Nov. 8, 1949 J. F. BELL 2,487,212

HIGH EFFICIENCY MODULATOR

Filed June 19, 1946 3 Sheets-Sheet 1

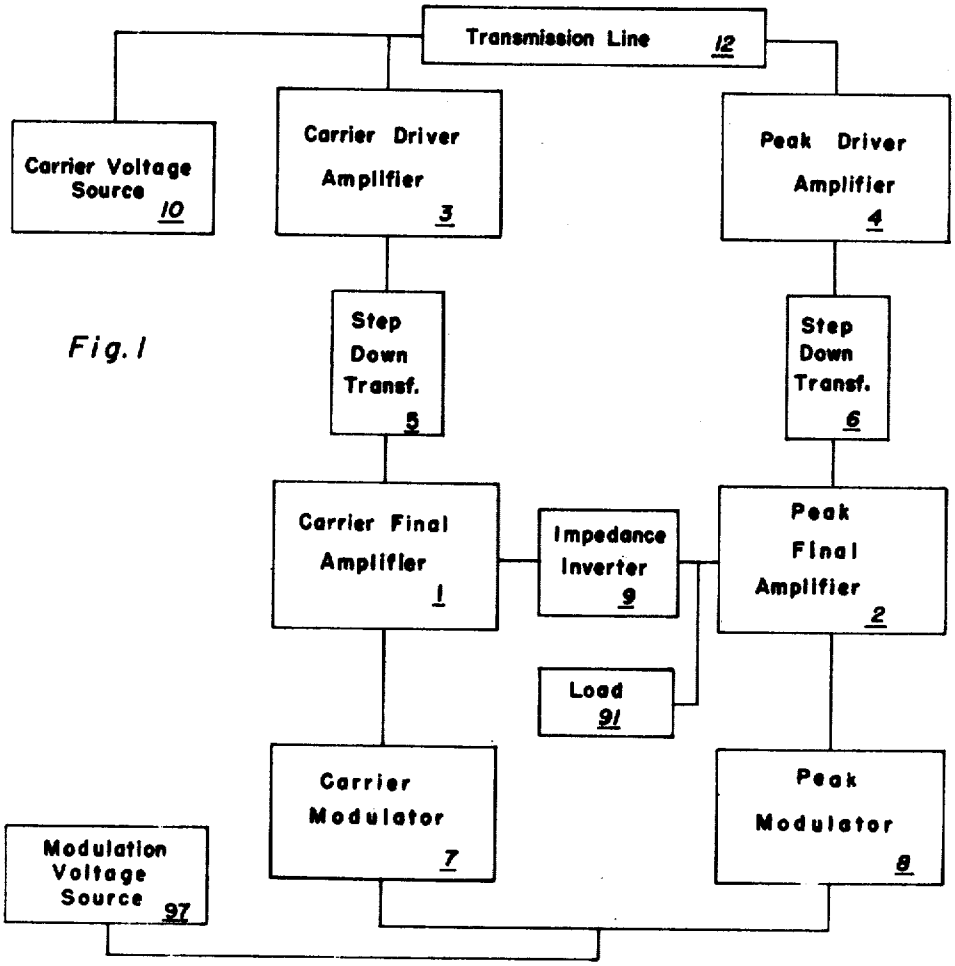
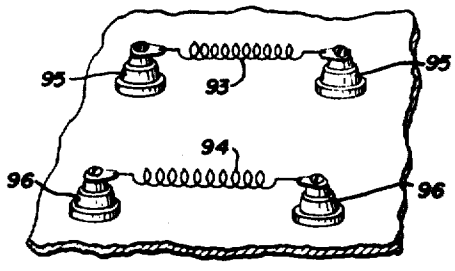


Fig. 1

Fig. 3



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Nov. 8, 1949 J. F. BELL 2,487,212

HIGH EFFICIENCY MODULATOR

Filed June 19, 1946 3 Sheets-Sheet 2

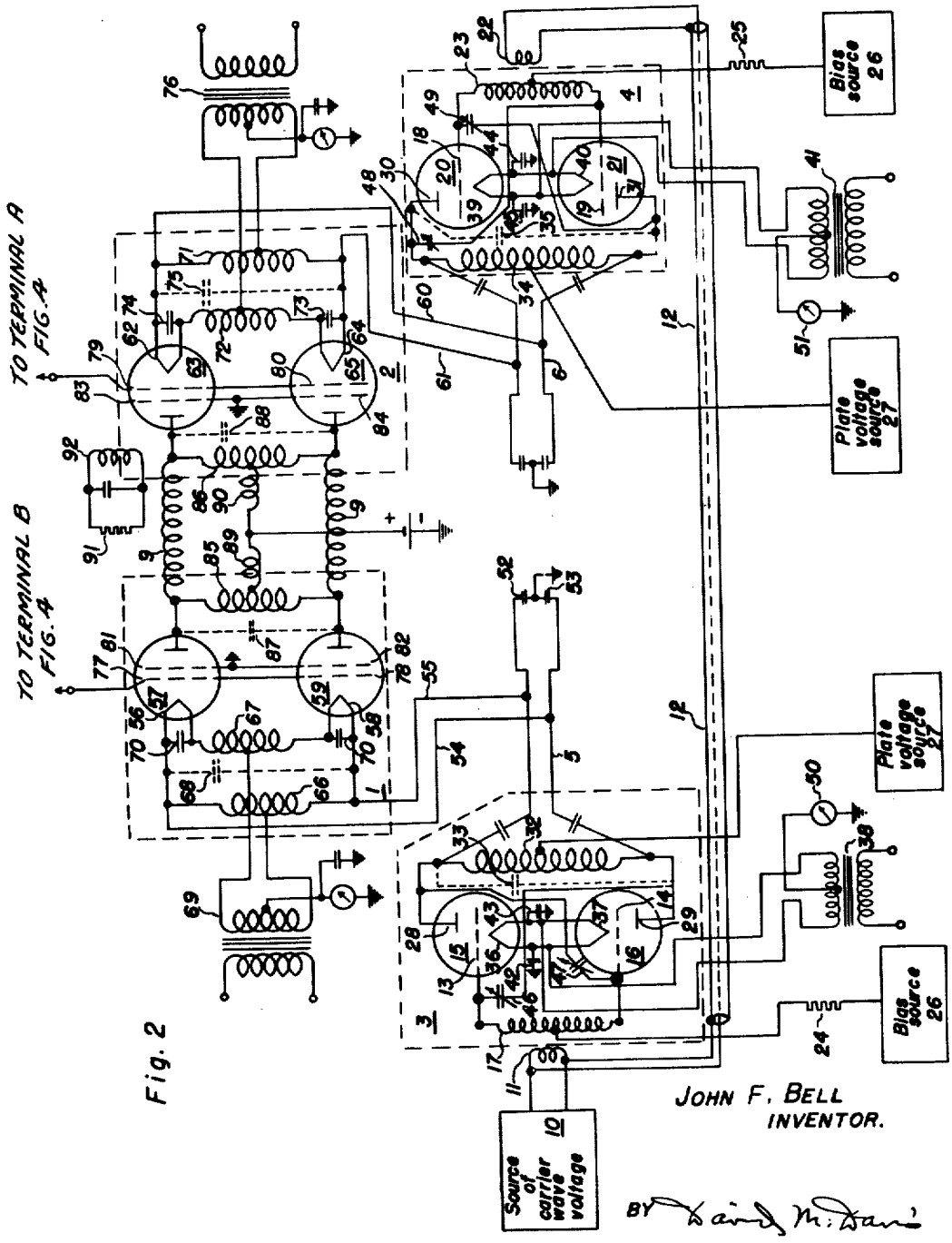


Fig. 2

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HIGH EFFICIENCY MODULATOR

Filed June 19, 1946 3 Sheets-Sheet 3

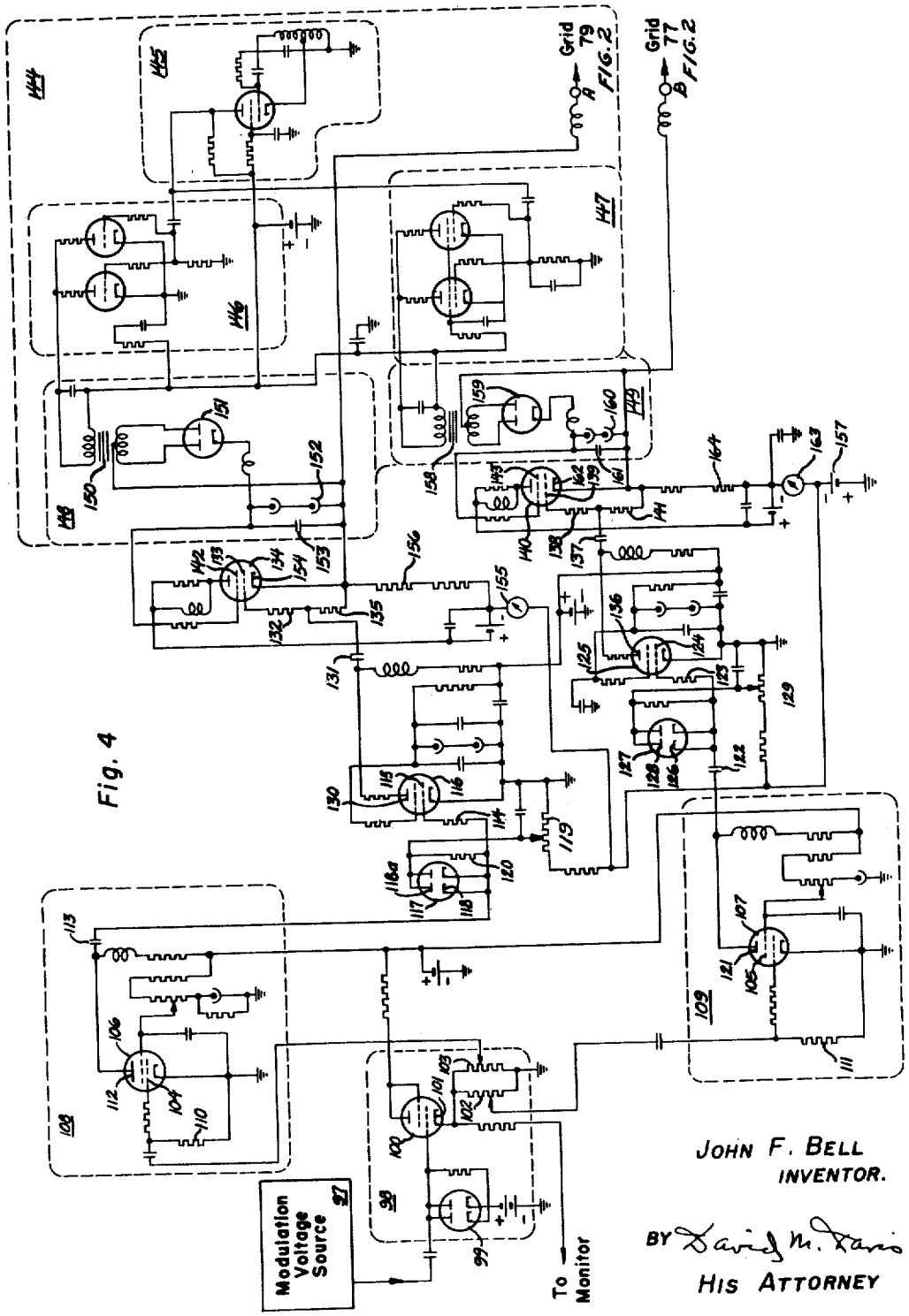


Fig. 4

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HIGH EFFICIENCY MODULATOR

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Application June 19, 1946, Serial No. 677,697

10 Claims. (Cl. 332—43)

1

This invention relates to carrier wave signal transmitting apparatus and more specifically to such apparatus arranged to operate with maximum overall efficiency.

In general, there exist grid modulated radio frequency amplifiers having two channels, the final stages of which are interconnected by an impedance inversion network. The final amplifier in one channel, called the "carrier" channel, operates throughout the modulation range. The final amplifier in the other channel, called the "peak" channel operates only when the modulation voltage exceeds approximately 50% of its maximum amplitude. The peak final amplifier not only supplies power to augment that from the carrier final amplifier but also acts as a variable load, which, when reflected through the impedance inversion network causes a reduction in the load resistance on the carrier amplifier and a corresponding increase in the power output from that stage.

Such an arrangement was described by F. E. Terman in the Proceedings of the Institute of Radio Engineers for August, 1938.

The principal object of this invention is to provide improvements in the high efficiency grid modulated amplifier which allow increased efficiency of the modulating stages and consequent increased overall efficiency of the signal transmitter, in addition to increasing the fidelity of the transmitted signals.

It is another object of this invention to provide a signal modulated carrier wave transmitter having increased overall efficiency.

A still further object of this invention is to provide such a transmitter of signal information which transmits that information with maximum fidelity.

These improvements make the signal transmitter especially adapted to the transmission of television or "video" signals. Therefore, this invention will be discussed in terms of a transmitter of video signals although the applicability of the invention is not so confined.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. The present invention itself, both as to its organization and manner of operation, together with further objects and advantages thereof may best be understood by reference to the following description taken in connection with accompanying drawings in which:

Figure 1 is a block diagram of a signal modulated radio transmitter embodying the features of this invention;

2

Figure 2 is a detailed circuit diagram of a portion of the transmitter of Figure 1;

Figure 3 is a drawing of an element of the circuit of Figure 2; and

Figure 4 is a detailed circuit diagram of another portion of the transmitter of Figure 1.

In Figure 1 carrier final amplifier 1 and peak final amplifier 2 are driven by carrier driver amplifier 3 and peak driver amplifier 4 through carrier transformer 5 and peak transformer 6, respectively. Carrier driver amplifier 3 and peak driver amplifier 4 are constant voltage amplifiers. By the term constant voltage amplifier is meant one which is self-biased and driven sufficiently hard to cause it to operate in the class C region. In class C operation the grid of the amplifier tube is biased to several times the potential required to cut off plate current in the tube, and only the peaks of the driving voltage are amplified. As the load resistance varies the self-bias varies and a change in plate current occurs which compensates the change in load resistance, with the result that the load voltage remains essentially constant.

In combination with stepdown transformers 5 and 6, driver amplifiers 3 and 4 form a source of extremely constant driving voltage despite variations in their load which is formed by carrier final amplifier 1 and peak final amplifier 2, respectively. The load on the driver amplifiers varies because the final amplifiers are grid modulated throughout a wide modulation range by signals from carrier modulator 7 and peak modulator 8. The use of constant voltage amplifiers for drivnig both the final amplifier stages aids in the elimination of amplitude distortion of the modulating signal.

By incorporating limiting circuits in carrier modulator 7 it is made to supply only those modulating signals which lie in the range from 0 to approximateyl 50% of the maximum amplitude of modulating signals. The amplitude of the modulating signals applied to peak final amplifier 2 by peak modulator 8 are from approximately 50% to 100% of the maximum amplitude of the modulating signals.

It is seen from the foregoing description that the term "limiting" includes both top and bottom clipping; in other words, specifically confining the range of signals which will be amplified.

When this invention is embodied in a" black-white" television or "video" transmitter, carrier

final amplifier 1 transmits signals corresponding to the white to gray portions of the overall television picture. Peak final amplifier 2 transmits the gray to black portions of the television picture, and in addition, transmits the synchronization impulses.

As a result of this amplitude splitting of the modulating signal, each of the modulating channels operates over a narrowed dynamic range, with the result that each operates with a considerably higher average efficiency than could be realized with a single channel amplifier. Furthermore, the linearity of power output with modulating power is retained and amplitude distortion is prevented.

The grid limiting circuits assure a constant maximum dynamic modulating signal range and thus prevent the distortion of the modulating signals which occurs when the power output from final amplifiers 1 and 2 corresponding to a given reference point on the modulating signal is not constant from signal to signal.

Final amplifiers 1 and 2 are coupled together by a compact transmission line impedance inverter 9 and peak final amplifier 2 is biased so it remains inoperative until the level of the modulating signals exceeds approximately 50% of the maximum amplitude of the modulating signals, with the result that both stages operate at relatively high efficiency and the linearity of power output with modulation is retained. Amplitude disortion of the modulating signal is thus prevented.

In Figure 2, in detail, radio frequency voltage at the desired frequency from an appropriate source 10 is applied simultaneously to inductance 11 and transmission line 12. The excitation voltage applied to grids 13 and 14 of vacuum tubes 15 and 16 from grid coil 17 is in time phase quadrature with the voltage applied to grids 18 and 19 of vacuum tubes 20 and 21 through link 22 and grid coil 23, because the electrical length of transmission line 12 is one-quarter wavelength or 90 electrical degrees at the carrier frequency. These excitation voltages are of sufficient amplitude so that they drive the grids of amplifier tubes 15, 16, 20 and 21 in class C operation when the maximum load appears across the tank circuit of amplifiers 3 and 4. Vacuum tubes 15, 16 and 20 and 21 are connected in a balanced or push-pull arrangement. They are biased to approximately twice the plate current cut-off voltage by grid current flowing through resistors 24 and 25, respectively. Grid bias source 26 provides a protective, relatively small, fixed bias which supplements the self-bias.

The continuous voltage obtained from plate voltage source 27 is applied to plates 28, 29, 30 and 31 of vacuum tubes 15, 16, 20 and 21 respectively.

Plate inductance 32 resonates with the inherent stray capacitance 33 existing between plates 28 and 29 to provide a purely resistive impedance at the carrier frequency. Similarly, plate inductance 34 resonates with the stray capacitance 35 between plates 30 and 31 at the carrier frequency.

Cathode 36 of vacuum tube 15 and cathode 37 of vacuum tube 16 are heated by current from transformer 38 to cause electron emission. Similarly, cathodes 39 and 40 of vacuum tubes 20 and 21, respectively, are heated by current from transformer 41.

Condensers 42 and 43 by-pass radio frequency currents around transformer 38. Similarly, condensers 44 and 45 by-pass radio frequency currents around transformer 41 and prevent degeneration.

Condensers 46 and 47 neutralize the grid to plate capacity of vacuum tubes 15 and 16, respectively, and prevent self-excited oscillation of the circuit containing those tubes. Similarly, condensers 48 and 49 neutralize the grid to plate capacity of tubes 20 and 21, respectively.

Indicator 50 is connected between the center tap of transformer 38 and ground. Thus indicator 50 measures the flow of plate current to tubes 15 and 16. Similarly, indicator 51 measures the plate current flowing to tubes 20 and 21.

Step-down transformer 5 is a transmission line or its equivalent, one-quarter wavelength long at the carrier frequency, effectively terminated by a short circuit because of the negligible reactance of condensers 52 and 53 at that frequency.

The impedance looking toward carrier driver 3 decreases as conductors 54 and 55 are connected to transformer 5 nearer and nearer to its short circuiting termination. The exciting voltages impressed between cathode 56 of vacuum tube 57 and cathode 58 of vacuum tube 59 correspondingly decrease. The combination of self-biased class C amplifier 3, which itself is capable of supplying current to maintain a nearly constant voltage across a varying load, with the impedance step-down transformer 5, provides a source of constant exciting voltage for amplifier 1, despite variations in the load presented to the combination by amplifier 1 as it is grid modulated throughout the dynamic range of the modulating voltages. Similarly, conductors 60 and 61 are connected to a low impedance point on peak step-down transformer 6 and impress an exciting voltage of constant amplitude between cathode 62 of vacuum tube 63, cathode 64 of vacuum tube 65, and ground.

Inductances 66 and 67, effectively in parallel, resonate with the reactance of stray capacitance 68 at the carrier frequency. Since conductors 54 and 55 are very short, the input capacitance to conductors 54 and 55 measured at their junction with step-down transformer 5 is extremely small and the broad band characteristics of the source of driving current for amplifier 1 are retained.

The use of two inductances 67 and 66 permits the introduction of filament power for tubes 57 and 59 from transformer 69 without introducing hum modulation of the output signal from amplifier 1. Condensers 70 by-pass radio frequency current across filament-cathode 56 and 58 of amplifier tubes 57 and 59, respectively.

Correspondingly, inductances 71 and 72, effectively in parallel because of the low reactance of by-pass condensers 73 and 74 to carrier frequency currents, resonate with stray capacitance 75 at the carrier frequency.

Cathode heating power is supplied by transformer 76 through inductances 71 and 72 to amplifier tubes 63 and 65.

Modulating voltages are impressed on grids 77, 78, 79, and 80 of tubes 57, 59, 63 and 65, respectively. These grids are at ground potential as far as voltages at the carrier frequency are concerned. Screen grids 81, 82, 83 and 84 are directly grounded.

By utilizing for amplifier tubes 57, 59, 63 and 65, tetrodes which have by their construction inherently low interelectrode capacitance, and low electrode-space capacitance, and, further, operating those tubes as grounded grid amplifiers, the cathode to ground, plate to ground, and plate

to plate capacitances are kept extremely low, thus increasing the spectrum of frequencies over which the amplifier performs favorably. Furthermore, the need for neutralizing condensers is obviated, thus aiding the reduction of circuit capacitance.

Final plate inductances 85 and 86 resonate with plate to plate capacitances 87 and 88 at the carrier frequency to form the plate tank circuits of amplifiers 1 and 2, respectively.

Radio frequency chokes 89 and 90 isolate radio frequency currents from the power supply circuits.

Impedance inverter 9 joins the tank circuits of amplifiers 1 and 2. Electrically, inverter 9 is a transmission line one-quarter wavelength long at the carrier frequency. This line has the characteristic, as its name implies, that the input impedance to the line varies inversely as the terminating impedance on the line.

As has been explained, up to carrier level (25% of full power) amplifier 2 is inoperative. The load terminating inverter 9 under these conditions is simply the impedance of load 91 reflected through the transformer formed by mutually coupled inductances 86 and 92. This impedance is made equal to one-half of the impedance into which amplifier 1 should operate at full modulation for optimum performance. This optimum load being called R, the terminating impedance up to carrier level is R/2 which reflects as a load 2R on carrier amplifier 1, the characteristic impedance of the transmission line forming inverter 9 being made equal to R. This high load impedance results in high efficiency for amplifier 1 in the modulation region up to carrier level. When peak amplifier 2 begins to supply power, the effective load from carrier amplifier 1 decreases and the power output from that stage increases. At the 100% modulation level peak amplifier 1 and carrier amplifier 2 are both effectively loaded with the optimum impedance R and each is supplying one-half of the total power output. It is of particular importance to the transmission of visual information with fidelity that, even though the efficiency of the final amplifier remains high throughout the modulation range, the linearity of the power output with modulation is retained and contrast in the signal information is not lost.

In a particular embodiment of this invention the optimum value of R was found to be 4,000 ohms. Therefore, the required value of the characteristic impedance for the transmission line forming inverter 9 was also 4,000 ohms. Open wire or coaxial lines using straight conductors rarely have characteristic impedance exceeding 1,000 ohms because the physical characteristics of lines having impedances exceeding that value tend to make such lines impractical.

In Figure 3 impedance inverter 9 includes coiled conductors 93 and 94 supported by insulating means 95 and 96 and separated by a reasonable distance. In a particular embodiment of this invention, given purely by way of example, this distance was 4 inches. By coiling the conductors comprising the transmission line the inductance per unit length of the line is increased more rapidly than the shunt capacitance is increased, with the result that the characteristic impedance of the transmission line, as given by the equation

$$Z=\sqrt{\frac{L}{C}}$$

is increased rapidly. The velocity of propagation through the transmission line is given by the equation

$$V=\sqrt{\frac{1}{LC}}$$

so that by coiling the conductors the velocity of propagation through the line is reduced.

Since the wavelength within the transmission line is given by the equation

$$\lambda=\frac{V}{f}$$

where V is the velocity of propagation, and f is the frequency, reducing V reduces the velocity of the propagation and correspondingly reduces the wavelength within the line. The required physical length of inverter 9 is reduced. A compact high impedance line is thus provided.

While the various amplifier stages in the preferred embodiment described and illustrated have been in push-pull or balanced arrangement, it should be understood that it is within the scope of this invention, where it is unnecessary to use such balanced amplifier stages, to use single-ended stages, in which case the impedance inversion network would include a single coiled conductor having an electrical length equal to a quarter of the carrier wavelength.

In Figure 4 the output of modulation voltage source 97 is fed to a direct current re-insertion circuit 98 including vacuum tubes 99 and 100. Here the maximum modulating signal amplitude is fixed. The signal output from cathode 101 of vacuum tube 100 in re-insertion circuit 98 is split by means of potentiometers 102 and 103 and fed in-phase to grids 104 and 105 of vacuum tubes 106 and 107, which are included in peak input amplifier 108 and carrier input amplifier 109, respectively.

Automatic self-bias is developed across resistors 110 and 111 in amplifiers 108 and 109, respectively, and the peaks of the modulating signal are held at the zero bias level of operation for vacuum tubes 106 and 107.

Potentiometer 103 is adjusted so that the amplitude of the signal applied to grid 104 of tube 106 is sufficient to allow only the upper (approximately half) portion of the signal to be amplified. The remainder of the signal lies below the grid bias cut-off point and is not reproduced in the output of tube 106. As a result, the signal amplified by peak input amplifier 108 contains only the gray and black portions of the television picture plus the synchronization tips.

The amplitude of the modulating signal applied to grid 105 of carrier input amplifier 109 is adjusted so that the entire television signal, including the white, gray and black portions of the television picture and the synchronization tips are amplified.

An output signal of negative polarity is taken from plate 112 of peak input amplifier 108 and is coupled through condenser 113 and grid clipping resistor 114 to grid 115 of intermediate amplifier 116. Diode vacuum tube 117 passes current when the amplitude of the negative signal coupled to cathode 118 from plate 112 exceeds the bias voltage impressed on plate 118a of diode 117 by potentiometer 119. When this current flows, a bias voltage appears across resistor 120 and prevents amplification of any portion of the signal exceeding a level set by potentiometer 119. The position of the synchronization tips is maintained at this level.

Similarly, the signals of negative polarity from plate 121 of vacuum tube 107 are coupled through condenser 122 and grid clipping resistor 123 to grid 124 of intermediate amplifier tube 125. The output from amplifier 109 is also impressed on cathode 126 of diode 127 and the negative potential on anode 128 is adjusted by means of potentiometer 129 so that the synchronization tips lie beyond the cut-off voltage for amplifier tube 125, and only the gray and white portions of the television picture are amplified.

The output signals from plate 130 of intermediate amplifier tube 116 are of positive polarity and are coupled through condenser 131 and resistor 132 to grid 133 of peak modulator tube 134. If the peaks of the signals impressed on grid 133 tend to exceed the zero bias operating point for the tube, grid current flows and a biasing voltage is produced across resistor 135 which is maintained at an average value by the combination of condenser 131 and resistor 135. As a result of the direct current re-insertion action just described, the portion of the signal lying below the grid bias cut-off voltage increases until once again the tips of the modulating signals lie at the zero bias level of operation for modulator tube 134.

In corresponding fashion the signal of positive polarity from plate 136 of amplifier tube 125 is coupled through condenser 137 and grid resistor 138 to grid 139 of carrier modulator tube 140. The maximum signal amplitude, which corresponds to the gray region of the transmitted television picture, is maintained constant at the zero bias level of operation for modulator tube 140 because of the biasing action of resistor 141 and condenser 137, in combination.

To assure low capacitance to ground on modulated grids 77, 78, 79 and 80 in final amplifiers 1 and 2, and hence, to minimize frequency distortion of the modulating signals, a number of special features are provided in modulators 134 and 140.

First, the modulators are operated as cathode followers which inherently assures low capacitance to ground.

Second, the continuous voltage for screen grid 142 in peak modulator tube 134 and for screen grid 143 in carrier modulator tube 140 is supplied from a low capacity power supply 144 which includes a high frequency oscillator 145, operating at 15 kilocycles in a particular embodiment of this invention, peak power amplifier 146 and carrier power amplifier 147 receiving exciting voltage from oscillator 145, and peak and carrier rectifiers 148 and 149, respectively.

Peak rectifier 148 includes step-up transformer 150, which has a very low capacity to ground because so few turns are required on the transformer to provide adequate inductive reactance at the high supply frequency, rectifier tube 151 across which the high voltage from transformer 150 is impressed, voltage regulator 152 and filter condenser 153. The continuous voltage appearing across filter condenser 153 is impressed between screen grid 142 and cathode 154 of peak modulator 134. The entire screen voltage supply thus has very low capacity to ground which aids in producing low capacity to ground for the modulator as a whole.

Grid current meter 155 is connected between grid load resistor 156 and grid bias source 157, which results in the addition of minimum capacitance between grids 79 and 80 of peak final amplifier tubes 63 and 65, and ground.

Similarly, carrier rectifier 149 includes step-up transformer 158, rectifier tube 159, across which the high voltage from transformer 158 is impressed, voltage regulator 160, which maintains a constant output voltage from the rectifier, and filter condenser 161, which aids in eliminating ripple from the continuous voltage delivered by the rectifier. The voltage appearing across filter condenser 161 is applied between screen grid 143 of carrier modulator 140 and cathode 162 of that same tube.

Carrier grid current meter 163 is connected between grid load resistor 164 and the negative terminal of bias supply 157, to minimize the capacitance shunted between grids 77 and 78, and ground.

While particular embodiments of the present invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from this invention in its broader aspects, and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

I claim:

1. The combination, in a device for transmitting signals having amplitude variations, of a source of carrier wave voltage, a pair of constant voltage amplifiers connected to amplify separately carrier wave voltage from said source, an impedance inversion network, a pair of carrier wave final amplifiers respectively driven by said constant voltage amplifiers and having output terminals interconnected by said impedance inversion network, a common load connected to one end of said network to which said final amplifiers supply power additively, and means for grid modulating said carrier wave final amplifiers according to said variations.

2. A high efficiency transmitter of signals having amplitude variations, including a source of carrier wave voltage; a pair of constant voltage amplifiers each excited by said source; a 90° phase shifting network interposed between one of said constant voltage amplifiers and said source to cause said amplifiers to be excited in time phase quadrature; an impedance inversion network; a pair of final amplifiers, including vacuum tubes having plate, grid and cathode elements, driven by said constant voltage amplifiers, for individually amplifying over contiguous portions of the maximum amplitude range of said signal variations, and interconnected by said impedance inversion network; a load connected to one end of said network, whereby said load receives power additively from said final amplifier; identical impedance step-down transformers respectively arranged to couple said constant voltage amplifiers to said final amplifiers to effect increased constancy of the driving voltage for said final amplifiers; and means for modulating the grid of each of said final amplifiers according to said signals over respective portions of the maximum amplitude range of said signals.

3. A transmitter of signals having amplitude variations including means for generating a carrier wave and means for modulating the amplitude of said carrier wave according to said variations, said first means including a source of carrier waves, a constant voltage amplifier connected to said source, a second constant voltage amplifier and a 90° phase shifting network connected between said second constant voltage amplifier and said source, a pair of impedance step-down trans-

formers, a pair of final amplifiers cathode coupled to said constant voltage amplifiers through said impedance step-down transformers, a common impedance inversion network connected between the plate circuits of said final amplifiers, and a load coupled to the plate circuit of the final amplifier associated with said second constant voltage amplifier, said means for modulating said carrier wave generator including a source of signal voltage, a direct current reinsertion circuit excited from said signal source and arranged to limit the maximum amplitude of said signal voltage, a pair of signal amplifiers separately driven by said direct current reinsertion circuit, one of said signal amplifiers including means for amplifying substantially only the lower amplitude portion of said signal voltage, the other of said amplifiers including means for amplifying substantially only the remaining portion of said signal voltage, one of said signal amplifiers being connected to grid modulate one of said final amplifiers and the other signal amplifier being connected to grid modulate the remaining final amplifier.

4. In combination, in a transmitter of signals having amplitude variations, a carrier final amplifier and a peak final amplifier each adapted to be modulated by said signal variations and each driven by a constant voltage source, said carrier and peak final amplifiers being connected to supply power additively to a common load, and being adjusted to amplify over contiguous lower and upper portions, respectively, of the maximum amplitude range of said signal variations, the impedance of said load tending to appear to said final carrier amplifier as increasing as said peak amplifier becomes operative, and an impedance inversion network connected between said carrier final amplifier and said peak final amplifier, said impedance inversion network including at least one coiled conductor having its terminals respectively connected with said final amplifiers, whereby the load impedance appears as decreasing at the carrier final amplifier as said peak final amplifier becomes operative.

5. A transmitter of signals having amplitude variations including means for generating a carrier wave and means for modulating the amplitude of said carrier wave according to said variations, said first mentioned means including a source of carrier waves, a constant voltage amplifier connected to said source, a second constant voltage amplifier and a 90° phase shifting network connected between said second constant voltage amplifier and said source, a pair of final amplifiers coupled to said constant voltage amplifiers through respective impedance step-down transformers, a common impedance inversion network connected between the plate circuits of said final amplifiers, and a load coupled to the plate circuit of the final amplifier associated with said second constant voltage amplifier, said means for modulating said carrier wave generator including a source of signal voltage, a direct current reinsertion circuit excited from said signal source and arranged to limit the maximum amplitude of said signal voltage, a pair of signal amplifiers separately driven by said direct current reinsertion circuit, one of said signal amplifiers including means for limiting the amplification therein to substantially only a portion of the signal from said signal source and the other of said signal amplifiers including means for limiting the amplification therein to substantially only the remaining portion of said signals, one of said signal amplifiers being connected to grid modulate one of said carrier wave final amplifiers and the other signal amplifier being connected to grid modulate the remaining carrier wave final amplifier, said signal amplifiers including tetrode vacuum tubes, and a low capacity voltage supply connected to the screen grid electrodes of said tetrode vacuum tubes, including a high frequency alternating voltage source, a low capacitance voltage step-up transformer connected to said alternating voltage source, and an ungrounded rectifier connected between said step-up transformer and said screen grid electrodes, whereby the capacitance shunted between said screen grid electrodes and ground is minimized.

6. A device for supplying to a load signals having amplitude variations within a given amplitude range comprising: an impedance inversion network connected to said load; a pair of amplifiers for individually modulating and amplifying a carrier wave signal in accordance with signal variations within an assigned portion of said range and having output electrodes coupled to the opposite ends of said network for supplying signals additively to said load through said network; and separate constant voltage amplifiers connected to drive each of said employed carrier amplifiers from a arrier wave source.

7. A transmitter of signals having amplitude variations including means for generating a carrier wav and means for modulating the amplitude of s id carrier wave according to said variations, said first means including a source of carrier waves, a constant voltage amplifier connected to said source, a second constant voltage amplifier and a 90° phase shifting network connected between said second constant voltage amplifier and said source, a pair of impedance step-down transformers, a pair of final amplifiers cathode coupled to said constant voltage amplifiers, a common impedance inversion network connected between the plate circuits of said final amplifiers, and a load coupled to the plate circuit of the final amplifier associated with said second constant voltage amplifier, said means for modulating said carrier wave generator including a source of signal voltage having variations within a given amplitude range, a direct current reinsertion circuit excited from said signal source and arranged to limit the maximum amplitude of said signal voltage, a pair of signal amplifiers separately driven by said direct current reinsertion circuit, one of sai signal amplifiers including means for amplifying one portion of said amplitude range, the other of said amplifiers including means for amplifying another portion of said amplitude range, one of said signal amplifiers being connected to grid modulate one of said final amplifiers and the other signal amplifier being connected to grid modulate the remaining final amplifier.

8. A transmitter of signals having amplitude variations within a given maximum amplitude range including: a source of carrier wave voltage; a pair of constant voltage amplifiers each excited by said source; a 90° phase shifting network interposed between one of said constant voltage amplifiers and said source to cause said amplifiers to be excited in time phase quadrature; a pair of impedance step-down transformers; a pair of signal amplifiers, including vacuum tubes having grid, anode and cathode elements, cathode-coupled through said transformers to said constant voltage amplifiers and operating with grids at a fixed reference potential

for said carrier voltage; means for limiting amplification in each of said final amplifiers to an assigned one of different portions of said maximum amplitude range; an impedance inversion network interconnecting said anode elements of said final amplifiers; a load connected to said network for receiving power additively from said final amplifiers; and means for modulating the grid of each of said final amplifiers according to its assigned portion of said amplitude range of signal variations.

9. A transmitter of signals having amplitude variations within a given maximum amplitude range including: a source of carrier wave voltage; a pair of constant voltage amplifiers each excited by said source; a 90° phase shifting network interposed between one of said constant voltage amplifiers and said source to cause said amplifiers to be excited in time phase quadrature; a pair of impedance step-down transformers; a pair of signal amplifiers, including vacuum tubes having grid, anode and cathode elements, cathode-coupled through said transformers to said constant voltage amplifiers and operating with grids at a fixed reference potential for said carrier voltage; an impedance inversion network interconnecting said anode elements of said final amplifiers; a load connected to said network for receiving power additively from said final amplifiers; and means for effecting grid modulation of each of said final amplifiers in accordance with an assigned one of different portions of said amplitude range of signal variations.

10. A device for supplying modulated carrier wave signals to a load comprising: a source of carrier wave voltage; a pair of constant voltage amplifiers coupled to said source; a 90° phase

shifting network interposed between one of said amplifiers and said source; a pair of final amplifiers coupled to and driven by said pair of constant voltage amplifiers; an impedance inverter coupled between said final amplifiers and coupled to said load for supplying signals additively to said load from said final amplifiers; a source of modulating signals having amplitude variations within a given maximum amplitude range; means for translating different portions of said range, including a pair of stabilizing networks for establishing a selected amplitude value of each of said different portions at a fixed reference potential; and a pair of modulators associated with said stabilizing networks and coupled to said final amplifiers for effecting modulation of each final amplifier in accordance with the stabilized modulating signal of an assigned one of said portions of said range.

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