June 21, 1955 R. H. RINES 2,711,530

RADIO-WAVE PHOSPHORESCENT INDICATOR

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Fig. 1.

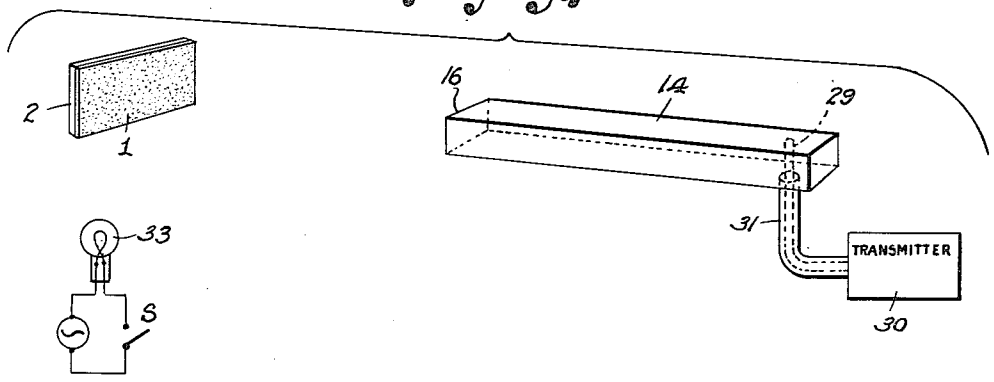



Fig. 2.

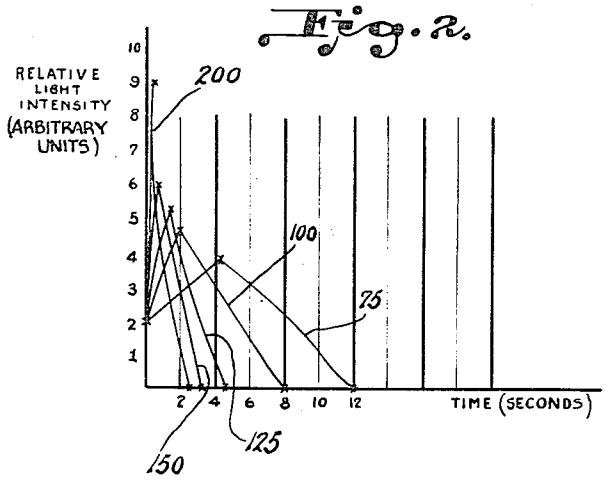



Fig. 4.

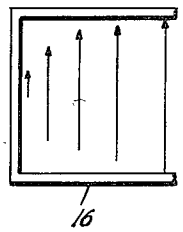



Fig. 5.

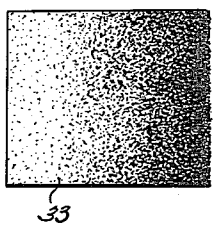
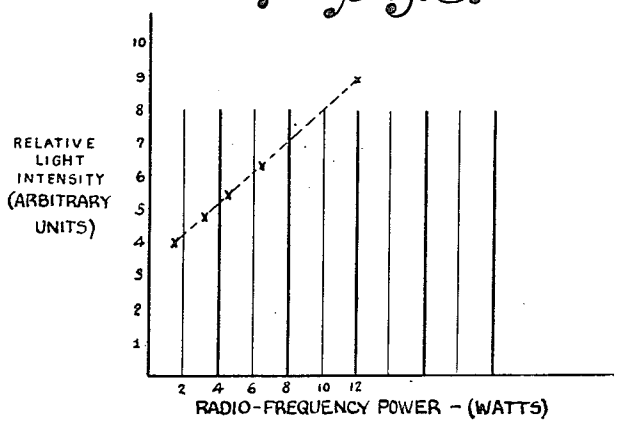



Fig. 3.




INVENTOR.
Robert H. Rines
BY Rines & Rines
ATTORNEYS

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RADIO-WAVE PHOSPHORESCENT INDICATOR

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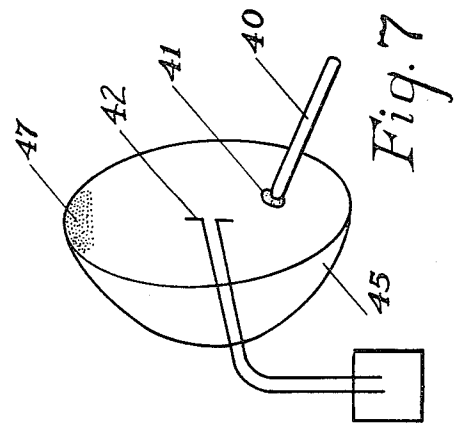



Fig. 7




Fig. 6

INVENTOR.
Robert H. Rines
BY Rines & Rines
Attorneys

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# RADIO-WAVE PHOSPHORESCENT INDICATOR

Robert H. Rines, East Falmouth, Mass.

Application June 20, 1951, Serial No. 232,625

38 Claims. (Cl. 343—17)

The present invention relates to methods of and apparatus for radio-wave indicating, and more particularly to methods of and systems for indicating the field distribution of radio waves. This application is a continuation-in-part of copending application Serial No. 616,778, filed September 17, 1945, now abandoned.

An object of the present invention is to provide a new and improved simplified radio-location method and system.

A further object is to provide a novel method of and apparatus for detecting the presence of an object in fog or darkness and producing a visible indication thereof.

A further object of the invention is to assist in the design and construction of radio-energy reflectors and antenna systems.

Still another object is to provide a new and improved system for visually mapping radio-wave field distributions.

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

In summary, the present invention relates to a method of exciting a phosphor to cause it to phosphoresce, preferably in the visible range, directing radio waves upon the phosphor during its phosphorescence and indicating the effect upon the phosphorescence of the radio waves. Preferred apparatus for mapping radio-wave fields and the like are hereinafter treated in detail.

The invention will now be described in connection with the accompanying drawings, Fig. 1 of which is a schematic perspective view illustrating the mapping of a radio-wave field in a wave guide in accordance with the present invention; Figs. 2 and 3 are graphs of experimentally obtained data illustrating the performance of phosphors utilized in accordance with the present invention for the mapping of radio-wave fields; Fig. 4 is a fragmentary view of the mouth or aperture of the wave guide of Fig. 1 illustrating the radio-wave electric vector distribution within approximately half of the aperture of the wave guide; Fig. 5 is a reproduction of an experimentally obtained photograph illustrating the performance of a phosphor-coated receiving system in mapping the electric vector distribution of Fig. 4; Fig. 6 is a diagrammatic view of a radio-location system operable in accordance with the present invention; and Fig. 7 is a similar view of a modification adapted for the design of antenna systems.

In the said copending application, it is disclosed that phosphors may be utilized to map or indicate field distributions of radio waves. With appropriate radio-receiving means provided with phosphors, radio-wave energy may be directed or focused upon the radio-receiving means and preferably visual indications may be obtained of the radio-wave field distribution.

Referring, for example, to Fig. 1, a radio transmitter 30 is shown energizing an antenna 29 by means of a coaxial transmission line 31 to propagate radio-frequency energy, preferably in the microwave range, along a rectangular wave guide 14. The radio-wave energy is emitted from the mouth or aperture 16 of the wave guide 14 in



the manner of an electromagnetic horn antenna. The mouth or aperture 16 may be flared in any desired planes, as is well known in the art. Such a horn antenna directs or focuses the radio-frequency energy into space as a directive radio-wave beam. Radio-receiving means 2, hereinafter discussed in detail, provided with a phosphor coating 1, may be interposed in the path of the directed or focused radio-wave energy to indicate visually the field distribution therealong of the radio waves directed or focused by the horn antenna.

As is also disclosed in the said copending application, the radio-receiving means may comprise conducting parasitic antenna elements such as strips or other configurations coated with phosphors. The phosphor coating may be formed merely by painting a solution of the phosphor salt upon the conducting element, as is done in the coating of the hands of watches and clocks to provide luminescence in the dark. The phosphor material may also be sprayed or may be dusted upon an adhering substance such as cement or glue. For extremely sensitive results, the thickness of the phosphor coating may be comparable with the wavelength of the radio-frequency energy utilized, though thin coatings have been found to work. The phosphor itself may be provided with an excitant so that it is auto-excited. Such auto-excited phosphors may comprise natural phosphors such as, for example, zinc sulfide, cadmium sulfide, barium oxide, and the like provided with a trace of radium or some other radio-active substance. Any other auto-excited phosphors may similarly be utilized as coatings upon the radio-receiving means. The phosphor will, of course, as described in the said copending application, luminesce in the dark as the result of its excitation by the excitant, namely, the radium or other radio-active material. It has been found that when the phosphor is subjected to high-intensity high-frequency radio waves, the phosphor will luminesce in intensities greater than the normal luminescence of the phosphor salt. If, for example, a high-frequency radio system, such as a parabolic antenna emitting waves of, say, ten centimeters wavelength, is rotated past a strip 2 coated with such a phosphor, the phosphor will be found to glow more brightly as the antenna beams on the strip and will be found to fade in luminescence during the continued rotation of the antenna. The field pattern of the antenna system will thus become mapped out in intensity modulation of the normal light radiation of the auto-excited phosphor.

The present invention is not, however, limited to auto-excited phosphors. As is also disclosed in the said copending application, any phosphor may be utilized in accordance with the present invention, though, the effect is not in the same degree for all phosphors. The radiation emitted by the phosphor, moreover, in response to the effects produced by the radio-frequency energy may be of wavelength invisible to the eye for some phosphors. The invisible radiation may, of course, be detected by appropriate means such as photographic films, later discussed. It is preferable, however, that phosphors emitting visible radiation in response to visible wavelength excitants be utilized, such as those previously listed. Not only may auto-excited phosphors be employed, therefore, but the natural phosphors themselves may also be used. It is desirable that coatings of the natural phosphors be of substantial thickness in order to produce enhanced effects. For ten-centimeter radio waves, for example, coatings a few centimeters in thickness may be satisfactory. For extremely strong ten-centimeter radiations of the order of ten to fifteen watts, extremely thin coatings, as are formed by sprinkling the powdered phosphor upon a cement layer may be utilized. Among the more successful natural phosphors utilized, are the Lenard-type phosphors. Among these phosphors are the sulfides of, for example,

zinc, cadmium, calcium, etc. and also oxides containing traces of other metals, such as copper, bismuth, antimony, manganese, etc. Extremely strong results have been obtained with zinc-cadmium sulfide phosphors, zinc-copper sulfide phosphors, zinc-silicon-silver sulfide phosphors, and other phosphors.

While the present invention is not dependent upon the existence or non-existence of theories, whether accurate or inaccurate, since it is sufficient to describe the invention as it has been found to work in practice, it may be that the theory underlying the present invention is somewhat as follows. All phosphors appear to phosphoresce or to emit radiation, whether visible or invisible, during the process of an electron wandering about the lattice and dropping back from excited levels to normal or unexcited levels in the atoms. In the presence of radio-wave energy, it appears that the electrons in working their way back to the unexcited or non-quantized state, will be given further heat energy that incites a faster movement and correspondingly a coincident increase in brightness of the phosphorescence, accompanied by a decrease in the duration of the emission of the light from the phosphor.

Though the use of conducting antenna elements **2** enhances the effect of receiving radio-wave energy, greater heat absorptivity and consequent heat transfer to the phosphor may be obtained through the use of heat absorbing elements such as various papers provided preferably with a layer of rubber cement or similar binder. Many other heat-absorbing materials such as leather and powdered graphite may similarly be utilized. Very successful results have been produced, for example, with the aid of black photographic wrapping paper coated with rubber cement for holding the powdered phosphor.

A typical experimental test will now be described in connection with Figs. 1 to 5. A radio-receiving element **2** comprising film wrapping paper upon which a thin layer of rubber cement was painted and to which a phosphor **1** such as zinc-cadmium sulfide was applied in the powdered state, was first exposed to light from an ordinary filamentary lamp **33** the filament of which was rendered incandescent by closing a switch S. The lamp **33** was extinguished, as by opening the switch S, and the light-excited phosphor **1** was observed to glow in the dark. The radio transmitter **30** was then turned on so that the horn **16** focused or directed a radio beam upon the radio-receiving means **2**. The visible phosphorescent radiation glow emanating from the phosphor **1** was observed markedly to increase in intensity rapidly, and then to decay within a matter of a few seconds. Referring to Fig. 2, for example, with a magnetron transmitter **30** producing approximately ten centimeter waves with a magnetron plate current of about 75 milliamperes, as indicated by the curve labeled "75," the light intensity of the radiation from the phosphor **1** was observed to increase to a maximum value within four seconds and then to decay to extinction within about twelve seconds. The rate of increase of illumination and the intensity of the increased illumination have been found to vary with the strength of the radio-wave energy, as disclosed in the said copending application. With successively increasing magnetron currents of 100, 125, 150, and 200 milliamperes, indicated by the curves respectively labelled "100," "125," "150" and "200" in Fig. 2, the maximum light radiation was reached in successively lower intervals of time ranging from about one and a half seconds down to about a quarter of a second, and the relative intensity of the maximum light radiation varied from about four units up to about nine units. An experimentally obtained variation of relative light-radiation intensity at the maximum point with radiated radio-frequency power is plotted in Fig. 3, illustrating corresponding variations between radio-frequency energy applied to the phosphor and the resulting light intensity radiation.

The present invention has been utilized, therefore, for mapping the distribution of radio-wave fields since the intensity of the light radiation produced by those phosphors that preferably give visible light, is related to the energy of the radio waves. As an illustration, the field distribution appearing across the mouth of the wave guide **16** has been mapped by placing the radio-wave receiving element **2** provided with the phosphor coating or layer **1** in close proximity to the mouth **16**. The electric-field intensity distribution within the mouth is indicated in Fig. 4 for half the mouth of the horn, increasing from zero value on the left-hand wall to a maximum intensity in the center. By placing a photographic film with its emulsion adjacent the phosphor coating or layer **1**, such as the film **33** shown in Fig. 5, a contact print may be taken of the illumination produced by the phosphor in response to the radio-wave field at the mouth **16**. In Fig. 5, a reproduction of an experimentally obtained photographic record or indication of this radio-wave field effect upon the phosphor is reproduced, illustrating maximum intensity indications near the center of the mouth and minimum intensity at the left-hand edge.

It has been found difficult to apply the phosphor coating or layer in a uniform manner so that very uniform results may be obtained. One of the techniques finally evolved for producing satisfactory results, such as those indicated in Fig. 5, is to place a layer of rubber or similar cement upon the desired carrier medium and to sprinkle the phosphor powder through a thin gauze upon the rubber cement along successive lines. By trial and error, the height of the gauze above the carrier may be regulated so that by successive back and forward movements of the gauze, closely positioned lines of phosphor powder may be sprinkled fairly contiguous with one another and with a fair degree of uniformity.

In Fig. 6, an application of the invention to radiolocation is illustrated, as disclosed in the said copending application. An ultra-high-frequency radio-wave generator **30** is shown exciting a dipole antenna **32** at the focus of a parabolic reflector **35**. The waves emitted by the dipole **32** are directed or focused by a further reflector **36** toward the parabolic reflector **35** from which they are directed or focused into space toward an object such as a tank **19**.

The radio waves are reflected and scattered from the object **19** toward a receiver system **24** comprising an electromagnetic lens **18** as of polystyrene, for focusing the reflected or scattered waves upon an array **17** of receiving elements. Any other well-known mirror, lens or focusing device may be employed in place of the lens **18** to direct or focus the reflected and scattered radio waves upon the array **17**.

The array **17** is shown constituted of a series of rows and columns of pick-up element metal strips or parasitic antennas, each provided on its front face with a phosphor coating or layer of the before-described nature. If desired, the paper or other heat-absorbing medium may be placed first upon the parasitic antenna and then the phosphor coating may be applied thereto. Extremely thick coatings, as before mentioned, may be directly applied to the metal antennas or upon the interposed heat-absorbing media. The elements **2**, **4**, **6**, **8** and **10** of the upper row each, for example, may be of length equal to a half or a quarter of the wavelength of the radio waves employed, and are shown provided with the phosphor coatings **1**, **3**, **5**, **7** and **9** etc. of the type previously discussed. The resonant dimensions of the antennas, of course, serve to enhance the reception of the radio-frequency energy. The elements of the next lower row, the first of which is shown at **12**, are also provided with phosphor-coated faces **11**, **13**, and **15**, etc.; the next lower row, the first strip of which is shown at **22**, with phosphor coatings **21**, **23** etc.; and so on. Each strip or element is shown insulated from adjacent strips or elements by insulators **35** such as rubber stripping, in order to provide separate radio-receiving antennas

that may, if desired, be separately connected to ground. This is to prevent intersection not only of the radio energy in adjacent elements but also of the phosphorescence of the adjacent phosphor coatings.

The first column from the left of coated surfaces is shown as composed of the surfaces **1**, **11**, **21**, etc.; the second column is composed of surfaces **3**, **13**, **23**, etc.; and so on. Though there are only a small number of rows and columns of elements shown, this is only in order to simplify the disclosure. It is understood that, in practice, a large number of rows and columns will be used to provide sharper definition of the visual indication of the presence of the object **19** as will now be explained.

The radio energy reflected and scattered from the object **19** is focused or directed, as previously described, by the lens **18** on the array of antenna receiving elements **17**. A radio-energy picture of the object **19** is thus impressed upon the array. The elements of the array will phosphoresce or radiate with additional light intensities dependent upon the strength of the radio energy impinged upon the particular pickup elements by the lens. There will thus be reproduced on the array **17** a visual indication of the object **19**.

Each elemental portion of the object **19** will reflect or scatter radio energy of intensities depending on the reflecting properties of the component parts of the object, and the lens **18** will focus this energy distribution on the elements of the array **17**. The layers **1**, **3**, **5** etc. will glow with intensities dependent on the energy from the corresponding elemental portions of the object **19**, to reproduce an indication of the object **19**. The smaller the size of the elements, the better the definition of the visual indication of the object, consistent, of course, with the frequency of the radio waves utilized.

With present-day multi-megawatt peak-power pulse transmitters, and ultra-high-frequency continuous-wave outputs of several hundred kilowatts as discussed, for example, in Electronics, McGraw-Hill, January, 1946, pages 92 to 95, the energy reflected from close-range large-surface reflecting objects will enable the detection of such objects with equipment of moderate size.

To facilitate observing the indication of the object **19** on the array **17**, the array may be enclosed in a dark, preferably air-tight box **24**. Sliding snugly within this box **24** at the front thereof is a member **26**, shown carrying the lens **18**. The member **26** is provided with a rod **27** by which the member may be slid in and out of the box **24**. The rod **27** is calibrated, as shown at **28**, to indicate the distance of the lens **18** from the front of the box **24**. A viewing aperture **20**, may be provided for enabling an observer to look at the array **17** therethrough, or a lens or mirror system may be utilized, not shown, so that the observer's head need not be at the front of the box. A darkened transparent screen **25** may be used to block off the normal or stray light radiation, if any, thus to permit only the increased radiations produced by the received rays to pass to the eyes of the observer at the aperture **20**. Auto-excited phosphors are particularly well suited to this application since the auto-exciter is always present.

There is a delay between the time that the radio energy hits the element and the time of the additional light radiation of the salt, as shown, for example, in Fig. 2. The invention will probably find best application, therefore, with relatively slow-moving objects **19** or with stationary objects.

By simple geometric optics, the ratio between the size of the object **19** and its distance from the lens **18** is proportional to the ratio of the size of the visual indication produced on the array **17** to the distance of the lens **18** from the array **17**. The calibrations **28** on the rod **27** may therefore be used as an approximate determination of the range of the object **19**, when the lens **18** is adjusted to present the sharpest possible indication on the array **17**. The system of Fig. 6 thus also provides a range finder.

While it has previously been proposed to convert radio-wave images into visual indications as, for example, with the aid of gas cells, scanning circuits and the like, the present invention provides a relatively inexpensive, light and simple indicator, particularly adapted for military and other purposes, that obviates the need for voltage sources, circuit connections, sealed gas cells, or scanning circuits and the like of the prior art.

The invention may also be used to assist in the design and construction of radio reflectors or other antenna systems including the wave-guide type illustrated in Fig. 1. If a parabolic reflector **45**, for example, as shown in Fig. 7, is coated with an even, and preferably relatively thick, coating **47** of a phosphor of the nature described, the energy grading over the reflector **45** may be observed visually. Adjustments may then be made to position properly a dipole **42** at or away from the focus for any desired performance. A probe antenna **40** provided with a phosphor coating **41** may also be used for determining energy distribution by moving the probe antenna within the field of the reflector **45**. If desired, of course, the reflector and the antenna **40** may be provided with appropriate grounding circuits.

Other and further modifications will occur to those 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. A method of the character described that comprises, exciting a phosphor to cause it to phosphoresce, directing radio waves from a source of radio waves upon the phosphor during the phosphorescence, and indicating the effect upon the phosphorescence of the radio waves.

2. A method of the character described that comprises, exciting a phosphor to cause it visually to phosphoresce, and directing radio waves from a source of radio waves upon the phosphor during the visual phosphorescence.

3. A radio-wave indicator that comprises radio-receiving means provided with a phosphor, and means for focusing the radio waves on the phosphor.

4. A radio-wave indicator that comprises radio-receiving means provided with a phosphorescent salt, and means for focusing the radio waves on the phosphorescent salt.

5. A radio-wave indicator that comprises radio-receiving elements provided with a radio-active autoexcited phosphor salt and means for focusing the radio waves on the radio-active salt.

6. An electric system having, in combination, means comprising a phosphor for receiving radio waves from an object, and means for focusing the received radio waves on the phosphor to produce an indication of the object on the phosphor.

7. A range-finder that comprises means comprising a phosphor for receiving radio waves from an object, means for focusing the received radio waves on the phosphor to produce a sharp indication of the object, and means for indicating the position of the focusing means for determining the range of the object.

8. An electric system having, in combination, a plurality of radio-receiving elements each provided with a phosphor coating for receiving radio waves, and means for directing radio waves upon the plurality of radio-receiving elements.

9. An electric system having, in combination, a plurality of radio-receiving elements having phosphor coatings, means for preventing interaction between the elements, and means for directing radio waves upon the plurality of radio-receiving elements.

10. An electric system having, in combination, means for receiving radio waves provided with phosphor coatings, means for keeping stray radiations from the coatings,

and means for directing radio waves upon the radio-receiving means.

11. An electric system having, in combination, a plurality of radio-receiving elements each provided with a phosphor coating, means for producing a radio-energy image of an object, and means associated with the radio-energy-image-producing means for causing the radio-energy image to fall upon the radio-receiving elements.

12. An electric system having, in combination, a plurality of radio-receiving elements for receiving radio waves from an object, each element having an autoexcited zinc-sulfide coating, means for preventing interference between the elements, and means for directing the radio waves from the object on the radio-receiving elements.

13. A radio-wave indicator that comprises radio-receiving means provided in heat-transfer relation with a phosphor layer of thickness comparable to the wavelength of the received radio waves in order that the heat energy of the received radio waves may produce an energizing effect upon the phosphor layer.

14. A radio-wave indicator that comprises radio-receiving means provided with means for absorbing the energy of radio waves and a phosphor in heat-transfer relation with the absorbing means responsive to the absorbing action of the absorbing means in order that the heat energy may produce an energizing effect upon the phosphor layer.

15. A radio-frequency-current indicator having, in combination, radio-frequency-current receiving means provided with a phosphor, means for exciting the phosphor to cause it to phosphoresce and means for applying radio-frequency current upon the phosphor during its phosphorescence.

16. A radio-wave indicator having, in combination, radio-receiving means provided with a phosphor selected from the group consisting of zinc sulfide, cadmium sulfide, zinc-cadmium sulfide, zinc-copper sulfide, zinc-silicon-silver sulfide and autoexcited compounds thereof, means for exciting the phosphor to cause it to phosphoresce and means for directing radio waves upon the phosphor during its phosphorescence.

17. A radio-wave indicator that comprises radio-receiving means provided with means for absorbing the energy of radio waves and a phosphor responsive to the absorbing action of the second-named means and selected from the group consisting of zinc sulfide, cadmium sulfide, zinc-cadmium sulfide, zinc-copper sulfide, zinc-silicon-silver sulfide and autoexcited compounds thereof.

18. A radio-wave indicator having, in combination, radio-receiving means provided with means for absorbing the energy of radio waves and a phosphor responsive to the absorbing action of the second-named means, means for exciting the phosphor to cause it to phosphoresce and means for disposing the phosphor in the path of radio waves during its phosphorescence.

19. A radio-wave indicator having, in combination, radio-receiving means provided with means for absorbing the energy of radio waves and a phosphor responsive to the absorbing action of the second-named means selected from the group consisting of zinc sulfide, cadmium sulfide, zinc-cadmium sulfide, zinc-copper sulfide, zinc-silicon-silver sulfide and autoexcited compounds thereof, means for exciting the phosphor to cause it to phosphoresce and means for disposing the phosphor in the path of radio waves during its phosphorescence.

20. A radio-wave indicator having, in combination, radio-receiving means comprising means for absorbing the energy of radio waves, a cement upon the absorbing means and a phosphor carried by the cement, means for exciting the phosphor to cause it to phosphoresce and means for disposing the phosphor in the path of radio waves during its phosphorescence.

21. A radio-wave indicator having, in combination, radio-receiving means provided with means for absorbing the energy of radio waves and a phosphor responsive to the absorbing action of the second-named means, means for exciting the phosphor to cause it to phosphoresce, means for disposing the phosphor in the path of radio waves during its phosphorescence, and means for indicating the effect upon the phosphorescence caused by the radio waves.

22. A method of the character described that comprises focusing radio waves from a source of radio waves upon radio-receiving means coated with a phosphor to determine the field distribution of the radio waves.

23. A method of the character described that comprises focusing radio waves from an object upon radio-receiving means coated with a phosphor to indicate the presence of the object.

24. In a transmitting or receiving system for use with radio waves of predetermined frequency, an antenna of dimension corresponding to the said predetermined frequency provided with a phosphor coating in heat-transfer relation with the antenna, in order that the phosphor coating may be energized by the heat energy of the radio waves transmitted or received by the antenna.

25. An electric system having, in combination, radio-frequency-current receiving means provided in heat-transfer relation with a phosphor coating for receiving radio frequency current and means for applying the radio-frequency current upon the radio-frequency-current receiving means in order that the energy of the applied radio-frequency current may produce an energizing effect upon the phosphor coating.

26. An electric system having, in combination, radio-receiving means provided in heat-transfer relation with a phosphor coating for receiving radio waves and radio-wave transmitting means for directing radio waves upon the radio-receiving means in order that the heat energy of the directed radio waves may produce an energizing effect upon the phosphor coating.

27. In a transmitting or receiving system for use with radio waves of predetermined frequency, an antenna of dimension corresponding to the said predetermined frequency provided with an autoexcited phosphor coating in heat-transfer relation with the antenna, in order that the phosphor coating may be energized by the heat energy of the radio waves transmitted or received by the antenna.

28. In a transmitting or receiving system for use with radio waves of predetermined frequency, a plurality of mutually-insulated antennas each of dimension corresponding to the said predetermined frequency and each provided with a phosphor coating in heat-transfer relation with the corresponding antenna, in order that each phosphor coating may be energized by the heat energy of the radio waves transmitted or received by the corresponding antenna only.

29. In a transmitting or receiving system for use with radio waves of predetermined frequency, an antenna of dimension corresponding to the said predetermined frequency provided with a zinc sulfide phosphor coating in heat-transfer relation with the antenna, in order that the phosphor coating may be energized by the heat energy of the radio waves transmitted or received by the antenna.

30. In a transmitting or receiving system for use with radio waves of predetermined frequency, an antenna of dimension corresponding to the said predetermined frequency provided with an autoactivated zinc sulfide phosphor coating in heat-transfer relation with the antenna, in order that the phosphor coating may be energized by the heat energy of the radio waves transmitted or received by the antenna.

31. In a transmitting or receiving system for use with radio waves of predetermined frequency, a radio-wave surface reflector antenna of dimensions large compared to the said predetermined frequency provided with a phosphor coating in heat-transfer relation with the antenna, in order that the phosphor coating may be energized by

the heat energy of the radio waves transmitted or received by the antenna.

32. In a transmitting or receiving system for use with radio waves of predetermined frequency, a radio-wave surface reflector antenna of parabolic contour of dimensions large compared to the said predetermined frequency provided with a phosphor coating in heat transfer relation with the antenna, in order that the phosphor coating may be energized by the heat energy of the radio waves transmitted or received by the antenna.

33. A radio-wave indicator having, in combination, radio-receiving means provided with a phosphor, means for exciting the phosphor to cause it to become energized to a state where it may phosphoresce and means for directing radio waves upon the phosphor while in such state.

34. A radio-wave indicator having, in combination, radio-receiving means provided with a phosphor selected from the group consisting of zinc sulfide, cadmium sulfide, zinc-cadmium sulfide, zinc-copper sulfide, zinc-silicon-silver sulfide and autoexcited compounds thereof, means for exciting the phosphor to cause it to become energized to a state where it may phosphoresce and means for directing radio waves upon the phosphor while in such state.

35. A radio-wave indicator having, in combination, radio-receiving means provided with means for absorbing the energy of radio waves and a phosphor responsive to the absorbing action of the second-named means, means for exciting the phosphor to cause it to become energized to a state where it may phosphoresce and means for disposing the phosphor in the path of radio waves while in such state.

36. A method of the character described that comprises, exciting a phosphor to cause it to become energized to a state where it may phosphoresce, applying radio-frequency current from a source of the same upon the phosphor while in such state, and indicating the effect upon the excited phosphor produced by the radio frequency current.

37. A radio-wave indicator as claimed in claim 3 and in which the phosphor is of the type that may be energized by heat energy to produce phosphorescence.

38. A method as claimed in claim 22 and in which the phosphor is of the type that may be energized by heat energy to produce phosphorescence.

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