Dec. 18, 1962 E. W. SEELEY ET AL 3,069,680

FERRITE-LOADED CAVITY BEAM-SHIFTING ANTENNA

Filed July 26, 1960

2 Sheets-Sheet 1

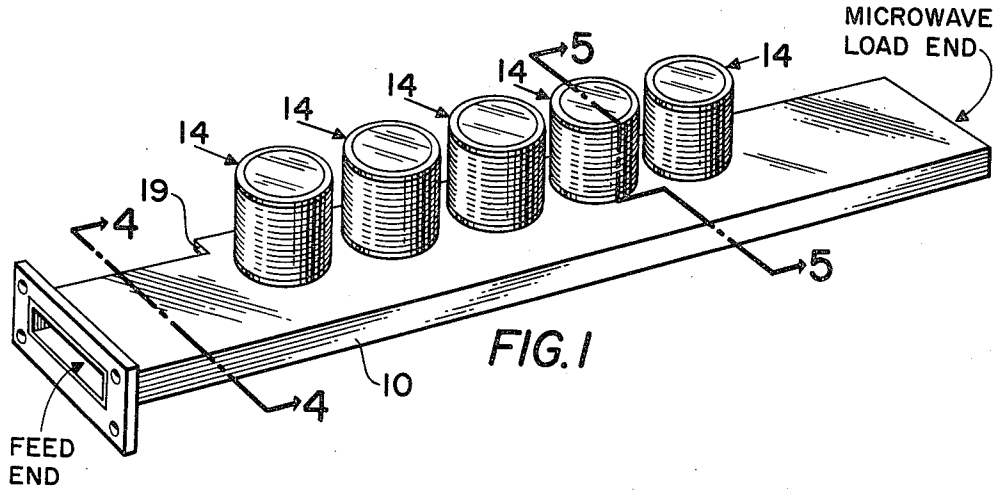


FIG. 1

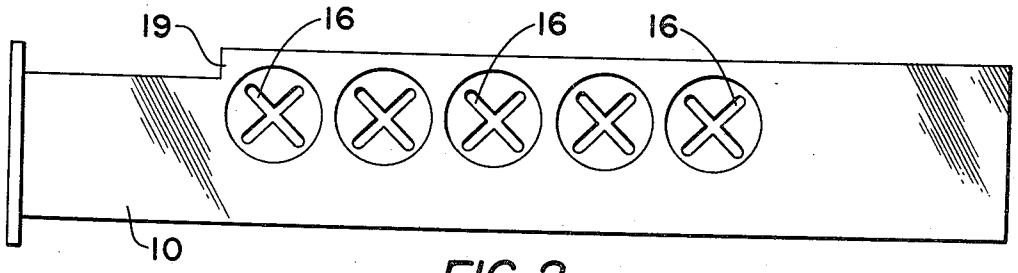


FIG. 2

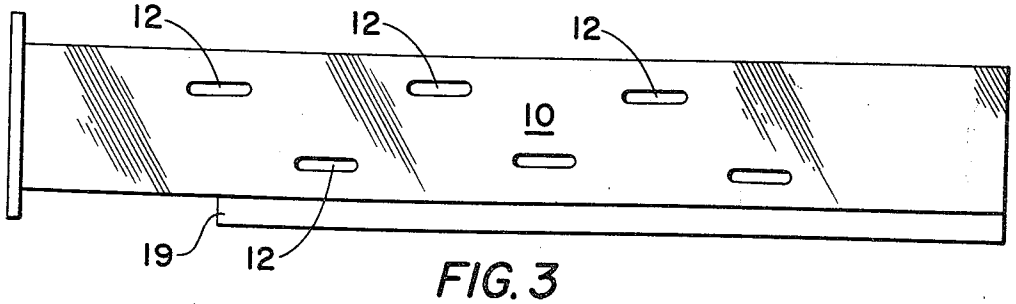


FIG. 3

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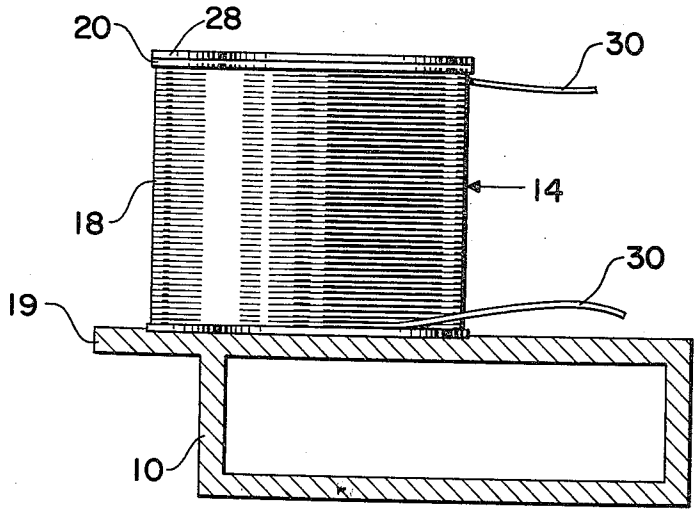


FIG. 4

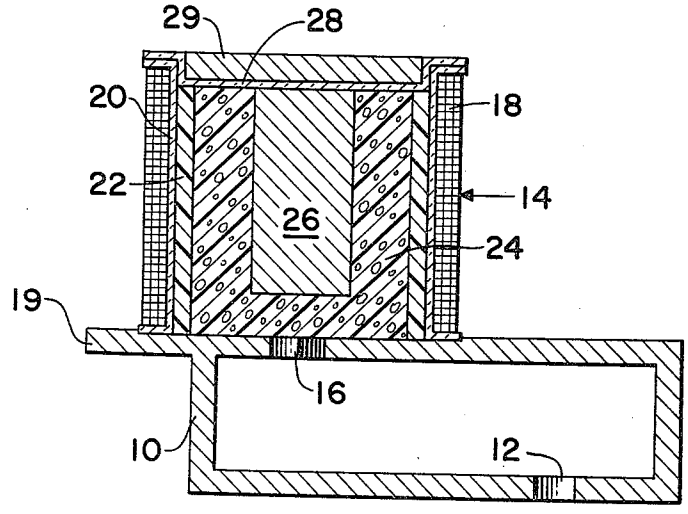


FIG. 5

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FERRITE-LOADED CAVITY BEAM-SHIFTING ANTENNA

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2 Claims. (Cl. 343—768)
(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention herein described may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

The present invention is related to beam-shifting antennas and more particularly to a simple lightweight and extremely compact multi-slot waveguide antenna.

Heretofore, beam shifting was produced by mechanical systems, or by a system of manifolding to distribute microwave energy to individual waveguide elements, where each element contained a phase shifter followed by a radiator. In the manifolded system beam shifting is accomplished by applying electric currents to the phase shifters. However, the mechanical method of beam shifting is slow and readily subject to wear and malfunction. Also, the manifolded method of beam shifting requires a considerable amount of space to accomplish power distribution and each consecutive phase shifter must shift a greater amount to maintain proper beam proportion since phase shift is not accumulative or reciprocal.

The present invention overcomes the above mentioned disadvantages of previous beam shifting systems by using ferrite-loaded solenoid-wound cylindrical cavities coupled with a slot array waveguide. The use of ferrite-loaded phase shift cavities induces phase shift into a waveguide containing a slot array and causes the beam lean angle to change; the phase shift is varied by changing the electromagnetic current in the solenoid coil around the cavity, thus changing the permeability of the ferrite in the cavity, thereby producing phase shift by Faraday rotation of the high frequency energy as it travels into thru and back out of the cavity. In the present invention the phase shift is accumulative.

It is an object of the invention, therefore, to provide a novel multi-slot beam shifting waveguide antenna that is extremely compact, lightweight and simple in construction.

It is also an object of the invention to provide a multi-slot waveguide antenna in which the beam may be electronically shifted at a very high rate without changing the frequency of the transmitter.

It is another object of the invention to provide a new beam shifting antenna having solenoid phase shifting elements.

It is a further object of the invention to provide beam shifting in a multi-slot waveguide antenna by applying current to solenoids coupled therewith.

Other objects and many of the attendant advantages of this invention will become readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIGURE 1 is a perspective view of a preferred embodiment of the invention;

FIGURE 2 is a planar view of the top side of the waveguide of FIGURE 1, with the solenoids removed, showing the coupling slots;

FIGURE 3 is a planar view of the bottom side of the waveguide of FIGURE 1 showing an example of a slot array therein;

FIGURE 4 is a cross-sectional view of the waveguide antenna taken along line 4—4 of FIGURE 1;

FIGURE 5 is a cross-sectional view of the waveguide antenna taken along line 5—5 of FIGURE 1.

Referring now to the drawings, like numerals refer to like parts in each of the figures of drawing.

A basically conventional waveguide section **10**, as shown in FIGURE 1, having a conventional slot array consisting of a plurality of radiating slots **12** on the under side thereof, as shown in FIGURE 3, is provided with a plurality of small cylindrical cavities **14** attached to the upper side thereof. The cylindrical cavities **14** are each located electrically between radiating slots **12**, along the longitudinal axis of the waveguide, and physically on the opposite side of the waveguide from the array of slots. Each cylindrical cavity is coupled to the waveguide **10** by a pair of crossed slots **16**, shown in FIGURE 2, and has a solenoid winding **18** surrounding its cylindrical surface. Flange **19** extends along one edge of the waveguide for partially supporting cavities **14**.

Cylindrical cavities **14** are ferriate loaded and may be constructed, as shown in FIGURE 5, from a cylinder **20**, of brass for example, having a circumferential flange at opposite ends thereof holding solenoid winding **18** in place. A polystyrene sleeve **22** fits within cylinder **20** and about the cylindrical sides of a poly foam support cup **24** which holds a small ferrite core **26**. A cavity cap **28**, of brass or the like, having a low frequency ferrite disc **29** recessed therein completely encloses the top of each cylindrical cavity **14**. Lead wires **30** are used for feeding current to the solenoids. Ferrite disc **29** has for its purpose to enhance the D.C. magnetic field or the static magnetic field of the solenoid **18**. Cylindrical cavities **14** are located more nearly along one side of the waveguide **10**, as can best be seen from cross-sectional views of FIGURES 4 and 5.

As microwaves travel along waveguide **10** they will enter each cavity **14** through a coupling cross slot **16**, pass up through the ferrite core **26**, be reflected by cavity cap **28** back through ferrite core **26**, and couple back to the waveguide by means of coupling slot **16** to proceed to the next cavity. Application of electric current to the solenoids **18** will alter the electrical length of the cavities **14** and thus alter the electrical spacing between antenna slots **12**; this will produce beam shift. In other words the ferrite loaded cavities **14** inject phase delay into the waveguide between the slots **12** of the slot array by effectively changing the electrical spacing between the slots through the application of current to the solenoids wound about the cavities. The amount of phase delay can be varied by varying the amount of current applied to the solenoids **18**. The size and shape of the ferrite core can also be varied to produce the results desired.

Extreme compactness of the antenna of the present invention can be achieved because the basic dimensions of a slot array require little alteration. The cavities **14** are, in effect, in series, producing a desired accumulated phase shift along the waveguide. Only a small amount of phase shift from each cavity is needed to produce a large amount of beam shifting in the array. Using the present system for phase shifting permits the beam of an antenna to sweep electronically and easily even at very high rates.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A beam shifting antenna comprising a section of waveguide having a plurality of radiating slots in one side thereof, a plurality of coupling slots in the side of said waveguide opposite said radiating slots and positioned electrically between said radiating slots along a length of said waveguide, a plurality of ferrite loaded

cavities mounted on said section of waveguide and coupled thereto by means of said coupling slots, each of said ferrite loaded cavities consisting of a metal cylinder having a foam-plastic cup-shaped support therein supporting a ferrite core, a solenoid winding about each of said ferrite loaded cavities, said solenoid wound cavities being operable to vary the electrical spacing between said radiating slots by applying varying amounts of current to said solenoid winding whereby the application of electrical current to the solenoid windings alters the electrical length of the cavities and thus alters the electrical spacing between antenna slots to produce beam shift, and wherein a small amount of phase shift from each cavity produces a large amount of beam shifting in the antenna.

2. A beam shifting antenna comprising a section of waveguide having a plurality of radiating slots in one side thereof, a plurality of coupling slots in the side of said waveguide opposite said radiating slots and positioned electrically between said radiating slots along a length of said waveguide, a plurality of ferrite loaded cavities mounted on said section of waveguide and coupled thereto by means of said coupling slots, each of said ferrite loaded cavities consisting of a metal cylinder having a foam-plastic cup-shaped support therein supporting a ferrite core and having a metal cap enclosing the end of each said cylinder at the open end of said plastic cup, said metal cap containing a disc of ferrite for enhancing the magnetic field of the solenoid, a solenoid winding about each of said ferrite loaded cavities, said solenoid wound cavities being operable to vary the electrical spacing between said radiating slots by applying varying amounts of current to said solenoid winding whereby the application of electrical current to the solenoid windings alters the electrical length of the cavities and thus alters the electrical spacing between antenna slots to produce beam shift, and wherein a small amount of phase shift from each cavity produces a large amount of beam shifting in the antenna.

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