Oct. 19, 1926. 1,603,600

R. A. HEISING

SIGNAL TRANSMISSION SYSTEM

Filed June 28, 1922

Fig. 1.

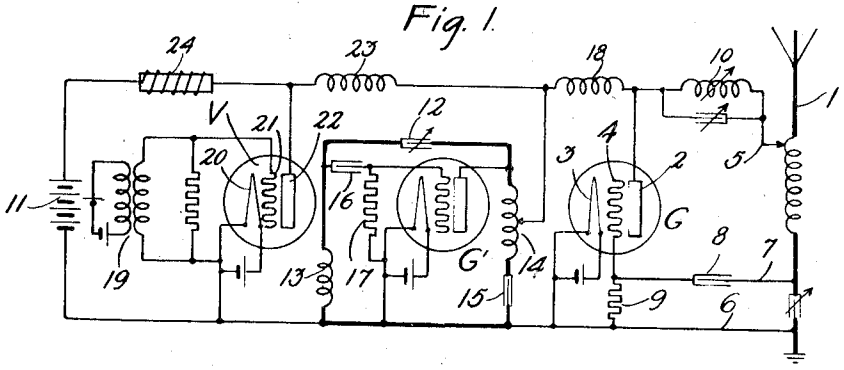


Fig. 2.

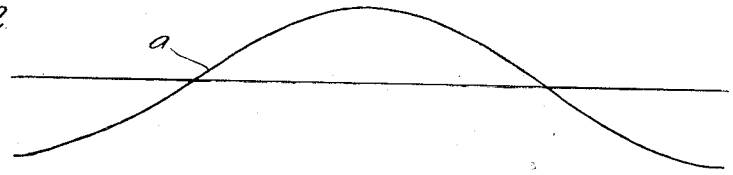


Fig. 3.

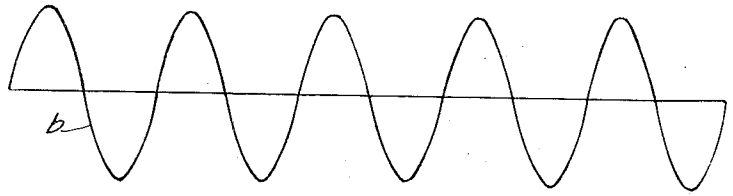


Fig. 4.

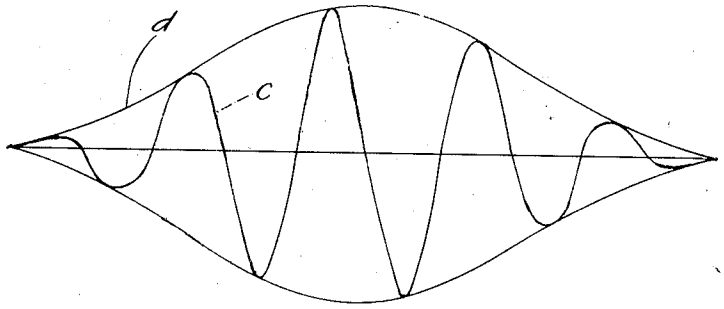
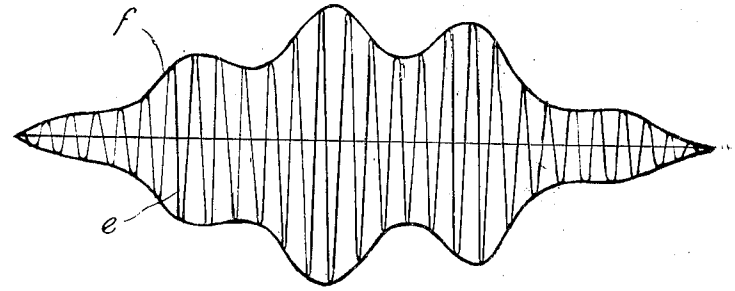


Fig. 5.



Inventor:
Raymond A. Heising.
by J. E. Roberts Att'y.

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UNITED STATES PATENT OFFICE.

RAYMOND A. HEISING, OF MILLBURN, NEW JERSEY, ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

SIGNAL-TRANSMISSION SYSTEM.

Application filed June 28, 1922. Serial No. 571,583.

This invention relates to a method of and apparatus for signaling by means of modulated carrier waves.

The object of the invention is to provide apparatus for and methods of signaling whereby the same signal can be transmitted through the agency of two different but simultaneous series of variations in a carrier current or electromagnetic wave.

A further object is to provide apparatus for and methods of producing and transmitting a carrier wave from which the same signal may be produced by detection in one stage or by detection in successive stages.

A further object is to provide a method of and means for producing a high frequency carrier wave, for example, 1,000,000 cycles per second, an intermediate frequency wave, for example 50,000 cycles per second, and a signal wave for example, of speech frequency, the signal wave being utilized to modulate the intermediate frequency wave and the high frequency carrier wave being modulated both in accordance with the signal wave and the modulated intermediate frequency wave.

If several transmitting stations in a given locality comprising apparatus of the kind herein described are operating simultaneously and transmitting on the same high frequency carrier wave but with different intermediate frequencies, a listening station having a single detector will hear a confused combination of all of the signals. However, individual stations having suitable arrangements for detecting a plural number of times and selecting the intermediate frequency corresponding to the station from which it is desired to receive signals will be able to receive from any selected one of the transmitting stations. A suitable arrangement for doing this would comprise a detector, means for selecting the proper intermediate frequency from the output of the detector, and a second detector for deriving the signal from the modulated wave of intermediate frequency.

The apparatus herein described is illustrative of one form only of the invention, the novel features of which are defined in the appended claims, and may be suitably modified in various ways as will be obvious to those skilled in the art. Certain features of the system are of general application.

Referring to the drawings, Fig. 1 is a diagram of a complete transmitting system making use of electric discharge devices in the form of vacuum tubes, and Figs. 2 to 5 inclusive are diagrams of the wave forms of oscillations existing in different parts of the system.

In Fig. 1 the antenna 1 constitutes an oscillatory or tuned circuit which is connected to the anode 2, cathode 3 and control element 4 of a highly evacuated vessel G of the audion type by leads 5, 6 and 7 respectively. In lead 5 are inductance and capacity elements which together constitute a tuned resonant circuit 10 whose function is hereinafter stated. In lead 7 is located stopping condenser 8. The leak resistance 9 connects the grid and the cathode. Space current for tube G and the other tubes hereinafter mentioned is supplied from the battery 11. The elements so far described function to generate high frequency oscillations in the antenna 1.

A second generating system for generating oscillations of a lower frequency, which will be herein referred to as the intermediate frequency, is constituted by the tube G′ which has associated therewith a tuned circuit comprising variable capacity 12, inductances 13, 14 and the large capacity 15. The usual stopping condenser 16 and high resistance leak path 17 are provided. Capacity 15 and the variable portion of the inductance 14 are coupled to the high frequency generating system by suitable connections so that oscillations existing in the intermediate frequency system will cause corresponding potential variations between the anode 2 and the cathode 3. Choke coil 18 is designed to offer a high impedance to currents of the high frequency and a relatively low impedance to currents of the intermediate frequency. Circuit 10 is tuned to the intermediate frequency and tends to prevent oscillations of the intermediate frequency from being impressed upon the antenna.

A vacuum tube V, similar to tubes G and G′, has its input circuit controlled by a microphone circuit 19 which is connected to impress variable potentials of the frequency of sound waves upon the control electrode 21 and the cathode 20. These potentials will cause corresponding variations of impedance of the conductive space between the cathode

20 and the anode 22. Inductance coil 23 is designed to offer a relatively high impedance to currents of the intermediate frequency but relatively low impedance to currents of speech or audible frequency. Choke coil 24 is designed to offer large impedance to current variations of the frequency of audible waves.

It will be observed that in the anode-cathode circuit of the generator G will be high frequency carrier currents, low frequency carrier currents and speech frequency currents superimposed upon direct current; in the anode-cathode circuit of generator G' will be superimposed the same currents with the exception of the high frequency carrier currents which are kept out by choke coil 18. In the anode-cathode circuit of tube V will be speech currents superimposed upon direct current. Direct current only will flow through the battery 11 as the series of coils 18, 23 and 24 will effectually keep all current variations of material magnitude out of the battery circuit.

In operation, the oscillations of the high and intermediate frequency systems will be varied in amplitude or modulated in accordance with sounds acting upon the microphone, while the high frequency oscillations will also be modulated in accordance with the modulated intermediate frequency oscillations.

The operation of this system may be understood by reference to the diagrams of Figs. 2, 3, 4 and 5. The curves of these diagrams are illustrative only and should not be understood to be exact as to wave form, phase relationship or relative intensities of the various factors involved, since these will depend upon the particular value of various constants of the system. In Fig. 2, curve *a* may be assumed to represent the sinusoidal current wave of audible frequency; in Fig. 3, curve *b* represents the unmodulated oscillations of the intermediate frequency; in Fig. 4, curve *c* represents the modulated intermediate frequency whose envelope *d* is of the frequency and general wave form of *a*; and in Fig. 5, curve *e* represents the high frequency modulated oscillations in the antenna whose envelope *f* varies in accordance with the frequencies and wave form of each of the curves *a* and *c*. If electric currents of the type illustrated by curve *e* be detected, the output of the detector will contain a current component represented by curve *a* and another component represented by curve *c*. If the first of these components be disregarded and the second be again detected, a component corresponding to the curve *a* will again be obtained in the output of the second detector.

While described as a radio transmitting system, this system may be adapted for use with a suitable conductive line connecting it with one or more receiving stations, as for example, by substituting a tuned circuit for the antenna 1 and coupling the line thereto.

It is within the scope of the invention to modulate by varying, at any desired stage, the amplitude, frequency, or other characteristic, or a combination of characteristics of the wave to be acted upon, or by generating a wave having the desired varying characteristic or characteristics.

The subject matter hereinafter claimed comprises a portion of the subject matter of applicant's application Serial No. 272,153, filed January 20, 1919, which has been abandoned.

What is claimed is:

1. In combination, an electron discharge device, means whereby said device functions as an oscillation generator, a second electron discharge device, means whereby the second device functions as a generator of oscillations of a frequency different than that of said first mentioned device, a third electron discharge device, means for causing current variations therethrough at a rate different from the frequency of either of said generators, and a common constant current source for supplying space current to said discharge devices.

2. In combination, a high frequency oscillation generating system, an intermediate frequency oscillation generating system coupled thereto for causing variations of amplitude in the high frequency oscillations generated, means for reducing the reaction of the first system upon the second, a lower frequency variation producing system coupled to the first and second systems for causing variations in amplitude of their generated oscillations, and means for reducing the reaction of the second system upon the third.

3. In combination, a space discharge device having an anode, a cathode and an impedance-varying element, a second space discharge device having an anode, a cathode and an impedance-varying element, a third space discharge device having an anode, a cathode and an impedance-varying element, means whereby the first of said devices causes a variation in voltage between the anode and the cathode of the second and third, and means whereby the second causes variations of voltage between the anode and the cathode of the third.

4. In combination, a tuned circuit, a vacuum tube device including an anode, a cathode and an impedance-varying element for generating oscillations in said circuit, a second tuned circuit, a second vacuum tube device including an anode, a cathode and an impedance-varying element for generating oscillations in said second circuit, said second circuit being coupled to a circuit including a conductive space of said first mentioned

vacuum tube device, a microphone controlled vacuum tube device and output circuit therefor, means for coupling the said output circuit to a circuit including a conductive space of said first mentioned vacuum tube device, and a common source of space current for said devices.

5. An energy transforming system comprising more than two electron discharge systems, input circuits individual to said systems, means for applying voltages of different frequencies to the respective input circuits, means for supplying space currents to said systems and maintaining the sum thereof of substantially constant, and output means for utilizing the energy transformed by said transforming system.

6. A system comprising a thermionic generator of oscillations, a source of modulating waves for said generator, and a modulating device controlled thereby, a portion of the circuit of said generator being in circuit with said source and in circuit with said device.

7. A system comprising a space discharge device, a source of waves to control said device, an amplitude varying device controlled by said discharge device, and a circuit connected between two electrodes of said space discharge device having a portion in common with circuits including said source and said amplitude varying device respectively.

8. A system comprising a space discharge device having an external circuit, a controlling device therefor, and a device controlled thereby, a portion of said circuit being in common to circuits including said last mentioned devices respectively.

9. A system comprising three devices which function respectively as first, second and third sources of waves of different frequencies, means functioning in cooperation with said second device whereby the waves produced by it are varied in accordance with the waves produced by the first device, and means functioning in cooperation with said third device whereby the waves produced by it are varied in accordance with the varied waves produced by said second device and additional means functioning in cooperation with said third device, whereby the waves produced by it will also be varied in accordance with the waves produced by said first device.

10. A vacuum tube system comprising a series of at least three vacuum discharge devices connected in a circuit arrangement which supports current variations of different ranges in combination with means for excluding the high frequency variations from all but one of the devices, means for excluding the next lower frequency from all but one of the remaining devices, and so on to the last device of the series from which all but the lowest frequency variations are excluded, in combination with means whereby one of said devices is caused to support current variations of all the frequencies.

11. A system in accordance with claim 10 in combination with a source of discharge current for all said devices.

12. A radio system comprising sources of low frequency current, intermediate frequency current and high frequency current in combination with three choke coils arranged in series, each of said coils being designed to offer high impedance to a range of frequencies including the frequency of one of said sources and a relatively low impedance to ranges of frequencies including the frequency of such of the said sources as are of lower value.

13. A circuit for use in signaling systems whereupon voltages of at least three frequencies are impressed, comprising at least three sets of conductively connected apparatus, impedance means included in said circuit whereby one set is limited to supporting currents of only one of said frequencies, impedance means functioning in cooperation with said first named impedance means whereby the second set is limited to supporting currents of that frequency and the next higher frequency, and means whereby the third set supports currents of all three frequencies.

In witness whereof, I hereunto subscribe my name this 27th day of June, A. D. 1922.

RAYMOND A. HEISING.