Feb. 3, 1942. J. C. WILSON 2,271,964

TUNING INDICATOR FOR CARRIER-SIGNAL RECEIVERS

Filed March 27, 1940

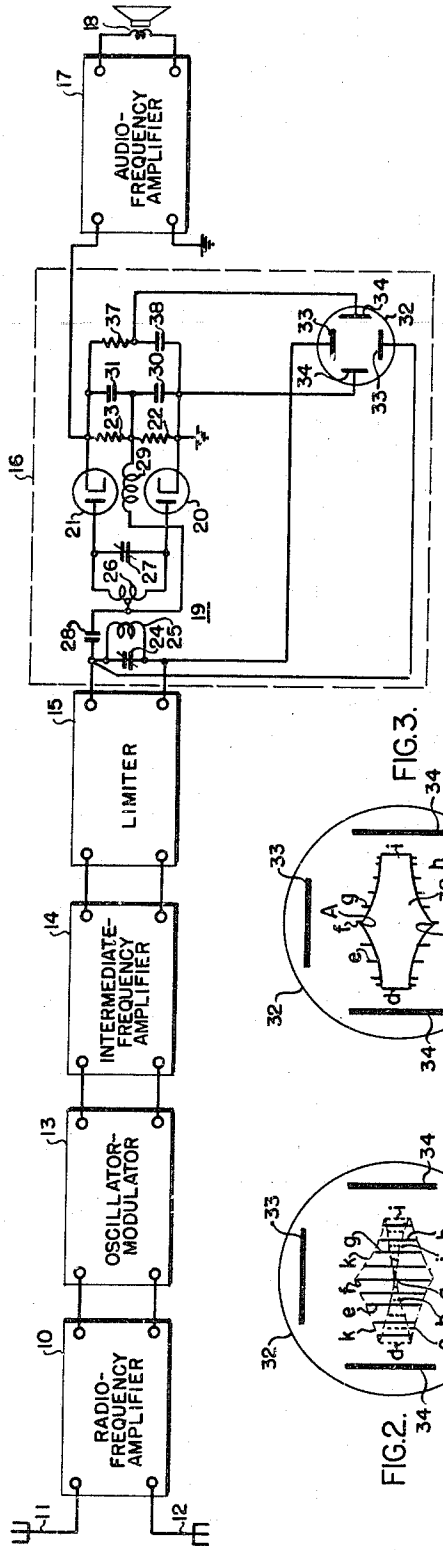


FIG.1.

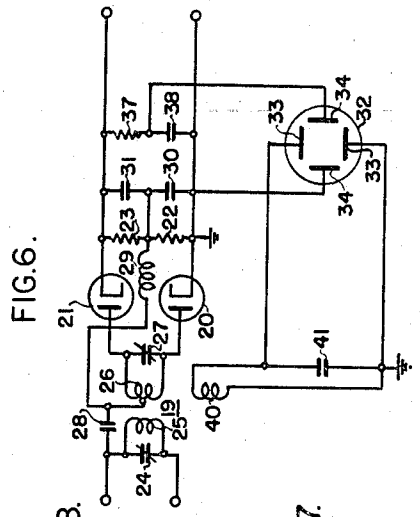


FIG.6.

FIG.3.

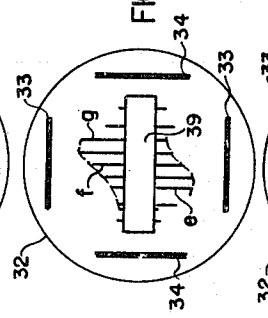


FIG.8.

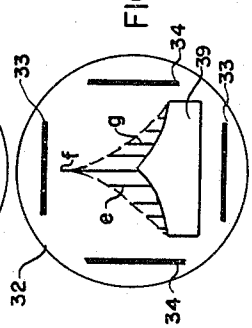


FIG.7.

FIG.2.

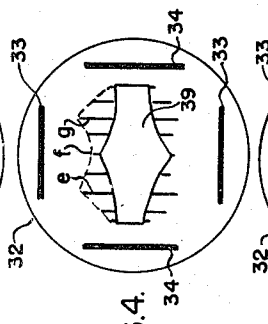


FIG.4.

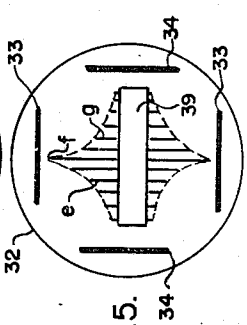


FIG.5.

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TUNING INDICATOR FOR CARRIER-SIGNAL RECEIVERS

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7 Claims. (Cl. 250—40)

The present invention relates to an improved tuning indicator for carrier-signal receivers and, particularly, to a tuning indicator especially suitable for embodiment in a tunable frequency-modulated carrier-signal receiver.

Carrier-signal receivers conventionally are provided with a manual control for tuning the receiver to a desired transmitting station. Since the failure accurately to tune the receiver to the desired station frequently results in undesirable distortion of the received signal, it is further conventional to provide the receiver with a visual tuning indicator by which the accurate tuning of the receiver to the desired station is facilitated.

The tuning indicators of the prior art are primarily useful only with amplitude-modulated carrier-signal receivers and generally consist of some device responsive to the magnitude of a unidirectional current or voltage, for example, the magnitude of an automatic amplification control or A. V. C. potential derived from the signal energy and which, therefore, varies in accordance with the intensity of the signal translated by the receiver. The strength of the translated signal is, in general, greatest when the receiver is accurately tuned to the desired transmitting station and the indication of the tuning device which measures the potential derived therefrom is likewise greatest under this condition of tuning.

Carrier-signal receivers designed for high-fidelity reception necessarily have broadly-tuned selector circuits which have substantially uniform response to a broad band of frequencies generally from 15 to 20 kilocycles wide. Since the majority of the prior art tuning indicators operate by virtue of the intensity of the signal energy appearing in the signal-translating channel which includes such broadly-tuned circuits, it is exceedingly difficult to ascertain, within a reasonable degree of accuracy, the condition of tuning of the receiver to a desired station by the use of such tuning indicators. While it is possible to provide an auxiliary highly-selective channel from which signal energy is supplied to operate the tuning indicator, it is difficult to maintain such sharply-tuned indicator system circuits at the mid-range frequency of the broadly-tuned circuits of the receiver due to changes of tuning of both the sharply-tuned and broadly-tuned circuits with changes of humidity, temperature, and the like. This is especially true in regard to frequency-modulation receivers in which any difference between the resonance frequency of the sharply-tuned tuning indicator channel and the broadly-tuned selector circuit of the detector system unavoidably results in distortion of the detected signal, particularly when there exists a high percentage of modulation of the transmitted carrier signal.

The prior art tuning indicators, in general, have the further disadvantage that they do not give a positive indication of the direction in which the receiver is mistuned from a desired transmitting station.

Additionally, the prior art tuning indicators, in general, cannot be embodied in frequency-modulation receivers since the intensity variations of translated signals are deliberately reduced by limiter devices, the function of which is to limit all translated signals to a substantially constant amplitude, generally that of the weakest carrier signal which the receiver is capable of reproducing satisfactorily. It is difficult, therefore, without the use of additional apparatus, to produce in this type of receiver automatic amplification control potentials which, in responding to the intensity of received signals, can be employed as a source of potential for the operation of tuning indicators.

It is an object of the invention, therefore, to provide a new and improved tuning indicator system for carrier-signal receivers which not only avoids the above-mentioned difficulties of the prior art devices but which, additionally, is of inexpensive yet sturdy construction and possesses a high degree of tuning accuracy, reliability, and sensitivity.

It is a further object of the invention to provide a tuning indicator, particularly suitable for use in frequency-modulation receivers, by which there is required an infinitesimally small operating energy to procure an indication of both the direction and degree of mistuning of the receiver from a desired carrier signal.

In accordance with one embodiment of the invention, a tuning indicator for a modulated-carrier signal receiver including an adjustable tuning means comprises means for deriving from a received signal a control signal, the magnitude of which varies in accordance with the degree of mistuning of said receiver on either side of a received signal. The indicator includes a cathode-ray tube and means responsive to the control signal for deflecting the cathode ray of the tube to produce a visual indication of the magnitude of mistuning. There is also provided means for periodically deflecting the cathode ray in another direction to produce for each tuning position a line the position of which varies with

the degree of mistuning. Predetermined portions of the visual indication are ambiguous, and means is provided for effectively masking these predetermined portions of the visual indication to aid in precisely tuning the receiver.

For a better understanding of the present 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.

Referring now to the drawing, Fig. 1 is a circuit diagram, partly schematic, of a complete superheterodyne frequency-modulation receiver embodying the invention in association with the balanced detector of the receiver; Figs. 2–5, inclusive, and Fig. 8 illustrate the tuning indications provided by different operating conditions of the receiver of Fig. 1; Fig. 6 is a circuit diagram of a modification of the invention; and Fig. 7 illustrates a tuning indication attainable by the modification of the invention of Fig. 6.

Referring more particularly to Fig. 1, there is shown schematically a complete frequency-modulation receiver of a conventional design embodying the present invention in a preferred form. In general, the receiver includes a radio-frequency amplifier 10 having its input circuit connected to an antenna system 11, 12 and its output circuit connected to a frequency changer or oscillator-modulator 13. Connected in cascade with the frequency changer 13, in the order named, are an intermediate-frequency amplifier 14 of one or more stages, an amplitude limiter 15, a balanced detector and tuning indicator 16, an audio-frequency amplifier 17 of one or more stages, and a sound reproducer 18. It will be understood that the units 10 and 13 include adjustable tuning means by which the receiver may be tuned to a desired carrier signal.

It will be understood that the various units just described, with the exception of the unit 16 comprising the present invention, may be of a 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 operation of the balanced detector and tuning indicator 16, presently to be described, a desired frequency-modulated carrier signal is received by the antenna system 11, 12, selected and amplified by the radio-frequency amplifier 10, converted to a frequency-modulated intermediate-frequency carrier signal in the frequency changer 13, amplified by the intermediate-frequency amplifier 14, limited to a predetermined substantially constant amplitude by the limiter 15, and detected by the detector of unit 16, thereby to derive the audio-frequency modulation components. The audio-frequency modulation components are, in turn, amplified in the audio-frequency amplifier 17 and reproduced by the sound reproducer 18.

Referring now more particularly to the portion of the system embodying the present invention, the balanced detector and tuning indicator 16 includes means for deriving from a received signal a control signal the magnitude of which varies in accordance with the degree of mistuning of the receiver on either side of the received signal. This means comprises a selector network 19 having a band-pass characteristic sufficiently broad to pass the intermediate-frequency carrier signal and its modulation components, a pair of diode detectors 20, 21, and individual load circuits therefor comprising resistors 22, 23, bypassed by condensers 30, 31, respectively. The selector network 19 comprises a primary tuned circuit including a condenser 24 and an inductor 25, the latter being inductively coupled to an inductor 26 of a secondary circuit tuned by a condenser 27. The primary tuned circuit 24, 25 and the secondary tuned circuit 26, 27 are tuned to the normal intermediate-carrier frequency of the receiver. A condenser 28 is connected between the high signal-potential side of the tuned circuit 24, 25 and the mid-point of the secondary inductor 26. A radio-frequency choke 29 is connected between the junction point of the resistors 22, 23 and the center tap on the secondary inductor 26 to provide a direct current return path for the diodes 20, 21.

The tuning indicator provided for the receiver additionally includes a cathode-ray tube 32, here illustrated by way of example as a tube of the deflecting-electrode type, having two pairs of deflecting electrodes 33, 33 and 34, 34, arranged at right angles to each other, the first pair 33, 33 being connected across the frequency-selector or primary tuned circuit 24, 25 while the second pair 34, 34 is connected through an audio-frequency filter, comprising a series resistor 37 and a shunt condenser 38, across the detector load resistors 22, 23.

In considering the operation of the circuit just described, it will be seen that the selector network 19 is, in general, similar to conventional frequency-responsive networks and, further, that the detector circuit utilizes the conventional principle of rectifying separately the sum and difference of the voltages across the primary and secondary circuits of a double-tuned selector circuit and combining differentially the rectified voltages so obtained to provide a voltage varying in magnitude and polarity with the frequency of a modulated-carrier signal applied thereto. That is, the circuit elements 19 to 31, inclusive, comprise means for deriving from a received signal a unidirectional control potential the magnitude and polarity of which vary, respectively, in accordance with the degree and direction of mistuning of the receiver on either side of the received carrier signal. The audio-frequency components of such voltage are amplified in amplifier 17 and reproduced by unit 18 in a conventional manner.

In considering the operation of the indicator, it will be assumed that the receiver is initially badly mistuned from a desired carrier signal. Under such conditions, little or no signal appears at the output of the limiter 15 and little or no control signal potential is, therefore, developed across the resistors 22, 23. Consequently, no deflection potential is supplied to either of the deflecting electrodes 33, 33 or 34, 34 and the undeflected cathode ray produces a spot of light at the center of the cathode-ray screen, as indicated by the spot *a* in Fig. 2. As the receiver is tuned into proximity with a desired carrier signal, a control-signal potential is derived from the received signal and appears across the resistors 22, 23, the potential being larger across one of the resistors 22, 23 according to the direction of mistuning of the receiver from the received signal. This control-signal potential excites the deflecting electrodes 34, 34 and causes the cathode ray to be deflected horizontally to one side or the other of its undeflected position *a*, the direction of deflection depending upon the polarity of the control-signal potential. At the same time, the

deflecting electrodes 36, 34 are supplied with an alternating potential, the magnitude of which varies with the degree of mistuning, thereby to deflect the cathode ray periodically in a vertical direction. There is thus formed on the cathode-ray tube screen a series of lines *b*, *c*, *d*, *e*, and *f* as the receiver is progressively tuned toward the received signal.

In this regard, it may be noted that the cathode ray is deflected horizontally from the point *a* to the position of the line *d* as the receiver is progressively tuned toward the received signal but reverses its direction of deflection to produce the series of lines *e*, *f*, etc., as the tuning continues in the same direction. This reversal of the horizontal deflection is produced by the gradual increase in amplitude of one of the control-signal potentials produced across the resistors 22, 23, this one potential increasing much more rapidly than the potential produced across the other resistor when the receiver is badly mistuned while the reverse condition holds true as accurate tuning is approached. The potentials across the resistors 22, 23 are of equal magnitudes and opposite polarities at the time when the intermediate-frequency signal of the receiver has a frequency equal to the mean resonant frequency of the frequency-selector circuit 19 at which time the receiver is tuned accurately to a desired carrier signal.

As the receiver is progressively tuned in the same direction through the signal, the control-signal potential across the resistors 22, 23 reverses polarity, while its magnitude varies in a similar manner with the degree of mistuning of the receiver. There is thus produced a series of lines *g*, *h*, *i*, and *j* of progressively shorter lengths, each corresponding to a position of mistuning of the receiver to the received carrier signal. The cathode-ray beam again comes to rest at the point *a* when the receiver is badly mistuned on the side of the signal carrier opposite to that from which the continuous tuning operation was begun. The envelope of the entire series of lines thus produced by a continuous tuning operation of this nature is symmetrical about the point *a*, as indicated in Fig. 2 by the broken-line envelope *k*.

From the foregoing explanation of the operation of the invention, it is evident that the tuning indicator produces a line corresponding to each tuning position of the receiver on either side of the received signal carrier, the length of the line, and thus its area, and its relative position on the screen of the cathode-ray tube providing a visual indication of the magnitude and direction of mistuning of the receiver from the received carrier signal. Thus, the deflecting electrodes 34, 34 of the tube 32 comprise means responsive to the control signal or potential, derived from the received carrier signal by unit 18, for deflecting the cathode ray of tube 32 to produce a visual indication of the magnitude and direction of mistuning of the receiver to the received carrier signal, and the deflecting electrodes 33, 33 and the tuned circuit 24, 25 comprise means for periodically deflecting the cathode ray of tube 32 in another direction to produce for each tuning position a line the position of which varies with the degree of mistuning. The tuned circuit 24, 25 further comprises means responsive to the degree of mistuning for varying the magnitude of the periodic deflection in accordance with the degree of mistuning further to indicate by the length of the lines the degree of mistuning of the receiver.

The portions of the cathode-ray deflection from the point *a* to either the line *d* or the line *i* furnish tuning indications which possibly may be misleading or ambiguous. Fig. 3 shows a modification of the invention wherein an opaque mask 39 is provided adjacent the screen of the cathode-ray tube to mask from view all of the shorter lines *b*, *c*, *j*, etc., no line being visible until the tuning is sufficiently accurate that the cathode-ray indication lies between the lines *d* to *i*, inclusive. This arrangement thus masks the indications provided by the cathode-ray tube until the accuracy of tuning is within predetermined limits. As in Fig. 2, the line *f* indicates that the receiver is accurately tuned to the desired carrier signal. The mask 39 preferably is provided with a pair of cusps or horns A, A corresponding to the position of the indicating line for precise tuning as a further aid in indicating the condition of resonance.

The deflection patterns illustrated in Figs. 2 and 3 correspond to those obtained under the assumed condition that the primary tuned circuit 24, 25 is sharply resonant and is less than critically coupled to the secondary tuned circuit 26, 27. In the event that the primary tuned circuit is more than critically coupled to the secondary tuned circuit, the deflection pattern produced by the cathode-ray tube 32 is of the type indicated by Fig. 4. While the line *f* of Fig. 4 is shorter than the lines *e* and *g*, by virtue of the decreased magnitude of the potential appearing across the primary tuned circuit at resonance, it still indicates the condition of exact tuning of the receiver to the desired carrier signal, since it corresponds to the position of the cathode-ray beam at zero horizontal deflection.

The indication at resonance may obviously be greatly exaggerated by causing the length of the lines greatly to increase in the vicinity of the line *f*, as indicated in Fig. 5. This may be accomplished by providing a primary tuned circuit having an extremely sharply-peaked response at the normal intermediate frequency of the receiver and by providing a very loose coupling between the primary and secondary tuned circuits.

The peaked characteristic of Fig. 5 may also be obtained by the modification of the invention shown in Fig. 6, wherein elements corresponding to like elements of Fig. 1 are designated by like reference characters. The arrangement of Fig. 6 is similar to that of Fig. 1 except that the selector network 19 has a winding 40 inductively coupled to the primary inductor 25. The potential induced in the winding 40 is supplied to the vertical deflecting electrodes 33, 33 of the cathode-ray tube 32. To obtain the maximum vertical deflection of the cathode-ray tube when the receiver is tuned to resonance with the desired carrier signal, the winding 40 is sharply tuned to the normal intermediate frequency of the receiver by a condenser 41. The low-potential side of tuned circuit 40, 41 is preferably grounded as indicated to produce a unilateral vertical deflection of the cathode-ray beam, as illustrated by the deflection pattern of Fig. 7. This has the advantage that the length of line *f*, which indicates exact tuning of the receiver to the desired carrier signal, is greatly accentuated relative to the lines on either side corresponding to slightly detuned positions of the receiver.

While the voltage supplied to the vertical deflecting electrodes 33, 33 of the Fig. 1 arrange-

ment is that appearing across the primary tuned circuit 24, 25, it is obvious that these deflecting electrodes might also be connected across the secondary tuned circuit 26, 27. Such connection is effective to provide the deflection pattern illustrated in Fig. 8 of the drawing, the line *f* indicating, as in the other deflection patterns, the point of exact tuning of the receiver to the desired carrier signal. The peculiar unsymmetrical shape of the pattern of Fig. 8 results from the fact that the voltage measured across the secondary tuned circuit is the result of the individual sum and difference voltages of the primary and secondary circuits by virtue of the connection of the circuits through the coupling condenser 28.

It is obvious that the mask 39 of Figs. 3–5, inclusive, 7 and 8 may have other contours than the preferred contours here illustrated without departing from the spirit of the invention. In fact, the mask 39 may be omitted entirely and the same effect obtained by deleting a similarly shaped area of the fluorescent screen of the cathode-ray tube 32. Thus the expression "effectively masking," as used in the claims, is intended to include any arrangement having the equivalent effect of an opaque mask as used to remove the visual effect otherwise produced by the cathode ray upon the fluorescent screen of the cathode-ray tube.

It will also be obvious to one skilled in the art that the receiver shown in Fig. 1 of the drawing may be changed to receive amplitude-modulated carrier signals by simply omitting the limiter 15, the primary tuned circuit 24, 25 thereupon being connected directly to the output of the intermediate-frequency amplifier and also to a conventional amplitude detector. Without further changes, the tuning indicator system shown would then operate in the manner previously described to provide an indication of the condition of tuning of the receiver to a desired amplitude-modulated carrier signal.

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

What is claimed is:

1. A tuning indicator for a modulated-carrier signal receiver including adjustable tuning means comprising, means for deriving from a received signal a control signal the magnitude of which varies in accordance with the degree of mistuning of said receiver on either side of said received signal, a cathode-ray tube, means responsive to said control signal for deflecting the cathode ray of said tube to produce a visual indication of the magnitude of said mistuning, means for periodically deflecting said cathode ray in another direction to produce for each tuning position a line the position of which varies with said degree of mistuning, predetermined portions of said visual indication being ambiguous, and means for effectively masking said predetermined portions of the visual indication to aid in precisely tuning the receiver.

2. A tuning indicator for a modulated-carrier signal receiver including adjustable tuning means comprising, means for deriving from a received signal a control signal the magnitude of which varies in accordance with the degree of mistuning of said receiver on either side of said received signal, a cathode-ray tube, means responsive to said control signal for deflecting the cathode ray of said tube to produce a visual indication of the magnitude of said mistuning, means for periodically deflecting said cathode ray in another direction to produce for each tuning position a line the position of which indicates the degree of mistuning, means responsive to said degree of mistuning for varying the magnitude of said periodic deflection in accordance with said degree of mistuning further to indicate by the length of said lines the degree of mistuning of said receiver, predetermined portions of said visual indication being ambiguous, and means for effectively masking said predetermined portions of the visual indication to aid in precisely tuning the receiver.

3. A tuning indicator for a modulated-carrier signal receiver including adjustable tuning means comprising, means for deriving from a received signal a unidirectional control potential the magnitude and polarity of which vary, respectively, in accordance with the degree and direction of mistuning of said receiver on either side of said received signal, a cathode-ray tube, means responsive to said control potential for deflecting the cathode ray of said tube to produce a visual indication of the magnitude and direction of said mistuning, means for periodically deflecting said cathode ray in another direction to produce for each tuning position a line the position of which indicates the degree of mistuning, means responsive to said degree of mistuning for varying the magnitude of said periodic deflection in accordance with said degree of mistuning further to indicate by the length of said lines the degree of mistuning of said receiver, predetermined portions of said visual indication being ambiguous, and means for effectively masking said predetermined portions of the visual indication to aid in precisely tuning the receiver.

4. A tuning indicator for a frequency-modulated carrier-signal receiver including adjustable tuning means, a frequency-selector circuit, and a frequency-detector circuit coupled thereto comprising, a cathode-ray tube having two sets of deflecting elements for producing deflection fields normal to each other, means for deriving from said frequency-detector circuit a unidirectional control signal the magnitude of which varies in accordance with the degree of mistuning of said receiver on either side of said received signal, means for utilizing said control signal for exciting a first set of said deflecting elements to produce a visual indication of the magnitude of said mistuning, means for exciting the other set of said deflecting elements from said selector circuit to vary the area of said visual indication, predetermined portions of said visual indication being ambiguous, and means for effectively masking said predetermined portions of the visual indication to aid in precisely tuning the receiver.

5. A tuning indicator for a frequency-modulated carrier-signal receiver including adjustable tuning means, a frequency-selector circuit, and a frequency-detector circuit coupled thereto comprising, a cathode-ray tube having two sets of deflecting elements for producing deflection fields normal to each other, means for deriving from said frequency-detector circuit a unidirectional control signal the magnitude of which varies in accordance with the degree of mistuning of said receiver on either side of a received

signal, means responsive to said control signal for exciting a first set of said deflecting elements to produce a visual indication of the magnitude of said mistuning, and means for exciting another of said sets of deflecting elements from said selector circuit periodically to deflect said cathode ray in another direction to produce a line for each tuning position of the receiver the length of which varies in accordance with said degree of mistuning, predetermined portions of said visual indication being ambiguous, and means for effectively masking said predetermined portions of the visual indication to aid in precisely tuning the receiver.

6. A tuning indicator for a modulated-carrier signal receiver including adjustable tuning means comprising, means for deriving from a received signal a control signal the magnitude of which varies in accordance with the degree of mistuning of said receiver on either side of said received signal, a cathode-ray tube, means responsive to said control signal for deflecting the cathode ray of said tube in a first direction in accordance with the magnitude of said mistuning, means for periodically deflecting said cathode ray in another direction to produce for each tuning position a line deflection the position of which varies with said degree of mistuning, and means for rendering predetermined portions of the said line deflections visible only within predetermined limits of tuning on either side of said received signal, less than those limits within which said line deflections would otherwise be produced.

7. A tuning indicator for a modulated-carrier signal receiver including adjustable tuning means comprising, means for deriving from a received signal a control signal the magnitude of which varies in accordance with the degree of mistuning of said receiver on either side of said received signal, a cathode-ray tube, means responsive to said control signal for deflecting the cathode ray of said tube to produce a visual indication of the magnitude of said mistuning, means for periodically deflecting said cathode ray in another direction to produce for each tuning position a line the position of which varies with said degree of mistuning, predetermined portions of said visual indication being ambiguous, and means for effectively masking portions of the cathode-ray deflection including said predetermined portions to eliminate said ambiguous indications, the contour of said masking means being proportioned to aid in selecting a predetermined one of said lines corresponding to a precisely tuned condition of said receiver.

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