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C. J. MILLER

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Fig. 1.

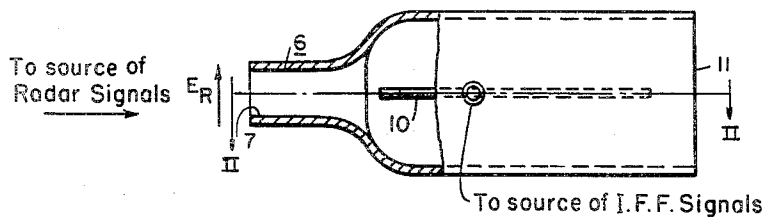


Fig. 2.

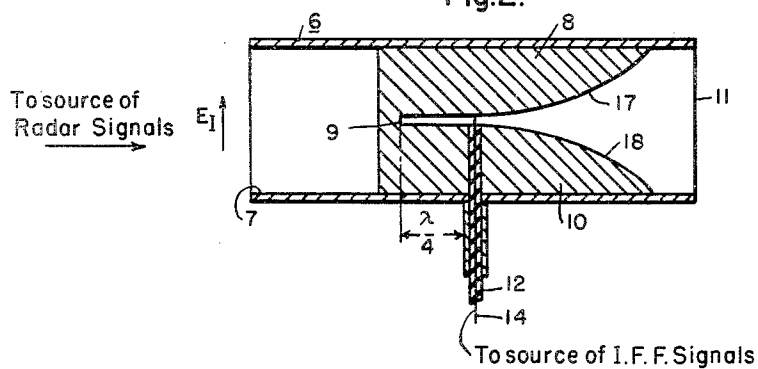


Fig. 3.

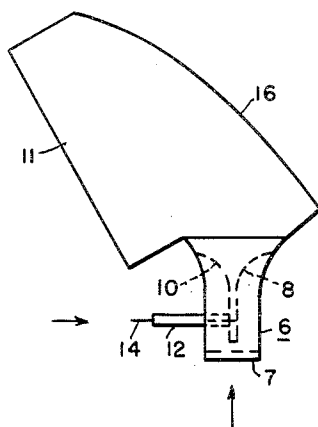
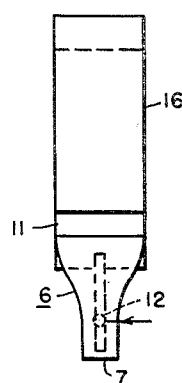


Fig. 4.



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7 Claims. (Cl. 250—33.69)

1 My invention relates to apparatus for trans-
mission of electromagnetic radiations, and more
particularly to apparatus for injecting signals of
one frequency into a radar antenna feed horn
which is designed primarily to transmit signals 5
of another frequency.

In the following description of my invention,
the term "waveguide" is used to refer to a hollow
conductor for electromagnetic oscillations. The
terms "horizontal polarization" and "vertical 10
polarization" are used to refer to the direction
in which the electric vector of the oscillations
extends.

In many types of radar apparatus it is de-
sirable that another frequency for identification 15
purposes, such as used for identifying friend or
foe, referred to hereinafter as an I. F. F. signal
or frequency, be emitted in the same direction
and at substantially the same time as the radar
signal. It is also desirable that the radiation 20
pattern of the I. F. F. signal be substantially the
same as that of the radar antenna. To accom-
plish this purpose, radar sets have been built
wherein an I. F. F. antenna is provided which is
pointed in the same direction as the radar an- 25
tenna utilizing vertical polarization, whereas the
radar set employs horizontal polarization. De-
vices have been utilized wherein a separate an-
tenna for the I. F. F. signals is mounted on the
same pedestal as the radar antenna so that I. F. F. 30
antenna and the radar antenna always point in
the same direction. However, where the radar
and I. F. F. frequencies are not far apart, the
same reflector may be used for both the radar
signal and the I. F. F. signal, provided a suitable 35
means of feeding the reflector with both signals at
the same time is available.

It is, accordingly, an object of my invention
to provide apparatus for feeding a radar antenna
reflector with both a radar signal and an I. F. F. 40
signal simultaneously while preventing the two
signals from interfering with each other.

It is another object of my invention to provide
appartus for supplying two frequencies to a
waveguide in such a manner that the oscillations 45
of one frequency are polarized at right angles to
the oscillations of the other frequency.

It is another object of my invention to provide
apparatus for supplying oscillations to a wave-
guide in such a manner that the polarization 50
of the oscillations so supplied may be controlled.

It is still another object of my invention to
provide apparatus for supplying oscillations of
two different frequencies to a waveguide in such
a manner that substantially no energy from 55

2 either one of the sets of oscillations travels to-
ward the source of the other set of oscillations,
and each set of oscillations flows through the
waveguide polarized at right angles to the other.

Still another object of my invention is to pro-
vide improved apparatus of the type disclosed
herein.

In accordance with my invention, I provide a
radar feed horn comprising a waveguide the
height of which is of such a dimension that it
will support the radar frequencies which it is
desired to employ, and the width of which is
sufficiently large to support the identification fre-
quency which it is desired to employ. Fastened
inside of the waveguide are provided two fins
or taper sections made of thin pieces of electri-
cally conducting material. These two fins are
oppositely disposed and lie in a plane which is
parallel to the sides of the waveguide and is
located approximately halfway between the sides
of the waveguide. These fins extend into the
waveguide to such a depth that they make an
electrical contact with each other over one part
of their length in the vicinity of the center of 25
the waveguide. From the place where the two
fins are in contact with each other, they are of
such configuration that the distance between
them becomes greater as one moves along the
waveguide in the direction of propagation, until
the distance between them equals the thickness
of the waveguide, i. e., until they taper to zero
width. In the preferred embodiment of my in-
vention the edges of these fins extending into
the waveguide form substantially a logarithmic
curve.

Extending through the wall of the waveguide is
a coaxial cable having its outer conductor at-
tached to one of the fins and its inner conductor
attached to the other of the fins, the connec-
tion between the coaxial cable and the fins being
in the region between the place where the two
fins are in contact with each other and the place
where the fins taper to zero width.

The radar signal travelling down the waveguide
is polarized at right angles to the plane of the
two fins. Therefore, the electric field of the radar
signal is perpendicular to the plane of the fins and
therefore the fins present an equi-potential sur-
face and have substantially no effect on the radar
signal.

On the other hand, the identification signal
which is supplied to the waveguide through the
coaxial cable finds itself presented with substan-
tially a ridged waveguide, wherein the two fins act
as ridges. A ridged waveguide is a conductor of

electromagnetic oscillations which is well known in the art. The ridged waveguide as commonly employed in the art is a hollow conductor having extending thereinto a re-entrant portion which extends along the conductor in the direction of propagation of energy in that conductor. Such a conductor offers substantially less impedance to the flow of energy therein than does a standard waveguide of the same external dimensions. Thus, the impedance to the I. F. F. signal is quite low. The I. F. F. signal is, therefore, caused to be polarized at right angles to the radar signal, i. e., the electric vector of the I. F. F. signal is parallel to the plane of the fins.

In the preferred embodiment of my invention the edges of the fins are formed in a logarithmic curve, so that the characteristic impedance varies in a smooth, logarithmic taper from the impedance of the guide at one end to the impedance of the coaxial line feeding the I. F. F. signal into the system at the other end. The point where the fins are connected together is preferably $\frac{1}{4}$ wave length distant, of the identification signals, back of the point where the coaxial cable is connected to the two fins. By making this distance $\frac{1}{4}$ wave length, a high impedance path is provided between the source of radar signals and the entrance to the I. F. F. coaxial cable. Thus, the identification signals emitted from the coaxial cable are discouraged from traveling back toward the source of radar signals.

The novel features which I consider characteristic of my invention are set forth with more particularity in the appended claims. The invention, however, with respect to both the organization and the operation thereof, together with other objects and advantages may be best understood from the following description of specific embodiments when read in connection with the accompanying drawing, in which:

Fig. 1 is a plan view of apparatus embodying my invention;

Fig. 2 is a cross-sectional view of the apparatus shown in Fig. 1, taken along the line II—II of Fig. 1;

Fig. 3 is an elevational view of apparatus embodying my invention wherein the waveguide is caused to flare outward at the mouth and a parabolic reflecting surface is provided for reflecting the oscillations toward the main reflector, and

Fig. 4 is a plan view of the apparatus shown in Fig. 3.

Referring now to the drawing, a waveguide 6 is provided which is designed to be supplied at one end 7 with radar signals of the desired frequency which are horizontally polarized. By "horizontally polarized" I mean the electric vector extends in the horizontal direction. The waveguide 6 is so constructed that over one part of its length, its horizontal dimension is that which is customarily employed in the art for a waveguide designed to conduct oscillations of the frequency of the aforementioned radar signals with their electric vector extending in the horizontal direction. However, over part of its length the waveguide is constructed so as to be substantially wider than such waveguides would normally be, while being of the same vertical dimension as the vertical dimension of the smaller part of the waveguide. It is the section of waveguide which is substantially wider than normal in which we are primarily interested, in the discussion which follows. The vertical dimension of the waveguide 6 is such that when the radar oscillations, which it is desired to employ, are caused to pass down

the waveguide 6 while being horizontally polarized, the dimensions of the waveguide 6 are not below the cut-off dimensions for the frequency of the radar oscillations. Since the radar waves are horizontally polarized, these waves are not greatly affected by a widening of the waveguide 6. The waveguide 6 at its widest portion is of such dimensions that it is not below the cut-off dimensions for the identification signal which it is desired to employ in the waveguide 6, which signal is vertically polarized.

Inserted in the wider portion of the waveguide 6 is a pair of oppositely disposed fins or taper sections 8 and 10 made of thin pieces of electrically conducting material. These fins 8 and 10 are so constructed that they touch each other at their end 9, closest the source of the radar signals, and that the distance between them increases, as one moves along the waveguide 6 toward the end 11, until the distance between the fins 8 and 10 becomes equal to the vertical dimension of the waveguide 6. In the preferred embodiment of my invention, the fins 8 and 10 lie in a plane parallel to the sides of the waveguide 6 and substantially equi-distant from the sides of the waveguide 6. The edges 17, 18 of the fins 8 and 10 which extend into the waveguide 6, in tapering from the end 9 where they touch each other toward the opposite end of the waveguide 6 form substantially a logarithmic curve in the preferred embodiment of my invention.

Extending through a wall of the waveguide 6 is a coaxial cable comprising an outer conductor 12 and an inner conductor 14. The outer conductor 12 is connected to the fin 10 and the inner conductor is connected to the fin 8. These connections between the coaxial cable and the fins 8 and 10 are preferably $\frac{1}{4}$ wave length distant from the point 9 where the two fins 8 and 10 are in contact with each other. The aforementioned $\frac{1}{4}$ wave length refers to the wave length of the identification (I. F. F.) signal, which it is desired to employ, as measured in the waveguide 6.

The radar oscillations passing down the waveguide 6 are horizontally polarized, that is, the electric field of the radar oscillations extends in a horizontal direction. The critical dimension for cut-off of the radar signals is therefore the vertical dimension of the waveguide 6. The fins 8 and 10 lie in a plane substantially at right angles to the electric field of the radar oscillations. Since the fins 8 and 10 are at right angles to the radar oscillations, they present substantially an equi-potential surface to the radar oscillations, and therefore if they are sufficiently thin compared to the width of the waveguide 6, they have very little effect on the radar oscillations.

The identification signals are caused to enter the waveguide through the coaxial cable provided by conductors 12 and 14. The identification signals are thus presented with a waveguide having, extending thereinto, a pair of conductors which are the fins 8 and 10, the conductors extending into the waveguide in a direction parallel to the electric field vector of the identification signal oscillations. Therefore, the fins 8 and 10 form, in connection with the rest of the waveguide 6, substantially a ridged waveguide which has a comparatively low impedance to the identification oscillations if these oscillations are vertically polarized. The identification signals are therefore encouraged by the fins 8 and 10 to oscillate in such a manner that their electric fields extend in a vertical direction. Thus, the

identification signals are caused to be vertically polarized. Since the connections between the coaxial cable provided by conductors 12 and 14 and the fins 8 and 10 are $\frac{1}{4}$ wave length from the point 9 where the two fins 8 and 10 are connected together, the connection between the two fins 8 and 10 presents a high impedance to the identification signals attempting to travel toward the source of the radar signals. The identification signals are therefore discouraged from traveling toward the source of radar signals, and substantially all of the energy of the identification signal oscillations is propagated along the waveguide in the direction in which the radar signals are being propagated.

Since the edges 17, 18 of the fins 8 and 10 are cut in such a manner that a smooth logarithmic taper, indicated by the reference character 17 and 18, is provided along the length of the fins from the impedance of the coaxial line at one end to the impedance of the waveguide at the other end, there are therefore substantially no reflections directed toward the source of radar oscillations or toward the source of identification oscillations.

By making the fins 8 and 10 sufficiently long, it is possible to provide apparatus wherein a very wide band of frequencies can be accommodated with very little mismatch.

In the embodiment shown in Figs. 3 and 4, the waveguide 6 is caused to flare outward in the vertical direction as one approaches the output opening. Connected to the end of the waveguide is a small parabolic reflector 16 for reflecting the oscillations emitted by the waveguide toward a main antenna reflector (not shown). In this embodiment it is assumed that an elliptical reflector (not shown) is to be energized, in which case the small parabolic reflector 16 at the mouth of the waveguide 6 is chosen to be of such dimensions as to properly feed the elliptical reflector.

I have described herein an embodiment of my invention wherein the central idea of my invention is employed in apparatus for feeding identifying (I. F. F.) signals into a radar system, however, it will be obvious to one skilled in the art that there are other applications for such an arrangement.

Although I have shown and described specific embodiments of my invention, I am aware that other modifications thereof are possible. My invention, therefore, is not to be restricted except insofar as is necessitated by the prior art and the spirit of the invention.

I claim as my invention:

1. A feed horn comprising a waveguide having substantially a rectangular cross-section, and having a top, a bottom and two sides, a pair of oppositely disposed fins inside said waveguide, said fins having one edge of one in contact with the top of said waveguide and one edge of the other in contact with the bottom of said waveguide and having the edge opposite said one edge of each extending into said waveguide so as to form substantially a logarithmic curve, said fins being separated from the sides of said guide at the ends of said fins, said fins being in direct electrical contact with each other at one end, a high frequency conductor extending through a wall of said waveguide into the region between said fins for supplying oscillations to said waveguide, connections for applying additional oscillations polarized normal to the plane of said fins connected to said waveguide beyond the ends of

said fins which are in electrical contact with each other.

2. A device for feeding a plurality of different frequencies to a common load comprising: a four sided waveguide, a pair of oppositely disposed fins inside said waveguide, said fins being connected together at one end thereof and having a generally logarithmic shape along the remainder of their length, a coaxial cable for supplying oscillations of a first predetermined frequency connected to the fins one-quarter wave length of said oscillations distant from the place where said fins are connected together, and connections for supplying oscillations of a second predetermined frequency to said waveguide at a point beyond where said fins are connected together.

3. A device for feeding a plurality of different frequencies to a common load comprising: a waveguide, a pair of oppositely disposed fins outside said waveguide, said fins being fastened to the top and bottom of said waveguide, respectively, and extending parallel to the direction of propagation of oscillations in said guide, said fins extending into said waveguide a variable distance over their length and at one point along their length the inner extremity of each touches the other, connections at a point distant from said fins for supplying high frequency power to said waveguide polarized at right angles to the plane of said fins, and a coaxial cable connected to said fins for supplying electrical energy to the region therebetween polarized parallel to the plane of said fins.

4. An antenna feed horn comprising a waveguide having at least one wall and substantially a rectangular cross-section, a pair of oppositely disposed fins inside said waveguide, each of said fins being made of conductive material and having one edge in contact with said waveguide and having another edge extending into said waveguide such that the latter edge is in the form of substantially a logarithmic curve, said fins lying substantially in a common plane and being in direct electrical contact with each other at respectively one end of each of said fins, supply means connected to said waveguide for supplying a polarized first signal of a first frequency to said waveguide, a coaxial cable member having a center conductor and an outer conductor connected to said waveguide for supplying a polarized second signal of a second frequency to the waveguide, with the polarization of said first signal being substantially perpendicular relative to the polarization of said second signal, and with the polarization of the second signal being substantially parallel relative to said plane, said cable member extending through the wall of said waveguide and into the region between said fins, with the center conductor of said cable member being connected to one of said fins and the outer conductor of said cable member being connected to the other of said fins.

5. An antenna feed horn comprising a hollow conductor having at least a wall, a pair of oppositely disposed fins of electrically conducting material located inside said conductor, a supply connection for supplying a polarized first signal of a first frequency connected to said conductor, coupling apparatus connected to said conductor and extending through said wall into the region between said fins for supplying a polarized second signal of a second frequency to said conductor, with the polarization of the first signal being substantially perpendicular relative to the polarization of the second signal, said fins lying in a

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common plane substantially parallel relative to the polarization of said second signal, with said fins touching each other over part of their length and being separated from each other over the remainder of their length.

6. In antenna apparatus, the combination of a hollow rectangular conductor having at least one side, a pair of oppositely disposed fins of conducting material positioned inside said conductor, supply means connected to said conductor for supplying a polarized first signal of a first frequency to said conductor, a coaxial cable member connected to said conductor for supplying a polarized second signal of a second frequency to said conductor, with the polarization of the first signal being substantially perpendicular to the polarization of the second signal, said fins lying in a common plane which is substantially perpendicular to said side, with each of said fins having one edge in contact with said conductor and being in direct electrical contact with each other at respectively one end of each of said fins.

7. In an antenna feed horn apparatus, the combination of a conductor having two side walls, a top wall and a bottom wall, a first and a second piece of conducting material positioned inside said conductor, with each of said pieces of conducting material extending in a direction substantially parallel to the direction of propagation of energy in said conductor, said first

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piece of conducting material having an edge adjacent to said top and lying in a plane substantially perpendicular to said top, said second piece of conducting material having an edge adjacent to said bottom and lying substantially in said plane, a supply connection connected to said conductor for supplying a polarized first signal of a first frequency to said conductor, coupling apparatus connected to said conductor and extending through one of said walls into the region between said pieces of conducting material for supplying a polarized second signal of a second frequency to said conductor, with the polarization of said first signal being substantially perpendicular to the polarization of said second signal, and with the polarization of said second signal being substantially parallel to said plane.

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