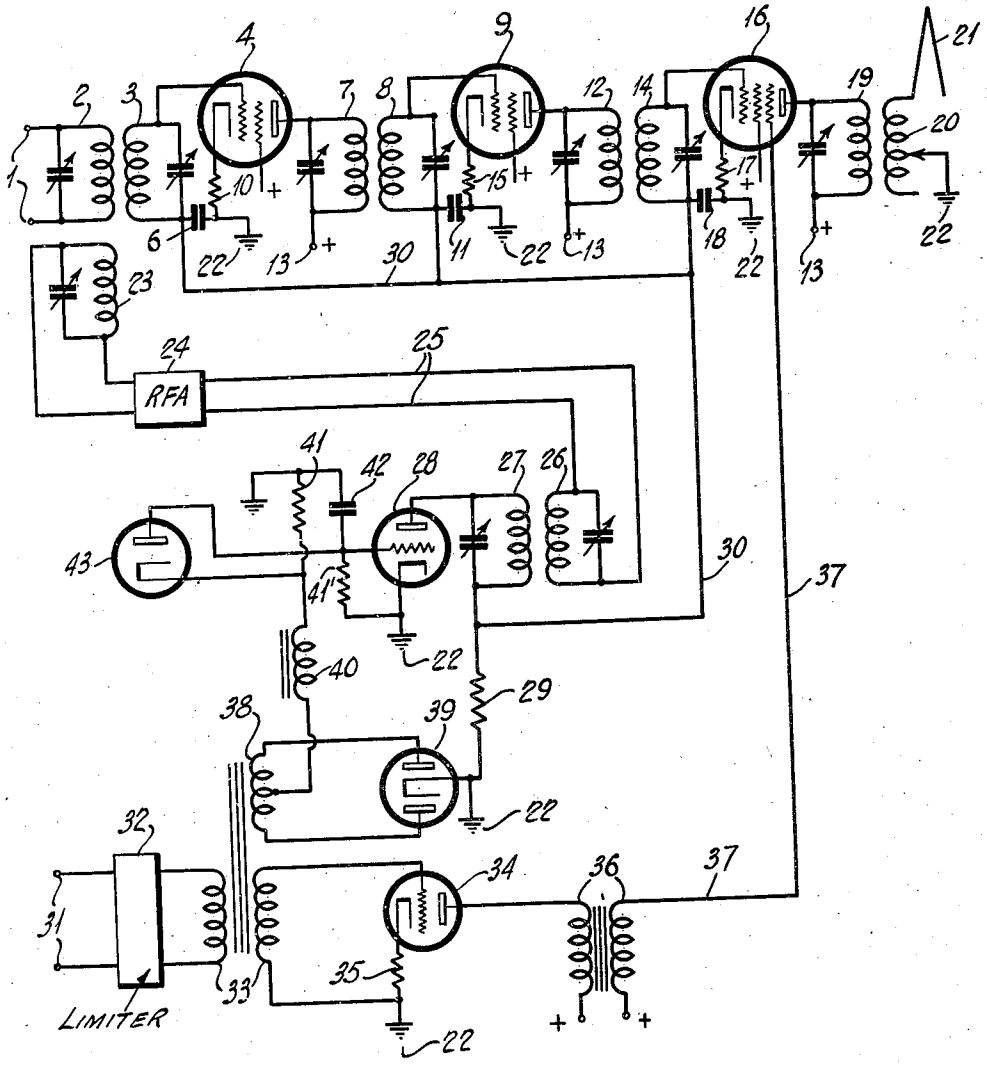
Aug. 14, 1945. R. L. HOLLINGSWORTH 2,382,567

SIGNALING SYSTEM

Filed June 7, 1943 2 Sheets-Sheet 1

Fig. 1.



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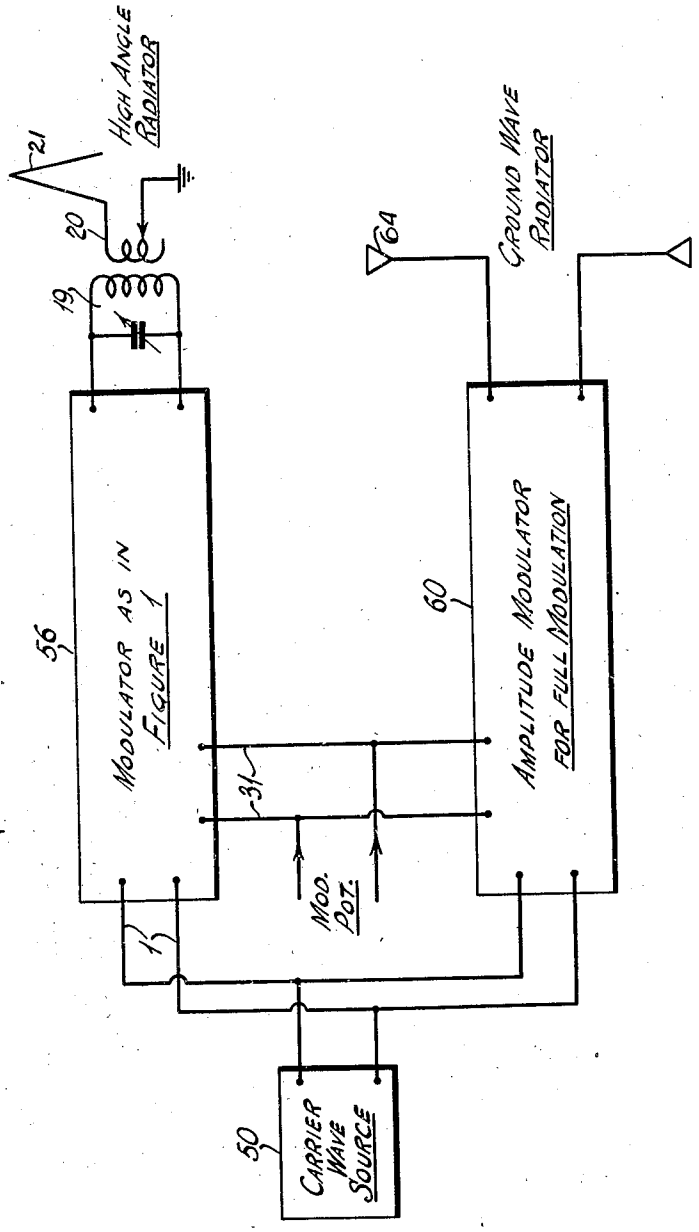


Fig. 2.

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SIGNALING SYSTEM

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Application June 7, 1943, Serial No. 489,915

21 Claims. (Cl. 250—17)

This application discloses a new method of and means for improving amplitude modulated radio wave transmission.

My new method and means is particularly applicable to transmission of amplitude modulated wave energy within the secondary service area.

In the system of my invention I control the intensity or amplitude of a carrier wave being modulated in accordance with signals to thereby maintain the desired degree or percentage of modulation to thereby reduce distortion.

In modulated radio wave transmission, using amplitude modulation, such as is in general use in the standard broadcast frequency bands and in the international short wave frequency bands it is the practice in many cases to make extensive use of the secondary coverage area. This area is reached by way of reflection from the Heaviside layer in the upper atmosphere. The continual shifting of this reflection medium produces multiple wave fronts, that in turn produces fading within the receiving antenna, since these various reflected electro-magnetic wave fronts arrive at the antenna out of phase.

In amplitude modulation reception, if distortion is to be avoided, there must be a sufficiency of carrier wave energy transmitted along with the side band energy. For instance, if 100% modulation is exceeded serious distortion occurs in both the primary and secondary service areas of the transmitter, since the upper and lower side band components beat with each other. In like manner, if a transmitter is modulated at 50% and in transmission 51% of the remaining carrier or a substantial portion thereof is lost in transmission, distortion equivalent to over-modulation will occur continually over the secondary coverage area where fading is continually taking place, especially during high percentage modulation intervals.

It is an object of this invention, therefore, to improve the transmission of amplitude modulated electro-magnetic waves in the secondary service area.

It is an additional object of this invention to improve the transmission of long distance short-wave modulated radio wave energy.

The manner in which the above objects and other objects are attained will appear from the detailed description of my invention which follows. In this description reference will be made to the two figures in the drawings.

The description of my invention follows and reference is made to Fig. 1 of the accompanying drawings. The component parts of this invention are identified as follows and their principle function is explained. Numeral 1 represents the radio frequency energy input from a constant frequency generator at the assigned carrier frequency. This energy passes through a tuned transformer consisting of tuned primary winding 2 and tuned secondary winding 3, to excite radio frequency amplifier 4. The output of radio frequency amplifier tube 4 is coupled to radio frequency amplifier tube 9 via tuned coupled circuits 7 and 8 for further amplification. The output of tube 9 in turn excites radio frequency amplifier tube 16 via tuned coupled circuits 12 and 14. 10, 15, and 17 are bias resistors, while 6, 11, and 18 are radio frequency bypass condensers. The plate supply connections are indicated by numeral 13. From tube 16 the carrier wave energy is fed to the antenna 21 via tuned coupled circuits 19 and 20. Ground potential throughout this drawing is indicated by 22. Thus, a radiated carrier source of electro-magnetic wave energy is indicated.

Coupled to the unmodulated radio frequency carrier source is tuned coupling coil 23 which connects to radio frequency amplifier 24, the output of which connects via leads 25, tuned coupled circuits 26 and 27 to the plate of triode tube 28. This radio frequency energy serves as a substitute for a battery supply to cause triode tube 28 to be conductive to produce a negative bias voltage across resistance 29 which is the plate load resistance for tube 28. Lead 30 supplies this bias to the control grids of radio frequency amplifier tubes 4, 9 and 16. This bias represents the fixed bias supply for these amplifier tubes together with their bias supplies from resistances 10, 15, and 17, until high percentage modulation is applied to the suppressor grid of tube 16.

The modulation from a microphone or another usable source is applied at terminals 31, and passes through limiter 32 where the amplitude level is automatically controlled when it reaches a value corresponding to 100% modulation in the transmitter tube 16. This is a practice generally used throughout the broadcasting industry. The output of limiter tube 32 is passed through audio frequency transformer 33 to amplifier tube 34. 35 is a bias resistor for tube 34. Transformer 36 couples the amplified output of tube 34 via lead 37 to the suppressor grid of tube 16 to modulate the carrier frequency supplied thereto. This type of modulation is used for simplicity of illustration, however, it is within the scope of this invention that other types of amplitude modulation could be used.

Transformer 33 also has another secondary winding shown at 38 which is connected to the plates of full wave rectifier 39. The center tap of transformer 38 is connected to filter choke coil 40. The other terminal of filter choke coil 40 is connected to ground through resistance 41 which serves as a load resistance for rectifier 39. 41' is a resistance that comprises one part of a time delay circuit while capacity 42 constitutes the second part of said time delay circuit which is connected to the control grid of triode 28. 43 is a diode tube which passes current in one direction only from across resistance 41 into time delay circuit 41' and 42. The ratios of transformer secondary windings of transformer 33 are such that rectifier 39 does not become conductive until the modulation level reaches approximately 40% of full modulation.

The operation of my invention is as follows: Let us assume that carrier wave energy is being radiated. Modulation at 40% is applied and the bias amplifiers 4, 9 and 16 remain unchanged. Now let us assume that the modulation level is raised to 50%. Rectifier tube 39 draws current and builds up a negative drop across resistance 41 which is applied to the grid of triode 28 through diode 43 via time delay circuit 41' and 42, reducing the current through triode 28; decreasing the bias on radio frequency amplifiers 4, 9, and 16, thus increasing the carrier energy to establish again a condition comparable to modulation at a level of 40%. As the modulation goes higher in level above 40% the higher goes the carrier level to insure in so far as possible a sufficiency of carrier wave energy, over the secondary coverage area of an amplitude modulated wave transmitter.

The variation of broadcast modulations takes place suddenly, thus the rapid action through diode 43 to the control grid of triode 28 increases the carrier level instantaneously with sudden rises in modulation. Time delay values 41' and 42 cause a slight holdover to provide smoothness of operation between wide variations in modulation level.

It is within the scope of this invention that the action of this circuit be applied only to a radio frequency amplifier supplying modulated carrier wave energy to a radiator, the characteristics of which would have only a high angle of radiation to improve secondary area coverage, while the modulated carrier energy is simultaneously fed to a radiator in a conventional manner which has a characteristic suitable only for primary or ground wave coverage. Explaining further, assume that WEAF or any other clear channel station use a one-half wave radiator for ground wave coverage in the primary service area, and that the radiation goes out over this radiator modulated up to 100%. Assume another radiator having an electrical length of from .62 to 1.0 wavelength, depending on the radiation angle desired to render secondary service. This radiator is then fed with the same radio frequency carrier source, through an amplifier stage which is operated in the manner described in this specification to supply a strong carrier supply throughout the secondary service area and to always maintain the equivalent of from 40 to 60 per cent modulation, insuring improvement of reception throughout the secondary service area, in that distortion due to fading would be greatly reduced. It is possible to select the proper angle of radiation to cause improved reception in the critical area, located in the regions where the ground wave is fast diminishing in field strength, and where the sky wave is increasing in intensity.

Such an arrangement is shown in Fig. 2, wherein 50 is the carrier source, 56 is the controlled amplifier such as, for example, as shown in Fig. 1, 21 is the high angle radiator for secondary area coverage, 60 is the amplitude modulator operating from say 0 to 100% modulation, and 64 is the $\lambda/2$ radiator for primary service area coverage.

Further, it may be desirable to focus WEAF or any other clear channel station to cover all of Mexico and Central America at night, or to reach down Rio way and at the same time render their normal domestic clear channel service in the United States. Such could be done very well with a suitable directive antenna array having the proper angle of radiation in addition to their regular antenna system. The clear channel stations located in the Pacific Northwest could cover Alaska and possibly the Orient, while simultaneously serving their local audience.

While I have shown and described a workable embodiment of my invention, I propose that I be limited only by this specification, the spirit thereof, and by appended claims.

I claim:

1. A method of signaling by means of wave energy of carrier wave frequency and modulating potentials which includes these steps, amplifying said carrier wave energy, controlling said amplification of said carrier wave energy in accordance with the amplitude of said original carrier wave energy, modulating the amplitude of the carrier wave energy in accordance with the modulating potentials and increasing the amplification of the carrier wave energy when the amplitude of the modulating potentials exceeds a selected value.

2. A method of signaling by means of wave energy of carrier wave frequency and of substantially constant amplitude and modulating potentials which includes these steps, amplifying said carrier wave energy, controlling said amplification of said carrier wave energy in accordance with the amplitude thereof, modulating the amplitude of the carrier wave energy in accordance with the modulating potentials, deriving from the modulating potentials which exceeds a selected magnitude a control potential and increasing the amplification of the carrier wave energy in accordance with the derived control potential.

3. A method of signaling by means of wave energy of carrier wave frequency and of substantially constant amplitude and modulating potentials which includes these steps, amplifying said carrier wave energy, rectifying carrier wave energy and controlling said amplification of said carrier wave energy in accordance with resulting rectified components, modulating the amplitude of the amplified carrier wave energy in accordance with the modulating potentials, rectifying modulating potentials which exceed a selected magnitude and increasing the amplification of the carrier wave energy in accordance with the rectified modulating potentials.

4. In a signaling system of the class described, a source of wave energy of carrier wave frequency and of substantially constant amplitude, a source of modulating potentials, an amplifier having an input coupled to said source of wave energy and having an output, means excited by said wave energy for deriving a biasing potential depending on the amplitude of said carrier and applying said biasing potential to said amplifier, means for modulating said carrier wave energy in accordance with said modulating potentials, and means

for supplementing said first mentioned biasing potential to increase the gain of said amplifier and the amplitude of the carrier when the modulating potentials exceed a selected magnitude.

5. In a signaling system of the class described, a source of wave energy of carrier wave frequency and of substantially constant amplitude, a source of modulating potentials, an amplifier having an input coupled to said source of wave energy and having an output, a modulator coupled to said amplifier, a wave energy coupling means associated with said wave energy source for deriving a biasing potential for said amplifier to supply carrier wave energy to said modulator of selected amplitude, connections excited by potentials from said modulating potential source for applying modulating potentials to said modulator, and other connections excited by modulating potentials from said modulating potential source which exceed a selected value for supplementing said first mentioned biasing potential to increase the action of said amplifier and the amplitude of the carrier fed to the modulator.

6. In a signaling system of the class described, a source of wave energy of carrier wave frequency and of substantially constant amplitude, a source of modulating potentials, an amplifier having an input coupled to said source of wave energy and having an output, a modulator coupled to the output of said amplifier, a rectifier coupled to said amplifier and excited by said wave energy for deriving a biasing potential for controlling the gain of said amplifier to supply carrier wave energy to said modulator of selected amplitude, connections excited by potentials from said modulating potential source for applying modulating potentials to said modulator and a second rectifier associated with said amplifier and excited by modulating potentials from said modulating potential source which exceed a selected value for applying to said amplifier biasing potentials in addition to said first mentioned biasing potential to increase the action of said amplifier and the amplitude of the carrier fed to the modulator.

7. In a system of automatic carrier compensation in modulated carrier wave transmission including a carrier wave source of electro-magnetic wave energy, a carrier wave radio frequency amplifier, means for modulating said carrier wave radio frequency energy in accordance with applied electric wave energy, a source of negative self-bias for said radio frequency amplifier, the value of which varies with changes in the amplitude of the carrier wave and a separate negative bias supply for said radio frequency amplifier that is automatically variable inversely to the level of the applied modulation level when said modulation level reaches a predetermined value.

8. In a system of automatic carrier compensation in modulated carrier wave transmission including a carrier wave source of electro-magnetic wave energy, a means of carrier wave radio frequency amplification, a means for modulating said carrier wave radio frequency energy, a radiating means, a source of negative self-bias for each individual radio frequency amplifying tube, the value of which varies with changes in the amplitude of the carrier wave and a separate negative bias supply for said radio frequency amplifiers that is automatically variable inversely to the level of the applied modulation level when said modulation level reaches a predetermined value.

9. In a system of automatic carrier compensation in modulated carrier wave transmission including a carrier wave source of electro-magnetic wave energy, a carrier wave radio frequency amplifier including a plurality of amplifier tubes coupled in cascade, a modulation source and means for modulating said radio frequency carrier energy, a separate negative bias supply for at least one of said radio frequency amplifying tubes, said separate negative bias supply comprising a rectifier excited by the unmodulated carrier wave energy, and a second rectifier excited by the modulating voltage when said modulation level exceeds a predetermined value and a coupling between said rectifiers for controlling said first rectifier by current rectified by said second rectifier.

10. A system of automatic carrier compensation in modulated carrier wave transmission including a carrier wave source of electro-magnetic wave energy, a means of carrier wave radio frequency amplification composed of amplifier tubes operating in cascade, a radiating means, a source of negative self-bias for at least one of said radio amplifying tubes, a source and means of modulating said radio frequency carrier energy, a separate negative bias supply for at least one of said radio frequency amplifying tubes, said separate negative bias supply comprising an amplifier excited by the unmodulated carrier wave energy, and a rectifier coupled to said amplifier said rectifier consisting of a triode tube which is grid controlled, a second rectifier which is responsive to the modulating voltage when said modulation level exceeds a predetermined value, and a one-way diode tube and a time delay circuit coupling said second rectifier to the grid of the triode rectifier.

11. In a signaling system in combination, a source of carrier wave energy, a first means for amplifying and modulating said carrier wave energy from zero to 100%, a ground wave radiator connected to said first means, a second means for separately amplifying said carrier wave energy and modulating same, and for expanding the power output thereof when the applied modulation level exceeds a predetermined level value, and a sky wave radiator connected to said second means.

12. A source of carrier wave energy, a first means for amplifying and modulating said carrier wave energy from zero to 100% and connected to a ground wave radiator, a second means for separately amplifying said carrier wave energy and modulating same, said second carrier wave amplifying means being capable of expanding the power output thereof when the applied modulation level exceeds a predetermined level value, and a sky wave radiator coupled to said second amplifying means.

13. A method of signaling by means of wave energy of carrier wave frequency and of substantially constant amplitude and modulating potentials which includes these steps, amplifying said carrier wave energy, rectifying carrier wave energy and controlling said amplification of said carrier wave energy in accordance with resulting rectified components, modulating the amplitude of the amplified carrier wave energy in accordance with the modulating potentials, rectifying modulating potentials which exceed a selected magnitude and controlling the rectification of the carrier wave energy in accordance with the rectified modulating potentials.

14. In a signaling system, a source of wave energy of carrier wave frequency, an electron discharge amplifier stage having input electrodes

coupled to said source and having output electrodes from which amplified modulated carrier wave energy may be derived, a controllable tube rectifier in a circuit including an impedance, a coupling between the impedance and the input electrodes of said amplifier, connections for impressing wave energy of carrier wave frequency on said rectifier, a source of modulating potentials coupled to said amplifier for modulating the carrier wave energy, and a second rectifier coupled to said source of modulating potentials and connected to the controllable rectifier for controlling the action thereof.

15. A system as recited in claim 14, wherein time delay elements are included in said last named connections.

16. In a signaling system, a source of wave energy of carrier wave frequency, an electron discharge amplifier stage having input electrodes coupled to said source and having output electrodes from which amplified modulated carrier wave energy may be derived, a tube rectifier having a control grid and having output electrodes connected through an output impedance, connections between said impedance and the input electrodes of said amplifier, a coupling to said rectifier for impressing wave energy of carrier wave frequency on said rectifier, a source of modulating potentials coupled to said amplifier stage for modulating the carrier wave energy, and a second rectifier coupled to said source of modulating potentials and connected to the control grid of said first rectifier for controlling the action thereof.

17. In a signaling system, a source of wave energy of carrier wave frequency, an electron discharge amplifier stage having input electrodes including a control grid coupled to said source and having output electrodes from which amplified modulated carrier wave energy may be derived, a tube rectifier having a control grid and having output electrodes connected through an output impedance, connections for impressing wave energy of carrier wave frequency on said rectifier, a coupling between the control grid of the amplifier and said impedance to supply the drop in potential across said impedance as a bias to the grid of said amplifier, a source of modulating potentials coupled to said amplifier for modulating the carrier wave energy, a second rectifier coupled to said source of modulating potentials and connected to a load impedance, and a connection between said last named impedance and the control grid of said first rectifier for controlling the action thereof in accordance with rectified modulating potentials.

18. A system as recited in claim 17, wherein time elements are included in said last named connections.

19. In a signaling system, a carrier wave amplifier tube having input electrodes including a grid and cathode excited by carrier wave energy and output electrodes from which amplified modulated carrier wave energy may be derived, a first rectifier tube of the control grid type having an anode and cathode connected by an impedance, a connection between the end of said impedance adjacent the cathode of said rectifier and the grid of said amplifier tube, a connection between the other end of said impedance and the cathode of said amplifier tube, connections for impressing wave energy of carrier wave frequency on said rectifier, a source of modulating potentials coupled by a modulation circuit to said amplifier tube, a second rectifier having an anode and having a cathode connected to the cathode of said first rectifier, a second impedance connecting the anode of the second rectifier to the cathode of the second rectifier, a connection between the anode end of the second impedance and the grid of the first rectifier, and means for impressing modulating potentials on said second rectifier.

20. A system as recited in claim 19, including a time delay network in the last connection.

21. In a signaling system, a carrier wave amplifier having input electrodes excited by carrier wave energy and output electrodes from which amplified modulated carrier wave energy may be derived, a first rectifier tube of the control grid type having as a load an impedance connected with the input electrodes of said amplifier for biasing the same, connections for impressing wave energy of carrier wave frequency on said first rectifier, a source of modulating potentials coupled by a modulation circuit to said amplifier, a second rectifier in series with an impedance associated with the grid of said first rectifier, and means for impressing modulating potentials on said second rectifier.

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