Sept. 25, 1945. O. DE GUIRE 2,385,566

SCREEN GRID MODULATION CONTROL

Original Filed April 7, 1941 4 Sheets-Sheet 1

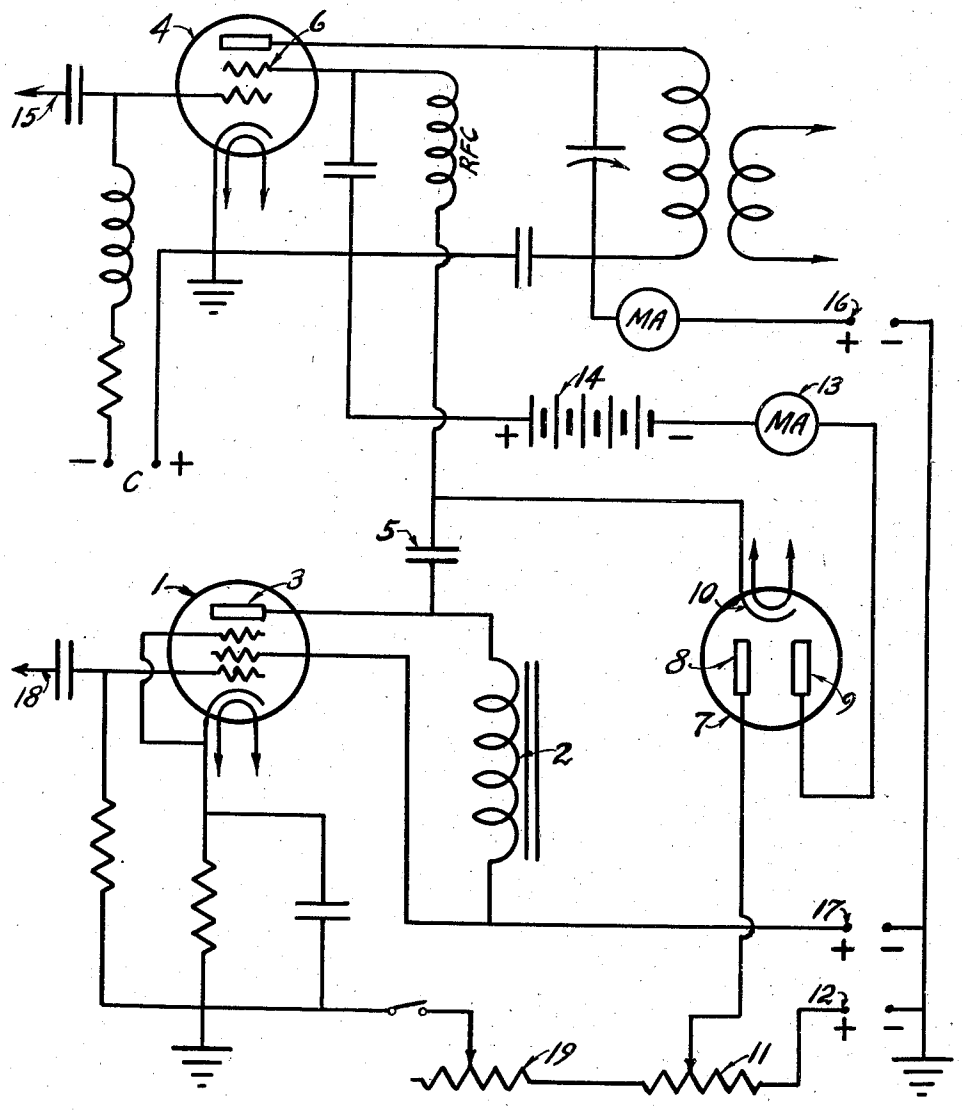


FIGURE No 1

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SCREEN GRID MODULATION CONTROL

Original Filed April 7, 1941 4 Sheets-Sheet 2

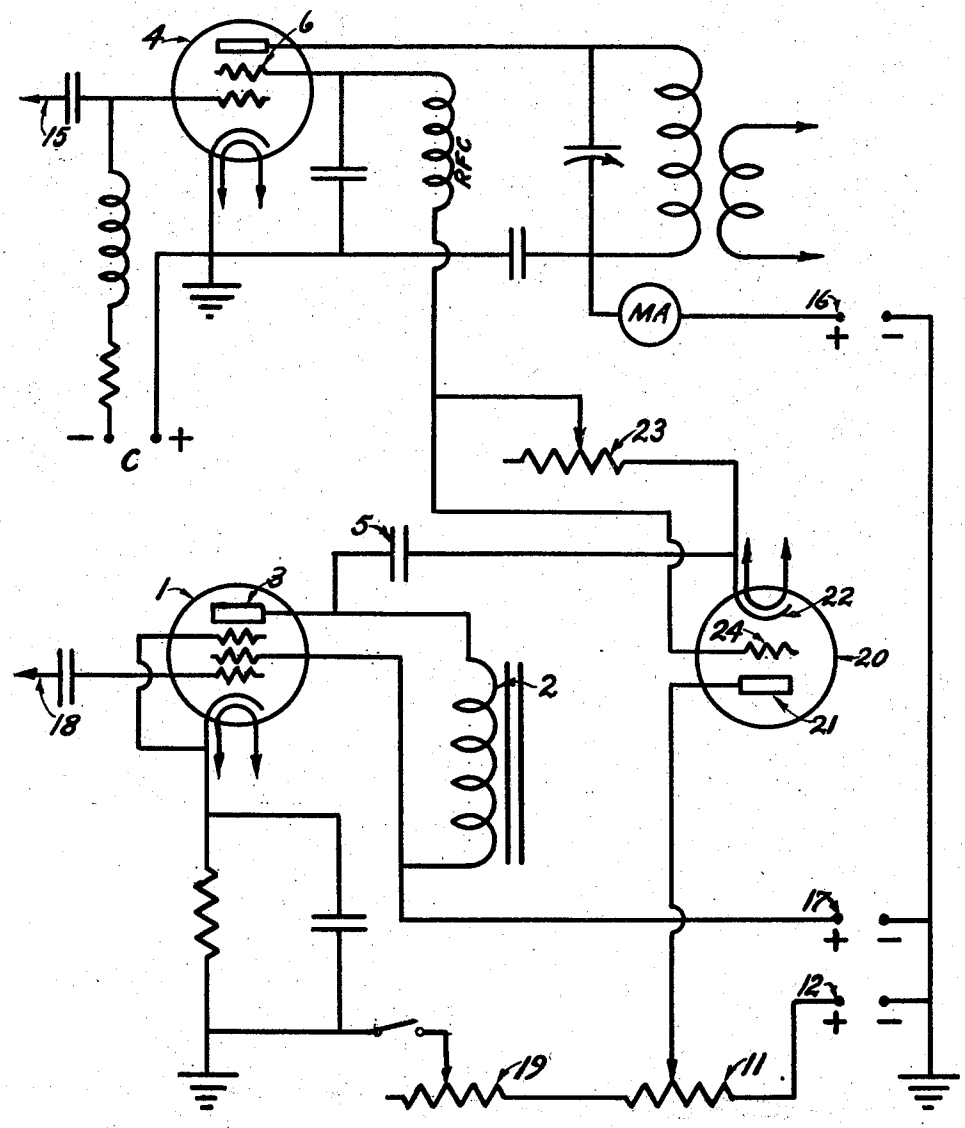


FIGURE Nº2.

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SCREEN GRID MODULATION CONTROL

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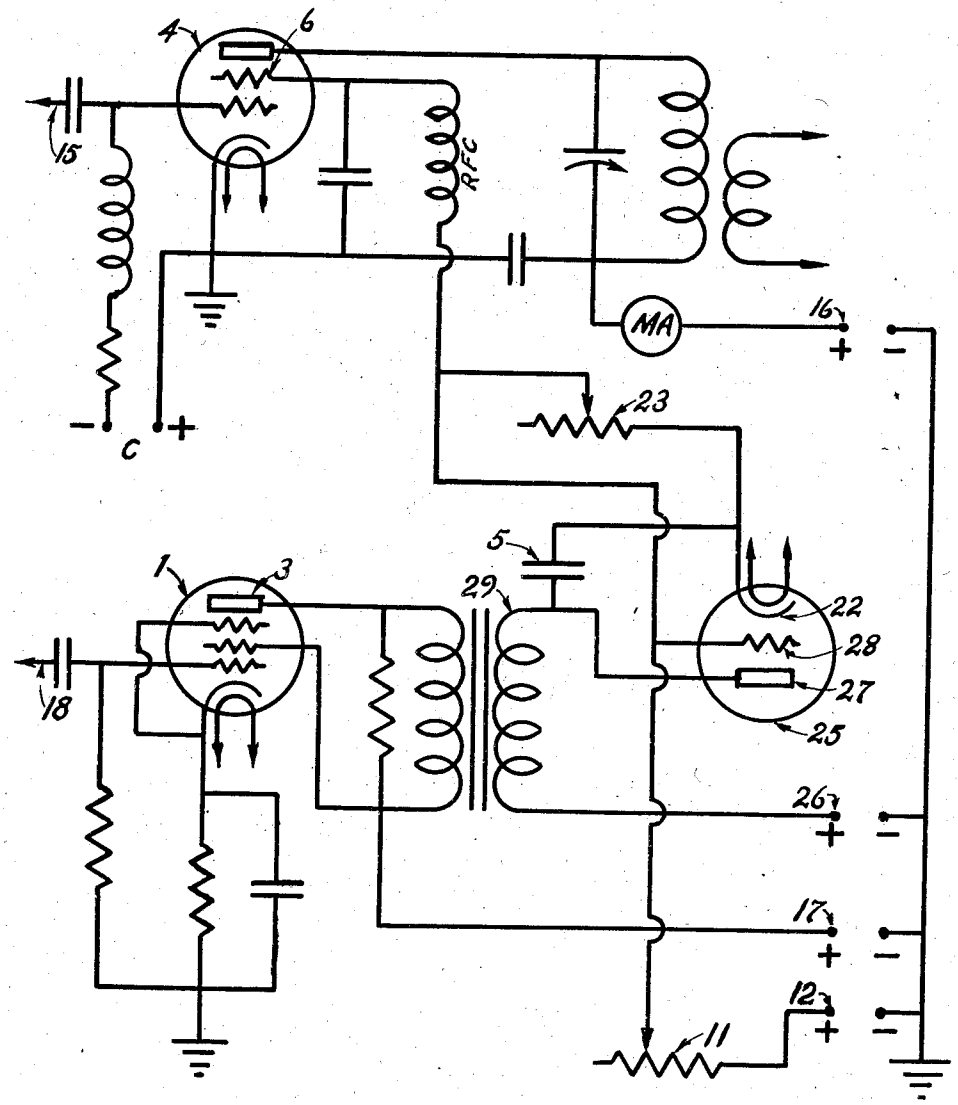


FIGURE No. 3.

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SCREEN GRID MODULATION CONTROL

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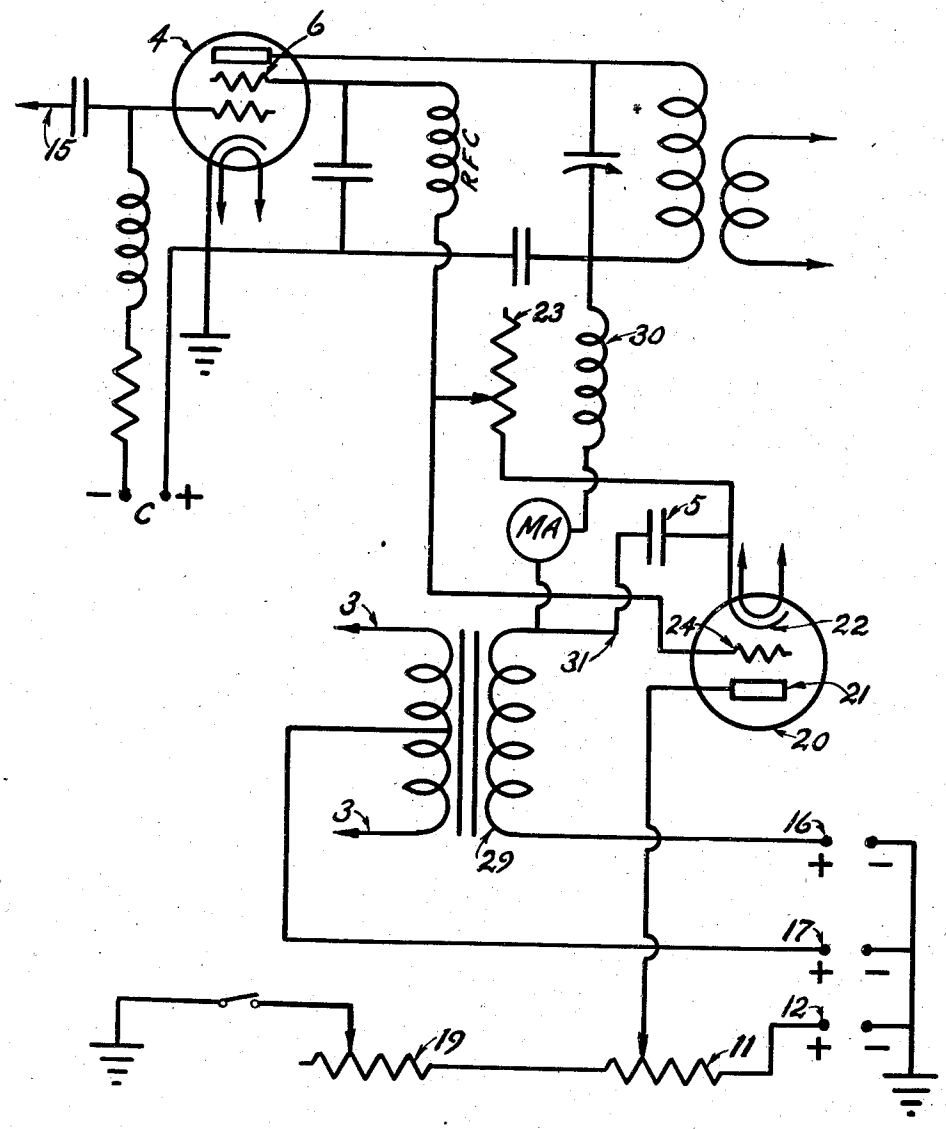


FIGURE Nº4.

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SCREEN-GRID MODULATION CONTROL

Olfan De Guire, Silverton, Oreg.

Substituted for abandoned application Serial No. 387,277, April 7, 1941. This application May 15, 1943, Serial No. 487,112

9 Claims. (Cl. 179—171.5)

This application is a substitute for application 387,277, filed April 7, 1941, and relates to improvement in screen grid modulation and has particular reference to modulation of a radio frequency amplifier having a screen grid and a circuit for same by means of a linear modulator, its object being to provide a control means for controlling the direct current and modulating component supplied for the screen grid circuit whereby an auxiliary circuit connected either in parallel or in series with the screen grid circuit is utilized or controlled by the action of the modulating current to either dissipate an excessive voltage swing from the modulation downward impulse or to counteract same, so as to retard a pre-determined amount the rate of reduction of the quantity of the electric current flowing through the screen grid circuit.

It is proposed in the present invention to provide a condenser having a capacity large enough to supply the modulated audio peak current from the modulator to the screen grid circuit of the radio frequency amplifier. Since a condenser blocks a direct current it will be necessary to use an auxiliary circuit to supply the unmodulated direct current component to the screen grid circuit, as well as using said auxiliary circuit to discharge the condenser when under modulation. If the resistance of the auxiliary circuit is controlled in a non-linear manner during modulation similar to the change in resistance of the screen grid circuit but in an opposite sense, said non-linear characteristic of the screen grid circuit can be counter-balanced by the auxiliary circuit, so as to give the effect of a constant impedance in as far as the modulator is concerned. Possibly a controlled auxiliary circuit in parallel across the screen grid circuit as a bleeder circuit could be used and thus not require the condenser, but said condenser simplifies matters and at the same time maintains a balanced load on the modulator, because it will not allow the modulator to supply power to the screen grid circuit without supplying an equal amount of power to the auxiliary circuit. It is also possible to a limited extent to utilize a fixed resistor to act as a balance against the screen grid circuit when a power supply is used in series with the resistor. The resistor and power supply circuit is connected so in effect it is across the condenser with the polarity of the power supply being such as to increase the discharging voltage of the condenser and to oppose the charging voltage, thus causing a condition which can be utilized with the screen grid circuit under certain conditions of operation to balance same.

By way of explanation it might be stated that because of the increasing resistance of the screen grid circuit when modulated from the positive to the negative peaks the power dissipated from the modulator will ordinarily be correspondingly reduced, so that the effective potential will become increasingly greater and thus aid to cause the rate of reduction of the quantity of the current flowing through the screen grid circuit to be too rapid. The screen grid circuit requires comparatively less reduction in the quantity of the current flowing through same to cause a linear drop in the plate current of the radio frequency amplifier as the voltage applied to the screen grid becomes less in relation to the plate voltage and thus requires a current variation having an increasing non-linear characteristic as the voltage applied to the screen grid is increased in relation to the plate voltage.

In this connection, for a better understanding of the problems of screen grid modulation, it might be stated that to obtain a carrier wave efficiency equal to that of plate modulation the screen grid voltage must be as high in proportion to the plate voltage of the radio frequency amplifier as the ratio used with plate modulation. Under these conditions the modulated positive peaks with screen modulation will be more efficient than the said peaks with plate modulation. Therefore, to obtain an average efficiency while under modulation equal to that of plate modulation the unmodulated screen grid voltage can be lower than that used with plate modulation.

This method of screen modulation allows a higher ratio of screen voltage to plate voltage than existing methods in use and at the same time reduces distortion.

Also by variations in resistance and voltage flexibility is attained, allowing operation at many different ratios of screen to plate voltage.

Figure 1 shows a modulator, radio frequency amplifier having a screen grid with both coupled together by means of a series condenser and an auxiliary power supply with a resistor in series forming a circuit connected in parallel with the screen grid circuit and the condenser when considered through the modulator circuit.

Figure 2 has the same arrangement except the resistance of the auxiliary circuit is not constant during modulation but is controlled by a means which functions due to changes in the quantity of the current flowing to the screen grid circuit.

Figure 3 has characteristics similar to Figure 1 with the addition of another auxiliary circuit connected directly across the series coupling con-

denser and consisting of a resistant circuit whose resistance is controlled by the current flowing to the screen grid circuit in combination with the current from the first auxiliary circuit. The modulator coupling is different but the relation of the condenser is similar.

Figure 4 shows an arrangement with an auxiliary circuit having the same relation to the condenser as that of Figure 2 the difference being in the modulator coupling which also includes the plate circuit of the radio frequency amplifier without the series condenser, same being in series only with the screen grid circuit.

Referring to Figure 1 in detail, modulator tube 1 is shown provided with a plate audio frequency choke 2, having its plate 3 coupled to the radio frequency amplifier 4 through an audio frequency condenser 5 connected to the screen grid 6 of said amplifier. A radio frequency by-pass condenser connects screen grid 6 to ground. A radio frequency choke in series with screen grid 6 can also be used if desired. A rectifier 7, having two plates 8 and 9 is connected to the screen grid 6 of amplifier 4, by its cathode 10. A resistor 11 is connected to plate 8 of the rectifier 7, having a practically constant positive voltage applied to the resistor at 12.

The unmodulated screen voltage, of screen 6, is determined by voltage 12 and the resistance of resistor 11.

The plate 9, of the rectifier 7, is connected to a milliammeter 13 in series with battery 14, thence to ground. The battery 14 is the amount of negative voltage required to cause the plate current, of the radio frequency amplifier 4, to drop to zero when its screen grid 6 is disconnected from 5 and 10 and connected to the negative side of battery 14 only. Full radio frequency excitation at 15 is left on while this is being done.

The purpose, of meter 13, battery 14 and plate 9 is an overmodulation indicator of the negative audio peaks and same has no part in the operation otherwise.

The operation and adjustment of the device may be explained as follows: With the proper voltages applied to the amplifier 4 and modulator 1, at 16 and 17 respectively, radio frequency excitation is applied to amplifier 4 at 15 and modulator 1 is connected to a suitable speech amplifier at 18. With a positive voltage connected to resistor 11 at 12, which should be maintained at approximately the modulation peak voltage or about twice the unmodulated voltage supplied for the screen grid 6, the modulator 1 is put in operation and the speech gain is adjusted till the plate current just shows overmodulation by a suitable plate meter connected between 16 and the plate of the radio frequency amplifier 4. Resistor 11 is then adjusted so the negative audio peaks indicated by meter 13 correspond to the positive audio peaks as indicated by the plate meter near 16. Readjustment of the speech gain may be necessary while doing this. If after making the required adjustments, with the voltage 12 being maintained near the modulation peak screen voltage, it is found the unmodulated screen voltage 6 is lower than desired it will be necessary to make readjustments with the voltage 12 being maintained below the modulation screen peaks, or the voltage dropping resistor 19 may serve as an aid in maintaining an unmodulated screen voltage which on opening the screen grid circuit is found to be lower than the modulation peak screen voltages. The unmodulated screen grid voltage will then be higher because of rectifier 7, which allows a reduction in the voltage 12 below the modulation peak voltage without same leaking back to ground and thus allowing resistor 11 to be reduced sufficiently to increase the unmodulated voltage with comparatively less resistance 11 in the circuit as well as to increase the discharging rate of condenser 5, which will cause an increased dissipation of the negative potential from said condenser and thus reduce the rate of the current reduction in the screen grid circuit and allow a higher unmodulated screen grid voltage 6, because of the increased non-linear characteristics of the modulated current in the screen grid circuit. If the voltage applied to plate 8 while on open circuit is less than the positive audio peaks which are about twice the unmodulated screen grid voltage, distortion will be greater. The open circuit voltage at 8 can be about half ways between the unmodulated screen voltage at 6 and the positive audio peaks without serious distortion. But to obtain the least distortion the current should start to flow a little just below the positive audio peaks. Therefore, to accomplish this the open circuit voltage at 8 should be equal to the voltage of the positive audio screen grid peaks. This can be accomplished with the circuit shown in Figure 1, only when the screen grid voltage 6 is comparatively low in relation to the plate voltage 16. Plate voltage 16 can be increased, to allow a higher screen voltage at 6 to obtain the full output of amplifier 4, but the efficiency of same will be reduced, due to the high plate voltage 16 required. Also operation in this manner does not require rectifier 7, except for the operation of meter 13.

Since the resistor 11 works well when the screen voltage 6 is comparatively low it follows, that by using a variable resistance controlled by the rapidly changing screen current 6 at higher screen voltages, a suitable combination would be obtained.

Figure 2 shows such a combination with vacuum tube 20 having a plate 21 connected in series with resistor 11. Cathode 22 is connected directly to audio condenser 5. Resistor 23 carries all the current supplied by both vacuum tube 20 and condenser 5 and needed by the screen grid 6. Therefore, since grid 24 is across resistor 23 the screen current 6 controls the resistance of tube 20. Since cathode 22 is connected directly to condenser 5, current can flow between same without affecting the resistance of tube 20. Then, at the negative audio peaks, the current will be the greatest through resistor 11 and tube 20, but condenser 5 will absorb all the current and the screen current 6 will be zero. As the negative audio peaks are reduced by modulator tube 1 the screen current 6 will increase comparatively slow at first because the current will reduce through resistor 11 and tube 20, as the screen voltage 6 raises which will prevent as rapid a raise in screen current 6, as will occur later when the quantity of the said current through resistor 11 and tube 20 is reduced. As this reduction in current takes place from the negative audio peaks to or near the positive audio peaks and since its quantity is very small at the positive peaks it has very little effect in bucking or preventing the rapid rise in current required at this point.

The adjustments required with the circuit in Figure 2 are rather easy since the voltage at 12 is made equal to the screen positive audio peaks, with resistor 11 being used to adjust the unmodulated screen voltage 6, while resistor 23 is used

to adjust the negative audio screen peaks correctly in relation with the positive audio peaks and thus being a means to control the rate of reduction of the quantity of the current flowing through the screen grid circuit by changing the modulation downward impulse, so that the nonlinear characteristics will be suitable to the unmodulated screen grid voltage 6 that is desired. If the voltage available for 12 is too high the dropping resistor 19 can be used as mentioned before.

Figure 3 shows a different arrangement which gives the same results with better efficiency since current through resistor 11 is reduced and the efficiency is otherwise increased.

This circuit will work without resistor 11 but the efficiency is then reduced, since the voltage applied to the modulation transformer at 29 cannot be modulated near 100% because a positive voltage will be required to overcome the resistance of tube 25, to supply the current required to prevent condenser 5 from becoming too negative during the screen grid negative impulse. This is due to the fact that the resistance of tube 25, is not zero even though its grid 28 is at zero potential. By using resistor 11 connected directly to the screen grid 6, current will flow between resistor 11 and condenser 5 through bias resistor 23, same being maximum at the negative screen grid peaks, causing grid 28 to become positive, thus reducing the resistance of tube 25, which thus allows a smaller applied voltage at 26.

The operation with this circuit, as shown in Figure 3 is also somewhat different since the vacuum tube 25 is connected with its plate 27 on the other side of condenser 5, which thus allows a positive voltage to be applied to said plate 27. Since the resistance of tube 25 is controlled by the screen grid current 6 it follows its resistance will be greatest at the positive screen grid peaks thus causing condenser 5 to supply all or most all the current. But as the resistance of tube 25 is reduced, as the screen grid current drops, part of the positive charge on condenser 5 will flow through said tube 25 reducing the negative charge correspondingly on the opposite side of said condenser 5 which thus prevents condenser 5 from causing screen grid 6 to go negative too rapidly.

Then by applying practically a constant positive voltage 12 to resistor 11, equal to the screen grid positive peak voltage and by using both resistors 11 and 23 to adjust the screen grid negative peaks and the unmodulated screen grid voltage 6, the desired results can be obtained as already explained.

The resistor 11 can be connected directly to cathode 22 or to resistor 23 at various points between the cathode 22 and grid 28 for controlling the modulated wave form somewhat if desired. Also another tube may be added to assist tube 25 where high ratios of screen grid to plate voltages are used, which may best be accomplished by combining the circuit shown in Figure 2 with that of Figure 3 and by using separate bias resistors for each tube or a common blending of the bias resistors in the circuit to the screen grid 6.

The modulation transformer 29 can be used with the circuits shown in Figure 1 or 2, or the audio frequency choke 2 may be used instead of the modulation transformer of Figure 3 if desired.

The methods of screen grid modulation described can be combined with plate modulation, the same being an advantage where a high ratio of screen grid to plate voltage is used, thus reducing the high screen grid current at the positive peaks which would occur with screen modulation under these conditions.

Figure 4 shows a circuit combining that shown in Figure 2 with plate modulation.

The class B modulation transformer 29 is shown connected, as if for plate modulation to the radio frequency choke 30 and through same to the tank circuit of the radio frequency amplifier. Audio frequency condenser 5 is connected to the modulation transformer at 31, and otherwise the circuit is the same as that shown in Figure 2.

With this circuit the percentage of plate modulation can be lowered either by reducing the unmodulated screen grid voltage 6, or by connecting the plate meter MA to a lower tap on the modulation transformer 29.

The operation and adjustment of screen grid modulation, combined with a percentage of plate modulation, are different because the plate voltage is higher on the positive peaks and lower on the negative peaks than with screen modulation only.

Having described my invention what I claim as new is:

1. In a modulation system, a screen grid radio frequency amplifier having an anode circuit and a screen grid circuit, an amplified source of carrier wave energy to be modulated coupled to said anode circuit for making said amplification with the aid of said amplifier, means for applying modulation voltages to vary the current flow in said anode circuit and in said screen grid circuit whereby the current flow in each of said circuits is reduced during a portion of the modulation cycle, means for reducing the rate of reduction in the screen grid current relative to the rate at which the anode current is reduced within the limits of said portion of the modulation cycle, said last means including an election discharge tube connected in said screen grid circuit for dissipating excessive screen grid modulation voltages during a large extent of said portion of the modulation cycle.

2. In a modulation system, a screen grid radio frequency amplifier having an anode circuit and a screen grid circuit, an amplified source of carrier wave energy to be modulated coupled to said anode circuit for making said amplification with the aid of said amplifier, means for applying modulation voltages to vary the current flow in said anode circuit and in said screen grid circuit whereby the current flow in each of said circuits is reduced during a portion of the modulation cycle, means for reducing the rate of reduction in the screen grid current relative to the rate at which the anode current is reduced within the limits of said portion of the modulation cycle, said last means including an electron discharge tube connected in said screen grid circuit for dissipating excessive screen grid modulation voltages during said portion of the modulation cycle.

3. In a modulation system, a screen grid radio frequency amplifier having an anode circuit and a screen grid circuit, an amplified source of carrier wave energy to be modulated coupled to said anode circuit for making said amplification with the aid of said amplifier, means for applying modulation voltages to vary the current flow in said anode circuit and in said screen grid circuit whereby the current flow in each of said circuits is reduced during a portion of the modulation cycle, means for reducing the ratio of screen grid current to anode current at a decreasing rate relative to the rate at which the anode current is reduced within the limits of

said portion of the modulation cycle, said last means including an electron discharge tube connected in said screen grid circuit for dissipating excessive voltages in the screen grid circuit for reducing said anode current at a more nearly rectilinear rate than the rate at which said screen grid current is reduced when the modulation voltages applied to said means are varied at a more nearly rectilinear rate than the rate at which said screen grid current is reduced.

4. In a modulation system, a screen grid radio frequency amplifier having an anode circuit and a screen grid circuit, means for applying modulation voltages to vary the current flow in said anode circuit and in said screen grid circuit whereby the current flow in each of said circuits is reduced during a portion of the modulation cycle, means for reducing the rate of reduction in the screen grid current relative to the rate at which the anode current is reduced within the limits of said portion of the modulation cycle, said last means including connections in the screen grid circuit to a condenser for applying modulation voltages and to an electron discharge tube having a grid for varying in a non-rectilinear manner the current flow in said electron tube to discharge said condenser sufficiently to dissipate excessive screen grid modulation voltages for reducing said anode current at a more nearly rectilinear rate than the rate at which said screen grid current is reduced when the modulation voltages applied to said means are varied at a more nearly rectilinear rate than the rate at which said screen grid current is reduced.

5. In a modulation system, a screen grid radio frequency amplifier having an anode circuit and a screen grid circuit, an amplified source of carrier wave energy to be modulated coupled to said anode circuit for making said amplification with the aid of said amplifier, means for applying modulation voltages to vary the current flow in said anode circuit and in said screen grid circuit whereby the current flow in each of said circuits is reduced during a portion of the varying action between maximum and minimum current flow, means for reducing the rate of reduction in the screen grid current relative to the rate at which the anode current is reduced within the limits of said portion of the varying action between maximum and minimum current flow, said last means including an electron discharge tube having a grid for varying in a non-rectilinear manner the current flow in said electron discharge tube coupled to said screen grid circuit to dissipate excessive screen grid modulation voltages for reducing said anode current at a more nearly rectilinear rate than the rate at which said screen grid current is reduced when the modulation voltages applied to said means are varied at a more nearly rectilinear rate than the rate at which said screen grid current is reduced.

6. In a modulation system, a screen grid radio frequency amplifier having an anode circuit and a screen grid circuit, an amplified source of carrier wave energy to be modulated coupled to said amplifier, means for applying modulation voltages to vary the current flow in said anode circuit and in said screen grid circuit whereby the current flow in each of said circuits is reduced during a portion of the varying action between maximum and minimum current flow, means for reducing the rate of reduction in the screen grid current relative to the rate at which the anode current is reduced within the limits of said portion of the varying action between maximum and minimum current flow, said last means including connections in the screen grid circuit to a condenser for applying modulation voltages and to an electron discharge tube having a grid for varying in a non-rectilinear manner the current flow in said electron tube to discharge said condenser sufficiently to dissipate excessive screen grid modulation voltages for reducing said anode current at a more nearly rectilinear rate than the rate at which said screen grid current is reduced when the modulation voltages applied to said means are varied at a more nearly rectilinear rate than the rate at which said screen grid current is reduced.

7. In a modulation system, a screen grid radio frequency amplifier having an anode circuit and a screen grid circuit, an amplified source of modulated carrier wave energy to be produced by said amplifier, means for applying modulation voltages to vary the current flow in said anode circuit and in said screen grid circuit whereby the anode and the screen grid are utilized to cause a reduction in the current flow in each of the respective circuits during a portion of the varying action between maximum and minimum current flow, means for reducing the rate of reduction in the screen grid current relative to the rate at which the anode current is reduced within the limits of said portion of the varying action between maximum and minimum current flow, said last means including connections in the screen grid circuit to a condenser for applying modulation voltages and to series circuit having resistance and conducting electrical energy from said condenser and another supply for discharging said condenser sufficiently to dissipate excessive screen grid modulation voltages for reducing said anode current at a more nearly rectilinear rate than the rate at which said screen grid current is reduced when the modulation voltages applied to said means are varied at a more nearly rectilinear rate than the rate at which said screen grid current is reduced.

8. In a modulation system, a radio frequency amplifier having an anode circuit and a grid circuit, an amplified source of modulated carrier wave energy to be produced by said amplifier, means for applying modulation voltages to vary the current flow in said anode circuit and in said grid circuit whereby the anode and the grid are utilized to cause a reduction in the current flow in each of the respective circuits during a portion of the varying action between maximum and minimum current flow, means for reducing the rate of reduction in the grid current relative to the rate at which the anode current is reduced within the limits of said portion of the varying action between maximum and minimum current flow, said last means including an electron discharge tube having a grid for varying in a non-rectilinear manner the current flow in said electron discharge tube coupled to said grid circuit to dissipate excessive grid modulation voltages for reducing said anode current at a more nearly rectilinear rate than the rate at which said grid current is reduced when the modulation voltages applied to said means are varied at a more nearly rectilinear rate than the rate at which said grid current is reduced.

9. In a modulation system, a screen grid radio frequency amplifier having an anode circuit and

a screen grid circuit, an amplified source of modulated carrier wave energy to be produced by said amplifier, means for applying modulation voltages to said anode circuit and to said screen grid circuit whereby the anode and the screen grid are utilized to cause a reduction in the current flow in each individual circuit during a portion of the modulation cycle, means for reducing the rate of reduction in the screen grid current relative to the rate at which the anode current is reduced within the limits of said portion of the modulation cycle, said last means including an electron discharge tube connected in said screen grid circuit for dissipating excessive screen grid modulation voltages for reducing said anode current at a more nearly rectilinear rate than the rate at which said screen grid current is reduced when the modulation voltages applied to said means are varied at a more nearly rectilinear rate than the rate at which said screen grid current is reduced.

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