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ANTI-PULLING DUPLEXER

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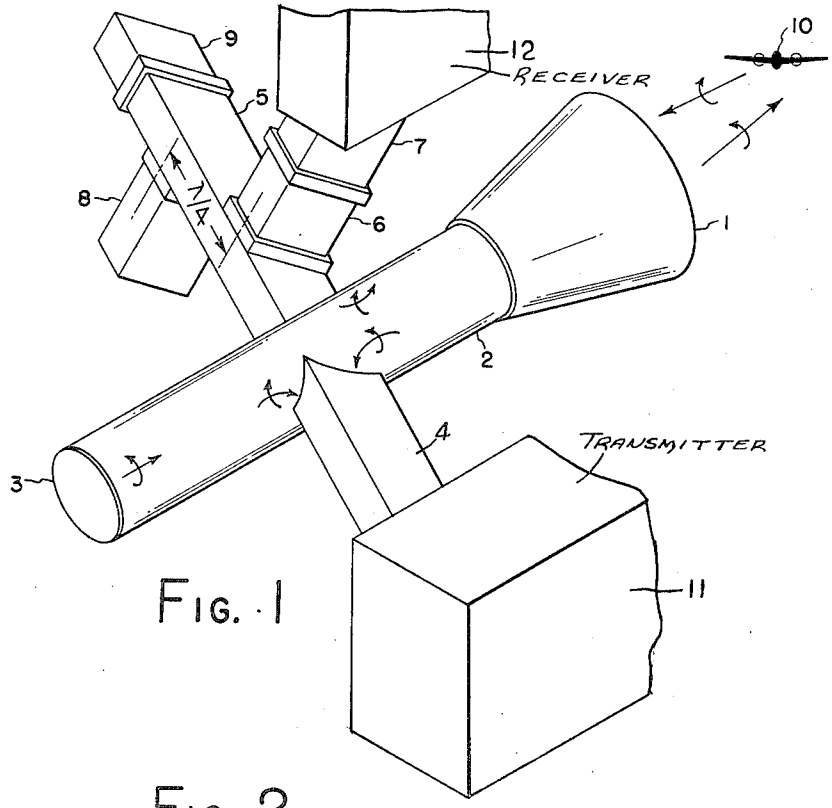


FIG. 1

FIG. 2

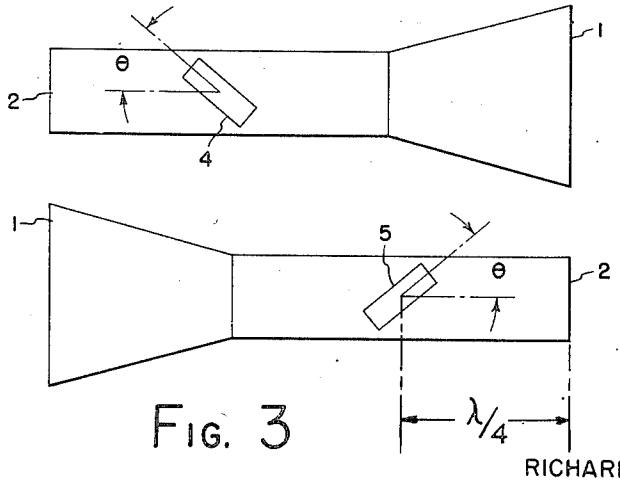


FIG. 3

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ANTI-PULLING DUPLEXER

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4 Claims. (Cl. 250—13)

This invention relates to apparatus for conducting microwave energy from a transmitter to an antenna and for conducting energy intercepted by said antenna to a receiver. It relates particularly to means for preventing frequency changes in the transmitter output due to changes in the loading impedance offered by the antenna.

In radar equipment employing pulsed microwave energy it is conventional practice to employ a common antenna system for the radiation of energy and the interception of energy reflected from a target. The energy is conducted to and from the antenna system over a common waveguide transmission line.

In order to be able to utilize a single antenna system for both transmission and reception, it is necessary to prevent any appreciable portion of the transmitted pulse energy from being applied to the receiver by the common transmission line, since this would damage the crystal detector normally employed. Since the received reflected energy is highly attenuated it is also necessary to prevent any loss of signal through dissipation in the transmitter.

In order to perform these functions, impedance switching arrangements, such as the classical TR–ATR devices, are incorporated into the transmission line. While such devices are operable to a degree, they are unable to prevent some application of spikes of high-level energy to the receiver and the loss of a certain portion of the received signal in the transmitter.

There is also another difficulty encountered in systems in which the reflector of the antenna system is mechanically scanned, thus continuously changing the physical relationship between the antenna horn and the reflector. This changing physical relationship causes a continuous change of the impedance presented by the antenna to the transmitter and results in corresponding changes in the frequency of the magnetron output. This renders more difficult the problem of AFC in the receiver since the local oscillator frequency must change to follow changes in transmitter frequency.

Among the objects of the invention are the following:

To provide a duplexing system which is substantially lossless;

To substantially eliminate pulling of the frequency of the transmitter of a radar system due to varying reflection from a scanning antenna;

To greatly reduce TR leakage in a duplexing system without the necessity of employing matched switching elements; and

To provide a duplexing system in which the application of energy directly from the transmitter to the receiver is substantially completely eliminated.

The above and other objects and advantages of the invention are realized by an arrangement in which the antenna is fed by a circular waveguide and the transmitter and receiver are connected to the circular waveguide by two collinear rectangular waveguides, the axes of all the waveguides intersecting. The two rectangular waveguides have a common plane of symmetry normal to their lines

of electrical intensity and this plane makes an angle with the axis of the circular waveguide such that energy fed into the circular waveguide from the transmitter excites a circularly polarized wave therein in the TE_{11} mode. The end of the circular waveguide opposite the antenna is terminated in a short circuiting plate. The receiver arm has a branch feeding the receiver through a conventional TR tube and the arm continuing past this branch is provided with an ATR tube and terminates in a dummy load.

In the drawing:

Fig. 1 is a view in perspective of a duplexing signal transmission system embodying the invention; and

Figs. 2 and 3 are side views of the circular waveguide and horn of Fig. 1, Fig. 2 being a view looking from the right and Fig. 3 looking from the left, of the arrangement as shown in Fig. 1.

Referring now more particularly to the drawing, there is shown in Fig. 1 a duplexing signal transmission system comprising a radiating horn 1 connected at its base to a circular waveguide 2. The opposite end of this waveguide is terminated in a short-circuiting plate 3.

A rectangular waveguide 4 joins the circular waveguide at an intermediate point thereof and a second rectangular waveguide 5 joins the circular waveguide on the opposite side. The free end of the waveguide 4 connects to a transmitter 11 of microwave energy. The distance from the junction of waveguide 4 to the shorting plate 3 is effectively an integral number of quarter wavelengths. The determination of the actual distance must allow for the effect of the junction.

The waveguides 4 and 5 are collinear and their axis intersects the axis of waveguide 2. They have a common plane of symmetry normal to their lines of electric intensity. This plane makes an angle θ with the axis of waveguide 2 such that excitation of the waveguide 4 in the TE_{01} mode will produce in the circular waveguide 2 a transmitted wave of circularly polarized form in the TE_{11} mode. The wave will proceed in both directions along the waveguide 2. The portion moving toward the antenna will be right-handedly polarized, while that moving in the opposite direction will be left-handedly polarized. The determination of the value of the angle θ can be made in the manner set forth on page 374 of "Microwave Transmission Circuits" by Ragan, which is vol. 9 of the Radiation Laboratory Series, published in 1949 by McGraw-Hill Book Company, Inc., New York city. As stated there the angle may be defined by the formula

$$\theta = \tan^{-1} \frac{2\pi a}{\lambda g}$$

where a is the radius of the waveguide 2 and λg its wavelength.

Connected to the waveguide 5, is a TR box 6. The other end of the TR box 6 has connected to it a branch waveguide 7 leading to the receiver 12.

Connected to the waveguide, and with its center line spaced a quarter wavelength from the center line of the TR box is a conventional ATR box 8. The waveguide 5 continues past the ATR box and terminates in a dummy load 9.

In the operation of the system of Fig. 1 pulses of microwave energy initiated by the transmitter and conveyed down waveguide 4 excite in the waveguide 2 a circularly polarized waveform which travels in both directions from the junction of waveguide 4. The energy travelling toward the antenna 1 is polarized in a right-handed sense, while that travelling toward the shorting plate 3 is polarized in a left-handed sense. The energy reaching the plate 3 is reflected back in a right-handed sense and reenforces the energy initially directed toward the antenna. It will not be admitted into waveguide 4, since this wave-

guide will be excited only by left-handedly polarized energy travelling in this direction.

No energy will couple directly to the waveguide **5** since this arm will accept only waves which are left-handedly polarized travelling from the direction of the antenna. The energy travelling toward the antenna will be radiated as right-handedly polarized energy. Energy reflected back from any mismatch existing at the antenna will not excite the arm **4** since it will be left-handedly polarized and hence will not be accepted by that waveguide. It will be coupled to the arm **5** and will be kept from the receiver branch **7** by the TR box **6**. It will propagate on down the arm **5** until absorbed by the dummy load **9**.

The energy radiated by the antenna **1** will be reflected by targets such as indicated at **10** and the returning wave will be left-handedly polarized. It will, therefore, not be coupled to the arm **4**, but will excite in the arm **5** a wave of the TE_{01} mode which will be applied to the receiver.

Although the antenna shown is of the horn type, this showing is only by way of example as any axially symmetric antenna type which is suitable for the microwave frequencies may be utilized with this system.

What is claimed is:

1. In a duplex signal transmission system including a transmitter and a receiver; an antenna, a circular waveguide feeding said antenna, means short circuiting the end of said circular waveguide remote from said antenna, a pair of branch waveguides of rectangular cross-section joining said circular waveguide on opposite sides thereof, said branch guides having a common axis at the junction, said axis being normal to and intersecting the axis of said circular waveguide at a point which is effectively an integral number of quarter wavelengths of the carrier frequency of said transmitter from said short circuiting means, said branch waveguides having a common plane of symmetry normal to the lines of electric intensity therein, said plane of symmetry making such an angle θ with the axis of said circular waveguide that energy of the TE_{01} mode in one of said branch waveguides will excite in said circular waveguide energy of the TE_{11} mode, said angle θ being defined by the formula

$$\theta=\tan^{-1}\frac{2\pi a}{\lambda g}$$

where a is the radius of said circular waveguide and λg is the wavelength thereof, said transmitter and said receiver each being connected to a respective one of said branch waveguides.

2. In a duplex signal transmission system including a transmitter and a receiver; an antenna, a circular waveguide feeding said antenna, means short circuiting the end of said circular waveguide remote from said antenna, a pair of branch waveguides of rectangular cross-section joining said circular waveguide on opposite sides thereof, said branch guides having a common axis at the junction, said axis being normal to and intersecting the axis of said circular waveguide at a point which is effectively an integral number of quarter wavelengths of the carrier frequency of said transmitter from said short circuiting means, said branch wave guides having a common plane of symmetry normal to the lines of electric intensity therein, said plane of symmetry making such an angle θ with the axis of said circular waveguide that energy of the TE_{01} mode in one of said branch waveguides will excite in said circular waveguide energy of the TE_{11} mode, said angle θ being defined by the formula

$$\theta=\tan^{-1}\frac{2\pi a}{\lambda g}$$

where a is the radius of said circular waveguide and λg is the wavelength thereof, said transmitter being connected to one of said branch waveguides, means connecting said receiver to the remaining branch waveguide, said means including a TR box, a dummy load terminating said remaining branch waveguide, and an ATR box joined to said remaining branch waveguide at a point an integral number of quarter wavelengths from said TR box.

3. In a duplex signal transmission system including a transmitter and a receiver; an antenna, a circular waveguide feeding said antenna, means short circuiting the end of said circular waveguide remote from said antenna, a first branch waveguide of rectangular cross-section joining said circular waveguide with the axes of said waveguides intersecting, said branch waveguide having a plane of symmetry normal to the lines of electric intensity therein, said plane of symmetry making an angle θ with the axis of said circular waveguide such that energy of the TE_{01} mode in said branch waveguide will excite in said circular waveguide energy of the TE_{11} mode which will propagate toward said antenna with circular polarization of one rotative sense, and will propagate toward the said short circuiting means with circular polarization of the opposite rotative sense, said angle θ being defined by the formula

$$\theta=\tan^{-1}\frac{2\pi a}{\lambda g}$$

where a is the radius of said circular waveguide and λg is the wavelength thereof, the distance of said branch waveguide from said short circuiting means being such that energy reflected therefrom will reenforce the said energy being propagated toward said antenna, said transmitter being connected to said first branch waveguide, a second branch waveguide joining said circular waveguide at a point opposite the junction of said first branch waveguide therewith, said branch waveguides being of the same cross-sectional dimensions and configuration and having at their junctions with said circular waveguide a common axis and plane of symmetry, said receiver being connected to said second branch waveguide.

4. The combination of claim 3, comprising means including a TR box connecting said receiver to said second branch waveguide, an ATR box connected to said second branch waveguide at a point an integral number of quarter wavelengths of the carrier frequency of said transmitter from said TR box and a dummy load terminating said second branch waveguide.

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