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UNITED STATES PATENT AND TRADEMARK OFFICE GRANTED PATENT

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June 21, 1955

Microwave scanning system

INVENTOR: HARVEY RINES ROBERT

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SUMMARY:

The present invention relates to microwave scanning systems, and more particularly to radio-receiving systems that, while having more general fields of usefulness, are especially adapted for use in television. The present application is filed in pursuance to a requirement for division of application Serial No. 557,807, filed October 9, 1944 now Patent No. 2,553,606 issued May 22, 1951.

An object of the invention is to provide a new and improved radio-receiving system.

A. further object is to provide a new and improved antenna system.

An additional object is to provide a novel system embodying a cavity resonator.

A further object is to provide a new and improved wave-guide structure.

Still an additional object is to provide a novel scanning antenna 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 radio-locator system for both detecting the presence of a body and rendering it visible.

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

The invention will now be more fully expalined in connection with the accompanying drawings, the single figure of which is a diagram showing an airplane object from which radio waves are reflected and scattered to a receiving system in accordance with the present invention.

An electromagnetic wave generator 4 is shown exciting a dipole 2 to produce ultra-high-frequency microwave pulsed-radio energy, say, of 3 or 1.5 centimeters wavelength. A continuous-wave or any other type of mpdulated-wave generator may be employed, but pulsed energy, at present, has the advantage of economical and easy high-power ultra-high-frequency generation.

The waves emitted by the dipole 2 may be directed by a reflector 3 upon a parabolic reflector 6. The parabolic reflector 6 is shown directing the waves in any desired direction, for example, toward an object, say, an airplane 8, from which they are reflected and scattered toward a receiving station.

At the receiving station, the radio waves thus reflected and scattered from the object 8 may be focused by an electromagnetic dielectric lens 5, such as polystyrene, upon a closed-ended resonant-cavity wave-guide cylinder 7. The dielectric lens 5 may be replaced by any other type of well-known lens, mirror or other directive system for focusing the electromagnetic energy scattered or reflected from the object 8 on the cavity cylinder 7.

The resonant-cavity cylinder 7 is provided with a longitudinally extending slot opening 10. In the preferred construction illustrated, the slot is disposed substantially parallel to the axis of the cylinder and lies substantially in part only of the focal region of the focusing device 5. In the position shown, the slot is in the right-hand side wall of the cylinder 7 facing the focusing device 5 in order, as hereinafter explained, to provide a novel technique for excitation of the wave-guide chamber 7. The cylinder 7 is provided with a member 47 fixed rigidly to one of the closed ends of the cylinder, which 5 member 47 is disposed to rotate axially and rigidly with the cylinder on bearings within a concentrically coaxially arranged adjacent outer-sleeve cylinder 12. The outer cylinder 12 may be supported upon semi-circular roller bearings, not shown in order to simplify the drawings. The cylinder 12 is provided with a plurality of sets of apertures or slots 14, 16, 18, and 22, the slots of each set being helically disposed along the cylinder 12. The rotation of the cylinder 7 is effected in the direction of the arrow A by means of a synchronous motor 24, driving a shaft fixed to the other end of the cylinder 7. A motor 26 similarly rotates the cylinder 12 in the same direction, indicated by the arrow B; but not in synchronism with the rotation of the cylinder 7.

Assuming, for the moment, the cylinder 7 to be statkmary& gt; and the cylinder 12 to be rotating, the radio waves reflected from the airplane 8 will enter the resonant chamber 7 at successively spaced positions along the preferably substantially parallel slot 10, through the slots 14, 16, 18, and 22.

As a result of this construction, therefore, during the rotation of the cylinder 12 through an angle such that the slots 14, 16, 18, and 22 become successively aligned with the slot 10, radio waves reflected or scattered from the object 8 will be focused by the lens 5 at successive positions along the slot from right to left. In effect, therefore, a horizontal element of the airplane object will become scanned along the slot antenna during this part rotation of the cylinder 12.

Preferably, the cylinder 7 may fit more or less snugly within the cylinder 12, to prevent energy losses through the opening 10. To the same end, the slot may be made quite narrow, consistent with the dimensions and frequencies employed.

The slots 14, 16, 18, and 22, of course, will all directly receive the reflected or scattered radio waves through the lens 5 simultaneously. Only that one of these slots at a time, however, that is aligned with the slot will permit focused

radio waves to enter the resonant chamber 7 through the slot 10, the remaining unj- aligned portions or parts of the slot being blocked or closed and thus effectively short-circuited by the sleeve 12. The respective slot antennas 14, 16, 18, and will each thus render successive portions of the slot effective to permit the entry into the resonant chamber go through the slot of a radio-frequency voltage corresponding to the scattering from corresponding regions of the object 8. The wave-guiding slots 14, 16, 18, and 22 will thus receive different field strengths of radio energy, corresponding to the amount of energy reflected or scattered from the various parts of the elemental regions of the object 8 and converged upon them by the lens 5.

The energy thus received in the resonant chamber excites the same and is picked up by a probe or coupling Co loop or other antenna 30, which constitutes an extension into the chamber 7, through one end thereof, of the inner conductor 34 of a coaxial line, the outer conductor of which is shown at 32. The coaxial line 32, 34 is shown as a rigid line passing through the member 47, and such that the rotation of the member 47 and of the cylinder does not result in rotation of the coaxial line 32, 34. This result may be effected with the aid of a bearing 43, which may also prevent leakage of energy out of the cavity; for example, it could be dimensioned in any well-known manner to provide a quarter-wave trap. The coaxial-line is shown feeding an amplifier 46, and the amplifier 46 is shown feeding a rectifier 48. The radio energy received in the cavity resonator becomes thus transduced into electrical signals, thereby producing an electrical indication of the reception of the radio waves. The rectifier 48 is connected by a conductor to the control electrode 92, and by a conductor 87 to the cathode 94, of the tube part 88 of a display oscilloscope 90. It will be understood that all the outer conductors of the coaxial cables have a common connection to ground (not shown).

Electrons emitted from the cathode 94 will become enabled, in response to the action of the electrical signals 1 in the amplifier 46 and the rectifier 48, to pass by the control grid 92 toward the anode 96 of the tube part of the oscilloscope 90. The electrons will continue to travel in a stream from the anode 96, between a pair of vertically disposed deflector plates 98 and 100, and between a pair of horizontally disposed deflector plates 102 and 104, to impinge finally on the fluorescent viewing screen 106 of the oscilloscope 90. A horizontal-sweeptime base applied to the horizontally disposed deflector plates 98 and will cause the electron stream from the cathode 94 to become deflected horizontally. The horizontal sweep will become brightened by the energy fed from the amplifier 46 and the rectifier 48 to the control grid 92 of the oscilloscope. Successive energizing voltages are thus produced from the amplifier 46 and the rectifier 48 on the control electrode 92 of the tube part of the cathode-ray-tube 90, of magnitude proportional to the radio-frequency energy received by the corresponding aligned slots. This will permit the passage of the electrons, in quantities dependent upon the radio-frequency energy in the corresponding aligned slots to the anode 96, and between the pairs of deflecting plates 98,100 and 102, 104, to the viewing screen 106. A visible picture will thus be produced upon the fluorescent viewing oscilloscope screen 106 of the horizontal scanned line of the airplane.

The above description has proceeded upon the assumption that the cylinder 7 is stationary during the rotation - of cylinder 12 and such operation is useful for onedimensional scanning. As the cylinder 7 also rotates in the direction of the arrow A, however, though at a much slower speed, the slot will assume successively lowered positions, thus effecting a periodic scanning of successively lower horizontal elements of the airplane 8. The narrow received radio-wave directivity pattern, therefore, 4 is scanned through an angle subtending the vertical dimension of a scene when the cylinder 7 is rotated and is scanned through an angle subtending the horizontal dimension of the scene when the cylinder 12, interposed between the cylinder 7 and the scene, is rotated.

The vertical-sweep-time base applied to the horizontally disposed deflector plates 102 and 104 will cause the electron stream to become deflected vertically as the slot becomes gradually lowered. Successively lowered horizontal sweeps, graded in intensity corresponding to horizontal elements of the airplane 8, will thus be produced on the oscilloscope screen. The radio-energy picture of the airplane 8, focused by the lens 5 upon the cylinders 7 and 12, therefore, will thus become converted into a visible picture or likeness 123 of the airplane upon the screen 106.

Though only five slots 14, 16, 18, and 22 are shown in each set of slots on the cylinder 12, and though only two sets of these slots are illustrated, it will be understood that this is in order to simplify the drawing, and that, in (practice, there will be many sets of these slots; say, as many as fifty sets, more or less; and that there will be many more than five

slots in each set; say, as many as two hundred more or less; all depending upon the dimensions of the cylinders and the frequencies of the radio waves employed. In order properly to excite the cavity 7, the frequency of the radio waves should preferably correspond to the resonant frequency of the cavity and, as before stated, the slot 19 may be related to that frequency or wavelength, or multiples thereof. Preferably, moreover, the length of each of these slots may, as is well known, be related to the full or half-wavelength or multiples thereof, such as one-half the half-wavelength or one-quarter of the full wave-length corresponding to the frequency employed. Another pick-up element or probe SO like the probe may then similarly be employed at the other end of the cylinder 7, so mat if there are the proper number of slots in each set, the probes will receive the radiation, allowed in the resonant chamber 7, in phase, and the two signals may be added into the amplifier 46. It is, of course, to be understood that all dimensions are consistent with standard wave-guide criteria where the transverse cross-section of the wave guide is sufficient to permit the passage therethrough of radio waves above a critical frequency related thereto, and that the broad underlying concept of the present invention is not, of course, dependent upon the particular illustrated shape or configuration of the wave-guiding structures or slots.

This additional pick-up element may be rigidly connected by means of a stationary coaxial cable comprising an outer conductor 52 and an inner conductor 54, within the cylinder 7, to join with the coaxial line 32, 34 so that the additive energy is fed to the amplifier 46. Further probes (not shown) may be inserted in the cylinder at appropriate phase positions.

A pulse generator 63 may be employed to trigger the horizontal time-base-sweep circuit 63 and a further pulse generator 64 may be employed to trigger the verticalsweep circuit 69, according to conventional and wellknown television technique.

For example, the pulse generators may be peak oscillators or, more specifically, free-running unbalanced multivibrators. The frequency of the generator should be adjusted to correspond to the period in which a set of slots 14, 16, 18, and 22 completely scans the longitudinal slot 10. A horizontal-time-base sweep will thereby be produced between the vertically disposed deflector plates 98 and 100, corresponding to each horizontal scan of the slot by the sets of slots 14, 16, 18, and 22.

The period of the vertical sweep between the horizontally disposed deflector plates 102 and 104 should correspond to the period in which the slot itself scans, in a vertical sense, the radio-energy picture focused upon it by the lens 5. This may be accomplished by adjusting the frequency of the pulse generator 64 to correspond to the period in which the slot scans the field converged by the lens 5.

The visible picture 123 of the airplane object 8 on the fluorescent screen 186 will accordingly correspond to the radio-frequency picture on the cylinders 7 and which, in turn, corresponds to the actual object 8.

Modifications will occur to persons skilled in the art, and all such are considered to fall within the spirit and scope of the invention, as defined in the appended claims.

ENGLISH-CLAIMS:
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What is claimed is:

1. An electric system having, in combination, a microwave wave-guide dimensioned to support a predetermined frequency of microwave radio energy and provided with an opening, means provided with a plurality of slots disposed substantially parallel to the opening, and means for periodically alining the opening with successive slots.

2. An electric system having, in combination, a microwave wave-guide dimensioned to support a predetermined frequency of microwave radio energy and provided with an opening of dimensions resonant to the said frequency, and means for periodically blocking parts of the opening.

3. An electric system having, in combination, a microwave wave-guide dimensioned to support a predetermined frequency of microwave radio energy and provided with an opening, means for focusing radio waves corresponding to the said frequency on the wave-guide, and means provided with a plurality of slot antennas for scanning the opening, thereby correspondingly to excite the waveguide.

2,71.1,440 4. An electric system having, in combination, a microwave radio-wave generator, means for transmitting the generated waves through space, microwave wave-guide means dimensioned to support the frequency of the transmitting means and provided with an opening for receiving the transmitted waves, and means for rendering various portions of the opening successively effective to receive the radio waves.

5. An electric system having, in combination, a microwave wave-guide dimensioned to support a predetermined frequency of microwave radio energy and provided with an opening of dimensions sufficient to pass waves of the said frequency, and means comprising a conductive sleeve positioned to cover at least a predetermined part of the said opening for blocking the said part of the said opening, the sleeve being movable with respect to the waveguide to permit the blocking of different predetermined parts of the said opening.

6. An electric system having, in combination, a cavity resonator provided with an opening in a side wall thereof, means disposed facing the opening for focusing radio waves received from space upon a focal region, the opening being dimensioned and positioned substantially in part only of the focal region in order to cause the focused waves within the said part only of the focal region to impinge upon the opening, thereby correspondingly to excite the cavity resonator, and means connected with the excited cavity resonator controlled in accordance with the focused radio waves for producing an electrical indication of the reception of the radio waves.

7. An electric system having, in combination, a cavity resonator provided with a slot opening in a side wall thereof, means disposed facing the opening for focusing radio waves received from space upon a focal region, the slot opening being dimensioned and positioned substantially in part only of the focal region in order to cause the focused waves within the said part only of the focal region to impinge upon the opening, thereby correspondingly to excite the cavity resonator, and rigid transmission line means connected with and terminating in the cavity resonator for receiving and carrying away the radio-wave energy within the excited cavity resonator to produce an electrical indication of the reception of the radio waves.

8. An electric system having, in combination, a cavity resonator provided with an opening, means disposed adjacent to the resonator for causing radio waves emanating from an object to scan the opening, thereby correspondingly to excite the cavity resonator, and means connected with the excited cavity resonator and controlled in accordance with the scanning for producing a likeness of the object.

9. A radio-wave system having, in combination, a cylindrical cavity resonator dimensioned to support a resonant frequency corresponding to the frequency of the radio waves and provided with a longitudinally disposed opening, and a cylinder in which the cavity resonator is disposed, the cylinder being provided with helically disposed means of dimensions resonant to the said frequency of the radio waves for scanning the opening, thereby to excite the cavity resonator.

10. An electric system having, in combination, a cavity resonator provided with an opening, means having a plurality of slots adapted to be successively alined with the opening, means for relatively moving the cavity resonator and the first-named means to cause radio waves from an object to scan the opening, thereby correspondingly to excite the cavity resonator, and means connected with the excited cavity resonator and controlled in accordance with the scanning for producing a likeness of the object.

11. An electric system having, in combination, a cylindrical cavity resonator provided with a longitudinally disposed opening,, a cylinder concentric with the cavity resonator having a plurality of helically disposed slots, means for relatively rotating the cylinders to cause radio waves from an object to scan the opening, thereby correspondingly to

excite the cavity resonator, and means connected with the excited cavity resonator for producing a likeness of the object.

12. An electric system having, in combination, a cavity resonator, means disposed adjacent to the resonator for causing radio waves from an object to scan the cavity resonator, thereby to excite the cavity resonator, an oscilloscope having a screen, and means connected with the excited cavity resonator and controlled in accordance with the scanning for producing a likeness of the object on the screen.

13. An electric system having, in combination, a radiowave generator for producing radio waves for transmito ting through space, a cavity resonator provided with slot means in its outer surface communicating with the interior of the resonator and resonant to the frequency of the transmitting means for receiving the transmitted waves, and means for focusing the received waves on the slot 2!) means of the cavity resonator.

14. An electric system having, in combination, a cavity resonator provided with an opening, means for focusing radio waves from an object, means for causing the focused waves to scan the opening, thereby correspondingly to excite the cavity resonator, and means connected with the excited cavity resonator and controlled in accordance with the focused radio waves for producing a likeness of the object.

15. An electric system having, in combination, a cavity resonator, a multiplicity of pick-up elements disposed within the cavity resonator, means for causing radio waves from an object to excite the cavity resonator, and means connected with the excited cavity resonator controlled by the energy in the pick-up elements for producing a likeness of the object.

16. An electric system having, in combination, a cylindrical cavity resonator dimensioned to support a resonant frequency of radio energy and provided with a longitudinally disposed opening of dimensions resonant to the said frequency, and a cylinder in which the cavity resonator is disposed and provided with successively disposed means for scanning the opening, thereby to excite the cavity resonator.

17. An electric system having, in combination, a cavity resonator dimensioned to support a resonant frequency of radio energy and provided with an opening, means movable with respect to the cavity resonator provided with a plurality of slots of dimensions resonant to the said frequency, and means for relatively moving g0 the relatively movable means and the cavity resonator to cause the plurality of slots to scan the opening, thereby correspondingly to excite the cavity resonator.

18. An electric system having, in combination, a cavity resonator dimensioned to support a resonant frequency of radio energy and provided with an opening, means provided with a plurality of slots disposed parallel to the opening, and means for periodically alining the opening with successive slots.

19. An electric system having, in combination, a go cavity resonator dimensioned to support a resonant frequency of radio energy and provided with an opening of dimensions resonant to the said frequency, and means for periodically blocking parts of the opening, 20. An electric system having, in combination, a cavity resonator dimensioned to support a resonant frequency of radio energy and provided with an opening, means for focusing radio waves corresponding to the said frequency on the cavity resonator, and means provided with a plurality of slot antennas for scanning the opening, thereby correspondingly to excite the cavity resonator.

21. An electric system having, in combination, a cylindrical cavity resonator dimensioned to support a resonant frequency of radio energy and provided with a longitudinally disposed opening, means for focusing radio waves on the cavity resonator, and a cylinder cooperative with the cavity resonator provided with helically disposed means for scanning the opening, thereby correspondingly to excite the cavity resonator.

22. An electric system having, in combination, a 5 cylindrical cavity resonator dimensioned to support a resonant frequency of radio energy and provided with a longitudinally disposed opening, means relatively rotatable with respect

to the cavity resonator provided with successively disposed slot antennas, and means for relalively rotating the relatively rotatable means and the cavity resonator to cause the successively disposed slot antennas to scan the opening.

23. An electric system having, in combination, a cavity resonator dimensioned to support a resonant 1 frequency of radio energy and provided with an opening, coupling means extending into the cavity resonator for transducing radio energy, and means for rendering various parts of the opening successively effective to permit the passage of radio energy therethrough.

24. An electric system having, in combination, a cylindrical cavity resonator dimensioned to support a resonant frequency of radio energy and having a longitudinally disposed opening, cylindrical means provided with a plurality of helically disposed slot antennas, means 2 for focusing radio waves upon the cylindrical means, and means for relatively rotating the cavity resonator and the cylindrical means to cause the helically disposed slot antennas to scan the opening.

25. An electric system having, in combination, a radiowave generator, means for transmitting the generated waves through space, a cavity resonator resonant to the frequency of the transmitting means and provided with an opening for receiving the transmitted waves, and means for rendering various portions of the opening successively 3 effective to receive the radio waves.

26. An electric system having, in combination,! a cavity resonator provided with an opening, means for focusing radio waves from an object upon the cavity resonator, means for moving the cavity resonator to cause the opening to scan the focused radio waves in one direction, means for scanning the opening in another direction to expose successive parts of the opening successively to the focused radio energy, means for detecting the radio energy in the cavity resonator during ; -; the scanning processes, a cathode-ray tube having a screen successively disposed areas of which correspond respectively to the successive parts of the opening as they are successively exposed, means for producing in the tube an electron stream impinging on the screen, means for causing the electron stream to scan the successively disposed areas of the screen in synchronism with the scanning processes, and means responsive to the detecting means and cooperative with the electron-stream-producing means for producing a likeness of the object on the -.-; screen.

29. An image reproducing system comprising a polystyrene member for forming a radio image of an object from microwave electromagnetic energy reflected from the object, a cylindrical scanning device having a helical array of scanning apertures for successively passing microwave energy from points of said image to the interior of the cylindrical device, means within the cylindrical device responsive to said energy for developing an electrical signal, means for transmitting said signals to a receiving station and means including a cathode ray tube at the receiving station for developing a visible image of the object.

30. An electric system having, in combination, a circular wave guide adapted to support radio waves and provided with slot means, a cylindrical sleeve rotatably mounted in closely fitting coaxial relation around the wave guide and having a plurality of spaced apertures, and means for relatively rotating the sleeve and the wave guide whereby the apertures become successively aligned with the slot means to permit the passage of radio waves therethrough.

31. An electric system having, in combination, a circular wave-guide cylinder adapted to support radio waves and provided with slot means extending substantially parallel to the axis of the cylinder, a cylindrical sleeve rotatably mounted in closely fitting coaxial relation around the wave-guide cylinder and having a plurality of spaced apertures, and means for relatively rotating the sleeve and the wave-guide cylinder whereby the apertures become successively aligned with the slot means to permit the passage of radio waves therethrough.

32. An electric system having, in combination, a circular wave-guide cylinder adapted to support radio waves and provided with slot means extending substantially parallel to the axis of the cylinder, means for focusing radio waves upon the wave-guide cylinder, a cylindrical sleeve rotatably mounted in closely fitting coaxial relation around the wave-guide cylinder and having a plurality of spaced apertures, and means for relatively rotating the sleeve and the wave-guide cylinder whereby the apertures become successively aligned with the slot means to permit the passage of

the focused radio waves therethrough.

33. An electric system having, in combination, a hollow substantially circular wave-guide cylinder adapted to support radio waves and having slot means extending substantially parallel to the axis of the cylinder distances substantially related to the half-wavelength of the radio waves, means for focusing radio waves on the wave guide, a cylindrical sleeve rotatably mounted in closely fitting coaxial relation around the wave guide and having a plurality of spaced apertures, and means for rotating the sleeve whereby its apertures are adapted to register successively with the slot means in a predetermined sequence for permitting radio waves to pass through successive portions of the slot means one at a time, the remaining portions of the slot means being closed and effectively short-circuited by the sleeve.

34. An electric system having, in combination, a v/ave 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 provided with slot antenna means of dimensions sufficient to pass the said radio waves, and means for opening and closing parts of the slot antenna means.

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