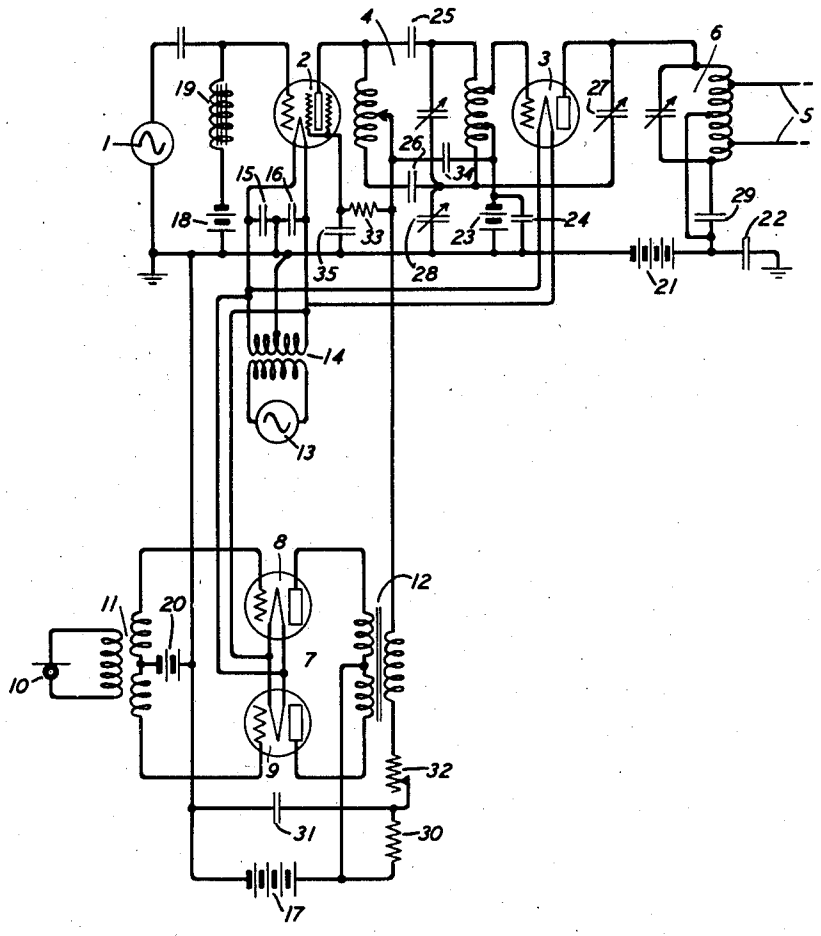
May 21, 1935. J. G. NORDAHL 2,002,209

MODULATING SYSTEM

Filed April 4, 1933



INVENTOR
J. G. NORDAHL
BY G. H. Stevenson
ATTORNEY

Patented May 21, 1935 2,002,209

UNITED STATES PATENT OFFICE

2,002,209

MODULATING SYSTEM

John G. Nordahl, Orange, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application April 4, 1933, Serial No. 664,292

10 Claims. (Cl. 179—171)

This invention relates to modulating systems particularly to modulating circuits for radio telephone transmitters.

An object of the invention is to simplify the control of the power output of a radio telephone transmitter.

In a specific preferred embodiment of this invention in a radio telephone transmitter, the voice or signal wave is amplified and supplied to the plate circuit of a radio frequency amplifier or oscillator tube to modulate the radio frequency wave in the plate circuit of the tube, both the radio frequency and audio frequency tubes being supplied with space current from the same direct current source. In order to control the power output of the transmitter without varying the degree or percentage of modulation, a variable impedance element is included in the common direct current and audio frequency circuit of the modulator tube. This permits the simultaneous control of the direct current and audio frequency voltages supplied to the modulator and consequently the simultaneous control of the radio and audio frequency currents. With a proper design of the circuit elements, it is possible by adjusting the variable impedance to so vary the audio frequency voltage supplied to the radio frequency tube in proportion to the variation in the direct current plate voltage as to permit the transmitter to be adjusted for different power outputs while maintaining the same percentage modulation.

The invention can be more readily understood by reference to the following detailed description in connection with the drawing which shows diagrammatically one embodiment of the inventtion in a radio telephone transmitter.

A source of radio frequency wave 1, such as a crystal controlled oscillator and buffer amplifier of the usual type, supplies radio frequency waves to the grid circuit of a tube 2 of the screen grid type which is operated as a modulating amplifier. The modulated radio frequency output of the tube 2 is applied to the grid circuit of a power amplifier tube 3 through a tuned circuit 4 and the resultant amplified energy is supplied to the transmission line 5 connected to an antenna (not shown) through a tuned output circuit 6.

Modulation is accomplished in the modulating amplifier tube 2 by superimposing the amplified audio frequency energy on the direct current voltages supplied to the plate and screen grid electrodes thereof. The modulating audio frequency voltage is obtained from the audio frequency amplifier 7. This amplifier comprises two tubes 8 and 9 connected in push-pull relation and having a grid circuit supplied with the audio frequency wave from a microphone 10 through the input transformer 11. The plates of the tubes 8 and 9 are connected to the primary winding of the output transformer 12.

The cathodes of the tubes 2, 3, 8 and 9 are heated by means of alternating current supplied from the source 13 through the transformer 14. Two condensers 15 and 16 connected in series across the cathode circuit and having their midpoints connected to ground and to the midpoint of the secondary winding of transformer 14 provide direct and alternating current connections to the effective midpoint of the cathodes of the tubes. Space current for the audio frequency amplifier tubes 8 and 9 and the modulator tube 2 is supplied from the battery 17 through a circuit which will be described in detail later. Grid biasing potential for the modulator tube 2 is obtained from the battery 18 through the choke coil 19. Grid biasing potential for the audio frequency amplifier tubes 8 and 9 is obtained from the battery 20. Space current for the power amplifier tube 3 is obtained from the battery 21 through the connection to the midpoint of the inductance coil of the tuned circuit 6. A bypass condenser 22 provides an effective alternating current ground connection to the midpoint of the inductance of the tuned circuit 6 and bypasses the alternating current around the battery 21. Grid biasing potential for the power amplifier tube 3 is obtained from the battery 23 through the right-hand inductance coil of the tuned circuit 4, the condenser 24 providing alternating current bypass around the battery 23, and an effective alternating current ground connection to an intermediate point of the inductances of the tuned circuit 4. Blocking condensers 25 and 26 are provided in the tuned circuit 4 for isolating the plate of the tube 2 from the grid of the tube 3 for direct current voltages.

The power amplifier tube 3 is neutralized to prevent the generation of undesired oscillations by means of condenser 27 connected between the plate of the tube 3 and the lower terminal of the tuned coupling circuit 4. A condenser 28 is provided to balance the plate to cathode capacity of the tube 2 to keep the coupling circuit 4 balanced with respect to ground. In the output circuit of the power tube 3 a condenser 29 is provided to similarly balance the anode to cathode capacity of the tube 3 to keep the outgoing line 5 balanced with respect to ground.

The direct current space circuit of the audio

frequency amplifier tubes 8 and 9 is completed from the grounded cathode terminal through battery 17 and the two halves of the primary windings of the transformer 12 in parallel to the anode of the tubes 8 and 9, the alternating current plate path being completed from the mid terminal of the primary winding of transformer 12 through resistance 30 and the bypass condenser 31.

The direct current is furnished to the plate and screen grid circuits of the modulator tube 2 from the grounded cathode terminal through battery 17, resistance 30, variable resistance 32, left-hand induction of the tuned coupling circuit 4 to the plate of the tube and resistance 33 to the screen of the tube 2. Radio frequency in the plate circuit of the modulating tube 2 is bypassed through the condenser 34 and in the screen circuit through the condenser 35. The audio frequency voltage for modulating the carrier wave in the modulating tube 2 is supplied from the secondary winding of the transformer 12, the audio frequency circuit being completed from the lower terminal of the secondary winding of the transformer 12, variable resistance 32 and bypass condenser 31 to the grounded cathode terminal. Thus modulation is attained by impressing the audio frequency voltage on both the plate and screen circuits of the modulating amplifier as disclosed and claimed in the copending application of W. L. Lawrence, Serial No. 584,099 filed December 31, 1931, Patent 1,923,543 of August 22, 1933.

It will be observed that the variable resistance 32 is included in both the direct current and audio frequency circuits of the modulator tube 2 so that an adjustment of the resistance 32 will vary the direct current and audio frequency components of the plate and screen voltages for the modulating amplifier tube simultaneously, thus permitting the power output of the transmitter to be varied while maintaining constant the percentage modulation.

Since the efficiency of the modulating amplifier 2 varies with the direct current plate voltage, the radio frequency voltage available in the plate circuit of the modulating amplifier tube will not be a linear function of the direct current voltage. As a result, it is necessary, in order to maintain the percentage modulation constant for varying power outputs, to vary the direct current and audio frequency components of the plate voltage at different rates. This is accomplished by the use of the resistance element 30 which is included in the direct current path of the plate circuit of the modulating amplifier tube 2 but not in the audio frequency path since it is shunted by the audio frequency bypassing condenser 31. An adjustment of the variable resistance element 32 will vary the audio frequency component of the voltage at a greater rate than the direct current component. Thus by a proper choice of values for the circuit elements, the ratio of the audio and radio frequency components of the plate and screen currents and consequently the percentage modulation can be maintained constant as the power output is varied.

The design of the system to maintain constant the percentage modulation is further facilitated by the fact that the audio frequency amplifier 7 can be designed to have an output which is inversely proportional to its load impedance. When so operated, an increase in the resistance of the variable resistance element 32 will decrease the audio frequency voltage applied to the modulating amplifier 2 not only by reason of its voltage dividing action but also because of the decrease in the output of the audio frequency amplifier resulting from the increase in the load impedance.

By taking advantage of either or both of these factors; namely, the effect of resistance element 30 and design of the audio frequency amplifier 7, great flexibility in design may be attained.

What is claimed is:

1. A modulating system comprising an electric discharge device, means for impressing a carrier wave upon said device, a transformer, means for impressing a signal wave upon the primary winding of said transformer, a source of direct current, a series circuit including said source of direct current and the secondary winding of said transformer connected between the anode and cathode of said device, and means included in said series circuit for simultaneously varying at different rates the direct current voltage from said source and the signal frequency voltage from said transformer impressed upon said device.

2. A modulating system comprising an electric discharge device, means for impressing a carrier wave upon said device, a series circuit connected between the anode and cathode of said device, said series circuit including a source of signal waves for modulating said carrier wave and a source of direct current for supplying space current to said device, and means including a variable resistance element for simultaneously varying at different rates the signal current voltage and the direct current voltage impressed upon said device.

3. A modulating system comprising an electric discharge device, means for impressing a carrier wave upon said device, a series circuit connected between the anode and cathode of said device, said series circuit including a source of direct current for furnishing space current to said device and a source of signal waves for modulating the carrier wave, and means including a variable resistance element common to the direct current and signal frequency path for simultaneously varying at different rates the direct current and signal frequency voltages impressed upon said device.

4. In a modulating system, an electric discharge device having a cathode, an anode, an input electrode and a shielding electrode located between said input electrode and said anode, a source of direct current for supplying space current and shielding electrode biasing potential to said device, means for supplying carrier waves to the input electrode of said device, a source of signal frequency voltage for modulating said carrier waves, a circuit including said source of direct current and said source of signal frequency voltage for supplying direct current and signal frequency voltages between the cathode and anode and between the cathode and shielding electrode of said device, and a variable impedance element connected in said circuit to simultaneously vary the direct current and signal frequency components of the voltages supplied between said cathode and anode and between said cathode and shielding electrode.

5. A modulating system comprising an electric discharge device having a cathode, an anode and an input circuit, means for impressing carrier waves on said input circuit, a circuit including a source of direct current and a source of signal frequency waves for impressing a voltage having a direct current component and a signal frequency component between said cathode and anode to modulate the carrier waves, and means for simultaneously varying the direct and signal

current components of said voltage in such proportions as to vary the power output of said device while maintaining substantially constant the percentage modulation of the resultant wave.

6. A modulating system comprising an electric discharge device having a cathode, an anode, a control electrode and a shielding electrode located between the control electrode and anode, means for supplying carrier waves between said cathode and control electrode, a source of direct current, a source of signal frequency waves for modulating said carrier waves, a circuit including said source of direct current and said source of signal frequency waves and having terminals connected to said anode, shielding electrode and cathode, respectively, for supplying between the cathode and anode and between the cathode and shielding electrode voltages each having a direct current component and a signal frequency component, and means including a variable impedance element connected in said circuit for simultaneously varying said direct current and signal frequency components in such proportions as to maintain substantially constant the percentage modulation while varying the power output of said electric discharge device.

7. A radio telephone transmitter comprising a source of audio waves, an electric discharge device for amplifying audio waves from said source, a second electric discharge device having an anode, a cathode and control electrode, means for impressing carrier waves between the cathode and control electrode of said second device, a source of direct current, connections from said source of direct current to the first electric discharge device for supplying space current thereto, other connections from said source of direct current to the cathode and anode of said second electric discharge device for supplying space current thereto and including means for impressing between the anode and cathode the amplified audio frequency output of said first electric discharge device, and means included in said other connections for simultaneously varying the audio frequency and direct current voltages impressed upon said second electric discharge device in such proportion as to maintain substantially the percentage modulation while varying the power output of said second electric discharge device.

8. A radio telephone transmitter comprising a source of audio waves, an electric discharge device connected to said source for amplifying the audio frequency waves, a second electric discharge device having a cathode, an anode, a control electrode and a shielding electrode mounted between said control electrode and said anode, means for supplying carrier waves between the cathode and control electrode of said second electric discharge device, a source of direct current, connections from said source of direct current to the first electric discharge device for supplying space current thereto, other connections from said source of direct current to said second discharge device for supplying direct current voltages between the cathode and anode and between the cathode and shielding electrode thereof, said other connections including means for impressing between the cathode and anode and between the cathode and shielding electrode of said second electric discharge device, the amplified audio frequency output of the first discharge device, and having a circuit portion common to both the direct current and audio frequency components of the voltages supplied between the anode and cathode and between the shielding electrode and cathode of said second electric discharge device, and a variable resistance element connected in said circuit portion for simultaneously varying the direct current and audio frequency components of said voltages in such proportions as to maintain substantially constant the percentage modulation while varying the power output of said second electric discharge device.

9. A modulating system comprising an electric discharge device having a cathode, an anode and a control electrode, a cathode-control electrode circuit therefor including a source of carrier waves, and a cathode-anode circuit therefor including a source of direct current, a source of signal frequency current, a path individual to the direct current, a second path individual to the signal frequency current, a variable resistance element common to the direct current and signal frequency paths, and an impedance element in the path individual to the direct current and having such a value of impedance that the ratio of the resistance value of said variable resistance element to the total signal frequency impedance of said anode-cathode circuit is greater than the ratio of said resistance value to the total direct current impedance of said circuit so that the power output of said electric discharge device may be varied while maintaining substantially constant the percentage modulation.

10. A modulating system comprising an electric discharge device, means for impressing a carrier wave upon said device, a series circuit connected between the anode and cathode of said device, said series circuit including a source of signal waves for modulating said carrier wave and a source of direct current for supplying space current to said device, and means for simultaneously varying at different rates the signal current voltage and the direct current voltage impressed upon said device, said signal current voltage being varied at a greater rate than said direct current voltage.

JOHN G. NORDAHL.