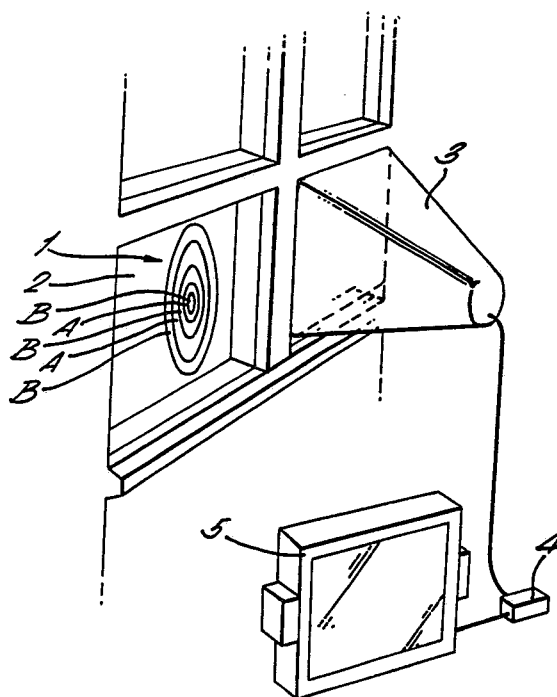




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<p>(51) International Patent Classification ⁵ : H01Q 19/06, 15/02, 1/12</p>	<p>A1</p>	<p>(11) International Publication Number: WO 90/07199 (43) International Publication Date: 28 June 1990 (28.06.90)</p>
<p>(21) International Application Number: PCT/GB89/01506 (22) International Filing Date: 18 December 1989 (18.12.89) (30) Priority data: 8829636.3 20 December 1988 (20.12.88) GB 8829672.8 20 December 1988 (20.12.88) GB (71) Applicant (for all designated States except US): MAWZONES DEVELOPMENTS LIMITED [GB/GB]; 2-6 Baldock Street, Ware, Hertfordshire (GB). (72) Inventor; and (75) Inventor/Applicant (for US only) : WRIGHT, Thomas, Michael, Benyon [GB/GB]; Glebe Cottage, 6 Hodwell, Ashwell, Baldock, Hertfordshire, SG7 5QG (GB). (74) Agent: BOULT WADE & TENNANT; 27 Furnival Street, London EC4A 1PQ (GB).</p>		<p>(81) Designated States: AT (European patent), AU, BE (European patent), CH (European patent), DE (European patent), DK, ES (European patent), FI, FR (European patent), GB, GB (European patent), IT (European patent), JP, LU (European patent), NL (European patent), NO, SE (European patent), SU, US. Published <i>With international search report.</i></p>

(54) Title: FOCUSING DEVICE FOR A MICROWAVE ANTENNA



(57) Abstract

A focussing device for a microwave antenna comprises a zone plate(1) which is all transparent to visible light whereby the device can be used as a window without unduly adversely affecting the passage of visible light through the window.

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FOCUSSING DEVICE FOR A MICROWAVE ANTENNA

This invention relates to a focussing device for a microwave antenna.

Microwave antenna are of increasing importance for the reception of microwave signals from television broadcast satellites or community television transmission stations.

The most commonly used antenna at present comprises a parabolic reflector focussing device which serves to focus received signals into a collector, in the form of a wave guide horn, which passes the signals onwards for decoding.

Parabolic reflectors are generally relatively expensive to manufacture and often are objected to as being unsightly when installed on private dwellings.

To overcome these disadvantages focussing devices in the form of zone plates have been proposed, a zone plate comprising a planar, at least in use, substrate of, for example, glass or plastics material transparent to the signals to be received, carrying an arrangement of rings of a material which either absorbs or reflects the signals to be received.

Two known arrangements of rings forming, respectively, a Fresnel zone plate and a Gabor zone plate,

can be used as such focussing devices.

It has been proposed to use such zone plate focussing devices as windows for a building with the associated collector being located within the building. It has also been proposed, see International Patent Publication No. WO88/10521, to provide such a zone plate focussing device in the form of a flexible member which can be easily stored when not in use, for example in the form of a roller blind located behind a window of a building and maintained in the rolled condition when not in use but unwound into a substantially planar condition when in use.

A disadvantage of known such zone plate focussing devices is that the rings are formed of a material which is substantially opaque or reflective to visible light, and thus when provided as a window or window blind they substantially reduce the amount of visible light passing through the window.

According to this invention there is provided a focussing device for a microwave antenna, comprising a substrate which is transparent to visible light and to microwave signals to be received, the substrate carrying an arrangement of rings of a material which either absorbs or reflects the microwave signals to be received, the rings being arranged to focus received microwave signals,

characterised in that the rings are of a material which is transparent to visible light.

Thus, the invention provides a focussing device which can be used, for example, as a window or a window blind, and which when so used will not unduly adversely affect the passage of visible light through the window or blind.

The substrate can be rigid and of either glass or plastics material, or can be flexible and then of, for example, plastics material.

The substrate and rings can together constitute a Fresnel zone plate or a Gabor zone plate.

Various materials are suitable for the rings and there are various methods by which the rings can be applied to the substrate, and detailed information on these matters can be obtained from GB-A-1307642, US-A-4166876, EP-A-0035906 and EP-A-0104870.

A particularly suitable material is metal coated glass available from Pilkington Glass Limited of England, and known as KAPPAFLOAT (trade mark) glass, such metal coated glass being transparent to visible light and the rings being easily formed by the removal of unwanted coating material as by etching. Another suitable material is Pilkington K Glass (trade mark) available from Pilkington Glass Limited of England, which is a glass

substrate with a low emissivity coating of doped tin oxide and a colour suppressing underlayer, the rings again being formed by etching.

A suitable plastics material substrate is stretched polyester to which rings formed of layers of silver alloy and oxides of titanium and indium can be applied by magnetron sputtering in a vacuum chamber to give the required ring arrangement, such coated plastics material being available from the Bekaert Group of companies.

This invention will now be described by way of example with reference to the drawings, in which:-

Figure 1 is a schematic perspective view of an antenna including a focussing device according to the invention;

Figure 2a illustrates the transmissivity profile of a Fresnel zone plate;

Figure 2b illustrates the transmissivity profile of a Gabor zone plate;

Figure 3a, 3b and 3c schematically illustrate a geometry for use in producing a Gabor zone plate;

Figure 4 is a diagrammatic representation of a focussing device according to the invention in use together with a second substrate carrying a coating of a material which absorbs or reflects the received microwave signals;

Figure 5 illustrates use of a focussing device according to the invention in the form of a window blind; and

Figure 6 illustrates a suitable arrangement of rings forming a Fresnel zone plate for use as a focussing device according to the invention.

Referring now to Figure 1, a focussing device in the form of a zone plate 1 in accordance with the invention, and comprising a glass or plastics material substrate 2 carrying an arrangement of circular or elliptical rings A of a material which absorbs or reflects microwave signals to be received and which is transparent to visible light, is fixed as a window pane, and serves to focus received microwave signals onto a transducer at the apex of collector in the form of a horn 3. For the sake of clarity the horn 3 is shown mounted over a pane adjacent that formed by the zone plate 1, but it will be appreciated that in use the horn 3 will be mounted over the zone plate 1. The horn 3 will with this arrangement be made from a transparent plastics material so as not to unduly adversely affect the passage of visible light through the window. Otherwise the horn 3 can be mounted at a position remote from the window (see Figure 5 for example). The horn 3 feeds the received signals to a converter 4 which in turn feeds a television or computer 5.

The zone plate 1 is preferably a Fresnel zone plate the operation and structure of which is well known and will not therefore be described herein. The microwave absorbing or reflecting rings A are deposited on substrate 2 which is transparent to microwave and visible radiation, and which may be of glass or plastics material. The rings A are separated by rings B of the microwave and visible light transparent substrate 2. The microwave absorbing or reflecting rings A can comprise a thin layer of indium tin oxide applied to the substrate 2 by any of a variety of different techniques as mentioned above, for example printing, sputtering, vacuum deposition or spraying. Any of a variety of other materials which absorb or reflect microwave radiation and yet are transparent to visible light can otherwise be used for the rings A.

Alternatively, it may be more convenient to coat an entire substrate 2 with a suitable ring-forming material, for example indium tin oxide, and then etch away that not required for the rings A.

In place of the Fresnel zone plate which has a square wave transmissivity profile as shown in Figure 2a, a Gabor zone plate having a sine square transmissivity profile as shown in Figure 2b can be used as the focussing device 1.

The Fresnel zone plate is well known in the optical

arts and will only be briefly described herein. Essentially, a Fresnel zone plate is constructed by applying an arrangement of rings of material which either reflects or absorbs incident microwave radiation, onto a substrate otherwise transparent to such radiation, in accordance with a simple geometrical relation which results in a half wavelength difference in the lengths of the paths from the edges of adjacent rings to a point on an axis of symmetry which is a focus for radiation incident on the zone plate.

A well known problem associated with the Fresnel zone plate, however, is that it produces not only a principal maximum in irradiance distribution at the primary focus, but also subsidiary maxima at higher order focal points. This introduces a focussing loss, which, coupled with the transmission loss deriving from the rings, imposes an inconvenient ceiling on the efficiency of the Fresnel zone plate.

The Gabor zone plate, or sinusoidal zone plate, focuses only at the primary focus, there being no higher order focal points. Consequently, there is no focussing loss of signal.

The Gabor zone plate is of central significance in the art of holography. Stated simply, the Gabor zone plate is the interference pattern associated with a point object imaged in a hologram.

A further requirement for convenient signal reception is that the focussing device 1 of the invention should be adapted to be mounted on, parallel to or integral with a window pane or other surface having a line of sight to a specified received signal source. The ring arrangement can therefore be in the form of a set of ellipses whose eccentricity and relative positions along a common axis are determined by the angle of elevation of the line-of-sight from the received signal source to the local horizontal and by the orientation of the mounting surface to the local meridian.

Referring now to Figures 3a, 3b and 3c, these illustrate a method of manufacturing a Gabor zone plate suitable for use as a focussing device according to the invention. A photo sensitive substrate 31 which provides microwave absorbing or reflecting material when exposed to light and developed is arranged so that light from a pair of monochromatic phase related light sources 32 forms an interference pattern on the substrate 31. The substrate 31 will, when developed, exhibit a sinusoidal transmissivity profile (see Figure 2b) and will constitute a Gabor zone plate.

As noted above, the ring arrangement of a focussing device is preferably in the form of ellipses whose eccentricity and relative positions to one another along a

common axis are in dependence on the angle of elevation of the line of sight from the received signal source to the local horizontal and by the orientation of the plane of the focussing device 1 to the local meridian. In the illustrated geometry utilised in manufacturing a Gabor zone plate for use as a focussing device 1, the substrate 31 is positioned with respect to the sources 32 in dependence upon the required eccentricity and relative positions of the rings of the zone plate.

The geometry of the manufacturing set up is determined according to the equation

$$\frac{1}{f} = \frac{\lambda}{\lambda^1} (D_1^{-1} + D_2^{-1})$$

where f = focal distance of the resultant zone plate
 λ = wavelength of the received microwave radiation
 λ^1 = wavelength of light used to make the zone plate (i.e. corresponding to peak response of photosensitive emulsion)

D_1, D_2 = distances of the phase related sources from the substrate.

For a received microwave signal of 2cm wavelength and a substrate 31 with an emulsion having a peak response at 4×10^5 mm then, for a focal length of 1m, D_1 and D_2 should be 5m and 5.55m respectively from the centre

of the resulting interference pattern on the substrate 31. This is illustrated in Figure 3A.

In particular, the substrate 31 may be arranged so that, for Cartesian axes centred on the centre of the interference pattern with the light sources 32 positioned on the x-axis, when an angle A is defined as the angle from the x-axis to the line defined by the intersection of the substrate 31 and the xy plane; and an angle B is defined as the angle from the x-axis to the line defined by the intersection of the substrate 31 and the zx plane, then angle A also corresponds to the angle of orientation of the substrate 31 in use as a focussing device 1 in an antenna, to the local meridian, and angle B also corresponds to the angle of elevation of the line of sight between the received signal source and the local horizontal.

Figure 3b illustrates the substrate 31 turned through angle A whereas Figure 3c illustrates the substrate 31 turned through angle B. In practice, the substrate 31 will be turned through both angles.

Referring now to Figure 4, as is known, the effectiveness of focussing devices in microwave antenna can be improved by the use of a microwave reflective member on the side of the focussing device remote from the received signal source, this resulting in a stronger

signal on the same side of the focussing device as the received signal source. Thus, as shown in Figure 4, a zoneplate constituting a focussing device 1 in accordance with the invention can be utilised together with a member 6 carrying a microwave reflective coating to obtain improved operation of the antenna of which the focussing device 1 forms part. Such an arrangement as shown in Figure 4 is ideally suited to the provision of a double glazed window serving as a focussing device, with the rings of the zone plate 1 being on either side A or B of the substrate and the microwave reflective coating of material transparent to visible light on either side C or D of member 6. The member 6 can comprise the same combination of substrate and coating material as used for the zone plate 1. The thickness of the substrates of the zone plate 1 and member 6, which substrates can be of glass or plastics material, and the spacing between the substrates, will be set to obtain the required operation, and the spacing can be zero provided that the rings of the zone plate 1 are not on the side B thereof when the coating of the member 6 is on the side C thereof. Preferably the spacing between the rings of the zone plate 1 and the coating of the member 6 is one quarter the wavelength of the received microwave signal.

Referring now to Figure 5, this shows an antenna arrangement including a focussing device 1 in accordance

with the invention, in which the focussing device 1 is in the form of a window roller blind. For such an arrangement the substrate for the zone plate 1 would be of flexible plastics material carried by a roller 7 mounted by means of brackets 8 to the frame 9 of a window 2 such that for use the focussing device 1 can be unwound from the roller 7 to cover the window 2, as shown in Figure 5. When not in use the focussing device 1 will be wound on the roller 7, leaving the window 2 clear. Also as shown, in this arrangement the collector horn 3 is arranged remote from the window 2, together with the converter 4 and the television 5.

Referring now to Figure 6, if a Fresnel zone plate is used as a focussing device 1 according to the invention, then a circular arrangement of rings will focus received signals at a point on the perpendicular axis intersecting the plane of the zone plate, provided that the plane is at 90° to the line of sight of the received signal source. Since this requirement would not be met by, for instance, direct broadcasting satellites radiating onto a vertical focussing device 1, modification of the circular system of zones is desirable. The modification is such that the ring arrangement becomes a set of ellipses not having a common centre but instead being displaced along their common major axis. Such a zone

plate is shown in Figure 6. In common with conventional circular ring zone plates, the radii of the substrate rings B and the microwave reflecting or absorbing rings A are such that the distance from the ring edges to the focal point (i.e. the collector horn 3) increases by half a wavelength of the incident radiation between adjacent rings, the distance of the focal point to the centre of the first, i.e. central, ring being approximately 1.5 times the width of the largest ring.

CLAIMS

1. A focussing device for a microwave antenna, comprising a substrate (2) which is transparent to visible light and to microwave signals to be received, the substrate (2) carrying an arrangement of rings (A) of a material which either absorbs or reflects the microwave signals to be received, the rings (A) being arranged to focus received microwave signals, characterised in that the rings (A) are of a material which is transparent to visible light.
2. A device as claimed in Claim 1, characterised in that the substrate (2) is rigid.
3. A device as claimed in Claim 1 or Claim 2, characterised in that the substrate (2) is of glass.
4. A device as claimed in Claim 1, characterised in that the substrate (2) is flexible.
5. A device as claimed in Claim 1, Claim 2 or Claim 4, characterised in that the substrate (2) is of plastics material.

6. A device as claimed in any preceding claim, characterised in that the substrate (2) and rings (A) together constitute a Fresnel zone plate (1).
7. A device as claimed in any one of Claims 1 to 5, characterised in that the substrate (2) and rings (A) together constitute a Gabor zone plate (1).
8. A device as claimed in Claim 6, characterised in that the rings (A) are elliptical and have their centres displaced along their common major axis.
9. A device as claimed in any preceding claim in the form of a window pane.
10. A device as claimed in Claim 4, or Claim 5, 6, 7 or 8 as dependent upon Claim 4, in the form of a window roller blind.
11. In combination, a planar device (1) as claimed in any one of Claims 1 to 8, and a planar member (6) comprising a substrate transparent to visible light carrying a coating of a material which reflects microwave radiation, arranged in a plane parallel to and spaced from the plane of the device.

12. A combination as claimed in Claim 11, characterised in that the device (1) and planar member (6) are spaced from each other.

13. A combination as claimed in Claim 11, characterised in that the device (1) and planar member (6) are in surface contact with no more than one of the rings (A) of the device (1) and the coating of the planar member (6) between them.

14. A microwave antenna including a focussing device or combination as claimed in any preceding claim.

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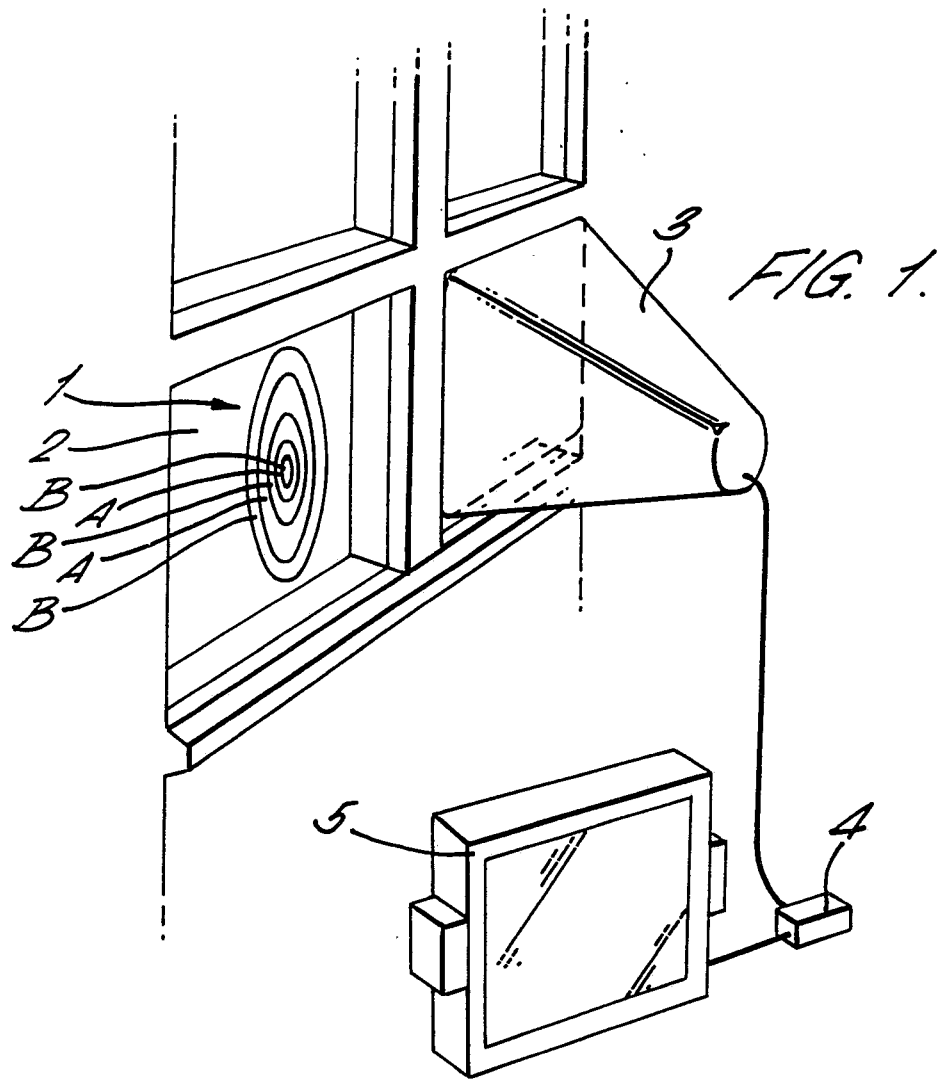
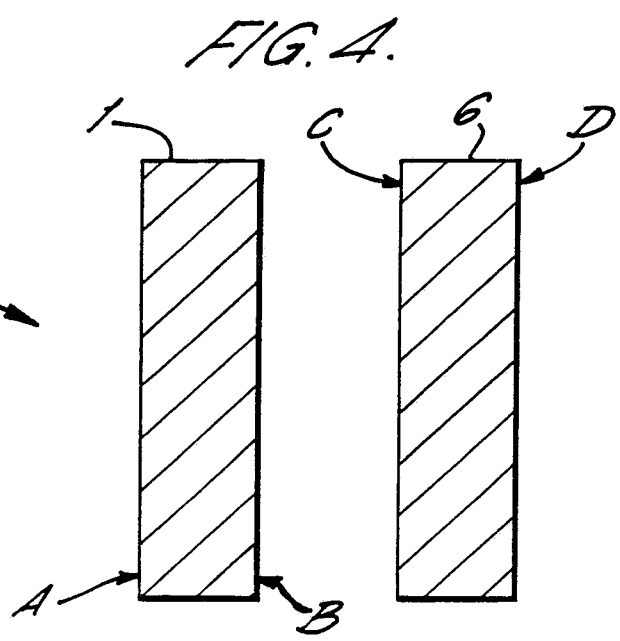
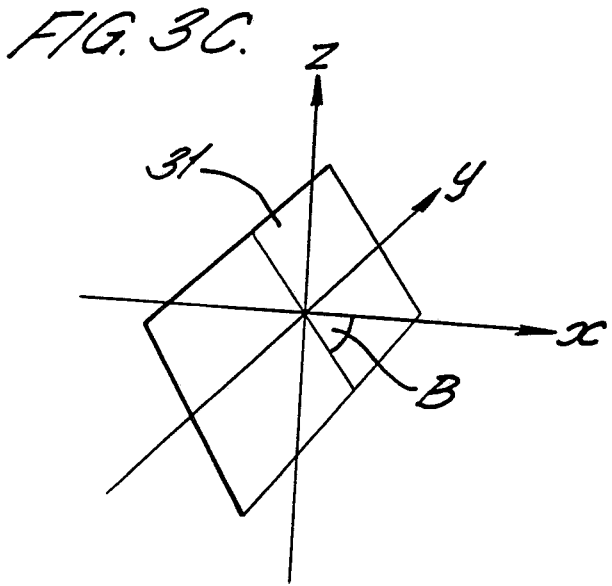
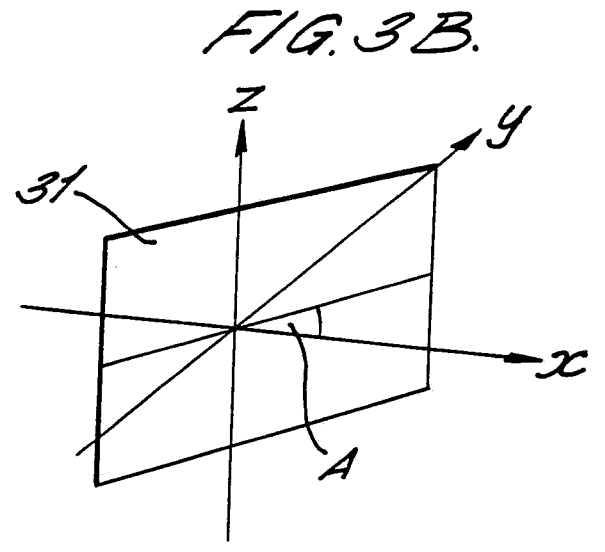
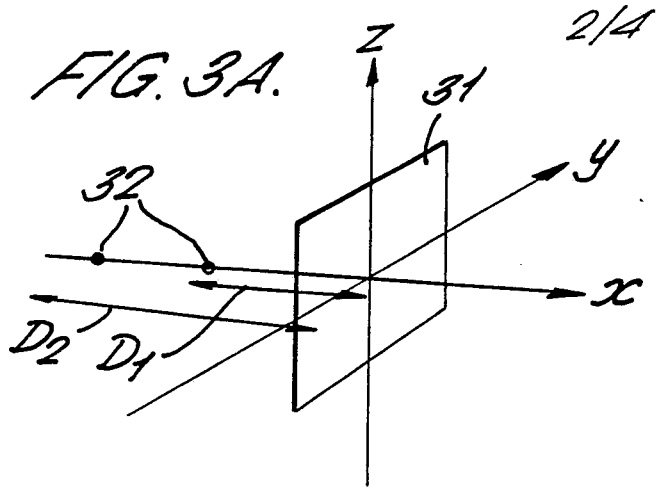


FIG. 2a.



FIG. 2b.





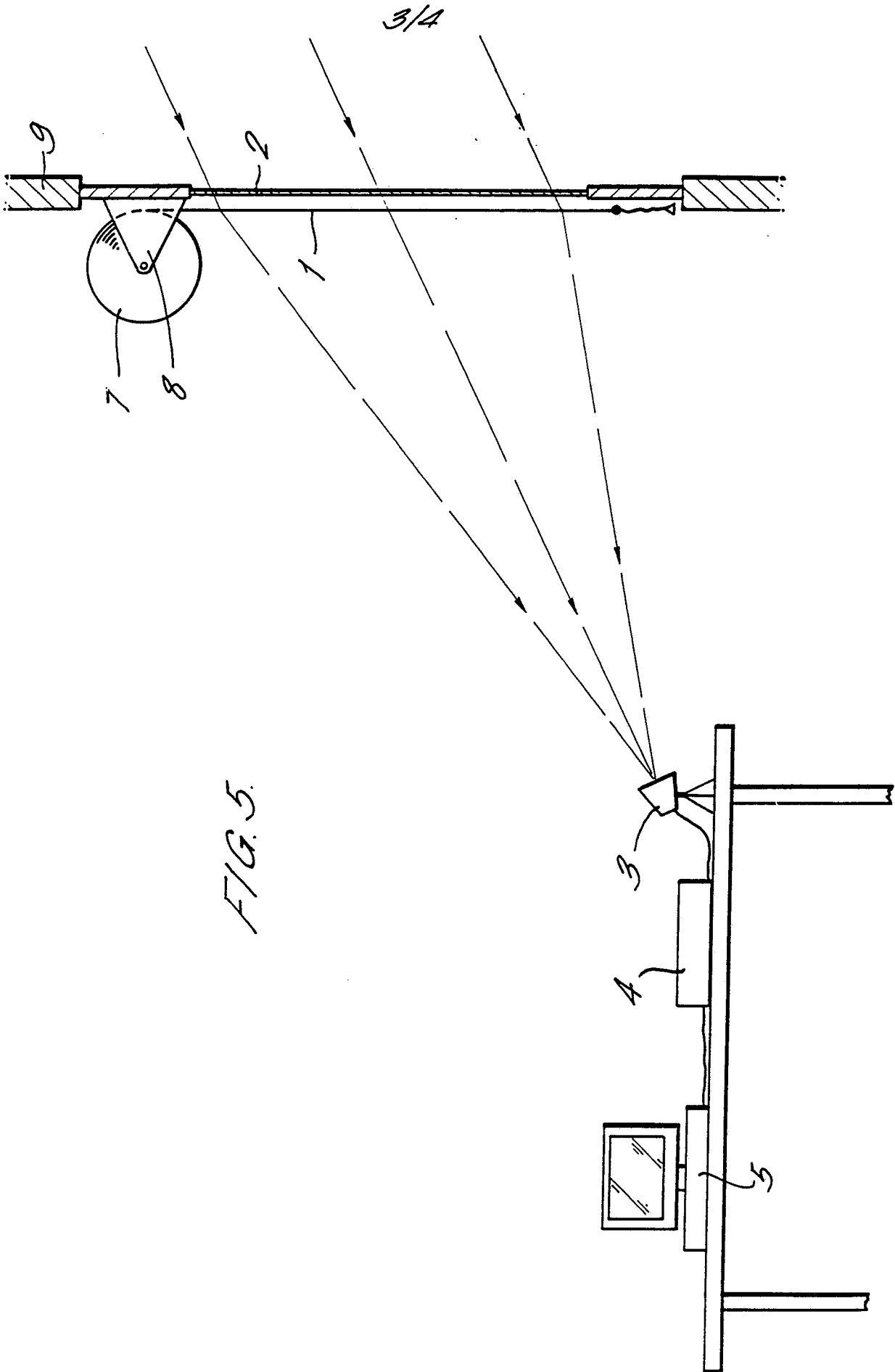
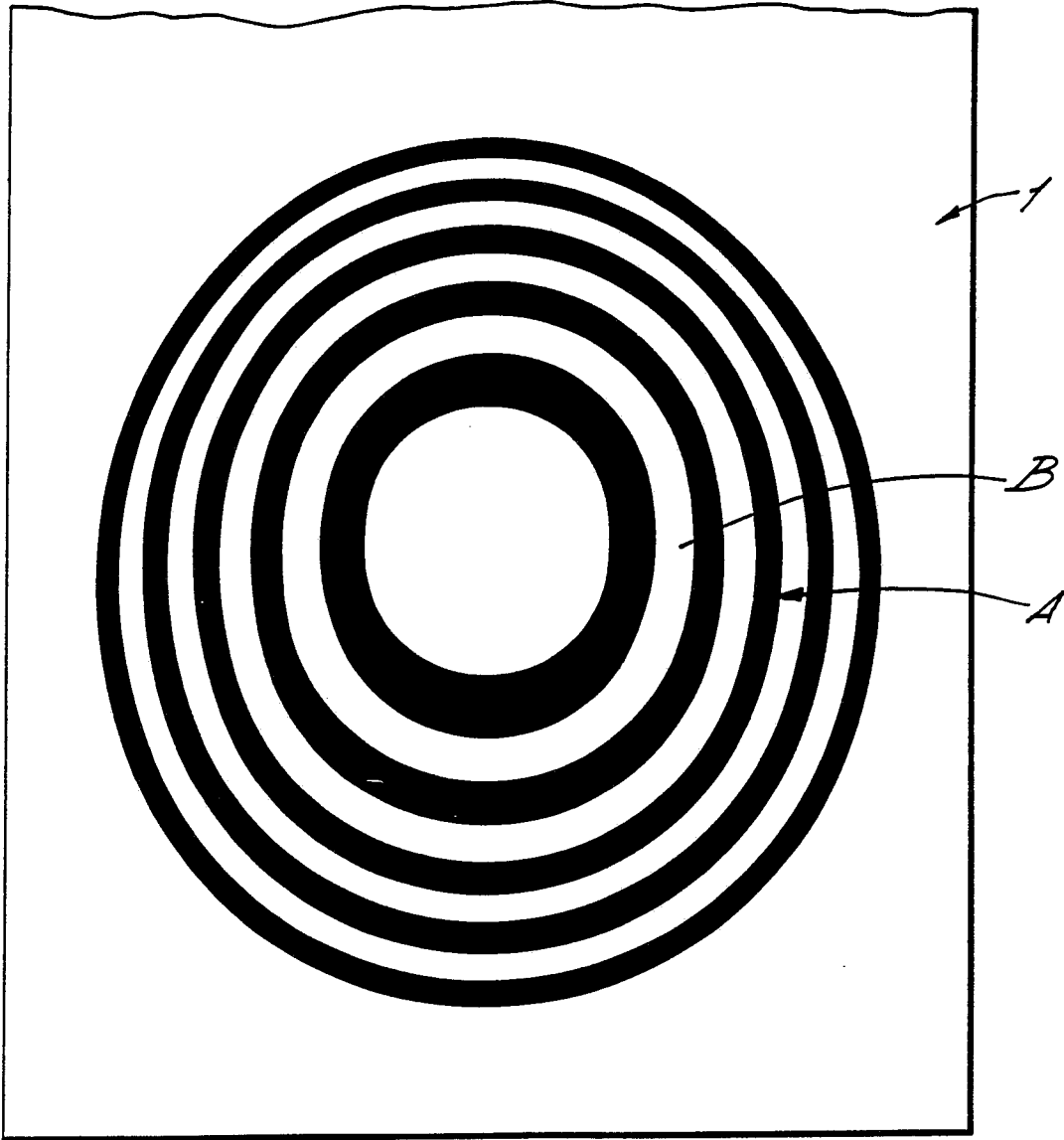


FIG. 5.

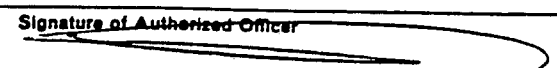
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FIG. 6.



INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 89/01506

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ⁶				
According to International Patent Classification (IPC) or to both National Classification and IPC				
IPC ⁵ : H 01 Q 19/06, H 01 Q 15/02, H 01 Q 1/12				
II. FIELDS SEARCHED				
Minimum Documentation Searched ⁷				
Classification System	Classification Symbols			
IPC ⁵	H 01 Q			
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸				
III. DOCUMENTS CONSIDERED TO BE RELEVANT ⁹				
Category ¹⁰	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³		
Y	Microwave & RF, November 1979, Hayden Publishing Co. Inc. (Rochelle Park, NJ, US) M.J. Lazarus et al.: "Fresnel-zone plate aids low-cost Doppler design", pages 78-80, see page 79, figures 1,2 --	1-3,5,6, 9,14		
Y	Patent Abstracts of Japan, vol. 10, no. 352 (E-458)(2408), 27 November 1986, & JP, A, 61150402 (MATSUSHITA) 9 July 1986, see the abstract --	1-3,5,6, 9,14		
A	Patent Abstracts of Japan, vol. 10, no. 386 (E-467)(2443), 24 December 1986, & JP, A, 61176201 (YAGI ANTENNA CO LTD) 7 August 1986, see the abstract --	1-3,9		
A	DE, A, 3536348 (MAX-PLANCK-GESELLSCHAFT ZUR FÖRDERUNG DER WISSENSCHAFTEN) 16 April 1987, see the whole document --	1,2,4,6,8		
<table style="width: 100%; border: none;"> <tr> <td style="width: 50%; border: none; vertical-align: top;"> <p>¹⁰ Special categories of cited documents:</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </td> <td style="width: 50%; border: none; vertical-align: top;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&" document member of the same patent family</p> </td> </tr> </table>			<p>¹⁰ Special categories of cited documents:</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p>	<p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&" document member of the same patent family</p>
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IV. CERTIFICATION				
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report			
16th March 1990	11 APR 1990			
International Searching Authority	Signature of Authorized Officer			
EUROPEAN PATENT OFFICE	 T.K. WILLIS			

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
A	Patent Abstracts of Japan, vol. 8, no. 95, (E-242)(1532), 2 May 1984, & JP, A, 5915309 (MITSUBISHI) 26 January 1984, see the abstract	11-13
P,A	DE, A, 3801301 (LICENTIA PATENT-VERWALTUNGS- GMBH) 27 July 1989, see claims 1-4; figure 1	11-13

ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO.

GB 8901506
SA 33194

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 03/04/90. The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE-A- 3536348	16-04-87	None	
DE-A- 3801301	27-07-89	None	