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HIGH FREQUENCY ELECTRICAL CIRCUIT ARRANGEMENT

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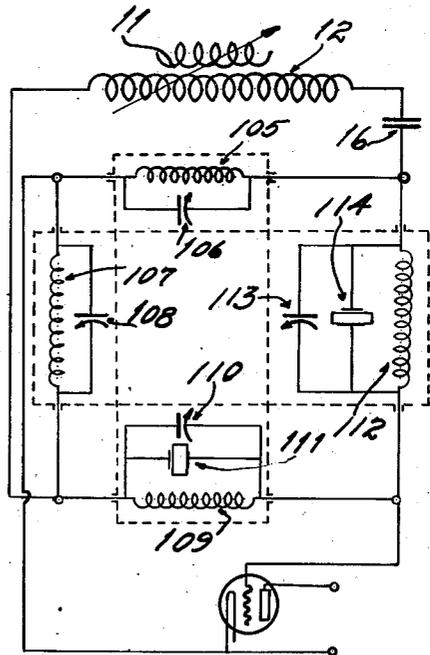
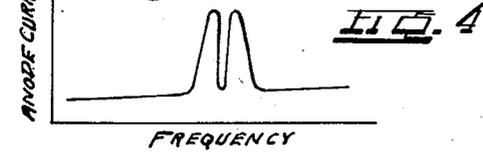
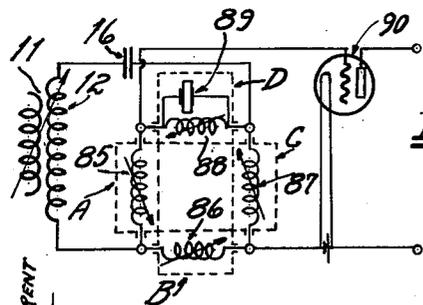
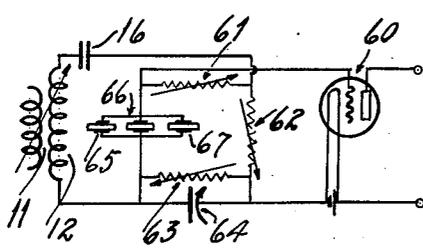
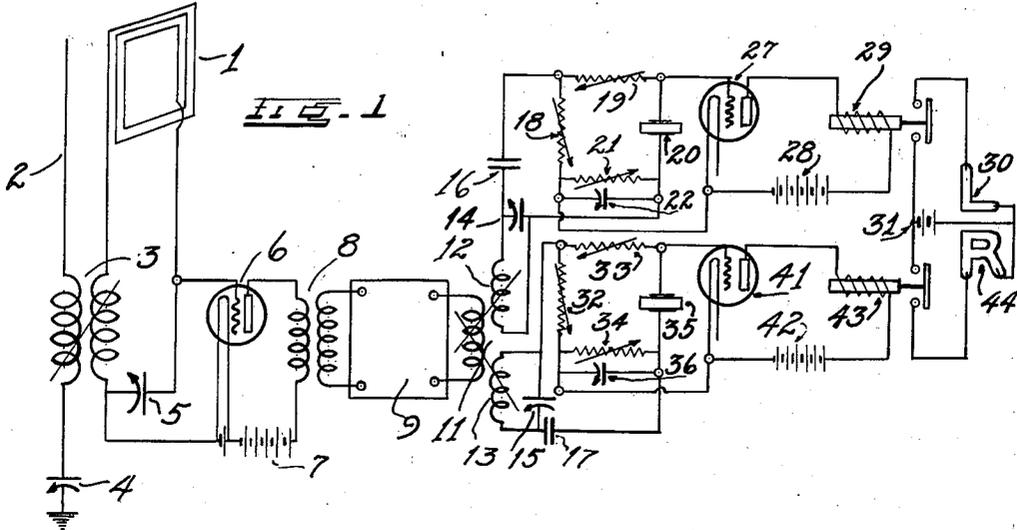
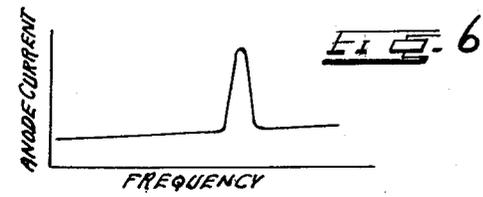


FIG. 5



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# UNITED STATES PATENT OFFICE

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## HIGH FREQUENCY ELECTRICAL CIRCUIT ARRANGEMENT

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10 Claims. (Cl. 250—11)

This invention relates to electrical circuit arrangements in general. More particularly this invention relates to electrical circuit arrangements employing selective frequency responsive elements which manifest substantial changes in their impedance characteristics at certain determinable frequencies.

An object of this invention is to provide an arrangement for guiding moving vessels, particularly aircraft, in accordance with signaling energy transmitted from a radio beacon, said arrangement having incorporated therein a balanced circuit which is adjusted to be unbalanced by signaling energy of a certain frequency or certain frequencies which is intercepted by the radio receiving system associated with said arrangement.

A further object of this invention is to provide an arrangement wherein electro-mechanically vibratile elements are employed to control the operation of electrical circuits in accordance with electrical energy corresponding to a frequency or frequencies of the electro-mechanically vibratile elements.

Another object of this invention is to provide an arrangement wherein electro-mechanically vibratile elements are employed to vary the impedance of a circuit in accordance with electrical energy impressed upon them whereby the operation of electrical circuits is controlled in accordance with the electrical energy impressed upon the electro-mechanically vibratile elements.

Still another object is to provide an arrangement wherein an electro-mechanically vibratile element is associated with the input circuit of an electron discharge device to control the operation of the electron discharge device in accordance with electrical energy of certain frequencies which are impressed upon the circuit of the electro-mechanically vibratile element.

Still a further object of this invention is to provide a balanced circuit with an electro-mechanically vibratile element for controlling the operation of an electron discharge device circuit arrangement in accordance with electrical energy of predetermined frequency which is impressed upon the balanced circuit.

Still a further object of this invention is to provide an arrangement in which circuits including electro-mechanically vibratile elements control the operation of electron discharge devices in accordance with signaling energy of a predetermined frequency for controlling the operation of indicator devices.

Other and further objects of this invention will

be more fully understood from the following specification and claims.

In accordance with this invention one or more electro-mechanically vibratile elements, such as piezo-electric crystals or other elements, the electrical impedance of which changes substantially at its natural period or periods or any harmonic thereof, are connected into a balanced circuit of the Wheatstone bridge type. Connections are provided between the balanced circuit and an electron discharge device which is to be controlled in operation by signaling energy corresponding to a frequency at which the impedance of the electro-mechanically vibratile element changes substantially. A relay and an indicator, which it is desired to control in accordance with signaling energy of predetermined frequency, are connected into the output circuit of the electron discharge device. An amplifier of any approved design, such as are used in conjunction with radio receiving systems, is arranged to amplify intercepted signaling energy and to energize the balanced circuit, with which the electro-mechanically vibratile element is associated. When signaling energy of the proper frequency is intercepted the balanced circuit is energized by energy of a corresponding frequency and the impedance of the electro-mechanically vibratile element is caused to change and disturb the impedance balance of the balanced circuit, whereupon the electron discharge device associated with the balanced circuit is energized in accordance with signaling energy of that proper frequency and the relay connected into the output circuit of the electron discharge device is actuated.

Other features and details of this invention will be more readily understood from the following specification and the drawing, in which:

Fig. 1 illustrates an embodiment of this invention;

Fig. 2 illustrates a modified form of the balanced circuit arrangement;

Fig. 3 illustrates another modified form of the balanced circuit arrangement;

Figs. 4 and 6 are curves illustrating operating characteristics of certain embodiments of this invention; and

Fig. 5 illustrates another modification of this invention.

Referring to Fig. 1 of the drawing in detail, reference numeral 1 designates a directional antenna of the loop type, which is coupled to the substantially non-directional antenna 2 through the transformer 3. A variable condenser 4 is connected into the circuit of the antenna 2. A 55

variable tuning condenser 5 is connected into the circuit of the loop 1. The loop 1 and the secondary winding of the transformer 3, together with the tuning condenser 5, are connected into the input circuit of the electron discharge device 6. The source 7 of anode current supply for the electron discharge device 6 is connected to the anode thereof through the primary of the high frequency transformer 8. The secondary of the transformer 8 is connected to the input of the amplifier 9. This amplifier may be of any type employed in radio receiving sets for amplifying high frequency signals. The transformer 11 is connected to the output of the amplifier 9. Secondary winding 12 of the transformer 11 is connected to the tuning condenser 14 and the series condenser 16. The impedance units 18, 19, 21, 22 and the electro-mechanically vibratile element 20 are connected to form the legs of a balanced circuit which is connected to receive high frequency energy from the secondary winding 12.

The impedance units 32, 33, 34 and 36 and the electro-mechanically vibratile element 35 are connected to form legs of another bridge circuit which is associated with the secondary 13 of the transformer 11. A tuning condenser 15 is connected across the secondary 13. Condenser 17 is connected in series with the circuit of the tuned secondary 13 and the bridge circuit including the electro-mechanically vibratile element 35, and is selected to be of a relatively small capacity. The adjustments of the condensers 16 and 17 are not critical, however, especially in cases where the secondary windings 12 and 13 are made up of a relatively large number of turns in comparison to the number of turns included in the primary of the transformer 11 and the tuning condensers 14 and 15 are omitted.

The condensers 22 and 36 are employed in the bridge circuits to facilitate obtaining the proper phase relation between high frequency currents flowing thru the legs of the bridge circuits. Where it is desired, additional variable condensers may be connected across each of the legs of the bridge circuits to facilitate obtaining the desired balanced conditions. In cases where non-inductive resistance units are used as the impedance units 18, 19 and 21 of the first bridge circuit and as the impedance units 32, 33 and 34 of the second bridge circuit it may not be necessary to shield these units by metallic shields, especially if the signaling frequencies at which this system is used are in the neighborhood of 500 kilocycles or less; however, in cases where the bridge circuits are made up into compact units, and also in cases where the system is employed at signaling frequencies of three to four thousand or more kilocycles, it is highly desirable that each leg of the bridge circuits be surrounded by metallic shields.

The input circuit of the electron discharge device 27 is connected to symmetrical points of the bridge circuit which includes the element 20. The input circuit of the electron discharge device 41 is likewise connected to symmetrical points of the bridge circuit which includes the element 35. A relay 29 and a source of anode current supply 28 are connected into the output circuit of the electron discharge device 27. The visual indicator 30, which may be a glow lamp or an incandescent lamp, is connected to be energized from the source of current supply 31 when the relay 29 is energized in accordance with signaling energy. The relay 43 and source of anode current supply 42 is connected into the output circuit of the electron

discharge device 41. The indicator 44, which is similar to the indicator 30, is connected to the current supply source 31 to be energized when the circuit of relay 43 is energized in accordance with signaling energy. The indicators 30 and 44 may be shaped in the form of the letters L and R, as shown in the drawing, in order that deviation of a moving vessel, such as an aeroplane, employing the system of this invention, to the left or right of the true course may be more readily ascertained accurately. These indicators 30 and 44 may also be connected directly into the output circuits of the electron discharge devices 27 and 41 and the relays 29 and 43 thus eliminated.

In operation the system of this invention illustrated in Fig. 1 is provided with a pair of electro-mechanically vibratile elements 20 and 35, such as piezo-electric crystals, which have frequency characteristics corresponding to the signaling frequencies of the radio beacon in conjunction with which this system is employed. These electro-mechanically vibratile elements are connected into individual bridge circuits upon which signals intercepted from the radio beacon are impressed. When signaling energy having a frequency corresponding to the frequency of the electro-mechanically vibratile element 20, for example, the balance of the bridge circuit including this electro-mechanically vibratile element is disturbed and the anode current of the electron discharge device 27 is caused to greatly increase in value, whereupon the relay 29 is caused to close the circuit of the lamp 30. If, however, signaling energy of a frequency corresponding to a frequency or harmonic thereof of the element 35 is intercepted by the system the balance of the bridge circuit including this element 35 is disturbed and the anode current of the electron discharge device 41 is increased, whereupon the relay 43 is caused to close the circuit of the indicator 44.

The signals transmitted from the radio beacon may be transmitted in two relatively narrow beams parts of which may be made to traverse the same area. The part of the beams of signaling energy traversing the same area consists of signals of both of the radio beacon frequencies; that is, frequencies corresponding to those of both of the electro-mechanically vibratile elements 20 and 35. When the moving craft employing the system of this invention is moving in the zone defined by the coinciding part of the beams, then both of the indicators 30 and 44 are energized, since signals of frequencies corresponding to both of the electro-mechanically vibratile elements 20 and 35 are intercepted.

In Fig. 2 is illustrated a modified form of electro-mechanically vibratile element arrangement. Impedance units 61, 62, and 63, which are preferably in the form of non-inductive resistance units, are connected into a bridge circuit, together with the electro-mechanically vibratile elements 65, 66 and 67. A variable capacity 64 is connected in parallel with the impedance unit 63 to facilitate obtaining a balanced condition in the bridge circuit. The electro-mechanically vibratile elements 65, 66 and 67 may be of the quartz piezo-electric crystal type each ground to a different frequency. By employing a plurality of elements each of a different frequency characteristic in one leg of the bridge circuit the balanced condition of the bridge circuit may be disturbed by impressing voltages of frequencies of any one of the elements upon the bridge circuit, and the electron discharge device 60 may be

caused to operate circuits associated with its output circuits by any one of the bridge balance disturbing frequencies. In place of the electro-mechanically vibratile elements 65, 66 and 67 a single electro-mechanically vibratile unit ground in step formation as disclosed in Patent No. 1,717,451 to August Hund may be employed. Where, however, it is desired to obtain a condition in which the balance of the bridge circuit may be disturbed at any frequency throughout a band of frequencies, a piezo-electric crystal, gradually tapered along its X-axis, may be employed.

Shielded impedance units of the inductance coil type may be employed in the balanced bridge circuit, as illustrated in Fig. 3 of the drawing. The secondary 12 of the transformer 11 is connected through the condenser 16 to the bridge circuit which is made up of the impedance coils 85, 86, 87 and 88. Electro-mechanically vibratile element 89 is connected across the coil 88. Electron discharge device 90 is connected between electrically symmetrical points of the impedance bridge circuit. A suitable relay is connected into the output circuit of the electron discharge device 90, as illustrated in Fig. 1 of the drawing. Suitable shields A, B, C and D are provided to the impedance coils 85, 86, 87 and 88, respectively, to facilitate balancing the bridge circuit. In order to balance the bridge circuit, the impedance coils may be made variable or in the form of variometer units or a small variable condenser may be connected across each of the impedance coils, as illustrated in Fig. 5. It is, of course, not necessary to connect the variable condenser across the entire impedance coil in each case, since these condensers may be connected across only a small portion of each coil. A second bridge circuit made up of impedance coils and an electro-mechanically vibratile unit is connected across the secondary 13 of the transformer 11. These secondary windings 12 and 13 may be made up of a relatively large number of turns of wire and the usual tuning condensers, such as employed in the form of this invention illustrated in Fig. 1 of the drawing, eliminated. Only one of the secondary windings 12 and 13 need be employed in cases where it is desired to reduce the weight of apparatus used, since both of the bridge circuits may be connected to one secondary thru proper condensers.

In Fig. 4 of the drawing is illustrated an anode current, frequency characteristic of the electron discharge device 90 obtained in cases where only one electro-mechanically vibratile element was employed in the bridge circuit, as illustrated in Fig. 3 of the drawing. From this characteristic curve it is seen that the flow of anode current is caused to increase substantially when voltages of frequencies slightly above or below the frequency of the electro-mechanically vibratile element are impressed upon the bridge circuit. The relay connected into the output circuit of the electron discharge device is caused to operate by the increasing anode current which is obtained on either side of the frequency of the electro-mechanically vibratile element. The frequency band over which the increased anode current is obtained may be adjusted in width by adjusting the impedance frequency characteristic of the bridge circuit with which the electro-mechanically vibratile element is associated. A much narrower band is obtained by tuning the inductance units employed in the individual legs of the bridge circuit. An embodiment of this

invention in which tuned inductance units 105, 107, 109 and 112 are employed in the balanced bridge circuit is illustrated in Fig. 5 of the drawing. Tuning condensers 106, 108, 110 and 113 are connected to the inductance units 105, 107, 109 and 112, respectively. Electro-mechanically vibratile elements 111 and 114 are connected across the inductances 110 and 112. These electro-mechanically vibratile elements may be connected across sections of these inductances only if desired.

When two electro-mechanically vibratile elements 111 and 114 are connected to the bridge circuit symmetrically with respect to the grid electrode connection, the anode current, exciting voltage frequency characteristic illustrated in Fig. 6 of the drawing, is obtained in cases where the frequency of one of the electro-mechanically vibratile elements is slightly higher than the frequency of the other electro-mechanically vibratile element. Only one point at which the anode current rises to a value substantially in excess of the normal anode current is obtained in the anode current, exciting voltage frequency characteristic when two electro-mechanically vibratile elements, bearing the proper frequency relation to each other, are employed in the bridge circuit. The variable condensers 106, 108, 110 and 113, which are associated with the legs of the tuned bridge circuit, must be adjusted so that the bridge is balanced at a frequency slightly above the frequency of the higher frequency electro-mechanically vibratile element or at a frequency slightly below the frequency of the lower frequency electro-mechanically vibratile element in order that the characteristic curve illustrated in Fig. 6 may be obtained. In order to obtain the characteristic illustrated in Fig. 6, the inductance and capacity units forming the legs of the bridge circuit must be relatively sharply tuned. These inductance and capacity units may, however, be placed into small aluminum shields without destroying their selective adjustment if the inductance units are small in diameter and the variable tuning condensers employed are small.

It will be observed that other modifications of this invention may be readily made without departing from the scope or spirit thereof as set forth in the foregoing specification; and that, therefore, I do not desire to limit this invention to the exact details as set forth except in so far as those details are defined in the appended claims.

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

1. In signaling systems, the combination of an antenna, signal receiving apparatus, a pair of vibratory elements having different frequency characteristics, means for energizing said vibratory elements in accordance with signaling energy of slightly different frequencies, indicating means connected to be energized in accordance with said signaling energy and means connected between each of said vibratory elements and said indicating means for producing a uni-directional current in accordance with signaling energy impressed upon the circuits thereof.

2. In radio receiving apparatus of the class described and for the purposes set forth, a plurality of vibratory members, each of said members having a natural period of vibration, exciting means therefor, signal-intercepting means for energizing said exciting means in accordance with signals of different frequencies radiated

from remote signal-transmitting apparatus and having relative intensity dependent upon the position of said signal-intercepting means with respect to the signal-transmitting apparatus, the natural period of each of said members corresponding to one of said frequencies whereby each member vibrates with amplitude dependent upon the intensity of the supplied current having its respective frequency, means associated with each vibratory member for producing a unidirectional electro-motive force having magnitude dependent upon the amplitude of vibration of the respective vibratory member, and means responsive to the relative magnitudes of said unidirectional electromotive forces.

3. In radio-receiving apparatus of the class described and for the purposes set forth, a plurality of vibratory members, each of said members having a natural period of vibration, exciting means therefor, means for intercepting and supplying to said exciting means a plurality of currents generated by remote radio-transmitting apparatus, said currents having different frequencies and having relative intensity dependent upon the position of said intercepting means with respect to the radio-transmitting apparatus, the natural period of each of said members corresponding to one of said frequencies whereby each member vibrates with amplitude dependent upon the intensity of the supplied current having its respective frequency, means associated with each vibratory member for producing a unidirectional electromotive force having magnitude dependent upon the amplitude of vibration of the respective vibratory member, and means responsive to the relative magnitudes of said unidirectional electromotive forces.

4. In radio-receiving apparatus of the class described and for the purposes set forth, a plurality of vibratory members, each of said members having a natural period of vibration, exciting means therefor, signal-intercepting means for energizing said exciting means in accordance with signals of different frequencies radiated from remote signal-transmitting apparatus and having relative intensity dependent upon the position of said signal-intercepting means with respect to the signal-transmitting apparatus, the natural period of each of said members corresponding to one of said frequencies whereby each member vibrates with amplitude dependent upon the intensity of the supplied current having its respective frequency, means associated with each vibratory member for producing a unidirectional electromotive force having magnitude dependent upon the amplitude of vibration of the respective vibratory member, relay means responsive to said unidirectional electromotive forces, and indicating means controlled by said relay means.

5. In position-determining apparatus of the radio-receiver type for use in conjunction with remote radio-transmitting apparatus setting up signal fields of distinct positional relationship and distinct frequency characteristics, the combination of means for intercepting said signals, means for increasing the amplitude of the intercepted signalling energy, a plurality of electro-mechanically vibratile elements respectively resonant to the respective signal frequencies and respectively energized thereby, balanced circuits respectively coupled with said electro-mechanically vibratile elements, a rectifier connected to each of said balanced circuits, and indicating means energized in accordance with current flow through said rectifiers.

6. In signal-receiving apparatus of the class described for use in conjunction with radio-transmitting apparatus setting up signals of two or more distinct characteristics, antenna means for intercepting such signals of distinct characteristics, means for amplifying said signals when intercepted, a plurality of circuits each of which is normally electrically balanced, said circuits being coupled to said amplifying means, a plurality of means, one in each of said balanced circuits and constituting a part thereof, each of which last-mentioned means is preferentially responsive to intercepted signals having a different one of said distinct characteristics, an electron discharge device connected to each of said balanced circuits for energization upon the unbalancing of its associated circuit, and indicating means connected to the output circuits of each of said electron discharge devices for indicating when radio signals of each of said distinct characteristics are intercepted.

7. In signal-receiving apparatus of the class described for use in conjunction with radio-transmitting apparatus setting up signals of two or more distinct characteristics, antenna means for intercepting such signals of distinct characteristics, means for amplifying said signals when intercepted, a plurality of circuits each of which is normally electrically balanced, said circuits being coupled to said amplifying means, a plurality of electro-mechanically vibratile means, one in each of said balanced circuits and constituting a part thereof, each of which electro-mechanically vibratile means is preferentially responsive to intercepted signals having a different one of said distinct characteristics, an electron discharge device connected to each of said balanced circuits for energization upon the unbalancing of the associated circuit, and indicating means connected to the output circuits of each of said electron discharge devices for indicating when radio signals of each of said distinct characteristics are intercepted.

8. In signal receiving apparatus of the class described, means for receiving signaling energy, amplifying means connected to said first means, a pair of Wheatstone bridge circuits, means for selectively unbalancing one or the other of said bridge circuits in accordance with signaling energy of distinct predetermined characteristics, electron discharge devices connected to said bridge circuits and indicating means connected to the output circuits of said electron discharge devices to indicate the unbalancing of said bridge circuits.

9. In signal receiving apparatus of the class described adapted to be employed for determining direction or course with respect to remote signaling means transmitting signaling energies having two or more distinct frequency components, means for intercepting said signaling energies, means for increasing the amplitude of said intercepted signaling energies, a plurality of vibratory members resonant to said frequency components, a plurality of Wheatstone bridge circuits each including one of said vibratory members in at least one of the legs thereof, said Wheatstone bridge circuits being connected to said amplifying means whereby signaling energy is impressed upon said vibratory members, electron discharge devices connected to said Wheatstone bridge circuits and indicating means connected to the output circuits of said electron discharge devices.

10. In signal-receiving apparatus of the class

described adapted to be employed for determining direction or course with respect to remote signaling means transmitting signalling energies having two or more distinct frequency components, means for intercepting said signaling energies, means for increasing the amplitude of said intercepted signaling energies, a plurality of vibratory members resonant to said frequency components, a plurality of vibratory members resonant to frequencies slightly displaced from said frequency components, a plurality of Wheatstone bridge circuits each including one of said

first-mentioned series of vibratory members in one leg thereof and one of said second-mentioned series of vibratory members in another leg thereof, said Wheatstone bridge circuits being connected to said amplifying means whereby signaling energy is impressed upon said vibratory members, electron discharge devices connected to said Wheatstone bridge circuits, and indicating means connected to the output circuits of said electron discharge devices.

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