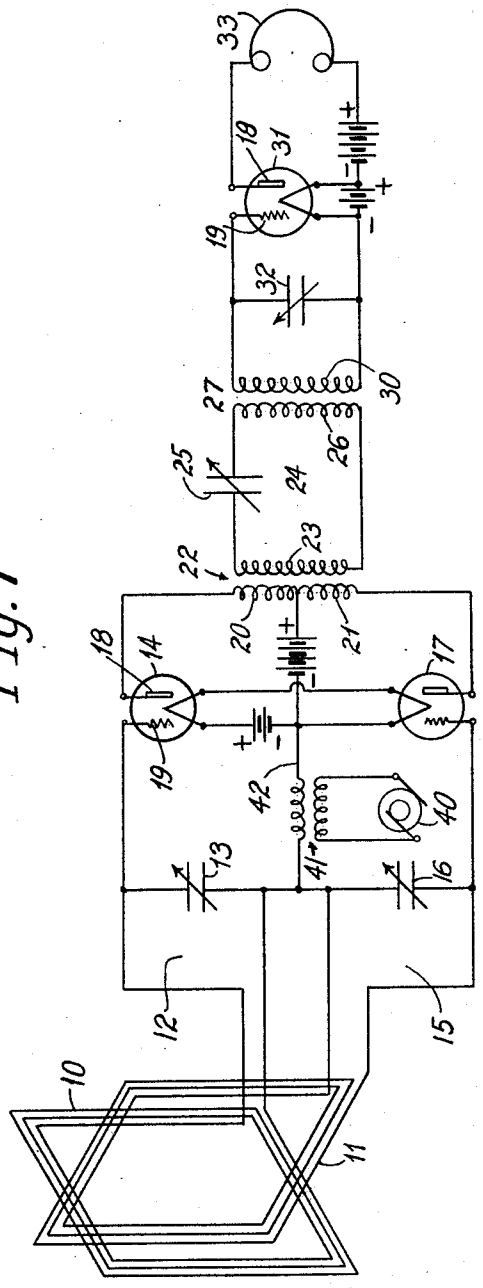
June 18, 1929. E. L. CHAFFEE 1,717,662

MULTICHANNEL RADIO SYSTEM AND METHOD OF RADIO RECEPTION

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Fig. 1



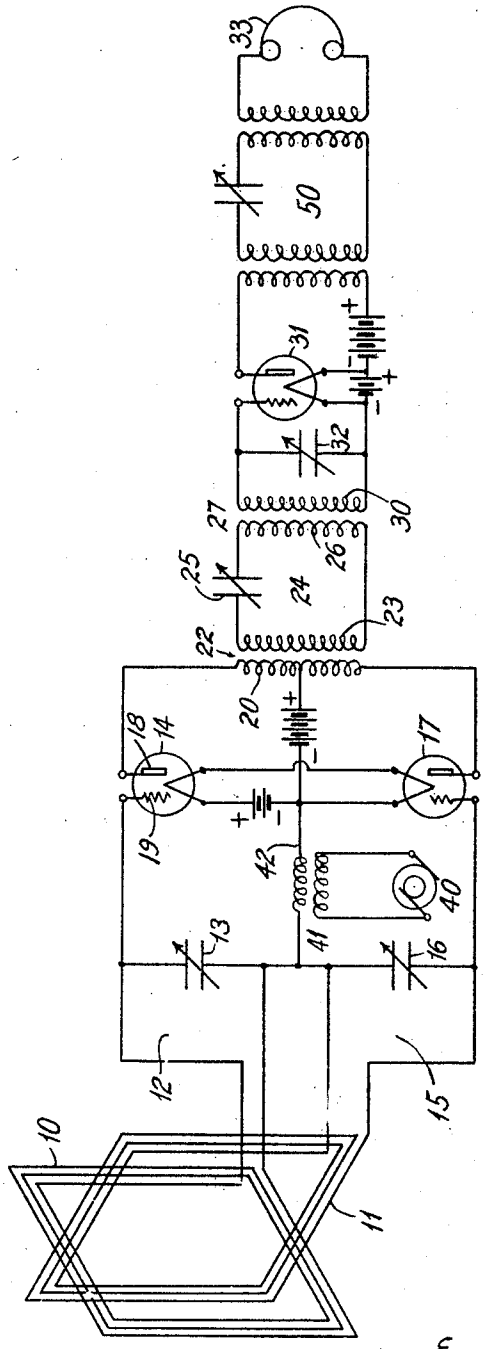
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MULTICHANNEL RADIO SYSTEM AND METHOD OF RADIO RECEPTION

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Fig. 2



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MULTICHANNEL RADIO SYSTEM AND METHOD OF RADIO RECEPTION

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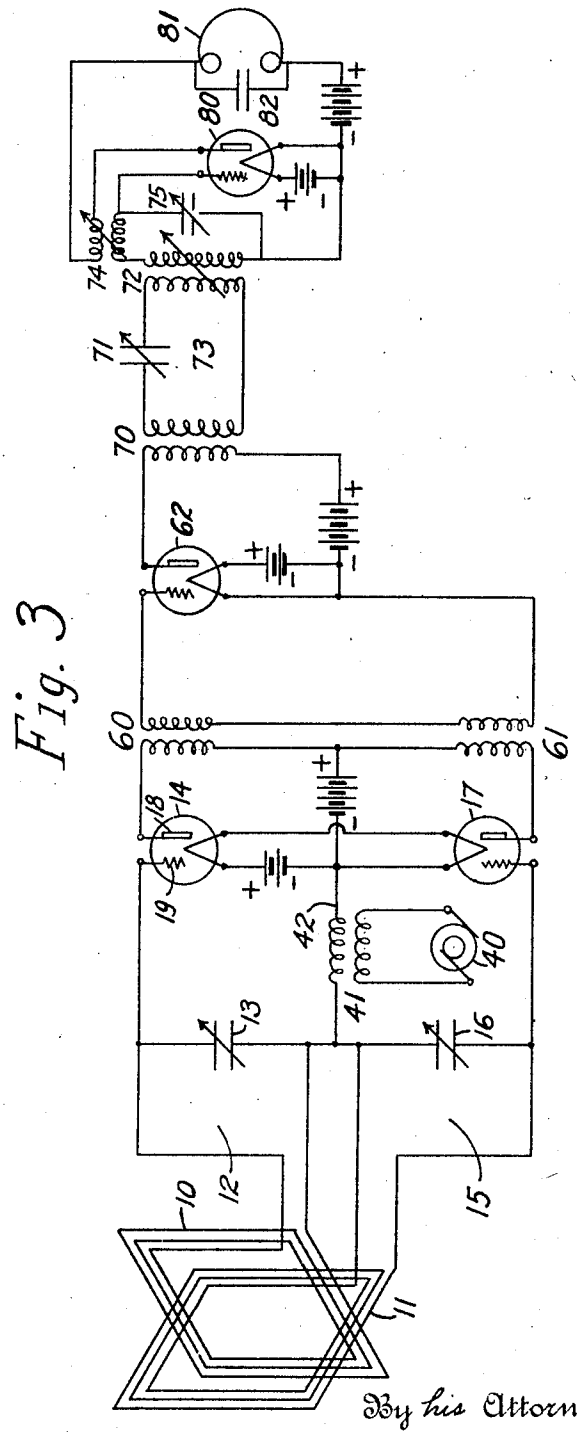


Fig. 3

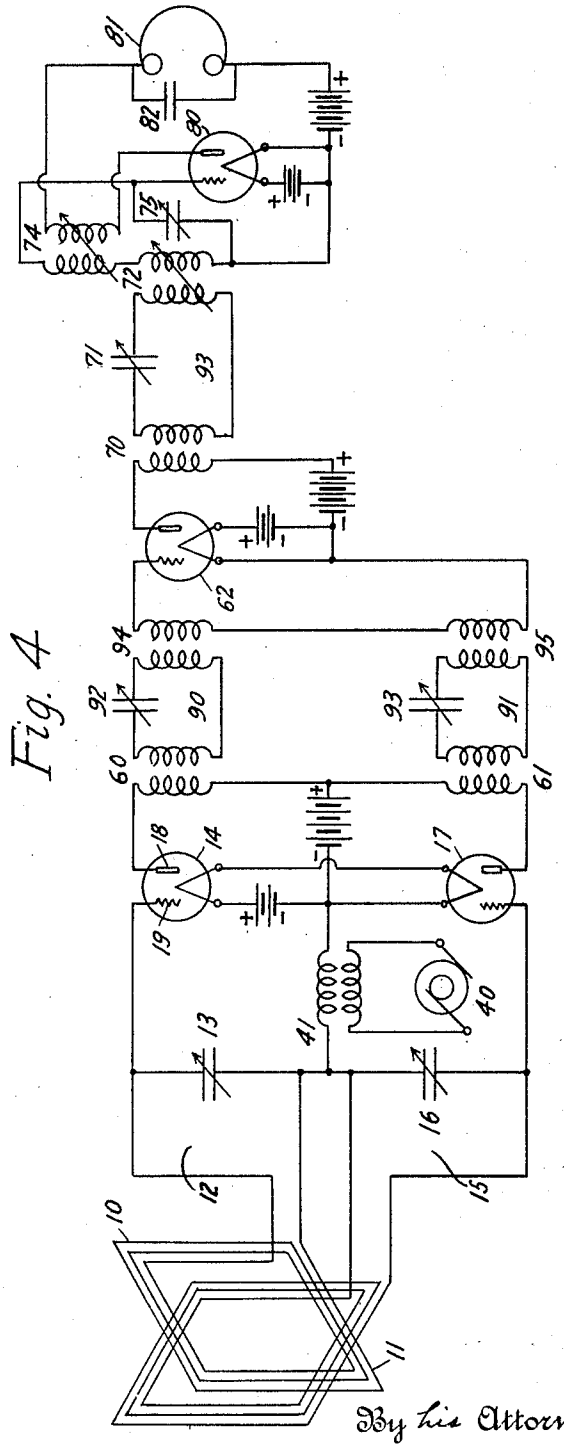
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MULTICHANNEL RADIO SYSTEM AND METHOD OF RADIO RECEPTION

Filed March 31, 1922 4 Sheets-Sheet 4

Fig. 4



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UNITED STATES PATENT OFFICE.

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MULTICHANNEL RADIO SYSTEM AND METHOD OF RADIO RECEPTION.

Application filed March 31, 1922. Serial No. 548,539.

Some of the objects of the present invention are to provide improved selectivity for methods of and systems for communication employing radiant energy; to provide improved means for the reception of radiant signals of such type that unauthorized listening in may be effectually prevented; to provide a system for the transmission of intelligence by Hertzian waves over a plurality of channels whereby a portion of the message may be transmitted over each of the channels so that only receiving stations having receiving apparatus of special character, may receive the complete message; to provide means for producing in connection with all of the channels beat notes of unlike frequencies; and to provide other features which will appear in the following description taken in connection with the accompanying drawing.

Referring to the drawing,

Figure 1 shows a diagrammatic representation of a receiving system embodying the invention;

Fig. 2 shows a modified form of system;

Fig. 3 shows still another form of system; and

Fig. 4 shows another modification of the invention.

In the drawings there is shown so much of the system of transmission of intelligence by Hertzian waves, or so-called wireless system, as is necessary to an understanding of the invention. It is understood that the sending equipment (not shown) is adapted to impress upon the ether a plurality of series of continuous or undamped waves. The message is transmitted by intermittently emitting or interrupting, or by changing the frequency, or modifying any other electrical characteristic, or producing other desired changes in these series of waves; and the plurality of series are employed for portions of the message respectively in sequential order. For example, one of the series or channels may be so modified whenever a dot is to be sent and another series or channel modified when a dash is to be sent. It is understood, however, that any desired method of distributing messages among the various channels may be employed.

Referring to the drawings, and more particularly to Figure 1, there is shown receiving means comprising a loop 10 and a second loop 11 at right angles thereto, both loops being positioned at an angle of substantially 45° to the direction from which the radiant energy is expected to be received. The loop 10 forms part of a closed circuit 12 including an adjustable condenser 13, resonant to a predetermined frequency, which frequency will be hereinafter represented by the symbol A_1.

The circuit of the loop 10 is operatively connected to a three-electrode electron device 14 having a usual heated filament forming a hot cathode for emitting electrons, a plate 18 upon which the electrons impinge, and a grid 19 for controlling their passage. The grid is connected to the loop 10 so as to be controlled by electrical oscillations flowing therein.

The loop 11 forms part of a closed circuit 15 in a similar manner. The circuit 15 includes an adjustable condenser 16 and is resonant to a second frequency A_2 differing from the first named frequency A_1. The circuit of the loop 11 is similarly connected to the grid of a second three-electrode electron device 17.

The plate circuits of the devices 14 and 17 include respectively windings 20 and 21 of a transformer 22. Inductively coupled to the windings 20 and 21 is a third winding 23 which is included in a resonant circuit 24 having for example a variable condenser 25 and a winding 26 of a coupling 27.

The coupling 27 is provided with a secondary winding 30 connected in circuit with the grid 19 of a three electrode electron device 31. A tuning condenser 32 may be provided in a conventional manner. The output circuit of the device 31 may include a controlled device such as a telephone receiver 33, which may also take the form of a solenoid or relay to control a movement or function of a body such as a torpedo boat or other object.

A heterodyne of suitable form shown conventionally as an alternator 40 and a transformer 41 is applied to a common conductor 42 included in the grid circuits of both devices 14 and 17. Operation of the heterodyne 40 produces an alternating electromotive force in the conductor 42 and in cooperation with impressed oscillations in the loops 10 and 11 a plurality of series of beats, as will be subsequently set forth.

In the operation of the receiving system of Fig. 1, the frequency of the heterodyne 40

is preferably such as to be less than A_1 and greater than A_2, and to differ from said frequencies by unlike amounts respectively. For example, with a frequency A_1=600,000 cycles per second, and a frequency A_2 of 500,000 cycles, the heterodyne 40 may generate an electromotive force having a frequency of 549,500 cycles per second, giving a beat frequency with A_1 of 50,500 and with A_2 of 49,500. Each of the devices 14 and 17 produces in its output circuit a superimposed current of the respective beat frequency, and by means of the coupling 22 currents of the frequencies 50,500 and 49,500 are induced in the circuit. The resonant circuit 24 is made broadly resonant to these frequencies. This may readily be done since these beat frequencies are relatively close to one another.

In the case cited by way of example, the heterodyne frequency is intermediate A_1 and A_2, and A_1 and A_2 may then differ from each other by any desired amount, other than that mentioned. But if the heterodyne frequency is greater or less than both A_1 and A_2, then these frequencies should differ by a relatively small amount, such as 1000 cycles per second. For example, if A_1=74,500 and A_2=75,500 a heterodyne having a frequency of 25,000 will produce primary beats of 49,500 and 50,500 cycles per second.

It will be noted that in each example, the frequencies of these beating currents differ from each other by 1,000 cycles, and consequently there are produced secondary beats of this frequency. The beating currents are induced by means of the coupling 27 into the circuit of the device 31. The device 31 acting as a rectifier or detector produces in its output circuit a superimposed current of the secondary beat frequency (1000), for controlling the indicator or other controlled device 33.

A modified form of receiving equipment is shown in Figure 2, which differs from Figure 1 in having a tuned circuit 50 between the output circuit of device 31 and the device 33. The circuit 50 is adjusted in a well known manner to be resonant to a frequency of substantially 1000 cycles per second.

In the operation of the system of Figure 2, the incoming radiant energy is received in the same manner as previously described, and causes current oscillations having frequencies differing from each other by for example 1000 cycles per second to co-exist in the circuit 24. The beating currents affect the grid of the device 31, and there is produced in the output circuit of thermionic device 31, acting as a rectifier or detector, a superimposed current having the frequency of the secondary beats, i. e., 1000 cycles per second. The output circuit is inductively coupled to the resonant circuit 50 tuned to the beat frequency and the impulses induced therein actuate the device 33.

Referring to the modified form of system shown in Figure 3, there is provided a pair of receiving loops 10 and 11, closed oscillatory circuits 12 and 15, electron devices 14 and 17, and a heterodyne 40, 41 as in Figure 1.

The plate circuit of the device 14 includes an inductance forming a primary winding of a transformer 60, and the plate circuit of the device 17 includes an inductance forming a primary winding of a transformer 61. The secondary windings of the transformers 60 and 61 are connected in series and are included in the grid or electron controlling circuit of an electron device 62.

The plate circuit of the device 62 includes an inductance forming a primary winding of a transformer 70 whose secondary winding is in series with an adjustable condenser 71 and a primary winding of a transformer 72 to form a closed oscillatory circuit 73 resonant to substantially only a single frequency of current and partially or wholly preventing the flow of currents of other frequencies. The secondary winding of the transformer 72 is connected in series with the secondary winding of a transformer 74 and the grid or electron controlling element of an electron device 80, whose plate circuit includes the primary winding of the transformer 74 and an indicating or other controlled device 81.

The windings of the transformer 74 are adjustably coupled so that the amount of energy induced from the plate circuit of the device 80, in which the primary winding is included, to the grid circuit in which the secondary winding is included, may be varied. The frequency of oscillations fed back may be varied by an adjustable condenser 75, of conventional type, in shunt with said windings collectively. A bypass condenser 82 of relatively small capacity provides a path for these oscillations, independent of the indicating device 81, without materially affecting the sensitiveness of the device 81.

In the operation of the receiving system of Fig. 3 the incoming radiant energy is received in the same manner as described, it being understood that the channels employed may have respectively currents of frequencies of say 500,000 cycles per second and 600,000 cycles per second impressed thereon. The heterodyne 40 may then be adjusted to produce oscillations of say 537,500 and through the agency of rectifying devices 14 and 17 cause primary beat frequencies of say 37,500 and 62,500 cycles per second in the respective plate circuits. These current oscillations exist independently in the circuits of the primary windings of the transformers 60 and 61 and are induced into the circuit of the secondary windings and in-

duced electromotive forces of these frequencies co-exist in said secondary circuit. The oscillations produce secondary beats of a frequency above audibility, in the example named, 25,000, and these beat electromotive forces act upon the grid of the thermionic device 62, acting as a detector, producing thereby rectified output currents in the plate circuit thereof. This secondary beat current is passed by the resonant circuits 73 and acts upon the grid of the thermionic device 80. The device 80 is arranged for so-called autodyne beat reception, the transformer being arranged to feed back a portion of the output current of the device 80 into its grid circuit so that there is produced a second oscillatory current differing in frequency from the secondary beat current existing in the resonant circuit 73 by an amount such that the resulting tertiary beats will actuate the indicating device 81 to produce an audible tone. Under the conditions cited by way of example the second named oscillatory current may have a frequency of 24,000 per second, thus producing tertiary beats of 1000 per second. In the case cited the heterodyne frequency is intermediate the radio frequencies. As in the case of Figure 1 the heterodyne frequency may be outside of these frequencies. For example the radio frequencies may be 600,000 and 625,000 respectively. A heterodyne frequency of 562,500 will give primary beat frequencies of 37,500 and 62,500 respectively. These beating with each other will give a secondary beat current of 25,000, and, assuming that the autodyne has a local feed back frequency of 24,000, there will be produced tertiary beats of 1000 cycles per second.

In the modified embodiment shown in Fig. 4 there is provided a pair of receiving loops 10 and 11, closed oscillatory circuits 12 and 15, electron devices 14 and 17, heterodyne 40, 41, primary windings of transformers 60 and 61 as in Fig. 3.

The secondary windings of the transformers 60 and 61 are included in independent resonant circuits 90 and 91 respectively, these circuits including primary windings of transformers 94 and 95, and suitable condensers 92 and 93 respectively for tuning said circuits to the respective secondary beat frequencies. The secondary windings of the transformers 94 and 95 are connected in series and are included in the grid or potential gradient varying circuit of an electron device 62. The output circuit of the thermionic device 62 is connected in the same manner as in Fig. 3. A secondary winding of the transformer 72 is included in the input circuit of an electron emitting device 80 whose output circuit includes an indicating device 81 and a winding of the transformer 74. By means of this transformer energy is fed back to the input circuit and there is thus produced a current adjusted by varying the condenser 75 to differ from the current to which the circuit 73 is resonant by an amount within the limits of audibility and which may readily actuate the indicating device 81, as in the so-called autodyne reception.

The operation of the embodiment of Fig. 4 is the same as for Fig. 3 with the exception that circuits 90 and 91 being resonant to the resulting secondary beat frequency afford additional selectivity.

It is obvious to those skilled in the art that the systems described may be employed for telegraphy, telephony, or for the control of a movable device such as a boat, or for any purpose of transmitting intelligence where it is desirable to afford secrecy and to avoid interference by others.

Each of the thermionic devices comprises an evacuated bulb, having therein a heated filament forming a hot cathode to emit electrons, a plate anode 18 upon which the electrons impinge, and a grid 19 for controlling the passage of electrons.

Illustrative apparatus and circuits have been shown for the purpose of showing some of the ways in which the invention may be practised; but it is expressly understood that the scope of the invention is not to be limited thereby, reference being had to the appended claims for that purpose.

What is claimed is:

1. A system for the reception of radiant energy, including a plurality of receiving devices tuned respectively to frequencies differing from each other by a predetermined amount, a single means for producing with oscillations of each of said frequencies two series of beats differing from each other by a predetermined amount, an indicating device, and means for causing said device to be responsive to oscillations having a frequency substantially equal to the difference in frequency of said beats.

2. In a system for the reception of radiant energy, including receiving devices exposed and responsive to ether waves, said devices being tuned respectively to frequencies differing from each other by a predetermined amount, means for producing with received oscillations of said frequencies, a plurality of series of beats differing in frequency by an amount above good audibility, means for detecting said beats to produce currents of the respective frequencies of the beats, and means for combining, detecting and indicating the beat currents.

3. A system for the reception of radiant energy, including receiving devices arranged to intercept ether waves and tuned respectively to frequencies differing from each other by a predetermined amount, means for producing a series of beats with oscillations of each of said frequencies, said beat

frequencies differing from each other by a relatively smaller amount, means for detecting said beats to produce currents of the respective frequencies of the beats, means for producing another series of beats by the first named series of beats beating with each other, means for detecting said last named series of beats to produce a current of the frequency of said beats, and indicating said current.

4. In a system for the reception of radiant energy, including receiving devices exposed and responsive to ether waves, said devices being tuned respectively to frequencies differing from each other by a predetermined amount, means for producing a series of beats with each of said frequencies, said beat frequencies differing from each other by a relatively smaller amount, means for producing another series of beats by the first named series of beats beating with each other, and a circuit selectively responsive to the last-named series of beats.

5. In a system for the reception of a message through the ether, including receiving devices exposed and responsive to ether waves, said devices being tuned respectively to frequencies differing from each other by a predetermined amount, means for producing a series of beats with each of said frequencies, said beat frequencies differing from each other by a relatively smaller amount, means for causing the first-named series of beats to beat with each other to produce a third series of beats, means selectively controlled by currents of a frequency substantially equal to the frequency of said third series of beats to give a signal, and means for transmitting oscillations having the frequency of said third series of beats to said last-mentioned means.

6. In a system for the reception of radiant energy, including receiving devices exposed and responsive to ether waves, said devices being tuned respectively to frequencies differing from each other by a predetermined amount, means for producing a series of beats with oscillations of each of said frequencies, means for detecting said beats to produce currents of the respective frequencies of the beats, means for combining the beat currents to produce a third series of beats, and means for detecting and indicating said third series of beats.

7. In a system for the reception of radiant energy, including two receiving devices exposed and responsive to ether waves, said devices being tuned respectively to frequencies differing from each other by a predetermined amount, means for producing a series of beats with each of said frequencies, said beat frequencies differing from each other by a relatively smaller amount, a network inductively coupled to both of said receiving devices, means controlled by said network for causing the first-named series of beats to beat with each other to produce a third series of beats and indicating means comprising a circuit selectively responsive to said third series of beats.

8. In a system for the reception of radiant energy, including two receiving devices arranged to intercept ether waves and tuned respectively to frequencies differing from each other by a predetermined amount, means for producing a series of beats with oscillations of each of said frequencies, said beat frequencies differing from each other by a relatively smaller amount, means for causing the first-named series of beats to produce a third series of beats by beating with each other, said last-mentioned means including a network inductively coupled to both of said receiving devices, an indicating device, and means for causing the indicating device to be operated under the control of currents of a frequency substantially equal to the frequency of said third series of beats.

9. In a system for the reception of radiant energy, including two receiving devices arranged to intercept ether waves and tuned respectively to frequencies differing from each other by a predetermined amount, means for producing a series of beats with oscillations of each of said frequencies, said beat frequencies differing from each other by a relatively smaller amount, means for causing the first-named series of beats to produce a third series of beats by beating with each other, said last-mentioned means including a single circuit coupled to both of said receiving devices, an indicating device, and means for causing the indicating device to be operated under the control of currents of a frequency substantially equal to the frequency of said third series of beats.

10. A system for the reception of radiant energy including a plurality of receiving devices tuned to frequencies differing from each other by a predetermined amount, a thermionic device operatively connected with each of said receiving devices, means for applying to the input circuit of each of said thermionic devices an oscillating current having a frequency differing from each of said first named frequencies by unlike amounts, a resonant circuit tuned to each of said last named difference frequencies for transmitting currents of said frequencies only, a single thermionic device operatively connected to both of said resonant circuits, a resonant circuit connected with the output of said thermionic device and tuned to the beat frequency of the currents transmitted by said first named resonant circuits for transmitting oscillating currents of said beat frequency only, and means for detecting and indicating said last named transmitted current.

11. A system for the reception of radiant energy including a plurality of closed oscillatory circuits each including a loop aerial, each of said circuits being tuned to frequencies differing from each other by a predetermined amount, a thermionic device operatively connected with each of said tuned circuits, means for applying to the input circuit of each of said thermionic devices an oscillating current having a frequency differing from each of said first named frequencies by unlike amounts, a resonant circuit tuned to each of said last named difference frequencies for transmitting currents of said frequencies only, single thermionic device operatively connected to both of said resonant circuits, a resonant circuit connected with the output of said thermionic device and tuned to the beat frequency of the currents transmitted by said first named resonant circuits for transmitting oscillating currents of said beat frequency only, and means for detecting and indicating said last named transmitted current.

12. A system for the reception of radiant energy including a plurality of receiving devices tuned to frequencies differing from each other by a predetermined amount, a thermionic device operatively connected with each of said receiving devices, means for applying to the input circuit of each of said thermionic devices an oscillating current having a frequency differing from each of said first named frequencies by unlike amounts, a single thermionic device operatively connected to the output circuit of both of said thermionic devices, a resonant circuit connected with the output of said third thermionic device and tuned to the beat frequency of the currents impressed upon said first named receiving devices for transmitting oscillating currents of said beat frequency only, and means for detecting and indicating said last named transmitted current.

13. A system for the reception of radiant energy including a plurality of closed oscillatory circuits each including a loop aerial, each of said circuits being tuned to frequencies differing from each other by a predetermined amount, a thermionic device operatively connected with each of said tuned circuits, means for applying to the input circuit of each of said thermionic devices an oscillating current having a frequency differing from each of said first named frequencies by unlike amounts, a single thermionic device operatively connected to the output circuit of both of said thermionic devices, a resonant circuit connected with the output of said third thermionic device and tuned to the beat frequency of the currents impressed upon said first named circuits for transmitting oscillating currents of said beat frequency only, and means for detecting and indicating said last named transmitted current.

14. A receiver for radiant energy, including a plurality of closed oscillatory circuits each comprising a loop aerial, each of said circuits being tuned to respond to a series of electromagnetic oscillations, said oscillations having frequencies differing from each other by a predetermined amount, means for producing with each of said series of oscillations beat currents of unlike periodicity, a resonant circuit responsive to each of said beat currents and adapted to transmit a current of substantially the respective frequency only, means for permitting currents of said beat frequencies to coexist and to produce currents having a secondary beat frequency substantially equal to the difference between the first named beat frequencies, a resonant circuit responsive to said secondary beat frequency and adapted to transmit a current of substantially said secondary beat frequency only, means for producing currents differing in frequency from said secondary beat current to produce a tertiary beat frequency current, and signal indicating means responsive to the tertiary beat current.

15. A receiver for radiant energy including a plurality of closed oscillatory circuits each including a loop aerial, each of said circuits being tuned to respond to a series of electromagnetic oscillations, said oscillations having frequencies differing from each other by a predetermined amount, means for producing a current differing in frequency from each of said series of oscillations by unlike amounts respectively so as to produce two beat currents of unlike periodicity, a detector operatively connected to respond to said beat currents, a resonant circuit coupled to the output circuit of said detector and tuned to a frequency substantially equal to the difference between said beat currents and adapted to transmit a current having a frequency substantially equal to said difference frequency only, and means coupled to said resonant circuit including an indicating device and an autodyne whereby said indicating device is responsive to said last named current.

16. A receiver for radiant energy including a plurality of closed oscillatory circuits each comprising a loop aerial, each of said circuits being tuned to respond to a series of electromagnetic oscillations, said oscillations having frequencies differing from each other by a predetermined amount, means for producing with each of said series of oscillations beat currents of unlike periodicity, a single circuit for combining said beat currents, a detector connected to said circuit, a resonant circuit operatively connected with the output side of the detector and tuned to a secondary beat current having a frequency

substantially equal to the difference between said first named beat currents, and an indicating device controlled by current transmitted through said resonant circuit.

17. A receiver for radiant energy including a plurality of closed oscillatory circuits each comprising a loop aerial, each of said circuits being tuned to respond to a series of electromagnetic oscillations, said oscillations having frequencies differing from each other by a predetermined amount, means for producing with said series of oscillations beat currents of unlike periodicity, a detector operatively connected with said beat current producing means, a resonant circuit operatively connected to the output circuit of said detector and tuned to the secondary beat frequency, and an indicating device controlled by currents transmitted through said resonant circuit.

18. A receiver for radiant energy including a plurality of closed oscillatory circuits each comprising a loop aerial, each of said circuits being tuned to respond to a series of electromagnetic oscillations, said oscillations having frequencies differing from each other by a predetermined amount, means for producing with each of said series of oscillations beat currents of unlike periodicity, a resonant circuit responsive to a secondary beat current having a frequency substantially equal to the difference between said first named beat currents and adapted to transmit a current of said secondary beat frequency only, a detector operatively connected with said circuit, and an indicating device responsive to currents transmitted through said resonant circuit.

19. A receiving system for radiant energy including a plurality of tuned receiving circuits adapted to receive electromagnetic waves of unlike frequencies respectively, a detector for each of said circuits, means for applying to said detectors an oscillating current having a frequency differing from each of said first named frequencies by unlike amounts, a resonant circuit tuned to each of said last named difference frequencies and connected operatively to said detectors for transmitting currents of said difference frequencies only, a circuit operatively connected with said resonant circuits and arranged to have impressed thereon currents of said difference frequencies, and a third resonant circuit tuned to the secondary beat frequency of said difference frequencies, a circuit operatively connected with said third resonant circuit and arranged to have impressed thereon an oscillating current differing from said secondary beat frequency to produce a tertiary frequency and indicating device controlled by oscillating currents of said tertiary beat frequency.

20. A method of receiving radio signals transmitted on a plurality of series of oscillations of different frequencies, which consists in selectively receiving the series of oscillations, heterodyning said series of oscillations with locally generated oscillations to produce from the series of oscillations beat currents of different frequencies respectively, and utilizing said beat currents to reproduce a signal.

21. A method of receiving radio signals transmitted on a plurality of series of oscillations of different frequencies, which consists in selectively receiving the series of oscillations, heterodyning all of said series of oscillations with locally generated oscillations of a single frequency such as to produce from the plurality of series of oscillations beat currents of different frequencies respectively, combining said beat currents to cause them to produce a third series of beats, and detecting and indicating said third series of beats.

22. A method of receiving radio signals transmitted on a plurality of series of oscillations of frequencies differing from each other by an amount above good audibility, which consists in selectively receiving the series of oscillations, heterodyning said series of oscillations with locally generated oscillations to produce from the plurality of series of oscillations beat currents of different frequencies, combining said beat currents to cause them to produce a third series of beats, and detecting and indicating said series of beats.

23. A method of receiving radio signals transmitted on two series of oscillations of frequencies differing from each other by an amount above good audibility, which consists in selectively receiving the series of oscillations, heterodyning both of said series of oscillations with locally generated oscillations of a single frequency of such value as to produce from the series of oscillations beat currents of frequencies differing from each other by an amount less than the difference between the frequencies of said series of oscillations but also above good audibility, combining said beat currents to cause them to produce a third series of beats, detecting said series of beats, heterodyning current of the frequency of said third series of beats with locally generated current and indicating the resultant current.

In testimony whereof I hereunto affix my signature.

EMORY LEON CHAFFEE.