Dec. 12, 1939. L. M. CRAFT 2,182,790

DISTORTION REDUCING SYSTEM FOR GRID-MODULATED AMPLIFIER

Filed July 16, 1937 2 Sheets-Sheet 1

Fig. 1

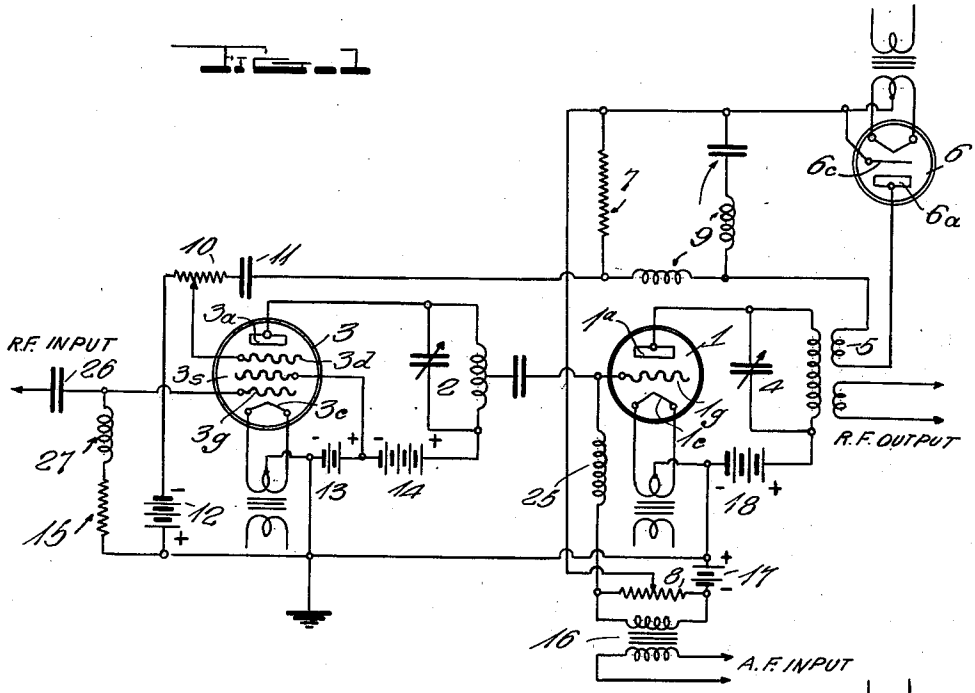
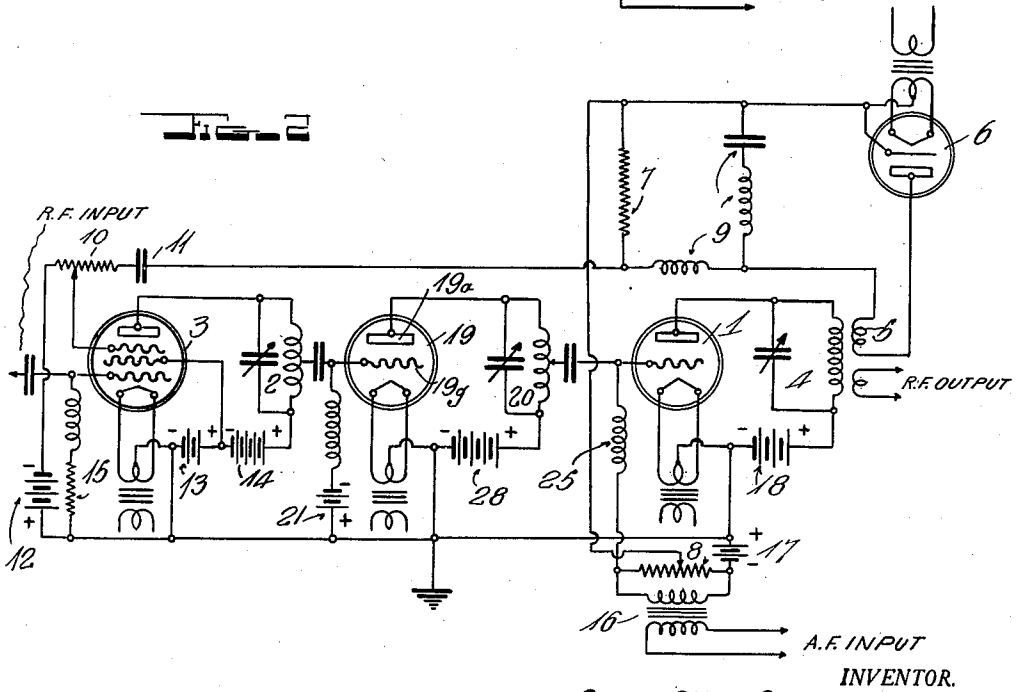


Fig. 2



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FIG. 3

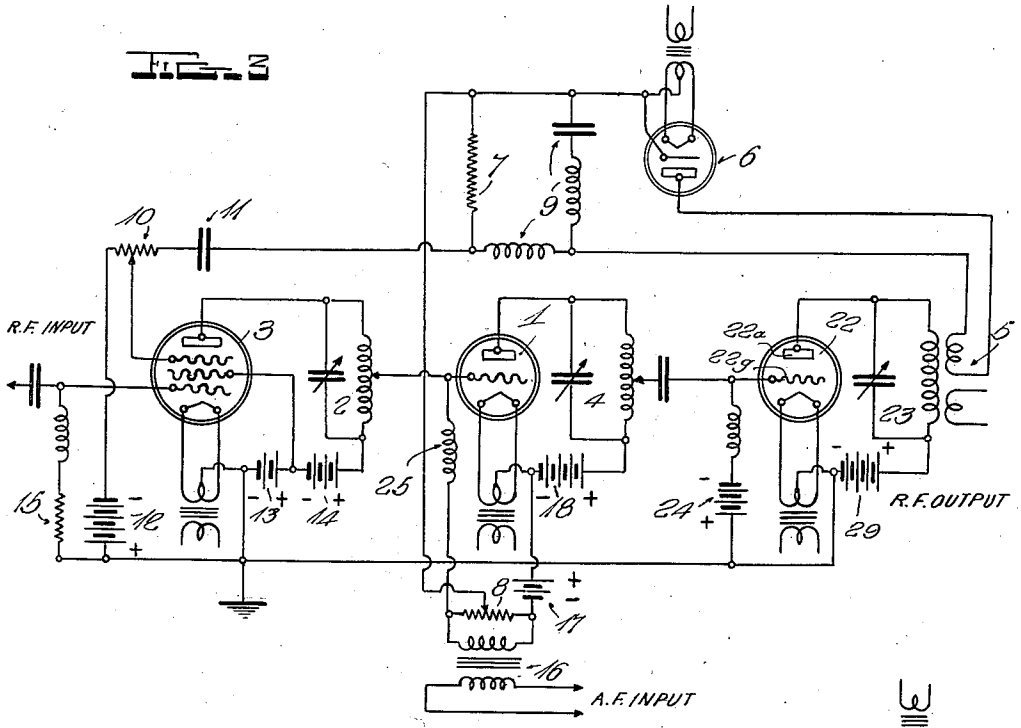
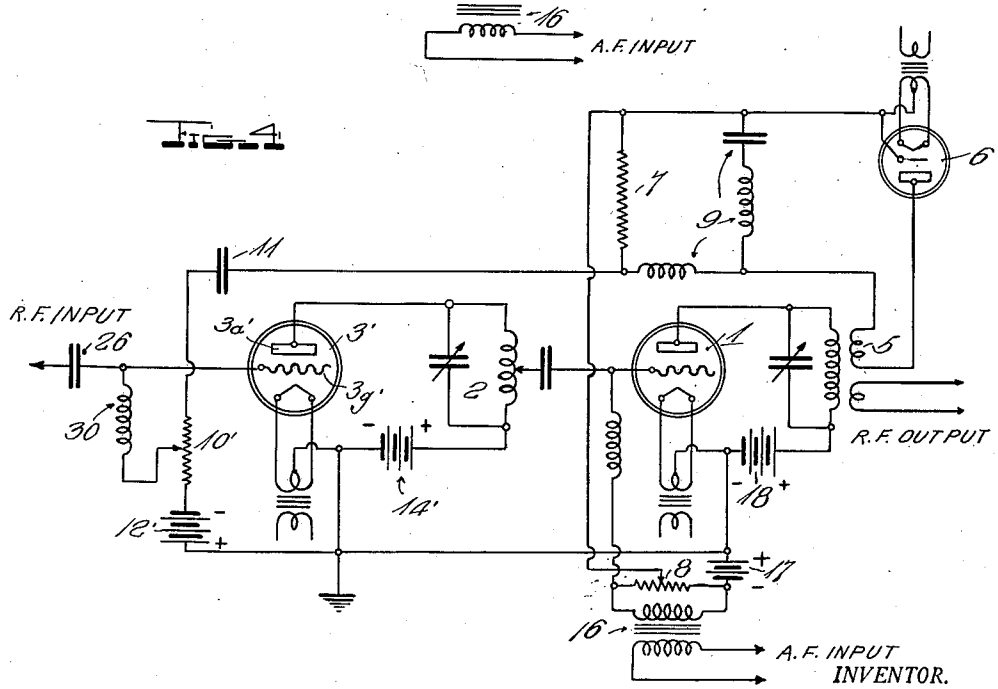


FIG. 4



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DISTORTION REDUCING SYSTEM FOR GRID-MODULATED AMPLIFIER

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12 Claims. (Cl. 179—171.5)

My invention relates broadly to radio transmitting systems and more particularly to circuits for substantially decreasing the distortion in the output of a transmitting system employing a grid modulated amplifier.

In a radio transmitting system wherein grid modulation is employed in a radio frequency amplifier stage, there is considerable amplitude distortion present as a result of non-linearity of the modulated amplifier, or of non-linearity of class B linear amplifiers which follow the modulated stage, or both. In addition, there may be hum components in the modulated output due to the use of an alternating current power supply, particularly for the filaments of the electron tubes. It is desirable to reduce the distortion and carrier or "ground" noise thus resulting to a minimum.

One of the objects of my invention therefore is to provide a system having means for reducing distortion in a transmitting system employing a grid modulated amplifier.

Another object of my invention is to provide a system having means for decreasing hum components of modulation originating in class B linear amplifier stages, or in a grid modulated amplifier.

A further object of my invention is to provide means for deriving distortion components of modulation from the output of a radio transmitter, and a system for reintroducing the distortion components as direct modulations on the radio frequency carrier in anticipation of cancellation thereby of substantially all of the distortion components in the transmitter output.

Still another object of my invention is to provide means for deriving distortion components of modulation from the output of a radio transmitter, and a separate modulation system whereby the distortion components may be imposed as direct modulations on the radio frequency carrier prior to its modulation by the signal to substantially compensate for distortion components as they originate in the signal modulator stage.

A still further object of my invention is to provide means for deriving distortion components of modulation from the output of a compensated radio transmitter, and a compensating system for reintroducing the distortion components as direct modulations on the radio frequency carrier, the system including amplification means for the thus modulated carrier prior to the signal modulator stage so as to compensate substantially for distortion components as they originate, leaving a residual distortion to energize the compensating system.

Other and further objects of my invention reside in the circuits and arrangements hereinafter more fully described with reference to the accompanying drawings, in which:

Figure 1 is a schematic diagram showing the circuit connections in a grid modulated amplifier employing the distortion reducing system of my invention; Figs. 2 and 3 show modifications of the circuit of Fig. 1, wherein additional amplifier stages are used; and Fig. 4 illustrates a modified circuit arrangement of the system of my invention in which a triode amplifier tube is employed instead of the pentode shown in Fig. 1.

My invention relates to that type of distortion reducing system wherein distortion components derived from a distorted modulated output are reintroduced into the modulating system in phase opposition to the distortion components as produced. Various methods have been proposed for deriving and reintroducing such components, more particularly for reintroducing them directly in the modulated stage or together with the modulating signal wave. The system of my invention, however, recognizing that the distortion fundamentally is an alteration of the character of the carrier wave, is predicated on the principle of conditioning the carrier, prior to distortion thereof and modulation thereof by the signal in the modulated amplifier, in such manner that the carrier will withstand distortion in the modulated amplifier and be delivered, modulated by the signal, at the output of the transmitter with only a minimum net alteration of its character by distortion. One of the major factors creating distortion in grid modulated amplifiers is the varying impedance of the input circuit to the carrier current, caused by the signal wave. The system of my invention effectively compensates the carrier in this respect, for example, by producing an increase or decrease in amplitude in the carrier to offset substantially the result of a corresponding increase or decrease in impedance.

In the application of feedback or distortion correction to modulated high frequency amplifiers as well as to high frequency amplifiers of modulated signals, one system is to obtain an audio frequency signal by rectifying one high frequency output and feeding a portion of this signal in proper phase into the input of the audio amplifier. Another fundamental procedure is to rectify a portion of the high frequency output and balance this against the modulating signal in a grid modulated amplifier and apply the distortion components only in series with the modu-

lating signal in proper phase to effect reduction in distortion in the output.

The amount of gain between the point of feedback and the point at which the feedback signal is obtained is of importance as to how effectively the system operates to reduce distortion. To this end the fundamental concept involved in the present invention is to make use of amplification at radio frequencies in order to effect improved performance in regard to distortion correction. Due to the additional gain inserted in the feedback circuit and in view of the fact that radio frequency amplifiers do not effect appreciable phase shift at audio frequencies, this concept can be readily seen to have considerable advantages over introduction of the distortion components back into the audio frequency amplifier, as audio transformers and associated circuit elements result in quite a variation in phase shift over the wide audio frequency range used in high fidelity broadcast equipment. The introduction of radio frequency modulator and amplifier stages to provide amplification of the distortion of feedback components—in lieu of amplifying them through the same or a separate audio frequency amplifier—is a basic characteristic of my invention.

Referring to the drawings in more detail, in Fig. 1, reference character 1 designates a grid modulated stage, which may comprise one or more tubes. The modulator 1 is shown as a triode having a grid 1*g* connected through capacity coupling to the tuned output circuit 2 of a preceding radio frequency amplifier stage 3. Audio frequency modulating voltages are introduced through transformer 16 and applied to the grid 1*g* and cathode 1*c* of the modulator 1, through a radio frequency choke coil 25. The output of the modulator is taken from the resonant circuit 4 connected with the anode 1*a* and cathode 1*c* of the modulator. Sources of grid bias and anode potential are shown at 17 and 18, respectively, as batteries but it will be understood that any suitable potential source may be employed here, and elsewhere in the circuits, instead of the battery means shown.

The distortion reducing system, as shown in Fig. 1, is energized from the resonant output circuit 4 of the modulator 1 through coupling coil 5. A portion of the distorted modulated output is thereby impressed on a rectifier 6, shown as an electronic half-wave rectifier having a hot cathode 6*c* and an anode 6*a*. A full wave rectifier may be employed, as desired. Radio frequency filter means 9 are connected in the output of the rectifier 6, and a resistor 7 completes the rectifier circuit, an audio frequency voltage appearing across the resistor in accordance with signal and distortion components in the modulated output of the modulator 1. A potentiometer 8 is connected across the secondary of audio frequency input transformer 16, and a portion of the voltage thereacross is applied to a series circuit including resistor 7, capacity coupling 11, potentiometer load 10, and bias sources 12 and 17, the potentials of which are effectively segregated by the blocking function of coupling condenser 11.

The audio frequency voltage taken from potentiometer 8 is connected in the series circuit in phase opposition to the signal components in the audio frequency voltage appearing across resistor 7. If no amplitude distortion occurs in the process of modulation, the wave form of the rectified voltage across resistor 7 will be the same as that of the signal voltage supplied by transformer 16, and potentiometer 8 can be adjusted so that no voltage will appear across the load 10, which is in series with resistor 7 and potentiometer 8. However, when distortion is present, a voltage appears across load 10 and is applied to a grid electrode 3*d* in the radio frequency amplifier stage 3 with the bias potential provided by source 12. The magnitude of this voltage may be varied in the potentiometer load means 10.

The radio frequency amplifier stage 3 as shown in Fig. 1 employs a pentode having an anode 3*a*, cathode 3*c*, control grid 3*g*, and a screen grid 3*s*, besides the grid 3*d* connected as described. Anode and screen grid potentials are derived from the source of potential shown at 13, 14. The carrier wave is impressed on the control grid 3*g* through capacity coupling 26; and the control grid is self biased by means of the grid leak resistor 15 connected through a radio frequency choke coil 27.

The effect of the application of distortion components of voltage to the grid 3*d* in the radio frequency amplifier stage 3 is to condition the carrier by modulation thereof in such phase relation that the modulations thus produced will be effective to reduce substantially the distortion components in the output of the modulator 1. In this manner, the circuits of the modulator are not complicated by further input means for reintroducing distortion components, the triode is not overburdened, and the system is greatly simplified for construction and operation. The results are entirely satisfactory and permit more efficient operation of the modulator stage so that the efficiency of the transmitter as a whole is increased.

The circuit arrangement shown in Fig. 1 illustrates the basic form of my invention. Fig. 2 shows a modification thereof in which an amplifier stage 19 with tuned output circuit 20 is inserted between the pentode stage 3 and the grid modulated stage 1. The amplifier 19 is shown as a triode having its grid 19*g* capacitively coupled to the output circuit 2 of the preceding stage 3. Bias potential for grid 19*g* is provided at source 21; and anode potential for the anode 19*a*, by source 28. The amplifier 19 must be operated so that amplitude modulation appearing in tuned circuit 2 will be amplified; that is, amplifier 19 may be a class B linear stage, or a class C stage operated below saturation, so that it will amplify small percentages of modulation. It will be understood that more than the single intermediate amplifier stage may be employed, the purpose being to provide sufficient amplification of the net distortion components found in the modulated output of the transmitter so that substantially all of the distortion may be offset.

Fig. 3 shows a second modification of the circuit of Fig. 1 in which an amplifier stage 22 follows the grid modulated stage 1, and the rectifier 6 is supplied from the output of amplifier 22, by coil 5 coupled to the tuned output circuit 23 connected with the anode 22*a*. The amplifier 22 is shown as a triode having its grid 22*g* capacity coupled to the modulator stage 1. Bias potential for the grid 22*g* is provided at source 24; and anode potential for the anode 22*a*, by source 29. In this case the amplifier 22 is a class B linear stage. Again, it will be understood that more than one stage may be employed, the purpose—similarly to that with respect to Fig. 2—being to provide sufficient amplification of the net distortion components so that substantially all of the distortion may be compensated. In the system of Fig. 3, a greater proportion of the voltage

across potentiometer 8 may be required to balance the signal modulations in resistor 7, depending upon the value of resistor 7, inasmuch as the signal modulations are likewise amplified in the stage 22.

Fig. 4 shows a more distinct modification of the circuit of Fig. 1 in which a triode is employed instead of the pentode shown in Fig. 1 in the amplifier stage 3. In the modification shown in Fig. 4 the triode 3' has its control grid 3g' excited through condenser 26 by the carrier wave. Voltages across potentiometer load means 10' are impressed on the grid 3g' through a radio frequency choke coil 30, together with bias potential for the grid from source 12'. Potential for the anode 3a' is provided at the source 14'. The operation is substantially like that of the circuit shown in Fig. 1.

Throughout the various circuits shown, neutralization means are employed in connection with all triodes but are omitted for clarity. The amplifier tubes are shown with directly heated filamentary cathodes supplied with alternating current through power transformer secondaries having center taps for grid and anode circuit connections. It will be understood that indirectly heated cathodes may be employed as desired.

It will be further understood that the system of my invention embraces any combination of Fig. 4 with additional amplifiers, in the manner shown in Figs. 2 and 3 as to the system of Fig. 1, as well as the various modifications which may be made by those skilled in the art. Thus, while I have shown my invention in certain preferred embodiments, I do not intend to be restricted thereby; and no limitations upon my invention are intended except as may be imposed by the scope of the appended claims.

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

1. A system for reducing distortion in a radio frequency grid circuit modulated amplifier, which comprises means for deriving distortion components from the modulated carrier, and preamplifier means having the output thereof connected with the input of said grid circuit modulated amplifier and having the input thereof energized by the unmodulated carrier and the distortion components derived by the aforesaid means for conditioning the carrier to compensate for the distortion thereof in said grid circuit modulated amplifier.

2. A system for reducing distortion in a radio frequency grid circuit modulated amplifier, which comprises means for deriving distortion components from the modulated carrier, and a separate modulated amplifier having the input thereof connected with the radio frequency input and the output thereof connected to the input of the aforesaid modulated amplifier, and means for impressing the distortion components derived by the aforesaid means on said separate amplifier for modulating the carrier in anticipation of and in phase opposition to distortion components subsequently arising.

3. A system for reducing distortion in a radio frequency grid circuit modulated amplifier, which comprises, a rectifier device supplied with a portion of the distorted modulated output of said amplifier, and a resistor connected with said rectifier and having an audio frequency voltage thereacross corresponding to signal and distortion components in the modulated output; an audio frequency signal input circuit connected with said grid circuit modulated amplifier, and a potentiometer device connected with said signal input circuit; potentiometer load means, and means for connecting said resistor and a portion of said potentiometer device in series with said potentiometer load means and in such relation that the voltages across said resistor and said potentiometer device are in opposition so that the signal components in said voltages are balanced and a voltage corresponding to the distortion components is produced across said potentiometer load means; and a separate modulated amplifier, means for supplying high frequency energy to said separate modulated amplifier, means for impressing said voltage corresponding to the distortion components on said separate modulated amplifier for modulating said high frequency energy, and means for coupling the output of said separate modulated amplifier with the input of the aforesaid modulated amplifier with the modulation in said output in phase opposition to distortion components produced in the aforesaid modulated amplifier.

4. A system for reducing distortion in a radio frequency grid circuit modulated amplifier comprising means energized by the distorted modulated output and the signal input of said modulated amplifier for deriving the distortion components, a potentiometer load device connected with said means for producing a voltage thereacross corresponding to the distortion components, a second modulated amplifier, means for supplying radio frequency energy to the input of the last said amplifier and means for coupling the output thereof to the aforesaid modulated amplifier, and means for impressing the voltage across said load device on said second modulated amplifier for modulating the radio frequency wave in phase opposition to distortion components as produced in the aforesaid modulated amplifier.

5. A method of reducing distortion in a radio frequency grid circuit modulated amplifier consisting of deriving the distortion components from the distorted modulated carrier independently of the modulated amplifier, applying the unmodulated carrier to the input of a separate modulated amplifier, modulating the unmodulated carrier by the distortion components derived from the distorted modulated carrier, and applying the thus modulated carrier to the input of the first mentioned modulated amplifier.

6. The method of reducing distortion in a radio frequency grid circuit modulated amplifier which includes amplification of the distorted modulated carrier, derivation of the distortion components therein by cancellation of the signal components with signal energy independently applied, application of the unmodulated carrier to the input of a separate modulated amplifier, modulation of the unmodulated carrier by the distortion components in phase opposition to the components as derived from the distorted modulated carrier, and application of the thus modulated carrier to the input of the first mentioned modulated amplifier.

7. The method of reducing distortion in a radio frequency grid circuit modulated amplifier which includes derivation of the distortion components in a distorted modulated carrier by cancellation of the signal components with signal energy independently applied, application of the unmodulated carrier to the input of a separate modulated amplifier, modulation of the unmodulated carrier by the distortion components in phase opposition to the components as derived, ampli-

fication of the thus modulated carrier for increasing the magnitude of the distortion modulation components, and application of the thus modulated and thus amplified carrier to the input of the first mentioned modulated amplifier.

8. A system for reducing distortion in a radio frequency grid circuit modulated amplifier comprising means for deriving distortion components from the modulated carrier including independent connections from the signal input to said modulated amplifier, and a second modulated amplifier having the input thereof connected with the radio frequency input and the output thereof connected to the input of the aforesaid modulated amplifier, and means for impressing the distortion components derived by the aforesaid means on said second modulated amplifier in phase opposition to the distortion components in the distorted modulated carrier.

9. A system for reducing distortion in a radio frequency grid circuit modulated amplifier comprising means for deriving distortion components from the modulated carrier including independent connections from the signal input to said modulated amplifier, and a second modulated amplifier having the output thereof connected with the input of the aforesaid modulated amplifier and comprising a pentode electron tube having anode, cathode and a plurality of grid electrodes, means for exciting one of the grid electrodes by the radio frequency input, and means for connecting another of said grid electrodes with the aforesaid means for excitation by the distortion components derived thereby, for modulating the radio frequency carrier in phase opposition to the distortion components in the distorted modulated carrier.

10. A system for reducing distortion in a radio frequency grid circuit modulated amplifier comprising means for deriving distortion components from the modulated carrier including independent connections from the signal input to said modulated amplifier, and a second modulated amplifier, means for supplying radio frequency energy to the input of the last said amplifier and means for coupling the output thereof to the aforesaid modulated amplifier, said second modulated amplifier comprising a triode electron tube having anode, cathode, and grid electrode, said grid electrode being excited by the radio frequency input energy, and means for connecting said grid electrode with the aforesaid means for excitation by the distortion components derived thereby, for modulating the radio frequency carrier in phase opposition to the distortion components in the distorted modulated carrier.

11. A system for reducing distortion in a radio frequency grid circuit modulated amplifier as set forth in claim 8 and including amplification means connected between the output of said second modulated amplifier and the input of the aforesaid modulated amplifier for increasing the magnitude of the distortion modulation on the carrier.

12. A system for reducing distortion in a radio frequency grid circuit modulated amplifier as set forth in claim 8 and including amplification means connected between the output of the aforesaid modulated amplifier and the said means for deriving distortion components from the distorted modulated carrier, for increasing the magnitude of the distortion components for modulation of the carrier in the said second modulated amplifier.

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