Sept. 23, 1941. R. A. BRADEN 2,256,608

MICROWAVE DEVICE

Filed March 31, 1939

FIG. 1.

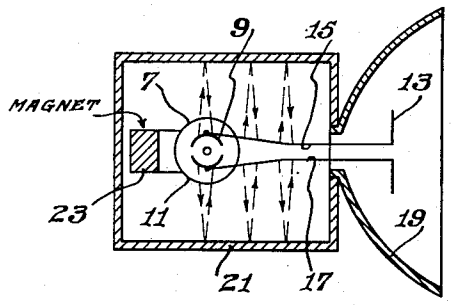


FIG. 2.

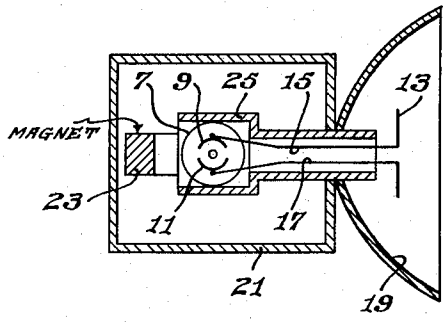


FIG. 3.

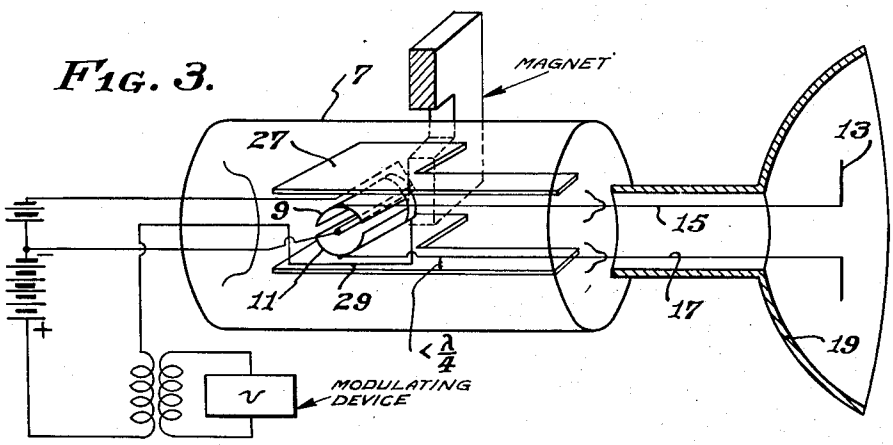


FIG. 5.

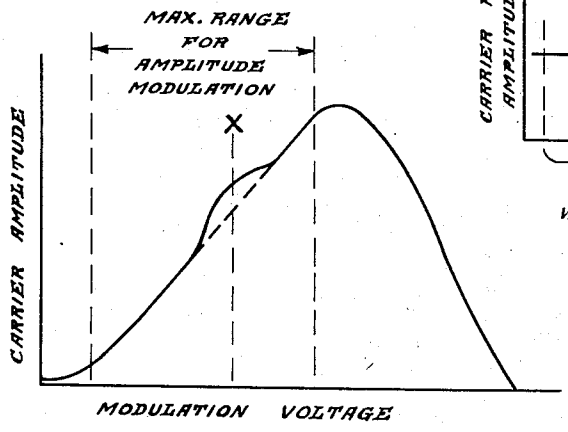
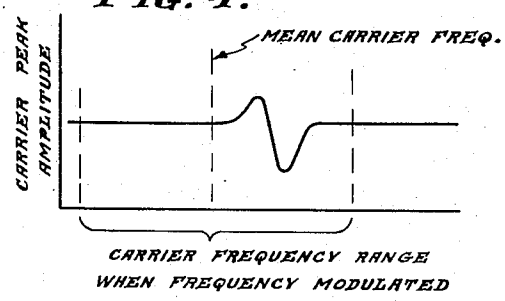


FIG. 4.



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UNITED STATES PATENT OFFICE

2,256,608

MICROWAVE DEVICE

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Application March 31, 1939, Serial No. 265,172

3 Claims. (Cl. 179—171.5)

This invention relates to micro-wave devices such as magnetron and Barkhausen-Kurtz oscillators and amplifiers, and the like, and has for its principal object a method of and means for correcting the undesired effects of waves which are reflected from nearby objects.

I have found that serious difficulty is encountered in the operation of micro-wave oscillators, for example, due to the reflection of radiated waves from nearby objects. These reflected waves may be either in or out of phase with the current generating them, and consequently tend to increase or decrease the oscillatory current. Reflections of this nature are produced by the magnet which is associated with a magnetron, for example, or by the associated power equipment, by supports and brackets which are usually necessary to hold the oscillator or the antenna, and by shielding boxes which are commonly employed to protect the device and to shield it from extraneous electrical disturbances.

The reflections are in the nature of standing waves, and consequently their phasal relation to the normal current varies with frequency. Thus, the effect of such reflections is especially harmful where it occurs in connection with a modulated oscillator, for the phasal relation of the carrier or one side band will differ from that of the other side band so that the relative amplitudes of the various components are distorted. Distortion produced in this manner may be further aggravated by a similar occurrence at the receiver.

In the case of an unmodulated oscillator, I have found that reflections from the adjacent apparatus may be so phased as to reduce the output of the oscillator. It is evident that when such a condition exists the oscillator is unstable since changes in the position of the oscillator itself or in the position of nearby apparatus will cause the amplitude of the currents to fluctuate.

The reflections referred to above are most harmful when the frequency of the oscillating current is varied, either intentionally to accomplish frequency modulation, or in connection with amplitude modulation, since in the latter instance, there is usually a certain amount of frequency modulation present. The nature of the effect produced by the reflections depends upon the phase relation between the current induced by the reflected waves and the normal current flowing in the circuit. When the phase angle between the two currents is 0°, the normal current is increased in amplitude. When the phase angle is 180°, the amplitude of the normal current is reduced. Either of these conditions is the equivalent of a non-reactive circuit connected to the system, which either absorbs power from, or returns power to the circuit.

When the phase angle between the normal current and that resulting from the reflected waves is either 90° or 270°, the effect on the circuit is equivalent to a reactive load, and the current is either advanced or retarded in phase. If the phase angle between the normal current and that due to the reflected waves has any intermediate value, the resultant current is effected in the same manner that would result from the application of an equivalent load circuit which has both reactance and resistance.

As long as the frequency is constant, the effect of the reflected waves is not particularly harmful, since the energy absorption is generally small, and the reactance reflected into the circuit can be balanced out by a slight adjustment of the transmission line and associated circuits. However, when the frequency varies due to intentional frequency modulation or due to unintentional changes which accompany amplitude modulation, at certain frequencies the absorbed energy becomes quite large so that the resultant current amplitude is decreased. Since the effect of the reflected waves has been shown to be the equivalent of a coupled reactive circuit, it is apparent that at certain frequencies the equivalent reactive circuit will be resonant. At resonance, the effect on the normal current amplitude is a maximum.

I have discovered that the change of frequency required to shift the current through the resonant frequency of the equivalent coupled circuit is inversely proportional to the distance between the current source and the reflecting medium. That is, the larger the distance to the reflecting surface, the smaller the frequency change required to move the current through the resonant frequency of the coupled circuit.

In accordance with my invention, I propose to overcome the difficulties which have been pointed out above by providing a reflecting member in the field of these elements which are most likely to be affected. This reflecting member is to be placed at such a distance from the source of radiation that the normal frequency variation of the oscillating current will not include the resonant frequency of the equivalent coupled circuit corresponding to the reflected energy. Consequently, the currents induced in the conductors by the reflected waves will not pass through a critical phase change.

When ultra high frequency apparatus is en-

closed in a metal box, or shield, the most undesirable condition occurs when standing waves are set up within the box. It is, therefore, necessary to avoid shielding containers whose dimensions are multiples of a half-wave length of the desired operating frequency. Preferably, all shields should be located less than a quarter-wave length from the circuits in which the oscillation currents are flowing. Since it is not always practical to design the normal shield or metallic enclosure with this consideration in mind, I propose to include reflecting members wherever necessary, within, or without the tube, to avoid reflections having harmful effects.

This invention will be better understood from the following description when considered in connection with the accompanying drawing, and its scope is indicated by the appended claims.

Referring to the drawing, Fig. 1 is a view, partly in section, of a micro-wave oscillator or detector illustrating the reflections which are produced by a metallic box; Fig. 2 illustrates one method of preventing harmful reflections; Fig. 3 is a view of a portion of a tube illustrating the application of reflecting members to electrodes and leads within a tube; Fig. 4 is a curve illustrating the effect of reflections on the modulation characteristic of a micro-wave oscillator; and Fig. 5 is a curve illustrating the use of reflections to correct for errors in a deficient modulating system.

Referring to Fig. 1, a micro-wave oscillator or detector 7 has a pair of anode electrodes 9 and 11 which are connected to a dipole antenna 13 by a pair of parallel conductors 15 and 17. The antenna is mounted, for example, in a parabolic reflector 19, while the oscillator 7 is mounted within a box 21, within which is also a permanent magnet 23, and probably other apparatus which has not been shown. As indicated by the dotted lines radiating from the anode electrodes and the parallel conductors, energy is radiated and reflected back from the box and the surrounding objects. At any frequency, it is likely that the distance from the source of radiation to some reflecting surface will be just right to produce a standing wave pattern and to cause the returned energy to be in phase opposition to the normal energy in the circuit. The more irregular the arrangement of the apparatus, the more likely that there will be undesirable reflections within any desired range of frequencies. One method of reducing the deleterious effect of reflections is illustrated in Fig. 2, to which reference is now made.

Fig. 2 is similar to Fig. 1, but shows in addition a reflecting member 25 enclosing the tube and the parallel conductors. While it is, of course, recognized that shielding, as such, is very old in the art, this invention proposes reflecting members for an entirely different purpose. The importance of the spacing of a shield to the shielded members when dealing with micro-waves has not been appreciated. If improperly utilized, a shield may do far more harm than it does good, since it may act as a reflector and produce harmful effects.

Fig. 3 illustrates an extension of my invention to include a pair of reflecting elements within the tube itself. Ultra high frequency tubes are commonly mounted in glass envelopes approximately a half to one wave length in diameter. In such a case it is impossible to provide a satisfactory reflector on the exterior of the tube, nor would a metallic envelope of the type frequently employed in broadcast receiver tubes be satisfactory, since at certain frequencies the walls of the tube would reflect energy back in phase opposition.

In accordance with my invention, therefore, a pair of reflecting elements 27, 29 are mounted in any suitable fashion within the tube. They should be located in the radiation fields of all electrodes and conductors which are at a high radio frequency potential. The parallel conductors 15, 17 may be enclosed in a small tube or merely placed near a flat reflector as shown.

It is important that the anode electrodes themselves also be provided with reflecting members, especially in the type of tube illustrated in which the anodes themselves constitute a large part of the oscillatory circuit. This tube comprises a longitudinally split cylindrical anode, the two halves of which are of such a length that a closed resonant circuit is formed which may be tuned by the output load. Such a construction is shown and claimed in a copending Linder application, Serial No. 210,968, filed May 31, 1938, entitled "Anode tank circuit oscillators," and assigned to the assignee of the present application.

For convenience in illustrating my invention, the method of mounting the various elements has not been shown as it is generally well known in the art. Circuit connections are conventional. The device may be frequency modulated by coupling a modulating device in the anode circuit. While I have illustrated a tube having no grid, it is apparent that my invention applies equally well to Barkhausen-Kurtz tubes, and other micro-wave tubes, operating either as oscillators or detectors.

Fig. 4 is a curve illustrating graphically the effect of reflections on the modulation characteristic of a micro-wave oscillator utilizing frequency modulation. The peak carrier amplitude is plotted against the frequency deviation from the normal carrier frequency. Such a curve should be linear. The distortion produced by reflected energy at various carrier frequencies is illustrated by the peaks and valleys in the curve.

The application of reflected energy to correct an irregularity in an amplitude modulation characteristic is illustrated in Fig. 5. The solid line is a curve relating the carrier current amplitude to the modulating voltage applied to the modulating electrode. The departure from linearity to be observed on the rising slope of the curve of Fig. 5 is to be corrected, in accordance with this invention, by providing a reflecting medium in such a location that at the frequency corresponding to the modulating voltage X, a sufficient absorption will occur to reduce the modulation characteristic to the position indicated by the dotted line. The range of modulation voltage over which the compensation effect is to be accomplished can be adjusted by selecting a suitable spacing between the reflecting medium and a convenient portion of the oscillation circuit. To obtain a correction over a wide range of voltage, corresponding to a wide range of frequency, the distance to the reflecting medium should be made correspondingly large. The degree or amplitude of the correction may be adjusted by suitably proportioning the size of the reflecting medium.

I claim as my invention:

1. An oscillator having an oscillatory circuit for the production of microwave oscillatory currents, reflecting means disposed in the region of said oscillatory circuit and spaced from said

circuit so that energy radiated from said oscillatory circuit and reflected by said reflecting means into said oscillatory circuit interferes with said oscillatory currents, and shielding means between said reflecting means and said oscillatory circuit spaced at a distance from said circuit which defines combined radiation and reflection paths solely of lengths other than integral multiples of one-half wave length at the operating frequency, whereby said interference is minimized.

2. A modulated oscillator having a oscillatory circuit for the production of microwave oscillatory currents within a range of frequencies above and below a predetermined frequency, reflecting means disposed in the region of said oscillatory circuit and spaced from said circuit so that energy radiated from said oscillatory circuit and reflected from said reflecting means into said oscillatory circuit interferes with said oscillatory currents, and shielding means between said reflecting means and said oscillatory circuit spaced at a distance from said oscillatory circuit, which distance defines combined radiation and reflection paths solely of lengths other than integral multiples of one-half wave-length at said predetermined frequency whereby said interference is minimized.

3. A frequency modulated oscillator having an oscillatory circuit for the production of oscillatory currents, means for varying the frequency of said currents within a band of frequencies, reflecting means disposed in the region of said oscillatory circuit and spaced from said circuit so that energy radiated from said oscillatory circuit and reflected from said reflecting means into said oscillatory circuit interferes with said oscillatory currents, and shielding means between said reflecting means and said oscillatory circuit spaced at a distance from said oscillatory circuit which defines combined radiation and reflection paths solely of lengths other than a half wave-length at any frequency within said band whereby said interference is minimized.

RENE A. BRADEN.