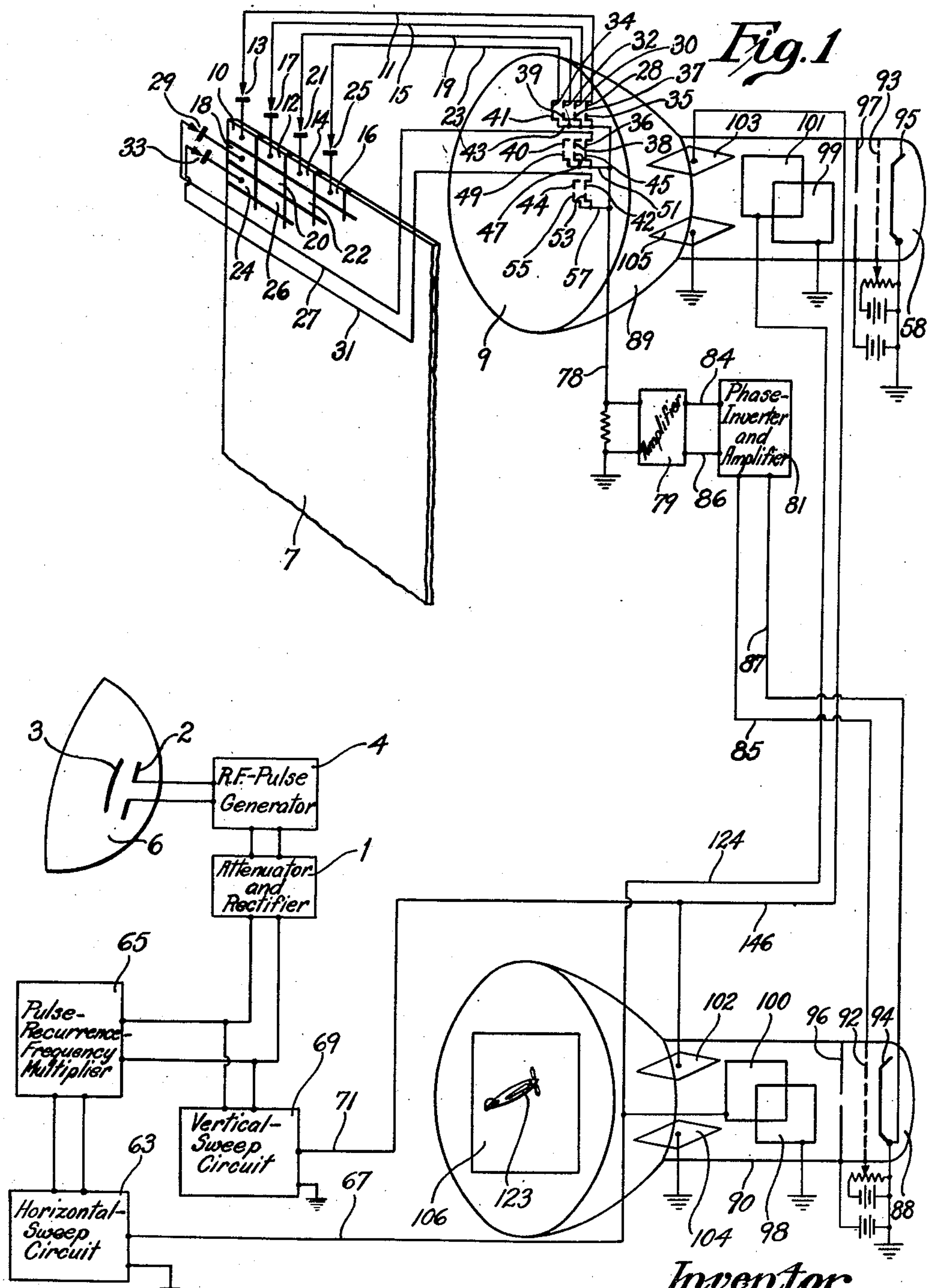
Dec. 7, 1954 R. H. RINES 2,696,522

VISUAL REPRODUCTION OF DISTANT OBJECTS

Filed Jan. 22, 1944 2 Sheets-Sheet 1

Fig. 1



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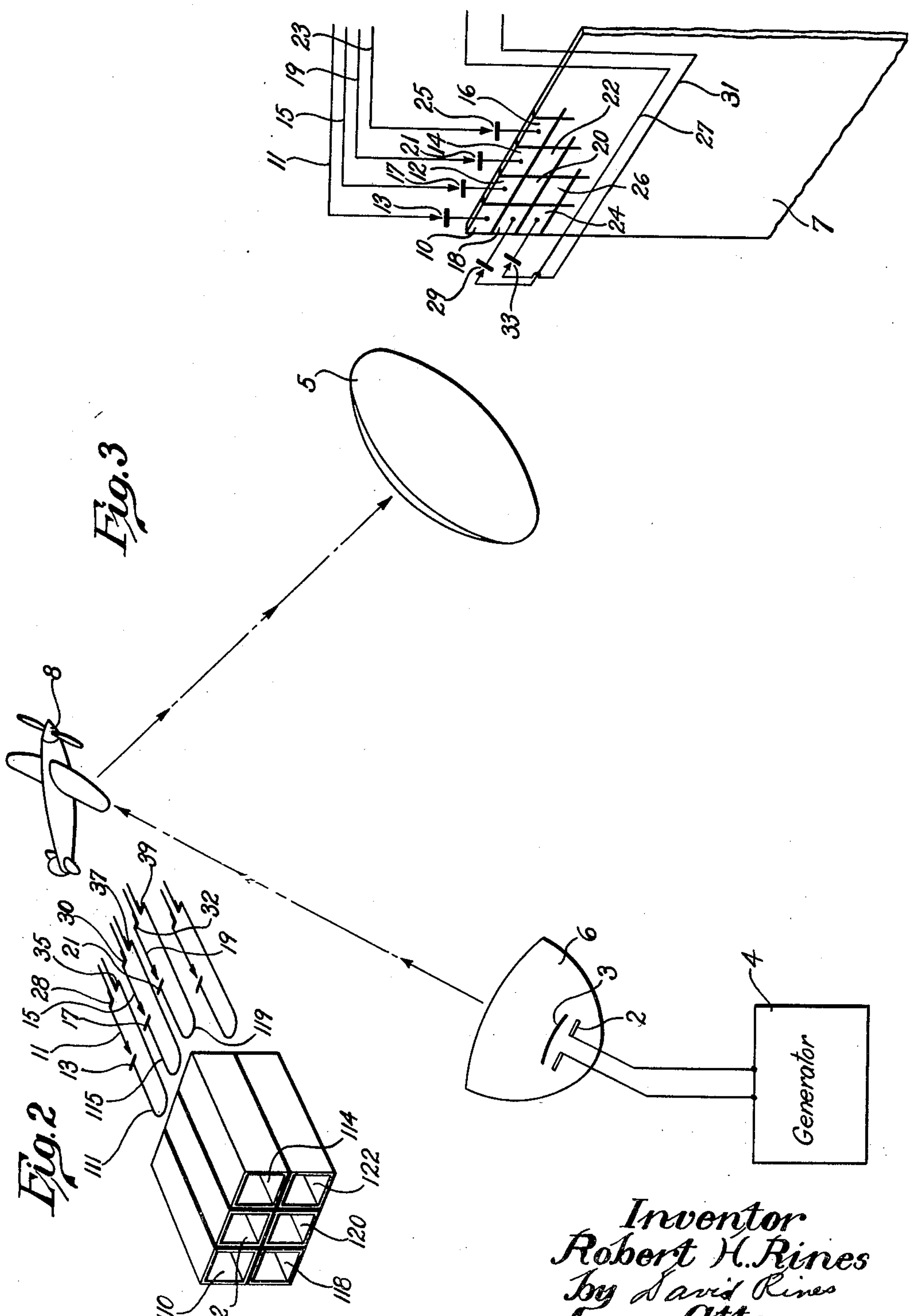

Fig. 2

Fig. 3

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VISUAL REPRODUCTION OF DISTANT OBJECTS

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10 Claims. (Cl. 178—6.8)

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 new and improved radio-receiving system.

Another object is to provide a new and improved television system.

Another object 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; and Fig. 3 is a diagram showing an airplane object from which radio waves are reflected and scattered to the receiving system of Fig. 1.

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 microwave 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 **7**, comprising a plurality of normally ineffective insulated 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 systems 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 as metal strips or other conducting antenna sections, separated by insulation strips to prevent radio interference and interaction between the antenna sections, and 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 pick-up 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 left-hand column. The sections **12, 20, 26**, etc., are disposed in the second column from the left. The sections **14, 22**, etc., are disposed in the third column from

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the left, 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. A system of 180 rows and columns of antenna sections of dipole dimensions will produce good picture definition of large close-range objects for a three-centimeter wave, assuming an eight-inch-display cathode-ray-tube screen.

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 area 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 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 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**. Though the tube **90**, and also the hereinafter-described 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 **106** images corresponding to the radio-frequency energy received by the pick-up elements.

Provision is made for first rendering the normally ineffective pick-up units **10, 12, 14, 16**, 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 in the display circuit; for then rendering the pick-up units **24, 26**, etc., of the third row successively effective momentarily; and so on.

A preferred way of effecting this result is with the aid of a novel electron-operated energy-scanning apparatus that, for the particular preferred radio-energy purposes described herein, comprises a plurality of insulated energy-storing devices shown as charging condensers and small rectifiers, equal in number to the number of pick-up sections. The rectifiers may be uranium-oxide or silicon beads, and serve respectively, to rectify the energy received by the respective pick-up units. The charging condensers and the rectifiers are connected to the pick-up sections by conductors, which should be extremely short transmission lines, preferably no more than 3 or 4 wavelengths long, and all the conductors should be of substantially the same electrical length. The sections **10, 12, 14, 16, 18** and **24**, for example, are shown connected by conductors **11, 15, 19, 23, 27** and **31**, respectively, to rectifiers **13, 17, 21, 25, 29** and **33**.

The conductor **11**, for example, connects the section **10**, through the rectifier **13**, to a condenser plate **28**; the conductor **15** connects the section **12**, through the rectifier **17**, to a condenser plate **30**; the conductor **19** connects the section **14**, through the rectifier **21**, to a condenser plate **32**; the conductor **23** connects the section **16**, through the rectifier **25**, to a condenser plate **34**; the conductor **27** connects the section **18**, through the rectifier **29**, to a condenser plate **36**; the conductor **31** connects the section **24**, through the rectifier **33**, to a condenser plate **42**; and so on.

The condenser plates are shown arranged in an insulating-disc bank or array **9** of rows and columns to correspond to the bank or array **7** of rows and columns, respectively, of the pick-up sections. The first or uppermost row comprises the equally spaced condenser plates **28, 30, 32, 34**, etc., corresponding to the pick-up antenna sections **10, 12, 14, 16**, etc., of the first row of antenna sections. The second row from the top comprises the equally spaced condenser plates **36, 38, 40**, etc., corresponding to the antenna sections **18, 20, 22**, etc., of the second row of pick-up units. The third row comprises the equally spaced condenser plates **42**, **44**, etc., corresponding to the third row of sections **24**, **26**, etc., and so on. The first column of condenser plates **28**, **36**, **42**, etc., corresponds similarly to the first column of sections **10**, **18**, **24**, etc. The second column of condenser plates **30**, **38**, **44**, etc., corresponds to the second column of sections **12**, **20**, **26**, etc. The third column of condenser plates **32**, **40**, etc., corresponds to the third column of sections **14**, **22**, etc., and so on.

The condenser plates **28**, **30**, **32**, **34**, etc., of the first row are shown respectively cooperating with condenser plates **35**, **37**, **39**, **41**, etc., that are all connected to a grounded condenser strip **43**. Condensers are thus provided, one plate of which is connected to the strip **43**, and the other plates of which are connected, through the respective rectifiers, to the sections **10**, **12**, **14**, **16**, etc.

The condenser plates **36**, **38**, **40**, etc., of the second row are similarly shown respectively cooperating with condenser plates **45**, **47**, **49**, etc., that are all connected to another grounded condenser strip **51**. The condenser plates **42**, **44**, etc., of the third row are similarly shown cooperating with condenser plates **53**, **55**, etc., that are all connected to a third grounded condenser strip **57**, and so on.

The condenser plates of the respective condensers are all preferably separated by the same distance. The condensers may conveniently have either large or small capacitance, varying, say, from micro-microfarads to farads, depending upon the type of antenna receiving circuits used.

The same result may, of course, be attained in other ways than through the use of the rectifiers. One such way is to connect the antennae **10**, **12**, **14**, etc., directly to the condenser plates **28**, **30**, **32**, **34**, etc. The condensers must now, however, have a small value of capacitance, in order to present a relatively high impedance to the radio-frequency energy. For 3-centimeter waves, capacitances of the order of 10^{-15} farads would be adequate. The short leads **11**, **15**, **19**, **23**, **27**, **31**, etc., should be connected by ultra-high frequency chokes, not shown, to prevent interaction. These chokes will not permit the passage of current from one metal pick-up section to the adjacently disposed metal pick-up section during the hereinafter-described discharge or short-circuiting of the condensers, since the time of the discharge or short-circuiting of each metal section is very short.

The condenser plates and strips may be embedded in the insulating disc **9**, at the screen end of the cathode-ray-oscilloscope-like member **89**, provided with a vacuum-tube electron-gun part **58**, comprising a cathode **95**, a control-grid 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 **97** of the tube **58** 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 **105**, of which the plate **105** 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 **95** 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 deflected vertically.

The before-described distance between the condenser plates may be made of value necessary to give the before-mentioned capacity, and the anode **97** may be adjusted so that this distance shall be substantially equal to the width of the electron stream, in order that the electron stream may fill the gap or region between these condenser plates, thereby to discharge the condensers. The rows of condensers may be positioned along the successive paths of the electron stream, as the electron stream successively sweeps out the successive rows of the array on the disc **9**.

It is not essential that the condenser plates be embedded in the disc **9**. They may be ordinary condensers, connected in parallel with rows and columns of pin-point electrodes (not shown) that are so embedded, and separated from each other by the said distance in order that the electron stream of the member **89** may fill the gap between them. The electron stream will then electrically bridge the pin-point electrodes of each pair, to cause the discharge of the corresponding condenser.

The antenna sections of the array **7**, and either the condensers in the disc **9**, or the pairs of pin-point electrodes (not shown), will thus correspond to one another. A condenser is provided corresponding to each pick-up unit, and corresponding condensers or pairs of pin-point electrodes and pick-up antenna sections may occupy corresponding positions.

Radio-frequency voltages received through the lens **5** upon the antenna sections of the array **7**, in the system of Fig. 1, are thus rectified, and there are built up across the corresponding condensers rectified direct-current condenser-charging voltages that are proportional to the strengths of the radio-frequency voltages received by the corresponding antenna sections. 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 between the condenser plates, or the pairs of pin-point electrodes, in the disc **9**, these built-up charges upon the condensers become successively discharged 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 antenna sections, and connected to the respective charging condensers.

The output of the amplifier **79** will obviously vary, at successive instants, in accordance with the discharge of the successive condensers, and this discharge is a measure of the strength of the radio energy received by the 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 **1**, 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 trigger the horizontal-sweep circuit **63**. A 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 antennae. The pulse generator **4** may also feed, through the attenuator and rectifier **1**, 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**, **105**, during the periods between successive radio-pulse transmissions, corresponding to as many horizontal sweeps as there are rows of antennae, causing each of the horizontal sweeps to appear at successively lower levels on the oscilloscope-sweep faces.

If the circuit **65** comprises an oscillator, the oscillations may be employed to trigger the horizontal sweep. The period of the oscillations which, as before explained, is much less than the duration of a radio pulse, corresponds to the time of discharge of one row of the condensers in the disc **9**, in response to energization of one row of the antenna sections of the array **7**. 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 antenna sections.

Means is provided, controlled by the discharge of the condensers, for producing, upon the screen **106** of the display oscilloscope **90**, images corresponding to the radio-frequency energy received by the corresponding pick-up antenna elements. Successively disposed areas of the fluorescent screen **106**, that correspond to the similarly disposed antenna elements, are energized by an electron stream in the oscilloscope **90** to illuminate them. This electron stream is synchronized to travel with the electron stream of the cathode-ray-tube-like member **89**. The horizontal sweep circuit **63** is connected to the horizontal-deflector plate **100** of the oscilliscope **90** by a conductor **67**, and to the horizontal deflector plate **101** of the oscilloscope-like member **89** by the conductor **67** and a conductor **124**. The vertical-sweep circuit **69** is connected to the vertical-deflector plate **102** of the oscilloscope **90** by a 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 **84** and **86**, to the phase-inverter and amplifier stage or stages **81** which, in turn, is connected, by conductors **85** and **87**, to the control-grid electrode **92** and the cathode **94** of the vacuum-tube electron-gun part **88** of the oscilloscope **90**. The condensers become thus successively connected, through the amplifier **79** and the phase-inverter **81**, to the control electrode **92**. Electrons emitted from the cathode **94** will become enabled, in response to the action of the amplifier **79** and the phase-inverter **81**, to pass by the grid **92**, to the anode **96** of the tube **88** 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 **104** is shown grounded, to impinge finally on the fluorescent viewing screen **106** of the oscilloscope **90**. The horizontal-sweep-time base applied to the vertically disposed deflector plates **98** and **100** will cause the electron stream from the cathode **94** to become deflected horizontally, and the vertical-sweep-time base, applied to the horizontally disposed deflector plates **102** and **104**, will cause the electron stream to become deflected vertically, in synchronism with the horizontal and vertical sweeps discharging the condensers in the disc **99** of the scope-like member **89**.

The magnitude of the voltage fed into the amplifier **79** from the condensers will depend upon the intensity of the radio-frequency voltage received from the object **8** through the lens **5** by the corresponding antenna sections. This is because the sections are successively rendered effective by the discharging of the corresponding condensers by the electron stream of the member **89**. The output of the amplifier **79** will therefore vary, at successive instants, in accordance with the potential upon the successive receiving antenna sections. Successive energizing positive voltages are thus produced from the amplifier **79** on the control electrode **92** of the tube part **88** of the cathode-ray tube **90**, of magnitude proportional to the radio-frequency energy received by the corresponding antenna sections. This will render the tube **90** effective to permit the passage of the electrons in quantities dependent upon the radio-frequency energy impinging on the particular antenna section, to the anode **96**, and between the pairs of vertically disposed deflecting plates **98**, **100** and horizontally disposed deflecting plates **102**, **104**, to the viewing screen **106**.

After each simultaneous horizontal sweep of both the scope **90** and the oscilloscope-like member **89** has been completed, a successively larger voltage will be applied to the horizontally disposed deflector plates **103**, **105** and **102**, **104**, respectively, by the vertical sweep circuit. After the last such horizontal sweep, the voltage between the horizontally disposed plates **103**, **105** and **102**, **104** 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 **90** will therefore correspond to the similarly disposed condensers in the disc **9** of the oscilloscope-like member **89**, and to similarly disposed antenna sections. 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** and the phase-inverting-and-amplifying circuit **81**, to the control electrode **92** of the tube **88** of the cathode-ray oscilloscope **90** to render the tube **90** effective to produce a likeness upon the screen **106**.

To each row of antenna sections, therefore, there corresponds, on the face **9** of the oscilloscope-like member **89**, a horizontal electron stream that discharges the horizontal row of charged condensers. To each row of antenna sections, moreover, there corresponds, on the oscilloscope screen **106**, a horizontal electron stream that is graded in intensity, due to the application of signal voltages, from successive antenna sections of the row, on the oscilloscope control-grid electrode **92**. This intensity is distributed in synchronism with the corresponding state of charge of the corresponding condensers on the disc **9** of the scope-like member **89**. This provides for successive horizontal time bases on the screen, and the successive areas of the screen **106** are thus illuminated in synchronism with the effective reception of the radio energy by the corresponding pick-up antenna sections. To each successive row of antenna sections, moreover, there corresponds a successively lowered level of operation of the electron stream on the screen **106** of the oscilloscope, corresponding to the measured voltage applied at that instant by the vertical sweep circuit **69**.

The sweeps of the two electron streams of the members **89** and **90** are thus synchronized, to produce intensity modulation on the oscilloscope screen **106**, corresponding to the radio-frequency distribution on the antenna sections of the bank **7**. The radio waves received successively by the antenna units along the successive rows and columns will thus become converted into successive portions of the visual likeness **123**, along correspondingly disposed rows and columns thereof, along the successive time bases. The visual picture **123** of the aircraft object **8** on the oscilloscope screen **106** will accordingly correspond to the radio-frequency picture on the array **7** of pick-up elements which, in turn, corresponds to the actual object **8**.

If the rectifiers **13**, **17**, etc., are not used, as previously suggested, but radio-frequency voltages are applied directly to the condenser plates **28**, **30**, **32**, **34**, . . . **36**, **38**, **40**, . . . **42**, **44**, . . . etc., then slight modifications may be incorporated as follows: the amplifier **79** and its input should be tuned to the radio-frequency energy that will be fed thereto during the scanning of the condenser, and the phase-inverter-and-amplifying stage or stages **81** should be followed by a rectifier (not shown), and then applied to the control grid **92** of the cathode-ray oscilloscope **90**.

Instead of the conducting antenna sections of the array **7**, other types of conventional ultra-high-frequency antenna units may be employed such, for example, as the hollow-pipe valve-guides illustrated in Fig. 2. Square-cross-sectional wave-guides are there shown, designated by the same reference numerals as the corresponding conducting antenna sections of Fig. 1, but agumented by **100**. Each wave-guide is provided with a pick-up loop that is connected, through the corresponding rectifier, to the corresponding condenser. Thus, the wave-guide **110** is provided with a pick-up **111** that is connected by the conductor **11**, through the rectifier **13**, to the condenser **28**, **35**; the wave-guide **112** is provided with a pick-up loop **115** that is connected by the conductor **15**, through the rectifier **17**, with the condenser **30**, **37**; the wave-guide **114** is provided with a pick-up loop **119** that is connected by the conductor **19**, through the rectifier **21**, with the condenser **32**, **39**; and so on. The operation is substantially the same as before described, with the condensers connected to feed the amplifier **79**, except that there is less need for feed-transmission lines and, therefore, less attenuation of the high-frequency energy. The wave-guides will, of course, have dimensions suitable for receiving the desired wave which, as before stated, may have a length of 3 or 1.5 centimeters.

Assuming that the size of the object **8** is known, the position of the lens **5** to produce a sharp electromagnetic image on the array **7** of dipoles, coupled with the size of the visual image **123**, may be used to deduce range, by simple geometrical optics. If, for example, the object seen is a fighter, or a bomber plane, the size of the image, divided by the known size of the fighter or bomber, will be proportional to the ratio between the distance of the lens **5** from the bank **7** of antennae, adjusted to obtain clear vision, divided by the distance of the object **8**. The range of the object **8** may also easily be obtained by monitoring the pulse emission and reflection, if radio pulses are used, on a separate oscilloscope, according to common practice.

Although the invention has been described in connection with antennae arranged in rows and columns, it will be understood that this is not essential, for other arrangements are also possible. Antennae arranged along concentric circles covering the field, or a continuous spiral, will also serve, though the oscilloscope arrangement would, of course, be correspondingly modified. In the case of the concentric circles and the spiral, the antennae would be rendered effective in two-dimensional order, as in the case of the rows and columns before described. The antennae 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.

What is claimed is:

1. An electric system having, in combination, a plurality of radio-receiving wave-guide elements, a plurality of antennae associated with the wave-guide elements, a plurality of condensers, one corresponding to each of the antennae, means for charging each condenser from the energy of the corresponding antenna, means for successively discharging the condensers, and means controlled by the discharge of each condenser for producing a likeness corresponding to the energy received by the corresponding element.

2. An electric system having, in combination, a cathode-ray-tube-like member having an electron-stream-producing means and a screen, a plurality of energy-storing means supported by the screen and each provided with a pair of oppositely disposed electrodes separated from one another, and means for causing the electron stream to fill the separated regions between the electrodes, thereby to discharge the energy storing means.

3. An electric system having, in combination, a plurality of radio-receiving elements, a plurality of electrical charging elements, rectifying means, means connecting the charging elements to the receiving elements through the rectifying means to energize the charging elements from the energy of the receiving elements, means for successively discharging the charging elements, and means controlled by the discharge of each charging element for producing a likeness corresponding to the energy received by the corresponding receiving element.

4. An electric system having, in combination, a plurality of radio-receiving elements, a plurality of electrical charging elements, one corresponding to each of the radio-receiving elements, a plurality of rectifiers, one corresponding to each of the electrical charging elements, means connecting the charging elements to the respective receiving elements through the respective rectifiers to energize the charging elements from the energy of the corresponding receiving elements, means for successively discharging the charging elements, and means controlled by the discharge of each charging element for producing a likeness corresponding to the energy received by the corresponding receiving element.

5. An electric system having, in combination, a two-dimensional array of wave-guide radio-receiving elements arranged in rows and columns for receiving radio waves from an object, a two-dimensional array of electrical charging elements arranged in rows and columns, one corresponding to each of the receiving elements, means for charging each charging element from the energy of the corresponding receiving element, means for scanning the charging elements in two-dimensional order along the rows and columns thereof successively to discharge the charging elements in two-dimensional order along the successive rows and columns, a normally ineffective electric circuit for producing a likeness corresponding to the radio energy received by the receiving elements from the object, means for connecting the charging elements to the circuit, and means controlled in synchronism with the successive discharges of the charging elements for rendering the circuit successively effective through the connecting means to produce successive portions of the likeness of the object in two-dimensional order along rows and columns corresponding to the rows and columns of the charging elements synchronously with the reception of the radio energy from the object by the corresponding receiving element.

6. An electric system having, in combination, a two-dimensional array of wave-guide radio-receiving elements for receiving radio waves from an object, a two-dimensional array of electrical charging elements, one corresponding to each of the receiving elements, means for charging each charging element from the energy of the corresponding receiving element, means for sending an electron stream to the charging elements in two-dimensional order successively to discharge the charging elements in two-dimensional order, an amplifier for amplfying the discharges of the charging elements, means for connecting the charging elements to the amplifier, an oscilloscope having a screen successively disposed areas of which correspond to the successively disposed receiving elements in two-dimensional order and means for producing an electron stream impinging on the screen, and means connected to the amplifier for controlling the operation of the oscilloscope electron stream in synchronism with the operation of the discharging electron stream to produce successive portions of a likeness of the object along the said areas of the screen in two-dimensional order synchronously with the reception of the radio energy from the object by the receiving elements corresponding to the said areas.

7. An electric system as claimed in claim 2 and in which there is provided radio-frequency means for energizing the energy-storing means.

8. An electric system as claimed in claim 2 and in which there is provided radio-frequency antenna means for energizing the energy-storing means.

9. An electric system as claimed in claim 2 and in which there is provided radio-frequency wave-guide means for energizing the energy-storing means.

10. An electric system as claimed in claim 2 and in which there are provided radio-frequency means, rectifying means, and means for energizing the energy-storing means from the radio-frequency means through the rectifying means.

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