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(71) Applicant (*for all designated States except US*): UNIVERSITY OF BRADFORD [GB/GB]; Bradford, West Yorkshire BD7 1DP (GB).

(72) Inventor; and
(75) Inventor/Applicant (*for US only*): McEWAN, Neil, John [GB/GB]; Dept. of Electrical Engineering, University of Bradford, Bradford, West Yorkshire BD7 1DP (GB).

(74) Agent: TUNSTALL, Christopher, Stephen; Dibb Lupton Broomhead, 117 The Headrow, Leeds LS1 5JX (GB).

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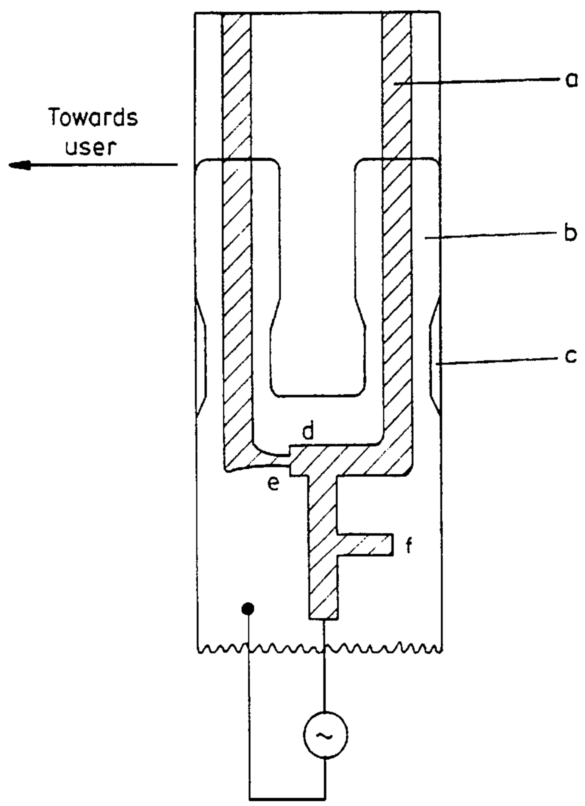
(54) Title: IMPROVEMENTS IN OR RELATING TO PORTABLE PHONES

(57) Abstract

A portable phone is disclosed having in-built user protection to ensure that transmission field strengths experienced by the user of the phone are relatively low as compared with those present in adjacent volumes of space. For example, a physical shield such as a reflector to shield the user from the incident radiation with a dielectric medium between the antenna and the reflector. Alternatively, the phone's antenna may be configured to produce asymmetric near-field transmission field strengths. One way of achieving this is by means of a near-field phased array such as two parallel half-wave dipoles separated by one quarter of a wavelength and excited in quadrature.



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Improvements In or Relating to Portable Phones

This invention relates to portable phones and in particular to portable phones which transmit radiation conveying information such as the speech of the user. Typically such radiation is radio frequency (RF), for example, RF of about 2 GHz.

For a hand-held portable telephone working at about 2 GHz the antenna will necessarily be close to the user's head. An antenna in the form of a simple vertical dipole or monopole gives, as is desired, fairly omnidirectional azimuth coverage but as a result the user, and in particular the user's head, is subject to incident radiation. It has been appreciated for some time that it would be desirable to reduce the incidence of such radiation on the user's head since the long term effects, if any, of accumulative use of portable phones are not yet known.

According to the present invention, there is provided a portable phone having means for transmitting radiation such that transmission field strengths experienced by the user of the phone are relatively low as compared with those present in adjacent volumes of space.

The phone may include means for shielding the user of the phone from at least a proportion of said radiation, for example a physical shield to shield the user from the incident radiation. The shield may be a reflector.

The phone will typically include an antenna, and preferably includes a dielectric medium between the antenna and the reflector. Preferably, the reflector is substantially parallel to the axis of the antenna.

The antenna may be a dipole antenna or the antenna/reflector combination may be a microstrip patch radiator.

In an alternative realisation of the present invention, the means for transmitting radiation includes an antenna configured to produce asymmetric near-field transmission field strengths. For example, the antenna may comprise an end-fire antenna, such as a tapered slot antenna which is shorter than one wavelength of the radiation transmitted. A Vivaldi printed tapered slot antenna is suitable.

Another example of an asymmetric antenna suitable for use in the present invention is a plurality of transmitters adapted to produce relatively phased transmission fields which interfere destructively so as to reduce the filed strengths experienced by the user. The antenna may comprise a near-field phased array.

A suitable array consists of two parallel half-wave dipoles, preferably separated by one quarter of a wavelength. The means for transmitting radiation may then include means for exciting the dipoles in quadrature.

Examples of possible arrangements will now be described with reference to the accompanying drawings.

Radiation Reflector

Because the importance of maintaining, as far as possible, an omnidirectional azimuth pattern, it would not normally be considered appropriate to disrupt this pattern by means of a reflector. However, it has been surprisingly discovered that a reflector small enough to go into a phone handset can reduce to a significant extent the amount of radiation incident on the user's head and without disturbing the pattern of transmitted radiation to a degree which significantly affects the performance of the device. A preferred combination is that of a reflector with a dipole antenna. Figure 1 illustrates a half-wave dipole of overall length 15.6 cm made of wire of 1.0 mm diameter. It is connected at the centre to semi-rigid 50 ohm cable and is equipped with a simple sleeve balun designed for 2.0 GHz. As shown in Figure 1, the balun is arranged normal to the dipole. Beyond the balun, the semi-rigid cable is gently curved and extends to measuring equipment. In a 50 ohm system, a minimum reflection (-16 dB return loss) was observed at 1.8 GHz. All measurements were made at 1.98 GHz, which is the resonant frequency of the microstrip antenna to be described below. At 1.98 GHz the reflection from the dipole increases to 7.6 dB. All measurements were made at the same frequency to allow comparisons without calibration uncertainties, the microstrip antenna having the sharpest resonance of all antenna tested.

The dipole antenna was equipped with reflectors cut from this aluminium plate and supported using a sheet of Melinex in order to ensure that there was no mechanical or electrical connection between them and the dipole. The balun was arranged normal to the reflector surface.

The reflectors height, width and spacing from the dipole can of course be varied. On the basis of investigations to date involving somewhat arbitrary choices as to parameters and ranges to be chosen, a preferred reflector has a width w (normal to the dipole) of about 3.75 cm, a length l (along the dipole) of about 10.0 cm, and a spacing d (from dipole centre to nearest reflector surface) of 0.5 cm. Preferred ranges for each of the above parameters are as follows:-

w 2.5 to 5 cm
l 5 to 15 cm
d 0.25 to 1 cm

All the near field measurements to be described are referenced using a Cartesian coordinate system in which the z axis is the expected direction of peak radiation, which is normal to both the dipole and the reflector surface. For measurements with a microstrip patch it is normal to the substrate, and for the slot antenna described later is it along the slot. The y axis is in the direction of principal electric polarisation, i.e. in the three cases it is respectively parallel to the dipole, to the microstrip feed line or to the slot substrate.

Measurements were made using a short dipole (1.3 cm long) or a small loop (square of side 1.1 cm) which are moved using a three axis Cartesian positioner using the coordinate system already mentioned. These probes are designed to be sensitive to electric and magnetic field respectively. Their relative calibration can be found in the far field of any of the antennas, where the ratio E to H is just ZO. Far field measurements have also been made, using an elevation over azimuth positioner in a straightforward way.

The screening efficiency of each antenna type can be obtained from a plot of the intensity of the y - component of electric field along the z axis (at x, y=0). The simple measurement is made by moving the Cartesian positioner in the z direction only, the distance of the small dipole probe from the antenna varying from z = 0.5 cm to z = 100cm. At the small distances we see the fields which would irradiate the user, and at 1m we are well into the far field of the antenna. By changing antennas while keeping the measuring set-up identical, all uncertainties due to shifting calibrations are avoided and a direct comparison of both near fields and far field gain is obtained.

The half-wave dipole without reflector is used as a reference. Curve 1 of Figure 4 shows the plot of Ey versus z for this antenna. z = 0 corresponds to the centre of the dipole itself, and the values are normalised to the value at z = 0.5 cm. The measurement is taken at 1.976 GHz with the antenna at resonance and about 5% of incident power reflected. (75 ohm dipole in a 50 ohm system.) Curve 2 in Figure 4 is for the same dipole with the reflector, keeping all parameters the same, except that z = 0 corresponds to placing the probe on the surface of the reflector. This is a "back" or shielded measurement, with the reflector between the main dipole and the probe. Thus the portion of z axis between about z = 2 and 20 cm is that which would intersect the telephone user's head. Still at 1.98 GHz, the reflected power is increased to 20% by the impedance change caused by the reflector. It follows that the difference D between curves 1, 2, at each z value, is an estimate of the protection offered to the user on the assumption that the same power is incident on the antenna from the transmitter. Although in a practical system this comparison should be made on the assumption of equal power accepted by the antenna, this difference is only about 1.0 dB for the mismatches found.

When a reflector is added, the dipole antenna is no longer omnidirectional and its peak gain is increased. Accordingly, the assumption of equal power accepted by the antennas may not be the best way of assessing the user protection achieved.

Curve 3 of Figure 4 shows the electric field intensity on the "front" side of the reflector, that is to say, in the direction of peak radiation. It should be appreciated that, for curves 1 and 2, the dipole is placed between the balun and the probe and the probe can approach the dipole or reflector closely. With curve 3, the balun has to lie between the dipole and probe and measurements can only be taken down to about $z = 10$ cm.

For $z > 15$ cm, we are in the far field of the antenna and the difference D between curves 1 and 3 approaches a constant value of 3.3 dB which is the gain of the composite antenna referred to the simple dipole.

If it is assumed that the user is prepared to orientate his head so that the boresight remains close to the base station, and if it is also assumed that the gains of both shielded and unshielded dipoles are not affected by the user's head, then for the same operating range, the power accepted by the antenna δ. Accordingly the protection offered at a given z value is increased from D to D + δ.

Figure 7 shows the azimuth pattern of the composite antenna (curve 1). If the user is prepared to maintain his head azimuth, referred to the base station, with a maximum error of $\pm \theta/2$, then θ is the working azimuth coverage and the power accepted by the antenna has to be increased, relative to the basic dipole, by (δ - β)dB to give the same operating range at the worst allowed azimuth depointing. Figures 8 and 9 (curves 1) show the user protection achieved against the azimuth coverage.

If the space between the dipole and reflector is filled with a dielectric and is reduced to a small thickness, then the structure has the appearance of a microstrip patch radiator. A high dielectric constant will reduce the dipole length and this in turn improves the shielding provided by a reflector of given outline. The microstrip structure has advantages in circuit integration, although a very thin substrate tends to work against ohmic efficiency of the radiator.

The patch and ground plane are analogous to the dipole and reflector respectively, but a practical microstrip radiator differs from the dipole/reflector pair in that the patch is fed in an inherently unbalanced way from the microstrip line which shares the same ground plane. Unlike the dipole/ reflector, the structure may not have a symmetrical E - plane pattern.

In the present example a patch was located on a high permittivity substrate, the material chosen being alumina with k = 9.0. A thickness of 0.635 mm was selected because that is the standard thickness.

Figure 2 shows the geometry of the patch designed, using Pozar's package, for a design resonant frequency of 2 GHz and an impedance of 50 ohms. The resultant antenna was found to give a resonance at 1.98 GHz, where reflection fell to -25 Db and measurements were made at this frequency.

Figure 5 shows the "near side" and "far side" plots of Ey against z where the two curves were referenced to the simple dipole curve 1 of Figure 4. It can be seen that the patch is about the same far field gain as the dipole with reflector. Figure 7 shows the H plane far field pattern of the patch and Figures 8 and 9 show the user protection versus coverage.

Endfire Antennas

A preferred endfire antenna is a printed tapered slot antenna of which the Vivaldi is noted for its broad band performance. It is normally made at least one wavelength long, but such a length would make the structure too unwieldy for a portable phone. Although a shorter structure would mean that the antenna would probably not work as a true travelling wave radiator, it has been surprisingly discovered that a shorter length version of the Vivaldi antenna give significant user protection. Figure 3 illustrates such an antenna, using the greatest length that appeared potentially tolerable.

The structure had minima in the input reflection at 1.63 GHz and 2.2 GHZ but was fairly broadband. Operated at 1.98 GHz, the return loss was 8.6 dB. Figure 6 shows the front and rear side curves of electric field intensity along the z axis, as before. In these plots z = 0 corresponding to 0.5 cm from the front and rear edges of the dielectric substrate, respectively. The far field H plane pattern, and protection factor, are shown in Figures 7, 8 and 9 as before.

Physical Separation

A preferred way of achieving physical separation between the antenna and the user's head is by increasing the distance of the antenna from the main body of a phone in a direction away from the user's head. By way of example, the antenna is placed on an extended "stalk" which has the further advantage of tending to improve the omnidirectionality of the pattern by reducing the blockage caused by the user's head. Such an antenna may be located on a telescoping member so that the full length of the stalk is only achieved when the phone is in use.

Figure 10 illustrates the design of an extended antenna arrangement. The object of the choke sleeve is to confine the radiating currents near the end of the structure. For an efficient radiator, only a section about one-half wavelength long needs to support currents which implies, at these frequencies, a length of only about 7 cm at the end of the stalk. This not only maximises the user protection but makes the antenna similar to a half wave dipole in terms of its convenient impedance and its vertical plane polar pattern. The latter, being fairly broad and peaking at broadside, is quite satisfactory for the phone application.

The dipole shown in Figure 10 is a half wavelength at 2 GHz. Measurements of the input reflection coefficient show that minimum reflection actually occurs at 1.78 GHz in a 50 ohm system. The behaviour of the dipole is therefore fairly close to that of a true half-wave dipole, some modification being expected due to the choke sleeve and PTFE spacers.

With the antenna excited at 1.78 GHz, Figure 11 shows a plot of the intensity of the electric field. The plot includes an outline of the antenna in its correct spatial relationship to the contours. The plot actually shows the intensity of the vertical component of the field, which is measured with the probe dipole vertical and its transmission line parallel to the y axis. An interesting feature of this plot is the crowding of the contours in the region labelled X, implying that the current in the antenna is falling rapidly, with y, in this region. Using a loop probe close to the conductors, a separate measurement of the current profile was made using a higher spatial resolution than in the contour plots. Figure 13 shows the profile deduced and confirms that the choke sleeve has the desired effect of keeping radiating currents close to the end of the stalk.

In assessing the extent of user protection, three representative points on a user's head were considered. One such point is at the outside surface of the ear near its centre, and the other two are 6 cm vertically above and below this point. The protection factor as a function of the vertical height extension is plotted for each point. This extension represents the true mechanical penalty for gaining the protection. If no protection is attempted, the antenna can be assumed to resemble a conventional half wave dipole. Hence to assess the protection factor, the field incident of the chosen head point, from the extended antenna at its given height should be compared with a field that such a reference dipole would produce if centred at the user's ear. Also, since the two antennas do not have identical gains or patterns, the power fed to them should be adjusted to give the same performance in communication terms. Accordingly the power fed to the two antennas should be adjusted to make the far field intensities equal in a plane broadside to the antenna.

The comparison neglects modifications of both the near and far fields by the head, and is therefore somewhat unfair to the extended antenna whose omnidirectionality should improve as it is raised above the head.

Figures 14 and 15 show the protection factors for the three points on the head. The parameter z in these plots is the distance from the outer surface of the ear to a vertical line along which the vertical displacement of the antenna's centre is being made. For the upper point, the protection at small extensions is negative since it initially moves closer to the antenna centre.

Near Field Phased Arrays

Although arrays have been considered where the problem is to produce a controlled radiation pattern in far-field angular space, arrays have not previously been considered relevant to the production of a controlled field in a volume of real space. In the near field of an array, field variations over regions of real space are produced not just by relative phasing effects, but also because the contributions from different parts of the structure have amplitudes and field vector directions which vary in different ways with position. In addition, field terms varying as $1/R^2$ and $1/R^3$, as well as $1/R$, are present and no simple assumptions can be made about their dominance. It has been surprisingly discovered that a near field phased array can be used to produce an antenna arrangement which will shield the user of a portable phone from radiation to a considerable extent.

An array is considered which consists of two half-wave dipoles, pointing along the vertical axis, horizontally separated by one-quarter wavelength, and excited in quadrature. In the horizontal (H) plane, this array produces a cardioid pattern with a null in the reverse endfire direction. In use this array has the z axis, on the side of the far-field null, passing through the centre of the user's head from ear to ear.

Figure 16 shows the near-field electric field intensities of this array. It is immediately apparent that a region of substantially reduced field does continue well into the near field and that this region fills a large enough volume to give useful user protection. By comparing the fields with those of a single half-wave dipole, excited at a level giving the same far-field strength in the best direction, it was found that the effective protection of point X in the figure (10 cm from the array centre) is 15 dB.

On the null axis, the E fields of the two elements are in the same direction but of an equal amplitude. Also, at small distances, the phase of a dipole's electric field lags behind the phase expected from a linear change which distance. To increase cancellation at finite distance, the excitation was increased in the element at the greater distance from the low field region, the phase difference between the excitations exceeding 90 degrees. Figure 17 illustrates this situation, the ratio of excitation currents being now 1.35 and the phase difference being increased to 100 degrees. The low field region has been "moved in" towards the antenna. The protection at point X is now 22 dB.

Referring to Figure 18 of the accompanying drawings, there is illustrated a simple form of handset phased array. As will be seen in this drawing, the handset supports two vertically polarised radiators which may be electrically short, or up to about /2 in length. They are separated by about /4 in a horizontal direction and the line of separation is approximately parallel to the line between the user's ears.

The radiator further from the user is excited with a current that is about 1.4 times the magnitude of that in the other radiator, and with a phase lagging about 100° behind it. The system is assumed to be operating close to 1.89 GHz, giving $\approx$ 16 cm. The corresponding separation of the elements is about 4 cm. In another embodiment this separation is reduced to as little as 2 cm, perhaps sacrificing some electrical efficiency.

As indicated in Figure 18, the simplest realisation of a simple 2-element phased array uses two conventional straight monopole antennas mounted on top of a fairly conventional handset. There is a substantial area of metal screening inside the top of the handset outer case, as shown in the drawing. This forms a ground plane and a counterpose to each of the radiators. It does not need to be continuous or to enclose all of the handset electronics.

The network N performs three functions: splitting of the input power, control of the relative amplitude and phase of the currents in the two radiators, and matching of the impedance at the input port to suit the transmitter. It is realised as a nominally lossless three-port network.

In another embodiment, the strong currents flowing on the outer surface of the ground plane, which occur in connection with the Figure 18 embodiment, are avoided so that as far as possible only vertical currents occur. Figure 19(a) illustrates configurations using "skirt" dipoles where the principal radiation contributions are from currents on the projecting upper half of the dipole and on the skirt.

Figure 19(b) illustrates the variation in which a discone structure is adopted giving overall reduced length. A further variation is shown in Figure 19(c) which makes use of a cylindrical sleeve dipole providing reduced lateral size with less bandwidth.

Referring now to Figure 20, a phased array is realised in printed circuit form. Each radiator is fed from a microstrip line, of which the live conductor projects beyond the ground plane at "a" to form one arm of a dipole radiator. The other half of the dipole is formed by the projecting portion of the ground plane at "b". Shaping of the ground plane at "c" helps to keep radiating currents away from the main part of the handset.

The embodiment shown in Figure 20 illustrates a purely printed microstrip form to split the network N. Phasing is controlled by the position of the line tapping point "d", and relative amplitude by controlled step "e" in the impedance of one of the lines. Additional stub(s) "f" may be provided for an overall impedance match to the transmitter.

In a variation of this embodiment, there are two printed panels one for each radiator. Each is normal to the line of separation of the radiators, and one panel is continuous with the panel carrying the electronics, which in a typical handset is parallel to the side of the user's head.

CLAIMS

1. A portable phone having means for transmitting radiation such that transmission field strengths experienced by the user of the phone are relatively low as compared with those present in adjacent volumes of space.

2. A phone according to claim 1 including a physical shield to shield the user from the incident radiation.

3. A phone according to claim 2 in which the shield is a reflector.

4. A phone according to claim 2 or claim 3 in which the means for transmitting radiation includes an antenna.

5. A phone according to claim 4 including a dielectric medium between the antenna and the reflector

6. A phone according to claim 4 or claim 5 in which the reflector is substantially parallel to the axis of the antenna.

7. A phone according to any one of claims 4-6 in which the antenna is a dipole antenna.

8. A phone according to claim 4 in which the means for transmitting radiation comprises a microstrip patch radiator.

9. A phone according to any preceding claim in which the means for transmitting radiation includes an antenna configured to produce asymmetric near-field transmission field strengths.

10. A phone according to claim 9 in which the antenna comprises an end-fire antenna.

11. A phone according to claim 10 in which the antenna comprises a tapered slot antenna which is shorter than one wavelength of the radiation transmitted.

12. A phone according to claim 11 in which the antenna is a Vivaldi printed tapered slot antenna.

13. A phone according to claim 9 in which the antenna comprises a plurality of transmitters adapted to produce relatively phased transmission fields which interfere destructively so as to reduce the filed strengths experienced by the user.

14. A phone according to claim 14 in which the antenna comprises a near-field phased array.

15. A phone according to claim 14 in which the array comprises two parallel half-wave dipoles.

16. A phone according to claim 15 in which the dipoles are separated by one quarter of a wavelength.

17. A phone according to claim 15 or claim 16 in which the means for transmitting radiation includes means for exciting the dipoles in quadrature.

AMENDED CLAIMS

[received by the International Bureau on 16 May 1994 (16.05.94); original claim 9 replaced by amended claim 2; claims 13-17, 10-12 and 2-8 replaced by amended claims 3-7, 8-10 and 11-17; claim 1 unchanged (2 pages)]

1. A portable phone having means for transmitting radiation such that transmission field strengths experienced by the user of the phone are relatively low as compared with those present in adjacent volumes of space.

2. A phone according to claim 1 in which the means for transmitting radiation includes an antenna configured to produce asymmetric near-field transmission field strengths.

3. A phone according to claim 2 in which the antenna comprises a plurality of transmitters adapted to produce relatively phased transmission fields which interfere destructively so as to reduce the field strengths experienced by the user.

4. A phone according to claim 3 in which the antenna comprises a near-field phased array.

5. A phone according to claim 4 in which the array comprises two parallel half-wave dipoles.

6. A phone according to claim 5 in which the dipoles are separated by one quarter of a wavelength.

7. A phone according to claim 5 or claim 6 in which the means for transmitting radiation includes means for exciting the dipoles in quadrature.

8. A phone according to claim 2 in which the antenna comprises an end-fire antenna.

9. A phone according to claim 8 in which the antenna comprises a tapered slot antenna which is shorter than one wavelength of the radiation transmitted.

10. A phone according to claim 9 in which the antenna is a Vivaldi printed tapered slot antenna.

11. A phone according to any preceding claim including a physical shield to shield the user from the incident radiation.

12. A phone according to claim 11 in which the shield is a reflector.

13. A phone according to claim 11 or claim 12 in which the means for transmitting radiation includes an antenna.

14. A phone according to claim 13 including a dielectric medium between the antenna and the reflector.

15. A phone according to claim 13 or claim 14 in which the reflector is substantially parallel to the axis of the antenna.

16. A phone according to any one of claims 13-15 in which the antenna is a dipole antenna.

17. A phone according to claim 13 in which the means for transmitting radiation comprises a microstrip patch radiator.

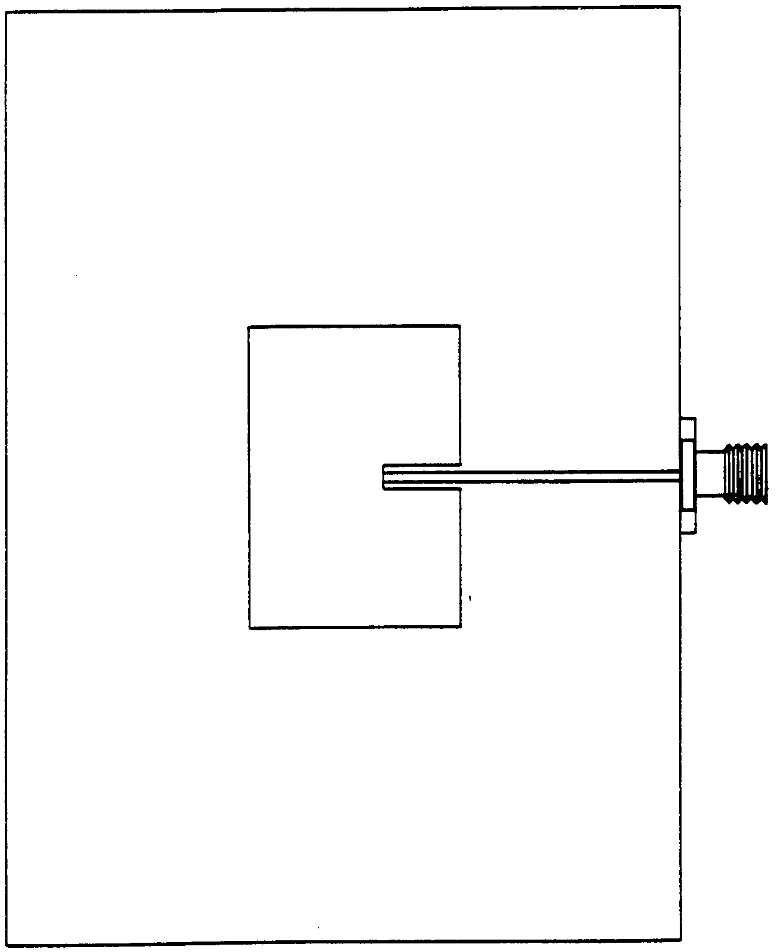

FIG 2

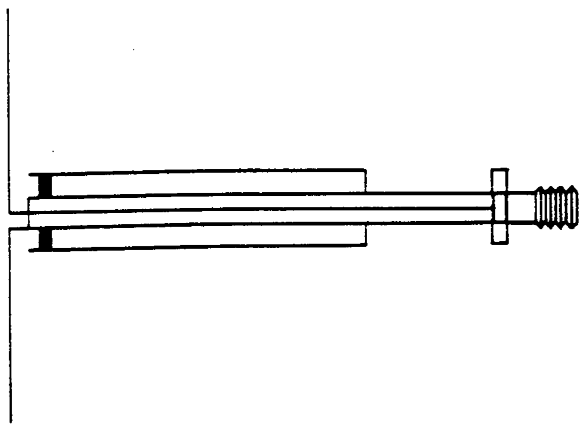

FIG 1

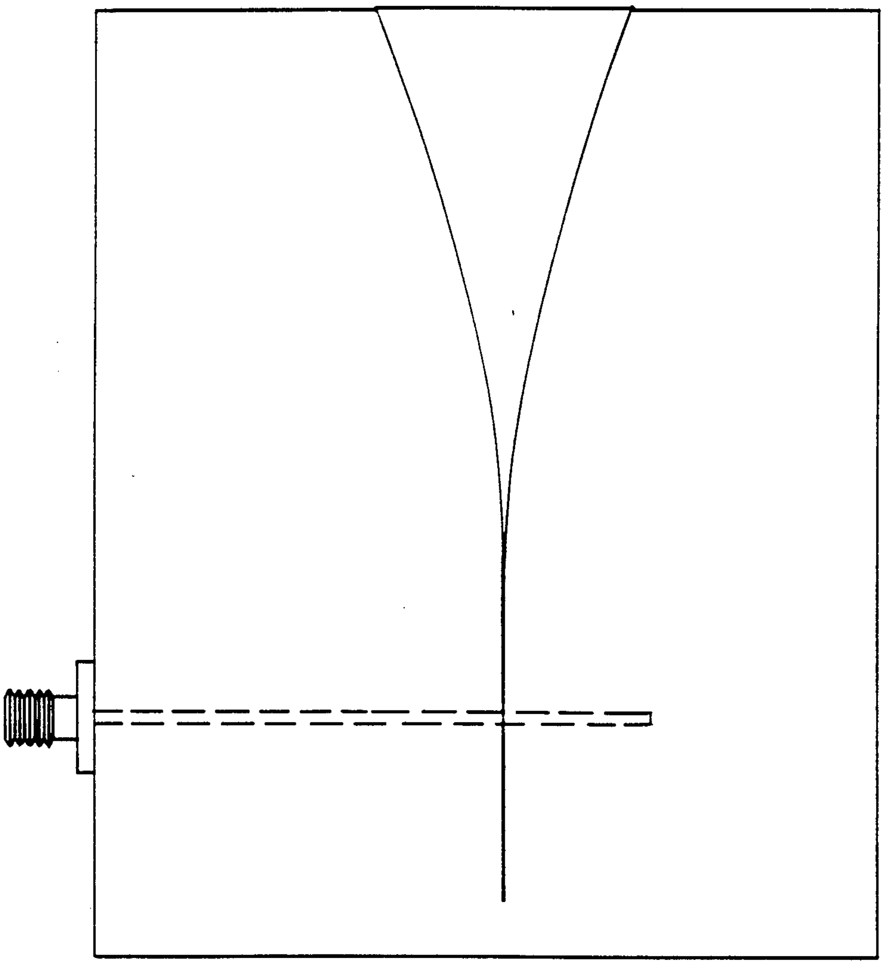

FIG. 3

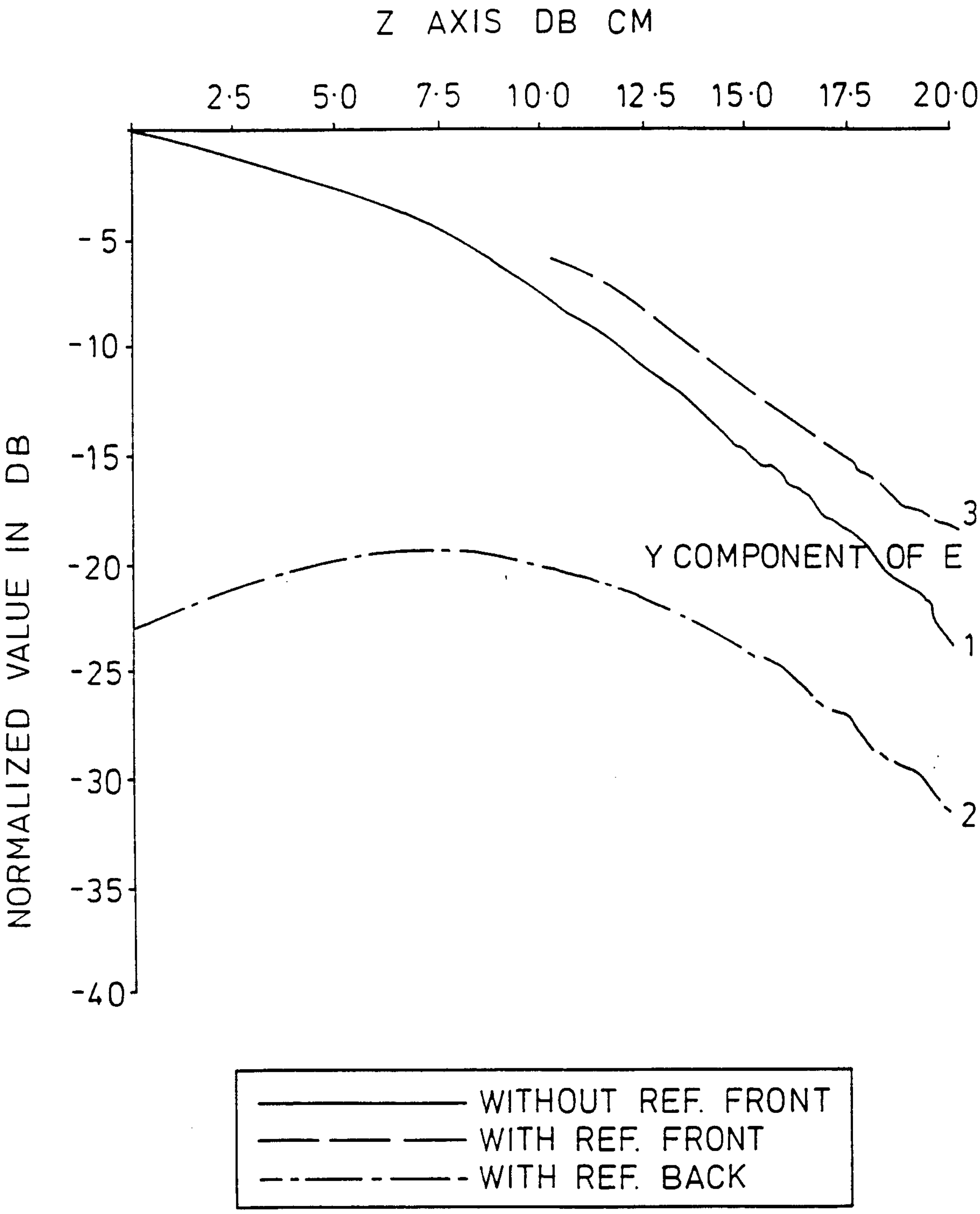
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FIG. 4

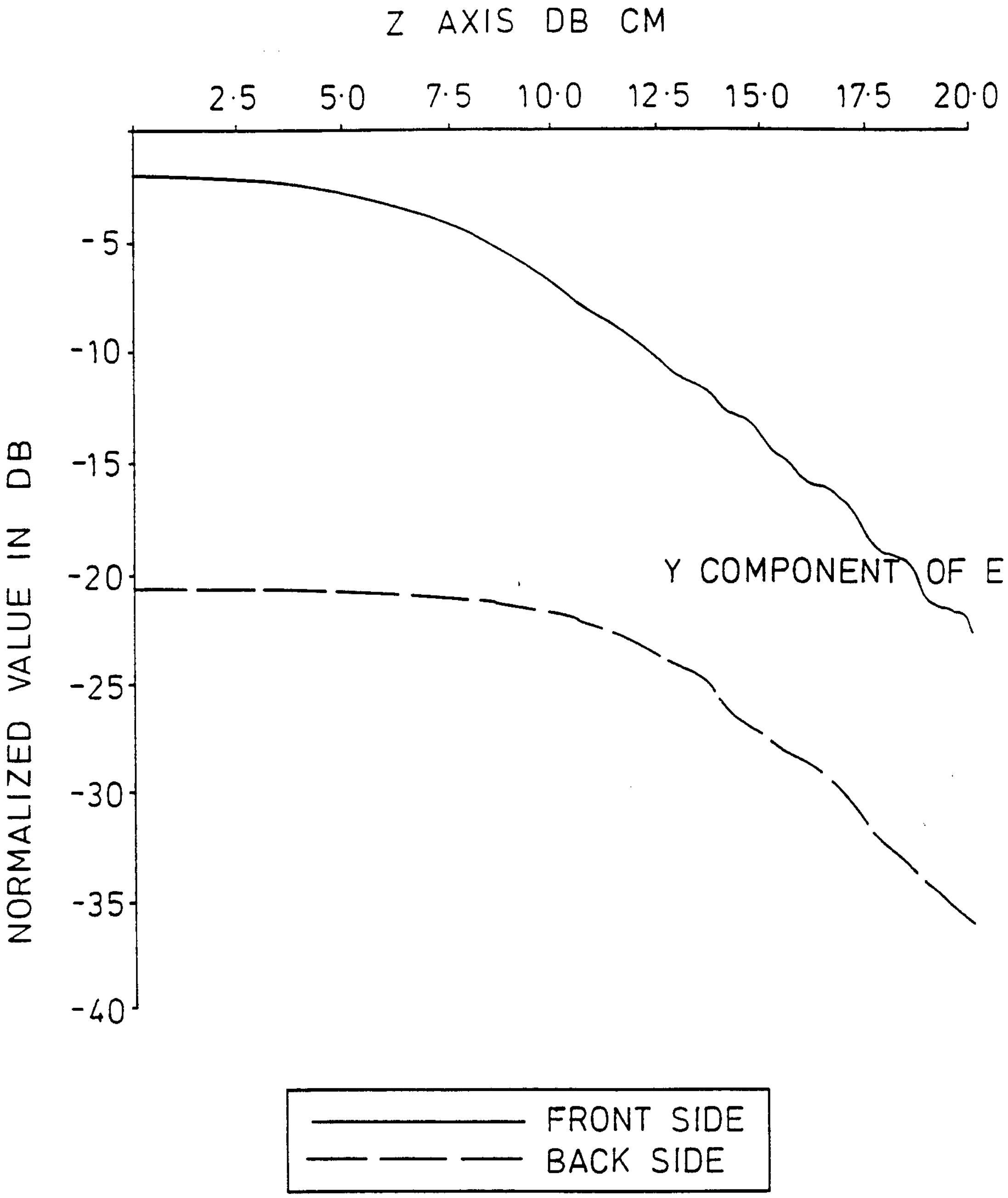
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FIG. 5

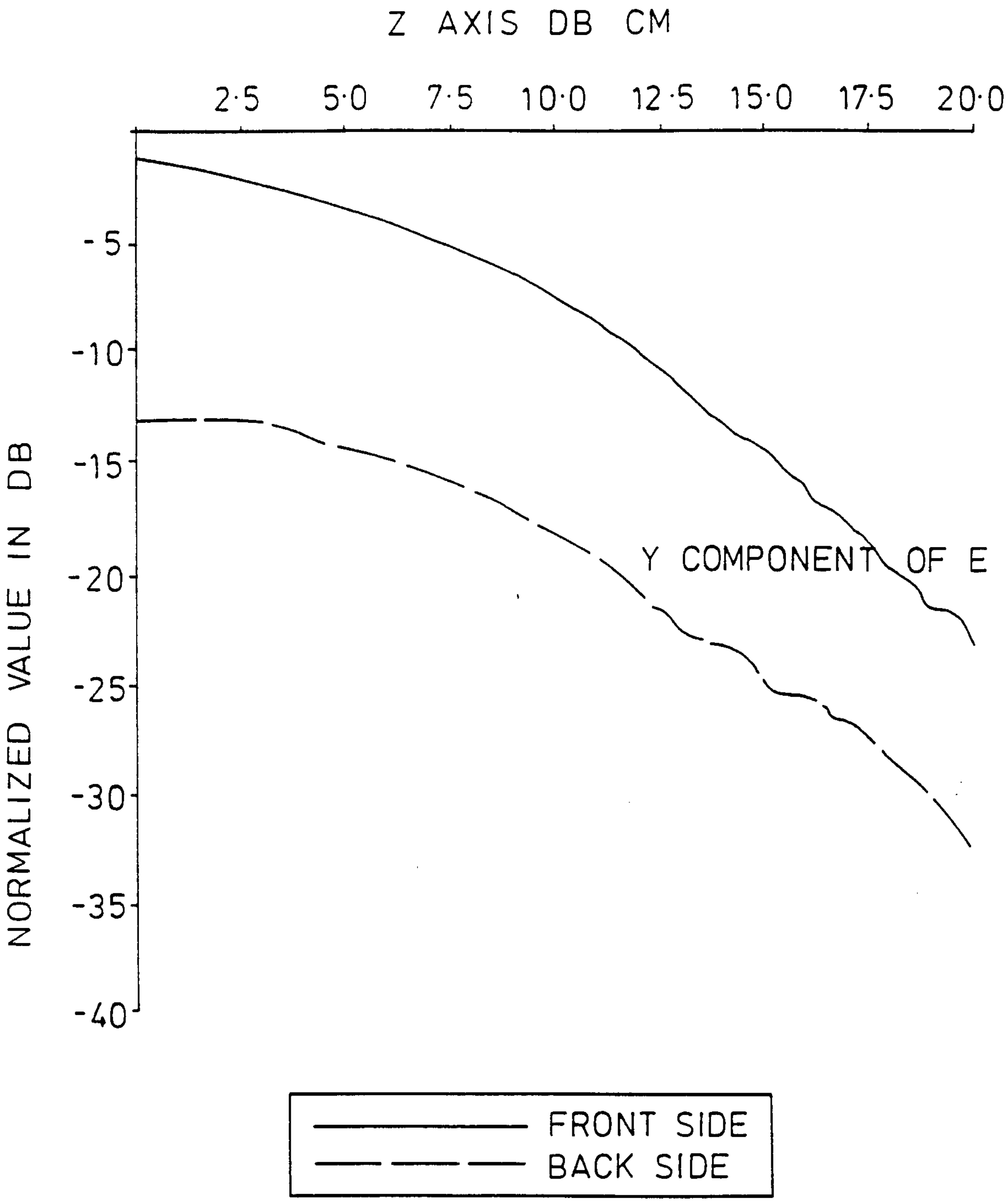
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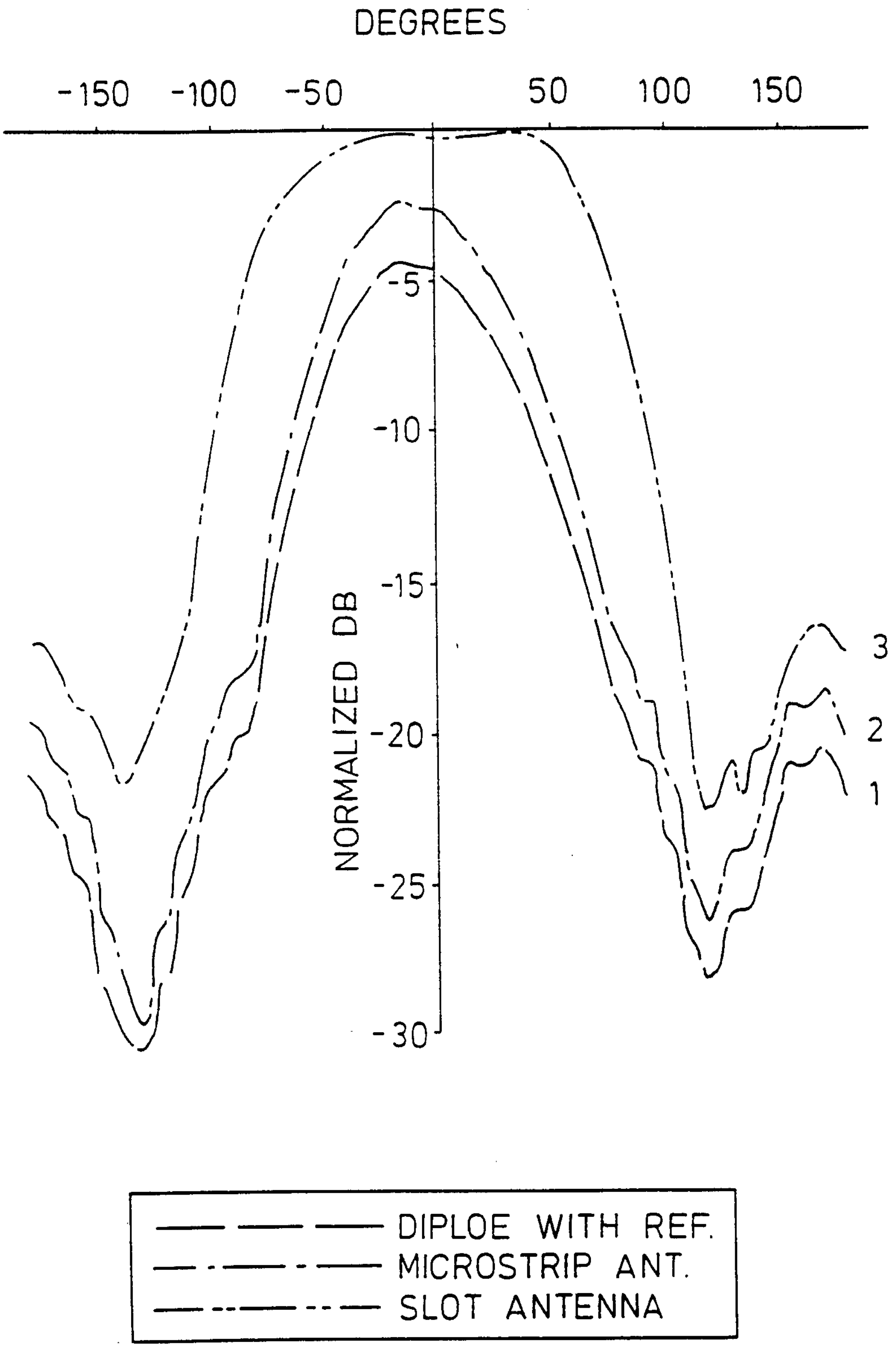
FIG. 6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SLOT ANTENNA

FIG. 7

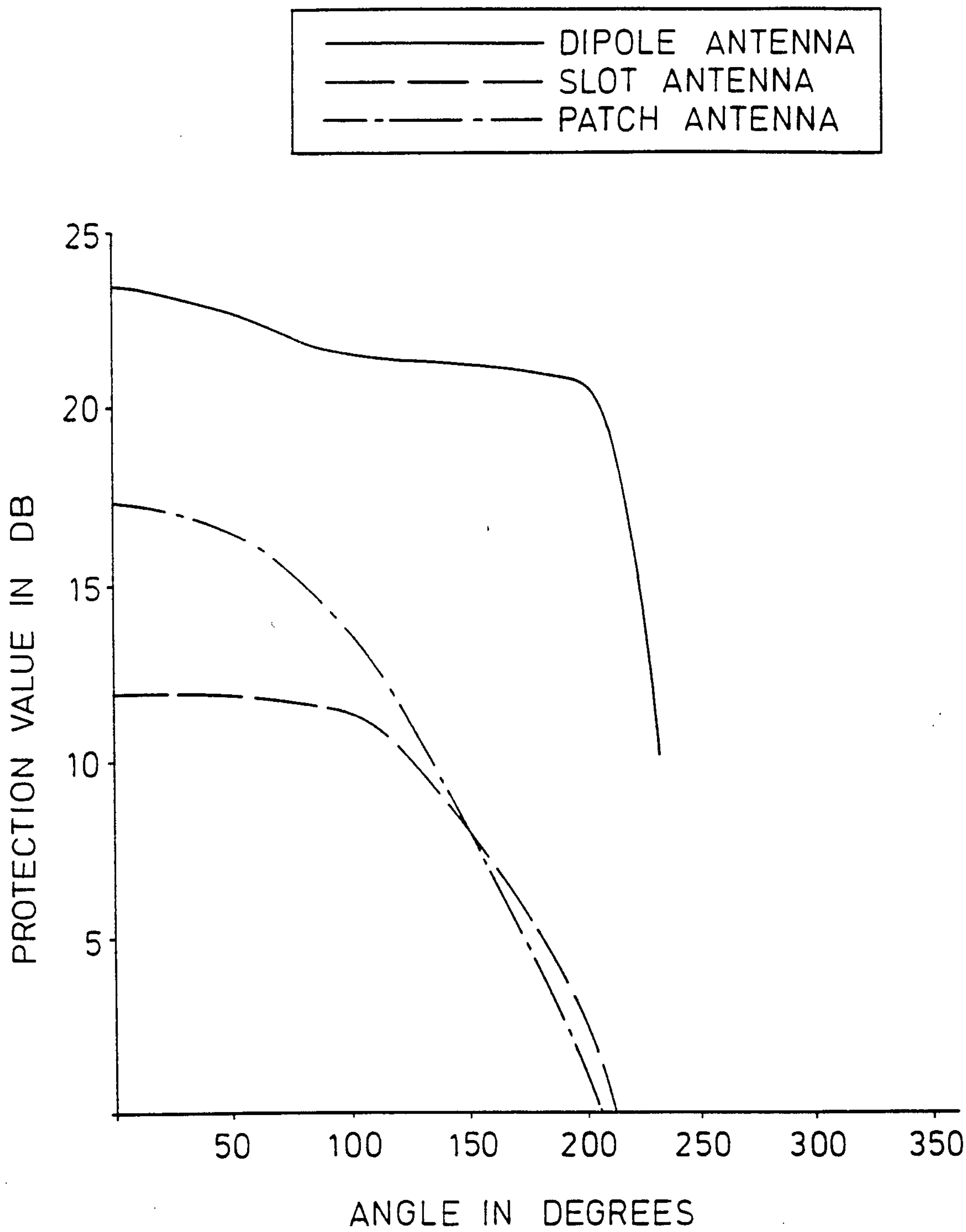
DIPOLE ANTENNA
SLOT ANTENNA
PATCH ANTENNA
25
20
15
10
5
PROTECTION VALUE IN DB
50
100
150
200
250
300
350
ANGLE IN DEGREES

FIG. 8

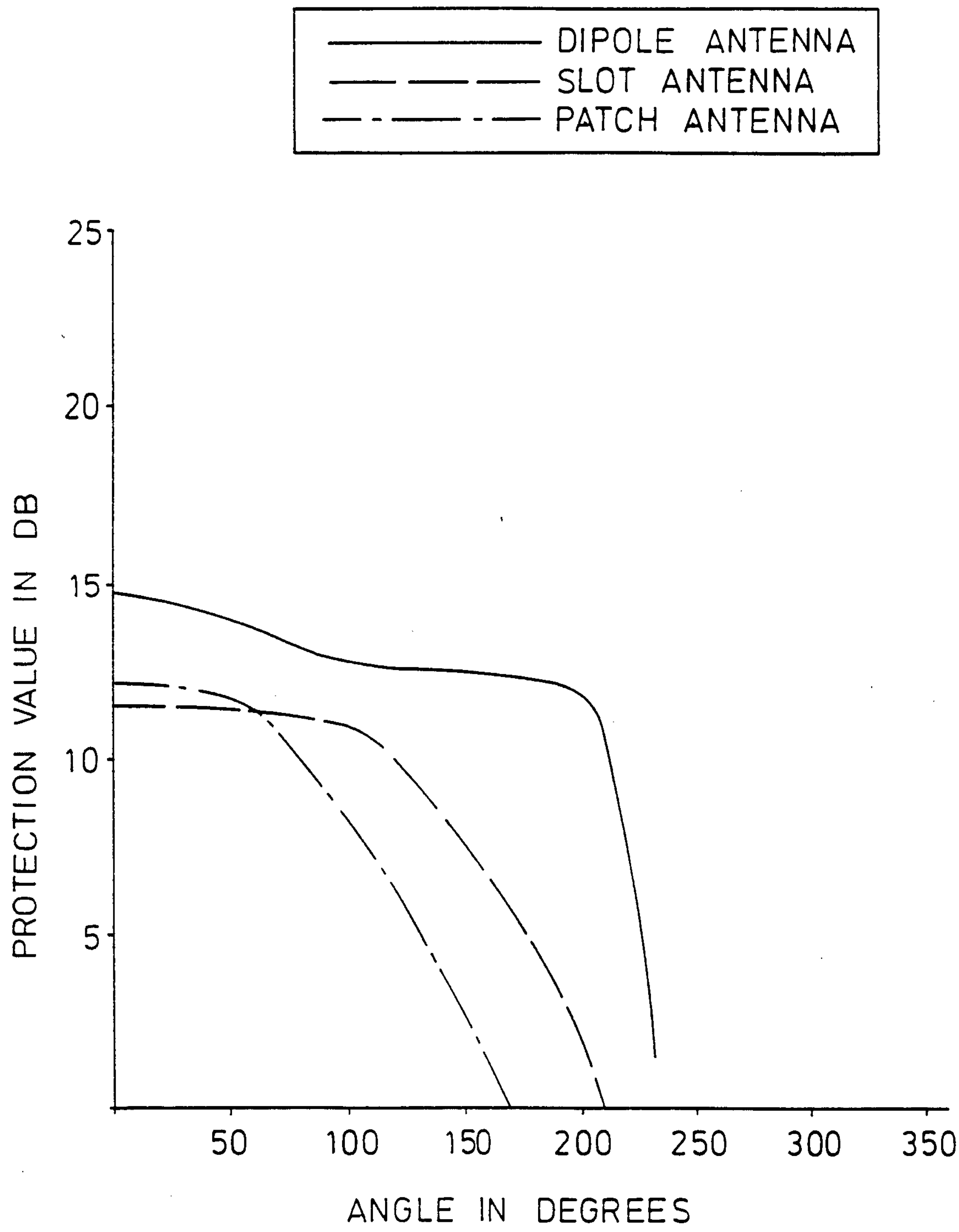
DIPOLE ANTENNA
SLOT ANTENNA
PATCH ANTENNA
25
20
15
10
5
PROTECTION VALUE IN DB
50
100
150
200
250
300
350
ANGLE IN DEGREES

FIG. 9

FIG. 10

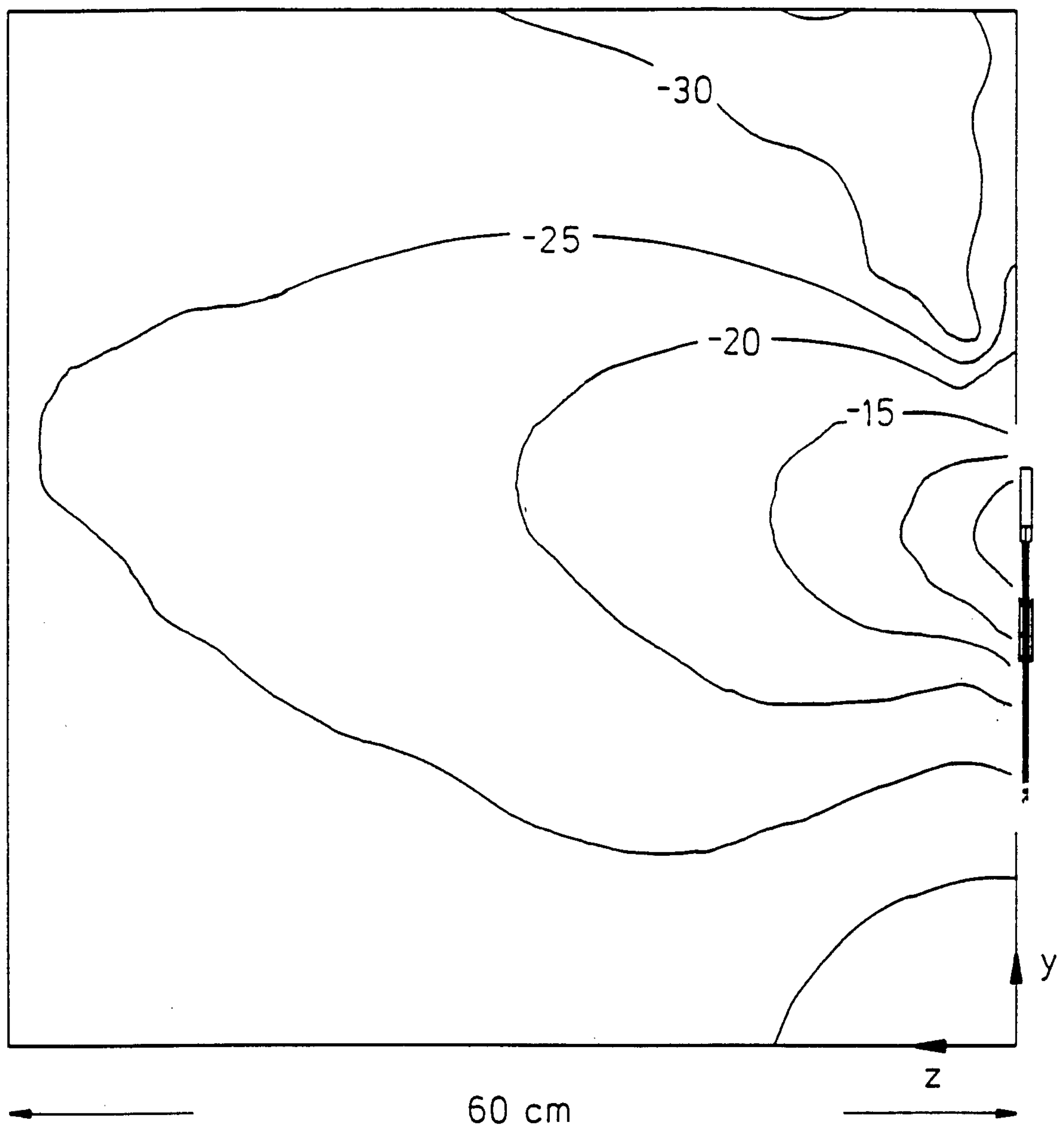

FIG. 11

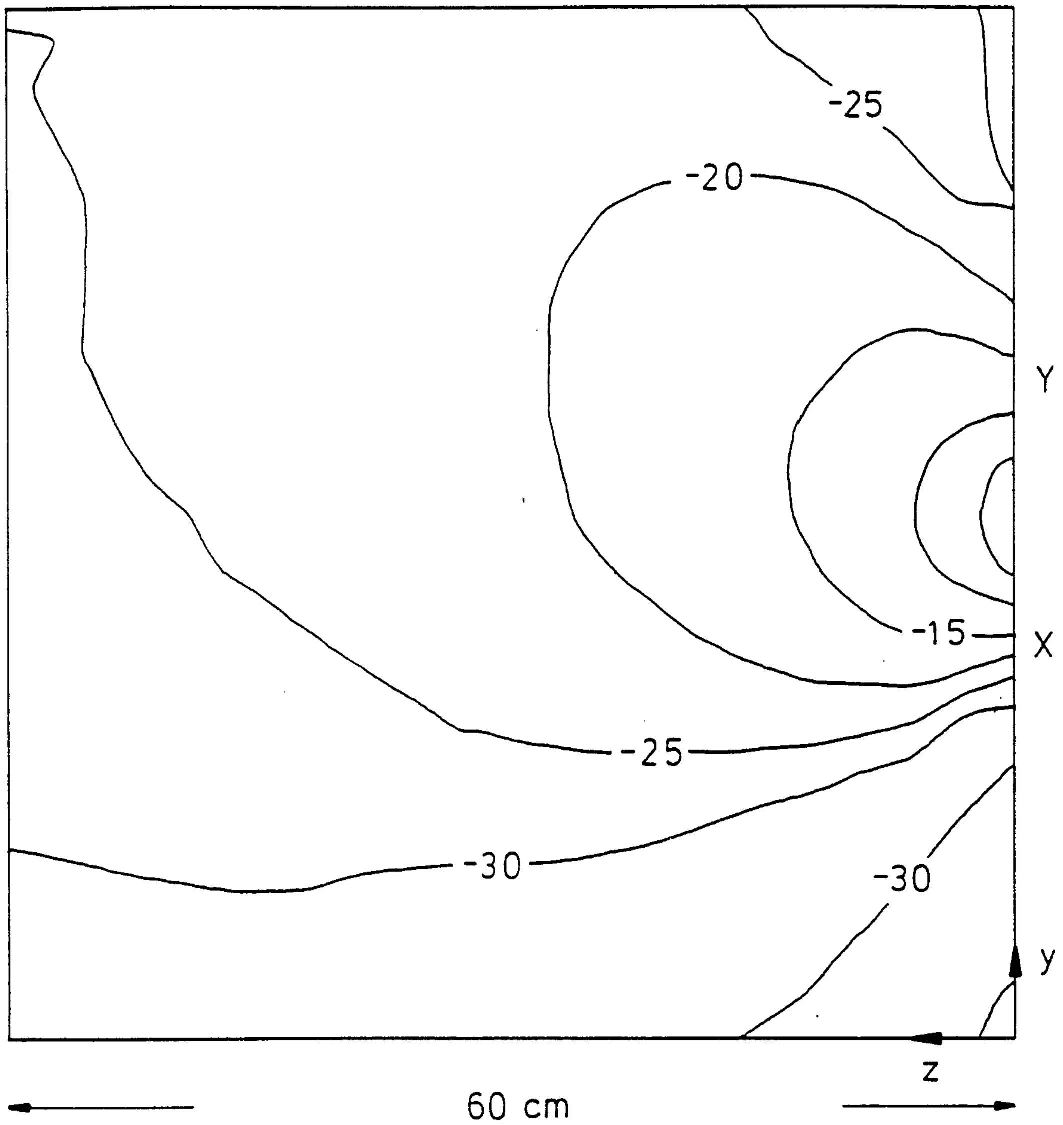

FIG. 12

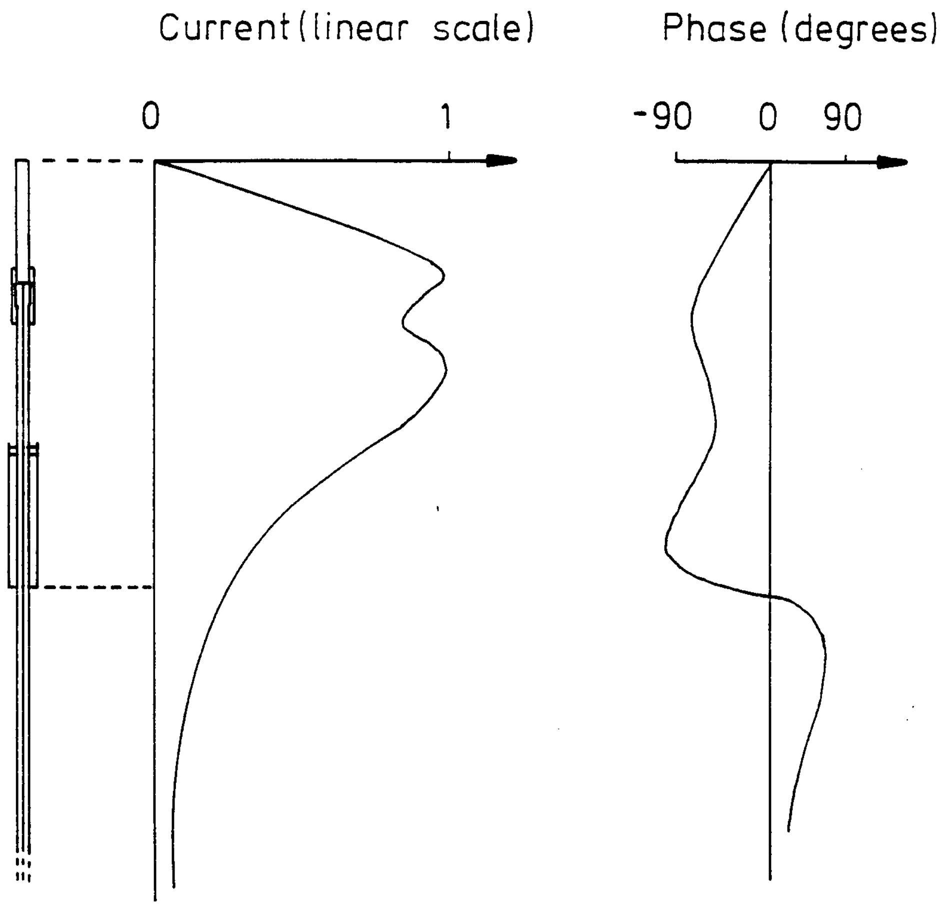

FIG. 13

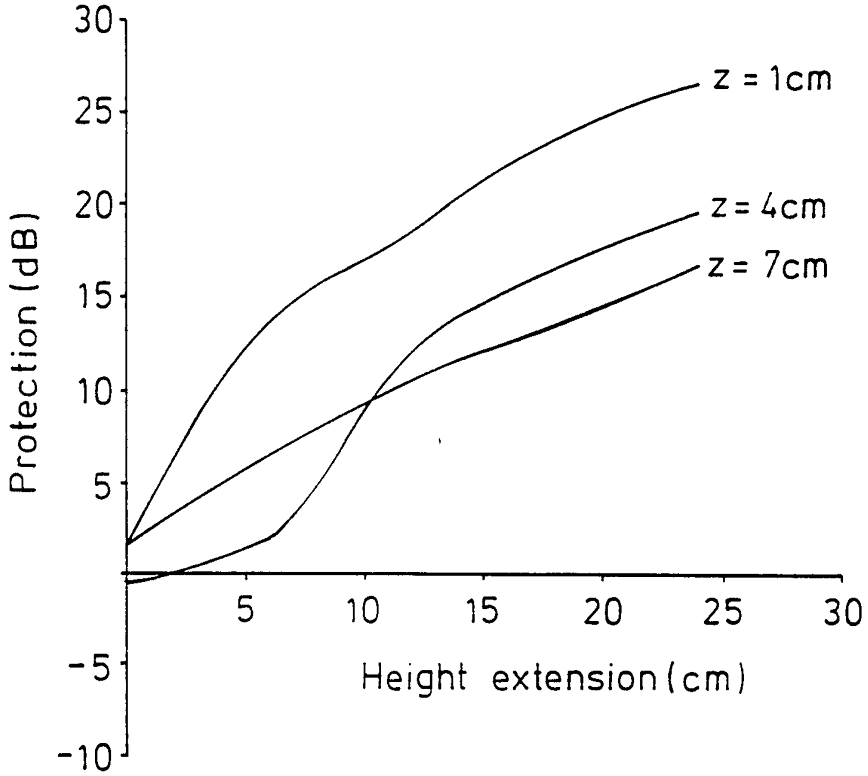
30
25
20
15
10
5
-5
-10
Protection (dB)
z = 1cm
z = 4cm
z = 7cm
5
10
15
20
25
30
Height extension (cm)

FIG. 14

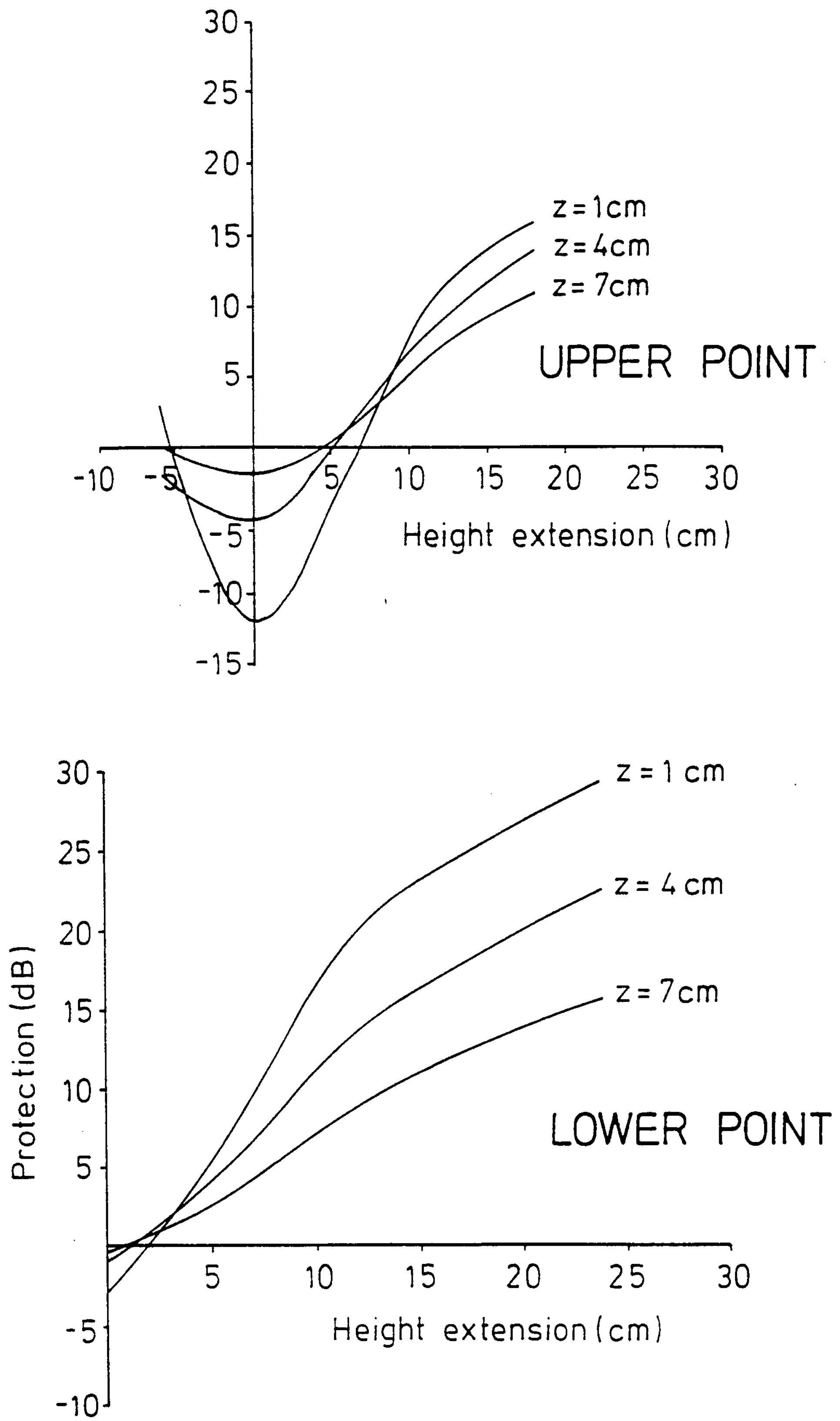
30
25
20
15
10
5
-5
-10
-15
-10
-5
5
10
15
20
25
30
z=1cm
z=4cm
z=7cm
UPPER POINT
Height extension (cm)
30
25
20
15
10
5
-5
-10
5
10
15
20
25
30
Protection (dB)
z = 1 cm
z = 4 cm
z = 7cm
LOWER POINT
Height extension (cm)

FIG. 15

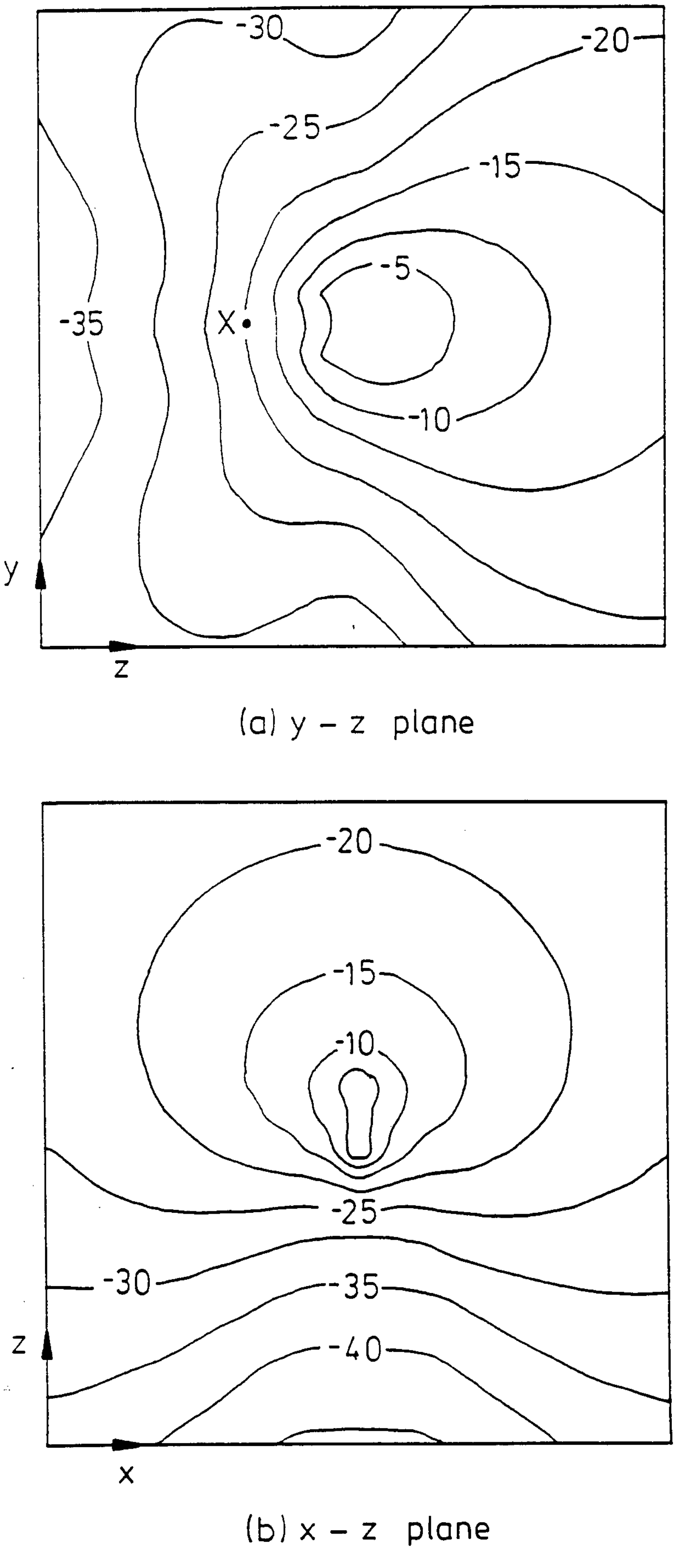

FIG. 16

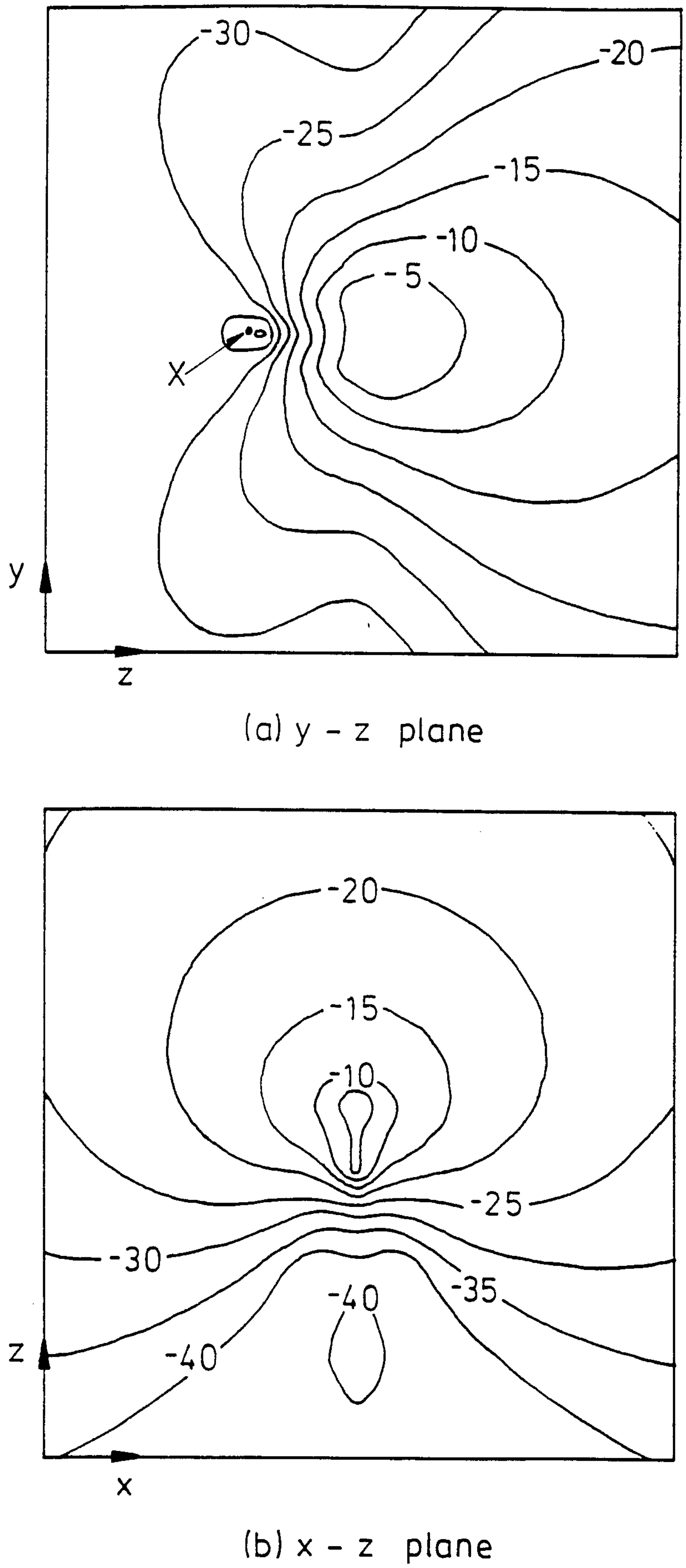

FIG. 17

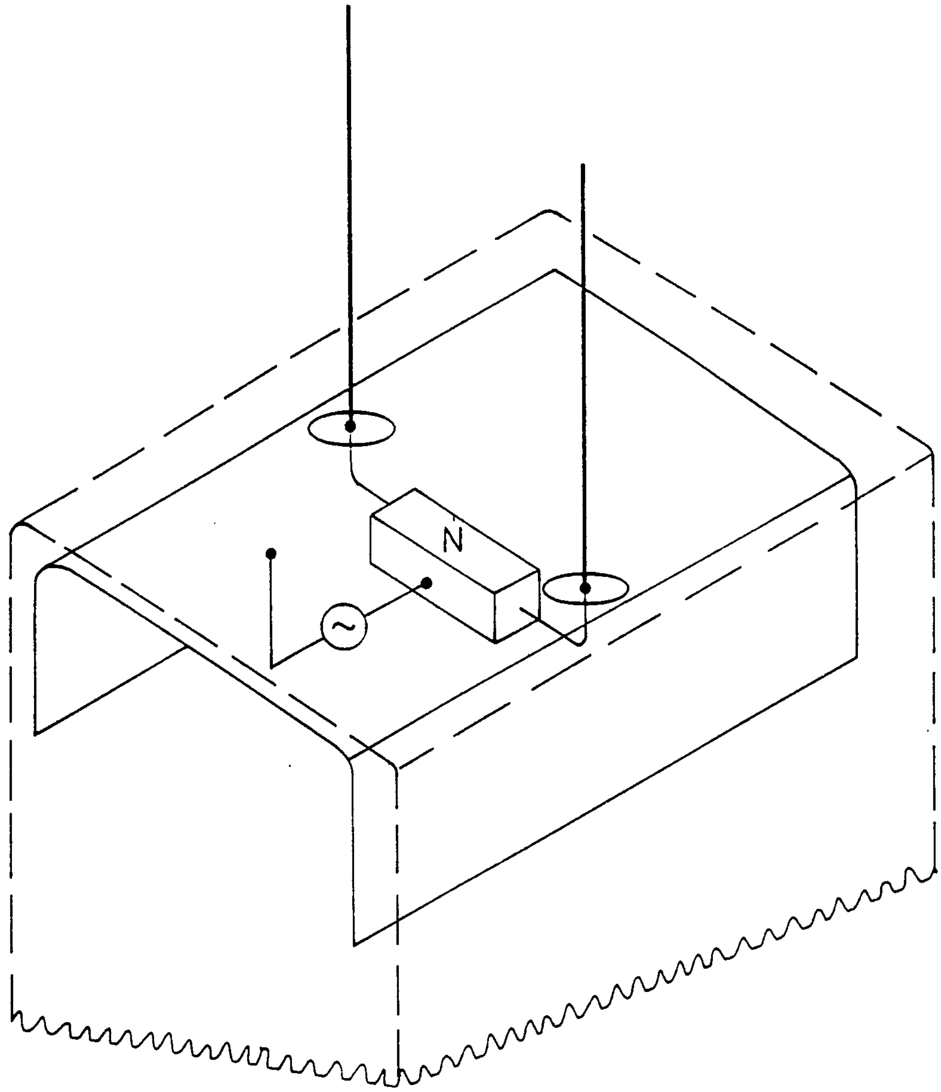

FIG. 18

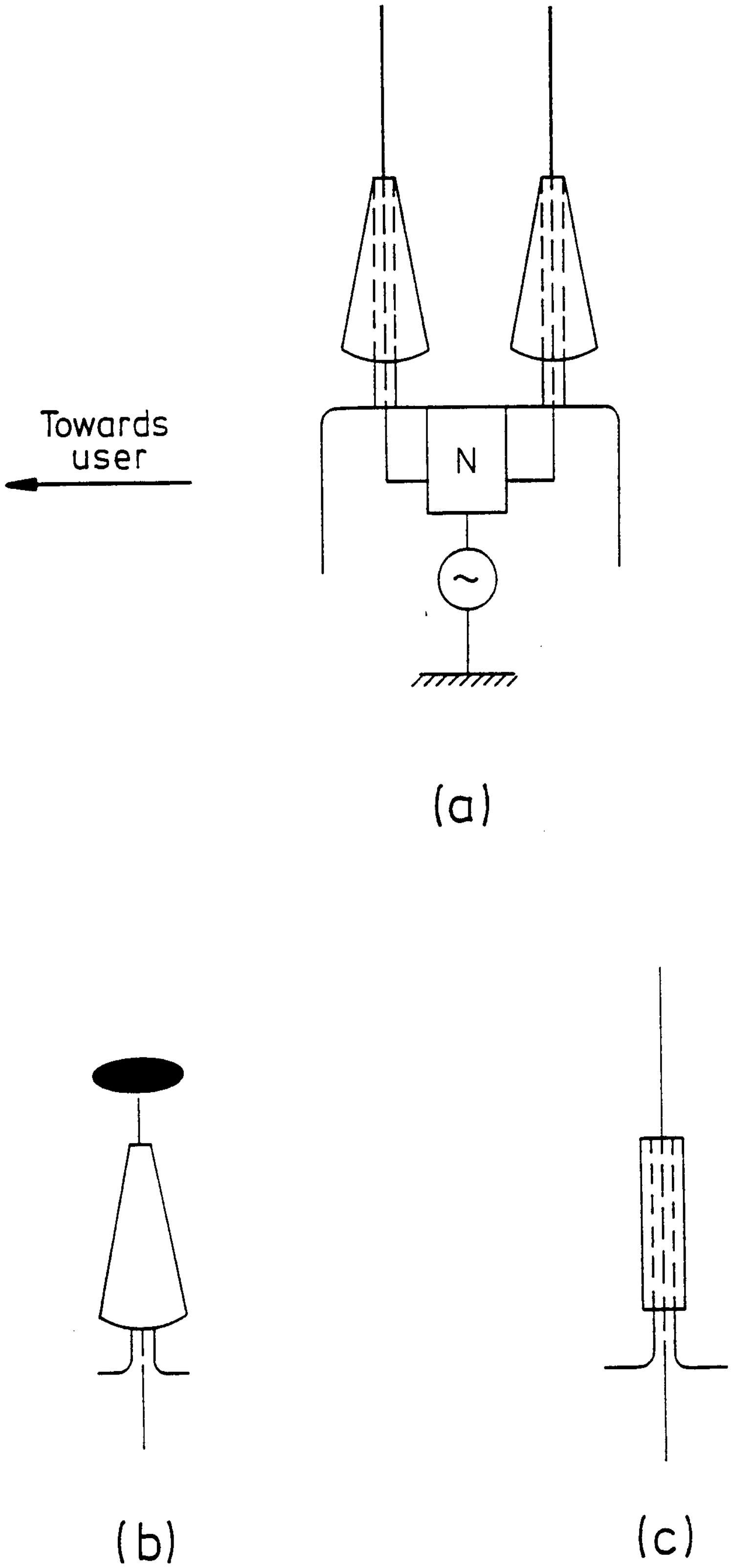

FIG. 19

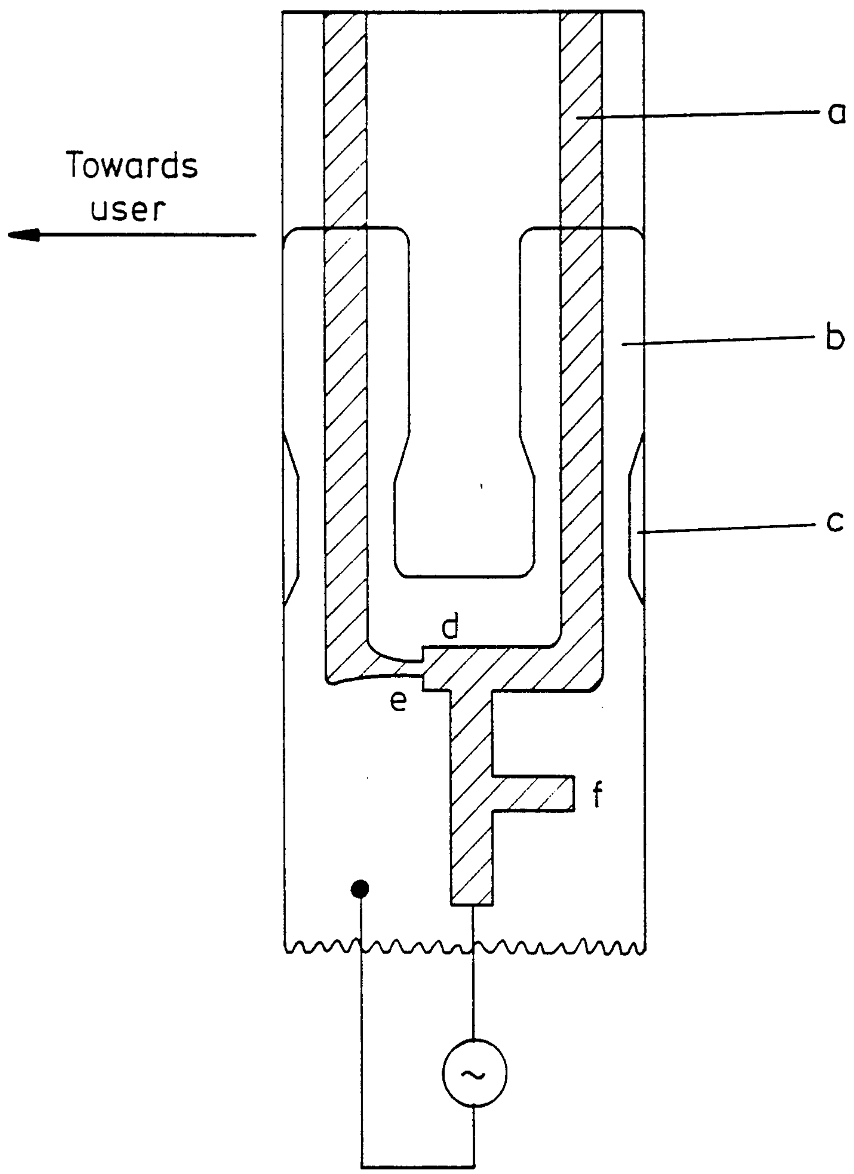

FIG. 20

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 93/02550

A. CLASSIFICATION OF SUBJECT MATTER
IPC 5 H01Q1/24 H04B1/38

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 5 H01Q H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PATENT ABSTRACTS OF JAPAN vol. 16, no. 570 (E-1297)10 December 1992 & JP,A,04 220 851 (MITSUBISHI ELECTRIC) 11 August 1992 see abstract ---	1-4
A	TRANSACTIONS OF THE INSTITUTE OF ELECTRONICS, INFORMATION AND COMMUNICATION ENGINEERS OF JAPAN vol. 74, no. 6 , June 1991 , TOKYO JP pages 1547 - 1555 YAMADA ET AL. 'Base and Mobile Station Antennas for Land Mobile Radio Systems' see page 1553, paragraph 4.2 - page 1554; figures 14-17 --- -/--	1,15-17

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

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Date of the actual completion of the international search	Date of mailing of the international search report
25 February 1994	17.03.94

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+ 31-70) 340-3016	Angrabeit, F

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 93/02550

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	IEEE INTERNATIONAL CONFERENCE ON COMMUNICATIONS BOSTONICC/89 vol. 1 , June 1989 , BOSTON,MA pages 216 - 222 ESTABROOK ET AL. 'A 20/30 GHZ PERSONAL ACCESS SATELLITE SYSTEM DESIGN' see page 219, paragraph 3 - page 220; figures 4-7 ---	1,8,9, 13,14
A	WO,A,90 13152 (NOVATEL COMMUNICATIONS) 1 November 1990 see page 3 see page 5; figures 1-4 ---	1,8
P,A	US,A,5 185 611 (BITTER,JR.) 9 February 1993 see the whole document ---	1,10-12
A	PATENT ABSTRACTS OF JAPAN vol. 8, no. 206 (E-267)20 September 1984 & JP,A,59 092 629 (HITACHI) 28 May 1984 see abstract ---	1
A	PATENT ABSTRACTS OF JAPAN vol. 16, no. 23 (E-1157)21 January 1992 & JP,A,03 238 936 (HITACHI) 24 October 1991 see abstract -----	1

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 93/02550

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO-A-9013152	01-11-90	AU-A- 5435190	16-11-90
		CA-A- 2014629	18-10-90
		US-A- 5231407	27-07-93
US-A-5185611	09-02-93	NONE	