Sept. 20, 1938. I. E. MOUROMTSEFF ET AL 2,130,893

MODULATION

Filed March 15, 1935 2 Sheets-Sheet 1

Fig. 1

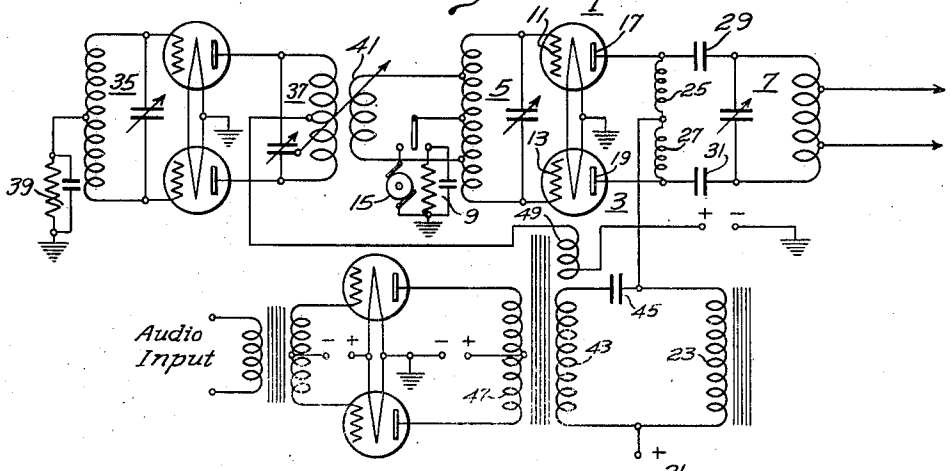



Fig. 2.

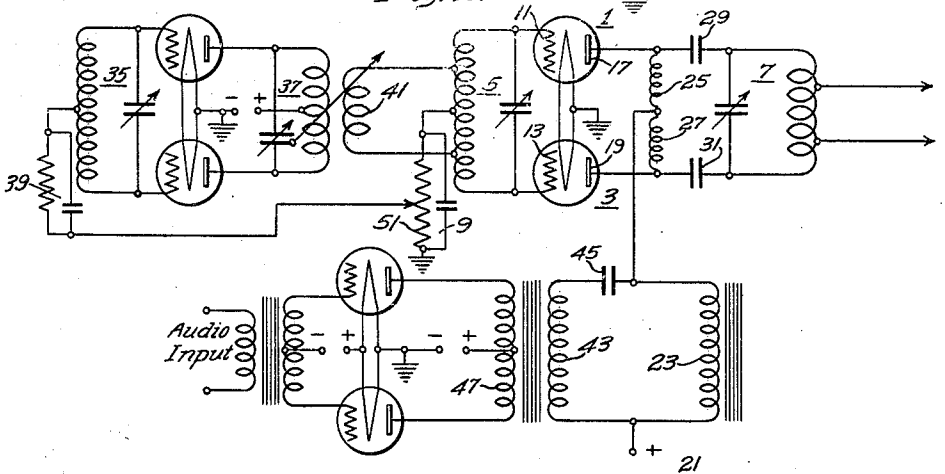
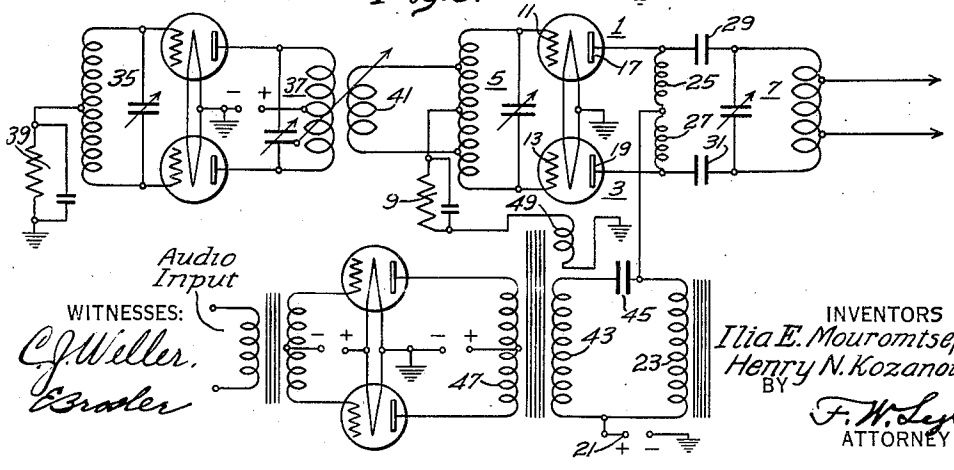



Fig. 3.

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MODULATION

Filed March 15, 1935 2 Sheets-Sheet 2

Fig. 4.

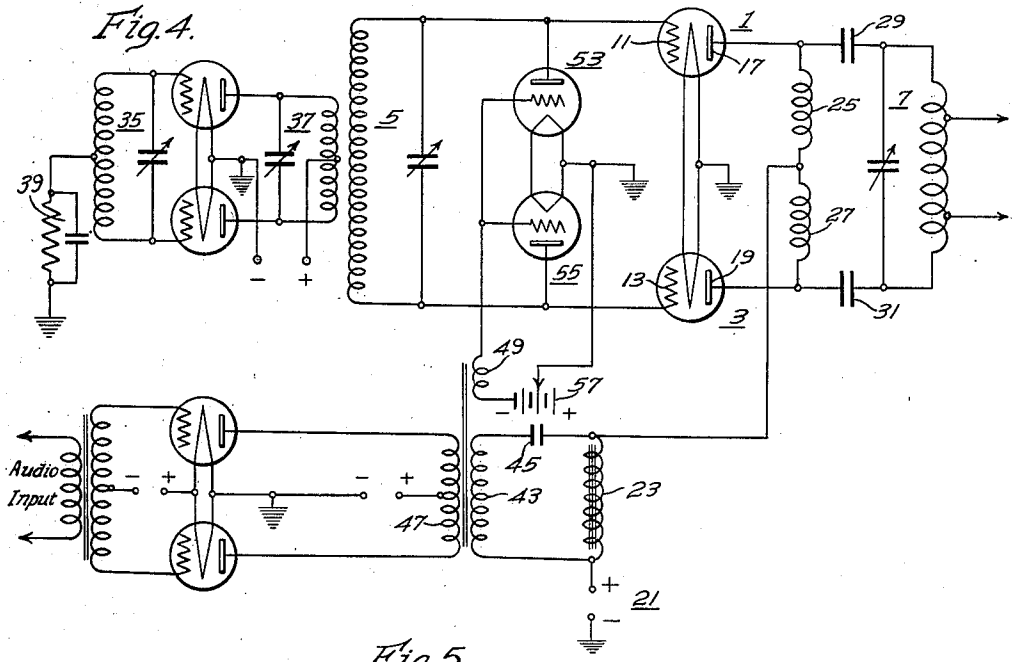
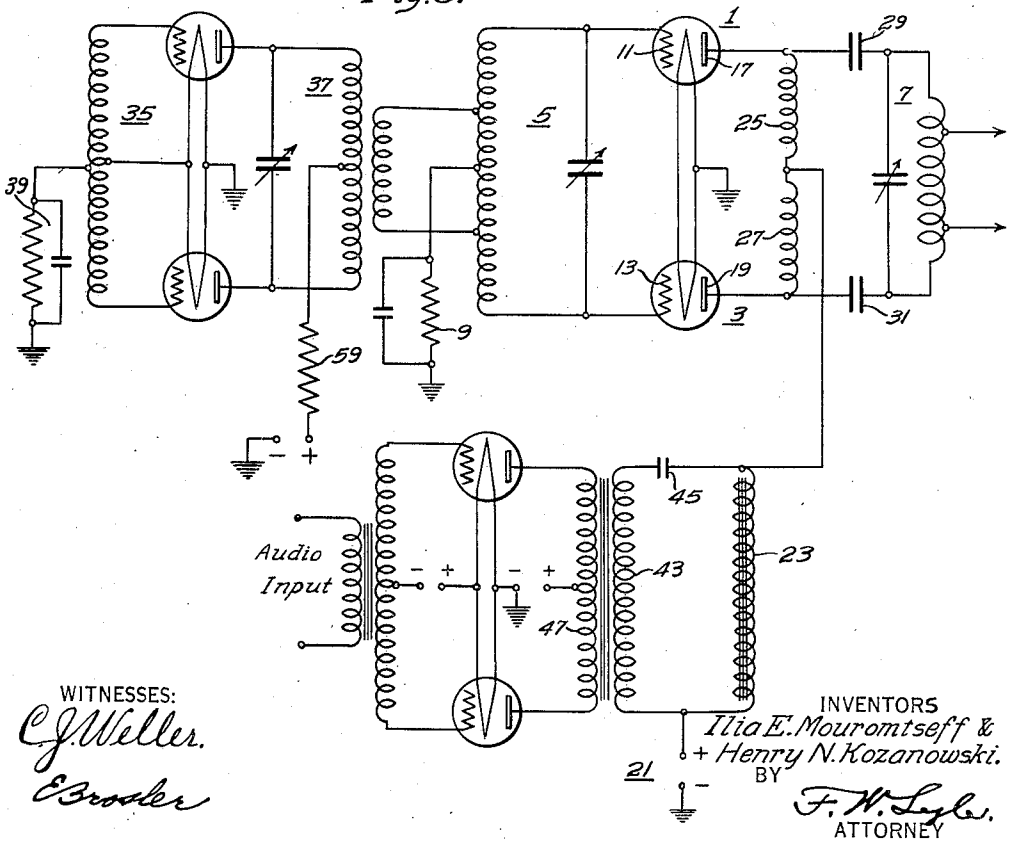



Fig. 5.

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# UNITED STATES PATENT OFFICE

2,130,893

## MODULATION

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Application March 15, 1935, Serial No. 11,272

19 Claims. (Cl. 179—171)

Our invention relates to improvements in modulation, more particularly with regard to the plate modulation of a class C amplifier.

Broadcast transmitters in which vacuum tubes are used in the output stage as class C amplifiers, in combination with modulators, usually of the class B type, because of their high overall efficiency are particularly suitable for high power installation.

A class C amplifier is an amplifier, the basic characteristic feature of which is the application of such high negative bias, that plate current is permitted to flow during only a fraction of the half cycle corresponding to the positive grid swing. This enables the tube to deliver into the output circuit a substantial amount of high frequency power at rather high efficiency. By reason of its high efficiency characteristic the class C type of amplifier is becoming more widely used in broadcast transmitter circuits.

Modulation of a class C amplifier is provided by coupling the output circuit of an audio amplifier, preferably of the class B type, into the plate or output circuit of the class C radio frequency amplifier, this arrangement conveniently permitting obtaining 100% modulation in the output stages of the transmitter. A class B amplifier is one which is normally biased to cut off and begins to draw plate current upon application of signal potentials to the grid thereof.

At the point of 100% modulation, the applied voltage to the plate circuit of the class C amplifier swings to zero on the negative half cycle of modulation and to twice the value of the applied direct-current voltage on the positive half cycle of modulation. It is natural to expect, therefore, at the instant that the voltage reaches twice that supplied from the direct-current source, that the output of the amplifier will increase as the square of this voltage and become four times as great as when no modulation is applied. The application of twice the normally applied potential, however, does not ordinarily result in the expected value of power output, nor does the efficiency of the tube remain at that value at which it functioned with no modulation applied to it. In fact, the efficiency drops upon the application of a modulating voltage, this drop in efficiency being particularly bad at and in the vicinity of the peaks of the modulating wave.

The power output of a 100% plate modulated class C amplifier might be greater or less than that expected. The efficiency, nevertheless, at the peaks of modulation will always be materially lower than under no modulation conditions.

It has been discovered that the type of bias applied to the amplifier determines for the most part whether the ultimate output of the amplifier, upon the application of 100% modulation is apt to be above or below that expected, and that various other factors enter into the causes for the reduced efficiency of the amplifier.

Bias might initially be applied either through the use of a generator or other source of fixed potential, or a self-biasing scheme may be employed, utilizing some such agency as a grid leak and condenser to provide the bias on the tube.

Upon the application of fixed generator bias, and radio frequency excitation of constant amplitude from a preceding stage, the grid potential of the amplifier is caused to vary in a well defined manner and this excitation will remain uniform regardless of the application of modulating potentials to the plate circuit of the amplifier.

With a predetermined value of direct-current potential applied to the anode of the amplifier and without the application of modulating potentials, the amplifier tube will operate along a dynamic characteristic curve such that the power generated by the tube will equal the power consumed by the load circuit, this representing a stable condition of operation. When the plate potential on the tube, due to the application of audio modulating voltages, shifts, the tube will shift its operating cycle to different dynamic characteristic curves, always seeking a condition of stability for each increment of change in applied plate voltage, wherein the power generated by the tube will equal the energy consumed by the load circuit, the resistance of which has already been previously determined for unmodulated carrier output and, therefore, is fixed in value. As the applied potential in the plate circuit reaches double normal value at a positive peak of 100% modulation, it was discovered that the particular dynamic characteristic curve which the tube had to follow in order to obtain this stable condition of operation, when employing fixed generator bias and constant radio frequency excitation on the grid, was such as to bring about an excessive loss in output of the amplifier during modulation, with a corresponding decrease in the efficiency of operation.

Utilizing a self-biasing scheme in a similar circuit in the form of a grid leak and condenser combination in the grid circuit, more complex changes in the operation of the device, from that obtained with fixed generator bias, were found to take place. As the modulating voltage increased the applied plate voltage to twice its nor-

mal value, as would occur at the peak of 100% modulation, we have found that the bias no longer remains constant and uniform upon the application of constant radio frequency excitation to the grid circuit, but that at the positive peaks of 100% modulation, the amplifier actually loses grid bias to such an extent as to run the amplifier into the region of class B and even under certain conditions into the region of class A operation. During such moments, when the amplifier is operating class B or class A, the amplifier no longer draws plate current only during those portions of the applied radio frequency excitation cycles to the grid, which are characteristic of class C operation, but draws plate current throughout practically the entire excitation cycles of the grid applied radio frequency excitation energy, even during portions of the cycles when the grid becomes highly negative which occurs during the negative half cycles of the radio frequency excitation. It was found that due to the above-mentioned loss of bias, the output from a plate modulated class C amplifier in the neighborhood of 100% modulation is actually greater than four times the carrier output without modulation. The efficiency, however, is found to decrease materially over what it was without modulation applied to the plate circuit, and investigation disclosed that this drop in efficiency could for the most part be traced to decidedly increased losses within the tube, brought about by the condition referred to above occurring at the peaks of 100% modulation, at which time plate current flowed at high negative grid potentials. Under these conditions, the grid is found to exert a marked focusing effect upon the electron stream to the anode, causing current concentration at localized points on the anode, thus resulting in excessive local heating of the plate electrodes. With bias obtained through the medium of a grid leak and condenser combination in the cathode lead, where it would be common to both the grid and plate circuits, one could expect that conditions would become more aggravated than with the grid leak and condenser in the input circuit exclusively.

In both cases whether generator bias operation or self-biasing operation is employed, the respectively reduced or excessive output of the amplifier with the accompanying reduction in efficiency of operation, results in decided distortion in the modulated output of the amplifier.

By combining both self-bias and generator bias in the same circuit, and relying upon the simultaneous effects of both, improved operation of a modulated class C amplifier could be expected but not to the extent desired. The success of this scheme depends, moreover, upon a constancy of tube and circuit characteristics. Since these are more or less beyond the control of any operator, it becomes necessary to make frequent adjustments of one or the other of the grid biasing agencies, and this cannot be accomplished conveniently.

We have accordingly devised other and more effective methods and remedies for curing the deficiencies of plate modulated class C amplifiers and these same methods and remedies can be utilized in connection with either scheme of grid bias control, to eliminate or practically avoid distortion, as well as to increase the efficiency of the amplifier to a value closely approaching the efficiency of the amplifier under no modulation conditions.

It is accordingly an object of our invention to provide a plate modulated amplifier of the class C type, the output of which shall be relatively free of distortion.

It is another object of our invention to obtain a distortionless output from a plate modulated amplifier of the class C type at an efficiency comparable to that obtained under conditions of no modulation.

It is a further object of our invention to provide a plate modulated amplifier of the class C type which shall permit the use of apparatus of lower rating than formerly considered necessary, without accompanying loss in efficiency or without accompanying distortion in the output of the modulator.

An additional object of our invention is to provide a plate modulated amplifier of the class C type which shall be economical in operation.

In addition, a further object of our invention is to provide means for obtaining a plate modulated amplifier of the class C type at 100% modulation without the customary distortion and loss of efficiency normally occurring in such amplifiers.

Additional objects of our invention will be pointed out in the following description of the same, taken in connection with the accompanying drawings wherein we have disclosed various schemes, which have been proposed by us whereby to obtain in plate modulated class C amplifier circuits undistorted output of the proper amount and at the proper efficiency of operation.

We have traced the underlying causes of distortion in class C amplifiers to the practice of applying radio frequency energy of constant amplitude as grid excitation to the input circuit of the amplifier. We have discovered that, by varying the grid excitation level a predetermined amount in accordance with the modulating potentials applied in the plate circuit, the effect will be such as to compensate for or avoid the deficiencies incident to the previous practice of applying constant excitation to the grid.

Variation of the grid excitation level in accordance with the modulating potentials applied in the plate circuit can be obtained in either of two general ways, the results, insofar as the modulated output is concerned, being substantially the same in either case although the effects which bring about these results may be different in character.

According to one scheme, we propose modulating the carrier excitation with modulating potentials corresponding to those applied in the plate circuit of the class C amplifier. The effect of this will be to increase the grid swing in the positive direction during positive half cycles of modulation.

In a class C amplifier utilizing generator bias, the increased swing of the grid in the direction of positive grid bias will cause the amplifier to draw increased plate current, and thus increase the modulated output energy to make up for the deficiency previously existent, where generator bias alone was relied on to provide the proper output.

In a circuit utilizing self-bias operation, the additional swing of the grid in the positive direction during positive half cycles of modulation will bring about an increase in the flow of grid bias current and thus develop sufficient additional bias to swing the operation of the amplifier back into the region of class C amplification, it having been previously pointed out that with self bias, the class C amplifier was quite apt to shift into the

region of class B amplification at 100% modulation and indirectly cause excessive localized heating of the anode.

In either case, therefore, whether the modulater carrier excitation be applied to a class C amplifier utilizing generator bias or self bias, the operation of the amplifier is compensated or corrected so as to bring about the desired efficiency and minimum of distortion expected from an amplifier of this type, when utilized in a modulating circuit employing 100% modulation.

The alternative method, which we propose for bringing about more nearly the ideal operating condition of a plate modulated class C amplifier embodies the idea of leaving the radio frequency excitation constant in value but varying the grid bias in accordance with the modulating potentials applied to the plate circuit.

When employed in connection with constant generator bias, the modulating potentials will be applied to the grid circuit in series with the generator, and will vary in the same direction as the modulating potentials applied to the plate; that is, during positive half cycles of modulation, the potentials applied to the grid circuit will be in such a direction as to cause the grid to swing more positive than ordinarily would occur, the effect of which would be to bring about an increase in the flow of current in the plate circuit and thereby provide greater output.

For a circuit utilizing self bias, the variation of the grid bias in accordance with the application of modulating potentials to the plate circuit will bring about, but in a more direct manner, the same results as described in connection with the application of modulated radio frequency excitation to the grids of the amplifier utilizing self bias. To obtain this similar but more direct effect, the compensating potentials are applied to the grid-circuit in accordance with, but inversely, as the modulating potential supplied in the plate circuit. That is, during the application of positive half cycles of modulation to the plate circuit of the class C amplifier, the corresponding compensating potential applied to the grid circuit will be in such a direction as to cause the grid to swing more negative thus, as explained before, causing the amplifier to swing back into the region of class C amplification during 100% modulation, where it previously had shifted into the region of class B operation; and thereby avoiding the condition which formerly brought about excessive localized heating of the anode.

While the methods previously described above are specifically different, they are generically similar in that in each case the method effects a variation in the excitation level of the grid of the class C amplifier.

While we have spoken of our invention as constituting a means for avoiding distortion and loss of efficiency in a plate modulated amplifier of the class C type, it embodies an adidtional advantage of importance, and this pertains in particular to economies realized in the initial cost and expense of operation of the apparatus embodying our invention.

For best operation, a class C amplifier requires exceedingly heavy negative bias, values as high as 4500 volts being recommended, such high negative bias resulting in fairly good efficiency of operation although bad distortion is quite likely to be present. In a self-biased class C amplifier, the performance is found to be rather erratic in the circuit of this type, requiring a resistance of very high value to provide the necessary heavy negative bias recommended. In the type of class C amplifier embodying fixed generator bias, the initial cost of rotating apparatus capable of providing the desired high biasing potentials is such that in the majority of cases, efficiency is sacrificed to enable the use of less expensive apparatus of lower voltage rating. The amount of distortion in either case is increased to a certain extent with a change to a negative bias of lower value.

Our invention as described above in general terms permits of the use of apparatus of voltage rating lower than formerly considered necessary for best operation, without incurring noticeable distortion in the modulated output energy of the amplifier and a loss of efficiency during modulation.

Figs. 1 through 5 disclose circuits which are illustrative of various methods of accomplishing these results and in each of the figures of the drawings, we have disclosed a class C amplifier receiving excitation from a preceding stage of radio frequency amplification, the class C amplifier being plate modulated by a source of modulating signals. In each of these circuits, we have disclosed a means for avoiding distortion and loss of efficiency in the class C amplifier in accordance with our invention.

Referring to Fig. 1 for a more complete description of the circuit, the class C amplifier is of the push-pull type comprising a pair of electron discharge devices 1 and 3 having a tuned input circuit 5 and a tuned output circuit 7, the output circuit constituting a tank circuit from which connections may be taken to a subsequent amplifier or to an antenna system. The input or grid circuits for these push-pull connected devices include in the common return lead to the cathodes a grid leak resistor and condenser combination 9 for the purpose of obtaining bias on the grids 11 and 13. As an alternative means of obtaining bias we have shown a generator 15 adapted to be switched into the circuit in lieu of the grid leak condenser combination 9. Plate potential for the anodes 17 and 19 of the class C amplifier is supplied from a source of direct current potential 21 and is impressed upon the plates of the tubes through a choke coil 23 and the balancing inductors 25 and 27, each of which is individual to one of the plate circuits.

Blocking condensers 29 and 31 are inserted between the tank circuit and the direct current power supply circuit, these blocking condensers and the choke coil 23 constituting filtering means for restricting the radio frequency component of the output circuit to the tank circuit 7, and for keeping the direct current components out of the tank circuit.

Excitation for the grids of the class C amplifier is obtained from the preceding stage of radio frequency amplification, this preceding stage, in turn, obtaining its excitation from a similar preceding amplifier or a constant frequency oscillator or other equivalent source of high frequency oscillation.

The excitation stage, as shown, constitutes a simple push pull arrangement having tuned input and tuned output circuits 35 and 37 respectively, with a grid leak and condenser combination 39 in the common return lead to the cathodes as a means for obtaining bias. Excitation from this stage to the grid circuits of the class C amplifier may be provided by simply coupling the tank circuit of the excitation stage to the input circuit of the class C amplifier, although we have con-

sidered it preferable to obtain this excitation through the medium of a link circuit comprising a coil 41 inductively coupled to the tank circuit coil of the exciter stage, the coil 41 being tapped into the winding of the input circuits of the class C amplifier, this arrangement being considered more flexible and more convenient.

Modulation of the class C amplifier is obtained by coupling the output circuit of a class B audio modulator to the plate circuit of the class C amplifier. This coupling is secured by shunting the choke coil 23 in the direct current plate circuit with an audio transformer secondary winding 43 having a blocking condenser 45 in series therewith to prevent flow of the direct current component of the plate circuit through this winding of the modulated transformer and thereby prevent saturation thereof. The primary 47 of this transformer may constitute the output or plate circuit of the class B audio modulator, this primary winding being center tapped for the purpose. The input to the modulator might be derived from any source of signal energy with which it is desired to modulate the output of the class C amplifier.

In accordance with our invention as disclosed in the embodiment of Fig. 1, we provide modulation to the output circuit of the exciter stage in such a direction that the radio frequency excitation to the gride of the class C amplifier will vary in accordance with the modulation potentials impressed upon the plate circuit of the class C amplifier. Thus, as the modulating or signal potentials increase or are added to the applied direct current plate voltage, the radio frequency excitation applied to the grids of the class C amplifier is caused to build up in the same direction.

The modulating potentials are applied to the plate circuit of the exciter stage through the medium of a third winding 49 on the core of the modulating transformer. The turns of this winding will be so adjusted as to number to give the correct variation in the excitation for the purpose. The correct variation in the excitation necessary to obtain the results attributed to our invention will constitute but a relatively small percentage of the modulating voltages applied to the plate circuit. The proper amount can be determined by calculation, but from a practical standpoint may be determined more conveniently and directly through trial by providing suitable taps on the auxiliary or third winding of the modulating transformer and shifting the connection to this winding from one tap to another until the proper value is obtained.

The various plate power supply terminals indicated in the circuit might constitute connections to a common supply source.

In the embodiment of our invention, as disclosed in the circuit of Fig. 2, compensation is obtained by tapping into the grid leak of the class C amplifier and including a portion 51 thereof in the input circuit of a preceding amplifier, which may be the excitation stage as shown. Thus, as the grid bias of the class C amplifier shifts at audio frequency during modulation in the manner described above, a variable potential corresponding thereto will be derived from the grid leak and applied to the grids of the preceding exciter stage in a direction such as to increase and decrease, at audio frequency, the excitation on the grids of the class C amplifier. By making the tap variable, the correct value of compensating potential may be taken from the grid leak on the class C amplifier and amplified through the exciter stage to the proper value for application to the grids of the modulated class C amplifier.

A further method of preventing distortion in a 100% plate modulated class C amplifier is disclosed in the circuit arrangement of Fig. 3, wherein the grid excitation of the class C amplifier is varied or caused to vary in accordance with the modulating signal potentials by including in the grid circuits of this amplifier a winding 49 in series with the grid leak, which winding will constitute a third winding on the modulating transformer. This winding will be so connected in direction that bias will be increased in a positive direction during positive half-cycles of modulation and in a negative direction during the negative half-cycles of modulation. While we have shown this embodiment as employed in connection with self-bias, it is equally applicable to a circuit employing generator bias, since the compensating potentials will remedy the distorting effect obtained at peaks of modulation irrespective of the type of bias arrangement.

In the circuit of Fig. 4, a third winding 49 on the modulating transformer is again employed as a means for obtaining compensating excitation on the grids 11 and 13 of the class C amplifier. However, in this particular embodiment, these derived potentials are not employed directly for compensating purposes, but are utilized as a means for indirectly causing the grid excitation of the class C amplifier to vary in accordance with signal modulating potential. In the specific embodiment disclosed in Fig. 4, a pair of electron discharge devices 53 and 55 are connected across the grids of the class C amplifier, the anodes of these discharge devices being connected each to the grid of one of the tubes, the filaments being connected in parallel and grounded. This connection of the tubes 53 and 55 places the impedance of each tube across the input of one of the tubes 1 and 3 in the class C amplifier. The impedance of each of these devices 53 and 55 is altered in accordance with the modulating potentials, by impressing the potentials derived from the third winding 49 of the modulating transformer upon the grids of these devices, these grids being connected in parallel for the purpose.

A battery 57 or other source of direct current potential may preferably be connected in series with the third winding 49 whereby a fixed value of bias of any desired amount may be applied to the grids of these electron discharge devices. This value of bias is so fixed that during the greater portion of a modulating cycle, the impedance of these discharge devices will be of a comparatively low value and yet provide satisfactory output of the class C amplifier. The third winding is then so connected in the grid circuit that during positive half cycles of modulation, the grid excitation of these devices will be rendered more negative, to increase the impedance of the tubes and so raise the excitation level of the grids of the class C amplifier. Thus, at positive peaks of modulation, when distortion would ordinarily occur, the excitation level of the grids of the class C amplifier will be increased in value and thus restore conditions within the tube and circuits, so as to avoid distortion and bring the efficiency of the apparatus up to its proper value.

An additional scheme for altering the excitation level of the class C amplifier to avoid distortion and loss of efficiency resides in the simple expedient of placing an impedance, preferably

in the form of a resistor 59 in the plate supply circuit of the exciter stage to provide for a high regulation characteristic in this circuit.

Since the output of the exciter stage will depend on the variations in the load, which this exciter stage supplies, namely the input circuits of the class C amplifier, it will become apparent that as the load increases, the plate current of the exciter stage will increase and thereby produce an increased drop in potential across this resistor. An increased drop in potential across this resistor will lower the potential across the tank circuit windings of the exciter stage and thereby reduce the value of the radio frequency excitation voltages to the grids of the class C amplifier.

Conversely, a decrease in load on the exciter stage will reduce the drop of potential across the resistor 59 and increase the radio frequency potential across the tank circuit windings. An increase in this potential will obviously increase the radio frequency excitation to the grids of the class C amplifier.

Thus, during the positive peaks of modulation, when the load on the exciter stage is at a minimum, the radio frequency potentials appearing across the tank circuit of the exciter stage will be a maximum and will thus serve to apply maximum increased excitation to the grids of the class C amplifier, thereby providing modulator output which will be substantially reduced in distortion.

Another circuit having this characteristic of high regulation suitable for fulfilling the objects of our invention can be obtained through the expedient of providing loose coupling between the output stage of the exciter amplifier and the input stage to the class C amplifier. This loosely coupled circuit may be relied on independently of the resistor in the plate circuit of the exciter stage or may be utilized to advantage in conjunction therewith.

Our explanation of our invention has dealt primarily with operation and compensation of the amplifier during positive half cycles of modulation. Distortion, however, in the uncompensated amplifier is present also during negative half cycles of modulation, but it is characteristic of our invention that once the circuit is adjusted for a condition of minimum distortion, the compensating means operates effectively during both the positive and negative half cycles of modulation.

While we have gone into great detail in pointing out the various embodiments and features of our invention, it should be apparent that many modifications thereof might suggest themselves to those skilled in the art and we accordingly do not desire to limit our invention to the specific details disclosed except as may be necessitated by the prior art and the appended claims.

We claim as our invention:

1. In an amplifier of the type normally biased beyond cut-off and wherein carrier excitation at high frequency of an amplitude sufficient to overcome said bias is applied to an input circuit, the peaks of said carrier excitation determining the grid excitation level of said amplifier, and voltage at modulation frequencies is applied to an output circuit, the method of compensating for distortion in such an amplifier which comprises varying the magnitude of carrier excitation thereto in accordance with the modulating voltage.

2. In an amplifier wherein modulating potential is applied to the plate circuit of said amplifier, and said amplifier is normally biased beyond cut-off, the method of compensating for distortion in such an amplifier, which comprises deriving potential from the modulating potential and controlling the impedance of said amplifier with said derived potential.

3. In combination, an amplifier, said amplifier comprising an electron discharge device having an input circuit and output circuit, means comprising a grid leak and condenser for normally biasing said discharge device to beyond its cut-off value, a source of carrier frequency energy coupled to said input circuit, means for impressing a varying potential on the output circuit of said amplifier, and means for impressing a similarly varying potential on the input circuit of said amplifier.

4. In an amplifier of the type normally biased beyond cut-off and wherein carrier excitation at high frequency of an amplitude sufficient to overcome said bias is applied to an input circuit the peaks of said carrier excitation determining the excitation level of said amplifier and voltage at modulation frequencies is applied to an output circuit, the method of compensating for distortion in such an amplifier, which comprises varying the grid excitation level in accordance with said modulating potential.

5. In an amplifier of the type normally biased beyond cut-off and wherein carrier excitation at high frequency of an amplitude sufficient to overcome said bias is applied to an input circuit, the peaks of said carrier excitation determining the grid excitation level of said amplifier, and voltage at modulation frequencies is applied to an output circuit, the method of compensating for distortion in such an amplifier, which comprises deriving potential from the source of modulating potential and causing said derived potential to vary the level of grid excitation of said amplifier in accordance with said derived potential.

6. The method of compensating for distortion in an amplifier of the class C type wherein modulating potential is applied to the plate circuit, which comprises deriving potential from the modulating potential of a lower value than said modulating potential, and varying the excitation to said amplifier in accordance with said derived potential.

7. In combination, an amplifier including an electron discharge device having an input and an output circuit, means for normally biasing said discharge device beyond plate current cutoff, a source of carrier frequency energy of sufficient magnitude to overcome said bias coupled to said input circuit, means for impressing a varying potential on the output circuit of said amplifier causing thereby a loading effect on said carrier frequency source, said effect varying in accordance with said potential impressed on said output circuit whereby distortion in said amplifier is apt to develop, and means for varying the voltage output of said carrier frequency source in proportion with the varying potential impressed on said output circuit whereby said distorting effect is substantially eliminated.

8. In an amplifier of the type normally biased beyond cut-off and wherein carrier excitation at high frequency of an amplitude sufficient to overcome said bias is applied to an input circuit the peaks of said carrier excitation determining the excitation level of said amplifier and voltage at modulation frequencies is applied to an output circuit, the method of compensating for distor-

tion in such an amplifier, which comprises deriving potential from the source of modulating potential and varying the grid excitation level in accordance therewith.

9. In an amplifier of the type normally biased beyond cut-off and wherein carrier excitation at high frequency of an amplitude sufficient to overcome said bias is applied to an input circuit, the peaks of said carrier excitation determining the grid excitation level of said amplifier, and voltage at modulation frequencies is applied to an output circuit, the method of compensating for distortion in such an amplifier, which comprises deriving potential from the source of modulating potential and causing said derived potential to vary the grid excitation level of said amplifier.

10. In an amplifier wherein modulating potential is applied to the plate circuit of said amplifier and excitation at high frequency is applied to the grid circuit thereof, and said amplifier is normally biased beyond cut-off during operation, the peaks of said excitation determining the grid excitation level of said amplifier, the method of compensating for distortion in such an amplifier, which comprises deriving potential from the modulating potential and impressing said derived potential on the control electrode of said amplifier to vary the grid excitation level thereof.

11. In combination, an amplifier, said amplifier comprising an electron discharge device having an input circuit and output circuit, means for normally biasing said discharge device to beyond its cut-off value, a source of carrier frequency energy coupled to said input circuit, said carrier frequency having an amplitude sufficient to overcome said bias, the peaks of said carrier excitation determining the excitation level of said amplifier means for impressing a varying potential on the output circuit of said amplifier, whereby distorting effects are apt to develop therein, and means for shifting the excitation level in the input circuit in accordance with said varying potential for substantially eliminating said effects.

12. In an amplifier wherein modulating potential is applied to the plate circuit of said amplifier, and said amplifier is normally biased beyond cut-off, the method of compensating for distortion in such an amplifier, which comprises varying the grid bias thereof in accordance with the modulating voltage.

13. In an amplifier wherein modulating potential is applied to the plate circuit of said amplifier, and said amplifier is normally biased beyond cut-off, the method of compensating for distortion in such an amplifier, which comprises deriving potential from the modulating potential and varying the excitation to said amplifier in accordance with said derived potential, simultaneously with the application of said modulating potential to the plate circuit of said amplifier.

14. In combination, an amplifier, said amplifier comprising an electron discharge device having an input circuit and output circuit, means for normally biasing said discharge device to beyond its cut-off value, a source of carrier frequency energy coupled to said input circuit, said carrier frequency having an amplitude sufficient to overcome said bias, means for impressing a varying potential on the output circuit of said amplifier, whereby distorting effects are apt to develop therein, and means for varying the magnitude of said radio frequency energy coupled to said input circuit, in accordance with said varying potential for substantially cancelling said effects.

15. In an amplifier of the type normally biased beyond cut-off and wherein carrier excitation at high frequency of an amplitude sufficient to overcome said bias is supplied to an input circuit, the peaks of said carrier excitation determining the excitation level of said amplifier, and voltage at modulation frequencies is applied to an output circuit, the method of compensating for distortion in such an amplifier, which comprises deriving potential from the source of modulating potential and utilizing this potential to vary the grid excitation level of the amplifier simultaneously with the application of modulating potential to the plate circuit of the amplifier.

16. In combination with an amplifier of the type normally biased beyond cut-off and having an input and an output circuit, a source of oscillations having an anode and a cathode for impressing carrier excitation at high frequency and of an amplitude to overcome said bias on the input circuit of said amplifier, a modulation frequency circuit supplying current to the output circuit of said amplifier, and a winding magnetically coupled to said modulation frequency circuit and connected between the cathode and the anode of said source of oscillations.

17. In combination with an amplifier of the type normally biased beyond cut-off and having an input and an output circuit, a source of oscillations having an anode, a control electrode and a cathode for impressing carrier excitation at high frequency and of an amplitude to overcome said bias on the input circuit of said amplifier, a modulation frequency circuit supplying current to the output circuit of said amplifier, means for altering the bias of said amplifier comprising an impedance in the input circuit of said amplifier, at least a portion of which impedance is included in the input circuit of said source of oscillations.

18. In combination with an amplifier of the type normally biased beyond cut-off and having an input and an output circuit, a source of high frequency oscillations having an anode, a control electrode and a cathode for impressing carrier excitation at high frequency and of an amplitude to overcome said bias on the input circuit of said amplifier, a modulation frequency circuit supplying current to the output circuit of said amplifier, an impedance connected in the input circuit of said amplifier, and a connection from the grid circuit of said oscillation generator to a point on said impedance.

19. In combination with an amplifier of the type normally biased beyond cut-off and having an input and an output circuit, a source of high frequency oscillations having an anode, a control electrode and a cathode for impressing carrier excitation at high frequency and of an amplitude to overcome said bias on the input circuit of said amplifier, a modulation frequency circuit supplying current to the output circuit of said amplifier, an impedance in the input circuit of said amplifier, and a connection including an impedance between the grid circuit of said oscillation generator to a point on said first impedance.

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