecting plates of tube **14**, and a second unidirectional potential variable in a predetermined relation in accordance with variations of frequency of the source, for instance, a potential in accordance with curve *a* of Fig. 2, is applied to the other set of deflecting plates. These unidirectional potentials have different types of variation over the frequency range of the indicator and the variations of at least one of the unidirectional potentials, for instance, that illustrated by curve *a* of Fig. 2, reverse in sense within the frequency range of the indicator and thus provide the circular rotation of the indicator spot. Furthermore, it will be noted that the means of accomplishing this result requires little additional equipment to that generally incorporated in a modern superheterodyne receiver. Scale **58** may be calibrated, as indicated, to give an indication of the degree of mistuning in kilocycles. The deflection of the indicating spot of the system of Fig. 1 is thus at any instant dependent upon the amplitudes of the differences of curves *a* and *b* from their respective mean values. Since the voltages represented by curves *a* and *b* are approximately sinusoidal and of approximately equal amplitude and deflect the spot at right angles to each other, the actual deflection of the spot is substantially a circular movement, the radius of which is equal to the square-root of the sun of the squares of the differences in amplitude of curves *a* and *b*, respectively, from their respective mean values; that is, the resultant deflection is approximately constant in magnitude. The diameter of circular path *e* varies with the amplitude of the input to selector **17** and for this reason it may be desirable to use a form of amplification control which will maintain a more uniform input amplitude to selector **17** with varying amplitude of received signals than that shown in the drawing. A form of automatic amplification control, particularly suitable for this purpose, is described in United States Patent No. 2,050,679, granted August 11, 1936, on the application of Harold A. Wheeler.

In order to cause the cathode spot to appear with maximum brilliance when the receiver is tuned to the desired signal and to appear with minimum brilliance, or to be invisible, when the receiver is tuned to frequencies remote from the desired signal, a biasing potential may be applied to grid **26** of cathode-ray tube **14** which is determined by the amount of mistuning. This potential is derived from coupled resonant circuits **45**, **46** and **47**, **48** which are tuned to the mean resonant frequency of the selector **17** to which they are coupled and are at least no less frequency-selective than selector **17**. A diode **49** is connected across the secondary circuit **47**, **48** and is provided with a load resistor **50** bypassed by a condenser **51** and develops a voltage which is applied between grid **26** and cathode **29** through resistance **52** and a portion of battery **30**.

The resultant voltage applied to grid 26 is represented by curve c of Fig. 3. It will be seen that this voltage is low or negative at points removed from the frequency of the desired signal and becomes a maximum at frequencies in the vicinity of the frequency of the desired signal. Therefore, the intensity of the cathode ray developed by the tube 14 varies with the amount of mistuning of the receiver and the cathode spot will appear with maximum brilliance when the receiver is correctly tuned. The positive portion of the curve c is indicated by dotted lines for the reason that the positive voltage is not effective on the grid of the cathode-ray tube because of the high resistance of resistor 52. This protects the tube 14 from excessive currents and maintains uniform brilliancy of the cathode spot over most of the circular path e. It is apparent that the control provided by each of the circuits including tubes 49 and 49', respectively, is similar in that each circuit is broadly tuned and in an alternative arrangement one of the circuits can be omitted and the other circuit can be used to provide both the automatic amplification control and brilliancy control potentials. It will be understood that, if desired, the tuning indicator of the invention can be used without the feature which controls the brilliance of the cathode spot in accordance with receiver tuning, and can be used in connection with any tuned circuit in which it is desired to determine the relationship between the resonant frequency of the circuit and the frequency of an associated alternating current source.

In Fig. 4 is illustrated a mechanical indicator which may be used in place of the cathode-ray tube 14 of Fig. 2. This indicator comprises a magnetized pointer 60 which moves about pivot 61 in accordance with the resultant field of windings 62 and 63. Voltages are applied to leads 31', 32' and 33', 34' which correspond to, and may be derived in the same manner as, the voltages applied to electrodes 31, 32 and 33, 34, respectively, of Fig. 1, and 64 and 65 represent amplifying devices of a conventional form, the outputs of these amplifiers being applied to coils 62 and 63, respectively. The indicator of Fig. 4 is adjusted so that the index of pointer 60 forms a movable visible point similar to the point formed by the cathode spot of the embodiment of Fig. 1 and moves from point x' around the dotted line e' in the same manner as was described for the spot of the indicating device of Fig. 1, and appears at z' when the receiver is correctly tuned.

While there have been described what are at present considered to be the preferred embodiments of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from this invention, and, therefore, it is aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of this invention.

What is claimed is:

1. Apparatus for indicating the relationship between the resonant frequency of a tuned circuit and the frequency of a source of alternating potential associated therewith, comprising a movable visible point, means including said circuit for developing a first unidirectional potential variable in a predetermined relation in accordance with variation of the frequency of said source, means for developing a second unidirectional potential variable in a predetermined relation in accordance with variation of said frequency source, said unidirectional potentials having different types of variation over the frequency range of said indicator and the variations of at least one of said unidirectional potentials reversing in sense within said frequency range, and means for shifting said point in two co-ordinate directions, each in response to one of said unidirectional potentials.

2. A frequency indicator comprising a tuned circuit, a source of alternating potential associated therewith, means for indicating the relationship between the resonant frequency of said circuit and the frequency of said source comprising a cathode-ray tube including a fluorescent screen and means for producing a luminous spot on said screen, means including said circuit for developing a first unidirectional potential variable in a predetermined relation in accordance with variation of the frequency of said source, means for developing a second unidirectional potential variable in a predetermined relation in accordance with variation of said frequency source, said unidirectional potentials having different types of variation over the frequency range of said indicator and the variations of at least one of said unidirectional potentials reversing in sense within said frequency range, and means for deflecting said spot in two co-ordinate directions, each in response to one of said unidirectional potentials.

3. A frequency indicator comprising a tuned circuit, a source of alternating potential associated therewith, means for indicating the relationship between the resonant frequency of said circuit and the frequency of said source comprising a pivoted polarized magnetic member, and means for developing two nonrotating magnetic fields, each variable in accordance with variation of the frequency of said source and having different types of characteristics over the frequency range of said indicator, the variation of at least one of said fields reversing in sense within said frequency range, said magnetic fields being disposed to act on said member.

4. In a modulated-carrier signal receiver including a signal detector and automatic frequency-control means, a signal-selecting system comprising a carrier-frequency signal-selector network, tuning means for adjusting the relation between the frequency of a desired signal and the mean resonant frequency of said selector network, electro-responsive means responsive to said control means, means responsive to the output of said signal detector, and means responsive to said two last-mentioned means for producing an indication of the relation between the frequency of said desired signal and said mean resonant frequency.

5. A modulated-carrier signal-selecting system comprising a carrier-frequency signal-selector network, tuning means for adjusting the relation between the frequency of a desired signal and the mean resonant frequency of said selector network, a first frequency-discriminating means for producing a first control variable in magnitude in accordance with the difference of said frequencies and having a polarity depending on the direction of said frequency difference, a second frequency-discriminating means for producing a second control variable in magnitude in accordance with said frequency difference, and means responsive jointly to both of said controls for producing an indication of the relation between said frequencies.

6. A modulated-carrier signal-selecting system comprising a carrier-frequency signal-selector network, tuning means for adjusting the relation between the frequency of a desired signal and the mean resonant frequency of said selector network, frequency-discriminating means for producing a first control variable in magnitude in accordance with the difference of said frequencies and having a polarity depending on the direction of said frequency difference, sharply selective frequency-discriminating means for producing a second control variable in magnitude in accordance with said frequency difference, and means responsive jointly to both of said controls for producing an indication of the relation between said frequencies.

7. A modulated-carrier signal-selecting system comprising a carrier-frequency signal-selector network, tuning means for adjusting the relation between the carrier frequency of a desired signal and the mean resonant frequency of said network, means responsive to the magnitude and direction of the difference between said carrier frequency and said resonant frequency, means substantially solely responsive to the magnitude of the difference between said resonant frequency and said carrier frequency, and visible indicating means responsive to said two last-mentioned means for producing an indication of the relation between said carrier frequency and said mean frequency.

8. A modulated-carrier signal-selecting system comprising a carrier-frequency signal-selector network, tuning means for adjusting the relation between the carrier frequency of a desired signal and the mean resonant frequency of said selector network, a cathode-ray tube, means responsive to the magnitude and direction of the frequency difference between said carrier frequency and said resonant frequency, means responsive to the magnitude of the difference of said resonant frequency and said carrier frequency, and means for controlling said tube jointly in response to said two last-mentioned means for producing an indication of the relation between said carrier frequency and said mean frequency.

9. A modulated-carrier signal-selecting system comprising a carrier-frequency signal-selector network, tuning means for adjusting the relation between the carrier frequency of a desired signal and the mean resonant frequency of said selector network, a cathode-ray tube including means for developing an electron beam, a fluorescent screen in the path of said beam, and beam-deflecting means, means responsive to the magnitude and direction of the frequency difference between said carrier frequency and said resonant frequency, means responsive to the magnitude of the difference between said resonant frequency and said carrier frequency, said deflecting means being responsive to said two last-mentioned means for producing an indication on said screen of the relation between said carrier frequency and said mean frequency.

10. A modulated-carrier signal-selecting system comprising a carrier-frequency signal-selector network, tuning means for adjusting the relation between the carrier frequency of a desired signal and the mean resonant frequency of said selector network, a cathode-ray tube including means for developing an electron beam, a fluorescent screen in the path of said beam, and means for deflecting said beam in two directions normal to each other, one of said deflecting means being responsive to the magnitude and direction of the frequency difference between said carrier frequency and said resonant frequency and the other of said deflecting means being responsive to the magnitude of the response of said network to said carrier frequency, thereby to produce luminous response on said screen indicative of the relation between said carrier frequency and said resonant frequency.

11. A modulated-carrier signal-selecting system comprising a carrier-frequency signal-selector network, tuning means for adjusting the relation between the frequency of a desired signal and the mean resonant frequency of said selector network, a cathode-ray tube including means for developing an electron beam, a fluorescent screen in the path of said beam, means for deflecting said beam in two directions normal to each other, rectifier means for deriving a first control voltage variable in magnitude in accordance with the difference of said frequencies and having a polarity depending on the direction of said frequency difference and for applying said voltage to one of said deflecting means, and rectifier means for deriving a second control voltage variable in magnitude with said frequency difference and for applying said second voltage to the other of said deflecting means, thereby to produce on said screen an indication of the relation between the frequency of said desired signal and said mean frequency.

12. A modulated-carrier signal-selecting system comprising tunable frequency-changing means for deriving from a selected modulated-carrier signal a second modulated-carrier signal having a carrier normally of a predetermined frequency but subject to deviations upon mistuning of said frequency-changing means, a carrier-frequency signal-selector network coupled to said frequency-changing means and resonant at said predetermined frequency, a cathode-ray tube, means responsive in magnitude and polarity to the difference between said second modulated-carrier frequency and said predetermined frequency, means responsive in magnitude to the response of said network to said second modulated-carrier frequency, and means responsive to said two last-mentioned means for controlling said tube to produce an indication of said deviations.

13. A modulated-carrier signal-selecting system comprising a carrier-frequency signal-selector network, tuning means for adjusting the relation between the carrier frequency of a desired signal and the mean resonant frequency of said selector network, visible indicating means responsive jointly to the relation between said carrier frequency and said resonant frequency and to the magnitude of the response of said network to said carrier frequency for producing an indication of the relation of said carrier frequency and said mean frequency, and means responsive to the magnitude of deviation of said carrier frequency from said mean frequency for varying the visibility of said indicating means.

14. A modulated-carrier signal-selecting system comprising a carrier-frequency signal-selector network, tuning means for adjusting the relation between the carrier frequency of a desired signal and the mean resonant frequency of said selector network, visible indicating means responsive jointly to the relation between said carrier frequency and said resonant frequency and to the magnitude of the response of said network to said carrier frequency for producing an indication of the relation of said carrier fre-

quency and said mean frequency, and means responsive to the magnitude of the deviation of said carrier frequency from said mean frequency for varying the visibility of said indicating means, said last means being no less frequency-selective than said selector network.

15. A modulated-carrier signal-selecting system comprising a carrier-frequency signal-selector network, tuning means for adjusting the relation between the carrier frequency of a desired signal and the mean resonant frequency of said selector network, a cathode-ray tube including means for developing an electron beam, a grid for controlling the intensity of said beam, a fluorescent screen in the path of said beam, beam-deflecting means, said deflecting means being responsive jointly to the relation between said carrier frequency and said resonant frequency and to the magnitude of the response of said network to said carrier frequency for producing an indication on said screen of the relation of said carrier frequency and said mean frequency, and rectifier means for developing a unidirectional voltage variable in accordance with the deviations of said desired signal from said mean frequency and for applying said voltage to said grid to vary the luminosity of said indication on said screen.

16. Apparatus for indicating the relationship between the resonant frequency of a tuned circuit and a source of alternating potential associated therewith, comprising an indicator having a movable visible point, means including said circuit for developing a first unidirectional potential variable in predetermined relation in accordance with the frequency of said source, means for developing a second unidirectional potential variable in a predetermined relation in accordance with the frequency of said source, said unidirectional potentials having different types of variation over the frequency range of said indicator, and means for shifting said point in two co-ordinate directions, each in response to one of said unidirectional potentials, the sum of the squares of the differences in amplitude of said potentials from their respective mean values being approximately a constant.

17. A frequency indicator comprising a tuned circuit, a source of alternating potential associated therewith, means for indicating the relationship between the resonant frequency of said circuit and the frequency of said source comprising a cathode-ray tube including a fluorescent screen and means for producing a luminous spot on said screen, means including said circuit for developing two unidirectional potentials, one of said potentials varying symmetrically and the other inversely on either side of the resonant frequency of said system, said one of said potentials having a maximum value of one sense and the other of said potentials being zero at said resonant frequency, said one of said potentials being zero for frequencies slightly removed from said resonant frequency and said other of said potentials having maximum values of opposite sense for frequencies slightly removed on either side of said resonant frequency, and means for deflecting said spot in two coordinate directions, each in response to one of said unidirectional potentials.

18. A frequency indicator comprising a tuned circuit, a source of alternating potential associated therewith, means for indicating the relationship between the resonant frequency of said circuit and the frequency of said source comprising a cathode-ray tube including a fluorescent screen and means for producing a luminous spot on said screen, means including said circuit for developing two unidirectional potentials, one of said potentials varying symmetrically and the other inversely on either side of the resonant frequency of said system, said one of said potentials having a maximum value of one sense and the other of said potentials being zero at said resonant frequency, said one of said potentials being zero for frequencies slightly removed from said resonant frequency and said other of said potentials having maximum values of opposite sense for frequencies slightly removed on either side of said resonant frequency, said one of said potentials having maximum values of sense opposite to said one sense and said other of said potentials being zero for frequencies greatly removed from said resonant frequency, and means for deflecting said spot in two coordinate directions, each in response to one of said unidirectional potentials.

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