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(56) Documents cited
GB 2080654 A GB 2053614 A EP 0308585 A2 US 4849762 A

(58) Field of search
UK CL (Edition K) **H4D DPRK DSPE DSPU**
INT CL^5 **G01S**
Online databases: WPI, CLAIMS, INSPEC

(54) **Radar target identification system**

(57) Pulses are transmitted using orthogonal polarisations. In the receiver, there is provided a polarisation splitter 5 operative to separate received echo signal returns into two signals having orthogonally related polarisation characteristics 6, 7. The amplitude and relative phase of the two signals are measured , computing means 9 responsive to the amplitude and relative phase of the two signals for each of two successive radar echo signal returns having orthogonally related characteristics being provided for computing co-polar nulls appertaining to a radar target. Storage means contain data appertaining to co-polar nulls for specified targets. Comparator means responsive to the stored data and to the computed co-polar nulls provide an output signal indicative of target identity when correspondence obtains between a stored and a computed co-polar null.

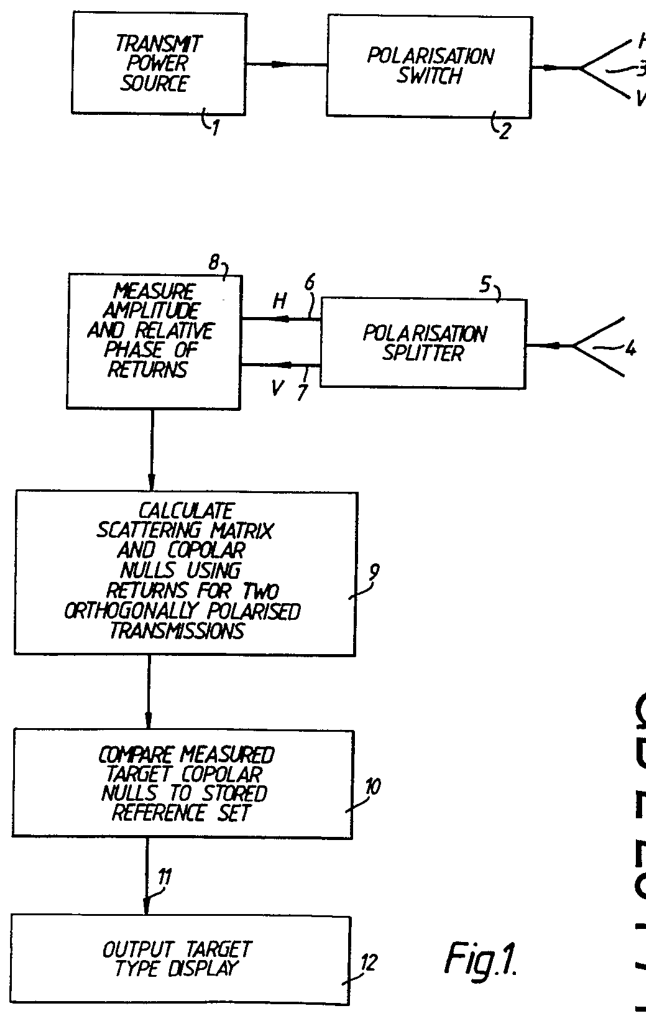

Fig.1.

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

The print reflects an assignment of the application under the provisions of Section 30 of the Patents Act 1977.

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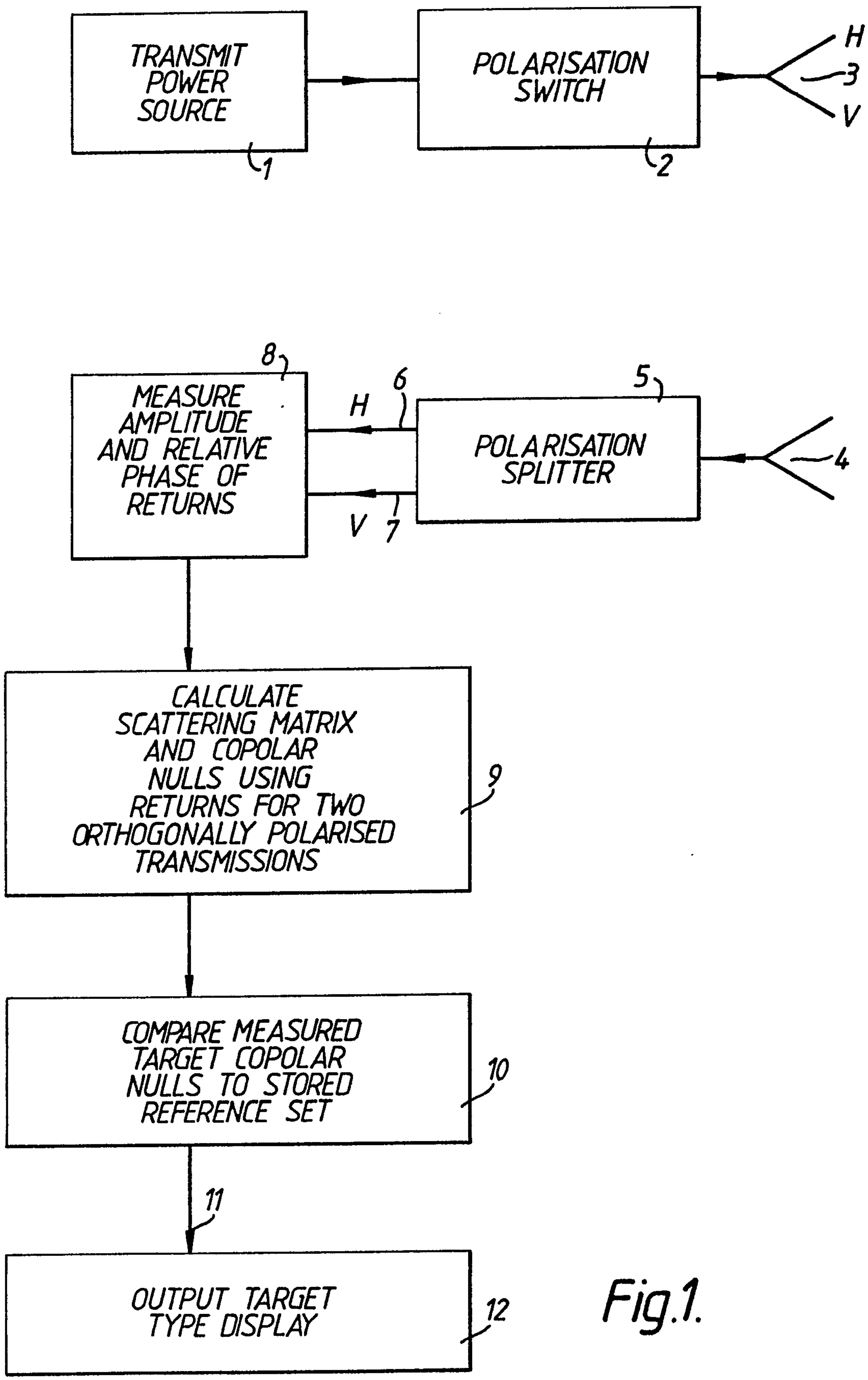
TRANSMIT POWER SOURCE
1
POLARISATION SWITCH
2
H
3
V
8
MEASURE AMPLITUDE AND RELATIVE PHASE OF RETURNS
6
H
V
7
5
POLARISATION SPLITTER
4
CALCULATE SCATTERING MATRIX AND COPOLAR NULLS USING RETURNS FOR TWO ORTHOGONALLY POLARISED TRANSMISSIONS
9
COMPARE MEASURED TARGET COPOLAR NULLS TO STORED REFERENCE SET
10
11
OUTPUT TARGET TYPE DISPLAY
12

Fig.1.

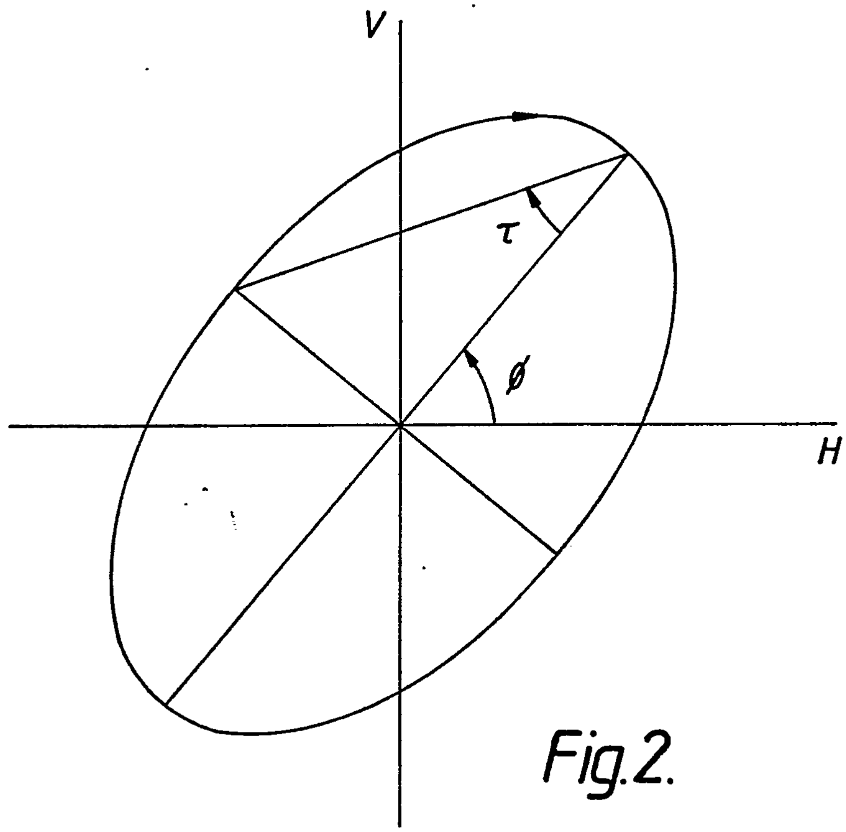

Fig.2.

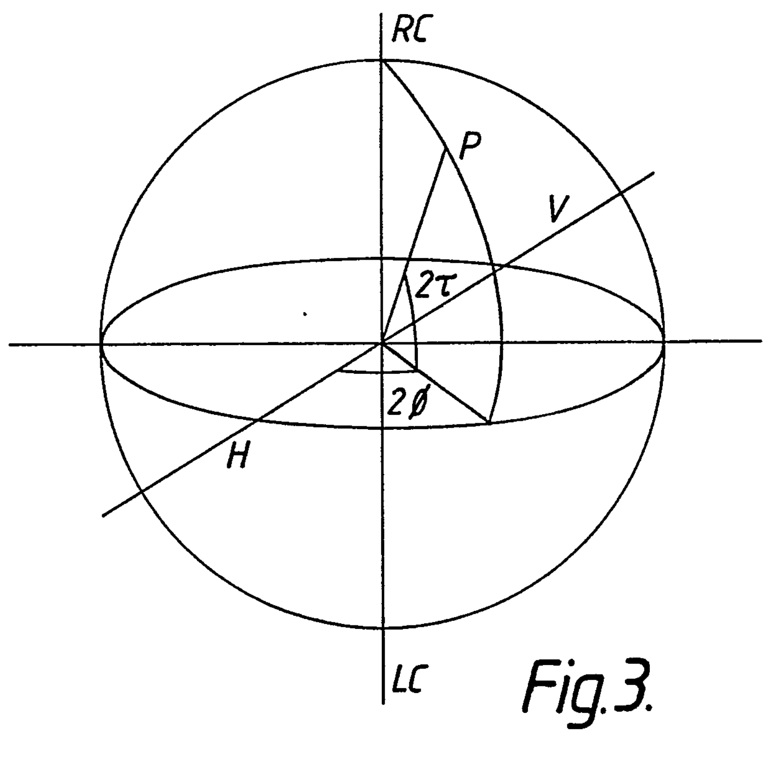

Fig.3.

RADAR TARGET IDENTIFICATION SYSTEM

This invention relates to a radar target identification system and more especially it relates to an automated system suitable for the recognition of a noncooperative target.

According to the present invention, a radar target identification system comprises a radar transmitter for the transmission of successive radar signals having orthogonally related polarisation characteristics and a radar receiver responsive to echo signal returns from a target to be identified, said receiver comprising a polarisation splitter operative to separate received echo signal returns into two signals having orthogonally related polarisation characteristics, measuring means for measuring the amplitude and relative phase of the two signals, computing means responsive to the amplitude and relative phase of the two signals for each of two successive radar echo signal returns having orthogonally related characteristics for computing co-polar nulls appertaining to a radar target storage means in which data appertaining to co-polar nulls for specified targets are stored, and comparator means responsive to stored data in the storage means and to the computed co-polar nulls for providing an output signal indicative of target identity when correspondence obtains between a stored and a computed co-polar null.

The co-polar nulls from successive pairs of orthogonally related radar transmitted pulses may be measured and aggregated whereby an average co-polar null identity for the target will be produced for comparison in said comparator means with the stored data.

One embodiment of the invention will now be described by way of example with reference to the accompanying drawings, in which:

Figure 1 is a generally schematic block diagram of a radar system for target identification,

Figure 2 is a graph of a polarisation ellipse, and,

Figure 3 is a graph of a Poincare sphere.

Referring now to Figure 1, a radar system for target recognition using polarisation properties comprises a transmitter 1 arranged to feed a polarisation switch 2 which is coupled to an antenna 3.

In operation of the system, the polarisation switch 2 is actuated so that radar pulses having relative orthogonal polarisations are transmitted from the antenna 3. Echo signal returns from a target to be identified are received by a second antenna 4 and fed to a polarisation splitter 5 which produces separate output signals having orthogonally related characteristics on the two lines 6 and 7. The signals on the lines 6 and 7 are fed to a measuring apparatus 8 which serves to measure the amplitude and relative phase of signals received on the lines. Data relating to the amplitude and phase of orthogonally related components of the echo signal return are thus produced for each echo signal return. Such data for two successive echo signal returns which result from orthogonally related transmitted pulses are fed from the measuring apparatus 8 to a computer 9 which uses the scattering matrix to compute the co-polar nulls for successive orthogonally polarised transmissions. Data appertaining to the calculated co-polar nulls for a particular target are fed to a comparator and store 10 wherein the received data appertaining to a target are compared with stored reference data appertaining to a number of different targets. When correspondence obtains between the stored data and the measured data an output signal is produced on a line 11 to provide a result which is indicated on a visual display unit 12.

It will be appreciated that echo signals from successive pairs of orthogonally related transmitted pulses may be aggregated to produce an average scattering matrix from which an average pair of co-polar null signals may be computed and thus a comparison may be made in the comparator and store 10 between an average co-polar null signal and the stored data for target identification purposes.

The system of target identification hereinbefore described is suitable for application to radar apparatus having a capability for measuring the target scattering matrix. It will be appreciated that the co-polar nulls are the polarisations which result in a received polarisation which is orthogonal to the transmitted polarisation, that is, using one of the co-polar null polarisations of a target for transmit and for receive will lead to a zero output signal. There are two co-polar null polarisations which in general are distinct. The co-polar nulls can easily be calculated from the scattering matrix as will be appreciated by those skilled in the art and they contain the same information apart from the overall amplitude factor.

The comparison of targets is in effect done using the distance between co-polar nulls on the Poincare sphere as will hereinafter be explained. The usual method for describing polarisation is by means of the electrical representation shown in Figure 2 whereby, in a polarisation ellipse, the vertical axis represents vertical polarisation and the horizontal axis represents horizontal polarisation. This ellipse is in effect described by the tip of an electric field vector looking along the direction of propagation. The polarisation state can thus be described using the orientation angle Φ and the ellipticity angle τ. By convention, positive τ represents right handed polarisation. Alternative representations using column vector of orthogonal components typically horizontal and vertical, that is,

$$\begin{pmatrix} E_H \\ E_V \end{pmatrix} \quad \text{———} \quad (1)$$

Scattering matrix represents the effect of a target on the transmitted polarisation

$$S = \begin{pmatrix} S_{HH} & S_{HV} \\ S_{VH} & S_{VV} \end{pmatrix} \quad \text{———} \quad (2)$$

If the transmitted signal T is of form (1), then the received signal R in form (1) is given by

$$R = \quad S\,T$$

The S_{HV} and S_{VH} components of S are equal because of reciprocity. A calculation of S can be achieved by measuring R for two orthogonal T signals and solving the set of equations to find components of S.

Co-polar nulls are polarisations for which R is orthogonal to T. Once S is known, co-polar nulls can be easily calculated.

Figure 3 shows how the polarisation state of a signal can be represented by a point P on the Poincare sphere using angles Φ and τ.

Considering now Figure 3, with the following different types of exmple targets:

Sphere $S = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$ co-polar nulls right and left circular

$\begin{pmatrix} 1 \\ j \end{pmatrix}$ $\Phi = 0$ $\tau = +45$

$\begin{pmatrix} j \\ 1 \end{pmatrix}$ $\Phi = 0$ $\tau = -45$

dihedral corner seam horizontal 

$S = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$ co-polar nulls $\pm$ 45 linear

$\begin{pmatrix} 1 \\ 1 \end{pmatrix}$ $\Phi = 45$ $\tau = 0$

$\begin{pmatrix} 1 \\ -1 \end{pmatrix}$ $\Phi = -45$ $\tau = 0$

Vertical wire

$S = \begin{pmatrix} 0 & 0 \\ 0 & 1 \end{pmatrix}$ co-polar nulls are coincident horizontal polarization

$\begin{pmatrix} 1 \\ 0 \end{pmatrix}$ $\Phi = 0$ $\tau = 0$

References will be stored as four values Φ and τ for the two co-polar nulls.

If the target is a sphere and the transmission is alternate horizontal and vertical with receive on horizontal and vertical.

For a horizontal transmission, horizontal receive = 1 and vertical = 0 (with amplitude effects ignored). For a vertical transmission, horizontal receive = 0 and vertical = 1. These four measurements allow a scattering matrix to be calculated and hence co-polar nulls. Co-polar nulls are then compared using angular distances between points on the Poincare sphere, by straightforward spherical geometry calculations. The distance between measured nulls and sphere nulls = 0° + 0°. The distance measured and dihedral nulls = 90° + 90°. The distance measured and wire nulls = 90° + 90°. Hence, the closest match is a sphere.

Various modifications may be made to the arrangement shown without departing from the scope of the invention and for example the most suitable type of measuring, computing or polarising apparatus may be used as will be apparent to those skilled in the art.

CLAIMS

1. A radar target identification system comprising, a radar transmitter for the transmission of successive radar signals having orthogonally related polarisation characteristics and a radar receiver responsive to echo signal returns from a target to be identified, said receiver comprising a polarisation splitter operative to separate received echo signal returns into two signals having orthogonally related polarisation characteristics, measuring means for measuring the amplitude and relative phase of the two signals, computing means responsive to the amplitude and relative phase of the two signals for each of two successive radar echo signal returns having orthogonally related characteristics for computing co-polar nulls appertaining to a radar target storage means in which data appertaining to co-polar nulls for specified targets are stored, and comparator means responsive to stored data in the storage means and to the computed co-polar nulls for providing an output signal indicative of target identity when correspondence obtains between a stored and a computed co-polar null.

2. A radar target identification system as claimed in claim 1, in which means are included whereby the co-polar nulls from successive pairs of orthogonally related radar transmitted pulses are measured and aggregated such that an average co-polar null identity for the target is produced for comparison in said comparator means with the stored data.

3. A radar target identification system as claimed in claim 1 or claim 2, including a display unit arranged to provide a visual display of the target identity output signal.

4. A radar target identification system substantially as hereinbefore described with reference to any one of Figures 1 to 3 of the accompanying drawings.

5. A method for the automatic identification of a radar target substantially as hereinbefore described.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number

9020389

Relevant Technical fields

(i) UK Cl (Edition K) H4D: DRPK, DSPE, DSPU

(ii) Int Cl (Edition 5) G01S

Databases (see over)

(i) UK Patent Office

(ii) ONLINE DATABASES: WPI, CLAIMS, INSPEC

Search Examiner

G A McLEAN

Date of Search

10 JANUARY 1991

Documents considered relevant following a search in respect of claims 1 - 5

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X, Y	GB 2,080,654 A (PLESSEY) - especially lines 14 - 20, page 1; claims 1 and 4	1, 3
X, Y	GB 2,053,614 A (ISE) - whole document	"
X, Y	EP 0,308,585 A2 (LICENTIA) - especially line 6, column 3 - line 1, column 4	"
X, Y	US 4,849,762 (UNISYS) - whole document, especially lines 53 - 58, column 1	"

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).

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