

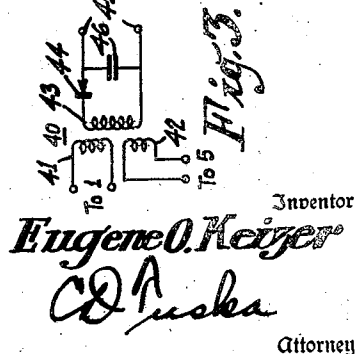
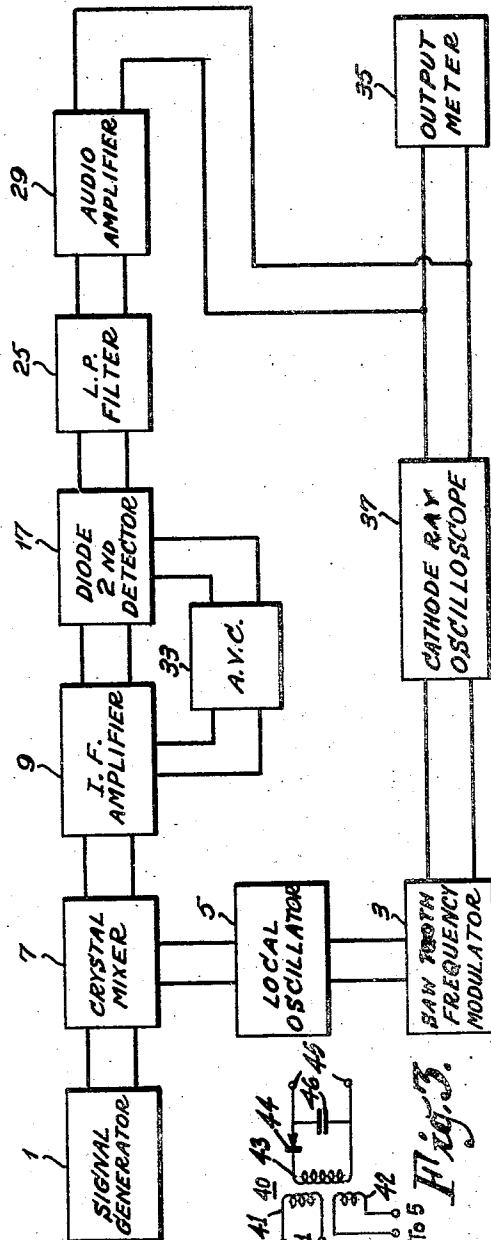
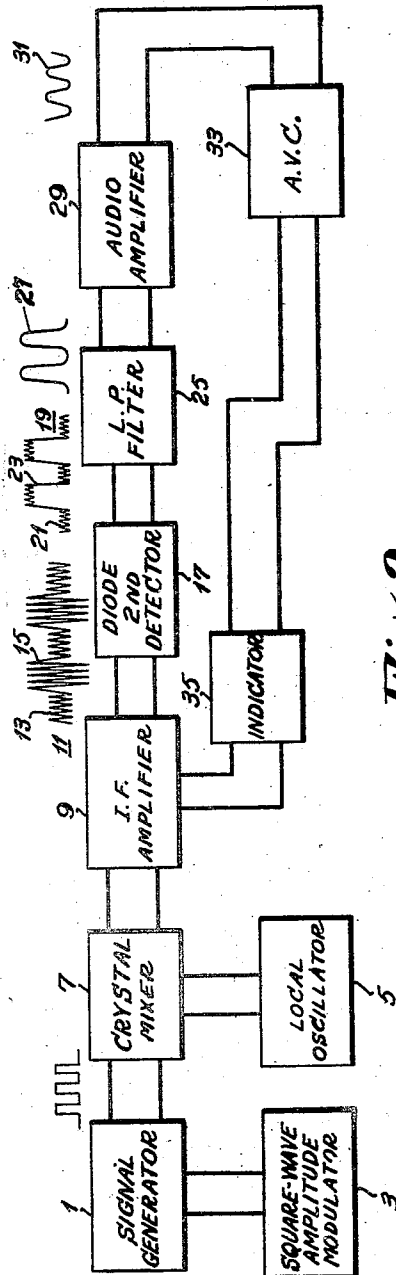
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ADJUSTMENT AND TESTING OF CRYSTAL RECTIFIERS

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ADJUSTMENT AND TESTING OF CRYSTAL RECTIFIERS

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9 Claims. (Cl. 250—20)

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This invention relates to microwave apparatus and more particularly to an improved method of and means for adjusting and testing crystal rectifiers under conditions comparable to their use in microwave apparatus.

Various types of crystal rectifiers constitute efficient and extremely sensitive detectors of low magnitude microwave energy. The selection and adjustment of catwhisker contact of crystal detectors at super-high frequencies involves different technique than that found satisfactory for detectors of ordinary radio frequencies, since the relatively low signal levels at super-high frequencies necessitate a relatively high signal-to-noise ratio in the microwave detector for satisfactory reception.

One type of microwave crystal detector which provides satisfactory operation at super-high frequencies comprises a silicon crystal having a knife edge for contact with a tungsten "catwhisker." A preferred embodiment of this type of crystal and the mounting thereof is described in the copending application of Wendell L. Carlson, Ser. No. 507,755, filed October 26, 1943, and assigned to the same assignee as the instant application.

Briefly, the instant invention comprises an improved method of and means for employing a microwave crystal detector in a circuit which will provide comparable operation to that encountered in a conventional microwave receiver, and wherein an indication is obtained of the signal-to-noise efficiency ratio of the crystal detector.

One embodiment of the invention comprises means for applying low frequency amplitude modulated microwave signals and unmodulated microwave signals of a different frequency to a mixer circuit which includes the crystal to be tested and adjusted. The modulated beat frequency signals derived from the detector crystal mixer, which include extraneous or noise current components, are applied to a conventional intermediate frequency amplifier. The amplified modulated beat frequency signals are detected by, for example, a diode detector and applied to the input of a conventional low-pass filter network. The filtered signals derived from the low-pass network are amplified at audio frequencies, corresponding to the original modulation frequency, and applied to an automatic volume control circuit to provide a control voltage for regulating the average gain of the intermediate frequency circuits so that the amplified audio output is maintained substantially constant. An indicator responsive to the control voltage applied to the intermediate frequency amplifier pro-

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vides an indication of the signal-to-noise ratio of the signals derived from the crystal mixer, since the constant magnitude audio output signals control the average magnitude of the intermediate frequency currents which are modulated by both noise and the audio signal components.

A second embodiment of the invention comprises means for applying unmodulated and saw-tooth frequency-modulated currents of microwave frequencies of different carrier frequencies to a mixer circuit including a crystal detector to be tested. The frequency modulated beat frequency signals derived from the mixer, which include extraneous or noise current components, are applied to a conventional intermediate frequency amplifier which has a band-pass of the order, for example, of one-third the frequency modulation band width. The signals derived from the intermediate frequency amplifier comprise pulses of intermediate frequency energy which are applied to a diode detector from which is selected the low frequency modulation component. A conventional automatic volume control circuit responsive to the output of the diode detector controls the average gain of the intermediate frequency amplifier. The low frequency signals derived from the diode detector are applied through a conventional low-pass filter to the input of an audio amplifier. The amplified signals derived from the audio amplifier are applied to an output signal indicator and to the vertical deflection electrodes of a cathode ray oscillograph. The horizontal deflection electrodes of the oscilloscope are connected to the source of saw-tooth frequency modulation signals to provide a timing voltage for the oscilloscope.

Among the objects of the invention are to provide an improved method of and means for testing microwave detectors. Another object of the invention is to provide an improved method of and means for testing and adjusting crystal rectifiers under conditions comparable to their use in microwave receivers. A further object of the invention is to provide an improved method of and means for testing microwave detectors by employing them as first detectors in a superheterodyne circuit and indicating the signal-to-noise efficiency ratio of the microwave first detector.

Other objects of the invention include improved methods of and means for testing microwave detectors by applying unmodulated and amplitude modulated microwave signals of different frequency to said detector and indicating the signal-to-noise ratio of the circuit including

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said detector. An additional object of the invention is to provide an improved method of and means for employing unmodulated and frequency modulated signals of microwave frequencies to a mixer circuit including the detector to be tested, applying beat frequencies derived from said detector to a relatively narrow band intermediate frequency amplifier, and indicating the signal-to-noise ratio of the signals derived from said detector and also indicating the frequency modulation characteristics of the frequency modulated source.

The invention will be further described by reference to the accompanying drawing of which Figure 1 is a schematic block circuit diagram of one embodiment thereof, Figure 2 is a schematic block circuit diagram of a second and preferred embodiment thereof and Figure 3 is a schematic circuit diagram of a mixer circuit including a crystal detector. Similar reference characters are applied to similar elements throughout the drawing.

Referring to Figure 1 of the drawing, a signal generator 1, such as, for example, a conventional magnetron oscillator, is amplitude modulated by a modulation source 2, such as, for example, a source of square wave modulation pulses. It should be understood that the modulation signals may be any other desired wave shape. The amplitude modulated signals from the signal generator 1 and unmodulated microwave signals having a different carrier frequency derived from a second local oscillator 5, such as, for example, a second magnetron oscillator, are applied to a detector crystal mixer circuit 7 which includes a microwave crystal detector which is to be tested.

Square wave amplitude modulated beat frequency signals derived from the crystal mixer circuit 7 are applied to the input of a conventional tuned intermediate frequency amplifier 9 from which are derived signals having a wave form indicated by the graph (11). In the absence of signals from either of the local signal generators 1 or 5, noise signals indicated by the high frequency oscillations 13 will be derived from the intermediate frequency amplifier 9. When the modulated beat frequency signals are derived from the crystal mixer circuit 7, these noise frequency oscillations will be modulated by the square wave modulation pulses as indicated by the portion of the graph 15.

The modulated beat frequency signals, including the noise components, are applied to the input of a diode detector 17 from which modulation signals characterized by the graph 19 are derived. These signals will include some noise components as indicated by the graph portion 21 and modulation pulses as indicated by the graph portion 23. The signals derived from the diode detector 17 are applied to the input of a conventional low-pass filter 25 from which is derived a substantially noise-free modulation signal characterized by the graph 27. The signals 27, derived from the output of the low-pass filter 25, are amplified by means of a conventional audio amplifier 29 to derive alternating potentials, characterized by the graph 31, which are applied to control a conventional automatic volume control circuit 33. Control voltages derived from the output of the automatic control circuit 33 are applied, through an indicator 35, to control the average gain of the intermediate frequency amplifier 9 thereby to maintain the audio output essentially constant.

Since the average gain of the intermediate fre-

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quency amplifier 9 is varied so the audio output is maintained at a uniform magnitude, the control voltage applied to the intermediate frequency amplifier, and indicated on the indicator 35, will be a measure of the relative magnitudes of the noise signal components 13 and the regulated maximum modulation signal components 15, and hence will indicate the signal-to-noise ratio of the crystal mixer. By substituting different crystal detectors in the crystal mixer circuit, the relative signal-to-noise efficiency of the various detectors may be determined.

One disadvantage of the circuit thus described is that unless the carrier frequencies of the signal generators 1 and 5 are maintained at constant values, the magnitudes of the modulated beat frequency signals derived from the intermediate-beat-frequency amplifier 9 will vary as a function of the band-pass characteristics of the amplifier 9, and hence will provide inaccurate indications of the signal-to-noise ratio of the crystal employed in the crystal mixer 7.

Referring to Figure 2 of the drawing, an unmodulated microwave signal generator of the type described heretofore, is connected to the input of a crystal type microwave mixer 7. A second local microwave oscillator 5, of any type known in the art, is frequency modulated by means of a sawtooth frequency modulator 3 to apply frequency modulated signals to a second input circuit of the crystal microwave mixer 7. Frequency modulated beat frequency signals, derived from the crystal mixer 7, are applied to the input of a conventional intermediate amplifier 9 having a band-pass, for example, of the order of one-third the frequency band of the frequency modulated beat frequency signals. The signals derived from the intermediate frequency amplifier 9 comprise pulses of intermediate frequency energy corresponding to the portion of the frequency modulated intermediate frequency spectrum transmitted by the intermediate frequency band-pass circuits.

These pulses of intermediate frequency energy are applied to a diode detector 17, from which is derived amplitude modulated pulses including noise components, and in which the frequency of the pulse modulation corresponds to the frequency of the modulation source 3. A portion of the output signals derived from the diode detector 17 is applied to control a conventional automatic volume control circuit 33 to provide a control signal which is applied to control the average gain of the intermediate-frequency amplifier.

Hence, the total modulation signal components and noise signal components derived from the intermediate frequency amplifier 9 and the diode detector 17 are averaged by the automatic volume control circuit 33. The modulation and noise signals derived from the diode detector 17 also are applied, through a conventional low-pass filter 25, to the input of a conventional audio amplifier 29 from which is derived alternating modulation signals having amplitudes characteristic of the relative magnitude of the modulation signal currents and the average energy transmitted by the intermediate frequency amplifier and diode detector. The signals derived from the audio amplifier 29 are applied to an output meter 35 which indicates the magnitude of the signals derived from the audio amplifier 29, and hence the signal-to-noise ratio of signals applied to the input of the intermediate frequency amplifier 9 from the crystal mixer 7. The alternating signals derived from the audio amplifier 29 also are applied to

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the vertical deflection electrodes of a conventional cathode ray oscilloscope 37 to provide vertical deflection of the cathode ray in accordance with the instantaneous values of the currents derived from the audio amplifier 29. The saw-tooth frequency modulator 3 is connected to the horizontal deflection electrodes of the cathode ray oscilloscope 37 to provide a timing voltage to indicate the relative portion of the frequency modulated spectrum of the intermediate frequency signals which is transmitted by the band-pass circuits of the intermediate frequency amplifier 9. It should be understood that, if desired, the automatic volume control circuit may be made responsive to the amplified audio output signals in the same manner as described in the device of Figure 1.

In this second embodiment of the invention, it is immaterial whether slight frequency variations occur in the microwave signal generators 1 and 5, since the only effect thereof upon the output indications will be to vary the horizontal position of the deflection pattern along the timing axis of the cathode ray oscilloscope. Hence, much more accurate indications of the signal-to-noise ratio of the crystal mixer 7 may be obtained since the intermediate frequency amplifier does not affect the signal-to-noise indication as a function of minor variations in the microwave carrier frequencies.

Figure 3 shows a typical mixer circuit comprising a tuned or untuned transformer 40 having a first primary winding 41 connected to the signal generator 1 and a second primary winding 42 connected to the local oscillator 5. A secondary winding 43 is serially connected through a crystal detector 44, or a thermionic tube detector to output terminals 45 which provide beat frequency signal currents. A capacitor 46 by-passes radio frequency currents around the output terminals 45.

Thus the invention described comprises improved methods of and means for testing the signal-to-noise ratio of microwave detectors under conditions comparable to their use in conventional microwave receivers, and provide means whereby the individual microwave detectors may be adjusted under comparable operating conditions for maximum efficiency.

I claim as my invention:

1. The method of testing a microwave detector providing signal and noise output current components comprising employing said detector as a mixer in a microwave superheterodyne circuit, applying unmodulated and modulated microwave currents of different frequencies to said detector, deriving therefrom modulated difference-frequency currents and indicating the efficiency of said detector in terms of the modulation signal-to-circuit noise current ratio of said derived currents.

2. The method of testing a microwave detector providing both signal and noise output current components comprising generating unmodulated microwave currents, generating modulated microwave currents, applying said modulated and said unmodulated currents to said detector, deriving from said detector noise currents and modulated currents of the difference-frequency of said microwave currents, rectifying and selecting the modulation current component from said noise and said modulated difference-frequency currents, deriving an automatic control voltage from said selected modulation current, applying said derived control voltage to regulate the aver-

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age magnitudes of said noise and said difference-frequency currents, and indicating the efficiency of said detector in response to the magnitudes of said control voltage.

3. The method of testing a microwave detector providing both signal and noise output current components comprising generating unmodulated microwave currents, generating amplitude modulated microwave currents, applying said modulated and said unmodulated currents to said detector, deriving from said detector noise currents and modulated currents of the difference-frequency of said microwave currents, rectifying and selecting the modulation current component from said noise and said modulated difference-frequency currents, deriving an automatic control voltage from said selected modulation current, applying said derived control voltage to regulate the average magnitudes of said difference-frequency currents, and indicating the signal-to-noise efficiency ratio of said detector in response to the magnitudes of said control voltage.

4. The method of testing a microwave detector providing both signal and noise output current components comprising generating unmodulated microwave currents, generating frequency modulated microwave currents, applying said frequency modulated and said unmodulated currents to said detector, deriving from said detector noise currents and amplitude modulated currents of predetermined difference-frequencies of said microwave currents, rectifying and selecting the amplitude modulation current component from said noise and said modulated difference-frequency currents, deriving an automatic control voltage from said derived currents, applying said control voltage to regulate the average magnitudes of said noise and said difference-frequency currents, and indicating the signal-to-noise efficiency ratio of said detector in response to the magnitudes of said selected modulation currents.

5. The method described in claim 4 including separately indicating the frequency relation of said derived predetermined difference-frequencies with respect to the complete frequency modulation difference-frequency spectrum.

6. Apparatus for testing microwave detectors providing both signal and noise output current components including means for generating unmodulated microwave currents, means for generating modulated microwave currents, a microwave detector, means for applying said modulated and said unmodulated currents to said detector, means for deriving from said detector noise currents and modulated currents of the difference-frequency of said microwave currents, means for rectifying and selecting the modulation current component from said noise and said modulated difference-frequency currents, means for automatically regulating said detected currents, and means responsive to said selected currents for indicating the signal-to-noise efficiency ratio of said detector.

7. Apparatus for testing microwave detectors providing both signal and noise output current components including means for generating unmodulated microwave currents, means for generating modulated microwave currents, a microwave detector, means for applying said modulated and said unmodulated currents to said detector for deriving from said detector noise currents and modulated currents of the difference-frequency of said microwave currents, means for rectifying and selecting the modulation current component from said rectified noise and said modulated difference-frequency currents, means for

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automatically regulating the magnitude of at least one of said detected current components, and means responsive to said selected currents for indicating the signal-to-noise efficiency ratio of said detector.

8. Apparatus for testing microwave detectors providing both signal and noise output current components including means for generating unmodulated microwave currents, means for generating frequency modulated microwave currents, a microwave detector, means for applying said modulated and said unmodulated currents to said detector for deriving from said detector noise currents and frequency modulated currents of the difference-frequency of said microwave currents, filter means for deriving a predetermined portion of said frequency-modulated difference-frequency

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currents, means for rectifying and selecting the modulation current component from said filtered noise and modulated difference-frequency currents, means for automatically regulating the magnitude of said detected currents, and means responsive to said selected currents for indicating the signal-to-noise efficiency ratio of said detector.

9. Apparatus of the type described in claim 8 including oscillographic means responsive to said frequency modulation means and to said selected currents for indicating the frequency relation of said derived predetermined portion of said difference-frequencies with respect to the complete frequency-modulation difference-frequency spectrum.

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