Aug. 4, 1953 LAN JEN CHU 2,648,003

VERNIER SCANNER

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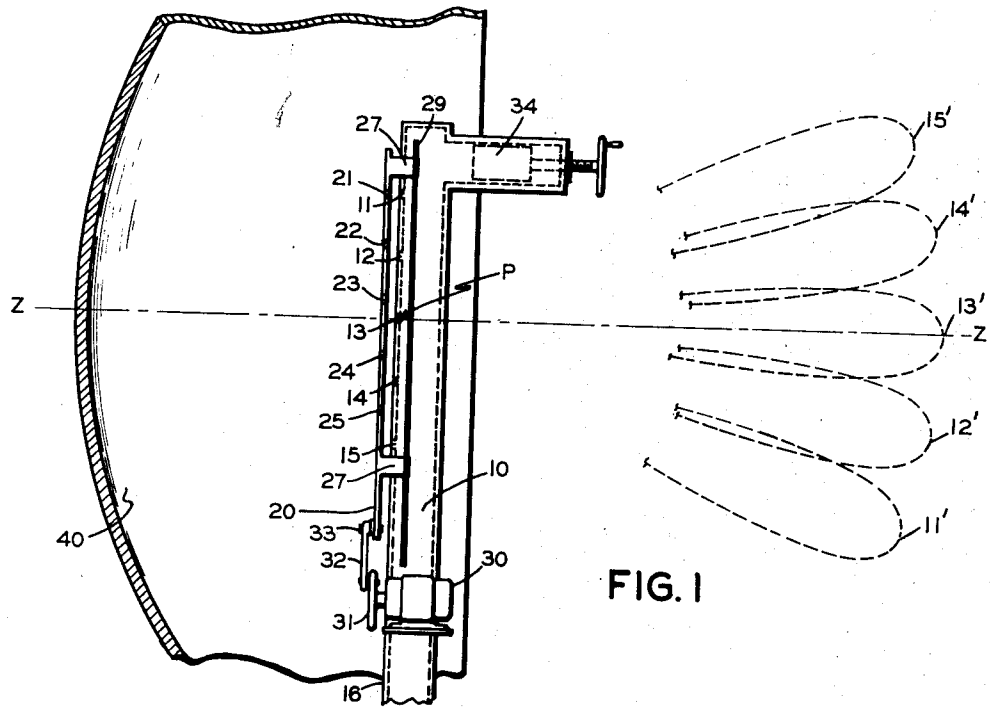


FIG. 1

FIG. 2

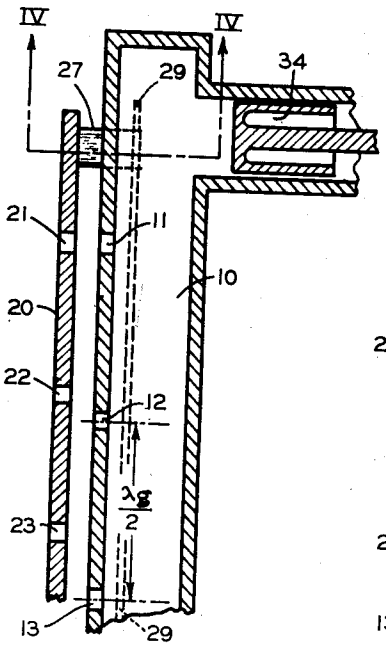
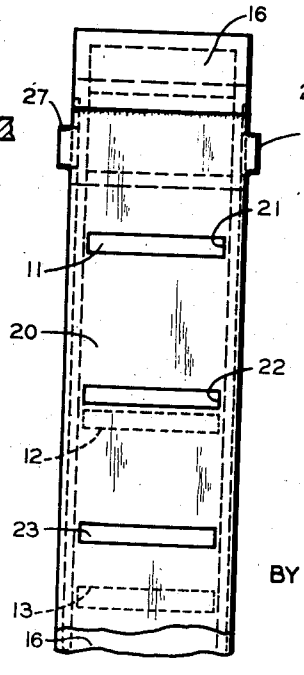


FIG. 3



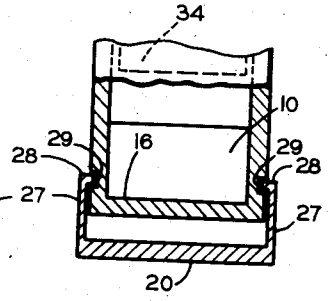


FIG. 4

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VERNIER SCANNER

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10 Claims. (Cl. 250—33.65)

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The present invention relates in general to radio antennas and in particular to directive antennas of the rapid scanning type.

It has heretofore been necessary when seeking to have a directive antenna scan its beam over a region requiring a large amplitude of scan angle to provide complex mechanical equipment capable of moving with a correspondingly relatively large amplitude. Such mechanical equipment, in addition to being complex, is cumbersome, and large amplitudes of mechanical motion introduce serious vibration and other disturbances into the antenna system.

It is accordingly an object of this invention to provide in a directive scanning antenna a large amplitude of scan angle with a small amplitude of mechanical motion in the scanning mechanism. This and other objects are accomplished by providing a linear array of antenna radiators adapted to radiate on the same phase, and exposing one after another of these radiators in the order of their positions in the array by means of an oscillating shutter designed after the fashion of a vernier scale with respect to the array. The further positioning of the array and shutter before a parabolic reflector about the focal point thereof permits scanning the beam of the entire assembly over a relatively wide field with a relatively small amplitude of oscillation of the shutter.

It is accordingly another object of the invention to provide in such an antenna an array of radiators and a shutter therefor that will expose said radiators one by one in the order of their array to permit them in succession to radiate or receive radiation.

It is a further object of the invention to provide such an array by cutting transverse slots in the wide wall of a rectangular wave guide in such a fashion that they are arrayed longitudinally with respect to the wave guide and spaced for equal feeding by the wave guide.

It is a still further object of the invention to provide a shutter for such a slotted wave guide array that will have similar slots similarly arrayed therein and so spaced with respect to said array of radiating slots that when the shutter is moved with respect to the wave guide longitudinally, the radiating slots will be exposed one by one each by the corresponding shutter slot, in the order of their array.

Other and further objects of the present invention will become apparent upon a careful consideration of the following detailed description when taken with respect to the appended drawing, in which:

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Fig. 1 illustrates in scheme a radiating system of my invention in combination with a parabolic reflector for producing a beam that may be scanned over a relatively wide field;

Fig. 2 illustrates in longitudinal section an expanded portion of the radiating system of Fig. 1;

Fig. 3 is a front elevation of Fig. 2; and

Fig. 4 is a cross section along the line IV—IV on Fig. 2.

In the drawing, a wave guide 10 has a plurality of transversely disposed slots 11, 12, 13, 14 and 15 cut in a wide wall 16 thereof. The slots 11, 12, 13, 14 and 15 are each adapted to radiate energy from the wave guide 10 when that wave guide is carrying energy in any suitable mode. In order that the radiation from each slot may be equal in intensity to that from the other slots, the slots are spaced apart a distance preferably substantially equal to one-half the length λ_g in the wave guide 10 of a wave of energy therein, as shown specifically in Fig. 2. This spacing permits the use of a single matching unit 34 for all the slots. The slots 11 through 15 inclusive are thus arrayed longitudinally along the wide wall of the wave guide 10, being specifically disposed side by side at the spacing hereinabove mentioned.

A shutter 20 of conductive material and substantially plane is disposed adjacent to the wide wall 16 of the wave guide 10, and has cut in it another array of slots 21, 22, 23, 24, and 25, respectively. The slots 21 through 25 inclusive are disposed in the same direction as the slots 11 through 15 inclusive and similarly arrayed; that is, the array of slots 21 through 25 inclusive is disposed longitudinally with respect to the longitudinal axis of the wave guide 10. However, the spacing between the slots 21 through 25 on the shutter 20 is less than the spacing of the slots 11 through 15 on the wave guide 10. The spacing between adjacent slots 21 through 25 inclusive is such that if the wave guide array were lengthened to have nine slots, an array of ten slots on the shutter 20 would be physically of the same length. This provides a vernier arrangement of the shutter slots 21 through 25 with respect to the wave guide slots 11 through 15. Such an arrangement of slots on the shutter 20 permits the exposure of one wave guide slot 11, 12, 13, 14 or 15 at a time by the corresponding shutter slot 21, 22, 23, 24, or 25 respectively, when the shutter 20 is moved longitudinally with respect to the wave guide 10.

In order that the shutter 20 may be moved longitudinally with respect to the wave guide 10 and yet not move away from or closer to the wide

wall 16 thereof, flanged side members 27 are provided on each side of the shutter 20 near each end thereof. The flanges 28 of these side members 27 engage in longitudinal grooves 29 cut in the outer narrow walls of the wave guide 10. A motor 30 and suitable linking mechanisms 31, 32, and 33 are provided for causing the shutter 20 to oscillate back and forth longitudinally with respect to the wave guide 10. The flanges 28 run in the slots 29 during such oscillation, and the slots 21 through 25 of the shutter 20 will successively expose one by one the slots 11 through 15 and then 15 through 11 respectively of the wave guide 10, so that these wave guide slots may radiate individually.

A tuning plunger 34 is provided at one end of the wave guide 10 in order that a proper standing wave configuration will be had at each of the the slots 11 through 15 inclusive in the wave guide 10.

A desirable form of a complete antenna may include a parabolic reflector 40, shown in Fig. 1 partly cut away and in section, into which the array of the wave guide 10 may feed its energy. Accordingly the array of the wave guide 10 is positioned along the axis Z—Z of the parabolic reflector 40 and at the focal point P thereof with the said focal point substantially midway along the array. The line of the array is perpendicular to the axis Z—Z at the focal point P. Thus when the wave guide slot 11 is being permitted to radiate or receive energy by the shutter slot 21, a beam 11' directed below the axis Z—Z will be produced. Similarly, as the shutter 20 is moved downward until the second wave guide slot 12 is permitted to radiate by the corresponding shutter slot 22, a second beam 12' is produced in place of the first beam 11'. Likewise, successive beams 13', 14' and 15' each directed in a different direction will be produced as the shutter 20 is further moved downward, thus progressively scanning the beam of the complete antenna of Fig. 1 over a relatively wide field as indicated. It will be appreciated that a relatively small motion of the shutter 20 is required to produce a relatively large scanning angle in the beam of the antenna of the invention.

As has been described hereinabove, the wave guide 10 and shutter 20 have equal numbers of slots 11 through 15 and 21 through 25 respectively in their slot arrays, although these need not be five in number. Equality in number is desirable to assure that only one wave guide slot may be exposed at a time, and never two simultaneously. However, for a particular number of wave guide slots having a particular interslot spacing, a vernier shutter may be provided with an interslot spacing predicated upon an array of any arbitrarily chosen number, X, of slots in the wave guide having the same physical length as a companion array of one more, X+1, slots in the shutter, provided that X is equal to or greater than the number of wave guide slots actually being used. Thus the particular shutter to wave guide interslot spacing ratio illustrated herein is not the only such ratio that can be used.

It will be apparent to one skilled in the art that, once the number of slots and the interslot spacing of the wave guide array are fixed, the higher the number X is chosen to be, the smaller will be the required amplitude of oscillation of the shutter 20 to expose all the wave guide slots. Thus, it is desirable that the number X used in finding the shutter interslot spacing be chosen as great as is permitted by the width of the slots being used. It should be noted that, when a reflector is used, as in Fig. 1, the scan angle of the beam depends upon the positions of the wave guide slots with relation to the reflector, and is in no way controlled by the amplitude of shutter oscillation.

As will be further appreciated by those skilled in the art, other forms of radiating elements in an array may be used to accomplish the purposes of my invention, and they may be used in combination with still other forms of vernier type scanning shutter devices. Likewise any motor or driving mechanism as desired may be used. While specific embodiments of the invention have been disclosed and described in detail, it is to be understood that various modifications and changes may be made in this invention without departing from the spirit and scope thereof as set forth in the appended claims.

What is claimed is:

1. A radio antenna comprising, a rectangular wave guide, a plurality of transversely disposed first slots longitudinally arrayed in a wide wall of said wave guide for radiating away energy being propagated therein, said first slots being uniformly spaced apart a distance substantially equal to one-half the length of a wave of said energy in said wave guide, a substantially plane conductive sheet disposed adjacent to said wide-wall substantially in plane parallelism therewith and longitudinally slidable with respect thereto, a plurality of second slots similar in number and character to said first slots and similarly disposed and arrayed in said sheet, said second slots being uniformly spaced apart a lesser distance than said first slots in such fashion that the arrays of said first slots and said second slots would be of equal longitudinal lengths if there were one more second slot than there are first slots, and means for oscillating said plane sheet longitudinally with respect to said wave guide so that said first slots are each exposed one by one by the corresponding second slot and permitted to radiate said energy individually in the order in which they are arrayed in said wide wall.

2. The apparatus of claim 1 in combination with a parabolic reflector, said wave guide being so disposed before said reflector that the center of said array of first slots and the focal point of said reflector are substantially coincident, the line of said array being substantially perpendicular to the axis of said reflector at said focal point, the radiation from said first slots being directed toward the concave face of said reflector.

3. A radio antenna comprising, a transmission means having a plurality of openings longitudinally arrayed in a wall thereof, an apertured conductive member disposed adjacent to said transmission means and longitudinally slidable with respect thereto, and means for oscillating said conductive member longitudinally with respect to said transmission means.

4. A radio antenna comprising, a length of wave guide having slots formed in the wall thereof, means for energizing said wave guide, a movable conductive member of substantially the same length of said wave guide disposed adjacent thereto and overlying said slots, said conductive member also having slots formed therein, and means for linearly oscillating said conductive member for permitting radiation from those of said wave guide slots which are instantaneously in register with slots of said conductive member.

5. A radio antenna comprising, a reflector, a length of wave guide having a plurality of linearly

arranged slots formed in a wall thereof disposed adjacent the focal point of said reflector, means for energizing said wave guide, a member having a corresponding number of linearly arranged and dissimilarly spaced slots disposed between said reflector and said length of wave guide and means for oscillating said member to allow radiation from successive ones of said slots in said wave guide to impinge on said reflector through successive slots in said member.

6. A radio antenna comprising, a length of wave guide having a plurality of slots formed therein, said slots being uniformly spaced apart by one-half wave length of energy at the frequency of operation of said wave guide, a conductive member disposed adjacent said wave guide and overlying said slots, said conductive member also having a plurality of slots formed therein and spaced uniformly a distance less than said one-half wave length, and means for oscillating said member to permit radiation from slots of said wave guide instantaneously in register with slots in said member.

7. A radio antenna comprising, a parabolic reflector, a length of rectangular wave guide having a series of slots formed in a wall thereof, said slots being disposed adjacent the focal point of said parabolic reflector, a conductive strip having a series of dissimilarly spaced slots formed therein, said strip being similar in dimension to said wave guide wall and slidably mounted thereon between said wave guide and said parabolic reflector, a motor for oscillating said conductive strip, means at one end of said length of wave guide for providing energy thereto whereby oscillation of said conductive strip and the consequent coaction of said wave guide and conductive member slots causes energy from successive slots in said wave guide to reach said reflector, and means at the other end of said length of wave guide for tuning said wave guide to cause the energy from each of said slots to be in similar phase.

8. A radio antenna comprising, transmission means formed with a plurality of spaced openings longitudinally arrayed in a wall thereof, a conductive member disposed adjacent and longitudinally slidable with respect to said transmission means and formed with a corresponding plurality of openings similarly arrayed and dissimilarly spaced, and means for oscillating said conductive member longitudinally with respect to said transmission means, whereby said openings coact to provide an oscillating energy transmission path from said transmission means through said conductive member.

9. A radio antenna for oscillating a beam of energy back and forth across a predetermined region comprising, a rectangular wave guide formed with a linear array of radiating slots substantially uniformly spaced apart in a broad wall thereof a distance equal to one-half wave length of energy as propagated in said wave guide, a conductive sheet slidably disposed adjacent said broad wall in the region of said slots and being formed with a corresponding number of linearly arrayed slots uniformly spaced apart a distance less than said half wave length, and means for oscillating said conductive sheet longitudinally with respect to said wave guide whereby the axis of said slot array on said sheet moves parallel to the axis of said slot array in said wave guide wall.

10. Apparatus as in claim 9 in combination with a parabolic reflector, said wave guide slots being disposed substantially in the region of the focal point of said reflector, said conductive sheet being disposed between said wave guide slots and said reflector.

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