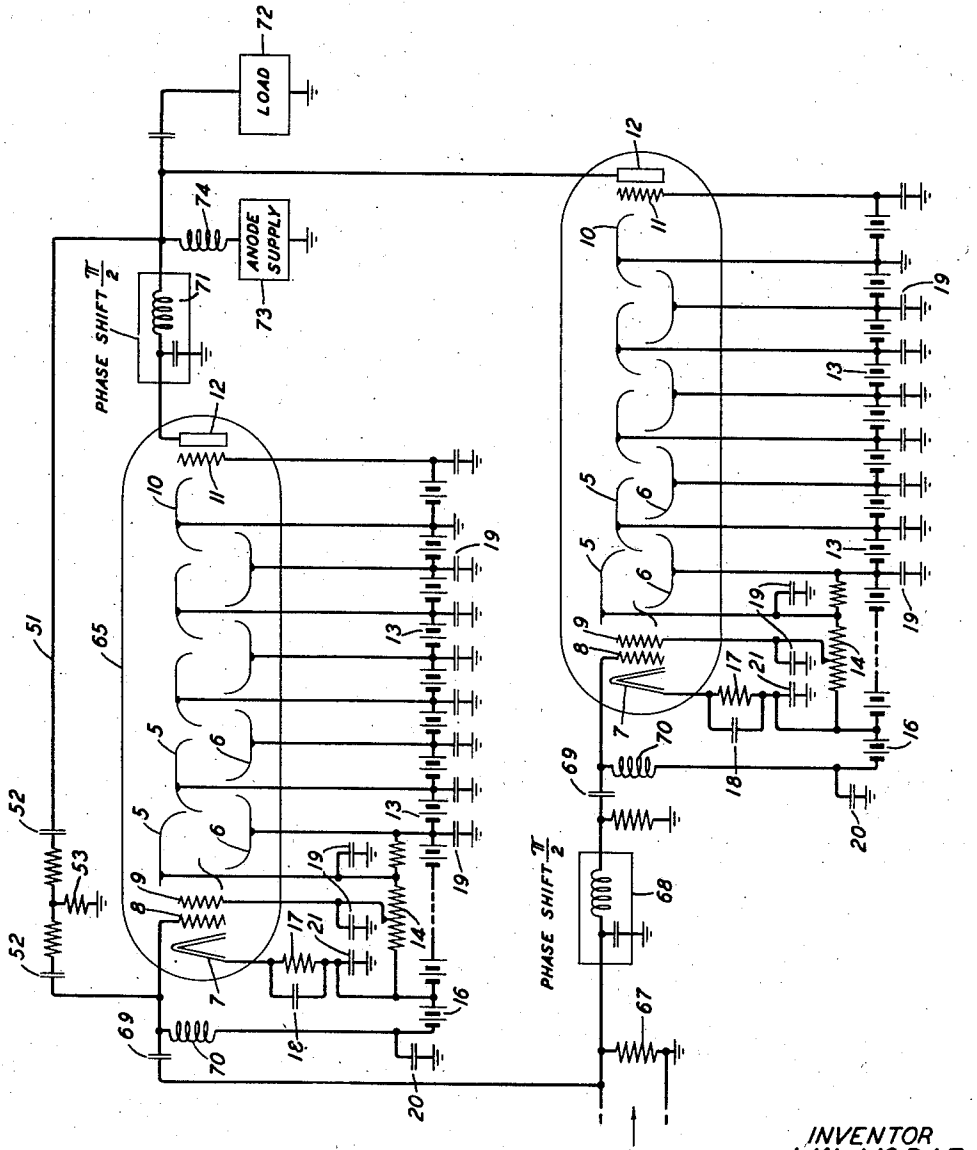
Aug. 22, 1944. J. W. McRAE 2,356,331

AMPLIFICATION WITH HIGH EFFICIENCY

Filed Oct. 10, 1941



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Patented Aug. 22, 1944 2,356,331

UNITED STATES PATENT OFFICE

2,356,331

AMPLIFICATION WITH HIGH EFFICIENCY

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Application October 10, 1941, Serial No. 414,439
In Canada July 17, 1941

5 Claims. (Cl. 179—171)

The present invention relates to power amplifier circuits for radio transmission or similar purposes, with special provision for reducing distortion and increasing efficiency of operation.

This is a continuation in part of my prior application Serial No. 352,722, filed August 15, 1940, now Patent No. 2,298,960, October 13, 1942.

A feature of the invention is the use of an electron multiplier type of amplifier as a power amplifier, with circuit provisions for reducing distortion and increasing efficiency.

Electron multipliers, as is known, permit of very large gains and have the advantage of not requiring electrodes of individual stages to be maintained at alternating current potentials. This makes them especially suited to high frequency amplification. Moreover, one of their characteristics is that the anode potential of the final or output stage has practically no effect on the anode current, at least in the normal operating range. This fact is favorable to the transmission through the multiplier of short pulses of current which retain their form under nearly complete control of the input circuit. The use of the short pulses permits high efficiency to be obtained in the output stage which couples to the load.

A feature of the invention is the association of two electron multipliers of the power amplifier type in a circuit in a manner to give high efficiency of signal power amplification.

The invention also comprises as features the use of over-all negative feedback at radio frequency and, therewith or separately, envelop frequency feedback around the initial stage to reduce noise and distortion.

These and the other features and the various objects of the invention will appear more fully from the following detailed description taken in connection with the accompanying drawing in which the single figure is a schematic circuit diagram of an amplifying system according to the invention.

In the drawing two electron multipliers 65 and 66, which may be identical in construction, are associated together to form a Doherty amplifier of the general configuration disclosed in United States Patent 2,210,028, August 6, 1940, but using electron multipliers in place of triodes.

The electron multiplier tube of itself forms no part of the present invention but may be of any suitable construction, the preferred embodiment being in accordance with the disclosure in my copending application Serial No. 371,124, filed December 21, 1940, now Patent 2,279,835, April 14, 1942. As illustrated herein each multiplier comprises a succession of suitably arranged and suitably treated emitting surfaces 5, 6, etc. with an input or starter section comprising cathode 7, control grid 8, accelerating grid 9 and first emitter plate 5, and with an output section or anode region comprising final emitter 10, positive grid 11 and anode 12. A suitable direct current supply source shown in the form of battery 13 applies steady positive voltage to the emitters, increasing in value from emitter to emitter throughout the tube. A voltage divider or potentiometer 14 may be used for applying potentials to certain of the electrodes. In the case of the later stages which draw more power from the supply it may be advantageous to use sections of the battery as indicated in the diagram. It would be obvious to employ other types of voltage supply in view of known practice. The emitter plates are by-passed to ground through large condensers 19.

The starter section includes an input circuit comprising the control grid 8, input coupling 69, 70, bias battery 16 and cathode resistor 17 which is shown shunted by capacity 18 (which may be omitted where not necessary) and cathode 7. This section includes an output circuit comprising first emitter plate 5, portion of resistor 14, cathode network 17, 18 and cathode 7. The battery 16 applies such a large negative potential to the grid that class B or class C operation is secured. That is, transmission through the starter section consists of pulses of half cycle or smaller duration.

In the case of a modulated high frequency input wave, the cathode network 17, 18 is preferably adjusted to vary the control grid bias at the envelope or signal frequency. Rectification in the plate circuit of the starter section causes a detected current of the signal frequency to flow through resistance 17, thus producing a varying grid bias which permits only the positive tips of the high frequency wave to be transmitted. For this use, condenser 18 acts as a radio frequency by-pass. At the same time, resistance 17 and condenser 18 provide negative feedback at the signal frequency. This negative feedback compensates for distortion in the starter section and the varying bias provides the short impulses that are favorable for securing highly efficient operation of the output or anode section as will be described later.

Grid 9 is biased to a positive potential to accelerate electrons toward the emitter 5. Condensers 20, 21 are blocking or by-pass condensers.

In the output or anode section the final emitter 10 is at direct current ground. Screen 11 is posi-

tive with respect to emitter 10, and anode 12 is maintained at average potential more positive than that of screen 11 by anode supply 73.

A negative feedback connection is made through lead 51, stopping condensers 52, and loss network 53, which may be adjustable, from anode 12 to control grid 8 for producing large negative feedback for reducing noise and distortion in the multiplier in accordance with the teachings of Black Patent 2,102,671, December 21, 1937.

The input waves, which may be signal modulated radio frequency waves or other type, are applied across the input coupling resistor 67. From this they are applied to the multiplier inputs in parallel, a quarter wave-length line 68 being inserted to the input to multiplier 66, in accordance with the Doherty disclosure. The input circuit is coupled in each case through a series capacity 69, the inductance 70 being a radio frequency choke.

The outputs of the multipliers 65 and 66 are connected to the output circuit or load 72 which may be a tuned circuit, such as an antenna, or may be of other type. Alternatively this load may be the input of a succeeding amplifier stage and may be untuned. The voltage for the final anode of each multiplier is obtained from suitable supply 73 such as a rectifier to which connection is made by way of radio frequency choke 74. The quarter wave-length line 71 is inserted between the output of multiplier 65 and the load in accordance with the teachings of the Doherty patent. The feedback connection 51 provides negative feedback around the two multipliers for increasing the linearity of the circuit.

The electron multipliers are especially suited to use in a Doherty circuit because of their high gain and ability to operate with short pulse excitation.

The high gain makes possible modulation at low power level and the short pulse operation results in high efficiency. Moreover, as pointed out above, the lack of tuned interstage circuits in the multiplier makes possible large gain with preservation of the wave form of the pulses and the negative feedback also increases the linearity of the amplifier.

What is claimed is:

1. In a high efficiency high gain amplifying system for amplitude-modulated oscillations, a first multistage electron multiplier, a second multistage electron multiplier, a source of modulated oscillations of varying amplitude, means causing each of said multipliers to transmit impulses of duration short compared with the fundamental period of said oscillations, under control of said source, a load circuit, means causing one of said multipliers to operate with an oscillating voltage of variable amplitude at its output terminals, and means including a quarter wave-length network cooperating with said one multiplier for causing the other of said multipliers to operate, during at least a portion of the modulation cycle, at a substantially constant oscillatory output voltage while supplying varying current oscillatory energy to said load.

2. In an amplifying system for high frequency amplitude-modulated waves, a pair of multistage electron multipliers having their inputs coupled to said source, means to bias their inputs to cause operation of their output stages with current interruption for a major fraction of the high frequency cycle, a load circuit common to said multipliers, means causing one of said multipliers to operate with a variable voltage across its output stage and means cooperating with said one multiplier for causing the output stage of the other multiplier to operate during at least a portion of the modulation cycle at a substantially constant output voltage while supplying varying current energy to said load.

3. A system according to claim 2 including an inverse high frequency feedback connection from an output point common to both multipliers, to the input of one of said multipliers.

4. In an amplifying system, a work circuit, a multistage electron multiplier having its output stage coupled to said work circuit and supplying thereto high frequency oscillations of constant amplitude during at least a portion of the cycle of operation, a second and similar electron multiplier having its output stage separately coupled to said work circuit and supplying thereto high frequency oscillations of signal-dependent amplitude, a quarter wave-length network included in the coupling between the output of one of said multipliers and said work circuit and means controlling the relative phases of the oscillations from said multipliers whereby they combine in phase in said work circuit.

5. In an amplifying system, a source of amplitude-modulated high frequency waves, a pair of multistage electron multipliers having their input stages coupled to said source, bias means preventing current flow in the input stages of said multipliers except for a fractional part of the positive half of the high frequency cycle, whereby the output stages of said multipliers conduct current only during corresponding portions of the high frequency cycle, a load circuit, circuits respectively coupling the output circuits of said multipliers to said load circuit, impedance inverting means included in one of said coupling circuits, and means controlling the relative amplitudes of the high frequency waves impressed on the input stages of said multipliers whereby the output voltage of one of said multipliers is maintained substantially constant in the presence of currents of varying amplitudes in the output stage of the other multiplier.

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