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Research Information

Service: Terms and Connectors Search
Print Request: Current Document: 38
Source: Utility, Design and Plant Patents
Search Terms: inventor(robert /2 rines)

38 of 81 DOCUMENTS

UNITED STATES PATENT AND TRADEMARK OFFICE GRANTED PATENT

2711534

Link to Claims Section

June 21, 1955

Electric system

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APPL-NO: 526269 (02)

FILED-DATE: March 13, 1944

GRANTED-DATE: June 21, 1955

PRIORITY: March 13, 1944 - 19440526269, United States (US)

PUB-TYPE: June 21, 1955 - Utility Patent having no previously published pre-grant publication (A)

PUB-COUNTRY: United States (US)

US-MAIN-CL: 342#417

US-ADDL-CL: 342#179, 343#757, 343#771, 348#162

CL: 342, 343, 348

SUMMARY:

The present invention relates to electric systems, and more particularly to radio-transmitting and 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.

An additional object is to provide a new and improved radio-wave antenna system useful for reception, transmission or both.

A further object is to provide a novel wave-guiding structure.

An additional object is to provide a novel transmitting scanning antenna system.

Still another object is to provide a novel receiving scanning antenna system.

Another object is to provide a new and improved tele- SO

vision system.

Another object is to provide a novel combined radioand-television system.

Another object of the present invention is to provide a new and improved direction-finding 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 particularly pointed out in the appended

ENGLISH-CLAIMS:
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claims.

The invention will now be more fully explained in connection with the accompanying drawings, in which Fig. 1 is a simplified diagrammatic view of circuits and apparatus arranged and constructed in accordance with a preferred embodiment thereof; Fig. 2 is a section taken upon the line 22 of Fig. 1, looking in the direction of the arrows; Fig. 3 is a diagram representing the scanning of a slot by a scanning guide, at each of eight positions, with a second slot yet unscanned by a corresponding second guide; Fig. 4 is a section taken upon the line of Fig. 2, looking in the direction of the arrows; Figs.

to 13 are explanatory diagrams, drawn to scale in relation to one another, diagrammatically illustrating the timing of the operation of the various parts: Fig. 5 illustrates a train of eight transmitted pulses, during the time of scanning of a first slot by a first aperture-guide of the hereinafter-described discs; Fig. 6 illustrates the corresponding received echoes; Fig. 7 is a diagrammatic representation of the positions occupied by the said scanning opening or guide at times corresponding to the said pulses; Fig. 8 is similar to Fig. 6, except that the received pulses are shown amplified in the electron multiplier; Fig. 9 is representative of the received amplified pulses as applied to the control electrode of the oscillograph tube; Figs. 10 and 11 are representative of the pulses produced by the horizontal-division and the horizontalsweep circuits; Figs. 12 and 13 are graphs corresponding to Figs. and 11 for the vertical division and the vertical-sweep circuits; Fig. 14 is a view of a transmitting device similar to the receiving device of Fig. 1; and Fig.

is a view of a modification.

Let it be assumed that electromagnetic waves which m& gt;534 At the receiving station, the radio waves thus reflected and scattered may be focused by an electromagnetic diupon a receiver wave-guide 20

3. The di-

The wave-guide 203 is shown provided with discs 207 having aperture-guides and slots, respectively.

in the wave.guide 203 is provided with any disc. The disc 209, disposed in the wave-guide 203 beyond the disc 207, is provided with slots 228, 230, 232, 234. 236, 238 and 240, corresponding in number and position to the number and the position of the guides in the disc 207, and placed successively below one another.

The guides in the disc 207 protrude from the disc 207 towards the corresponding slots in the disc 209, as shown in Fig.

4. The discs 207 and 209 may be relatively rotatable. The disc 207, for example, may be rotated by a motor 48 and the disc 209 may be stationary, as shown.

The disc 207 is shown rotatable in a groove 206, in order to prevent radiation losses, and to this end, the groove may serve as a quarter-wave trap. The guides in the disc 207 will thus successively scan the corresponding slots in the disc 209.

During a single rotation of the disc 207 by the motor 48. therefore, all the slots of the disc 209 will be scanned, in

succession, at equally spaced intervals of time, beginning with the first slot 228, and ending with the last slot 240, as shown in Fig.

2. Continued rotation of the disc 207 by the motor 48 will result in successive repetitions of this scanning process. The disc 209 may, of course, be rotated at a slower speed than the disc 207, thus permitting a wider area of scan than if it were stationary.

Improper phase relations, such as may be caused by the zone-plate effect, may be prevented in well known ways. The lengths of the dielectric guides protruding from the holes in the disc 207, for example, may be varied, as illustrated, for producing the proper phase relations.

Though only a small number of guides and slots is shown in the respective discs, this is merely for illustralive purposes, and in order not to confuse the disclosure.

It will be understood that, in practice, a large number of guides and slots will be employed.

The slots in the disc 209 will receive different field strengths of radio energy, corresponding to the amount of energy reflected or scattered from the various parts of the object, such as the before-mentioned airplane, and converged upon the disc 209 by the lens

5. A radioenergy picture or scene of the said object is thus distributed upon the disc 20

9. By means of the present invention, this radio-energy picture or scene, limited to the area occupied by the slots in the disc 209, 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 screen 106 of a display cathode-ray oscilloscope tube 90. Though the tube is shown operating on the electrostatic principle, a magnetic-scope deflector or a combination of magnetic and electrostatic forces may be employed. The invention thus provides a means for producing upon the screen 106 images or indications corresponding to the radio-frequency energy received by the corresponding slots and guides of the discs 209 and 207, respectively.

The radio-frequency-energy pulses converged on the slots in the disc 209 by the lens 5, and scanned by the small guides 210, 212, 214, 216, 218, and 222 of the disc 207 of the radio-wave pick-up device 203, etc after transmission through the small guides and through the wave-guide 203, are received upon an antenna 202 of preferably fixed or constant polarization, as shown. The wave-guide 210, for example, couples or absorbs the converged energy from, and scans, the uppermost elemental path or region of the radio-wave-energy distribution imaged upon the plane of the disc 209 from a region of space containing the scene, such as the airplane object beforementioned. For some purposes, of course, the said uppermost elemental path or region may itself be regarded as the radio-wave image that is thus scanned, though it is not the complete image of the scene. Similar remarks apply to the physically displaced scanning paths or regions of the other wave-guides 212, 214, 216, 218, 220, 222, etc each of which may be regarded itself as a radiowave image. The scanned waves are converted into electrical signals, being transmitted to an electron multiplier and a rectifier 26, and from there to the control-grid electrode 92 of the vacuum-tube part 88 of the oscilloscope tube 90.

For simplicity, the connections between the antenna 202 and the electron multiplier 24 are shown as leads whereas, in reality, they may be wave guides or conducting dielectrics or low-loss coaxial lines.

If the scanned waves received in the wave-guide 203 are of the type having a horizontal electric vector, the circular path described by the aperture will cause slight variations in intensity transmitted during the scanning of each slot. This may be compensated for by inserting varied attenuating dielectrics along the slots.

The output of the antenna 202 may be superheterodyned in any well-known crystal mixer, if desired, or it may be rectified by a crystal rectifier in the guide (Ultra High Frequency Technique, by Brainerd, Koehler, Reich and Woodruff, pages 486, 487).

Electrons emitted from the cathode 94 of the vacuumtube part 88 of the oscilloscope will become enabled to pass by the grid 92 to the anode 96 of the tube 88.

The electrons will continue to travel in a stream from the anode 96, between a pair of vertically disposed oscilloscope deflector plates 98 and 100, and between a pair of horizontally disposed Oscilloscope deflector plates 102 and 104, to impinge finally on the viewing screen of the oscilloscope 90. A 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 a vertical-sweeptime base, applied to the horizontally disposed deflector plates 102 and 104, will cause the electron stream to become deflected vertically. The plates 98 and 104 are shown grounded.

During the scanning of a particular slot of the disc 209 by a particular guide of the disc 207, the pulse generator 4 triggers a horizontal-division circuit 63. This division circuit produces one pulse for every group of input pulses created during the scanning of one slot, and that one pulse, in turn, triggers a horizontal sweep-curt generator 263 (see Terman s Radio Engineering, fiO such pulses page 740; 1937 edition). This causes the electron beam of the cathode ray tube to sweep horizontally across the tube 90, between the vertically disposed plates 98 and 100, the electron stream then being quickly returned to its normal position. During this horizontal sweep, the grid 92 of the vacuum tube 88 receives varying degrees of energy from intermediate received or picked-up radioenergy echoes of the transmitted pulses that have been converted into electrical signals, causing an intensity gradation along the horizontal sweep corresponding to energy received from a horizontal scan of part of the object. Each spot, along a particular horizontal sweep, will become brightened according to the amount of radio -energy received at the point of its scan by the corresponding guide in the disc 207.

The pulse generator 4 feeds also a vertical-division circuit 69, which produces one pulse for every complete rotation of the disc 207, corresponding to every complete picture scan. This triggers a vertical sweep circuit 269, causing each successive horizontal sweep, corresponding to each of the substantially parallel radio-wave scanning paths, to be displaced orthogonally, namely, vertically, in order to occur below its predecessor, corresponding to the orthogonal displacement of the radio-wave scanning paths, until the complete frame has been scanned.

The division circuits 63 and 69 may be unbalanced multivibrators, or any other conventional circuit which gives one output pulse to every so many input pulses (see Reich: Theory and Application of Electron Tubes, pages 359 to 361, 1939 edition, or Terman s Radio Engineering, page 374, 1937 edition).

The definition depends upon the number of transmitted and received pulses corresponding to the scanning of each slot. The more of these, the less the range, naturally, that the object can be televised. This is because the range is chiefly determined by the interval between pulses; that is, by the time allowed for the echo to return. The definition depends also on the number of slots to be scanned as well as on their dimensions. The apertureguides in the disc 207 and the slots in the disc 209 should, of course, be of sufficient size to be consistent with the well-known wave-guide conditions; namely, the guides should be of transverse cross-sectional configuration sufficient to permit the propagation therethrough of electromagnetic radio waves above a critical frequency related to the said transverse cross-sectional configuration, as otherwise, electromagnetic energy of the proper frequency will not pass therethrough.

As an illustration, let it be assumed that there are apertures in the disc 207 and, correspondingly, slots in the disc 209. Let it be further assumed that the electromagnetic pulses are of one microsecond duration. Let it be assumed also that the range to be covered is ten to twelve miles, or 15,000 meters. This corresponds to a time distance 000 t ; rr-nr i o-TSsO microseconds velocity of llght 3X1 T[le pulse-recurrence frequency is the reciprocal of this, or 20,000 per second.

If /t be assumed th at, during the exposure of each hole, eight pulses pass, then 50X8=400 microseconds per hole (omitting pulse duration, which is relatively negligible).

For holes, this would be 0.04 seconds per complete scan, or one frame every four-hundredths of a second, which is

above the flicker limit of the eye. This corresponds to a rotation of the motor 48 at cycles per second, or 1500 revolutions per minute.

Transmitted pulses of one microsecond duration and 20,000 cycles per second recurrence frequency are diagrammatically represented by Fig. 5. A train of eight is shown, representing the energy transmitted during the time that the first aperture-guide of the disc 207 scans the first slot 228 in the disc 209.

Successive moments of the scan are represented in Fig.

7 as positions 1 to 8 of the opening along the slot 228, as illustrated in Fig. 3. After eight transmitted pulses have occurred, the opening 210 has completely scanned the slot 228, and the opening 212 is starting to scan the slot 230. The last pulse of Fig. represents the open ing starting to scan the slot 228 again, a complete scan of all the slots by the respective aperture-guides or openings having been made in the time represented by the dotted horizontal line 73 in Fig. 5.

Fig. 6 shows the echoes of the pulses received by the slot 228 which is being scanned by the opening 210, These received pulses, in Fig. 6,-represent the-energy returning from various portions of the object along that scan.

Fig. 8 represents these received pulses as amplified pulses 77 in the electron multiplier 24. These are then rectified by the rectifier 26, and the rectified pulses 79, as illustrated in Fig. 9, are fed between the control-grid and the cathode 94 of the cathode-ray tube 90.

Fig. shows the single pulse 81 produced once to every eight transmitter pulses by the horizontal-division circuit 63, as previously described. This triggers the saw-tooth generator 263, causing it to produce a horizontal-sweep voltage 83, shown in Fig. 11, which is applied to the vertically disposed horizontal deflector plate 100. This causes the electron stream to sweep across the screen 106, and the pulses of Fig. 9 modulate the intensity of the sweep at successive portions thereof, according to the respective strength of radio energy from the object.

Fig. 12 shows the output of the vertical-division circuit 69, which produces one pulse 85 corresponding to every complete scan of the disc 209. This, in turn, triggers the vertical-sweep circuit 269, which gives the wave form 87 of Fig. 13 on the vertical deflection plate 102. This causes successive horizontal sweeps to appear at successive lower positions on the screen 106, until the complete scan is accomplished, when a repetition process is effected.

The horizontal dotted lines 89, 91, 93, 95, 97, 99 and 101 have the same significance, in Figs. 6 and 8 to 13, respectively, that the line 73 has in Fig. 5.

The pulse generator 4 may comprise a crystal or other stable oscillator as a source of steady alternating-current voltage to feed the horizontal and vertical division and sweep circuits with synchronizing pulses, thereby to obtain and maintain the said synchronized relationship between the motor 48 and the sweep circuits.

While, for illustrative purposes, the scanning antenna system of the present invention has been described in connection with the reception of radio waves and the production of a likeness or indication corresponding to the received radio-wave distribution, it may similarly be used as a transmitting antenna with or without a focusing device, depending upon the desired result. In Fig. 14, for example, a transmitting antenna 3 is shown corresponding to the receiving antenna 203 of Fig. 1, similar parts being given similar reference numerals with the prefix "200" omitted. It is to be understood that the previous description of the operation and possible modification of the receiving scanning antenna 203 applies equally to the transmitting scanning antenna 3. The antenna 2 is connected to a transmitter such as a radio-frequency pulse generator 4. When both the disc 7 carrying the guides 10, 12, 14, 16, 18, 20, 22, etc. and the disc 9 having the wave-guiding apertures, openings or slots 28, 30, 32, 34, 36, 38, 40, etc. are rotated, as before described in connection with a modified operation of Fig. I, a narrow directivity pattern or pencil of radiation is caused to be directed through angles subtending two dimensions of a scene to be scanned, namely, perpendicular radial and circumferential dimensions.

In fact, a unit such as 3, 7, 9, etc. or 203, 207, 209, etc. can also serve, if desired, as a common transmitterand-receiver as shown at 111 in Fig. 15, if, after transmission, the antenna is connected to the receiving apparatus, and after reception, back to the transmitting ci cuit, by any well-known switching device such as relays or spark gaps.

It has been stated that the dielectric lens 5 may be replaced by a parabola or any other suitable ray-direction-changing focusing mirror. A parabola 103, for focusing or collimating the radio image on a common transmitting-and-receiving scanner 111, as before described, is illustrated in Fig. 15, the axis of the reflector 103 being shown in line with the center of the scanner 111. and the plane of the front face of the scanner being substantially perpendicular to the said axis. The transmitted pulses are caused to travel from the transmitting channel 105, shown as a circular wave-guide, which is connected by a switching mechanism 107, as mentioned previously, to wave-guide 109. The waveguide 109 transmits the pulses to the combination transmitting-and-receiving wave-guide 111, which corresponds to the wave-guide system 3, 7, 9, etc. of Fig. 14. After scattering and reflection from, for example, the airplane object, the reflected and scattered rays will be returned to the combination transmitting-and-receiving waveguide 111, whereupon they will be guided back along the guide 109 to a receiving wave-guide 113 for visual or other presentation. The scanning energy-coupling or energy-absorbing guides of the device 111, corresponding to the guides 10, 12, 14, etc. or the guides 210, 212, 214, etc. of respective Figs. 14 and 1, will describe circular paths or regions displaced from one another and surrounding the focal point along the axis of the reflector 103 as a center, illustrated by the merging ray lines at F on the front face of the scanner 111 of Fig. 15.

The wave-guides of the present invention, furthermore, may be conical, rectangular or any other desired shape, though circular may be the most convenient, the broad underlying concept of the invention clearly not being dependent upon the particular illustrated shape or configuration of the guides or slots. The electromagnetic radio waves employed, moreover, are preferably in the ultra-high-frequency microwave range, say of 3 or 1.5 SO centimeters wavelength, and may be of the continuouswave type or of any other type of modulated wave, though pulsed energy, before described, at present has the advantage of economical and easy high-power ultrahigh-frequency generation.

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, means for receiving microwave radio waves from an object, a plurality of microwave transmitting means, means provided with a plurality of openings, one corresponding to each microwave transmitting means, means for relatively moving the microwave transmitting means and the openings-provided means to enable the radio waves to pass through the openings and the corresponding microwave transmitting means in succession, thereby to scan a region of space traversed by the radio waves, and means for transmitting the scanned radio waves to the microwave receiving means.

2. An electric system having, in combination, a plurality of microwave transmitting means, means providing a plurality of openings, one corresponding to each microwave transmitting means, means for causing microwave radio waves from an object to produce a radioenergy image of the object, and means for relatively moving the microwave transmitting means and the openings to scan the image to cause each transmitting means to go scan only the corresponding opening.

3. An electric system having, in combination, a plurality of microwave wave-guide means of the type having a transverse cross-sectional configuration to permit the propagation therethrough of microwave radio waves (; f) above a critical frequency related to the said transverse cross-sectional configuration, the wave-guide means being adapted to be positioned for the transmission therethrough of radio waves from an object of microwave frequency above the critical frequency, means for causing the wave-guide means to scan the radio waves from the object, and means for receiving the microwave radio waves after transmission through the wave-guide means.

4. An electric system having, in combination, a plurality of microwave wave-guide means of the type having a transverse cross-sectional configuration to permit the propagation therethrough of microwave radio waves above a critical frequency related to the said transverse cross-sectional configuration, means comprising the plurality of wave-guide means for successively scanning a region of space traversed by radio waves from an object of a frequency above the critical frequency along two orthogonal directions in substantially parallel paths, and means for receiving the scanned radio waves.

5. An electric system having, in combination, a plurality of microwave wave-guide elements of the type having a transverse cross-sectional configuration to permit the propagation therethrough of microwave radio waves above a critical frequency related to the said transverse cross-sectional configuration, and means for operating , the microwave wave-guide elements successively to cause lo Suldes and openings-providing means to enable radio them to scan successively different portions of a region of space traversed by radio waves of a microwave fre-

quency above the critical frequency.

6. An electric system having, in combination, rality of microwave wave-guide elements of the type having a transverse cross-sectional configuration to permit the propagation therethrough of microwave radio waves above a critical frequency related to the said transverse cross-sectional configuration, means for operating the microwave wave-guide elements successively to cause them to scan successively different portions of a region of space traversed by radio waves of a microwave frequency above the critical frequency, and microwave means for receiving the scanned radio waves.

7. An electric system having, in combination, a microwave wave guide and a plurality of microwave wave-guide elements of the type having a transverse cross-sectional configuration to permit the propagation therethrough of microwave radio waves above a critical frequency related to the said transverse cross-sectional configuration, and means comprising the microwave wave-guide elements for scanning a region of space traversed by radio waves of a microwave frequency above the critical frequency and for directing these canned radio waves to the microwave wave guide for transmission through the microwave wave guide

8. An electric system having, in combination, a microwave wave guide and a plurality of microwave waveguide elements of the type having a transverse cross-sec- 4.3 tional configuration to permit the propagation therethrough of microwave radio waves above a critical frequency related to the said transverse cross-sectional configuration, means for operating the microwave wave-guide elements successively to scan a region of space traversed by radio waves of a microwave frequency above the critical frequency, the microwave wave guide being positioned for the transmission therethrough of the scanned radio waves, and microwave means for receiving the scanned radio waves after transmission through the microwave wave guide 9. An electric system having, in combination, a plurality of microwave wave guides of the type having a transverse cross-sectional configuration to permit the propagation therethrough of microwave radio waves above a oo configuration, means for converging radio waves from an critical frequency related to the said transverse crosssectional configuration, means disposed near the plurality of wave guides and cooperative therewith providing a plurality of openings, one corresponding to each microwave wave guide, and means for relatively moving the microwave wave guides and the openings-provided means.

10. An electric system having, in combination, a wave guide and a plurality of wave-guide elements of the type having a transverse cross-sectional configuration to permit the propagation therethrough of radio waves above a critical frequency related to the said transverse crosssectional configuration, means for operating the waveguide elements successively to scan a region of space traversed by radio waves from an object of a -frequency above the critical frequency, the wave guide being -pos tioned for the transmission therethrough of the scanned radio waves, means for receiving the scanned radio waves after transmission through the wave guide, and means controlled in accordance with the scanned radio waves received by the receiving means for producing an indication of the object.

11. An electric system having, in combination, a plurality of microwave wave guides of the type having a

transverse cross-sectional configuration to permit the propagation therethrough of microwave radio waves above a critical frequency related to the said transverse crosssectional configuration, means providing a plurality of openings, one corresponding to each microwave wave e, means for relatively moving the microwave wave waves from an object of a rmcrowave frequency above e crltlcal frequency to Pass through the openings and the corresponding microwave wave guides in succession, [hereby tQPscan | fegion rf space by radjo plu- 2Q waveSj microwave means for receiving the scanned radio waveS(and means controlled in accordance with the scanned radio waves received by the microwave receiving means for producing an indication of the object.

12. An electric system having, in combination, a wave guide and a plurality of wave-guide elements of the type having a transverse cross-sectional configuration to permit the propagation therethrough of radio waves above a critical frequency related to the said transverse crosssection configuration, means for operating the wave-guide elements successively to scan successive portions of a region of space traversed by radio waves from an object of a frequency above the critical frequency, the wave guide being positioned for the transmission therethrough of the scanned radio waves, means for receiving the scanned radio waves after transmission through the wave guide, an oscilloscope having a screen and means for producing an electron stream impinging on the screen, means f r causing the electron stream to scan the screen in synchronism with the scanning of the radio waves by the successively operating wave-guide elements, and means controlled in accordance with the scanned radio waves received by the receiving means for controlling the electron stream durinS its scanning of the screen to produce a likeness of the object on the screen.

13- An electric svstem having in combination, microwave wave-guide means of the type having a transverse cross-sectional configuration to permit the propagation therethrough of microwave radio waves above a critical frequency related to the said transverse cross-sectional configuration, means for converging radio waves from an obJect of a microwave frequency above the critical frel cy to Pr duce a radio-energy image of the object, and mean comprising the microwave wave-guide means for scanning the image.

14. An electnc system having, in combination, microwave wave-guide means of the type having a transverse cross-sectional configuration to permit the propagation therethrough of microwave radio waves above a critical frequency related to the said transverse cross-sectional object .of a microwave frequency above the critical frequency to produce a radio-energy image of the object, means comprising the microwave wave-guide means for scanning the image and for transmitting the scanned radio waves, and microwave means for receiving the scanned radio waves after transmission.

15. An electric system having, in combination, a plurality of microwave wave guides of the type having a transverse cross-sectional configuration to permit the propagation therethrough of microwave radio waves above a critical frequency related to the said transverse crosssectional configuration, means for causing radio waves from an object of a microwave frequency above the critical frequency to produce a radio-wave image of the T5 object, means for moving the microwave wave guides to scan the image, and means for confining the radio waves of the radio-wave image to particular scanning microwave wave guides during the scanning.

16. An electric system having, in combination, microwave wave-guide means of the type having a transverse cross-sectional configuration to permit the propagation therethrough of microwave radio waves above a critical frequency related to the said transverse cross-sectional configuration, means for converging radio waves from an object of a microwave frequency above the critical frequency to produce a radio-wave image of the object, means comprising the microwave wave-guide means for scanning the image and for transmitting the scanned radio waves, microwave means for receiving the scanned radio waves after transmission, an oscilloscope having a screen and means for producing an electron stream impinging on the screen, means for initiating the scanning of the electron stream in synchronism with the scanning of the radio waves by the wave-guide means, and means controlled in accordance with the scanned radio waves received by the receiving means for controlling the electron stream during its scanning of the screen to produce a likeness of the object on the screen.

17. An electric system having, in combination, microwave waveguide means of the type having a transverse

cross-sectional configuration to permit the propagation therethrough of microwave radio waves above a critical frequency related to the said transverse cross-sectional configuration, means for converging radio waves from an object of a microwave frequency above the critical frequency to produce a radio-energy image of the object, means for scanning the image and for directing the scanned waves to the microwave wave-guide means for transmission through the wave-guide means, and microwave means for receiving the scanned radio waves after transmission through the wave-guide means.

18. An electric system having, in combination, microwave v/ave-guide means of the type having a transverse cross-sectional configuration to permit the propagation therethrough of microwave radio waves above a critical frequency related to the said transverse cross-sectional configuration, means for converging radio waves from an object of a microwave frequency above the critical frequency to produce a radio-energy image of the object, means comprising the microwave wave-guide means for scanning the image, microwave means for receiving the scanned radio waves, and means controlled in accordance with the scanned radio waves received by the receiving means for producing a likeness of the object.

19. An electric system having, in combination, wav guide means of the type having a transverse_ cross-sectional configuration to permit the propagation therethrough of radio waves above a critical frequency related to the said transverse cross-sectional configuration, means for converging radio waves from an object of a frequency above the critical frequency to produce a radio-energy image of the object, means for scanning the radio-energy image, means for directing the scanned radio waves to the wave-guide means for transmission ough the wave-guide means, means for receiving the CO [he radio.wave scanned radio waves after transmission through the waveguide means, an oscilloscope having a screerfand means for producing an electron stream impinging on the screen, means for initiating the electron stream scanning of the screen in synchronism with the scanning of the radio waves by the wave-guide means, and means controlled in accordance with the scanned radio waves received by the receiving means for controlling the electron stream to produce a likeness of the object on the screen.

20. An electric system having, in combination, a plurality of microwave guides of the type having a transverse cross-sectional configuration to permit the propagation therethrough of microwave radio waves above a critical frequency related to the said transverse crosssectional configuration, means providing a plurality of openings, one corresponding to each microwave wave guide, means for causing radio waves from an object of a microwave frequency above the critical frequency to produce a radio-wave image of the object, means for relatively moving the microwave wave guides and the openings-provided means to scan the image, and means controlled in accordance with the scanning for providing a likeness of the object.

21. An electric system having, in combination, a plurality of spirally disposed wave guides of the type having a transverse cross-sectional configuration to permit the propagation therethrough of radio waves above a critical frequency related to the said transverse cross-sectional configuration, means for operating the wave guides successively to cause them to scan successively different portions of a region of space traversed by radio waves of a frequency above the critical frequency, and means for receiving the scanned radio waves.

22. An electric system having, in combination, a plurality of helically disposed wave guides of the type having a transverse cross-sectional configuration to permit the propagation therethrough of radio waves above a critical frequency related to the said transverse crosssectional configuration, means for causing radio waves from an object of a frequency above the critical frequency to produce a radio-wave image of the object, and means for moving the wave guides to scan the image.

23. An electric system having, in combination, a plurality of microwave wave-guide elements of the type having a transverse cross-sectional configuration to permit the propagation therethrough of microwave radio waves above a critical frequency related to the said transverse cross-sectional configuration, means for converging radio waves from an object of a microwave frequency above the critical frequency to produce a radio-wave image of the object, means providing a plurality of openings, one corresponding to each microwave wave-guide element, means for relatively

moving the microwave wave-guide elements and the openings-provided means to cause the microwave wave-guide elements to scan the corresponding openings, thereby to scan the image, and means for receiving the scanned radio waves.

24. In combination, means for imaging radio waves from a scene, a radio wave pick-up device comprising a wave guide, and means for scanning the said radio wave image by said pick-up device and converting the energy thus picked up into an electrical signal.

25. In combination, means for imaging radio waves from a scenej a radjo wave pjck-up device comprising a f& gt; r, wave gu; de kavmg an open end positioned to receive energy from said image and having the other end mounted On and terminating in a rotatable wave guide joint, and means for scanning the said radio wave image by said pick-up device and converting the energy thus picked up mto an electrical signal 26. In combination; means for imaging radio waves from a scene& gt; a radio.wave pick.up device comprising wave-guide means, means for scanning an area successive ions of which c ond to successive portions of and means controlle/in accord.

i. i j ancf wl& lt; h the scanning for converting the energy picked UP bv the P.lck-uP device om e d!ffe, rellt Pr lons of tte ttaa ei into corresponding electrical signals.

In combination, means for imagmg radio waves from a scene to be reproduced, a radio-wave pick-up device comprising wave-guide means, means for scanning an area successive portions of which correspond to suecessive portions of the radio-wave image, means controlled in accordance with the scanning for converting the energy picked up by the pick-up device from the different portions of the image into corresponding electrical signals, an image-reproducing means, means for initiating the operation of the image-reproducing means in synchronism with the scanning, and means for supplying the signals to the image-reproducing means, whereby a picture of the scene is obtained.

28. In combination, means for imaging radio waves from a scene, a radio-wave pick-up device comprising wave-guide means open-ended to receive energy from the radio-wave image and mounted on and terminated in a rotatable wave-guide joint, means for scanning an area successive portions of which correspond to successive portions of the radio-wave image, and means controlled in accordance with the scanning for converting the energy picked up by the pick-up device from the different portions of the image into corresponding electrical signals.

29. In combination, means for imaging radio waves from a scene, a radio-wave pick-up device comprising a plurality of wave guides having open ends positioned to receive energy from the image and having ends mounted on and terminating in a rotatable wave-guide joint, means for scanning the radio-wave image by the plurality of wave guides of the pick-up device, and means for converting the energy thus picked up into electrical signals.

30. In combination, means for imaging radio waves from a scene to be reproduced, a radio-wave pick-up device comprising wave-guide means open-ended to receive energy from the image and mounted on and termiuating in a rotatable wave-guide joint, means for scanning the radio-wave image by the pick-up device, means for converting the energy thus picked up into electrical signals, an image-reproducing means, means for initiating the operation of the image-reproducing means in synchronism with the scanning, and means for supplying the signals to the image-reproducing means, whereby a picture of the scene is obtained.

31. In combination, means for imaging radio waves from an object, a radio wave pick-up device comprising a wave guide, and means for scanning the said radio wave image by said pick-up device and converting the energy thus picked up into an electrical signal.

32. In combination, means for imaging radio waves from an object, a radio wave pick-up device comprising a wave guide having an open end positioned to receive energy from said image and having the other end mounted on and terminating in a rotatable wave guide joint, means for scanning the said radio wave image by said pick-up device and converting the energy thus picked up into an electrical signal, an image reproducing means, and means for supplying

said signal to said reproducing means whereby an indication of said object is obtained.

33. In combination, means for imaging radio waves go from part of a scene, a radio wave pick-up device comprising wave-guide means having crystal detector means, and means for scanning the said radio wave image by said wave-guide means and converting the energy thus picked up and detected by the crystal detector means into an electrical signal.

34. An electric system having, in combination, waveguide means of the type having a transverse crosssectional configuration to permit the propagation therethrough of radio waves above a critical frequency _ related to the said transverse cross-sectional configuration, scanning means comprising the wave-guide means, means for operating the scanning means to cause it to scan only a. limited region of space occupied by an object, such as an airplane, traversed by radio waves from the object gg radio-frequency energy having, in combination, slot of a frequency above the critical frequency, means for receiving the scanned radio waves, and means controlled in accordance with the scanned radio waves received by the receiving means for producing an indication of the object.

35. An electric system having, in combination, waveguide means of the type having a transverse crosssectional configuration to permit the propagation therethrough of radio waves above a critical frequency related to the said transverse cross-sectional configuration, scanning means comprising the wave-guide means, means for operating the scanning means to cause it to scan only a limited region of space occupied by an object, such as an airplane, traversed by radio waves from the object of a frequency above the critical frequency, means for receiving the scanned radio waves, and cathode-raytube means controlled in accordance with the scanned radio waves received by the receiving means for produring an indication of the object.

36. Radiant energy direction-finding apparatus comprising a paraboloid reflector, a first energy-absorbing unit, means for directing said unit in a closed-curve path, the center of said closed-curve path substantially cointiding with the focal point of said reflector, a further energy-absorbing unit, and means for directing said further unit in a further closed-curve path, both of said units being positioned to cooperate with said reflector, said closed-curve paths being physically displaced from one another.

37. Radiant energy direction-finding apparatus comprising means having an axis for changing the direction of rays of electromagnetic energy waves, first and second electromagnetic energy coupling units positioned to cooperate with said ray direction changing means, means for directing said first coupling unit in a first path, said first path surrounding said axis, and means for directing said second coupling unit in a second path, said first and second paths being physically displaced, said apparatus when employed for radiating radiant energy being effective for maintaining the plane of polarization of said radiant energy substantially constant.

38. Ultra high frequency direction-finding apparatus comprising means having an axis for collimating electromagnetic energy, a plurality of electromagnetic coupling units positioned to cooperate with said collimating means, and means for directing said units in different paths, the center of the area of one of said paths substantially lying along said axis.

39. Apparatus as in claim 38 wherein all of said paths are substantially disposed in a plane perpendicularly oriented relative to said axis.

40. Apparatus as in claim 39 wherein each of said coupling means includes the mouth of a wave-guide.

41. Wave-energy direction-finding apparatus comprising a directive reflector having the form of a paraboloid of revolution, three energy-absorbing units, and means for causing said units to traverse separate circular paths, all of said paths substantially lying in a plane disposed at right angles to the axis of said antenna.

42. Apparatus as in claim 41 wherein at least one of said paths has a center substantially positioned along the axis of said reflector.

43. An electric system for transmitting or receiving radio-frequency energy having, in combination, means for feeding the radio-frequency energy along a plurality of paths of different length to a plurality of wave-guide elements normally ineffective to cooperate with space, the wave-guide elements being of different lengths such as to compensate for the differences in path-length of the feed thereto, and means for rendering the successive wave guides of the plurality of wave guides successively effective to propagate the radio-frequency energy to or from space.

44. An electric system for transmitting or receiving means for transmitting or receiving the radio-frequency energy, attenuating dielectric material disposed along the siot means, and wave-guide means for scanning the slot means to transmit or to receive the radio-frequency energy through the successively disposed portions of the attenuating dielectric material along the slot means.

45. An electric system having, in combination, a plurality of wave-transmitting means, means providing a plurality of openings, one corresponding to each wavetransmitting means, and means for relatively moving .the wave-transmitting means and the openings-provided means to cause each wave-transmitting means to scan only its corresponding opening.

46. An electric system having, in combination, a plurality of wave guides of the type having a transverse cross-sectional configuration to permit the propagation therethrough of radio waves above a critical frequency related to the said transverse cross-sectional configuration, means providing a plurality of openings, one corresponding to each wave guide, and means for relatively moving the wave guides and the openings-provided means.

47. In a radio-wave transmitter or receiver system, an antenna system comprising a plurality of slot means for transmitting radio waves from the transmitter or receiving and feeding radio waves to the receiver, each of the slot means extending along a first dimension and being displaced along a second dimension from the other slot means, and means for successively transmitting radio waves from the transmitter or successively receiving and feeding radio waves to the receiver at successively disposed portions along the first dimension of each suecessive slot means displaced along the second dimension in succession.

48. A radio scanning system including, in combination, wave-guiding means for forming a narrow directivity pattern of radio-wave energy, means for scanning said directivity pattern through an angle subtending one dimension of a scene to be viewed, supplementary means including a continuously rotatable element interposed between said wave-guiding means and said scene for scanning said directivity pattern of radio-wave energy through an angle subtending another dimension of said scene, and a radio-wave focusing device for focusing the scanning radio-wave energy directivity pattern.

49. An electric system having, in combination, a wave guide of the type having a transverse cross-sectional configuration to permit the passage therethrough of radio waves above a critical frequency related to the said transverse cross-sectional configuration and provided with slot means of dimensions sufficient to pass the said radio waves, means disposed in closely fitting relation to the wave guide and having aperture means, and means for relatively moving the wave guide and the closely disposed means to align the slot means with the aperture means in order to permit the passage of radio waves ther through.

50. An electric system having, in combination, a wave guide of the type having a transverse cross-sectional configuration to permit the passage therethrough of radio waves above a critical frequency related to the said tran verse cross-sectional configuration provided with an opening for permitting the passage of the said radio waves between the exterior and interior of the wave guide through the opening, means disposed adjacent the opening and provided with aperture means, and means ,-,-, determined frequency from the object to form a radiofor relatively moving the opening and the aperturepprovided means to align the aperture and opening means in order to permit the passage of radio waves therethrough, 51. An electromagnetic system for scanning an object Cl, to the said transverse cross-sectional configuration subthat comprises means for focusing radio waves of predetermined frequency from the object to form a radiowave distribution corresponding to different parts of the object, wave-guide means of the type having a transverse

cross-sectional configuration to permit the passage ther through of radio waves above a critical frequency r lated to the said transverse cross-sectional configuration substantially equal to or less than the said predetermined frequency for scanning the radio-wave distribution along one dimension, and further radio-wave-guiding means for (t termined frequency from the object to form a radio-wave scanning the radio-wave distribution along another dimension.

52. An electromagnetic system for scanning an object that comprises means for focusing radio waves of predetermined frequency from the object to form a radiowave distribution corresponding to different parts of the object, wave-guide means of the type having a transverse cross-sectional configuration to permit the passage therethrough of radio waves above a critical frequency related to the said transverse cross-sectional configuration substantially equal to or less than the said predetermined frequency for scanning the radio-wave distribution along one dimension, and further radio-wave-guiding means for scanning the radio-wave distribution along another dimension disposed at right angles to the said one dimension.

53. An electromagnetic system for scanning an object that comprises means for focusing radio waves of predetermined frequency from the object to form a radiowave distribution corresponding to different parts of the object, wave-guide means of the type having a transverse cross-sectional configuration to permit the passage therethrough of radio waves above a critical frequency related to the said transverse cross-sectional configuration substantially equal to or less than the said predetermined frequency for scanning the radio-wave distribution along one dimenson, and further radio-waveguiding means operable during the scanning along the said one dimension for scanning the radio-wave distribution along another dimension.

54. An electromagnetic system for scanning an object that comprises means for focusing radio waves of predetermined frequency from the object to form a radiowave distribution corresponding to different parts of the object, wave-guide means of the type having a transverse cross-sectional configuration to permit the passage therethrough of radio waves above a critical frequency related to the said transverse cross-sectional configuration substantially equal to or less than the said predetermined frequency for scanning the radio-wave distribution along one dimension, and further radio-waveguiding means operable during the scanning along the said one dimension for scanning the radio-wave distribution along another dimension disposed at right angles to the said one dimension.

55. An electromagnetic system for scanning an object that comprises means for focusing radio waves of predetermined frequency from the object to form a radio-wave distribution corresponding to different parts of the object, wave-guide means of the type having a transverse cross4-, sectional configuration to permit the passage therethrough of radio waves above a critical frequency related to the said transverse cross-sectional configuration substantially equal to or less than the said predetermined frequency for scanning the radio-wave distribution along one dimension, .-(& lt; and further radio-wave-guiding means interposed between the object and the scanning means for scanning the radiowave distribution along another dimension.

56. An electromagnetic system for scanning an object that comprises means for focusing radio waves of prewave distribution corresponding to different parts of the object, wave-guide means of the type having a transverse cross-sectional configuration to permit the passage therethrough of radio waves above a critical frequency related stantially equal to or less than the said predetermined frequency for scanning the radio-wave distribution along one dimension, and further radio-wave-guiding means interposed between the object and the scanning means and opc-erable during the scanning along the said one dimension for scanning the radio-wave distribution along another dimension.

57. An electromagnetic system for scanning an object that comprises means for focusing radio waves of prededistribution corresponding to different parts of the object, wave-guide means of the type having a transverse crosssectional configuration to permit the passage therethrough of radio waves above a critical frequency related to the said transverse cross-sectional configuration substantially equal to qr less than the said predetermined frequency for scanning the radio-wave distribution along one dimension, and further radio-wave-guiding means interposed between the object and the scanning means and operable during the scanning along the said one dimension for scanning the

radio-wave distribution along another dimension disposed at right angles to the said one dimension.

58. A radio vision scanning system including in combination, wave guiding means for forming a narrow directivity pattern of radio wave energy, means for directing said directivity pattern through an angle subtending one dimension of a scene to be viewed, and supplementary means including a continuously rotatable element interposed between said wave guiding means and said scene for directing said narrow directivity patern of radio wave energy through an angle subtending another dimension of said scene.

59. A radio vision scanning system including in combination, wave guiding means for forming a narrow direcivity pattern of radio wave energy, means for directing 20 953 898 said directivity pattern through an angle subtending one dimension of a scene to be viewed, and supplementary means including a continuously rotatable element interposed between said wave guiding means and said scene for directing said narrow directivity pattern of radio wave 25 2 306 212 energy through an angle subtending a dimension disposed at right angles to the first mentioned dimension.

60. A radio vision scanning system including in combination, wave guiding means for forming a narrow directivity pattern of radio wave energy, means for directing said directivity pattern through an angle subtending one dimension of a scene to be viewed, and supplementary means interposed between said wave guiding means and said scene for directing said narrow directivity pattern of radio wave energy through an angle subtending another dimension of said scene.

61. A radio vision scanning system including in combination, wave guiding means for forming a narrow directivity pattern of radio wave energy, means for directing said directivity pattern through an angle subtending one dimension of a scene to be viewed, and supplementary means interposed between said wave guiding means and said scene for directing said narrow directivity pattern of radio wave energy through an angle subtending a dimension disposed at right angles to the first mentioned dimension.

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