March 23, 1954 R. H. RINES 2,673,343

ELECTRIC SYSTEM

Filed Jan. 29, 1944

Fig.1

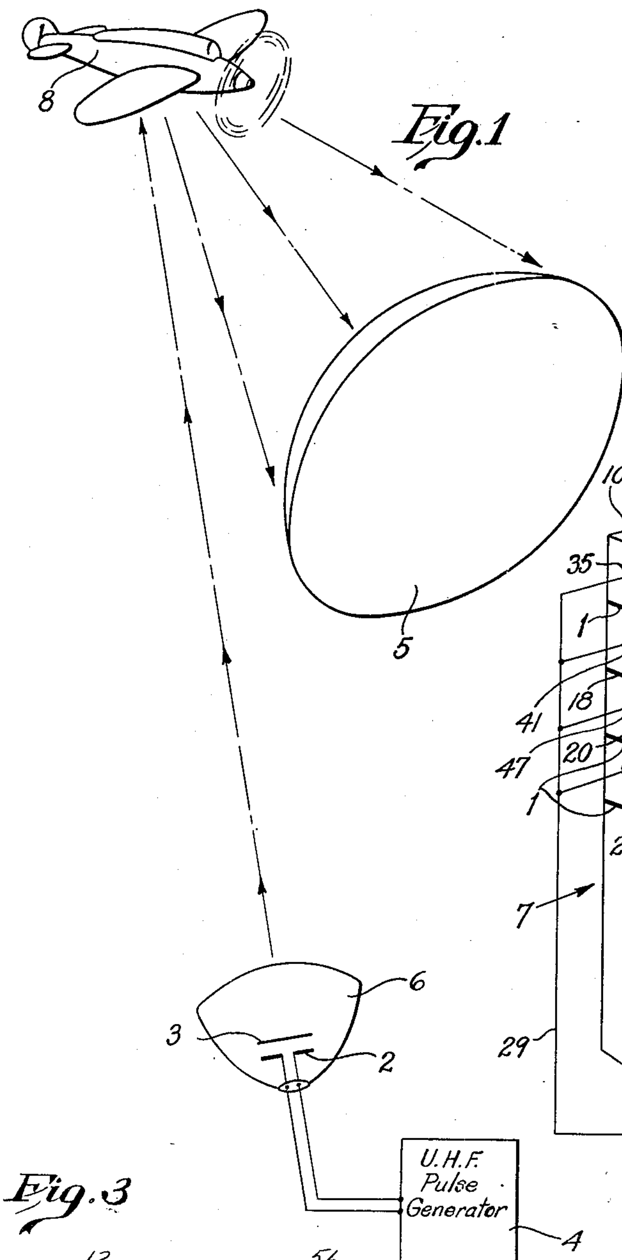


Fig.2

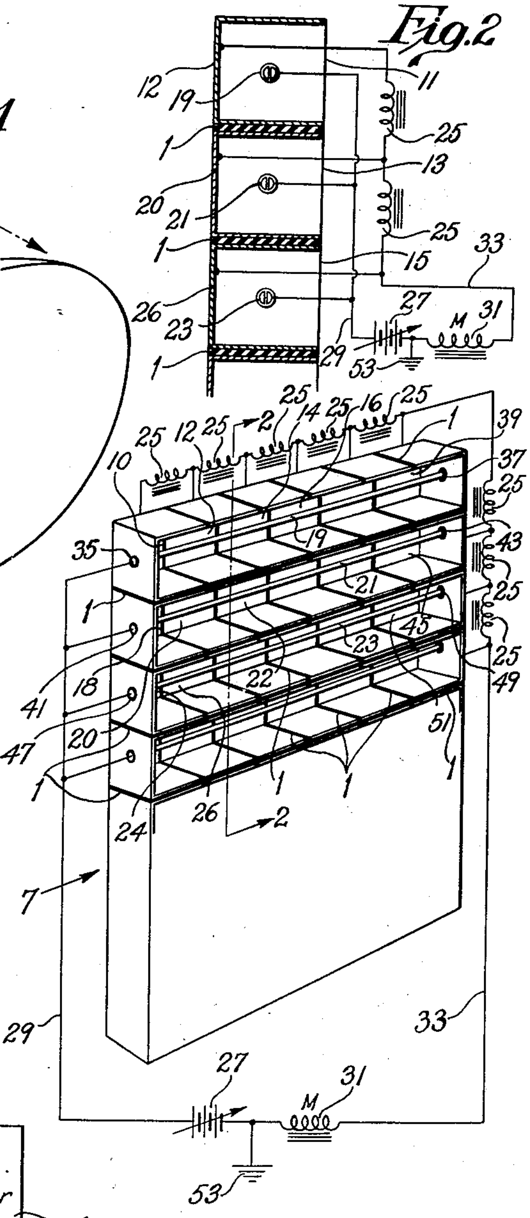
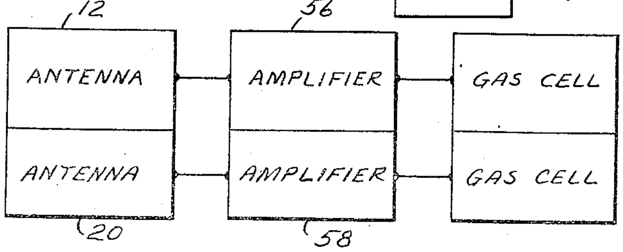


Fig.3



Inventor
Robert H. Rines
by David Rines
Attorney

Patented Mar. 23, 1954

2,673,343

UNITED STATES PATENT OFFICE

2,673,343

ELECTRIC SYSTEM

Robert Harvey Rines, Brookline, Mass.

Application January 29, 1944, Serial No. 520,335

19 Claims. (Cl. 343—17)

1

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.

A further object is to provide a new range-finder.

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, showing also the airplane object from which the radio waves are reflected and scattered to the receiving system; Fig. 2 is a section of a modification, upon a larger scale, taken upon the line 2—2 of Fig. 1, looking in the direction of the arrows; and Fig. 3 is a schematic fragmentary view similar to Fig. 2 of a modification.

An electromagnetic-wave generator **4** is shown exciting a dipole **2** to produce ultra-high-frequency microwave-radio energy, say, of 3 or 1.5 centimeters wave-length. A continuous-wave or any other type of modulated-wave generator may be employed, though 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 system for focusing the electro-

2

magnetic energy scattered and reflected from the object **8** on the bank or array **7** of antenna elements.

The pick-up elements may be in the form of square thin metal antenna sections ¾ centimeter length and breadth, and separated by electrical insulation strips **1** one millimeter thick. ¾ centimeter is one-quarter the wave-length of a three-centimeter wave. The insulation **1** prevents discharge between the antenna elements by preventing interaction between them. The square pick-up antenna elements may constitute the front sides of hollow cubes (not shown), the rear sides of which may be open, as shown in Fig. 1, or covered by a screen or screens, as shown in Fig. 2. The inside faces of the cubes are preferably polished, in order that they may constitute mirrors. In each hollow cube there may be disposed a neon or other appropriate gas cell connected by a conductor to the front face of the cube, or other gas-discharge means may be employed.

The square pick-up antenna elements 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 for example, is illustrated as comprising the sections **10**, **12**, **14**, **16**, etc., shown as equally spaced horizontally. The last antenna section of the first row is indicated at **39**. The second row from the top is shown comprising the sections **18**, **20**, **22**, etc., and the last section of this second row is shown at **45**. The third or next-lower row is shown comprising the sections **24**, **26**, etc., with the last section at **51**; and so on for the remaining rows of sections. Though only a small number of antenna 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 antenna units will be employed in each row. In order to fix the ideas, for purposes of description, let that number be chosen as 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 the left, and so on. There may be as many columns as there are antenna sections in each row. The columns and rows are separated by the insulation strips **1**. Though each column is shown as comprising only a few antenna units, this is again in order not to complicate the drawings. In actual practice, the number of antenna strips in each column may be quite large, say 180.

The number 180 may of course, be varied. 150 to 180 rows and columns of antenna sections of resonant dimensions will yield good definition for large close-range objects when three-centimeter waves are used. For the dimensions given above, the array 7 would be approximately five feet square.

Though the antenna elements may be in the form of cubes (not shown), as before stated, it is preferred to have the pick-up elements of each row constitute the front side of a long, hollow rectangular prism or cell the rear side of which is open, as shown in Fig. 1, or covered by a screen or screens, as shown in Fig. 2, and the inside faces of which may be polished, to constitute mirrors; and to dispose a long neon or other gas cell in each prism, directly behind the pick-up elements of the corresponding row, and extending substantially throughout the length of the row. In this case, as in the case of the cubical cells (not shown) before mentioned, at least portions of the neon-gas-discharge cells are each associated with an correspond to one of the antenna elements, energization of which by the received radio-frequency energy will produce a likeness on the array of antenna elements corresponding to the energy received by the corresponding antenna elements.

Preferably, indeed, the hollow prisms may themselves constitute the gas-discharge cells, bounding, at least in part, the dielectric gaseous medium, particularly if their rear sides are hermetically covered with a screen and, if desired, provision may be made for maintaining constant pressure of the gas within the hollow-prism gas-discharge cells in any well known manner.

Thus, the first row of metal antenna sections 10, 12, 14, 16, etc., may constitute the front side of a hollow metal prism, the rear side of which is covered by a screen 11, as shown in Fig. 2. The second row of antenna sections 18, 20, 22, etc., may constitute the front side of a hollow metal prism the rear side of which is covered by a screen 13, as also shown in Fig. 2. The third row of antenna sections 24, 26, etc., may constitute the front side of a hollow metal prism the rear side of which is covered by a screen 15 (Fig. 2), and so on. There will be as many such hollow prisms, the rear sides of which are covered by screens, as there are rows; say, 180. Each of these prisms may be hermetically sealed, and may contain a suitable gas, such as neon, to constitute a gas cell. Each screen 11, 13, 15, etc., may be constituted of darkened transparent material to serve as a suitable weak filter. If neon is the gas employed, the filter should be orange-colored. The prisms will be separated from one another by the insulating strips.

The screens 11, 13, 15, etc., may be regarded as the single screen of the antenna array 7. Though omitted from Fig. 1, this screen is shown embodied in the apparatus illustrated in Fig. 2.

A thin electrode may extend throughout substantially the length of each hollow-prism gas cell. The first or uppermost hollow prism is shown provided with a thin electrode 19, the second with a thin electrode 21, the third with a thin electrode 23, and so on. A bank or array of hollow-prism gas cells is thus provided, all insulated from one another, each of square transverse section and oblong longitudinal section, polished on five of its inner faces, provided with a screen on the sixth or rear face, and each

having an elongated electrode extending substantially throughout its length.

The electrodes are shown mounted on the first and last antenna sections of the respective hollow-prism cells by insulating rings. Thus, the electrode 19 is shown mounted by an insulator ring 35 to the first section 10, and by the insulator ring 37 to the last section 39, of the first row; the electrode 21 is shown mounted on the first section 18, by the insulator ring 41, and by the insulator 43 to the last section 45, of the second row; the electrode 23 is shown mounted by the insulator ring 47 to the first section 24, and by the insulator 49 to the last section 51, of the third row; and so on.

Each two adjacently disposed antenna sections are connected together through an ultra-high-frequency isolating element illustratively shown as a choke inductance in the form of a coil 25. Though these choke coils will serve to minimize the coupling, interaction or transfer of radio energy between the antenna elements and thus to prevent discharge between the antenna elements by preventing the flow of radio-frequency energy between adjacently disposed antenna sections, they will not prevent the flow of direct current between them. Each antenna element, therefore, will receive a radio distribution from the distant object 8 that corresponds to a particular area of the object, and that distribution will be undisturbed by the distribution received by adjacent antenna elements. The possibility of interference of the glow produced by one of the elements with the glow produced by the other elements is further reduced by the use of the individual prismatic glow-tubes before described.

A direct-current voltage may be supplied from any desired source, such as a battery 27, to one side of which one end of each of the electrodes 19, 21, 23, etc., may be connected by a conductor 29. The left-hand ends of the electrodes 19, 21, 23, etc., near the insulators 35, 41, 47, etc., are thus connected in parallel to the conductor 29. The other end of the battery 27 may be connected to the choke coils 25, through a master choke coil 31, by a conductor 33. The conductor 33 thus connects, through isolating choke coils 25, to each of the antenna sections. The antenna sections are furthermore shown grounded at 53 through the master choke coil 31, as well as through the individual choke coils 25.

A permanent direct-current striking voltage is thus provided by the battery 27 between the electrodes 19, 21, 23, etc., and the row of surrounding hollow-prism cells or antenna sections, with their radio-receiving elements, of the system. This direct-current voltage is sufficient to serve as the ignition voltage of the gas in the various hollow-prism cells. A glow discharge will thus be established through the gas-discharge neon cells between each electrode and the mirror faces of the hollow-prism antenna cell in which it is enclosed, these mirror faces serving as cathodes.

The totality of pick-up antenna-section units will, of course, all receive the reflected or scattered radio waves through the lens 5 simultaneously. There will be focused on each antenna section 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 reflected or scattered radio energy, corrresponding to the amount of energy reflected or scattered from the various parts of the object 8 and converged upon the totality of parts of the array of pick-up elements by the lens 5. A radio-energy picture of the object 8 is thus recorded upon the array, specific elemental areas of which will correspond to specific elemental areas of the object 8, and this specific elemental-area correspondence will be preserved by reason of the fact that there is no discharge between the antenna elements. By means of the present invention, this radio-energy picture may be converted into a visible picture. While it has heretofore been proposed to convert such a radio-energy image into a visual likeness, in accordance with a feature of the present invention, improved results are obtained through the preservation of elemental-area correspondence between the object, the radio-energy image thereof and the likeness produced therefrom.

The received radio energy conducted along the surfaces of the pick-up antennae will disturb or modify the normal relation between the pick-up antennae, serving as cathodes, and the electrodes 19, 21, 23, etc., serving as anodes of the hollow-prism cells in which they are disposed. The electrodes 19, 21, 23, etc. do not directly receive the radio energy from space, but, on the contrary, are shielded from space by the antenna elements along the surfaces of which, of course, as before stated, the radio-frequency energy does flow. The glow through the various portions of the neon cells will become correspondingly modified in accordance with the radio-frequency energy received by the corresponding antenna elements.

Two electrodes, an antenna-section cathode and one of the corresponding electrodes 19, 21, 23, etc., are required to produce the ignition initially from the battery 27. Only a single electrode, however, is needed to ionize a gas by radio-frequency energy. A single-wire conductor inserted in the neon cell, and connected to the antenna section, will therefore serve to ignite the cell. Only the single antenna-section electrode 10, 12, 14, etc., need be excited by the radio-frequency energy, therefore, to produce further gas excitation and ionization. Since these sections 10, 12, 14, etc., are also polished mirrors, they will glow noticeably, reflecting the illumination produced by the gas-discharge glow.

By suitable design, it is possible to operate on a portion of the characteristic of the neon cell such that a nearly linear relationship shall exist between the radio frequency excitation and the illumination or glow intensity of the neon cells, within the range of operation. Such a portion of the characteristic has been found to exist, applicable for use in varying the illumination proportional to the current.

There is a steep linearity between, say, 30 and 55 milliamperes, and again between 50 and 80 milliamperes. The radio-frequency currents that may be employed with this invention are of the order of microamperes; and the linearity is so steep that every microampere may produce its effect.

The radio distribution received by each radio-receiving element may therefore be converted, according to the present invention, into a corresponding light distribution.

The color corresponding to the direct-current excitation is orange. The direct-current voltage of the battery 27, therefore, produces an orange glow throughout the system. The color corresponding to the ionization resulting from the radio-frequency excitation impinging on the antenna elements, on the other hand, is pink. The radio-frequency energy received by the anenna sections, therefore, will result in modifying the orange color in the corresponding section by a pinkish hue, of intensity depending upon the strength of the received radio-frequency energy. The response is very sensitive; even differences of the order of microamperes will produce a difference in this color intensity.

To fix the ideas, consider the cell 12, for example, where a direct-current potential is established by the battery 27 between the electrode 19 and the antenna section 12. This causes ionization of the neon and a slight orange glow between the electrode 19 and the antenna section 12. The impressing of radio-frequency energy at the section 12 will cause the section 12 to glow with an additional modifying pink glow behind the element 12. The intensity of this glow bears a fixed relation to the amount of radio-frequency energy. The orange glow is thus modified by the pink. The mirror surfaces of the section 12 reflect this hue through the screen 11.

There will be little or no interference between the glows in the prism-shaped cells behind adjacent antenna sections, because the radio-frequency-exciting electrode gas-glow boundaries between the antenna sections are rather sharply defined. The slightly darkened aspect produced by the orange-colored filters 11, 13, 15, etc. will help to keep the daylight off the gas, thus preventing affecting the ignition characteristics. The weak orange filtering action serves also to help produce the pink glow in response to the radio-frequency signals, filtering out the background of the orange direct-current glow, and thus helping to produce on the bank of hollow-prism neon cells the visible image of the object 8 as impressed, in radio-frequency form, on the antenna sections.

As before stated, however, separate neon tubes may be employed, with separate cathodes, connected to the respective radio-receiving elements. A uniform background is attained in this manner. The picture of the object 8 would be visible on the neon cells themselves, if cells separate from the hollow prisms were employed. A striking radio-frequency voltage, moreover, may be applied to the cells from the transmitter 4, suitably attenuated, instead of the direct-current ignition potential from the battery 27. The neon cells may, furthermore, be supplied with control-grid electrodes and anodes, omitted from the disclosure for the sake of simplicity. If the radio-frequency signals should be weak, they may be enhanced by means of amplifiers 56, 58, etc. between the antennas 12, 20, etc. and the neon cells, as shown in Fig. 3. The hollow chambers, and the spacing between the inner electrodes and the antenna sections shown in Figs. 1 and 2, however, can provide for resonance and slight amplification. This resonance, of course, makes the system quite sensitive to weak radio fields and the construction lends itself to the microwave frequencies before mentioned. In all cases, a likeness corresponding to the radio energy received by the radio-receiving array 7 of antennae will thus be electromagnetically produced on the screen of the gas-discharge neon cells.

This likeness will be a distinct, definite, sharp visible image of the distant object. The definition of the likeness depends merely upon the size of the antenna elements and their number.

The greater the number of the elements, and the smaller their size, the more sharp the definition.

Not only will this invention provide a picture of the object 8, but it will provide also a range-finder, 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 pick-up units, coupled with the size of the visual image, may be used to deduce the 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.

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 insulated radio-receiving elements, choke inductance means for preventing transfer of energy between the elements, and means for producing a likeness corresponding to the enegy distribution received by the radio-receiving elements.

2. An electric system having, in combination, a plurality of radio-receiving elements, means for preventing transfer of radio-frequency energy between the elements, gas-discharge means having portions associated with the corresponding elements, electrode means, means for shielding the electrode means from direct reception of the received radio-frequency energy, means for producing a glow discharge between the elements and the electrode means through the gas-discharge means, and means for modifying the glow discharge through the gas-discharge means in accordance with the radio-frequency energy received by the corresponding elements to produce a likeness corresponding to the energy distribution received by the radio-receiving elements.

3. An electric system having, in combination, a plurality of radio-receiving elements, electrode means, means for shielding the electrode means from direct reception of the received radio-frequency energy, means for producing a direct-current potential between the elements and the electrode means, means for producing a glow discharge between the elements and the electrode means, and means for producing a likeness corresponding to the energy distribution received by the radio-receiving elements.

4. An electric system having, in combination, an electric circuit having an anode and a cathode, two members respectively connected to the anode and the cathode, one of the members comprising a plurality of radio-receiving elements for receiving radio waves from an object, the other member comprising gas-discharge means having portions connected with the corresponding elements, and means controlled by the radio waves received by the elements for energizing the gas-discharge means to produce a likeness of the object.

5. An electric system having, in combination, means for receiving radio waves, gas-discharge means, means for producing a background-color gas discharge through the gas-discharge means, means controlled by the received radio waves for modifying the background color of the gas discharge with another color, and means for filtering out the background color.

6. An electric system having, in combination, means for receiving radio waves, neon-gas-discharge means, means for producing an orange-background-color gas discharge through the neon-gas-discharge means, means controlled by the received radio waves for pinkishly modifying the orange color of the neon-gas-discharge, and means for filtering out the orange-background color.

7. An electric system having, in combination, means for receiving radio waves from an object, means for focusing the waves upon the receiving means to produce upon the receiving means a radio-energy likeness specific elemental areas of which correspond to specific elemental areas of the object, the receiving means being provided with interaction-preventing means to maintain the said specific elemental-area correspondence, and means controlled by the receiving means for converting each said elemental area on the receiving means into a visible elemental area, thereby to produce a visible likeness of the object.

8. An electric system having, in combination, means for converging radio waves from an object, a plurality of radio-receiving elements disposed in rows and columns adapted to be disposed simultaneously in the path of the radio waves converged from the object so as simultaneously to receive the radio waves from the object, each radio-receiving element corresponding to a predetermined elemental portion of the object from which elemental portion it receives radio waves, a column of illuminating elements, each illuminating element being connected to a row of radio-receiving elements, and means controlled by each radio-receiving element in accordance with the radio waves received thereby from the corresponding elemental portion of the object for producing upon the corresponding illuminating element a likeness of the said corresponding elemental portion of the object.

9. An electric system having, in combination, means for converging microwaves from an object, a plurality of dielectric-filled microwave-receiving elements bounded by conducting walls and adapted to be disposed simultaneously in the path of the microwaves converged from an object so as simultaneously to receive the said microwaves from the object, each microwave-receiving element corresponding to a predetermined elemental portion of the object from which elemental portion it receives micro-waves, and means controlled by each microwave-receiving element in accordance with the microwaves received thereby from the corresponding elemental portion of the object for producing a likeness of the said corresponding elemental portion of the object.

10. An electric system having, in combination, means having a plurality of parts for receiving radio waves, means for converging radio waves from an object upon all the parts of the receiving

means to produce on the totality of parts of the receiving means a radio-wave likeness of the object, whereby each of the parts of the receiving means corresponds to a predetermined elemental portion of the object from which elemental portion it receives the converged radio waves, means for preventing the transfer of radio-wave energy between the parts, and means controlled in accordance with the radio waves converged upon each radio-receiving part from the corresponding elemental portion of the object for producing a likeness of the said corresponding elemental portion of the object.

11. An electric system having, in combination, a plurality of radio-receiving elements for receiving radio waves, the elements being of dimensions resonant to the radio waves, gas-discharge means connecting with the receiving elements, means connected with the gas-discharge means for producing a luminous indication along the dimensions of each of the radio-receiving elements of the radio waves received by the corresponding element, and means for preventing interference between the radio-wave energy received by each of the elements.

12. An electric system having, in combination, means for receiving radio waves comprising a mirror-like surface for reflecting the illumination produced by a glow discharge, and gas-discharge means connected with the mirror-like surface for producing a glow discharge at the mirror-like surface that may be reflected thereby corresponding to the radio energy received by the radio-receiving means.

13. An electric system having, in combination, a plurality of radio-receiving elements for receiving radio waves, electrode means spaced from the radio-receiving elements a distance sufficient to produce resonance to the radio waves between the radio-receiving elements and the electrode means, and gas-discharge means connected with the spaced means for producing a likeness of the radio-wave energy received by the radio-receiving elements.

14. An electric system having, in combination, plurality of radio-receiving elements adopted to be disposed simultaneously in the path of radio waves from an object so as simultaneously to receive the radio waves from the object, a plurality of gas-discharge means one corresponding to each of the radio-receiving elements, a plurality of amplifying means for connecting the respective radio-receiving elements to the respective gas-discharge means, and means connected with the amplifying means for producing a likeness of the object upon the gas-discharge means.

15. An electric system having, in combination, a two-dimensional array of gas-discharge elements, radio-receiving means for receiving radio waves from an object, and amplifying means connected with the receiving means and connecting the receiving means to the gas-discharge elements for producing a likeness of the object upon the array of gas-discharge elements.

16. An electric system having, in combination, a plurality of radio-receiving elements, means for preventing transfer of radio-frequency energy between the elements, means for amplifying the energy received by the elements, and means connected with the amplifying means for producing a likeness corresponding to the energy distribution received by the radio-receiving elements.

17. An electric system having, in combination, dielectric-filled radio-wave receiving means bounded in part by conducting walls, conducting means spaced within the dielectric from one of the conducting walls to produce resonance to the received radio waves, and means connected with the radio-wave receiving means and the conducting means and responsive to the received radio waves for producing a likeness corresponding to the radio-wave energy received by the radio-wave receiving means.

18. In a radio-wave receiving system having a plurality of radio-receiving means and gas-discharge means, apparatus of the character described that comprises means for producing a background glow discharge within the gas-discharge means, means for converging radio waves upon the plurality of radio-receiving means, means for conducting the radio waves converged upon the radio-receiving means within the gas-discharge means, means for modifying the glow discharge in the gas-discharge means in accordance with the received radio waves, and means for preventing the transfer of radio-wave energy between the radio-receiving means.

19. In a radio-wave system having a plurality of radio-receiving means and gas-discharge means, apparatus of the character described that comprises means for producing a background glow discharge within the gas-discharge means, means for impinging radio waves upon the radio-receiving means, means for conducting the radio waves impinged upon the radio-receiving means within the gas-discharge means, means for resonating the received radio waves within the gas-discharge means to modify the glow discharge in the gas-discharge means in accordance with the received radio waves, and means for preventing the transfer of radio-wave energy between the radio-receiving means.

ROBERT HARVEY RINES.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
2,015,885	Dallenbach	Oct. 1, 1935
2,083,292	Cawley	June 8, 1937
2,123,242	Hallmann	July 12, 1938
2,155,471	Cawley	Apr. 25, 1939
2,168,566	Goldsmith	Aug. 8, 1939
2,395,850	Colman	Mar. 5, 1946
2,396,112	Morgan	Mar. 5, 1946