May 24, 1938. W. T. DITCHAM 2,118,172

MODULATED CARRIER WAVE TRANSMITTER

Filed April 15, 1936 2 Sheets-Sheet 1

Fig. 1

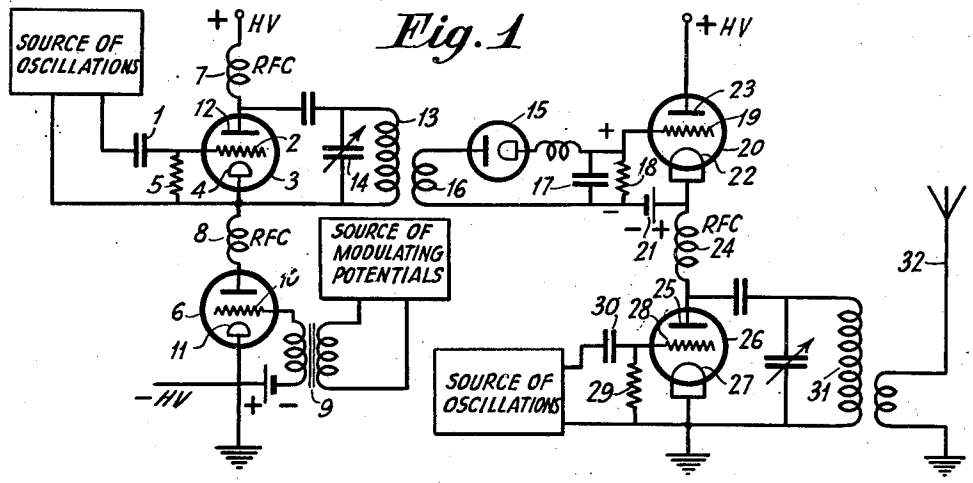
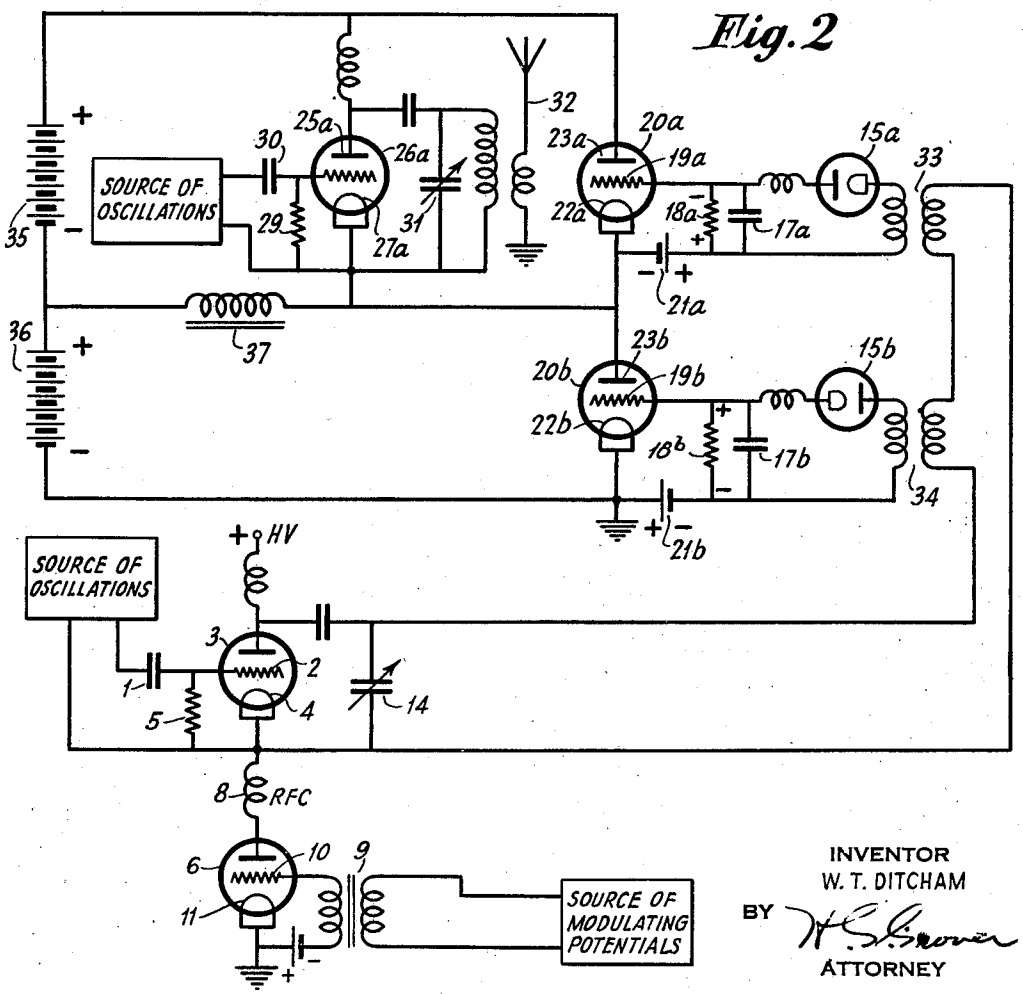


Fig. 2



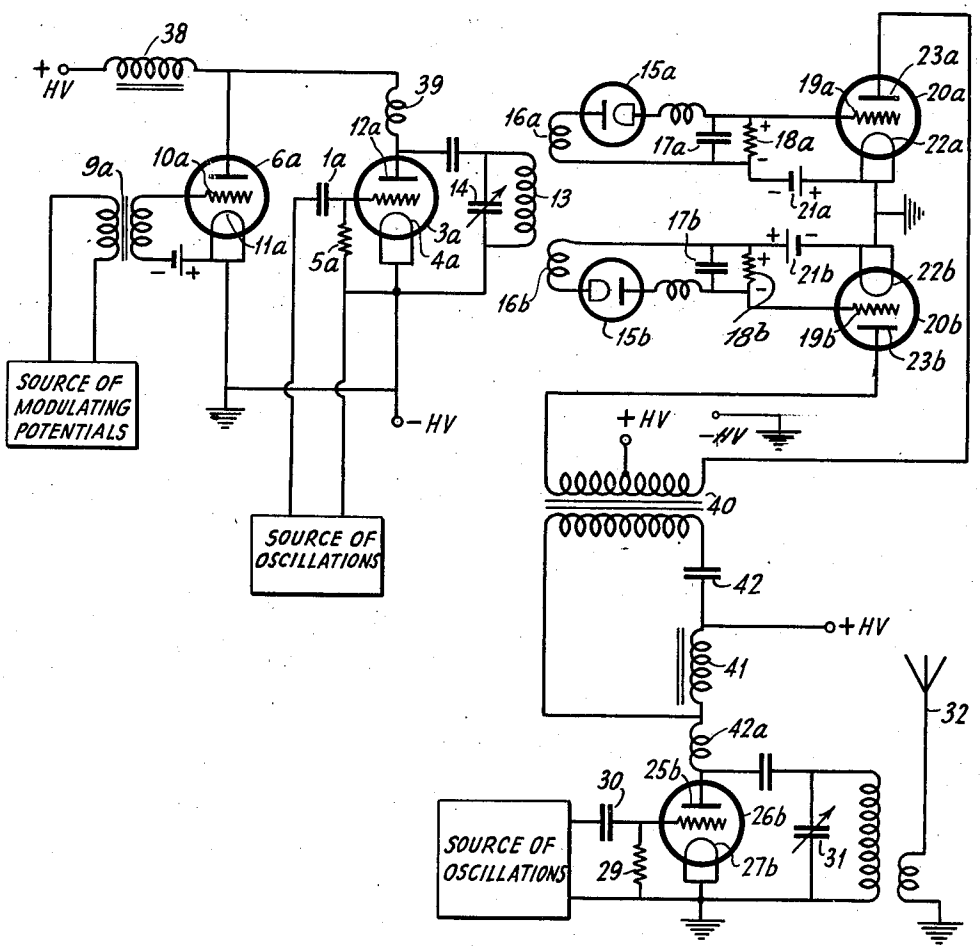
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Fig. 3



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2,118,172

MODULATED CARRIER WAVE TRANSMITTER

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Application April 15, 1936, Serial No. 74,401
In Great Britain April 10, 1935

5 Claims. (Cl. 179—171)

This invention relates to modulated carrier wave transmitters suitable for transmitting speech, music, television signals, and other forms of intelligence.

It is common practice at the present time to effect modulation of carrier waves to be transmitted at a fairly high power carrier frequency amplifying stage of the transmitter, the modulating potentials being amplified by audio or similar modulating frequency amplifiers until of sufficient strength to enable modulation at the high power stage to be effected.

According to this invention modulating potentials are applied to modulate a carrier wave at a relatively low power stage (which may be an oscillator or a carrier frequency amplifier stage) and the resultant modulated carrier energy is rectified to derive uni-directional potentials which are then utilized to effect modulation at a high power carrier stage of the transmitter. The rectifying means for transforming the low power modulated carrier wave energy into uni-directional potentials may be of various different forms, for example they may comprise thermionic diodes and associated filter or smoothing circuits, and the low power carrier which is modulated may be of the same carrier frequency as the carrier to be transmitted or it may be of any other desired suitable frequency.

In carrying out this invention the uni-directional potentials obtained are applied to what may be termed a high power modulating tube, (or bank of tubes) by which modulation at the high power modulated stage is effected, and it will be appreciated that various different adjustments of the normal grid potential of the high power modulating tube may be made to produce different desired results. For example, the uni-directional potentials applied to the grid of the high power modulating tube may be arranged to be of negative polarities and no additional bias provided, in which case, assuming that complete modulation was effected at the low power modulated carrier wave stage, the grid potential of the high power modulating tube may be varied by the applied varying uni-directional potentials from zero to cut off or beyond (depending upon the initial adjustment) so that so-called class A operation (up and down the relatively straight portion of the characteristic) or so-called class B operation (starting from the bend of the characteristic) of the high power modulator may be obtained.

Alternatively the working point on the characteristic of the high power modulating tube may be adjusted to a potential which is the resultant of the rectified uni-directional potentials (which may be arranged to be either positive or negative) and an additional applied bias potential of opposite sense (negative or positive) and in such a case it is possible to obtain the effect that the characteristic of the modulator is fully "swept over" with quite a low degree of modulation of the low power stage and without operating the rectifying means over the non-rectilinear lower portion of its characteristic.

Again in carrying out the present invention the low power modulated stage may be coupled to two larger power modulating tubes (or banks of tubes) one of which has in its grid circuit a rectifier producing negative uni-directional potentials from the low power modulated output, said rectifier being in series with and opposed by a source of positive bias potential and the other of which has in its grid circuit a similar rectifier producing positive uni-directional potentials said positive uni-directional potentials being opposed by and in series with a negative bias source. With such an arrangement the following effects will occur:

During the half cycles of signal potential producing an increment of the oscillatory current, one of the main modulating tube grids will be rendered less negative and the other modulating tube grid will be rendered more negative, while during the half cycles of signal potential producing a decrement of the oscillatory current the reverse effect will occur. In this manner, given suitable connections between the anode circuits of the two modulating tubes and the load circuit, results like those of the so-called "push-pull" Class A or Class B type modulators can be obtained in a more simple manner than by the usual chain of phase-opposed transformer-coupled amplifiers.

The invention is illustrated in the accompanying drawings where Figures 1 to 3 inclusive each show diagrammatically various circuit embodiments of my novel modulation circuit.

Referring to Figure 1 which shows one specific embodiment of the invention carrier frequency energy of low power is applied through a coupling condenser 1 to the grid 2 of what is herein termed a sub-modulated amplifier 3 the said grid being connected to the cathode 4 through a grid resistance 5. The anode-cathode space of the sub-modulated amplifier 3 is in series with the anode-cathode space of what is herein termed a sub-modulator tube 6 the two valves being in series across a source of anode potential HV and the

circuit extending from the positive terminal of said source through a high frequency choke 7 through the sub-modulated amplifier 3 through a second high frequency choke 8 and through the sub-modulator tube 6 to the negative terminal and earth. Modulated potentials are applied through a transformer 9 between grid 10 and cathode 11 of the sub-modulator tube. Coupled to the anode 12 of the sub-modulated amplifier 3 is a carrier frequency tuned circuit 13—14 the coil 13 in which is coupled to a rectifier which may be, for example, as shown, a diode 15, said diode being in series in a loop circuit with the coupling coil 16 and a condenser 17. The said condenser is shunted by a resistance 18 one end of which (the positive end) is connected to the grid 19 of a high power modulating tube 20 (or bank of tubes). The negative end of resistance 18 is connected to the negative terminal of a grid bias battery 21 whose positive terminal is connected to the cathode 22 of the said high power modulating tube 20. The anode 23 of the high power modulating tube 20 is connected to the positive terminal of a source of anode potential HV and the cathode 22 is connected through a high frequency choke 24 to the anode 25 of a high power carrier frequency amplifier tube 26 (or bank of tubes) whose cathode 27 is earthed as is the negative terminal of the source HV. The grid 28 of the tube 26 is connected to the cathode 27 thereof through a grid resistance 29 and wave energy of the carrier frequency to be transmitted and of high power is applied to the said grid 26 through a coupling condenser 30. Coupled to the anode of the high power carrier frequency amplifier 26 is a tuned output circuit 31 from which energy is taken to any suitable utilization device, such as an aerial 32.

In a modified arrangement illustrated in Figure 2 the low power modulated carrier energy output from the sub-modulated amplifier 3, the elements of which are designated by reference characters similar to those used in Figure 1, is passed through the series connected primaries of two transformers 33, 34. Transformer 33 has one end of its secondary connected through a rectifier 15*a* to the grid 19*a* of a first high power modulating tube 20*a* (or bank of tubes) the other end of said secondary being connected through a bias battery 21*a* to the cathode 22*a* of said tube said battery being of such polarity as to oppose the rectified potentials. The bias battery is also in series between the cathode 22*a* and the grid 19*a* through a grid resistance 18*a* which is shunted by a condenser 17*a*. The second transformer 34 has its secondary connected through a similar circuit arrangement including a rectifier 15*b*, resistance 18*b*, condenser 17*b* and battery 21*b* across the grid-cathode circuit 19*b*, 22*b*, of a second high power modulating tube 20*b* and again the bias battery 21*b* and the rectifier 15*b* oppose one another, but in this case the rectifier 15*b* and bias battery 21*b* are the opposite way round as compared to the corresponding elements (15*a*, 21*a*) in the grid circuit of the tube 20*a*. The two high power modulating tubes 20*a*, 20*b* are in series with one another the cathode 22*b* of tube 20*b* being earthed and the anode 23*a* of the tube 20*a* being connected to the positive terminal of a source 35 of anode potential whose negative terminal is connected to the positive terminal of a second source 36 whose negative terminal is in turn earthed. The junction point of the two sources 35, 36, is connected to a point between the two series connected high power modulating tubes 20*a*, 20*b* through a low frequency choke 37. The anode to cathode space of that high power modulating tube which is on the positive side (i. e., tube 20*a*) is shunted across a circuit including the anode to cathode space 25*a*, 27*a* of a high power carrier frequency amplifier 26*a* the arrangement being, as shown, such that the high power modulating tubes 20*a* and the carrier frequency amplifier tube 26*a* are connected in a parallel modulation circuit. The anode of tube 20*b* is connected to the cathode of tube 26*a* the arrangement being such that 26*a* and 20*b* are in a series modulation circuit. Tubes 26*a* and 20*a* are in parallel as to the direct current source 35, while the output impedance of 26*a* is in a direct current series circuit including the output impedance of 20*b* and reactor 37 in parallel. In the whole arrangement modulation in one direction is effected by the parallel modulator 20*a* and modulation in the other is effected by the series modulator 20*b*.

In a further modification illustrated in Figure 3 the positive terminal of a source of anode potential HV is connected through a low frequency choke 38 and the anode-cathode space of a sub-modulator tube 6*a* to earth and modulating potentials are applied between grid 10*a* and cathode 11*a* of this sub-modulator tube in any convenient way, e. g., by means of a transformer 9*a*. In shunt across the anode-cathode space of the tube 6*a* is a circuit including a high frequency choke 39 in series with the anode-cathode space 12*a*—4*a* of a sub-modulated amplifier 3*a*, carrier frequency at low power being applied through a coupling condenser 1*a* across a grid resistance 5*a* in the grid circuit of the said amplifier 3*a*. The anode 12*a* is coupled to a tuned output circuit 13, 14 the coil in which acts as the primary of a transformer having two secondaries. One secondary 16*a* is connected at one end through a rectifier 15*a* in series with a high frequency choke to the grid 19*a* of one high power modulating tube 20*a* and the other end of said secondary is connected through a bias battery 21*a* to the cathode 22*a* of the said tube 20*a* the said battery being also in series between cathode 22*a* and grid 19*a* through a capacity shunted resistance combination 17*a*, 18*a*. The arrangement is such that the bias battery 21*a* opposes the potential applied to the grid 19*a* from the rectifier 15*a*. The cathode 22*a* of the high power modulating tube 20*a* is connected to the cathode 22*b* of a second, similar, high power modulating tube 20*b* and the grid cathode circuit 19*b*—22*b* of this second modulating tube 20*b* includes an arrangement like that provided in the grid circuit of the first mentioned high power modulating tube except that the bias battery 21*b* and the rectifier 15*b* are the opposite way round from the corresponding elements 21*a*, 15*a*. The two anodes 23*a*, 23*b* of the two high power modulating tubes 20*a*, 20*b* are connected to one another through the center tapped primary of a low frequency transformer 40 the center tap being taken to the common cathode point of the two said high power modulating tubes through a suitable anode potential source (not shown). The secondary of the low frequency transformer 40 is connected in a loop circuit with a low frequency choke 41 and a condenser 42 the junction point of said choke and condenser being connected to the positive terminal of a source of anode potential HV and the other end of said choke being connected through a high frequency choke 42*a* to the anode 25*b* of a high power carrier frequency modulated amplifier 26*b* whose cathode 27*b* is earthed. The carrier

frequency to be transmitted is supplied at high power to the grid of the amplifier 26b through a coupling condenser 30, the said grid being connected to the earthed cathode 27b of the said tube through a grid resistance 29. The anode of the high power modulated carrier amplifier is coupled to a tuned output circuit 31 which in turn feeds into a utilization device such as an aerial 32.

The invention has several important advantages: For example, in many constructions in which it is desired to position the modulating tube at a point having a relatively high potential to earth, it is a matter of difficulty to construct an effective grid input transformer with sufficiently low inter-capacity to prevent loss of high note response, whereas in carrying out the present invention the coupling between the low power modulated stage and the grid circuit of the high power modulating tube or tubes can readily be arranged to have negligible capacity to earth.

Again, if it is required to operate a high power modulating tube over a very wide frequency band from an initial signal of small amplitude, much difficulty is experienced on account of the appreciable self-capacity of the tubes necessary to produce the required modulating potentials, whereas by employing the present invention the difficulty is considerably reduced.

The modulated low power oscillator or amplifier may be arranged to produce a constant carrier and modulation side bands or in certain applications the carrier may be suppressed and only the modulation side bands or one of them rectified and applied to the main modulating stage.

The carrier frequency of the modulated low power stage may in all cases be the same as that to be transmitted or it may be widely different therefrom.

If desired, in carrying out the invention, the process of modulating a relatively low power carrier, rectifying the modulated output and applying the rectified potentials to effect modulation at a relatively high power stage may be repeated as many times as desired, i. e., the modulated output from the relatively high power stage may be rectified and the resultant rectified potentials utilized to effect modulation at a stage of still higher power, and so on.

I claim:

1. In a modulated carrier wave transmitter comprising a relatively low power carrier frequency relay stage, a modulating stage interconnected with said relay stage for modulating the amplitude of the carrier energy output of said relay stage in accordance with signals to be transmitted, a pair of rectifiers connected in circuits coupled to the output of said low potential relay stage and energized by modulated energy therefrom, said circuits each including an impedance wherein the rectifier of the circuit produces uni-directional potentials, a relatively high power carrier frequency relay stage connected with a second modulating stage in a series modulation current circuit, means connecting said relatively high power carrier frequency relay stage with a third modulating stage in a parallel modulating current circuit, said second and third modulating stages each comprising an electron discharge tube having a grid circuit, means for applying said uni-directional potentials produced in the impedance in one rectifier circuit together with superimposed opposing direct current bias to the grid circuit of said second modulating stage whereby said second modulating stage acts as a series modulator to effect modulation in one direction, means for applying uni-directional potentials produced in the impedance in the other rectifier circuit together with superimposed opposing grid bias to the grid circuit of the third modulating stage whereby said third modulating stage acts as a parallel modulator to effect modulation in the other direction, and a utilization circuit energized from the output of said high power relay stage.

2. In means for producing substantially linear modulations on carrier wave energy characteristic of a wide band of signalling potentials, a low power carrier wave amplifier stage including an electron discharge device having input electrodes on which said carrier wave energy may be impressed and output electrodes from which modulated carrier wave energy may be derived, means for impressing modulating potentials characteristic of said wide band signalling potentials on the electrodes of said device to modulate therein said carrier wave energy, a high power carrier wave amplifier tube having input electrodes coupled to a source of oscillations of carrier wave frequency, and having output electrodes coupled to a utilization circuit, a modulator tube, a source of direct current potential, a modulation potential circuit connecting the impedance of said modulator tube in series with the impedance between the output electrodes of said high power amplifier tube and with said source of direct current potential, said modulator tube having input electrodes, a rectifier having input electrodes coupled to the output electrodes of said device of said low power amplifier stage, and a circuit coupling the output electrodes of said rectifier to the input electrodes of said modulator tube.

3. In a system for producing substantially linear modulation of carrier wave energy in accordance with signalling potentials, a low power carrier wave amplifier tube having input electrodes coupled to a source of oscillating potentials and output electrodes coupled in an output circuit, a modulator tube having output electrodes coupled in series with a source of direct current potential and with the output electrodes of said low power amplifier tube, said modulator tube having input electrodes, means for impressing modulating potentials on said input electrodes, a high power amplifier tube having input electrodes coupled with a source of carrier wave oscillations and having output electrodes connected in a series modulation circuit comprising the impedance between the said output electrodes of said high power amplifier tube and the impedance between the output electrodes of a second modulator tube and a source of direct current potential, said second modulator tube having input electrodes, a rectifier having output electrodes connected to the input electrodes of said second modulator, said rectifier having input electrodes and a circuit coupling the input electrodes of said rectifier to the output electrodes of said low power amplifier tube.

4. A system as recited in claim 3 wherein said second named modulator tube, having the impedance between its output electrodes connected in the series modulation circuit including the impedance between the output electrodes of said high power amplifier and said source of direct current potential, is in a portion of said direct current circuit of relatively high direct current potential with respect to the low potential terminal of said source of direct current.

5. In a system for accomplishing substantially

linear modulation of carrier wave energy in accordance with signals, a low power carrier wave amplifier tube having input electrodes coupled to a source of oscillations and having output electrodes coupled with an output circuit, one of said electrodes being a cathode, a modulator tube having cathode coupled between the output electrodes of said amplifier tube and ground, said modulator tube having input electrodes coupled to a source of modulating potentials, a source of direct current potential connected in shunt to the output impedances of both of said tubes, a high power amplifier tube having input electrodes coupled to a source of oscillations and having output electrodes coupled to a load circuit, a source of direct current potential, a second modulator tube having input electrodes and having output electrodes coupled by a modulating potential reactor in shunt to a portion of said source of direct current potential, means connecting the output electrodes of said high power amplifier tube in shunt to another portion of said source of potential whereby said high power amplifier tube and said second modulator tube are connected in a series modulation circuit, a third modulator tube having its output electrodes coupled in shunt to the output electrodes of said high power amplifier tube to form therewith a parallel modulation circuit, said third modulator tube having input electrodes, a pair of rectifiers each having input electrodes coupled in input circuits and output electrodes coupled in output circuits including impedances, means for impressing modulated wave energy from the output of said low power amplifier on the input circuits of said rectifiers, said rectifiers being reversed to produce potential drops of opposed polarity in said impedances, means for impressing the potential drop in one of said impedances on the input electrodes of said second modulator and means for impressing the potential drop in the other of said impedances on the input electrodes of the third of said modulator tubes.

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