April 15, 1941. W. T. DITCHAM 2,238,255

MODULATED CARRIER WAVE TRANSMITTER

Filed Nov. 30, 1938

Fig. 1

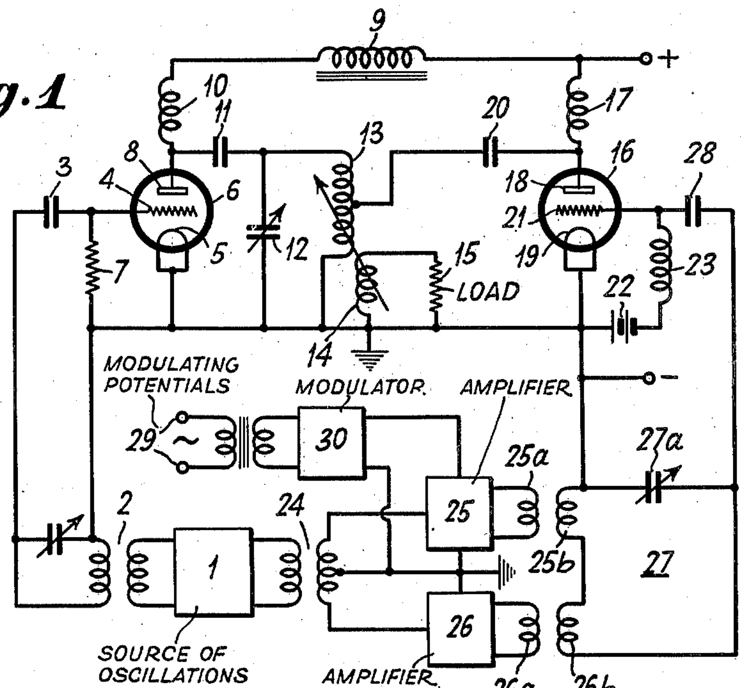
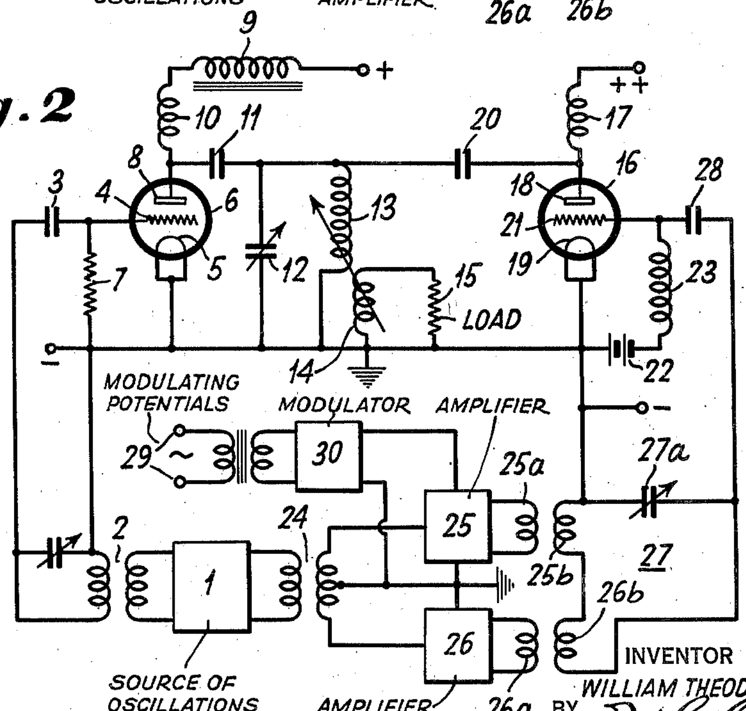


Fig. 2



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MODULATED CARRIER WAVE TRANSMITTER

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6 Claims. (Cl. 179—171.5)

This invention relates to radio and other modulated carrier wave transmitters and has for its object to provide improved modulated carrier wave transmitters wherein high efficiency of the high power amplifier tubes employed is obtained.

According to this invention a load circuit which is to be energised with modulated carrier wave energy is fed from the output circuits of two thermionic tube amplifiers one of which receives unmodulated carrier input and has anode potential applied thereto through a modulation frequency impedance of high value, the other of said amplifiers receiving side band energy of the carrier wave on its grid together with a fixed bias and a carrier frequency input of such amplitude and phase that zero or approximately zero anode current is obtained when the oscillations in the load circuit correspond to the unmodulated condition, said two amplifiers feeding into the common load circuit and being so arranged that the amplitude of the carrier frequency component on the output electrode of said one amplifier is about twice that on the output electrode of said other amplifier.

In a modification the amplitude of the radio frequency on the anodes of both amplifiers is the same but the direct-current voltage for one amplifier is twice the direct-current voltage on the anode of the other amplifier so that the division of power between the amplifiers in this modification and the prior modification is substantially the same.

The invention is illustrated in the accompanying drawing which shows diagrammaticlly two embodiments thereof.

Referring first to Figure 1, output from a source 1—a master oscillator—of carrier frequency oscillations is applied via a tuned transformer 2 and coupling condenser 3 between the grid 4 and cathode 5 of a triode or other high power thermionic tube 6 (hereinafter termed the first main tube) which is so adjusted as regards the negative bias upon its grid and the anode voltage applied thereto that it operates as an efficient so-called class C amplifier. A grid resistance 7 is connected between grid 4 and cathode 5. The anode 8 of tube 6 receives anode potential from any suitable D. C. source (not shown) through a high impedance audio frequency inductance 9 in series with a carrier frequency choke 10. The said anode 8 is coupled by means of a condenser 11 to one end of a carrier frequency parallel tuned oscillatory circuit 12, 13 whose other end is connected to the cathode 5 and earthed. The inductance element 13 in this tuned circuit is coupled in any convenient way as by a coil 14 to a load circuit, such as a transmitting aerial, but which is represented conventionally by a resistance 15.

A second thermionic tube 16 (hereinafter termed the second main tube), for example a triode, has its anode connected to the positive terminal of any convenient D. C. source e. g. as indicated the same source as that which supplies the first main amplifier tube 6, through a carrier frequency choke 17, and its output circuit is coupled to the load circuit in such manner that the voltage component of carrier frequency between anode 18 and cathode 19 of the second main tube 16 is about half that which exists between anode 8 and cathode 5 of the first main tube 6. For example, as shown the anode 18 may be capacity coupled by a condenser 20 to a point near the middle of the inductance 13 the cathode 19 being earthed and connected to the cathode 5.

The grid 21 of the second main amplifier 16 is negatively biassed to the point of anode current cut-off for the particular anode D. C. potential employed, this bias being applied from a source 22 in series with a carrier frequency choke 23. In addition there is applied between the grid 21 and cathode 19 a carrier frequency potential of such amplitude and phase that the anode current is zero or approximately zero for oscillations in the oscillatory circuit 12, 13 corresponding to the carrier or unmodulated condition. Oscillations of side band frequency are also applied between the grid 21 and cathode 19 of the second main amplifier 16. For example, as shown, carrier wave oscillations may be taken from the carrier wave source 1 through a transformer 24 with a mid-tapped secondary and applied to excite in phase opposition two thermionic tube amplifiers 25, 26 feeding into a carrier wave tuned circuit 27 included (in series with a coupling condenser 28) in the grid cathode circuit of the second main amplifier 16, the two outputs from the amplifiers 25 and 26 being combined in this tuned circuit 27 in opposition. Any means known per se are provided for modulating the amplitude of the oscillations in one of the amplifiers 25, 26 so that, in the condition of balance as respects the carrier frequency in these amplifiers, potentials of side band frequency only will reach the grid 21 of the second main amplifier 16. As shown modulating potentials are applied at 29 to a modulator 30 associated with the amplifier 25. In the circuit of Figure 1 the output circuits 25*a*, 26*a* of the two amplifiers **25**, **26** may be coupled each to one or another of two series coils **25b**, **26b** which are together shunted by a condenser **27a** to constitute the carrier frequency tuned circuit **27**, this tuned circuit being coupled at one end by the condenser **28** to the grid **21** and being connected to the common cathode point of the two main amplifiers (hitherto assumed, as is usual, to be earth) at the other end. The coupling of the two amplifiers **25**, **26** to the common tuned circuit **27** is slightly unbalanced to produce the requisite amplitude and phase of carrier frequency required on the grid **21** of the second main amplifier **16**.

Figure 2 shows a slight variation, which has been found in experimental practice to give somewhat better results, of the circuit of Figure 1. The essential difference between the arrangements of Figure 2 and Figure 1 is that, in Figure 2 the anodes **8**, **18** of the two main amplifiers are coupled to the same point on the tuned circuit **12**, **13**—as shown the live end thereof—and the anode **18** of the second main amplifier **16** is supplied from a source of potential (indicated by two positive signs) of about twice the value of that from which the anode **8** of the amplifier **6** is supplied.

In the unmodulated condition the tube **6** supplies carrier power to the load **15** at high efficiency, because it is biassed for class C operation and because the impedance of the circuits **12**, **13**, **14**, **15** is such that the peak potential across **12**, **13** is nearly equal to the supply D. C. potential. Note that the anode feed to **6** is supplied through the constant current choke coil **9**.

The tube **16** is biassed by **22** to such a value that the D. C. potential on its anode produces only a small anode current. Tube **16** is also driven by a carrier frequency potential of such amplitude and of such phase relative to the carrier frequency potential applied to its anode from the connection to **13** that the anode current is still practically negligible.

Note that this carrier frequency driving potential is obtained by unbalancing the modulation comprising amplifiers **25**, **26** and modulation potential source **30**.

During the so called upward swing of modulation, that is when the phase of the side-band frequency potentials applied to grid of tube **16** is such as to cause **16** to supply potentials to **12**, **13** in phase with those supplied by tube **6** the potential across **12**, **13** will increase. This increase in potential would tend to reduce the feed current in **6**, but owing to the presence of choke coil **9** this reduction is not possible at the normal audio frequencies (30 to 10,000 cycles per second) and consequently the supply potential on **6** rises eventually reaching twice the static value. When the tube **16** supplies power to tank circuit **12**, **13** of the same phase as the power supplied from tube **6** to the tank circuit **12**, **13** then to maintain a given voltage across the tank circuit less current need be supplied from tube **6**. In other words, from the point of view of tube **6**, the effect of tube **16** is exactly equivalent to an increase in the impedance in the tank circuit **12**, **13**. In the presence of a constant direct-current potential, such an increase in tank impedance would be accompanied by a decrease in direct current but since the reactor **9** maintains the direct-current constant, the direct-current potential on the anode **8** of tube **6** must increase.

During the so called downward swing of modulation, that is when the phase of the side-band frequency potentials applied to grid of tube **16** is such as to cause **16** to supply potentials to **12**, **13** in phase opposition to those supplied by tube **6**, or in another aspect to cause tube **16** to absorb power from **12**, **13**, the potential across **12**, **13** will be reduced. This reduction in potential would tend to increase the feed current in **6** but owing to the presence of choke coil **9** this increase is not possible and consequently the supply potential on **6** falls.

It should be obvious that if tube **16** is to be capable of supplying power to circuit **12**, **13** it must be connected at a point on this circuit of which the potential is considerably less than the D. C. supply potential, as is indicated in Figure 1, or alternatively must be supplied from a D. C. source of considerably higher voltage than the D. C. source for tube **6**, as indicated in Figure 2.

The desirability of applying carrier frequency bias to grid of **16** is to improve efficiency and linearity. If **16** was biassed to cut off merely for the D. C. supply potential, that is for linear class B amplification, then when subjected to the carrier frequency potential from **12**, **13** a considerable current would flow causing loss of power. If on the other hand the static bias on grid of **16** was made high enough to prevent appreciable anode current flow under these conditions, then **16** would not give linear amplification of the side-band energy.

What is claimed is:

1. A modulating system comprising, in combination a source of voltages of carrier wave frequency, a class C amplifier fed from said source, means for preventing variation at modulation frequency of direct current fed to said amplifier, a load circuit for said amplifier, a source of modulating potentials, means for deriving from said sources side band energy corresponding to the modulating potentials, a second amplifier having its input excited by said side band energy and its output coupled to the load circuit of said first amplifier, said latter coupling being so adjusted that at maximum delivery of power to said load the ratio of alternating plate voltage to direct current plate voltage is substantially the same in both of said amplifiers.

2. In a modulation system, a tuned reactance, a source of wave energy of a frequency to which said tuned reactance is of high impedance, a source of modulating potentials, an electron discharge tube having input electrodes connected to said source of wave energy and having an output electrode connected to said tuned reactance, means for biasing said tube for class C operation, means for supplying substantially constant direct current to said output electrode, an electron discharge device having input electrodes and having output electrodes coupled to a portion of said tuned reactance, means connected with said source of wave energy and with said source of modulating potentials for producing a carrier frequency voltage and side band voltages, means for impressing said carrier and side band voltages on said input electrodes of said device, the phase of the carrier voltage so impressed being opposite to the phase of the voltage of the output electrode of said tube whereby said side bands produce alternating currents in said reactance which oppose the alternating currents impressed on said reactance by said tube on modulation swings in one direction and aid said alternating currents on the modulation swings in the other direction.

3. In a modulation system, a load impedance, a source of wave energy to be modulated in ac-

cordance with signals, a first tube having input electrodes coupled to said source of wave energy and having output electrodes coupled to said load impedance and connected to a source of substantially constant direct current, a discharge device having output electrodes connected to said load impedance and having input electrodes, a source of signal potential, modulating means connected with said source of signal potentials and said source of wave energy for producing a carrier and side band energy, means for impressing said carrier and side band energy on the input electrodes of said device, the phase of said carrier impressed on the input electrodes of said device being substantially the same as the phase of the carrier supplied to said tube, and means for biasing said device by a potential such that in the presence of carrier energy only on said input electrodes of said device the anode alternating current supplied to said load impedance by said device is substantially zero.

4. In a modulation system, a load impedance, a source of wave energy to be modulated in accordance with signals, a first tube having input electrodes coupled to said source of wave energy and having an output electrode coupled to said load impedance and connected to a source of substantially constant direct current, a discharge device having output electrodes connected to said load impedance and having input electrodes, a source of signal potentials and means connecting said source of signal potentials to said source of wave energy for producing a carrier and side band energy in a desired ratio, means for impressing said carrier and side band energy on the input electrodes of said device the phase of said carrier impressed on the input electrodes of said device being substantially opposed to the phase of the alternating voltage on the output electrode of the tube, and means for biasing said device by a potential such that in the absence of side band energy on the input electrodes of said device the anode alternating current supplied to said impedance by said device is substantially zero.

5. In a modulation system, a source of wave energy to be modulated, a source of signalling potentials for modulating said wave energy, a first tube having a control grid and cathode coupled to said source of wave energy and having an anode, a source of substantially constant direct current connected to the anode of said tube, a discharge device having a control grid, a cathode, and an anode, a circuit connecting the anode and cathode of said device to a source of direct current potential, a modulator connected to said source of carrier wave energy and to said source of modulating potentials, means for deriving side band energy and carrier energy from said modulator and impressing the same on said control grid and cathode of said discharge device, means for biasing the control grid of said discharge device to a potential such that in the absence of side band excitation negligible alternating current flows in said device, and a load reactance coupled to the anode and cathode of said tube and to the anode and cathode of said device, the voltage ratios of said couplings being different.

6. A modulating system comprising, in combination a source of voltage of carrier wave frequency, a class C amplifier fed from said source, means for supplying direct current to said amplifier, means for substantially preventing variation at modulation frequency of direct current supplied to said amplifier, a load circuit for said amplifier, a source of modulating potentials, separate means for deriving from said source of voltage and source of modulating potentials side band energy corresponding to the said modulating potentials, a second amplifier having its input excited by said side band energy and its output coupled to the load circuit of said first amplifier, means for supplying direct current to said second amplifier, said latter coupling being so adjusted that at maximum delivery of power to said load the ratio of alternating plate voltage to direct current plate voltage is substantially the same in both of said amplifiers.

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