

July 15, 1930.

W. L. CARLSON

1,770,838

RADIO SIGNALING APPARATUS

Filed May 10, 1928

Fig. 1.

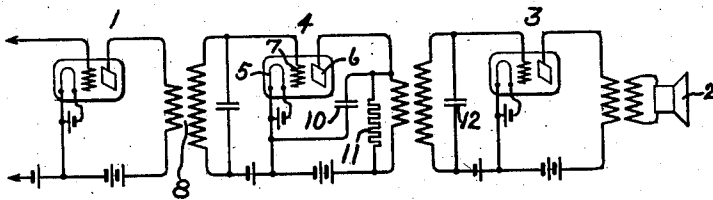


Fig. 2.

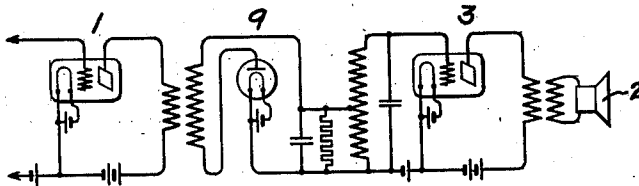


Fig. 3

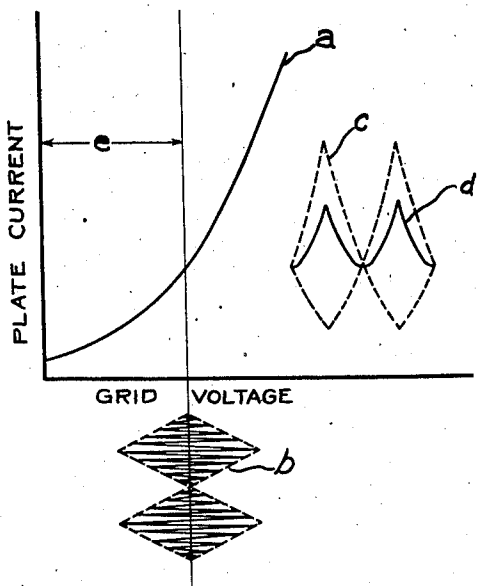
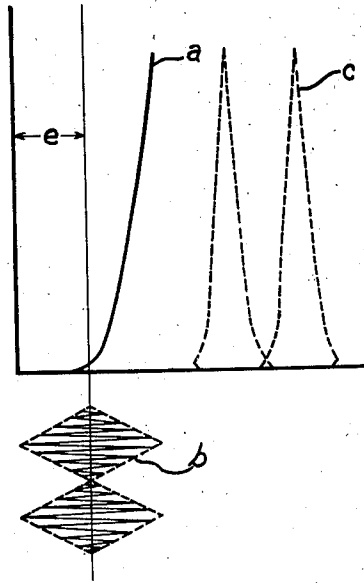


Fig 4



Inventor:
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His Attorney

UNITED STATES PATENT OFFICE

WENDELL L. CARLSON, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL
ELECTRIC COMPANY, A CORPORATION OF NEW YORK

RADIO SIGNALING APPARATUS

Application filed May 10, 1928. Serial No. 276,732.

My invention relates to radio signaling apparatus, and has for its principal object the provision of an improved apparatus and method of operation whereby radio signals may be received without harmonic distortion and without distortion due to audio acoustic regeneration and irregularities from the power supply circuit.

One of the most serious difficulties encountered in the transmission and reception of radio signals is the harmonic distortion produced by operating on a detector tube characteristic having a continually changing slope. It is well known that distortion varies directly as the percent modulation of the carrier wave and has been heretofore supposed that it was due entirely to second harmonic side bands beating against one another. As the result of numerous observations, I have discovered that harmonic distortion is largely dependent on the character of the detector and on the conditions under which it is operated.

Thus, if the detector is subjected to a comparatively low operating voltage, the distortion of the detected current is due primarily to the opposition of the negative cycle. This opposition increases in percentage as the modulation cycle approaches the zero axis and decreases as the percent modulation is reduced and the envelope of the detected current is further removed from the zero axis. If the detector is subjected to a comparatively high voltage, however, the distortion of the detected current is due mainly to the non-linear amplification on the positive cycle, the negative cycle opposition being a minor factor under these conditions. In accordance with my invention harmonic distortion is greatly reduced by operating the detector under conditions for improving the linear response of the positive cycle. This is accomplished by operating the detector at the knee of the characteristic curve near plate current cut off, and impressing a substantially high modulated voltage on the tube as compared to the voltage usually employed heretofore in the art.

Contrary to the action of normal amplifiers, the fidelity improves as the applied

voltage to the detector is increased unless exceeding the value of the grid negative bias.

The detector circuit in a radio receiver does not usually affect the stability directly except in so far as the ratio of radio and audio amplification is altered to work the detector at various power levels. The difficulties arising from audio amplification such as hum from the power supply circuit, acoustic regeneration, poor audio frequency characteristic and blasting or overloading of the loud speaker can all be largely eliminated by reducing the audio amplification and increasing the radio amplification, thus operating the detector at a comparatively high power level. Such a procedure also results in higher rectification efficiency. With improved acoustic response, particularly at low frequencies, it has become increasingly difficult to avoid the alternating current hum and the regenerative howl with audio systems heretofore employed. A receiver including two stages of audio amplification and a loud speaker is seldom assembled in a cabinet without being subject to distortion produced by audio regeneration. In accordance with my invention, this difficulty is avoided by operating the detector with input voltages and power output of such magnitude that a single stage of audio frequency amplification furnishes sufficient energy for the operation of the loud speaker.

My invention will be better understood from the following description when considered in connection with the accompanying drawing and its scope will be pointed out in the appended claims.

Referring to the drawing, Figs. 1 and 2 illustrate different radio receivers wherein my invention has been embodied and Figs. 3 and 4 relate to the operation of these figures.

The receiver illustrated by Fig. 1 includes a radio frequency amplifier 1 and a telephone or loud speaker 2 which are interconnected through an audio amplifier 3 and a detector 4 provided with a cathode 5, an anode 6 and a grid 7. The radio frequency amplifier 1 and the detector 4 are coupled together through a transformer 8. Due to the fact that this transformer feeds from a comparatively low

impedance circuit, its primary is untuned. The operation of the receiver illustrated by Fig. 1 will be readily understood upon consideration of Figs. 3 and 4.

In Fig. 3 the curve "a" represents the static characteristic of the detector when it is operating with 100 volts applied to its plate circuit and with no external plate load resistance. Assuming that a bias voltage indicated by "e" is applied to the grid of the detector and that a wave "b" composed of a carrier wave of 1 volt modulated 100 per cent is superimposed on this grid bias voltage, the envelope of the plate current variations is represented by the curve "c" and the rectified modulation is represented by the curve "d". It is apparent that even harmonics are present to such an extent that the slope of the envelope "d" is not a straight line and does not conform to the envelope of the wave "b". This distortion in the curve "d" is due primarily to the opposition of the negative half cycles. This opposition increases in percentage as the modulation cycle approaches the zero axis. With lower per cent modulation this distortion is reduced because the envelope wave is further from the zero axis.

In Fig. 4 the input has been increased ten times. The detector characteristic is the same as for Fig. 3 but plotted to a different scale. Under these conditions, the distortion is due mainly to the non-linear amplification on the positive cycle. The negative cycle opposition is a minor factor. A reduction in per cent modulation would improve the fidelity to the extent that the varying audio envelope would be operating over a more nearly linear characteristic on the positive cycle. It is thus apparent that by adjusting the detector circuit constants for substantially maximum rectification a substantially linear ratio between the rectified response and the percentage modulation of the carrier wave is realized and distortion is largely avoided.

The receiver illustrated by Fig. 2 differs from that of Fig. 1 in that it includes a detector 9 of the kenetron or two-element type which operates with somewhat lower harmonic distortion than the three-element detector of Fig. 1. In the modification of Fig. 2 an auto-transformer is connected between the detector and audio amplifier.

In determining the power requirements of an audio detector constructed and operated in accordance with my invention, it is necessary to consider the per cent modulation of the carrier wave, the audio amplification ratio, and the grid voltage swing of the audio output tube.

The normal per cent modulation of a transmitting station is a rather uncertain factor but from practical observations checked against test data it is apparent that a carrier wave 15% modulated should be capable of loading the output tube. An audio interstage

transformer having a 3 to 1 step-up ratio with a capacity 10 and a resistance 11 connected in shunt to its primary circuit and with a capacity 12 connected in shunt to its secondary circuit has been found satisfactory with a 3 element detector tube. If a detector of the three-element type is utilized, the grid bias voltage of this detector should be such as to cause the grid to take current and limit the audio input voltage before the load of the audio amplifier becomes excessive. Under these conditions, the detector functions automatically as a load limiting device and prevents the blasting and breaking up of the sound which is due to overloading of the audio amplifier. The plate voltage should be substantially higher than customary on audio detectors and of such a value in relation to the grid negative bias as to give low plate current when no signal voltage is impressed.

For excessive loudspeaker outputs the power capabilities of the detector most approach the values usually assigned to output tubes. In fact my investigation may be interpreted as justifying operation of the loudspeaker directly from a power detector tube.

The embodiments of the invention illustrated and described herein have been selected for the purpose of clearly setting forth the principles involved. It will be apparent however that the invention is susceptible of being modified to meet the different conditions encountered in its use and I therefore aim to cover by the appended claims all modifications within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States, is:—

1. A radio receiver including a detector having its circuit constants adjusted for substantially maximum rectification, means for applying to said detector a modulated carrier wave of such amplitude as to produce a substantially linear ratio between the rectified response and the percentage modulation of said carrier wave, a sound producing device, and a single stage audio amplifier connected between said detector and said sound producing device.

2. A radio receiver including a detector, means for applying to said detector a modulated carrier wave of such amplitude as to produce a substantially linear ratio between the rectified response and the percentage modulation of said carrier wave, and an output circuit of comparatively low amplification.

3. A radio receiver including a detector, means for applying to said detector a modulated carrier wave of such amplitude as to produce a substantially linear ratio between the rectified response and the percentage modulation of said carrier wave, a sound producing device, a single stage audio amplifier for said device provided with input and out-

put circuits, a transformer provided with a primary circuit connected to said detector and with a secondary circuit connected to the input circuit of said amplifier, and a resistance and a capacity each connected in shunt to the primary circuit of said transformer.

4. A radio receiver including a detector having its circuits adjusted for substantially maximum rectification, means for applying to said detector a modulated carrier wave of such amplitude as to produce a substantially linear ratio between the rectified response and the percentage modulation of said carrier wave, and a low impedance output circuit connected to said detector.

5. The method of operating a radio receiver including a detector and an output circuit of low impedance, which includes, adjusting said detector for its maximum rectification and applying to said detector a modulated carrier wave of such amplitude as to produce a substantially linear ratio between the rectified response and the percentage modulation of said carrier wave.

6. The method of operating a radio receiver including a detector, which includes adjusting said detector for its maximum rectification and applying to said detector a modulated carrier wave of such amplitude as to produce a substantially linear ratio between the rectified response and the percentage modulation of said carrier wave.

In witness whereof, I have hereunto set my hand this 9th day of May, 1928.

WENDELL L. CARLSON.

DISCLAIMER

1,770,838.—Wendell L. Carlson, Schenectady, N. Y. RADIO SIGNALING APPARATUS. Patent dated July 15, 1930. Disclaimer filed March 15, 1934, by the assignee, *General Electric Company*.

Hereby enters this disclaimer to that part of the specification which consists of claim 6, which is in the following words:

"6. The method of operating a radio receiver including a detector, which includes adjusting said detector for its maximum rectification and applying to said detector a modulated carrier wave of such amplitude as to produce a substantially linear ratio between the rectified response and the percentage modulation of said carrier wave."

[*Official Gazette April 3, 1934.*]

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