Jan. 1, 1946. R. J. McELHANNON 2,391,914

METHOD AND APPARATUS FOR VARIABLY REFLECTING RADIO WAVES ELECTRICALLY

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FIG. 1.

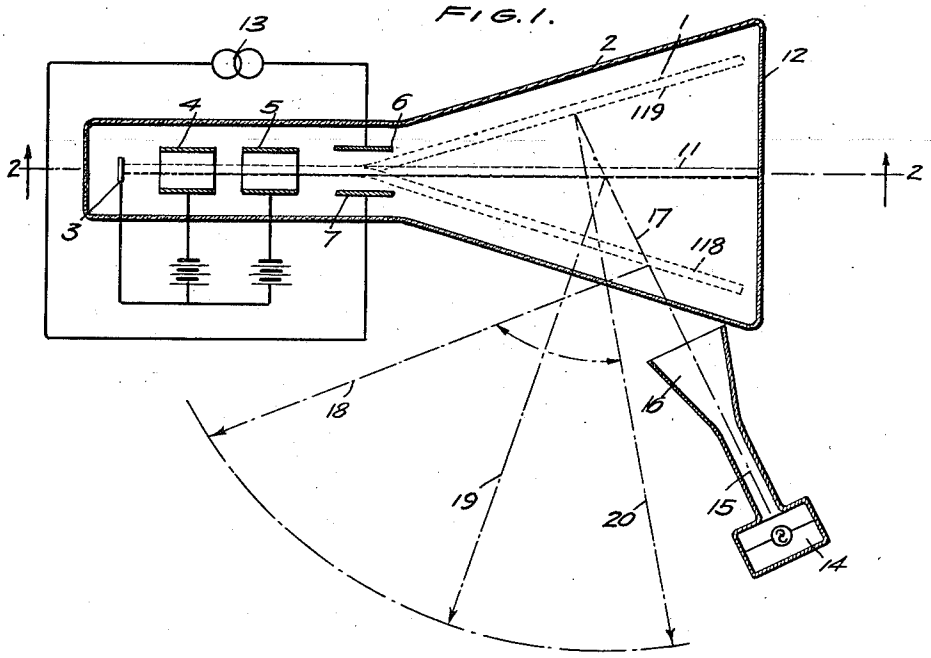
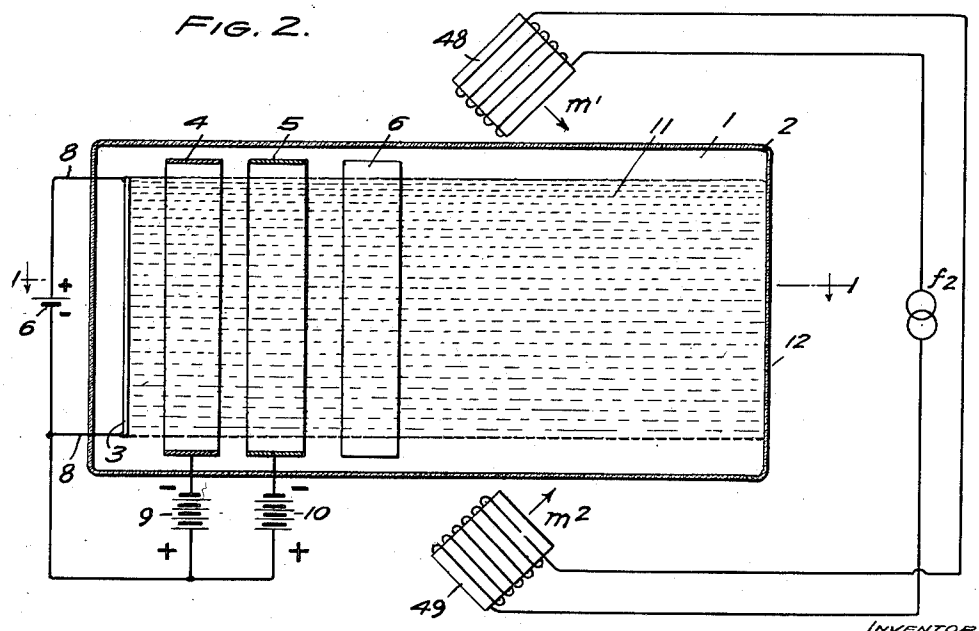


FIG. 2.



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FIG. 3.

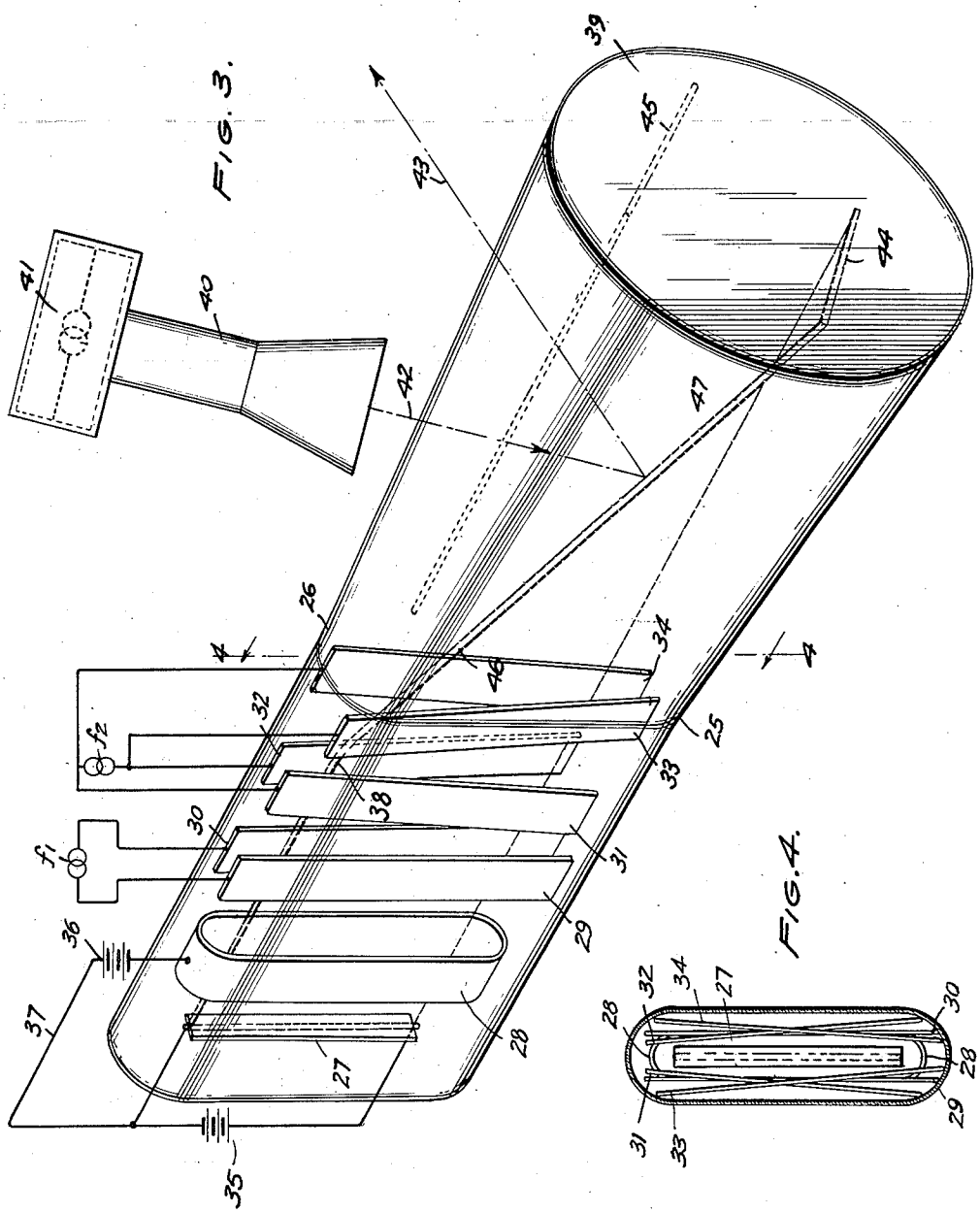


FIG. 4.

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UNITED STATES PATENT OFFICE

2,391,914

METHOD AND APPARATUS FOR VARIABLY REFLECTING RADIO WAVES ELECTRICALLY

Raymond J. McElhannon, Flushing, N. Y.

Application May 21, 1943, Serial No. 487,899

8 Claims. (Cl. 250—11)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

The invention described herein may be manufactured and used by or for the Government for governmental purposes, without the payment to me of any royalty thereon.

This invention pertains to method and apparatus for variably reflecting radio waves by purely electrical means and without the use of any mechanically moveable elements.

The invention finds application in radar systems, among others, for searching or scanning, i. e., for directing transmitted pulses of ultra high frequency energy to successive portions of an area to be searched or scanned, whereby objects may be located by reflected radio waves returned to the radar. Heretofore, radar systems have required mechanically movable elements, usually a metal paraboloid and associated antenna combination, termed a "spinner" for accomplishing this purpose. The use of such mechanically deflectable scanning devices for variably directing the transmitted pulses to successive portions of an area to be searched, places definite limitations on the scanning speed and image definition obtainable, due to the centrifugal and related stresses, etc., set up in the scanning equipment.

I propose, in accordance with my invention, to variably direct such radio waves into space by purely electrical and inertialess means and without necessity for any mechanically moveable elements. The basic principle employed consists briefly in reflecting a beam of radio waves from a sheet or blanket of moving electrons established between an elongated cathode and an associated screen of an appropriately constructed cathode ray tube. For variably reflecting into space the radio waves incident on this electron sheet, I employ the usual electrostatic or magnetic deflecting plates or coils, thereby to variably deflect the cathode beam, and hence the angles of incidence and reflection of the radio waves, whereby the incident waves are variably reflected to successive portions of an area to be scanned.

The usual or known arrangement of the electrostatic or magnetic deflecting plates or coils, provides only transverse deflection of the electron sheet, thereby to provide scanning in but one direction or plane, namely, that perpendicular to the electron sheet. In accordance with a feature of the present invention, simultaneous scanning in two directions or planes may be obtained, for example, both horizontal and vertical scanning may be accomplished by a novel special arrangement and combination of electrostatic or magnetic deflecting plates or coils, as hereinafter set forth.

Referring now to the accompanying drawings for a more detailed explanation of the invention:

Figure 1 is a schematic plan view of an apparatus for carrying out the invention, in which scanning is effected in but one plane; while Figure 2 is a longitudinal sectional elevation at 2—2 of Figure 1.

Figure 3 is a perspective view of a further modification of the invention according to which scanning is effected in two planes to provide, for example, concurrent horizontal and vertical scanning; while Figure 4 is a section at 4—4 of Figure 3.

Referring to Figures 1 and 2, there is shown a cathode ray tube 1, of the rather unusual contour shown in sectional elevation in Figure 2. Within the glass container 2, of the cathode ray tube, there are provided, in spaced relation as shown, an elongated or filamentary cathode 3, a pair of elongated slot-like focusing electrodes 4, 5, arranged in spaced relations as shown, and a pair of parallel electrostatic deflecting plates 6, 7, spaced apart as shown. The cathode 3 is energized from a battery 6, or other suitable source of voltage, connected to the terminals of the cathode over conductors 8. The focusing electrodes 4, 5, are maintained at suitable negative potentials relative to the cathode 3, by batteries 9, 10 or equivalent, connected at the negative terminals to the focusing electrodes, and at the positive terminals to the cathode battery 6.

With the cathode and focusing electrodes energised as above stated, a focused sheet 11 of electrons will flow from the cathode 3 through slots of the focusing electrodes 4, 5 to the screen 12 of the cathode ray tube. This sheet of electrons will likewise flow between the parallel electrostatic deflecting plates 6, 7 as shown. Connected between these deflecting plates, 6, 7, is a source of alternating current 13 of a suitable scanning frequency, for alternately deflecting the cathode beam between the limiting positions 118 and 119, indicated by the dotted lines.

Associated with the cathode ray tube is suitable apparatus, comprising a high frequency generator 14 and associated wave guide 15, for directing a beam of short radio waves against the cathode sheet 11. The high frequency generator 14 is so connected to the wave guide 15, in a known manner, as to launch the short radio waves into the guide, and thence, into space from the open end 16, thereof. The exit 16 from the guide is conically flared outwardly as shown, in order to afford a better impedance match between the

guide proper and the space into which the radio waves are launched. For imparting optimum directivity to the radio waves, this conically flared terminus 16 of the guide should subtend an angle of about 60°. The proper design of the wave guide for this purpose is fully set forth in U. S. Patent 2,283,935, granted May 26, 1942, to A. P. King.

Generator 14 and associated wave guide 15 are preferably designed to transmit a radio beam of about 1 to 10 centimeters in wave lengths, a more desirable range being about 1 to 3 centimeters. The transmitter output is fed through the hollow guide as shown, to a point adjacent cathode ray tube for directing the beam of short radio wave, radiated from the guide, at an angle against the sheet of electrons 11, as indicated in Figure 1 by the dotted line 17. In consequence, as the electron sheet 11 is variably deflected between the limiting positions 118, 119 in the manner explained above, the angle of incidence of radio waves will vary, thereby to variably reflect these waves in directions 18, 19, 20 and between the limiting positions 18 and 20.

In the modification of the invention described in Figures 1 and 2, variable scanning reflection of the radio waves occurs in but one plane, namely, that perpendicular to the plane of the electron sheet 11. As above stated, Figure 3 shows a modification of the invention according to which scanning may be simultaneously effected in two directions, such for example, as concurrent horizontal and vertical scanning.

Referring now to Figure 3, there is shown a cathode ray tube 25, comprising an hermetically sealed and evacuated glass receptacle 26, housing the various electrodes, viz. cathode 27, focusing electrode 28, transverse deflecting plates 29, 30 and special deflecting plates 31, 32 and 33, 34 for rotating the electron sheet in a manner explained hereinafter. The cathode 27 is energised by a battery 35 or equivalent. Negative potential is applied to the focusing electrode 28 by a battery 36 or equivalent, included in a connection 37, extending from the cathode to the focusing electrode as shown.

As in the modification of Figures 1 and 2, with the cathode and focusing electrode energized by sources 35 and 36, a sheet of focused electrons, indicated by the dotted lines 38 will flow from the cathode 27, through the focusing electrode 28 and between the pairs of deflecting plates 29, 30, 31, 32 and 33, 34 to the screen 39 of the tube. Associated with the cathode ray tube is a wave guide 40, similar to that of Figure 1, provided at its closed end with a short wave generator or transmitter 41, for transmitting a beam of short radio waves against the electron sheet 38, as indicated by the dotted lines 42, which radio waves are reflected from the electron sheet, at the instant depicted, in the direction of the arrow 43.

For providing transverse deflection of the electron sheet 38, a voltage source of frequency *f*—1 is connected between the deflecting plates 29, 30, thereby to variably deflect the electron sheet transversely between limiting positions, such as 44, 45. This provides variable reflection of the incident radio wave in one plane, as for example, to provide horizontal scanning.

The pairs of deflecting plates 31, 32 and 33, 34 are arranged to provide concurrent scanning in a direction at right angles to that provided by plates 29, 30. To accomplish this, plates 31, 32 are mounted in inclined relation to each other in one direction; while plates 33, 34 are inclined to each other in the opposite direction. A voltage source of a suitable scanning frequency *f*—2 is connected between the associated plates 31, 32 and is oppositely connected between plates 33, 34. The effect of this arrangement is to cause the electron sheet 38 to be rotated alternately clockwise and counterclockwise through a certain angle, thereby to variably reflect the incident radio wave in a vertical direction with the equipment.

The explanation of this action is as follows: Since the plates of pairs of deflecting plates 31, 32 and 33, 34 are disposed in inclined relation to each other, the voltage gradient between plates, due to source *f*—2, will vary progressively from top to bottom of each plate pair. For plates 31, 32 this gradient will be greatest at the top and will progressively decrease toward the bottom. Conversely for the oppositely inclined plates 33, 34, the voltage gradient will be least at the top and will progressively increase toward the bottom. Therefore at the top of the electron sheet 38, plates 31, 32 will have a greater deflecting action than plates 33, 34, and the reverse will be true at the bottom of the electron sheet. Furthermore since plates 31, 32 are connected to source *f*—2 in opposite polarity to plates 33, 34, the result will be that at any given instant, plates 31, 32 will tend to deflect the electron sheet in opposite direction to that of plates 33, 34. Also since, as above stated the deflecting action of plates 31, 32 is greater at the top and that of plates 33, 34 is greater at the bottom, and since their deflecting actions are in opposite directions, there will result a skewing or rotation of the electron sheet 38 about its longitudinal axis, as shown in the drawing at 46, 47. This skewing or rotation of the electron sheet will vary in the vertical direction the angle of reflection of the radio waves incident thereon from source 40, 41.

In this manner vertical scanning of the radio waves is accomplished due to rotation of the electron sheet about its longitudinal axes. And since this rotation occurs concurrently with the transverse displacement of the electron sheet due to the action of deflecting plates 30, 31, both horizontal and vertical scanning are simultaneously accomplished. That is to say, the incident radio waves are variably reflected in the horizontal direction between limiting positions and at the scanning frequency *f*—1, while at the same time variable reflection occurs in vertical direction between limiting positions and at the scanning frequency *f*—2.

The scanning frequencies *f*—1 and *f*—2 are selected to provide complete repetitious searching of the area scanned corresponding to that of the usual television scanning in which *f*—1 represents the line scan, and *f*—2 the picture or frame scan.

Instead of electrostatic deflection of the electron sheet, magnetic deflection may be employed. As a magnetic substitute for the transverse deflecting plate 29, 30, the usual coil arrangement may be employed, in which coils are placed above and below the electron sheet to provide a varying magnetic field which is perpendicular to the plane of the electron sheet.

To provide the rotative or skewing action of plates 31, 32 and 33, 34, a coil arrangement as shown in Figure 2 may be employed. A pair of coils 48 and 49 are mounted respectively above and below the electron sheet with their axes in the plane of the electron sheet and inclined as shown at such an angle as to provide minimum magnetic coupling between coils.

The coils are energized in like phase from an alternating current source of frequency *f*—**2**, to provide, at any given instant, opposing magnetic fluxes, as indicated by arrows m^1 and m^2. The flux due to coil **48** will decrease in intensity from top to bottom of the electron sheet, and the reverse will be true of the flux from coil **49**, with practically no flux at the axis of the electron sheet where the fluxes are equal and opposed. Due to this effect and the fact that the coil fluxes are oppositely directed at each instant, there will result a rotation or skewing of the electron sheet.

For providing efficient reflection of the radio waves, the electron sheet should have as heavy current density as possible, since the heavier current density, the greater the percentage of radio wave reflection.

I claim:

1. Apparatus for variably reflecting short radio waves electrically comprising: means for creating a sheet of electrons in space adapted to reflect said waves, means for directing a beam of said waves onto said electron sheet for reflection therefrom and controllable means for electrically deflecting said electron sheet thereby to vary to a predetermined extent the direction of reflection of said radio beam.

2. Apparatus for variably reflecting short radio waves electrically, comprising: means for creating a sheet of electrons in space adapted to reflect said waves, a source of said radio waves, means for projecting a beam of said waves from said source onto said electron sheet, and controllable means for electrically deflecting said electron sheet thereby to vary to a predetermined extent to direction of reflection of said radio beam.

3. Apparatus for variably reflecting short radio waves, comprising: cathode ray tube means for generating a sheet of moving electrons in space adapted to reflect said radio waves, and means for directing a beam of said waves onto said electron sheet for reflection therefrom.

4. Apparatus for variably reflecting short radio waves electrically, comprising: cathode ray tube means for generating a sheet of electrons adapted to reflect said radio waves, means for projecting a beam of said waves onto said electron sheet, and means for electrically deflecting said electron sheet thereby to vary the direction of reflection of said radio beam.

5. The method of variably reflecting radio waves, which comprises: generating a sheet of electrons moving in space, directing radio waves onto said electron sheet for reflection therefrom, and electrically deflecting said electron sheet transversely to the paths of said electrons to a predetermined extent, thereby to alter controllably the direction in which said radio waves are reflected.

6. Apparatus for variably reflecting radio waves electrically, comprising: means for creating a sheet of moving electrons in space adapted to reflect said waves, means directing radio waves onto said electron sheet for reflection therefrom, means for electrically deflecting said electron sheet transversely for variably reflecting said radio waves about a first axis of rotation, and means for electrically rotating said electron sheet about its longitudinal axis for variably reflecting said radio waves about a second axis of rotation angularly inclined with respect to said first axis.

7. Apparatus for variably reflecting radio waves electrically, comprising: cathode ray tube means for generating a sheet of electrons moving from a cathode to a screen, means for projecting a beam of radio waves onto said electron sheet, means for electrically deflecting said electron sheet transversely for variably reflecting said radio waves about a first axis of rotation, and means for electrically rotating said electron sheet for variably reflecting said radio waves about a second axis of rotation angularly inclined with respect to said first axis, whereby said radio waves may be variably reflected concurrently with respect to both said axes of rotation.

8. Apparatus for variably reflecting radio waves electrically, comprising: cathode ray tube means for generating a sheet of electrons moving from a cathode to a screen, means for projecting a beam of short radio waves onto said electron sheet for reflection therefrom, means including a pair of parallel spaced electrodes disposed on opposite sides of said electron sheet, for electrically deflecting said electron sheet transversely for variably reflecting said radio waves about a first axis of rotation, and means for rotating said electron sheet about its longitudinal axis for variably reflecting said radio waves about a second axis inclined to the first, said last named means including a first pair of spaced electrodes mutually inclined in one direction transversely of said electron sheet, a second pair of spaced electrodes mutually inclined in the opposite direction, said electron sheet passing between the spaced electrodes of each of said pair, and means oppositely connecting the electrodes of said first and second pairs to a variable voltage source.

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