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ADJUSTABLE POLARIZATION WAVEGUIDE FOR RADAR

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Fig.1.

Fig.2.

Fig.3.

Fig.4.

Fig.5.

Fig.6.

Fig.7.

Fig.8.

Fig.9.

Fig.10.

Fig.11.

Fig.12.

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ADJUSTABLE POLARIZATION WAVEGUIDE FOR RADAR

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This invention relates to radar apparatus of the kind in which the polarization of the radiated signals may be adjusted.

According to this invention radar apparatus wherein a transmitter is connected to a radiator by a waveguide system including a length of square waveguide containing a vane parallel to one of the sides of the guide and movable transversely thereto so as to form a phase shifter for varying the phase of a signal component in said square waveguide polarized parallel to one side of the guide with respect to the phase of a signal component polarized transversely thereto, is characterised in that the transmitter is coupled to said length of square waveguide by a feed system including first and second rotatable couplers with a length of waveguide between the couplers whereby said length of waveguide is rotatable with respect to the square waveguide, the first rotatable coupler being arranged so that plane polarized signals are fed into the rotatable waveguide with a plane of polarization which is rotatable with that guide and said second rotatable coupler being arranged so that signals are fed out of the rotatable waveguide through the second coupler without change of polarization.

With the apparatus described above, if the signals are fed into the phase shifter with the plane of polarization at an angle to the walls of the guide, the polarization of the radiated signals may be varied through any ellipticity between linear and circular polarization by adjusting the phase shifter (assuming that this phase shifter has sufficient range of adjustment which may readily be obtained by making the vane of sufficient length). Both right handed and left handed circular polarization may be obtained if the vane is adjustable to produce phase shifts of plus or minus 90 electrical degrees and by rotating the rotatable waveguide. If the phase shifter is adjusted to give a linearly polarized radiated signal, the plane of polarization may be rotated by rotating the rotatable waveguide. By arranging that the rotatable waveguide can rotate through plus and minus 90°, linearly polarized signals with any plane of polarization required may be radiated. It will be particularly noted that with this arrangement the variable phase shifter is in a fixed guide. There is thus no need to transmit variably polarized signals through any rotatable coupler and remote control of the phase shifter is facilitated. Such remote control may be effected conveniently by spring-loading the vane so that it is biased to lie against one wall of the waveguide and providing a power-driven cam or the like for moving the vane in the other direction against the spring pressure.

Most conveniently a single antenna system is used for both transmitting and receiving, the transmitter and the receiver being connected through a duplexer to the first coupler. If the transmitted radar signals are reflected back with their polarization unchanged, the movable vane will convert the received signals into linearly polarized signals polarized in the same plane as the transmitted signals fed into the circular polarizer and hence the receiver would detect these signals. As is well known, however, a flat plate or drops of rain will return circular or elliptically polarized signals with the polarization reversed in sense, i.e. right handed elliptically polarized signals will be returned with a left handed sense of rotation and hence would not be fed to the receiver.

Most transmissions on microwave frequencies are linearly polarized and by using the arrangement of the present invention any interference to a radar set from such a transmission can be considerably reduced or possibly eliminated by adjusting the radar apparatus to operate with a polarization at right angles to that of the interfering station. Furthermore with the apparatus of the present invention it is possible to transmit and receive signals with circular or elliptical polarization and by adjusting the ellipticity, it is possible to reduce or eliminate reflections from rain signals whilst still receiving signals from radar targets having more complex reflecting surfaces such as aircraft or ships.

The first rotatable coupler might be a length of flexible waveguide permitting rotation of the rotatable waveguide through plus or minus 90°. Preferably, however, it is a rotatable joint in a coaxial line. In one form of construction the signals from the transmitter are fed into a rectangular waveguide as linearly polarized TE_{01} waves. Extending into this rectangular waveguide through an aperture in a broad face thereof is a probe forming the inner conductor of a coaxial line, the outer conductor of which is a circular tube connected coaxially to another rectangular waveguide. The aforementioned first rotatable coupler is constituted by a rotating joint in this coaxial line which couples the fixed part of the line to a similar line in which the waves are launched as TE_{01} waves having their plane of polarization at right angles to the broad face of the rectangular waveguide in the rotatable portion of the assembly.

The second coupler is most conveniently formed by a rotatable joint in a circular waveguide through which the signals are transmitted as TE_{11} waves.

If the first rotatable coupler comprises a coaxial line coupler feeding into a rectangular waveguide as described above and the second comprises a rotatable joint in a circular waveguide, the rotatable portion of the waveguide conveniently includes a rectangular waveguide with a transition section leading to a square waveguide with its walls parallel to the walls of the rectangular guide and a further transition section leading to the circular waveguide. The square waveguide in the rotatable portion may include a trap for unwanted signals.

With the construction described above, the phase shifter in the square section waveguide does not have to rotate. This portion of square waveguide may be coupled directly to a radiating horn, conveniently by means of a length of square waveguide. If the phase shifter is set to give circular polarization the signals through this feed to the horn would comprise TE_{01} and TE_{10} components. The horn may in the known manner be associated with a reflector to give a narrow directional beam.

The following is a description of one embodiment of the invention, reference being made to the accompanying drawings in which:

FIGURE 1 is a diagrammatic representation of an antenna feed system for a pulse radar apparatus; and

FIGURES 2 to 12 are sections through the feed system along the lines 2—2 to 12—12 respectively to show the form of waveguide employed.

Referring to the drawings there is shown diagrammatically a pulse transmitter 20 arranged to produce short duration pulses of microwave energy which are fed through a duplexer 21 to a rectangular waveguide 22 and thence through the feed system to be described in further detail later to a horn 23 having a rectangular aperture, which horn feeds the transmitted energy onto a suitably shaped reflector to product a narrow directional beam, part 24 of which reflector is illustrated diagrammatically. Reflected signals from distant targets reach-

ing the reflector are reflected into the mouth of the horn 23 and thence through the feed system to the rectangular waveguide 22 and the duplexer 21 to a receiver 25.

The signals fed into the rectangular waveguide 22 from the transmitter 20 are plane polarized with their electric vector in the direction parallel to the shorter side of the waveguide so that they are transmitted through this waveguide as linearly polarized TE_{01} waves. Extending into this rectangular waveguide through an aperture in the broad face thereof is a probe 26 forming the inner conductor of a coaxial line 27 the outer conductor of which is a circular tube as shown in FIGURE 3. This coaxial line 27 leads to a rotatable joint 28 which couples the fixed part of the line 27 to a similar circular section coaxial line 29 leading into a rectangular tube 30. The inner conductor of the line 29 is terminated in a manner to launch the waves as TE_{01} waves having their plane of polarization at right angles to the broad face of the rectangular tube 30 which thus constitutes a rectangular waveguide. This rectangular waveguide is connected by a transition section 31 to a square section waveguide 32 having its walls parallel to the walls of the rectangular guide 30. The square waveguide 32 is coupled by a further transition section 33 to a circular waveguide 34 for propagating TE_{11} waves but beyond cut-off for TM_{01} waves. This circular waveguide 34 forms one part of a rotatable joint 35 leading to a further fixed circular waveguide 36 which in turn is connected by a transition section 37 to a fixed square waveguide 38. This square waveguide 38 leads to the aforementioned rectangular-apertured horn 23. The square waveguide 38 is dimensioned so that it can propagate TE_{01} and TE_{10} modes but is beyond cut-off for TE_{11} and TM_{11} modes.

It will thus be seen that there are two rotatable joints in the feed system and that the whole section from the circular coaxial line 29 to the circular waveguide portion 34 forms a rotatable assembly. Signals are transmitted through this rotatable assembly plane polarized in a direction parallel to the short side of the rectangular waveguide 30. Hence the plane of polarization of the signals fed through the rotatable coupler 35 may be rotated by turning the whole rotatable assembly. The signals fed into the square waveguide 38 thus have a plane of polarization which may be varied and which may be considered to have two components polarized parallel to two adjacent walls of the square waveguide 38. The relative magnitude of these two components may be adjusted by rotating the rotatable portion of the feed system. Located in the square waveguide 38 is a vane 40 parallel to one of the sides of the guide 38 and movable transversely to its plane. This vane is made of dielectric material and constitutes a phase shifter for altering the phase of the component polarized in the plane of the vane relative to the component transversely thereto. The phase shifter vane 40 is made of sufficient length to adjust the relative phases of the two components such that the output may be varied through any ellipticity between linear and circular polarization. Preferably the phase shifter 40 is movable across the waveguide so as to give phase shifts of plus or minus 90°. The vane 40 is spring-loaded by springs 41 so as to tend to urge it to one side of the guide and it may be moved transversely across the guide by a remove control system indicated diagrammatically by a cam 42 which may be rotated by means of a remotely controlled electric motor and which serves to move the vane across the guide against the pressure of the springs 41.

It will be seen that plane polarized signals from the transmitter 20 are transmitted through the rotatable coupling 35 as plane polarized signals polarized in a plane which can be adjusted by rotation of the rotatable portion of the feed system between the couplings 28, 35. If this rotatable section is adjusted to give signals in the waveguide 38 polarized parallel to one of the sides thereof, then linearly polarized signals will be radiated from

the horn 23. If on the other hand the rotatable section of the feeder is adjusted so that the signals in the guide 38 are polarized in a plane not parallel to the walls thereof, then the radiated signal will be ellipticaly or circularly polarized by an amount depending on the adjustment of the phase shifter vane 40. By setting the rotatable section of the feeder to give signals polarized in a plane at 45° to the wall of the guide 38, the phase shifter 40 may be adjusted to give any desired elliptical polarization from linear polarization to circular. Both right and left handed circular polarization may be obtained as required by appropriate setting of the phase shifter, assuming that the rotatable unit is adjusted to feed signals into the square waveguide 38 polarized at 45° to the plane of the walls thereof and similarly right and left handed elliptical polarization may be obtained by suitable adjustment of the rotatable section and/or the phase shifter vane. It will be seen that received signals, if they are linearly polarized, will be transmitted through the feed system as linearly polarized signals and will be fed through the waveguide 22 as TE_{01} waves which pass to the receiver 25 through the duplexer 21. If the radiated signals are elliptically or circularly polarized, it will be seen that reflected signals polarized with a sense of rotation to the opposite hand will pass through the feed system and will be converted to linearly polarized waves by the phase shifter 40 and will be fed through the waveguide 22 as TE_{01} waves and pass to the receiver. Reflected signals which are elliptically or circularly polarized but with the same sense of rotation will however, pass through the rotatable coupling 35 as plane polarized signals polarized at 90° to the transmitted signals and hence will be rejected by the rectangular section waveguide 22. Preferably a trap is provided in the square section guide 32 for such unwanted signals. This trap may comprise a grating in the form of a series of thin wires 43 arranged across the waveguide and may also include a narrow rectangular slot 44 in one of the walls of the guide which slot is arranged to be non-radiating for the signals of the required polarization but to couple signals of transverse polarization strongly into an external absorbing circuit (not shown) which may comprise a rectangular waveguide with an absorbing load. If for any reason these signals should be required, this slot 44 may be arranged to couple the signals to a suitable receiver. The grating 43 is preferably positioned so as to reflect transversely polarized signals towards this slot 44.

I claim:

1. In radar apparatus having a transmitter and a radiator, a waveguide system connecting said transmitter to said radiator comprises a length of square waveguide rigidly coupled to said radiator, a vane in said length of square waveguide parallel to one of the sides of the guide and movable transversely thereto so as to form a phase shifter for varying the phase of the signal component in said square waveguide polarized parallel to one side of the guide with respect to the phase of a signal component polarized transversely thereto, and a feed system coupling said transmitter to said length of square waveguide, which feed system includes first and second rotatable couplers, a length of waveguide between the couplers whereby said length of waveguide between the couplers is rotatable with respect to the square waveguide, the first rotatable coupler being arranged so that plane polarized signals are fed into the rotatable waveguide with a plane of polarization which is rotatable with that guide and said second rotatable coupler being arranged so that signals are fed out of the rotatable waveguide through the second coupler without change of polarization.

2. Radar apparatus as claimed in claim 1 and having a receiver wherein a single antenna system is used for both transmitting and receiving, the transmitter and the

receiver being connected through a duplexer to the first coupler.

3. Radar apparatus as claimed in claim 1 wherein said first rotatable coupler comprises a length of flexible waveguide permitting rotation of the rotatable waveguide through plus or minus 90°.

4. Radar apparatus as claimed in claim 1 wherein said first rotatable coupler comprises a rotatable joint in a coaxial line.

5. Radar apparatus as claimed in claim 1 wherein said second rotatable coupler comprises a rotatable joint in a circular waveguide through which the signals are transmitted as TE_{11} waves.

6. Radar apparatus as claimed in claim 1 wherein the length of waveguide between the couplers includes a trap for unwanted signals.

7. Radar apparatus as claimed in claim 1 wherein said radiator comprises a horn associated with a reflector to give a narrow directional beam.

8. In a microwave transmission system, the combination of signal input transmitting means, a first length of square waveguide, a first rotatable coupler coupling said signal input transmitting means to said first length of square waveguide, a second length of square waveguide, a second rotatable coupler coupling said first length of square waveguide to said second length of square waveguide, and a vane in said second length of square waveguide, which vane is arranged parallel to one of the walls of that waveguide and is movable transversely thereto.

9. In a microwave transmission system, the combination of a signal input transmitting means, a first length of square waveguide, a first rotatable coupler coupling said signal input transmitting means to said first length of square waveguide to launch signals from said signal input transmitting means in said first length of square waveguide as plane polarized signals polarized in a plane parallel to one of the walls of said first length of square waveguide, a second length of square waveguide, a second rotatable coupler coupling said first length of square waveguide to said second length of square waveguide, and a vane in said second length of square waveguide, which vane is arranged parallel to one of the walls of that waveguide and is movable transversely thereto.

10. The combination as claimed in claim 9 wherein means are provided in said first length of square waveguide to attenuate any signals polarized in a plane at right angles to said plane parallel to one of the walls.

11. The combination as claimed in claim 9 wherein said first rotatable coupler comprises a rotatable joint in a co-axial line, and wherein there is provided a transition section between said rotatable joint and said first length of square waveguide, the co-axial line having an inner conductor fixed in said transition section to feed signals thereto for transmission therethrough polarized in a plane parallel to one of the walls of said first square waveguide section, said inner conductor extending through the rotating joint to form a pick-up probe in said signal input transmitting means.

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