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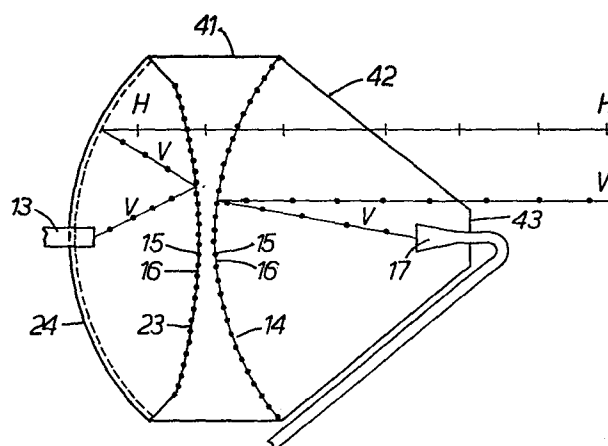
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(54) Antenna assemblies.

(57) There are a number of occasions when it is desirable for a radar system to be capable of transceiving two distinct signals from a single location. Indeed, it may be the case that it is required to be able to use a «single» antenna simultaneously to transceive the two signals in such a way that the sections of the system dealing with one signal are in no way influenced by the other signal. Various ways of attaining the desired end have been suggested in the past, but none have proved entirely satisfactory.

The present invention seeks to deal with the requirement for the simultaneous transception of two high power signals by the simple, but apparently previously unconsidered, expedient of employing a radar antenna assembly comprising two separate antennae (11/12, 14) arranged closely together in tandem, the fore antenna (14) being a direct antenna and the rear antenna (11/12) being a Cassegrain antenna, the reflector of the former being transparent to the radiation transceived by the latter.



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ANTENNA ASSEMBLIES

This invention relates to antenna assemblies, and concerns in particular such assemblies as may be used for the simultaneous transmission and/or reception of electro-magnetic radiation in the form of two distinct signals.

Radar is now a common way of employing electromagnetic radiation at radio frequencies to "see" distant target objects. The technique involves emitting radiation (usually as a controlled, directed beam), and receiving any "echo" that may be returned by way of reflection off some target, the receiving apparatus being such that there may be determined at least the direction, and usually the delay time, of the returned signal, and hence that there may be calculated the relative position of the reflecting object. Present-day radar systems operate at frequencies in the hundreds of megahertz, and even in the tens of gigahertz (thousands of megahertz), there being certain quite well user-defined frequency bands in this range referred to by letters of the alphabet - thus, L, X, S, J and Q-band radars cover the frequencies from about 220MHz to 50GHz. The invention is primarily about the antennae employed to transceive radar signals at these frequencies.

The size and shape of a radar antenna depends to a considerable degree both upon the nature of the beam to be emitted by the antenna (and consequently upon its sensitivity pattern to received radiation) and upon the frequency of the signal to be transceived. For example, an antenna designed to emit a narrow, pencil-like beam (such as is used in a tracking radar system) tends to be a combination of a parabolic reflector (the surface of the solid generated by revolving a parabola about its axis) and an emitting element placed at the principal focus of the reflector. The dimensions of the antenna aperture are determined primarily by the beamwidth required of the antenna.

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Thus, a typical radar antenna for transceiving tight beam electromagnetic radiation in the S-band region is a dish - a generally disc-shaped object - of parabolic section having a diameter of about 1 metre, a "depth" 5 (from front to back of the dish) of about 0.25 m, with its emitting element about 0.25 m beyond the dish front.

Radar antennae are often of the Cassegrain reflector type (the name is derived, by analogy, from a particular variety of astronomical optical telescope). Such an 10 antenna is one wherein radiation from a focus is collimated from one surface and reflected by another, and in its most typical form it uses a main, parabolic reflector facing a secondary reflector of hyperbolic form with a radiation-emitting element in between so that it 15 (the element) appears, by reflection off the secondary reflector, to be at the focus of the parabolic reflector (its actual position is known as the "Cassegrain focus").

There are a number of occasions when it is desirable for a radar system to be capable of transceiving two 20 distinct signals from a single location. Indeed, it may be the case that it is required to be able to use a single antenna simultaneously to transceive the two signals in such a way that the sections of the system dealing with one signal are in no way influenced by the other signal. 25 One such occasion is when the weather, or the general atmospheric condition, causes significant deterioration of signals of one frequency or polarisation but not of another, in which case the system can switch automatically to whichever signal is the better, while another is when 30 it is desired actively to track a target object with a pulse signal while at the same time illuminating the object - say, for the benefit of a separate, passive radar system. (a "passive" system is one that merely receives radiation,

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and does not emit any itself) - with a continuous wave signal. In the past it has been suggested that two distinct signals could be simultaneously transceived from a single antenna by the simple expedient of "combining" the two signals and emitting the combination from a single emitting element. Unfortunately, such an arrangement requires complicated microwave assemblies of duplexer and filters to effect the combination (and the subsequent separation of a received signal), and, where (as is usually the case) two different frequencies are involved, the single antenna cannot have the ideal configuration for both.

It has also been suggested that two distinct signals could be transceived from two separate antennae placed side-by-side and close enough to appear to be at a single location. Unfortunately, however, the sheer physical bulk and inertia of such an arrangement makes it unsuitable for many types of application - specifically for those in which the antenna must turn rapidly so as to point in any one of a large number of directions within a few seconds - while it is difficult to ensure that both antennae are accurately mounted so as to point together in the same direction at any one time.

It has further been suggested that a truly single antenna could be used to transceive two different signals if the antenna is of the Cassegrain type, a first emitting element (for signals of the first type) is at the Cassegrain focus, a second emitting element (for signals of the second type) is at the main reflector's principal focus, and the secondary reflector is reflective to the first signal but transparent to the second signal. Even this arrangement has, however, a number of not insignificant problems associated with its use in a high power system. One such is that the flux that has to be transmitted through the secondary reflector (both from the principal focus

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emitter and from the primary reflector itself) may be sufficient to cause heating (by dielectric absorption) of the secondary reflector to the point where it is destroyed, while another such is yet again the very real difficulty of ensuring adequate isolation between the two transceiving systems without the use of costly high performance filtering components.

The present invention seeks to deal with the requirement for the simultaneous transception of two high power signals by the simple, but apparently previously unconsidered, expedient of employing two antennae close together in tandem, a direct antenna at the fore and a Cassegrain antenna at the rear, the reflector of the former being transparent to the radiation transceived by the latter.

In one aspect, therefore, the invention provides a radar antenna assembly comprising two separate antennae arranged closely together in tandem, the fore antenna being a direct antenna and the rear antenna being a Cassegrain antenna, the reflector of the former being transparent to the radiation transceived by the latter.

By the expression "in tandem" is meant that the two antennae are aligned on a common axis one behind the other and pointing in the same direction.

By the expression "radiation transceived" as applied to a reflecting surface is meant either the radiation reflected off the surface during transmission or the radiation directed onto the surface during reception. Thus, if the reflecting surface is imagined as being disposed between the emitting element and a (notional) target, the expression refers to the radiation on the target side of the reflecting surface.

It is assumed that each antenna is such as to focus the radiation in some desired fashion. Apart from that, each antenna may, as regards the general nature of its (or its primary) reflecting surface, be of

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any convenient variety. Nevertheless, in terms of overall shape each antenna has preferably a parabolic dish reflector (of a size suitable to the intended purpose of the antenna), and, as is explained in more detail hereinafter, the Cassegrain antenna primary reflector is advantageously a twist reflector while the direct antenna reflector is advantageously a parallel wire reflector.

The two antennæ are mounted in tandem close together. It is not easy to define the scope of the word "close" as used in this context. Some indication may be given, however, by pointing out that it is an important requirement of the assembly that its overall volume and its inertia be kept low (so that it may be mounted and/or housed within a volume much the same as that occupied by any single antenna it may replace, and so that it may be employed - for example, in nutating, pivoting or rotating mode - in the same manner). In addition, an upper limit for the distance between the two antennæ - specifically, between their two reflectors - can be said to be less than the focal length of the Cassegrain antenna's primary reflector. And at this juncture it should perhaps be pointed out that in theory the rear antenna in the assembly could be a direct antenna (like the front one), but that then any reasonable construction of the two antennæ would necessitate the distance between the two reflectors being too large for the assembly to fulfil the requirements of relatively small volume and inertia. Accordingly, it is a major feature of the inventive assembly that the rear antenna be a Cassegrain antenna, the actual "depth" of the rear antenna as a whole then being small so that it can indeed be mounted close behind the front antenna.

The fore antenna is a direct antenna, having its emitting element in front of it and at the prime focus of the reflecting surface. The emitting element may be of any convenient form appropriate to the radiation involved, and no more need be said about it here.

The rear antenna is a Cassegrain antenna, having its emitting element at the Cassegrain focus, the position of which is determined generally by the nature and position of the secondary reflector. The secondary reflector may
5 in general be of any convenient shape and size - it may be flat or convex or concave (towards the primary reflector), and it may extend across either the full aperture of the primary reflector or only a small central area of the aperture. In the latter case it may be totally opaque to
10 the radiation involved, but in the former case it must naturally be reflectively opaque to the emitting element side radiation but transparent to the target side radiation (the radiation transceived). The full aperture type of secondary reflector is preferred, and, as explained
15 in more detail hereinafter, a particularly preferred variety transparent to the radiation transceived is a parallel wire reflector.

The emitting element of the Cassegrain antenna may be of any convenient form appropriate to the radiation
20 involved, and no more need be said about it here.

The inventive antenna assembly requires that the reflective surface of the direct antenna, which is mounted in front of the Cassegrain antenna, be transparent to the radiation transceived by the Cassegrain antenna. While it
25 is conceivable that this requirement could be met in other ways, it is presently the intention to meet it by constructing the direct antenna's reflector so that it is polarity selective, and then operating the antenna assembly in such a way that the radiation transceived by
30 the direct antenna is of such a polarity that it is reflected while the radiation transceived by the Cassegrain antenna is of such a polarity that it is transmitted. Thus, for example, if the direct antenna's reflector is constructed in essence of appropriately spaced parallel
35 conductive elements (wires or strips), so as to reflect

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radiation plane polarised in a direction aligned with the elements but transmit radiation plane polarised transverse to the elements, and in operation the reflector is so disposed that its elements are horizontal, then if the direct antenna is operated so as to transceive horizontally plane polarised radiation while the Cassegrain antenna is operated so as to transceive vertically plane polarised radiation the direct antenna's reflector will reflect the former but transmit the latter.

As stated hereinbefore the Cassegrain antenna may have a secondary reflector extending across only a small part of the aperture of the primary reflector, in which case the primary reflector may be quite opaque to the radiation transceived by the Cassegrain antenna (for it will block only a small part of that radiation). Preferably, however, the secondary reflector extends across the full aperture of the primary reflector, in which case it too, like the direct antenna's reflector, must be transparent to the radiation transceived by the Cassegrain antenna - and yet at the same time it must, of course, be reflective to the radiation on the emitting element side of the primary reflector. This too may be achieved upon the basis of the polarity of the radiation - by constructing the Cassegrain antenna's secondary reflector so that it has a polarity sensitivity matching that of the direct antenna's reflector, and constructing the primary reflector so that it is a polarity converter (changing the polarity of radiation reflectable by the secondary reflector to a mode to which the secondary reflector is transparent), and then operating the assembly so that each antenna's emitting element transmits or receives radiation of the same polarity mode, and the Cassegrain antenna's primary reflector changes that mode into one to which both the secondary reflector and the direct antenna's reflector are transparent. In the particular case where the two

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polarity modes are planar, one transverse to the other (as in horizontal and vertical), the Cassegrain antenna's primary reflector can be a twist reflector, while its secondary reflector can be constructed in essence of

5 appropriately spaced parallel conductive elements (wires or strips) aligned with and generally similar to those from which the direct antenna's reflector can be constructed. Assuming, for example, that the direct

10 antenna is to be operated so as to transceive horizontally plane polarised radiation, then its reflector will be reflective to that and transparent to vertically plane polarised radiation, and so the radiation transceived by the Cassegrain primary reflector will be vertically plane polarised, the secondary reflector will be

15 transparent to that but reflective to horizontally plane polarised radiation, and the Cassegrain antenna's emitting element will transceive horizontally plane polarised radiation which, after reflection from the secondary reflector, is twisted by the Cassegrain primary reflector

20 into the vertical mode. An embodiment analogous to this (but the other way round) is described hereinafter with reference to the accompanying drawings.

Reflectors that are selectively reflective/transparent to plane polarised radiation, or that twist the plane of

25 such radiation, are well known. Such reflectors are discussed in detail in "Microwave Antennae derived from the Cassegrain Telescope", P.W. Hannan, IRE Transactions, Antennae and Propagation, Vol. AP-9, pp 140-153, March 1961. A typical parallel wire

30 reflector might comprise a rigid sandwich of a plastics foam filling with front and back plastics skins, having laid in the front skin a multitude of fine parallel wires - typically 6000 gauge (about 0.1 mm) at a spacing of roughly ten times their gauge or 5% of the wavelength to

35 be transmitted; the higher the frequency (shorter the wavelength) the thinner and closer the wires. The actual

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dimensions of the sandwich, including its thickness, are matched to the frequencies/wavelengths involved. A typical "twist" reflector is very similar, except that it has a reflective back skin spaced $\lambda/4$ from the wires, and in operation in a system using vertically and horizontally plane polarised radiation it is so arranged that the wires are at 45° to each polarisation plane.

The antenna assembly of the invention is of particular value as part of a high power radar system. As intimated above, a problem with the earlier - and otherwise quite satisfactory - "dual" signal systems of the sort wherein there is used a single antenna with one emitting element at the principle focus and a second at the Cassegrain focus is that of necessity there must be a secondary reflector which is in the way of - and inevitably absorbs some of - the radiation emitted by both elements. Indeed, experience has shown that even with an optimised secondary reflector the power absorbed can be sufficient to raise the reflector's temperature to a point at which destructive physical changes - buckling, delamination, and so on - take place. The assembly of the invention reduces power absorption in the secondary reflector by a very considerable proportion, for one of the radiated signals - that from the front, direct, antenna - never passes through it at all.

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Various embodiments of the invention are now described, though only by way of illustration, with reference to the accompanying drawings in which:-

5 Figures 1 and 2 each show diagrammatically vertical "sections" through different inventive antenna assemblies; Figure 3 shows diagrammatically a perspective view of a third inventive antenna assembly; and Figure 4 shows diagrammatically a horizontal "section" through a fourth inventive assembly.

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In order to avoid needless confusion and complexity, the Figures are described in transmit mode only.

15 The inventive antenna assembly shown in Figure 1 comprises a closely-spaced tandem arrangement of direct antenna at the fore and Cassegrain antenna at the rear. The Cassegrain antenna has a parabolic primary reflector (11), a secondary reflector (12) and, at the Cassegrain focus, an emitting element (13); the secondary reflector 20 12 is a small convex one, not covering the full aperture of the primary reflector 11, and thus is reflectively opaque. The direct antenna has a parabolic reflector (14) in the form of many horizontally-disposed parallel wires (as 15) embodied within a radiation-transparent support structure (generally 16; see Figure 6), with an emitting 25 element (17) placed at its principal focus.

As can be seen from the Figure, the rear antenna's emitting element 13 is radiating vertically plane polarised "radar" waves (V) to which its own secondary and primary 30 reflectors (12,11) are reflectively opaque, and to which the fore antenna's reflector 14 is transparent, while the fore antenna's emitting element 17 is radiating horizontally plane polarised "radar" waves (H), to which its own reflector 14 is reflectively opaque.

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In Figure 2 there is shown a similar system except that the fore antenna's reflector (21) is now a parabolic vertical strip reflector, and reflects vertically plane, polarised from/to an "off axis" emitting element (22), while the rear (Cassegrain) antenna now has a concave full aperture secondary reflector 23 (which, like the fore antenna's reflector 21, is a vertical strip reflector), and its primary reflector (24) is now a twist reflector (see Figure 5).

In this embodiment, the rear antenna's emitting element 13 radiates vertically plane polarised "radar" waves (V) which are reflected off the vertical strip secondary reflector 23 onto the primary, twist, reflector 24, from which they are reflected in turn but as horizontally plane polarised waves (H). As such, they pass through the fore antenna's reflector 21, which appears to be transparent. The fore antenna's emitting element 22 is also emitting vertically plane polarised "radar" waves (V), and these are reflected off its reflector 21.

The perspective view of Figure 3 shows an antenna assembly like that of Figure 2 except that the former's fore antenna has a "cylindrical" parabolic reflector (31) - some of the vertical wires (as 32) have been drawn in - and a line emitting element (33) rather than the "spherical" reflector 21 and point emitter 22 of the latter.

The embodiment of Figure 4 has a rear antenna like that of Figure 2 and a fore antenna like that of Figure 1 (it should be emphasised that Figure 4 is a horizontal section, and that the fore antenna's emitting element is radiating vertically plane polarised "radar" waves). It needs little separate discussion, except to point out that the illustrated assembly is enclosed within an integral "radome" (with side and front portions 41,42,43).

CLAIMS:-

1. A radar antenna assembly comprising two separate antennae arranged closely together in tandem, the fore antenna being a direct antenna and the rear antenna being
5 a Cassegrain antenna, the reflector of the former being transparent to the radiation transceived by the latter.
2. An assembly as claimed in Claim 1, wherein in terms of overall shape each antenna has a parabolic "main" reflector.
- 10 3. An assembly as claimed in either of the preceding Claims, wherein the rear (Cassegrain) antenna primary reflector is a twist reflector, while the fore (direct) antenna reflector is a parallel wire reflector.
4. An assembly as claimed in any of the preceding
15 Claims, wherein the secondary reflector of the rear (Cassegrain) antenna extends across the full aperture of the primary reflector and is reflectively opaque to the emitting element side radiation but transparent to the target side radiation (the radiation transceived).
- 20 5. An assembly as claimed in Claim 4, wherein the full aperture secondary reflector is a parallel wire reflector.
6. A high power radar system whenever using a radar
25 antenna assembly as claimed in any of the preceding Claims.

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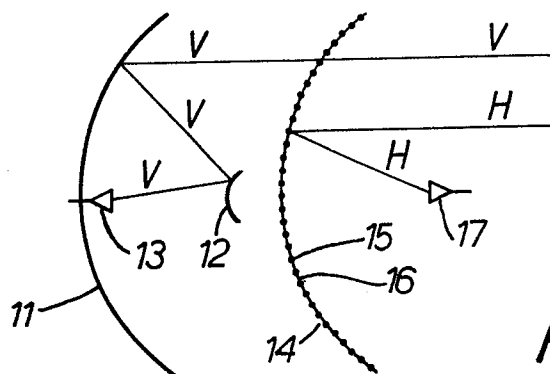


FIG. 1.

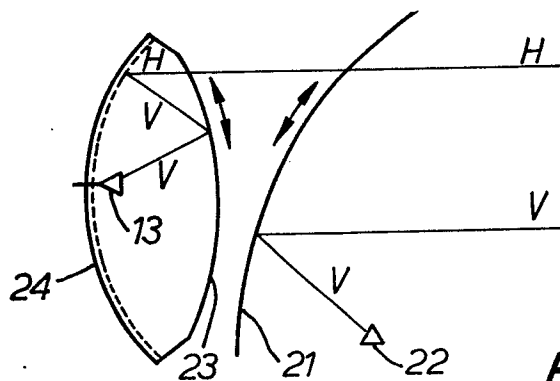


FIG. 2.

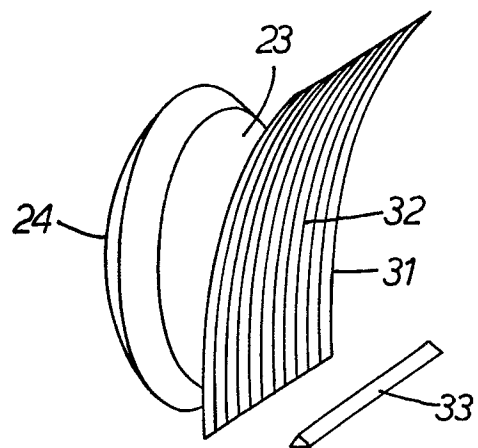


FIG. 3.

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EUROPEAN SEARCH REPORT

Application number

EP 82 30 6095

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. ³)
Y	--- US-A-3 049 708 (B.BERKOWITZ) *Figures 1,2; column 2, lines 29-51; column 5, lines 42-50*	1-6	H 01 Q 19/195 H 01 Q 25/00
Y	--- US-A-3 820 116 (E.A.R.CARLSSON et al.) *The whole document*	1-6	
A	--- FR-A-1 214 296 (C.F.T.H.) *The whole document*	1,2	
A	--- US-A-2 990 544 (R.LA ROSA) *Figure 4; column 5, line 61 to column 6, line 53*	1	
A	--- US-A-3 271 771 (P.W.HANNAN et al.) *Figure 3*	1-3	TECHNICAL FIELDS SEARCHED (Int. Cl. ³)
A	--- GB-A-1 048 354 (CSF) *Figures 3,6; page 2, lines 12-71*	1,3-5	H 01 Q
A	--- DE-C- 582 007 (E.GERHARD)		
A	--- GB-A- 758 957 (THOMSON-HOUSTON)		
--- -/-			
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 10-02-1983	Examiner CHAIX DE LAVARENE C.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	



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EUROPEAN SEARCH REPORT

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. ³)
A	US-A-3 898 667 (A.R. RAAB) -----		
			TECHNICAL FIELDS SEARCHED (Int. Cl. ³)
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 10-02-1983	Examiner CHAIX DE LAVARENE C.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			