June 24, 1930. L. C. YOUNG 1,766,050

MULTIPHASE CORNET SYSTEM

Filed July 20, 1928 2 Sheets-Sheet 1

Fig. 1

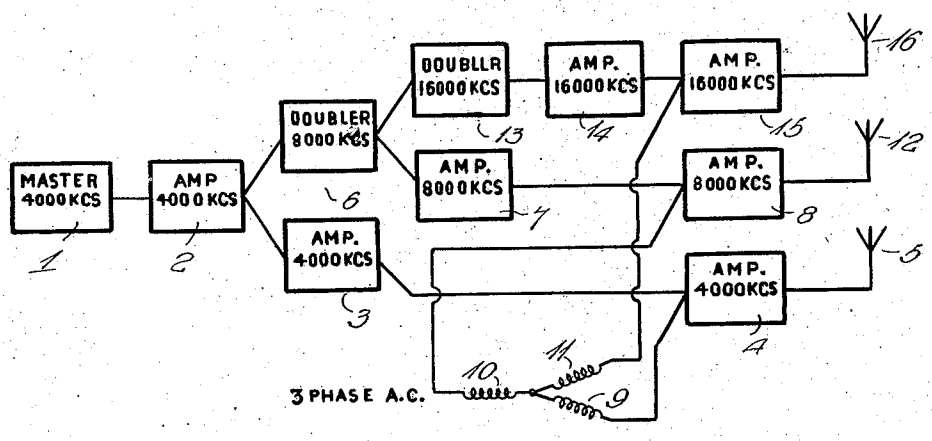
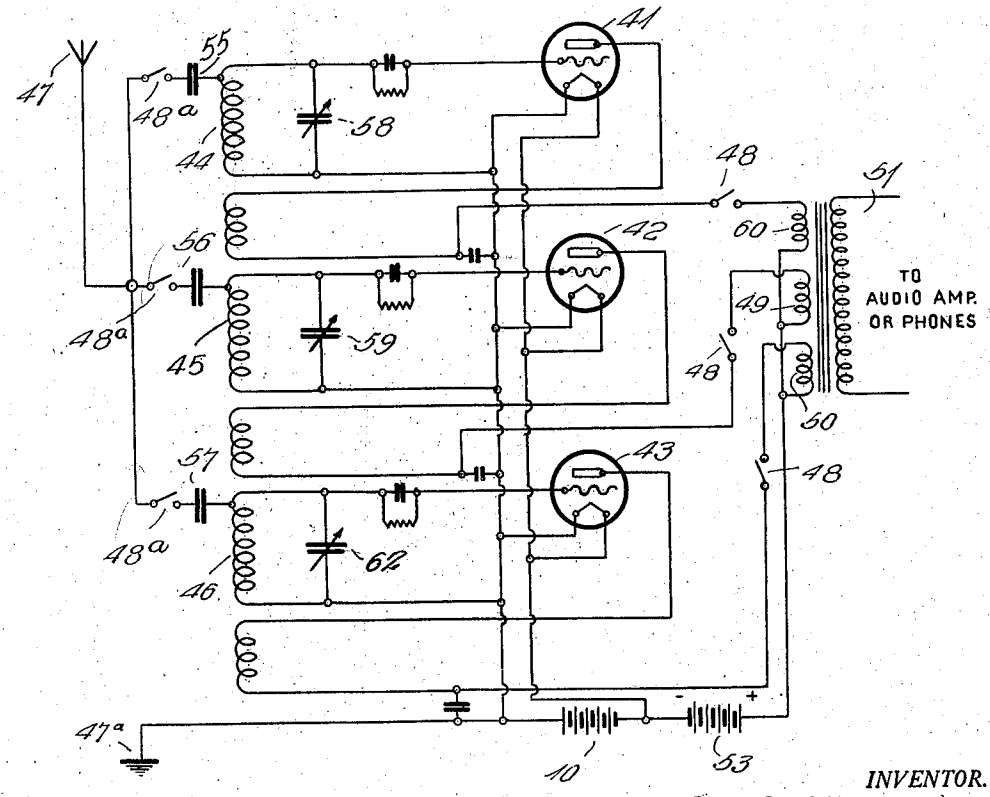


Fig. 3

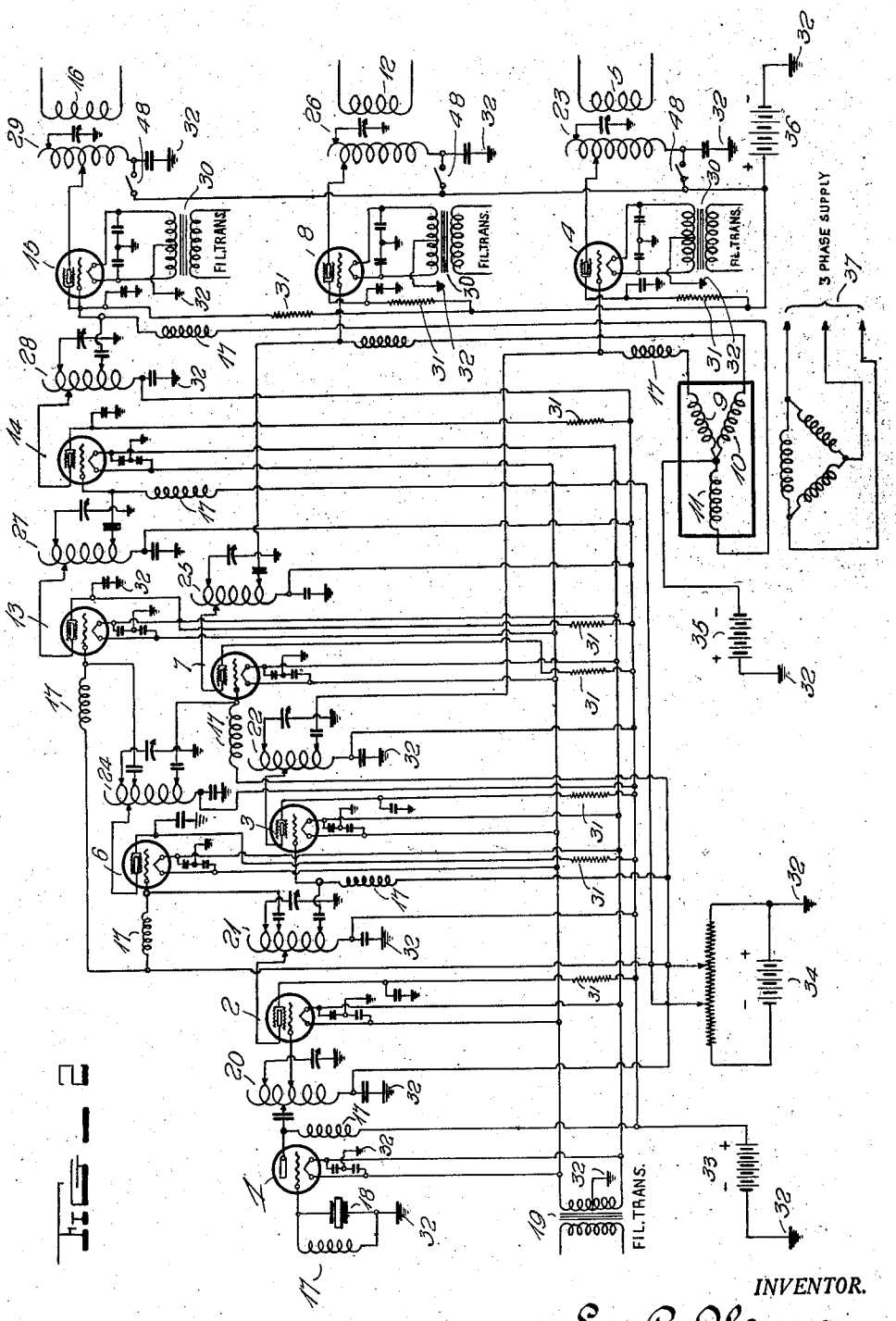


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UNITED STATES PATENT OFFICE

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MULTIPHASE CORNET SYSTEM

Application filed July 20, 1928. Serial No. 294,284.

My invention relates to transmission and reception systems in general and more specifically to systems wherein a plurality of frequencies are employed for the transmission and reception of high frequency signaling energy.

An object of my invention is to provide an improved system for the transmission and reception of high frequency signaling energy whereby uniform reception at all times is made possible.

A general understanding can be had of the transmission and reception system of my invention by referring to the accompanying drawings in which:

Figure 1 is a diagrammatic illustration of the general embodiments of my invention; Fig. 2 is a schematic circuit diagram of the transmission system of my invention and Fig. 3 is a schematic circuit diagram of the receiving system of my invention.

In high frequency signaling systems and especially in systems wherein ultra-high frequency energy is employed, uniform signal strength at the receiving station is not usually obtained during a considerable period of time. Signaling energy of one frequency is subject to fading while at the same time other frequencies are not materially affected. It is also true that the non-uniform reception during day and night and difference in the time between widely distant points interferes with reliable communication. Signaling energy of one frequency might be received with an audible signal strength and simultaneously signaling energy having a frequency differing from the first mentioned signaling energy might be inaudible. However, after an elapse of considerable time the signal strength ratio of the two signals might be reversed.

In the drawings Fig. 1, a master oscillator 1 having frequency characteristics of 4,000 kilocycles is shown associated with an amplifier 2 tuned to the same frequency. The output energy from amplifier 2 is shown coupled to amplifier 3 and a frequency doubling circuit 6. Amplifier 3 is tuned to 4,000 kilocycles and is associated with a second amplifier 4 which is tuned to the same frequency. A load circuit 5 is associated with the output of amplifier 4. A source of energy 9 of varying amplitude controls the operation of amplifier 4 according to the frequency of variation. The output of the frequency doubling circuit 6 is connected to amplifier 7 which is tuned to 8,000 kilocycles. A second amplifier 8 having a load circuit 12 is associated with amplifier 7 and tuned to a frequency of 8,000 kilocycles. A source of energy 10 of periodically varying amplitude is associated with amplifier 8 and controls the operation according to the frequency of variation. A second frequency doubling circuit 3 is associated with frequency doubling circuit 6. Amplifier 14 is connected to frequency doubling circuit 13 and to a second amplifier 15 and load circuit 16. Frequency doubling circuit 13, amplifiers 14 and 15 and load circuit 16 are each tuned to the frequency 16,000 kilocycles. A source of energy 11 of periodically varying amplitude is associated with amplifier 15 and controls the operation according to the frequency of variation. Sources of energy 9, 10 and 11 having different phase relations, energize amplifiers 4, 8 and 15 respectively at different intervals of time. High frequency energy is transmitted to the load circuits 5, 12 and 16 at successive intervals of time. In the example cited the high frequency signaling energy of 4,000 kilocycles is transferred to the load circuit 5, followed by the 8,000 kilocycle signaling energy transferred to the load circuit 12 and the latter followed by the 16,000 kilocycle signaling energy transferred to load circuit 16. The cycle is then repeated.

Referring to the schematic circuit diagram Fig. 2, the circuit arrangement and electrical connections are illustrated. A thermionic vacuum tube 1 having grid, filament and plate electrodes and grid, filament and plate circuits associated therewith, constitute a source of high frequency signaling energy. The filament circuit is illustrated as being energized from an alternating current transformer 19 having a connection from its electrical center to ground 32. The grid circuit of thermionic vacuum tube 1 includes a mechanically vibratile element 18,

which may be a piezo electric crystal, and radio frequency choke coil 17. One terminal of the mechanically vibratile element 18 and of radio frequency choke coil 17 is connected to ground. This connection completes the grid circuit since the electrical center of the filament is likewise connected to ground 32. The mechanically vibratile element 18 maintains the oscillatory circuit, of thermionic vacuum tube 1 at a constant frequency. The radio frequency plate circuit includes inductance 20 and suitable capacities. The plate circuit is adjusted to a frequency value corresponding to the approximate frequency characteristics of mechanically vibratile element 18. The direct current plate supply includes source 33, the negative terminal of which is connected to ground 32, and radio frequency choke coil 17 which excludes radio frequency energy from direct current source 33. Vacuum tube 2 having grid, filament, plate and shielding plate electrodes amplifies the radio frequency output energy from oscillator 1. The grid electrode of amplifier 2 is supplied with a biasing potential from source 34. The positive terminal of source 34 is shown grounded although the polarity might be in the reversed order depending upon the particular characteristics of vacuum tube 2. A resistance 31 is employed in series with the shielding plate potential 33 whereby the plate has a higher positive potential in respect to the shielding plate electrode and filament circuits. Inductance 21, in the radio frequency plate circuit, is tuned to a frequency value corresponding to the frequency of the oscillator 1. A second amplifier is associated with amplifier 2 and includes vacuum tube 3 having filament, grid, plate and shielding plate electrode and associated circuits. Inductance 22, in the output circuit of amplifier 3 is tuned to a frequency value corresponding to amplifier 2. A source of grid biasing potential 34 maintains the grid electrode of amplifier 3 at the proper potential depending upon the characteristics of the particular type of tube employed. Resistance 31 is employed in series with the shielding plate electrode and source of plate potential 33. A parallel connected grid bias circuit is shown employing a radio frequency choke coil 17 for excluding radio frequency energy from source of potential 34. The input circuit of a third amplifier 4 is associated with the output circuit of amplifier 3. Amplifier 4 includes a thermionic vacuum tube having grid, filament, plate and shielding plate electrodes and associated grid, filament and plate circuits. A source of potential of varying amplitude 9 energizes the grid electrode according to the frequency of variation. A constant value of potential 35 is shown connected in series with the source of varying potential 9 and the grid circuit of amplifier 4. The plate circuit of amplifier 4 includes inductance 23 which is tuned to a frequency value corresponding to that of amplifier 3. The filament circuit of amplifier 4 is shown energized by transformer 30, the electrical center connected to ground 32. A source of plate potential 36, with its negative terminal connected to ground 32 also supplies a positive potential to the shielding plate electrode through resistance 31. A switch 48 is provided for interrupting the operation of amplifier 4 if so desired. A load circuit 5 is associated with inductance 23, and may be either a space radio radiating system, a wired radio transmitting system or additional amplifier circuits.

A frequency doubling circuit is associated with the plate circuit inductance 21 of amplifier 2 and includes thermionic vacuum tube 6 having grid, filament, plate, shielding plate electrodes and associated grid, filament and plate circuits. A source of grid biasing potential 34 maintains the grid electrode of thermionic vacuum tube 6 at the proper potential for best operation. The value of the potential and polarity of the same depends upon the operational characteristics of the particular type of tube employed. Radio frequency choke coil 17 excludes radio frequency energy from the source of potential 34. The plate circuit of vacuum tube 6 includes inductance 24 which is tuned to a frequency value corresponding to twice the frequency of amplifier 2. Source of plate potential 33 is connected in series with inductance 24, the plate electrode and the ground connection 32 which is common to the electrical center of all filament circuits. The shielding plate electrode is supplied with a positive potential from source 33 through resistance 31. An amplifier is associated with the output circuit of frequency doubling circuit 6 and includes thermionic vacuum tube 7 having grid, filament, plate, shielding plate electrodes and associated grid, filament and plate circuits. A source of grid biasing potential 34 supplies the proper potential to the grid electrode. Radio frequency choke coil 17 excludes radio frequency energy from source of potential 34. A source of potential 33 supplied the plate electrode and shielding plate electrode with a positive potential in respect to the filament circuits. Resistance 31 is included in the potential supply circuit to the shielding plate electrode thereby giving it a lower potential in respect to the potential supplied the plate electrode. The plate circuit of amplifier 7 includes inductance 25 tuned to a frequency corresponding to the frequency of inductance 24. A second amplifier 8 of similar circuit arrangement is coupled to the output circuit of amplifier 7. A source of potential of varying amplitude

10, 35 is supplied the grid electrode of amplifier 8. A load circuit 12 is associated with plate circuit inductance 26, and is tuned to a frequency value corresponding to the frequency of amplifier circuits 7 and 8. A frequency doubling circuit 13, is associated with frequency doubling circuit 6 and tuned to a frequency corresponding to twice the frequency of amplifier 7; that is four times the frequency of the source of signaling energy 1. Amplifiers 14 and 15 are of similar circuit arrangement to amplifiers 7 and 8 respectively. The frequency characteristics of inductances 28 and 29, however, are of a value twice the frequency of inductances 25 and 26 respectively. A load circuit 16 is coupled to the plate circuit of amplifier 15. A separate source of grid biasing potential 11, 35 of varying amplitude controls the operation of amplifier 15 in accordance with the frequency of variation.

A source of multi-phase potential 37, herein illustrated as a three phase alternating current, supplies a potential of varying amplitude and alternating potential to the respective grid circuits of amplifiers 4, 8 and 15. Because of the source of constant potential direct current 35, the respective grid circuits will be energized by a potential of varying amplitude in alternate rotation. When the proper potential is not supplied the respective grid electrodes of amplifiers 4, 8 and 15 no amplification of the signal results. By exciting the respective grid circuits at successive intervals of time, the amplification of signaling energy and the energization of the respective load circuits will correspond to the frequency of such excitation.

A schematic circuit diagram of the receiving system of my invention is shown in Fig. 3 wherein 47 and 47ª represent antenna and ground connections respectively. Instead of a space radio receiving system, the source of incoming signaling energy could be a wired radio system or several aperiodic amplifiers having no natural period of their own. Three thermionic vacuum tubes 41, 42 and 43 each having grid, filament and plate electrodes, are connected in regenerated circuit arrangements. The respective grid circuits associated with vacuum tubes 41, 42 and 43 include inductances 44, 45 and 46 and capacities 58, 59 and 62 respectively. The audio frequency plate circuits of vacuum tubes 41, 42 and 43 include the transformer windings 60, 49 and 50 respectively. A single output winding 51 may connect to an audio frequency amplifier or directly to a reproducer. The three plate circuits include a source of potential 53. The three grid circuits are tuned to three different frequencies corresponding to the three respective frequencies transmitted. Switches 48ª are provided whereby either or all of the three receiving circuits may be employed. Coupling capacities 55, 56 and 57 are provided for transferring the respective sources of high frequency signaling energy to the thermionic vacuum tube circuits 41, 42 and 43. These capacities can be of the proper value corresponding to the particular frequency of the source of energy transferred to the respective circuits. By referring to both Figs. 1 and 3 an understanding can be had of the operation of the complete system for transmission and reception.

In Fig. 1 the master oscillator 1 maintains the frequency of the complete transmitting system at a constant value. The frequency doublers 6 and 13 double and quadruple the frequencies transferred to the amplifier circuits 8 and 15 respectively. The load circuits 5, 12 and 16, therefore, are supplied with high frequency energy having frequency values corresponding to the fundamental frequency of the master oscillator, the first even harmonic and the second even harmonic respectively. The three frequencies, in the example cited, are 4000 kilocycles, 8000 kilocycles and 16,000 kilocycles respectively and are amplified and transferred to the respective load circuits 5, 12 and 16 at different time intervals as determined by the multi-phase sources of potential 9, 10 and 11. Thus the fundamental and multiple frequencies are controlled from a common source 1 and modulated by means of a multi-phase alternating current or multi-phase rate of fluctuating direct current so that the fundamental frequency and the multiple frequencies thereof are radiated or transmitted in rotation or succession one after the other.

Since the high frequency energy of the fundamental frequency and the energy of the respective harmonic frequencies bear a definite phase relation without regard to sources 9, 10 and 11, it is obvious that this phase relation will continue when the three frequencies are combined at the receiving station. Without deriving the harmonic frequencies from a single high frequency master oscillator but from different oscillators, it is obvious that the high frequency energy of the fundamental and the energy of the harmonics would neutralize each other, which would not be desired.

The reference herein to signaling energy includes any form of high frequency energy adapted for signaling purposes. The superimposition of signals upon the carriers may be in common or individual in any manner desired as is well known to those skilled in the art. The signaling may be accomplished by keying any or all of the several amplifiers, the common amplifier or in any manner desired. The carrier energy may be modulated by voice frequencies, by any of the

various means well known to those skilled in the art.

In Fig. 3, the three grid circuits associated with thermionic vacuum tubes 41, 42 and 43 are adjusted to frequency values corresponding to 4000 kilocycles, 8,000 kilocycles and 16,000 kilocycles respectively. The multi-phase relation of the respective frequencies corresponds to the multi-phase relation as transmitted. In the output circuit 51 the audio frequency signal strength will be the sum of the received audio frequency signal strength in the respective windings 60, 49 and 50, neglecting losses and the fact that there still exists a phase relation between the respective frequencies. The effect however is as though the strength of the respective audio frequencies is the sum of the individual frequencies. It is therefore evident that fading on one frequency would subtract only little from the strength of the audio frequency signal in the output circuit 51. The fading at one frequency is usually accompanied by a uniform, or sometimes increased, signal at other frequencies. Due to the non-uniform signal strength at the various frequencies during the day and night cycle, the highest frequency channel may be dispensed with, employed alone or in combination with one of the other frequency bands. Interference from other stations or severe static disturbances on one frequency can be eliminated by not employing that particular frequency band.

In the foregoing specification and accompanying drawings, the particular frequencies chosen are chosen only for the purpose of explaining the operation and are only arbitrary. The three frequencies employed need not be the fundamental and even multiples thereof, but might be any combination of high frequencies, combination of lower frequencies or combination of relatively ultra-high and high frequencies. Batteries are illustrated as sources of constant potential, however it is obvious that any suitable source of potential may be employed. The source of potential for energizing the filaments might be a constant source of direct current instead of the alternating current supply illustrated. Three electrode thermionic vacuum tubes may be employed in the place of the four electrode tubes illustrated in the amplifier circuits. Some of the circuits are shown employing series connected plate supply and parallel connected grid biasing supply. It is likewise obvious that the plate circuits and grid circuits may be supplied with a potential connected in any suitable manner. Frequency doublers are shown but it is understood that any frequency multiplier could be employed without departing from the spirit of my invention. The three phase alternating current for periodically controlling the respective amplifiers might be rectified before it is employed to energize the respective grid circuits. Such means for alternately energizing the respective circuits might be employed by causing a multi-phase current, either alternating or direct, to successively energize the respective plate electrodes thereby controlling the phase relation of a plurality of transmitted frequencies. It is likewise obvious that the intermediate amplifiers 3, 7 and 14 may be dispensed with, or the circuits of these amplifiers may be controlled by the sources of multi-phase energy 9, 10 and 11 thereby controlling the input energy to amplifiers 4, 8 and 15 respectively and hence the energy in the associated load circuits 5, 12 and 16.

In Fig. 3, the three vacuum tube circuits need not be of the regenerative type illustrated but might be radio frequency amplifiers or audio frequency amplifiers. The output transformer and windings 60, 49, 50 and 51 might be either air core or iron core depending on the frequency. The antenna circuit 47, 47a might be either the output circuit of a wired radio transmission system or the output of preceding amplifier circuits. I realize that many circuit arrangements may be employed differing from those illustrated in the accompanying drawings and described in the foregoing specification without departing from the spirit of my invention and it is not intended that my invention be restricted to the accompanying drawings or to the foregoing specification but only as defined in the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is as follows:

1. A high frequency transmission system comprising a common source of high frequency signaling energy, means for doubling the frequency value of said high frequency source of energy, means for amplifying the energy at a frequency corresponding to the frequency of said source of energy, means for amplifying said double frequency and means for causing alternate transmission of signals having a frequency corresponding to the frequency of said source of energy and said double frequency energy at successive intervals of time.

2. A high frequency transmission system comprising a single source of high frequency signaling energy, means for amplifying harmonic frequencies of the energy of said source of energy, means for amplifying the energy at a frequency corresponding to the frequency of said source of energy and means for causing the transmission of said source of energy and said harmonic frequencies in a predetermined alternate order.

3. A high frequency transmission system comprising in combination a source of high frequency energy, means for amplifying the

energy at a frequency corresponding to the frequency of said source of energy, means for amplifying harmonic frequencies of the frequency of said source of energy and a plurality of sources of energy having a definite phase relation associated with said amplifying means whereby the energy of fundamental frequency of said source of high frequency energy and the energy of said harmonic frequencies are amplified in a predetermined alternate and successive order.

4. A transmitting system comprising in combination a thermionic vacuum tube circuit arrangement for generating oscillations of high frequency energy, thermionic vacuum tube amplifying means for amplifying said generated oscillations, means for amplifying harmonic frequency energy of the generated high frequency energy and means for alternately energizing said first mentioned amplifying means and said last mentioned amplifying means for effecting the alternate transmission of the fundamental frequency energy of said generated oscillations and said harmonic frequency energy.

5. A transmitting system comprising in combination constant frequency generating means, means for amplifying the fundamental frequency of the generated energy from said means, means for amplifying harmonic frequency energy of said fundamental frequency energy from said generating means, sources of varying potential for energizing said amplifying means and means for alternately energizing said amplifying means at predetermined successive intervals of time.

6. In a transmitting system wherein a fundamental frequency of a source of high frequency energy and a plurality of harmonic frequencies of the fundamental frequency of said source are transmitted, means for alternately energizing said system whereby said fundamental frequency and the energy of said harmonic frequencies are transmitted at predetermined successive intervals of time.

7. A high frequency transmission system comprising in combination a constant frequency vacuum tube oscillator circuit, a plurality of amplifiers adjusted to frequency values corresponding to a plurality of different multiples of the oscillator frequency and a multi-phase source of energy for alternately and in successive order energizing said amplifiers from said multi-phase source of energy.

8. A high frequency transmission system comprising in combination a source of constant frequency energy, means for amplifying the energy of fundamental frequency of said energy, means for amplifying the energy of harmonic frequencies of said high frequency energy and a source of multi-phase energy for alternately energizing said amplifying means in successive order.

9. A transmission system comprising in combination a thermionic vacuum tube oscillator circuit, a plurality of vacuum tube amplifiers for amplifying the energy of the fundamental frequency of said oscillator circuit and the energy of the harmonic frequencies of said oscillator circuit respectively by alternately energizing said amplifiers from a source of multi-phase potential.

10. A transmission system of high frequency energy comprising in combination a source of high frequency energy, means for selecting and amplifying energy of the harmonic frequencies of said source of energy and means to alternately and in successive order transmit energy of the fundamental frequency of said source of energy and the energy of said harmonic frequencies.

11. A transmission system wherein the fundamental high frequency energy of constant frequency value and energy of multiple frequency of said high frequency energy are amplified by independent means, means for alternately and in successive order transmitting the fundamental frequency energy of said high frequency energy and said multiple frequency energy by alternately energizing said independent means.

12. A transmission system of high frequency signaling energy comprising in combination a thermionic vacuum tube oscillator circuit and means for maintaining the frequency characteristics of the same constant, means for amplifying the fundamental frequency energy of the high frequency energy from said oscillator, means for amplifying harmonic frequency energy of the fundamental frequency energy of said oscillator circuit and a source of multi-phase potential for alternately energizing said amplifiers in successive order to effect alternate transmission of said fundamental frequency energy and said harmonic frequency energy.

13. A transmission system for high frequency signaling energy comprising in combination a source of constant frequency energy of fundamental frequency and energy of harmonic frequencies of said source of energy, a source of multi-phase energy and means for causing said source of multi-phase energy to control the alternate transmission of the fundamental frequency of said source of energy and the energy of said harmonic frequencies.

14. A transmission system for high frequency signaling energy comprising in combination a thermionic vacuum tube oscillator circuit for generating high frequency energy of a fundamental frequency, means for amplifying said high frequency energy of fundamental frequency, means for selecting and amplifying energy of even multiple harmonic frequency of said high fre-

quency energy of fundamental frequency, a plurality of sources of electrical energy and means for causing said last mentioned sources of energy to energize said amplifying means according to the phase relation of said last mentioned sources of energy whereby said energy of fundamental frequency and energy of even multiple harmonic frequency is transmitted in alternate order.

15. A transmission system of high frequency signaling energy comprising in combination a thermionic vacuum tube generating means and a mechanically vibratile element for maintaining the frequency of said generating means constant, thermionic vacuum tube amplifiers having the frequency characteristics thereof adjusted to amplify the fundamental frequency of said signaling energy from said generating means, thermionic vacuum tube amplifiers having the frequency characteristics thereof adjusted to amplify energy having frequency values corresponding to harmonic frequencies of said signaling energy of fundamental frequency, a source of multi-phase energy associated with said amplifiers and means for causing said source of multi-phase energy to excite said first and last mentioned amplifiers in alternate and successive order corresponding to the frequency of said source of multi-phase energy.

16. A high frequency transmission system comprising a thermionic vacuum tube generator of constant frequency energy, means for causing multi-phase sources of potential to energize said system whereby the fundamental frequency of said constant frequency energy and harmonic frequency energy of said constant frequency energy alternately energize associated load circuits at predetermined successive intervals of time.

17. A system for the transmission of high frequency signaling energy comprising in combination a thermionic vacuum tube high frequency oscillator for producing high frequency energy, means for selecting harmonic frequency energy of said high frequency energy from said oscillator, a multi-phase source of electrical energy and means for causing the transmission of the fundamental frequency of said high frequency energy and said harmonic frequency energy in alternate and successive order according to the frequency of said multi-phase source of electrical energy.

18. A high frequency transmission system comprising in combination a thermionic vacuum tube oscillator for generating high frequency energy, thermionic vacuum tube amplifying means associated with said oscillator, a source of multi-phase electrical energy and means for causing said multi-phase energy to alternately energize amplifiers having their frequency characteristics adjusted to the fundamental frequency of said generating means and amplifiers having their frequency characteristics adjusted to harmonic frequencies of the fundamental frequency of the generated energy whereby the energy of said harmonic frequencies and the energy of said fundamental frequency are alternately transmitted.

19. A system for the transmission of high frequency energy comprising in combination a source of constant frequency signaling energy, means for selecting harmonic frequencies of the fundamental frequency of said source of signaling energy and a source of multi-phase energy for causing the alternate transmission of the energy of fundamental frequency of said source of signaling energy and said harmonic frequencies of the fundamental according to the frequency of said source of multi-phase energy.

20. A transmission system of high frequency signaling energy comprising in combination a thermionic vacuum tube for generating high frequency energy, means for selecting energy of harmonic frequency of the fundamental frequency of said generated energy, a source of multi-phase electrical energy and means for causing said multi-phase energy to control the alternate transmission of said generated high frequency energy of fundamental frequency and said energy of harmonic frequency in a successive and alternate order as determined by the frequency of said source multi-phase electrical energy.

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