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UNITED STATES PATENT AND TRADEMARK OFFICE GRANTED PATENT

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October 16, 1951

Radio wave receiving system

INVENTOR: RINES ROBERT H

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SUMMARY:

The present invention relates to electric systems, and more particularly to radio-receiving systems that, while having more general fields of usefulness, are especially adapted for use in television. The present application is filed in response to a requirement for division in application, Serial No. 648,482, filed February 18, 1946.

An object of the invention is to provide a new and improved radio-receiving system.

A further object is to provide a new and improved bridge circuit.

Another object is to provide a novel bridge circuit, employing electrets that are adapted to receive radio waves.

Other and further objects will be explained hereinafter and will be more particularly pointed out in the appended claims.

The invention will now be more fully explained in connection with the accompanying drawings, in which Fig. 1 is a diagrammatic view of circuits and apparatus arranged for radio-location purposes; Fig. 2 is a view of a modification; Fig. 3 is a diagram showing an airplane object from which radio waves are reflected and scattered to the receiving system of Fig. 1; and Fig. 4 is a view of the preferred bridge-circuit radio-receiving system of the present application.

An electromagnetic-wave generator 4 is shown exciting a dipole 2 to produce ultra-high-frequency pulsed-radio energy, say, of 3 or 1.5 centimeters wavelength. A continuous-wave or any other type of modulated-wave generator may be employed, but pulsed energy, at present, has the advantage of economical and easy high-power ultra-high-frequency generation.

The waves emitted by the dipole 2 may be directed by a reflector 3 upon a parabolic reflector 6. The parabolic reflector 6 is shown directing the waves toward an object, say, an airplane 8, from which they are reflected and scattered toward a receiving station.

At the receiving station, the radio waves thus reflected and scattered from the object 8 may be focused by an electromagnetic dielectric lens 5, such as polystyrene, upon a bank or array T comprising a plurality of normally ineffective radio-receiving pick-up unit antenna elements. The dielectric lens 5 may be replaced by any other type of well-known lens, mirror or other directive system for focusing the electromagnetic energy scattered and reflected from the object 8 on the bank or array 7 of pick-up elements.

The pick-up elements of the bank or array 7 are shown arranged in the form of rows and columns, in the proximity of the focal plane of the lens 5. The first or uppermost row of the bank is illustrated as comprising the sections 10, 12, 14, 16, etc., shown as equally spaced horizontally. The second row from the top is shown comprising the sections 18, 20, 22, etc. The third or next-lower row is shown comprising the sections 24, 26, etc., and so on for the remaining rows of pickup elements. Though only a small number of pick-up units is shown in each row, this is merely for illustrative purposes, in order not to confuse the disclosure. It will be understood that, in practice, a large number of pick-up units will be employed in each row, say, 180. The sections 10, 18, 24, etc., are arranged in the first or right-hand column. The sections 12, 20, 26, etc., are disposed in the second column from the right. The sections 14, 22, etc., are disposed in the third column from the right, and so on. There may be as many columns as there are pick-up units in each row. Though each column is shown as comprising only a few pickup units, this is again in order not to complicate the drawings. The pick-up units will, of course, all receive the reflected or scattered radio waves through the lens 5 simultaneously. There will be focused on each pick-up unit a radio-frequency voltage corresponding to the scattering from a corresponding view of the object 8. The pick-up elements will thus receive different field strengths of radio energy, corresponding to the amount of energy reflected or scattered from the various parts of the object 8 and converged upon the array 7 of pick-up elements by the lens 5. A radio3S energy picture of the object 8, as will be presently explained, is thus recorded upon the array, specific elemental areas of which will correspond to specific elemental areas of the object 8. By means of the present invention, this radio-energy in picture may be converted into a visible picture 123. According to the preferred embodiment of the invention, the visible picture 123 is caused to appear upon the fluorescent viewing screen 106 of a display cathode-ray oscilloscope tube 90.

The pick-up units are shown arranged In an Insulating disc 9 at the screen end of the oscilloscope-like member 89, and the pick-up units may be constituted of electrets.

An electret is a permanently charged dielectric formed by filling the gap between two electrodes with, say, molten resin, carnauba wax, or beeswax, and subjecting the electrodes to high voltage. By allowing the wax to cool during the application of the high voltage, a solidified per-i manently charged electric dipole Is produced, having permanent piezo-electric properties. Investigations in this field are described, for example, by A. Gemant in the Philosophical Magazine, S. 7, vol. 20, No. 136, Suppl. November, 1935, pages 929 to 952.

As described by W. G. Cady in Piezoelectricity, McGraw-Hill, page 235, mixtures of the resin or carnauba wax with other dielectric substances have produced long-lasting electrets. It will presently be explained that if these dielectric bases are combined in the same manner with radio-absorbing-and-rectifying materials, such as silicon or uranium oxide, the electrets can be particularly well adapted to the purposes of the present invention. One of the electrodes of the electret, further, may serve to enhance the response to radio energy if, it is, for example, tuned to the radio waves, if it is one-quarter of a rave-length long.

The pick-up units previously described may be such electrets. The first row of units is shown composed of charged dielectrics 10, 12,14, 16, etc., provided with top electrodes 110, 112, 114, 116, etc., respectively, and a common strip 41. The second row of units similarly is shown comprised of charged dielectrics 18, 20, 22, etc., provided with top electrodes 118, 120, 122, etc., and a common strip 61 connected to the strip 43. Similarly, the third row is shown composed of charged dielectrics 24, 26, etc., with top electrodes 124, 126, etc., and a common terminal strip 57 connected to the other common strips 48 and 81. The strips 43, 51 and 5T are shown connected by a conductor 78 to a grounded impedance 88, In the input circuit of an amplifier 79.

The cathode-ray-oscilloscope-like member 89 is shown provided with a cathode 98, a controlgrid electrode 93 and an anode 97. Electrons emitted from the cathode 96 will become enabled, in response to proper stimulation of the grid 93, to pass by the grid 93 to the anode 97 of the member 89. The electrons will continue to travel in a stream from the anode 97, between a pair of vertically disposed deflector plates 99 and 101, of which the plate 99 is shown grounded, and between a pair of horizontally disposed deflector plates 103 and IDS, of which the plate 108 is shown grounded, to impinge finally on the disc 9 of the member 89. A horizontal-sweep-time-base, applied, as hereinafter more fully explained, to the vertically disposed deflector plates 99 and 101, will cause the electron stream from the cathode to become deflected horizontally, and a vertical-sweep-time base, applied to the horizontally disposed deflector plates 103 and 105, will cause the electron stream to become deunits may be positioned along the successive paths of the electron stream to enable the stream to impinge on them as it successively sweeps out the successive rows of the array 7.

If, accordingly, the lens I is caused to focus the radio-energy picture on the oscilloscope-like member 89, the bank of electrets will act to absorb the incident radio-frequency energy. The absorbed radio-frequency energy will alter the initial permanent polarizing static charge or voltage with which the electrets become sensitized during their preparation. This alteration results from several factors, including heating or pyroelectrlc effects, the negative temperature coefficients of resistance and the piezo-electric properties of the electrets. Silicon and uranium-oxide detectors are known to absorb radio-frequency energy and to exhibit negative temperature coefficients of resistance.

The energy absorbed by each electret is a measure of the intensity of the radio-frequency energy impinged thereon.

Across the electrodes of each electret, moreover, the radio-frequency energy will become rectified to produce direct-current potential differences. These potential differences are representative of the radio-frequency energy impressed on the top tuned electrodes of the electrets in the radio-receiving circuits comprising these tuned electrodes, the detecting electrets and the grounded conductor 78. The rectification is produced by the detecting dielectric disposed between the electret electrodes.,. The variation of potential and charge along the bank of electrets Is thus a measure of the radio-frequency energy impinged on the array by the lens 5.

The resistance of the silicon or uranium oxide, as well as of the wax of the electret, since their temperature coefficients are negative, changes with the intensity of the impinging radio-frequency energy. A resistance, variation is thus produced along the bank of electrets that is representative of the radio-frequency energy received by the respective electrets.

These three effects involving the change of the electret charge upon the absorption by the electrets of the radio-frequency energy, the production of the direct-current potentials as a result of the detection or rectification in the above-mentioned radio-receiving circuits, and the resistance changes render the electrets extremely sensitive. A radio-energy image of the object 8 becomes thus recorded upon the array of electrets as charge, potential and resistance distributions.

The bank of electrets may be scanned according to either of two principles or according to a combination of the same. One principle involves measuring the variation In the electric charge and potential of the bank at the moment that the electron stream impinges.upon the successively disposed electrets to short-circuit them. The other principle involves measuring in a grounded preferably linear amplifier 79 the current along the electron stream as It Impinges upon areas of different potential of the variously resistive electrets, completing the circuit to the ground through the successive

electrets by way of the conductor 78.

Each electret will absorb and rectify the radio-frequency energy. Dependent upon the magnitude of this energy, it will change the resistance and the charge of the electret. This change fleeted vertically. The rows of electret pick-up will result both as a consequence of the absorption and of the rectifying action by the electrets of the radio-frequency energy received by the electret electrodes. As the electron stream successively impinges upon the successively disposed electrets, during the scanning, it successively discharges them. This produces a corresponding change in the input voltage to the amplifier 79, indicative of the radio-frequency energy impinged on the respective electrodes.

The electron stream will instantaneously discharge each differently-charged and differently-potentialed electret to give an indication in the load 58 and the amplifier 79, or it will give rise to a change in the electron-beam current when it impinges upon the variously resistive electret jg elements, or there may be a combination of these effects.

The scanning of the electrets may obviously also operate on the principle of change in electron-beam current transmitted to the load 58 upon impinging on surfaces of various resistances. As the stream hits, these electrets of different resistances, a change in beam current occurs, which manifests itself in the input circuit of the amplifier 79.

Mosaics of electrets for the member 89 may also take the form of Pig. 2, where electrets 81, 84, 86, 88 are provided with front electrodes 181, 184, 186, 188 exposed to the radio energy converged by the lens 5. The electrode strips 181, 184, 186, 188 may be of length one-quarter of the wave-length of the radio waves and may be in the interior of the tube 89, facing the electron stream, and may be scanned by it. The electrodes 281, 284, 286, 288 will be capacitively coupled to the front electrodes and will assume the homocharge of the electret. Thus, the electron stream will impinge on surfaces of different charge or potential, and the scanning will take place according to the principles previously described.

The electrets may be separated from adjacent electrets by dielectric material 2OB.

As the electron stream produced from the cathode 95, in response to appropriate horizontal-sweep-time-base voltages applied to the vertically disposed deflector plates 99 and 101 of the cathode-ray-tube-like member 89, travels across the pick-up elements in the disc 9, they will successively discharge into a grounded preferably linear amplifier 79, by way of a conductor 78. If desired, the amplifier 79 may be replaced by a bank of linear amplifiers, one corresponding to each of the pick-up elements.

The output of the amplifier 79 will obviously 6g vary, at successive instants, in accordance with the radio-frequency energy received by the successive corresponding pick-up elements.

A pulse generator, which may, if desired, be the same pulse generator 4, may be employed to trigger a horizontal-time-base-sweep circuit 63 and a vertical-sweep circuit 69, according to conventional and well-known television technique. The pulse generator 4 may feed, through an attenuator and rectifier I, to an oscillator or ?.. any similar or equivalent television circuit. One such circuit is shown as a pulse-recurrence-frequency multiplier 65, for applying many pulses corresponding to each radio-frequency pulse for the period between successive radio-pulses, to _n trigger the horizontal-sweep circuit 63. The horizontal-time-base sweep will thereby be produced between the vertically disposed deflector plates 99 and 101, occurring as many times, say, between successive radio-frequency transmissions, as there are rows of pick-up antennas. The pulse generator 4 may also feed, through the attenuator and rectifier I, to trigger the vertical-sweep circuit 69, once corresponding to every radio-frequency transmission. One vertical sweep will then occur between the horizontally disposed plates 103, during the periods between successive radio pulse transmissions, corresponding to as many horizontal sweeps as there are rows of antennas, causing each of the horizontal sweeps to appear at successively lower levels on the oscilloscope-sweep face.

If the circuit comprises an oscillator, the oscillations may be employed to trigger the horizontal sweep. The period of the oscillations which, as previously explained, is much less than the duration of each radio pulse, corresponds to the time of sweep across one row of the pick-up units in the disc 9.

If, as previously mentioned, continuous-wave radio transmission is employed, the vertical-sweep circuit 69 may be triggered to produce one vertical sweep corresponding to as many horizontal sweeps from the horizontal-sweep circuit 63 as there are rows of pick-up units.

Means is provided for producing upon the screen 106 of the display oscilloscope 90, images corresponding to the radio-frequency energy received by the corresponding pick-up mosaic antenna elements. The screen 106 is illuminated by an electron stream in the oscilloscope 90. This electron stream is synchronized to travel with the electron stream of the cathode-ray-like member 89. The horizontal-sweep circuit 63 is connected to the horizontal-deflector plate of the oscilloscope by a conductor 67, and to the horizontal-deflector plate 101 of the oscilloscope-like member 89 by the conductor 67 and a conductor 134. The vertical-sweep circuit 69 is connected to the vertical-deflector plate 102 of the oscilloscope hya conductor 71, and to the vertical-deflector plate 103 of the oscilloscope-like member 89 by the conductor 71 and a conductor 146.

The amplifier 79 is connected, by conductors and 87, to the control-grid electrode 92 and the cathode 94 of the oscilloscope 90. The mosaic of electrets becomes thus successively connected, through the amplifier 79, to the control electrode 92. Electrons emitted from the cathode 94 will become enabled, in response to the action of the amplifier 79, to pass by the grid 92, to the anode 96 of the oscilloscope tube 90. The electrons will continue to travel in a stream from the anode 96, between the pair of vertically disposed oscilloscope deflector plates 98 and 100, of which the plate 98 is shown grounded, and between the pair of horizontally disposed oscilloscope deflector plates 102 and 104, of which the plate (D4 is shown grounded, to impinge finally on the fluo-1 rescent viewing screen 106 of the osci loscone 9H.

After each simultaneous horizontal sweep of both the oscilloscope 90, and the oscilloscope-like member 89 has been completed, a successively larger voltage will be applied to the horizontally disposed deflector plates 102, 104 and 103, 105, respectively, by the vertical-sweep circuit. After the last such horizontal sweep, the voltage between the horizontally disposed plates 102, 104 and 103, will become restored to zero. The next horizontal sweep, therefore, will start again at the first or top row.

Successively disposed areas of the screen 106 of the oscilloscope will therefore correspond to the similarly disposed mosaic-antenna sections In the disc I of the member II. Each spot along a particular horizontal sweep, therefore, will become brightened on the screen III according to the amount of radio energy received by the corresponding pick-up element, and fed, by way of 5 the amplifier II, to the control electrode 12 of the cathode-ray oscilloscope II.

A more sensitive video signal device to which the present application is particularly directed might be any well-known bridge detector of, say. the Wheatstone construction. A bridge circuit embodying an electret in an arm of the bridge provides for taking advantage of the before-described sensitive properties of the electret in affecting the balance of the bridge. For the particular radio-wave-location purposes above mentioned, if a plurality of electrets are connected, for example, in a direct-current series circuit, then the bank of electrets may serve as an extremely sensitive radio-detecting element of a Wheatstone bridge, in which they may be balanced against fixed impedance elements 212, 214 and 211, as shown in Fig. 4. The short-circuiting or exploring of each successive electret by the electron stream, diagrammatically shown as shorting switches 215, 211, 211, in parallel with the electrets 204,201,201, would thus be markedly indicated in the amplifier 79 and fed to the control electrode 92 of the display oscilloscope II.

Although the invention has been described in connection with mosaic-antennas arranged in rows and columns, it will be understood that this is not essential, for other arrangements are also possible. Antennas arranged along concentric circles covering the field, or a continuous spiral, will also serve, though the oscilloscope arrangement would, of course, be correspondingly modi-1 fled.

In the case of the concentric circles and the spiral, the antennas would be rendered effective in two-dimensional order, as in the case of the rows and columns before described. The antennas disposed along one of the circles, for example, would first be rendered effective, then those along the next circle, and so on.

Further modifications will occur to persons skilled in the art, and all such are considered to fall within the spirit and scope of the invention, as denned in the appended claims.

ENGLISH-CLAIMS:
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What is claimed is:

1. A bridge having a plurality of arms one of which comprises electret means, and means for indicating variations in the bridge.

2. A bridge having arms one of which comprises a plurality of electrets for receiving radio waves, and means for indicating variations in the balance of the bridge in response to radio waves recejved by the electrets.

3. A bridge having a plurality of arms connected together to form a plurality of pairs of vertices one of the arms having radio-receiving means including electrets, an input circuit connected to one of the pairs of vertices, and an output circuit connected to another pair of vertices.

4. A bridge having four arms connected together to form two pairs of oppositely disposed vertices, one of the arms having electret means, an input circuit connected to one of the pairs of vertices, and an output circuit connected to the other pair of vertices.

5. A bridge having four arms connected together to form two pairs of oppositely disposed vertices, one of the arms having a plurality of series-connected electret elements, an input circuit connected to one of the pairs of vertices, 76 and an output circuit connected to the other pair of vertices.

6. A bridge having four arms connected together to form two pairs of oppositely disposed vertices, one of the arms comprising a plurality of electret elements, an Input circuit connected to one of the pairs of vertices, an output circuit connected to the other pair of vertices, and means for causing the successive electret elements to produce successive indications In the output circuit.

7. A bridge having arms one of which a plurality of electrets for receiving radio waves, each electret comprising a dielectric base impregnated with a radio-wave absorbing-and-rectlfying material, and means for tn n& gt; ti g variations in the balance of the bridge in response to radio waves received by the electrets.

8. A bridge having arms one of which contains a plurality of electrets for receiving radio waves. each electret comprising wax impregnated with silicon, and means for indicating variations in the balance of the bridge in response to radio waves received by the electrets. .

9. A bridge having arms one of which contains a plurality of electrets for receiving radio waves. each electret comprising a .dielectric base impregnated with a radio-wave-absorbing-and-rectifying material, and the other arms of which contain fixed electrical elements, and means for indicating variations in the balance of the bridge in response to radio waves received by the electrets.

10. A bridge having arms one of which contains electret means for receiving radio waves comprising a dielectric base impregnated with radio-wave-absorbing-and-rectifying material and provided with electrode means tuned to the frequency of the radio waves, and means for indicating variations in the balance of the bridge in response to radio waves received by the electret means.

11. A multi-arm electrical bridge circuit one arm of which comprises electret means for receiving and rectifying radio waves and the other arms of which are provided with fixed electrical elements, and means for indicating variations in the balance of the bridge in response to radio waves received by the electret means.

12. A bridge having a plurality of arms one of which comprises a permanently charged element comprising permanently polarized dielectric base electret means, means for directing an electron stream toward the electret means, and means for indicating variations in the bridge.

13. A bridge having four arms connected together to form two pairs of oppositely disposed vertices, one of the arms having means comprising a permanently polarized dielectric base, an input circuit connected to one of the pairs of vertices, an output circuit connected to the other pair of vertices, and means for directing an electron stream toward the dielectric base.

14. A bridge having four arms connected together to form two pairs of oppositely disposed vertices, one of the arms having ah electric network comprising a plurality of elements each comprising a permanently polarized dielectric base, an input circuit connected to one of the pairs of vertices, an output circuit connected to the other pair of vertices, and means for causing the successive elements to produce successive indications hi the output circuit.

15. A bridge having arms one of which contains an electric network comprising means for receiving radio waves comprising a permanently polarized dielectric base impregnated with a radio-wave absorbing-and-rectifying material, and means for indicating variations in the balance of the bridge in response to radio waves received by the receiving means.

16. A bridge having arms one of which contains an electric network comprising means for receiving radio waves comprising permanently polarized wax impregnated with silicon, and means for indicating variations in the balance of the bridge in response to radio waves received by the receiving means.

17. A bridge having arms one of which contains an electric network comprising a plurality of elements for receiving radio waves, each element comprising a permanently polarized dielectric base impregnated with a radio-wave-absorbing-and-rectifying material, and the other arms of which contain fixed electrical elements, and means for indicating variations in the balance of the bridge in response to radio waves received by the elements.

18. A bridge having arms one of which contains means for receiving radio waves comprising a permanently polarized dielectric base impregnated with a radio-wave-absorbing-and-rectify-ing material and provided with electrode means tuned to the frequency of the radio waves, and means for indicating variations in the balance of the bridge in response to radio waves received by the receiving means.

19. A bridge having four arms connected together to form two pairs of oppositely disposed vertices, one of the arms comprising a plurality of elements each comprising a permanently polarized dielectric base, an input circuit connected to one of the pairs of vertices, an output circuit connected to the other pair of vertices, and means for scanning the successive elements to produce successive indications in the output circuit.

ROBERT H. RINES.

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