Dec. 27, 1955 E. M. WELLS 2,728,912

RADIO BEAM SCANNERS

Filed June 3, 1952 4 Sheets-Sheet 1

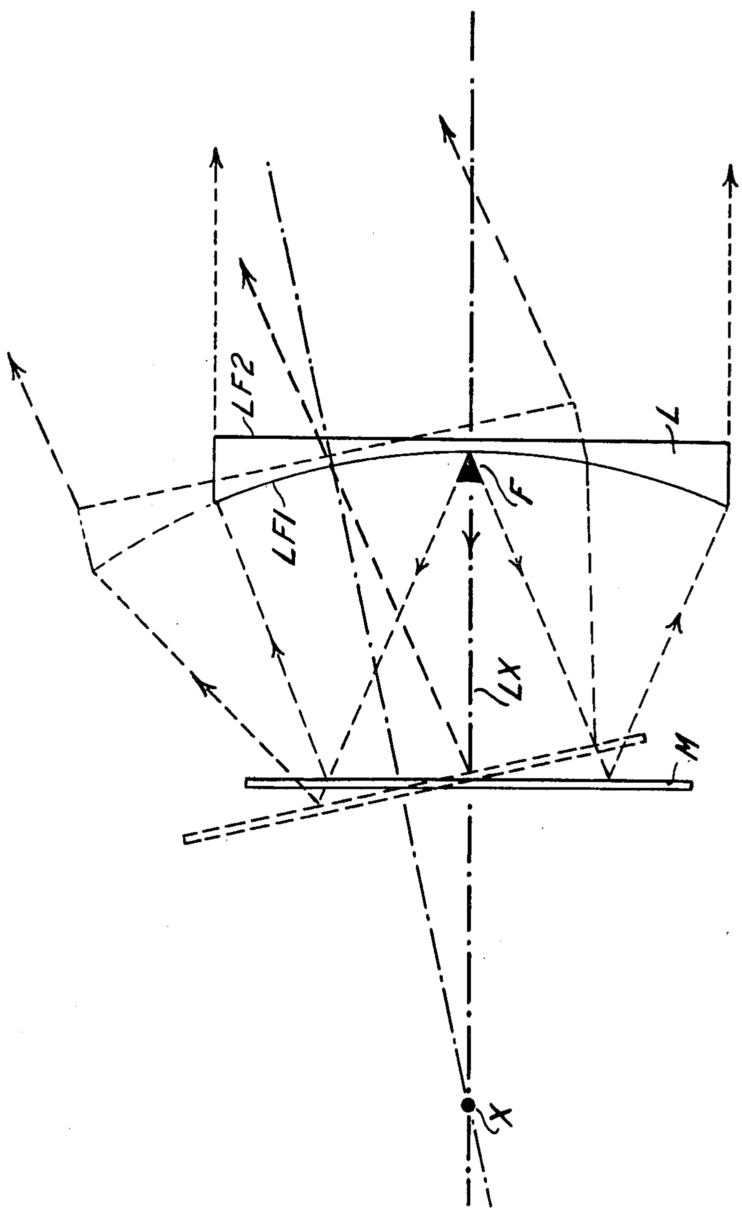

Fig. 1.

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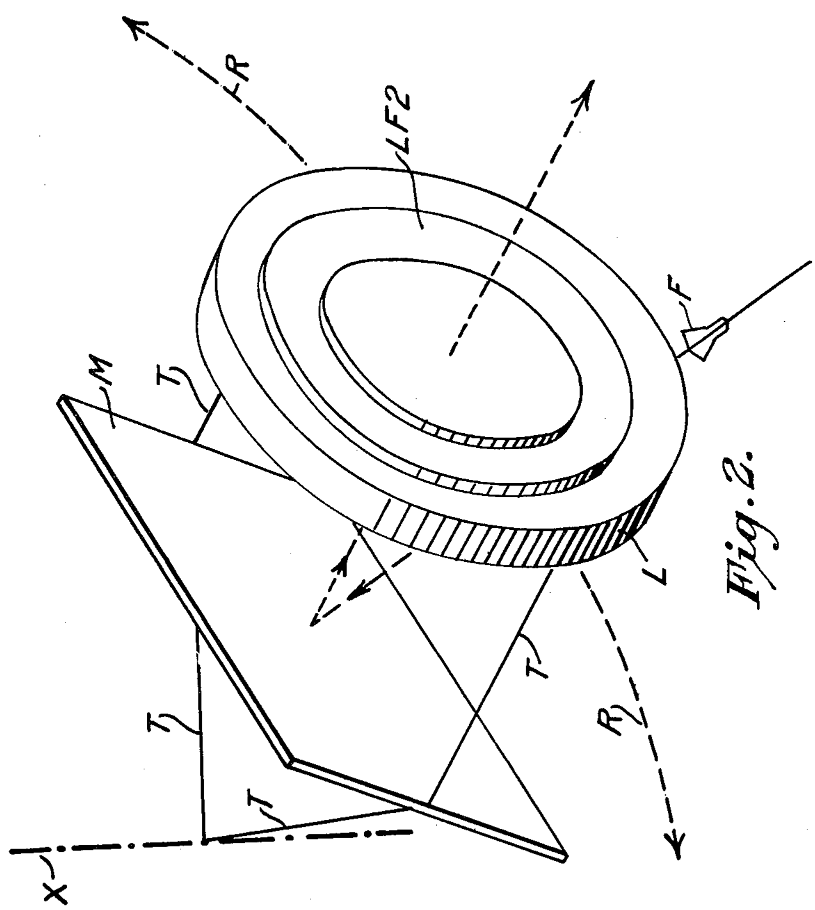

Fig. 2.

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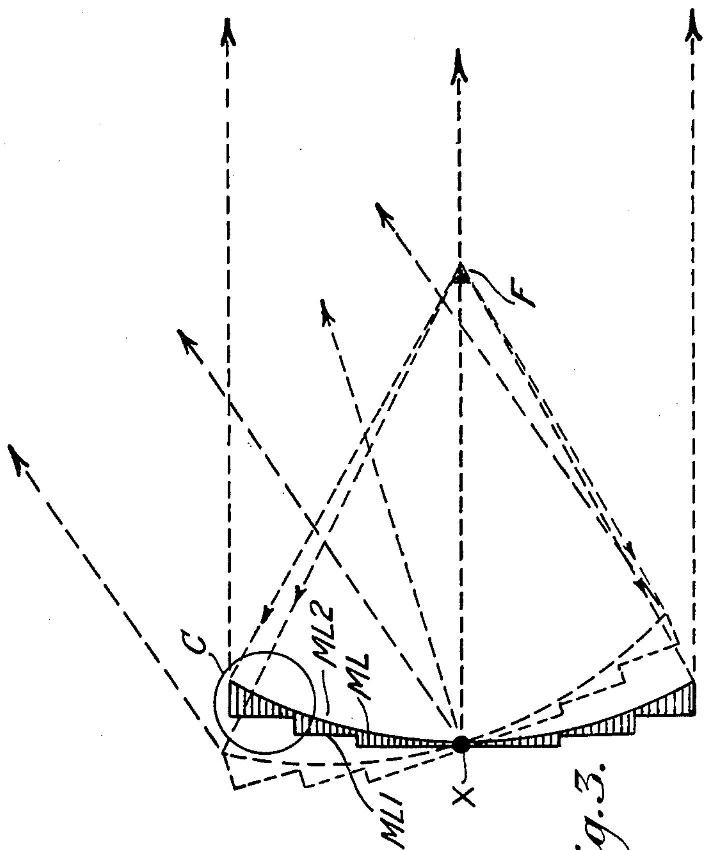

Fig. 3.

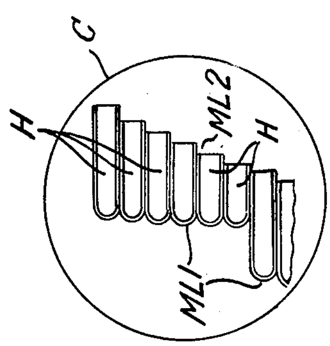

Fig. 4.

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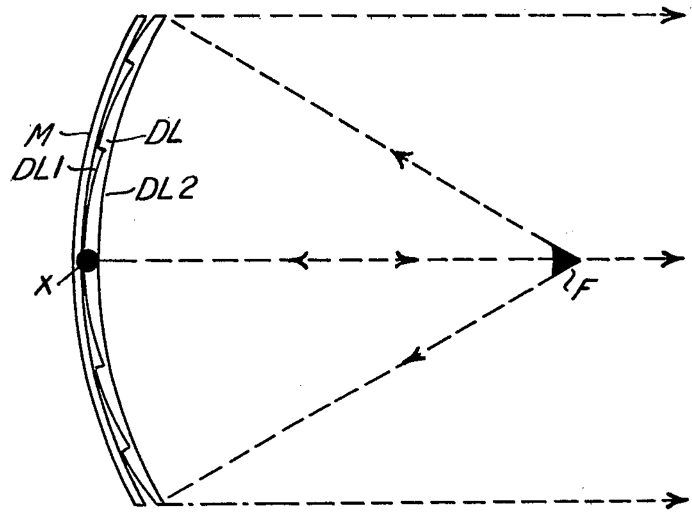

Fig. 5.

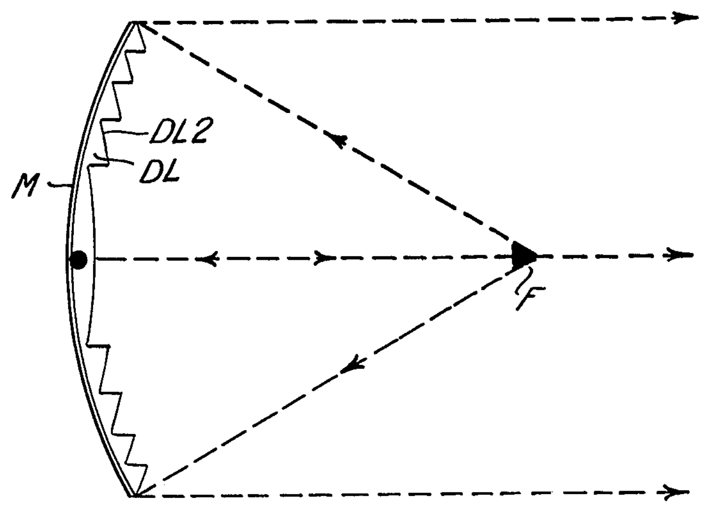

Fig. 6.

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RADIO BEAM SCANNERS

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Application June 3, 1952, Serial No. 291,475

Claims priority, application Great Britain June 5, 1951

12 Claims. (Cl. 343—754)

This invention relates to radio beam scanners such as are required for radar systems and more specifically to radio beam scanners wherein a sharply directional pencil like beam of ultra high frequency radio energy is required to be scanned over a relatively wide angle comparatively slowly e. g. at the order of several seconds per scanning cycle.

The object of the invention is to provide improved mechanically convenient and simple scanners wherein the necessity for moving the radio feed source shall be avoided, wherein difficulties due to loss of focus of the beam during scanning shall be reduced to a minimum and wherein the obtained angle of swing of the radio beam shall be large in relation to the mechanical movement required to produce the required displacement.

According to the main feature of this invention a radio beam scanner comprises a radio feed source, a radio mirror towards which said source is directed, a radio lens positioned in the path of radio energy reflected by said mirror, and means for swinging said mirror and lens as a unit about an axis of rotation which meets the lens axis at a point substantially in or behind the mirror.

By "radio mirror" as above employed is meant any device adapted to reflect substantially all incident radio energy thereon. A radio mirror may be built of, for example, metal sheet, rod or netting and many forms are known. By "feed source" is meant a device, such for example, as a radio horn, a flared wave guide, or a polyrod which, when coupled to a source of radio energy, is adapted to radiate a radio beam to illuminate the mirror.

The feed source may be between the lens and the mirror but preferably said source is offset so that the beam axis through the source does not pass through the lens and the mirror is correspondingly tilted with relation to the lens.

In a modification of the main feature of the invention the lens and the mirror are in effect combined to form a so-called phase corrected mirror with regard to which the source may be offset. In this modification the axis of rotation preferably passes through the mirror. In order to increase the maximum available angle of scan the first i. e. the non-reflecting surface of the mirror is preferably arcuate in which case the reflecting surface i. e. that remote from the source, may be stepped as known per se. Such a mirror may be constituted by a matrix of stopped tubes.

The invention is illustrated in the accompanying drawings showing a number of embodiments schematically, and in which:

Figure 1 illustrates a radio beam scanner assembly arranged in accordance with my invention and employing a plane radio mirror, a radio lens and a fixed feed source;

Fig. 2 illustrates a radio beam scanner assembly according to my invention and shown in perspective and illustrating particularly the manner of off-setting the feed source;

Fig. 3 shows a modified form of my invention embodied in a phase corrected mirror;

Fig. 4 is an enlarged fragmentary view of a portion of the mirror-lens of Fig. 3;

Fig. 5 shows a further modification of my invention in which a dielectric-lens is employed in place of the mirror-lens in the radio beam scanner of my invention and in which a smoothly curved front surface having a stepped rear surface is provided; and

Fig. 6 shows a further modified form of my invention in which a dielectric-lens is employed having a stepped front surface and a rear smoothly curved surface.

Referring to Fig. 1 a plane radio mirror M, a radio lens L and a fixed feed source F are employed. The feed source F, which may for example be a wave guide fed radio beam projector, is between the lens and the mirror and pointed towards the latter. The face LF1 of the lens towards the mirror is arcuate and the other, or front, face LF2 is shown as plane for simplicity but may be stepped in accordance with well known principles so as to appear, in sections, as a series of suitably curved surfaces joining the steps. The axis LX of the lens, which is shown by a chain line and in which the focus of the lens lies, passes through the mirror normal to the surface thereof and the mirror and lens are mounted to be movable as a unit for scanning purposes about an axis X of rotation which meets the lens axis LX at the center of curvature of arcuate face LF1. The emitted scanning beam is, of course, the emergent beam from the lens and it will be seen that it will swing through an angle which is twice that through which the lens-mirror unit is swung. There is no need for any rotational joints in the wave guide to the feed source while the maintenance of sharpness of the emergent scanning beam presents no serious difficulties. Fig. 1 shows the parts in full line in the central position of the scan and in broken lines at one extreme position, central and boundary rays for both these positions being conventionally indicated by broken lines marked with arrow heads.

In order to avoid matching difficulties and also to avoid deterioration of the emergent scanning beam due to what may be termed the "shadow" of the feed source at the center of the lens aperture, it is preferred to modify the above described embodiment by off-setting the feed source and correspondingly tilting the mirror out of a plane parallel to the axis of rotation. Such an arrangement is shown in diagrammatic perspective in Fig. 2 in which similar reference characters to those of Fig. 1 are used. In Fig. 2 the front face LF2 of the lens is shown as stepped and the axis of rotation is shown by a chain line, the mechanical tie members for tying the parts together for rotation as a unit being represented by the lines T. The broken line arrows R represent the arcuate swing about the axis. Off-setting the feed in this manner will, of course, cause distortion of the arc scanned by the emergent beam and twist of polarization during scanning. The position of the axis of rotation and the angle between the feed axis and the emergent beam axis are related and must be so chosen as to ensure that substantially all the energy radiated by the feed illuminates the lens in all positions of scanning while keeping the forms of distortion (distortion of arc and twist of polarization) just mentioned as small as possible.

If desired, the mirror and lens may be in effect combined to form a phase corrected mirror. Such mirrors are broadly known per se. One arrangement of this nature is shown schematically in Fig. 3 in much the same manner as that adopted for Fig. 1. Fig. 3 shows a preferred form of mirror-lens ML which has a smoothly curved front face ML2 as shown—i. e. the face nearer the feed source F—and a rear face ML1 which is stepped as known per se. The mirror-lens shown is of honeycomb or tubular structure, also as known per se. The construction is better shown in Fig. 4 which is a diagrammatic enlargement of the portion of the mirror lens of Fig. 3 ringed round by the circle C. In such a phase correcting mirror the rear face ML1 is, of course, the reflecting face, and incident energy passes into the open mouths of the honeycomb or tubular sections H (see Fig. 4) to the bottoms thereof, being then reflected back from the bottoms of the said sections, the phase corrections being obtained by reason of the different time delays occasioned by the radio energy in passing down and back along the sections of different lengths. In a preferred form of phase correcting mirror the sections are constituted by brass or other tubes, resembling cartridge cases, of the required different lengths, each stopped at one end. These tubes are soldered or otherwise fixed together so that their axes are parallel to one another and to the mirror axis and so that the open tube mouths lie in the required front surface of the mirror, the stopped ends lying in the required stepped rear or reflecting surface of the mirror. The mirror-lens arrangement of Figs. 3 and 4 has the advantages that any desired surface shapes can easily be built up while "shadows" due to the steps are largely avoided since the steps are in the reflecting surface. In Fig. 3 the axis of rotation is at the center of the mirror lens.

Other constructions of lens and mirror combinations may be used. For example Fig. 5 shows a modification which differs from that of Figs. 3 and 4 only in that there is employed, in place of the mirror-lens ML a dielectric lens DL with a smoothly curved front surface DL2 and a stepped rear surface DL1, a curved mirror M being arranged behind the lens and close up against it, while in the modification of Fig. 6 the front face DL2 of a dielectric lens is stepped and the rear face is smoothly curved the mirror M being in the form of a silver deposit on the smooth surface.

I claim:

1. A radio beam scanner comprising a radio feed source adapted to emit a beam of radio energy, a radio mirror, a radio lens which is fixed in relation to said mirror, and means interconnecting said mirror and lens for swinging said mirror and lens as a unit about an axis of rotation which meets the lens axis at a point substantially in or behind the mirror, said source being directed toward said mirror and being fixedly mounted so that upon swinging said mirror and lens as a unit the beam emergent from said lens is scanned through an angle large in relation to the angle of swing of said unit.

2. A scanner as claimed in claim 1 wherein the feed source is between the lens and the mirror.

3. A scanner as claimed in claim 1 wherein the feed source is offset so that the beam axis through the source does not pass through the lens and the mirror is correspondingly tilted with relation to the lens.

4. A scanner as claimed in claim 1 wherein the lens and the mirror are combined to form a phase corrected mirror.

5. A scanner as claimed in claim 1 wherein the lens and the mirror are combined to form a phase corrected mirror and the radio feed source is offset.

6. A scanner as claimed in claim 1 wherein the lens and the mirror are combined to form a phase corrected mirror the non-reflecting surface of the mirror lens being smoothly curved arcuately and wherein the reflecting surface that is remote from the feed source is stepped.

7. A scanner as claimed in claim 1 wherein the lens and the mirror are combined to form a phase corrected mirror and wherein the radio feed source is offset, the non-reflecting surface of the mirror lens being smoothly curved arcuately and the reflecting surface, that is remote from the feed source, being stepped.

8. A scanner as claimed in claim 1 wherein the lens and the mirror are combined to form a phase corrected mirror the non-reflecting surface of the mirror lens being smoothly curved arcuately and the reflecting surface, that is remote from the feed source, being stepped, said phase-corrected mirror being constituted by a matrix of stopped tubes.

9. A scanner as claimed in claim 1 wherein the lens and the mirror are combined to form a phase corrected mirror and the radio feed source is offset so as to be substantially out of the path of the emergent beam from said phase corrected mirror, the non-reflecting surface of the mirror lens being smoothly curved arcuately and the reflecting surface, that is remote from the feed source, being stepped, said phase-corrected mirror being constituted by a matrix of stopped tubes.

10. A scanner as claimed in claim 1 wherein the lens and the mirror are combined to form a phase corrected mirror-structure consisting of a dielectric lens with one smoothly curved surface and one stepped surface and a smoothly curved mirror close against said lens.

11. A scanner as claimed in claim 1 wherein the lens and the mirror are combined to form a phase corrected mirror-structure consisting of a dielectric lens with one smoothly curved surface and one stepped surface and a smoothly curved mirror close against said lens, said mirror being constituted by a reflecting deposit on the smoothly curved surface of the lens.

12. A scanner as claimed in claim 1 wherein the lens and the mirror are combined to form a phase corrected mirror, the axis of rotation passing through the mirror.

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