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Electret array sensitive to radio waves

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.

An object of the invention is to provide a novel combined radio-and-television system.

Another object of the present invention is to provide a new and improved radio-locator system for both detecting the presence of a body and rendering it visible.

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 and constructed in accordance with a preferred embodiment thereof; Fig. 2 is a view of a modification; Fig.

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 a further modification.

An electromagnetic-wave generator 4 is shown -5 responding to the scattering from a correspondexciting 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 plained, is thus recorded upon the array, specific 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, of the present invention, this radio-energy picfrom 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 7 comprising a plurality of normally ineffective radioreceiving 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 go pick-up elements.

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, t2, 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 pick-up elements; Though only a small number of pickup 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 pick-up 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 coring 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 radio-energy picture of the object 8, as will presently be exelemental areas of which will correspond to specific elemental areas of the object 8. By means ture 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.

Though the tube 90, and also the hereinafterdescribed cathode-ray oscilloscope-like member 89, are shown operating on the electrostatic principle, magnetic deflection or a combination of magnetic and electrostatic forces may be employed. The invention provides a means for producing upon the screen 108 images corresponding to the radio-frequency energy received by the Provision is made for first rendering the normally ineffective pick-up units 10, 12, 14, IB, etc of the first row successively effective momentarily in the display circuits; for then rendering the pick-up units 18, 20, 22, etc of the second row successively effective momentarily; for then rendering the pick-up units 24, 26, etc of the third row successively effective momentarily; and so oil.

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 dielectrie formed by filling the gap between two electrades with molten

fesin,carnauba: wax& gt; or beeis-HO the sticcessive"rows of ttte-arfay t]!-! :

wax, and subjecting the electrodes to high voltage. By allowing the wax to cool during the ap-plication of the high voltage, a solidified perma-"" nently charged electric dipole is producedHav-" ing permanent piezo-electric properties. ;-Ih-; vestigations in this field are described, for example, by A. Gemant in the Philosophical Maga-" zine, S. 7, vol. 20, No. 136. Suppl.November 1935;:; pages 929 to 952.

As described by W. G. Cady, in Piezoelectricity, 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 with" radio-absorbing-and-rectifying ma- 25 resistance.

terials, 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 tuned to the radio waves for example, if it is one-quarter of a wave-length long. It will hereinafter be explained that the electret rectifies the received radio-frequency energy. As explained in "O. S. Letters Patent 2,460,109 to Southworth, since the electret surface has been provided with a saturation charge, one half of the cycles of the radio energy received by the tuned electrode is unable to increase the charge between the terminals of the electret, whereas the opposite polarity half-cycles flow along the electret between its terminals, resulting in the developing of direct current voltages across the electret.

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 MO, 112, (14, 116, etc respectively, and a common strip 43. The second row of units similarly is shown comprised of charged dielectrics 18, 20, 22, etc provided with top electrodes 1(8, (20, 122, etc and a common strip 51 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 co nected to the other common strips 43 and 51.

The strips 43, 5! and 57 are shown connected by a conductor 78 to a grounded impedance- 58 in the input circuit of an amplifier 79.

The cathode-ray-oscilloscope-like member 89 is shown provided with a cathode 95, a controlgrid electrode 93 and an anode 97. Electrons emitted from the cathode 95 will become enabled, in response to proper stimulation of the grid 93, to pass by the grid 93 to the anode 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 !05, of which the plate (03 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 plate 103 and 105, Will cause the electron stream to become defleeted vertically. The rows of electret pick-up Units may be positioned along the successive paths of the electron stream to enable the stream to impinge on them as it successively sweeps out if, accordingly, the lensVis" caused to focus the radio-energy picture on the oscilloscope-like member 89, the bank of electrets will act to absorfc 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 sensitizred1 during their preparation. This alteration results from several factors, including heating 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 ahd to exhibit negative temperature coefficients of r .- a 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 off the top tuned" electrodes of the electrets" in the radio-receiving "circuits comprising-these -

tuned electrodes, the detecting electrets and the grounded conductor7 8. The rectification is pro l duced by the detecting dielectric disposed be-"" tween the electret electrodes. The variation of potential arid charge along the bank of electrets is thus a measure of the radio-frequency energy " impinged on the array by lens 5. " " -

The resistance of the silicon "or uranium oxide, as well as of the wax of the electret, since "their f temperature coefficients are negative, "changes with the intensity of the impinging r adio-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 pro-" duction of the direct-current potentials as ar re53 suit of the detection or rectification in the abovementioned radio-receiving circuits, and the resistance changes render the electrets extremely sensitive. A radio-energy image of the objects 8 become thus recorded upon the- array of electrets as charged, 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 of 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.

2,6IO;245 Each electret will absorb and rectify the radiofrequency energy. Dependent upon the magnitude of this energy, it will change the resistance and the charge of the electret. This change will result both as a consequence of 1 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 differentlypotentialed 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 elements, or there may be a combination of these effects.

A preferred scanning arrangement involves ing to as many horizontal sweeps as there are the circuit traceable from the grounded cathode 95, along the electron beam to the tuned electrode II0, for example, through the electret 10, the conductor 78, the load 58, and back to ground. The voltage appearing across the load 58 when the electron stream impinges on a particular element of the mosaic 7 will be dependent upon the value of the series resistance of the electret. As before explained, this resistance is a function of the impinged radio-frequency energy.

As the stream scans the successive elements 110, 112, etc therefore, the signal across the load varies in accordance with the value of the resistance of the successive electrets which manifests itself in the input circuit of the amplifier 79.

Mosaics of electrets for the member 89 may also take the form of Kg. 2, where electrets 81, Sfl. 8G, 88 are provided v/ith 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. The other electrodes 281, 284, 286, 288 may be in the interior of the tube 89. The electrode strip 181, 184, 186, 188, etc. may face 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 surf aces 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 200.

As the electron stream produced from the cathode 95, in response to appropriate horizontalsweep-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 seccessively discharge into a grounded preferably linear amplifier 79 by way of a conductor 18 If -65 cathode desired the amplifier 79 may be replaced by a bank of linear amplifiers, one corresponding to rfoS5S"SSSEr.7. will obviously - The electrons, will conUnue to,WT-#,a vary, at successive instants, in accordance with the radio-frequency energy received by the suecessive 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 attenufttor 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 radtorfrequency pulse for the period between successive radio pulses, to trigger the horizontal-sweep circuit 63. The horizontaltime-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, correspond1 TOWS 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 verticalsweep circuit 69 may be triggered to produce one vertical sweep corresponding to as many horizontal sweeps from the horizontal-sweep circuit 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 antenria elements. The screen 106 is illuminated by an electron stream in the oscilloscope "90.

This electron stream is i 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 100 of the oscilloscope by a conductor 67, and to the horizontal-deflector plate 101 of the oscilloscopelike 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 by a conductor 71, and to the ver-

Weal-deflector plate 103 of the oscilloscope-like member 89 by the conductor 71 and a conductor The amplifier 79 is connected, by conductors and 87, to the control-grid electrode 92 and the cathode 94 of the oscilloscope 90. s The mosaic of electrets becomes thus successively connected, through the amplifier 79, to the control electrode 92. Electrons emitted from the will become enabled) m response to ffi6 action f lifler ?9 to. ss by the grfd ano(Je ge Qf oscilloscope tube stream from the anode .86, 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 04, of which the plate 104 is shown grounded, to impinge finally on the fluorescent .viewing screen. 6-.o the oscilloscope 90.

After .each simultaneous horizontal sweep of bath, the oscilloscope and the oscilloscopes-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, and "J& lt;C3, 10.5; will become restored to zero. The next .horizontal sweep.-theref

ore, will start again at the first or top row. .

Successively disposed: areas& lt; of the-screen 108 of the .oscilloscope;90 will therefore correspond to thfirsimilarly disposed mosaic-antenna sections in the- disc ff of the member 89 Each spot along, a particular horizontal sweep, therefore, will become-brightened on the screen 106 according to the amount of radio energy received by the corresponding pick-up element, and fed, by way of the amplifier 79, to the control electrode 92 of the cathode-ray oscilloscope 90.

A more sensitive video signal device might be any well-known bridge detector of, say, the Wheatstone construction. If, -the electrets are connected in a direct-current series circuit, then the bank of condenser 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:2"! 6; as shown in Hg. 4. The short-circuiting of each successive electret by the electron stream, diagrammatically shown as shorting switches 205, 207, 209, in parallel with the electrets 204, 208, 208, would thus be markedly indicated in the amplifier 79 and fed to the control electrode 32 of the display oscilloscope 90.

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 modifled. 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 defined in the appended claims.

ENGLISH-CLAIMS:
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What is claimed is:

1. An electric system having, in combination, a plurality of successively disposed radio-receiving elements for receiving radio waves, each element including an electret comprising a polarized dielectric base in combination with radio-wave absorbing material provided on one side with an electrode tuned to the frequency of the radio waves and connected on another side to a common.load circuit, means for focusing a radiowave image of an object upon the radio-receiving elejhents, means for producing a first electron stream for impinging on the elements, means for causing the first electron stream to scan the suecessive elements of the plurality of elements, an oscilloscope having a screen and means for produping a second electron stream impinging on the screen, means for causing the second electron stream to .scan the successive portions .-.of,, the screen- in-synchronism- with" the scanning -ot the successive elements of the plurality of elements by-the.-firstrnamed scanning means, and means connected to the common load circuit controlled by the first electron, stream and responsive to the radio energy received by the successive radioreceiving elements for modulating the second electron stream during its scanning process to produce a likeness of the object upon the screen.

2. An electric system having, in combination, a plurality of successively disposed radio-receiving elements for receiving radio -waves, each element including an electret comprising a polarized dielectric base combined with a radio-wave-absorb-

ing-material provided, on one side with means tuned to the frequency of the radio -waves-and connected on another side to a common load circurt;-means for focusing a radio-wave image of an-object, upon the radio-receiving elements, means for scanning the successive elements of the plurality of elements, display means, and means connected to the

common load circuit controlled by the scanning means" and responsive to the radio energy received by the successive radio receiving elements for controlling the display means during the scanning process to produce a likeness of the object upon the display means,

3. An electric system having, in combination, a plurality of successively disposed radio-receiving elements for receiving radio waves, each element including an electret comprising a polarized dielectric base in combination with uranium oxide provided on one side with means tuned to the fre-

queney of the radio waves and connected: on.aiiother-side to a common load circuit, means lor foeusingia radio-wave image of an object upon the radio-receiving elements, means for scanning the successive elements of the-plurality of elements, display means, and means connected to the common load circuit controlled by the scanning -means and responsive to the radio energy received - by the successive radio-receiving elements for controlling the display means during -the scanning process to produce a likeness of the object upon the-display means.

4. An electric system having, in combination, a plurality of successively disposed radio-receiving elejnents for receiving radio waves, each element including an electret comprising a polarized dielectric base in combination with silicon provided on one side with means tuned to the frequency of the radio waves and connected on another side to& gt; a common load circuit, means for focusirig a radio-wave image of an object upon the radioreceiving elements, means for scanning the suecessive elements, of the plurality of elements, dis-

Play means, and means connected to the common load circuit controlled by the scanning means and responsive to the radio energy received by the successive radio-receiving elements for controlling the display means during the scanning -process to produce a likeness of the object upon the display means; 5.: An electric system having, in combination, a plurality of successively disposed radio-receiving elements for receiving radio waves, each element including an electret; comprising a polarized dielectric base in combination with a radio-wave absorbing material provided on one side with means tuned to the frequency of the radio waves and connected on another side to & common load circuit, means for focusing a radio-wave image of an object; upon, the: radio-receiving : elements, means for producing : a: first electron stream for Impinging on the elements, means for causing Number the first electron stream to scan the successive elements of the plurality of elements, an oscilloscope having a screen and means for producing a second electron stream impinging on the screen, 5 2,175,691 means for causing the second electron stream to scan the successive portions of the screen in synchronism with the scanning of the successive elements of the plurality of elements by the firstnamed scanning means, and means connected to 10 2,306,272 the common load circuit controlled by the first electron stream and responsive to the radio energy received by the successive radio -receiving elements for modulating the second electron stream during its scanning process to produce a 15 2,423,125 likeness of the object upon the screen.

ROBERT H. RINES. 2,429,933 Gebson --------- ____ Oct.

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