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		10.260 EPC	April 12, 1988 Kr/ha

European Patent Application No. 88103388.0
MASPRODENKOH KABUSHIKIKAISHA

Referring to Rule 88 EPC we file a new sheet 4/3 of the drawings in triplicate, wherein a mistake has been removed. Fig. 9 of the original drawings comprises the reference numeral "t2" twice, namely for indicating the thickness of the cylindrical part 35 as described in the specification page 19, lines 22 and 23 and for indicating the thickness of the receiving domain 17h, which corresponds to "t1" of fig. 7. In the enclosed new sheet of drawings, fig. 9 has been corrected by removing the wrong reference numeral "t2" for the thickness of the receiving domain 17h.

Kramer

Enc.
1 sheet of drawing
(fig.7,8,9,10,11)
in triplicate

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A request for correction of the originally filed drawings has been filed pursuant to Rule 88 EPC. A decision on the request will be taken during the proceedings before the Examining Division (Guidelines for Examination in the EPO, A-V, 2.2).

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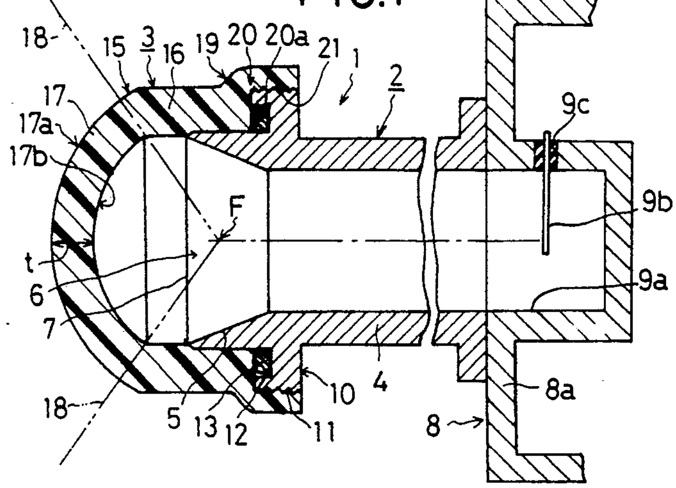
(54) **Primary radiator for parabolic antenna.**

(57) An illumination aperture (6) for receiving radio waves in a radio wave introducing member (2) is blocked by a covering member (17), and thus dust is prevented from coming into the illumination aperture externally by the covering member. The covering member is so thick as will coincide with the trough in a transmission loss curve of radio wave of the synthetic resin used as a forming material for the covering member. Accordingly, a mechanical strength of the covering member is high. Then, an expected attentuation of the radio wave going toward the illumination aperture through the covering member is very little.

FIG.1



EP 0 322 498 A2

PRIMARY RADIATOR FOR PARABOLIC ANTENNA

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a primary radiator used in a parabolic antenna for receiving radio waves such as microwave, millimeter wave and the like. More particularly, the invention relates to a primary radiator having the radio wave receiving opening covered with a covering member, thereby preventing incoming of dusts from the opening toward the interior.

2. Description of the Prior Art

In a primary radiator, if dust is incoming from a radio wave receiving opening provided on its one end, then the dust comes to stick on a receiving member provided on the other end through an internal space in the primary radiator. As a result, insulations degrade in the receiving member, leading to a defective operation.

Now, therefore, the aforementioned opening will be covered with a covering member, thereby preventing the incoming of dusts. Such art is known, for example, in Japanese Utility Model Laid-Open No. 121306/1985.

If the covering member is mounted as mentioned above, the radio wave comes into the primary radiator by way of the aforementioned covering member, therefore the covering member is capable of giving a loss to the radio wave.

Accordingly, the covering member was formed as thin as possible in the past, thereby minimizing the aforementioned loss. However, if pecked at by birds or hit on by foreign matters blown away by the wind, such thinned covering member is easily broken down to lose its dust protective effect.

SUMMARY OF THE INVENTION

A first object of the invention is to provide a primary radiator for which incoming of dusts can be prevented by a covering member.

A second object of the invention is to provide a primary radiator for which a covering member is formed to a satisfactory thickness, thus the covering member ensuring a mechanical strength full to an impression of external forces such as pecking by birds, hitting by foreign matters and so forth.

A third object of the invention is to provide a primary radiator for which a loss of radio wave due to a covering member formed to a large thickness, as required, can be minimized to the utmost extent, thereby receiving radio waves efficiently.

In the invention, a thickness of the aforementioned covering member is selected to the thickness coincident with the trough in a transmission loss curve of radio wave of a synthetic resin material used for formation.

Accordingly, the thickness can be adjusted to a thickness sufficiently large to obtain a required mechanical strength, and at the same time, even such large thickness is substantial enough to minimize a loss to arise in the process of the radio wave transmitting the covering member.

Other objects and advantages of the invention will become apparent during the following discussion of the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a longitudinal sectional view of a primary radiator with the intermediate portion partly omitted therefor.

Fig. 2 is a graph indicating transmission loss characteristics of radio wave of one example of a synthetic resin forming a covering member with reference to various frequencies.

Fig. 3 is a drawing exemplifying a primary radiator in service.

Fig. 4 and Fig. 5 are longitudinal sectional views representing different examples of a covering member each.

Fig. 6 is a graph indicating a difference in transmission loss curve of radio wave according to a synthetic resin material.

Fig. 7 is a longitudinal sectional view representing a further different example of the covering member.

Fig. 8 is a graph indicating transmission loss characteristics of radio wave of a synthetic resin material different from Fig. 1 and Fig. 6.

Fig. 9 is a view, partly broken, representing another example of a shape of the covering member.

Fig. 10 and Fig. 11 are views representing other examples of an installing means of the covering member to a primary radiator body each.

Fig. 12 is a longitudinal sectional view representing a different example of the form of a radio wave introducing member.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In Fig. 1, a reference numeral 1 denotes a primary radiator used for receiving a 12 GHz band radio wave as one example of a microwave. The primary radiator 1 comprises a cylindrical body 2 indicated as one example of a radio wave introducing member, and a covering member 3 provided on the nose thereof.

The body 2 is formed cylindrically by means of a conductive material such as copper, aluminum alloy, brass or the like. In the body 2, a reference numeral 4 denotes a waveguide part, which is 21 mm, for example, in inside diameter. This may be a circular waveguide corresponding to C-120 of IEC Standards. A reference numeral 5 denotes a horn part ranging to one end of the waveguide part 4, with its inside working as an illumination aperture 6 for receiving radio waves. A reference numeral 7 denotes an aperture end of the horn part 5. A frequency converter 8 is coupled to the other end of the waveguide part 4. In the frequency converter 8, a reference numeral 9 denotes a receiving member, comprising a cavity for resonance 9a and a probe 9b provided therein. In the receiving member 9, a radio wave of waveguide mode coming into the cavity 9a through the waveguide part 4 is extracted as a signal of coaxial mode by the probe 9b. Then, the extracted signal is given to a frequency conversion circuit provided within a case 8a of the frequency converter 8, not indicated but known so well, and is converted into a signal with lower frequency there. Next, a reference numeral 10 denotes a collar for mounting the covering member which is provided on an outer periphery side of the nose portion in the body 2, with a male screw 11 formed on its outer periphery. A reference numeral 12 denotes a recessed groove, which is formed annularly, and a waterproof ring packing 13 is provided therein.

Next, the covering member 3 is formed of a synthetic resin material (or polycarbonate, for example). In the covering member 3, a reference numeral 15 denotes a block part for blocking the illumination aperture 6. In the block part 15, a reference numeral 17 denotes a radio wave receiving domain for allowing the incoming radio wave to pass toward the illumination aperture 6. An outside 17a and an inside 17b of the domain 17 are formed spherically around (spherical center) a common point F. A thickness t of the receiving domain 17 is formed to the thickness (a size obtainable through multiplying half of the received radio wavelength by a velocity factor (0.6 in the case of polycarbonate) correspondting to a material of the covering member 3, which is 8.3 mm in the example) coincident with a first trough in the transmission loss curve of radio wave of the synthetic resin which is a material for forming the covering member 3. Then, a radius of the inside 17b is 20.8 mm long. Two-dot chain lines 18, 18 indicate a radio wave receivable range of the aforementioned receiving domain 17. A reference numeral 16 denotes a cylindrical takeout part. The takeout part 16 displaces the receiving domain 17 somewhat ahead of the aperture end 7 of the horn 5. As the result of displacement, the aforementioned point F comes to position within the illumination aperture 6 on an inside of the horn 5. Further, the point F is positioned on an axis of the illumination aperture 6. When the point F is positioned inside the horn 5 and also on the axis, radio waves focusing toward the point F as will be described hereinlater pass through any portions of the receiving domain 17 all on equal conditions. Accordingly, the radio waves can be received efficiently within the horn 5. Then, the point F may be located on the central axis of the horn 5 at a position longitudinal of a side of the receiving domain 17 or the waveguide part 4 in the range of one fourth wavelength or so from the inside of the horn 5. The aforementioned takeout part 16 is formed generally to the thickness in the same degree as the receiving domain 17, however, it may be thinned or thickened subject to obtaining a necessary and satisfactory strength. In case then where the aforementioned point F is positioned inside the horn part 5 as mentioned above without the takeout part 16, the takeout part 16 will not particularly be formed. Next, a reference numeral 19 denotes a mounting member formed integrally with the block part 15, which is intended for installing the covering member 3 on the body 2. The member 19 is formed annularly to have a step 20 intermediately and has a female screw 21 mating with the male screw 11 formed thereon. If the block part 15 is so thick as mentioned, then the mounting member 19 thick likewise can be formed integrally with the block part 15. This may be serviceable to omission of a separate part for mounting the covering member 3 on the body 2. Then, an end surface 20a of the step 20 is brought into contact watertightly with the aforementioned packing 13.

In the above-described construction, since the block part 15 shields the illumination aperture 6, even if a dust happens to cover the primary radiator 1 in outdoor service, the dust is prevented from coming into the primary radiator 1. As a result, a deterioration of electrical characteristics due to denaturation of the inside of the horn part 5 or the waveguide part 4 can be prevented. Then, in the frequency converter 8 mounted on the other end of the waveguide part 4, the dust is not capable of depositing on the surface of an insulating member 9c, thus preventing a deterioration of insulation between the probe 9b and inside of the cavity 9a which may lead to a defective operation.

Then, in the above-mentioned service, since the block part 15 is so thick, a failure of the block part is prevented despite hitting by stones blown by the wind or pecking by birds. Further, the block part 15 is thick, as described above, enough to withstand long a weathering by sunbeams or rain and wind, thus serving for a long period of time. Still further, the end surface 20a is brought into contact close with the packing 13, therefore rain water is prevented from coming into the primary radiator 1. As a result, a corrosion of the inside of the horn part 5 or the waveguide part 4 and a failure of the receiving member 9 can be prevented.

In the above-described service, a 12 GHz radio wave coming from left of Fig. 1 in the receivable ranges 18, 18 passes through the radio wave receiving domain 17 and comes into the illumination aperture 6 of the horn part 5. The incoming radio wave propagates in the interior of the horn part 5 and the waveguide part 4 as known well, reaches the frequency converter 8, and is received by the receiving member 9.

Next·Fig. 2 indicates a relation between thickness and transmission loss of radio wave of polycarbonate used as a forming material for the covering member 3. In Fig. 2, A indicates a transmission loss curve at received radio wave frequency being 12 GHz (satellite broadcasting), B indicates that at 23 GHz (CATV relaying), and C indicates that at 50.5 GHz (simplicity radio). In the example given in Fig. 1, a thickness of the radio wave receiving domain 17 is that of coinciding with a first trough of the curve A as indicated by a reference character A1 in the curve A. Then, the transmission loss of radio wave due to the covering member 3 is generally acceptable when it is about 0.3 dB or below. Accordingly, the aforementioned trough implies a range wherein the transmission loss is about 0.3 dB or below.

The following may be understood also from Fig. 2. That is to say, as will be apparent from the curve B, a transmission loss to the 23 GHz radio wave is minimized in the case of covering member having a radio wave receiving domain 4.3 mm thick as indicated by a reference character B1. Accordingly, it can be utilized as a covering member in the primary radiator for receiving 23 GHz radio wave. Then, a covering member having a radio wave receiving domain 8.7 mm thick as indicated by a reference character B2 can be utilized likewise on the primary radiator for receiving 23 GHz radio wave. In those cases, first and second troughs in the curve B are utilized each. Further, as will be apparent from the curve C, covering members having radio wave receiving domains 2 mm, 4 mm and 6 mm thick each as indicated, for example, by reference characters Cl, C2, C3 have small transmission loss to the 50.5 GHz radio wave each, therefore they can be utilized on a primary radiator for receiving the radio wave. In this case, first, second and third troughs in the aforementioned curve are utilized each. These may be tabulated as shown in Table 1.

Table 1

Operating frequency band	Thickness of radio wave receiving domain (mm)		
	Using 1st trough	Using 2nd trough	Using 3rd trough
23 GHz (23.0 to 23.6 GHz) CATV relaying	4.3	8.7	13.0
50 GHz (50.44 to 51.12 GHz) Simplicity Radio	2.0	4.0	6.0

Next, if the outside 17a and the inside 17b of the radio wave receiving domain 17 are shaped as described hereinabove, then the following advantages will be ensured. That is to say, even in case radio waves are incoming through wide range as indicated by reference numerals 18, 18, the receiving domain 17 is even in thickness everywhere to the radio waves in the range. Accordingly, if the receiving domain 17 is thick to coincide with the trough of higher order to be several times (double, treble, quadruple, for example) as long as the received wavelength, the radio waves incoming through the aforementioned range are capable of passing through the receiving domain 17 and coming into the illumination aperture 6 with less loss. Thus, the covering member having a thick radio wave receiving domain as mentioned can be developed.

Next, as a covering member in the primary radiator for receiving a radio wave 10 GHz or so which is somewhat lower than 12 GHz, the covering member having a radio wave receiving domain formed somewhat thicker than 8.3 mm indicated by Al can be utilized. In this case, the first trough is utilized. Then, as a covering member in the primary radiator for receiving a radio wave 25 GHz or so which is somewhat higher than 23 GHz, the covering members having radio wave receiving domains formed somewhat thinner than 4.3 mm, 8.7 mm indicated by Bl, B2 respectively can be utilized. In each case, the first or second trough is utilized.

Next, an example of a parabolic antenna using the primary radiator 1 of Fig. 1 is shown in Fig. 3. In Fig. 3, a reference numeral 24 denotes a reflector for the parabolic antenna, which is mounted on an upper portion of a strut (mast) 25 with its lower end fixed on the ground plane or structure by means of a known fixture 26. A reference numeral 27 denotes an arm with its base fixed on the reflector 24, and the primary radiator 1 is mounted on its nose portion. Then, the mounting comes in a state where a focal point of the reflector 24 coincides with the point F in the primary radiator 1. As the primary radiator 1, meanwhile, that with an angle of the radio wave receivable ranges 18, 18 in the primary radiator 1 equal or somewhat wider as compared with an illumination angle 29 of the reflector 24 is used, and an arrangement is such that the radio wave focused by the reflector 24 is ready for coming into the illumination aperture 6 of the horn part 5 efficiently. A reference numeral 28 denotes a frequency converter connected to a rear end of the waveguide part 4 in the primary radiator 1.

In the above-described example, SHF radio wave arriving from a broadcasting satellite is reflected by the reflector 24 and focused toward the primary radiator 1. In the primary radiator 1, the aforementioned radio wave passes through the covering member 3 and comes thereinto from the illumination aperture 6, and is then given to the frequency converter 28. The frequency converter 28 converts the radio wave into a signal with a lower frequency as known well and sends it toward a tuner. Then, in the embodiment, the above-described parabolic antenna is that for receiving a radio wave (11.7 to 12.0 GHz) from the broadcasting satellite as SHF radio wave. Besides, the parabolic antenna comes in a parabolic antenna for receiving 12 GHz radio wave from a communication satellite, a parabolic antenna for sending 14 GHz radio wave toward the communication satellite, a parabolic antenna for sending/receiving 3 to 50 GHz microwave and millimeter wave and so forth.

Next, Fig. 4 represents another embodiment of the invention, giving an example wherein a radio wave receiving domain 17e in a covering member 3e is formed to have a 16.6 mm thickness (size obtained through multiplying a received radio wavelength by the velocity factor). In this case, where receiving the 12 GHz radio wave, the thickness coincides with the second trough in the curve A as indicated by A2 in Fig. 2. Then in the case of covering member 3e having the receiving domain 17e thick as above, a transmission loss is small (thickness coincident with the fourth trough) also to the 23 GHz radio wave as indicated by B4, therefore it is available for receiving the 23 GHz radio wave.

Then, an alphabet "e" is put to the reference character identical to the foregoing figure for the portion conceivable as same or equal in construction as that of the foregoing functionally, thus omitting a repeated description thereof. (In this connection, alphabets "f", "g", "h", "i", "j", "k" are put in that order likewise in the next figure on, thereby omitting a repeated description.)

Next, Fig. 5 represents a further embodiment of the invention, giving an example wherein a radio wave receiving domain 17f in a covering member 3f is formed (thickness coincident with the third trough of the curve A as apparent from A3 in Fig. 2) to have a 24.9 mm thickness (size obtained through multiplying 1.5 times of a received radio wavelength by the velocity factor).

Next, Fig. 6 indicates a difference in transmission loss curve of radio wave according to a material of the covering member, wherein D represents the case of polycarbonate (dielectric constant ϵr = 2.8), E represents the case of polyallylate (ϵr = 3.6), and G represents the case of unsaturated polyester (ϵr = 4.0).

In case the covering member is formed of a material other than polycarbonate such as, for example, polyallylate or unsaturated polyester, a thickness of the radio wave receiving domain may be given at values shown in Table 2.

Table 2

Material	Dielectric constant ϵr	Thickness of radio wave receiving domain (mm)		
		Using 1st trough	Using 2nd trough	Using 3rd trough
Polyallylate	3.6	7.3	14.6	22.0
Unsaturated polyester	4.0	6.9	13.9	20.8

Next Fig. 7 represents a further different embodiment of the invention, giving an example wherein the block part is formed like a flat plate (curved surface infinite in radius). A covering member 3g provided with a plate-like block part 15g is formed, for example, of polyphenylene oxide. A thickness tl of the plate-like block part 15g is formed (8.2 mm in the example) to coincide with the first trough in the transmission loss curve of radio wave of synthetic resin material which is a forming material for the covering member 3g. However, the thickness may be such as will coincide with higher order (second, third) troughs. On a collar 10g, the covering member 3g is mounted by means of a clamp ring 31. That is to say, in the covering member 3g, a reference numeral 32 denotes a mounting member formed integrally with the block part 15g, which consists of a cylindrical part 33 and a collar part 34. The clamp ring 31 clamps to fix the collar part 34 to the collar 10g. Then the clamp ring 31 is formed of a conductive material such as copper, aluminum, brass or the like, and operates a primary radiator 1g as a singlet corrugated horn.

The covering member 3g shaped as described above is easy to fabricate as compared with that of having the aforementioned spherical radio wave receiving domain, thus moderating the manufacturing cost.

In the plate-like block part 15g mentioned as above, an electrical thickness to the radio wave incoming slantingly to an axis of a horn part 5g is large as compared with an electrical thickness of the radio wave incoming along the axis. Then, larger the angle of inclination of an incoming radio wave to the aforementioned axis, the greater the electrical thickness. Accordingly, it is preferable that the covering member 3g having such block part 15g as mentioned above be used on a parabolic antenna with an illumination angle of the reflector viewed from a horn part 5g relatively small (90° or below, for example). Then, other forming materials for the covering member and thicknesses of the block part 15g when SHF radio waves 11.7 to 12.0 GHz are handled are exemplified by polycarbonate (7.8 mm thick), polytetrafluoroethylene (9.6 mm), polytetraethylene copolymer (7.8 mm) and so forth.

Next, Fig. 8 indicates transmission loss characteristics of radio wave of polyphenylene oxide used as a forming material for the covering member 3g, giving a thickness of the material on the quadrature axis and a transmission loss of SHF radio wave on the axis of ordinates. Then, in the characteristics, a thickness of the block part 15g in the covering member 3g is specified to the thickness coincident with a first trough I of transmission loss curves H1 to H3 of SHF radio wave (H1 indicating transmission loss curve at 10.95 GHz, H2 at 11.3 GHz, H3 at 11.7 GHz). Further in the aforementioned trough, the thickness is selected properly in the range where the aforementioned transmission loss becomes a value not to exert a big influence on the reception of SHF radio wave, that is, in the range where the transmission loss becomes a permissible value (0.3 dB, for example) or below. In the trough, further, the thickness whereat the transmission loss is minimized is a size obtainable through multiplying a half wavelength of SHF radio wave by the velocity factor of synthetic resin which is a forming material of the covering member. The aforementioned half wavelength of radio wave refers to a half of the average taken between a wavelength in free space and a wavelength in a waveguide part 4g.

Next, another embodiment of the invention will be described with reference to Fig. 9. In the example, a block part 15h is provided with a cylindrical part 35 on a rear side of the peripheral edge portion. A presence of the cylindrical part 35 gives rise to a space 36 between an aperture end 7h of a horn part 5h and a plane 15a opposite to the aperture end 7h in the block part 15h. A thickness t2 of the cylindrical part 35 and a width W of the space 36 are sizes obtainable through multiplying a quarter of the free space wavelength of SHF radio wave to handle by the velocity factor of a forming material for covering member 3h. Then, in the example, the covering member 3h is provided with a clamp ring 37 formed integrally therewith.

From providing the cylindrical part 35 and the space 36 as above, a transmission loss of radio wave which may arise due to a presence of the block part 15h is kept less as in the case where the block part is not present, and VSWR is improved as in the case where the block part is not present.

Next, Fig. 10 and Fig. 11 represent examples wherein covering members 3i, 3j are constituted of block parts 15i, 15j only respectively. In the examples the covering members 3i, 3j have each outside diameter formed slightly larger than inside diameters of waveguide parts 4i, 4j. Then, for installation on bodies 2i, 2j, the covering members 3i, 3j are fitted into the waveguide parts 4i, 4j. In this case, a circumferential overhang 38 comes in contact with the inside of a horn part 5j to place the covering member 3j in position automatically in the example of Fig. 11. Accordingly, it can be fitted easily as deep as a predetermined position.

Since the covering members 3i, 3j shown in Fig. 10 and Fig. 11 are simplified in shape, they can be manufactured with ease. Further the manufacturing cost is moderated. They can be incorporated in the bodies 2i, 2j simply, too.

Then in the examples, the covering members 3i, 3j may be bonded watertightly on inner peripheries of the waveguide parts 4i, 4j at each full circumference with an adhesive.

In Fig. 12 next, there is shown a primary radiator provided with a radio wave introducing member variant in form. A radio wave introducing member 40 is fabricated integrally with a case 8ak of a frequency converter 8k. Then, the radio wave introducing member 40 has only a horn part 5k for receiving radio waves, and a receiving member 9k is coupled to the horn part 5k.

As many apparently different embodiments of this invention may be made without departing from the spirit and scope thereof, it is to be understood that the invention is not limited to the specific embodiments thereof except as defined in the appended claims.

Claims

1. In a primary radiator, comprising:

a radio wave introducing member having an illumination aperture for receiving radio waves;

a covering member formed of a synthetic resin material through which radio waves are transmittable, and installed to said radio wave introducing member to block said illumination aperture;

the improvement characterized in that a portion to block said illumination aperture in said covering member is so thick as to coincide with a trough in a transmission loss curve of radio wave of the synthetic resin used as a forming material for said covering member.

2. The primary radiator as defined in claim 1, wherein outside and inside of the portion to block said illumination aperture in said covering member are spherical with one point on an axis of the illumination aperture as a common center in said illumination aperture.

3. The primary radiator as defined in claim 1, wherein the portion to block said illumination aperture is shaped like a flat plate in said covering member.

4. The primary radiator as defined in claim 3, wherein a space for lowering VSWR is formed between an aperture end in said illumination aperture and a plane opposite to said aperture end in the plate-like portion for blocking said illumination aperture.

5. The primary radiator as defined in any of claims 1 to 4 wherein said radio wave introducing member has a male screw for mounting the covering member around said illumination aperture, said covering member has a mounting member formed integrally with a portion to block said illumination aperture, that mounting member has a female screw for mating with said male screw.

FIG.1

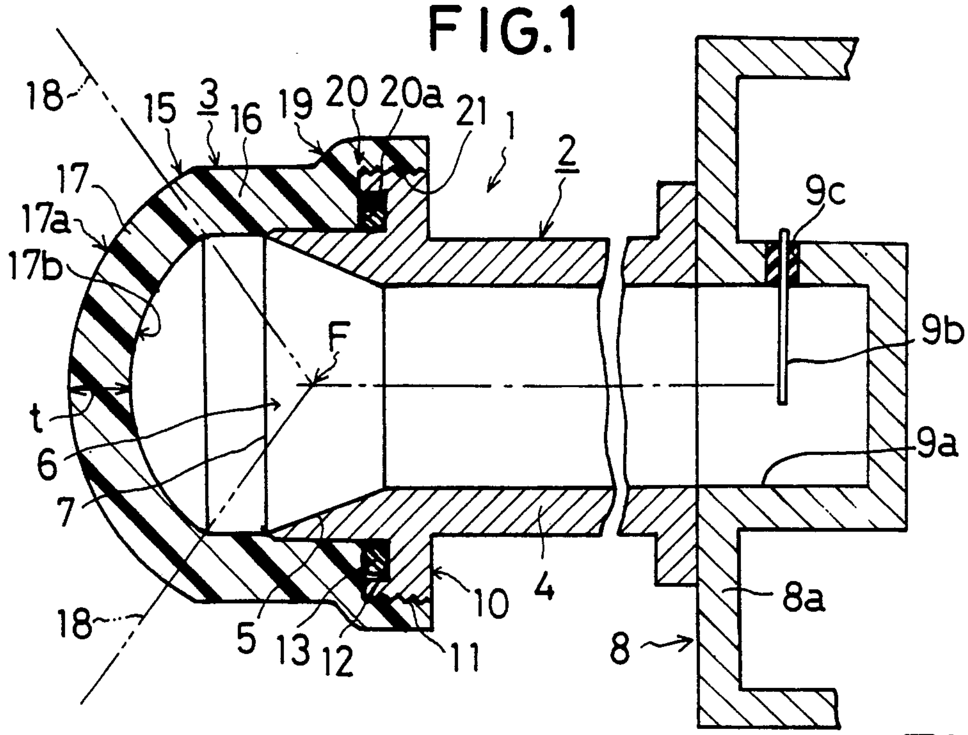


FIG.4

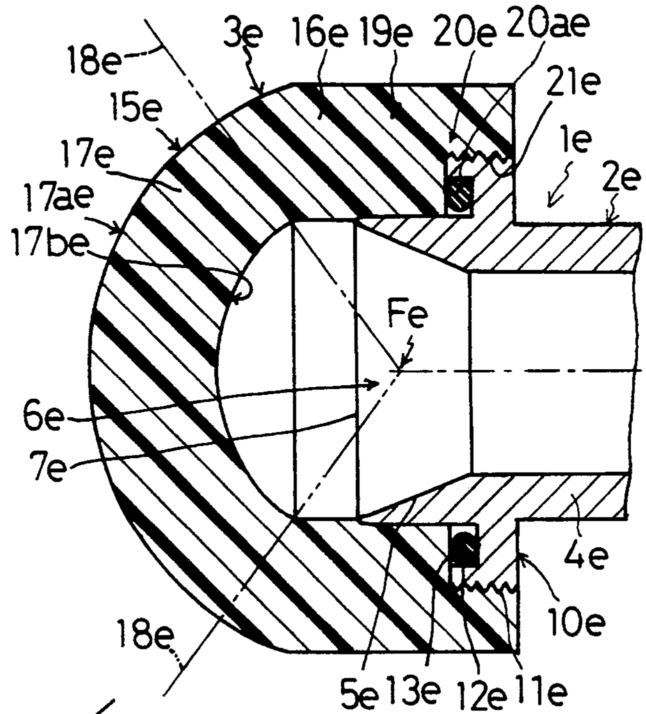


FIG.3

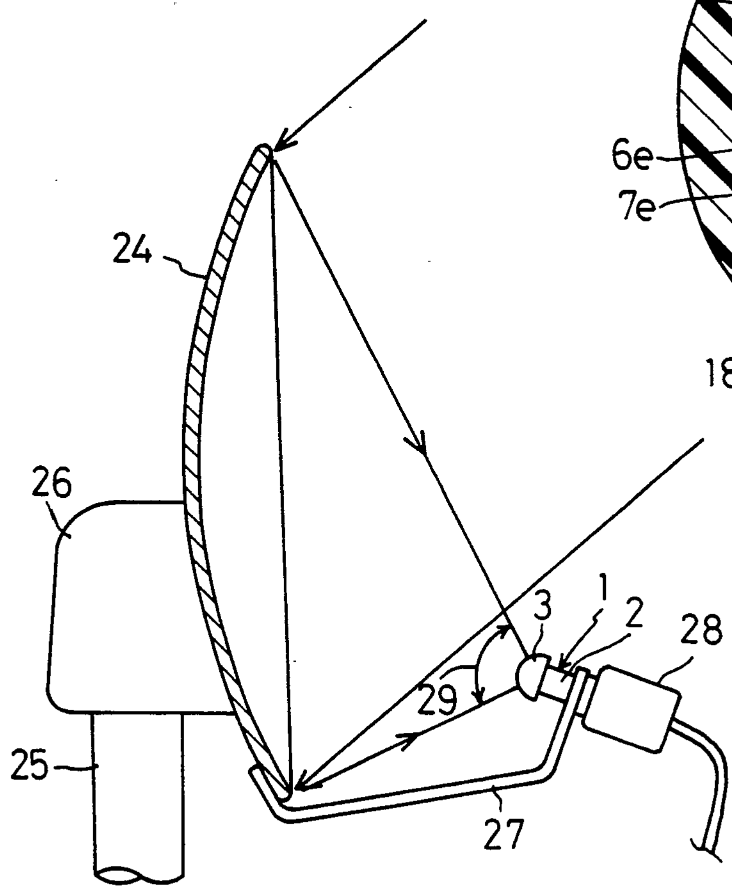


FIG.5

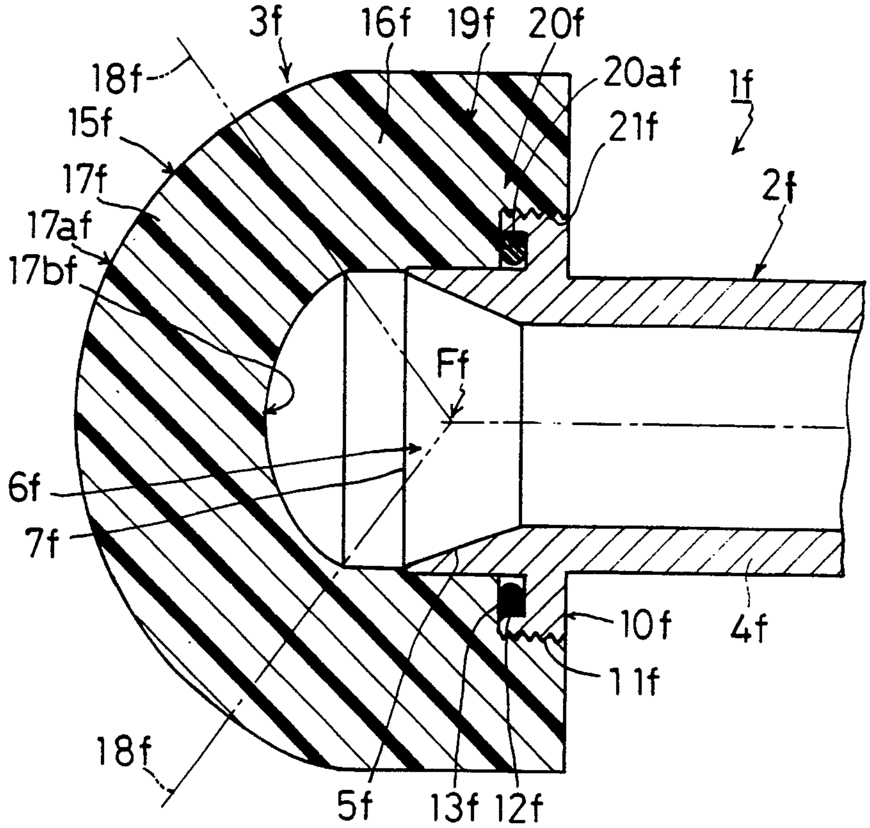

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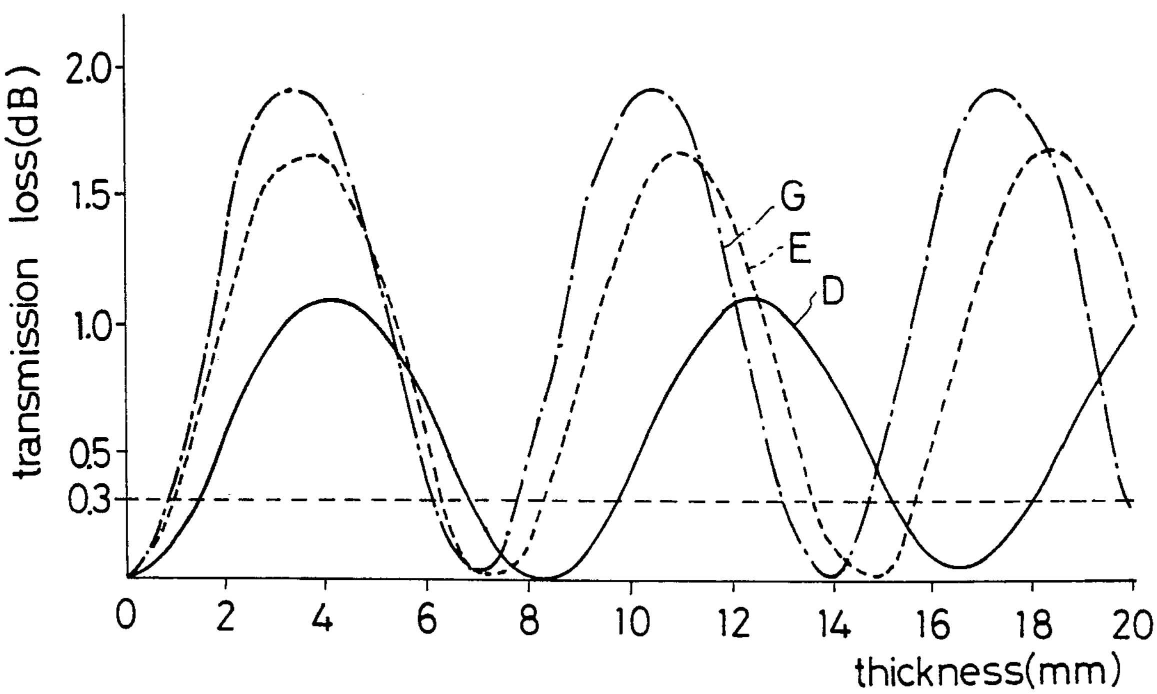
FIG.6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1.5
1.0
0.5
0.3
G
E
D
0
2
4
6
8
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16
18
20
thickness(mm)

FIG.7

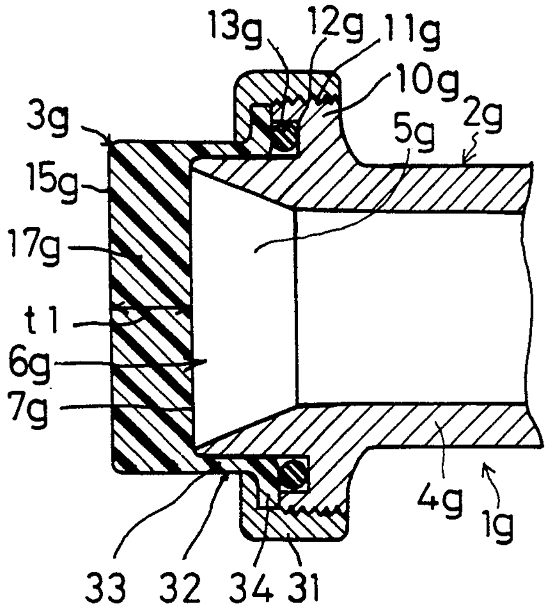


FIG.9

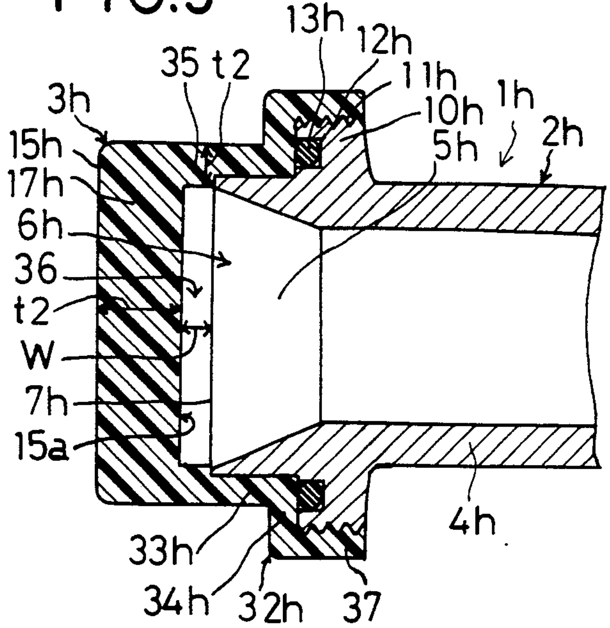


FIG. 8

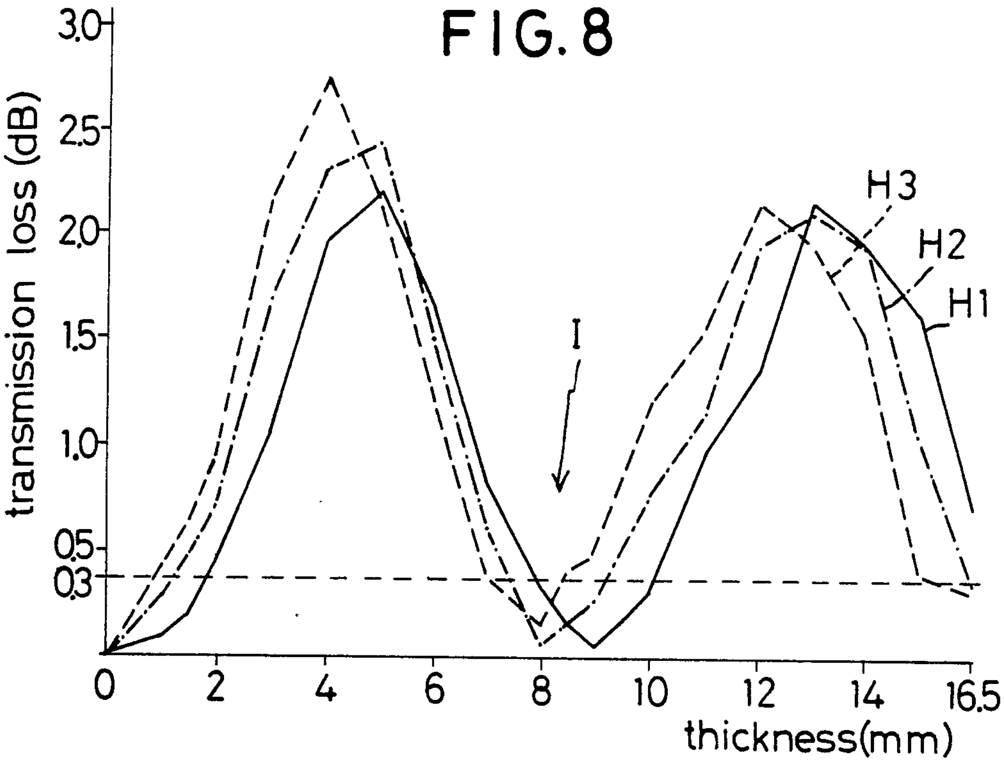


FIG.10

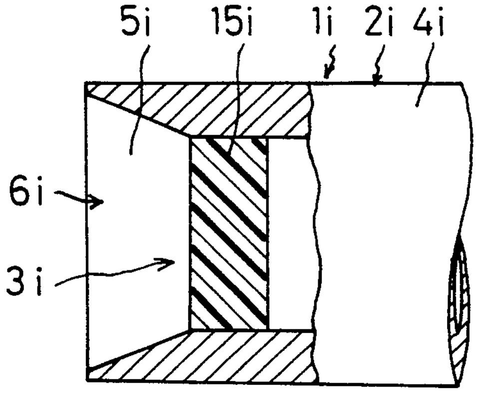


FIG.11

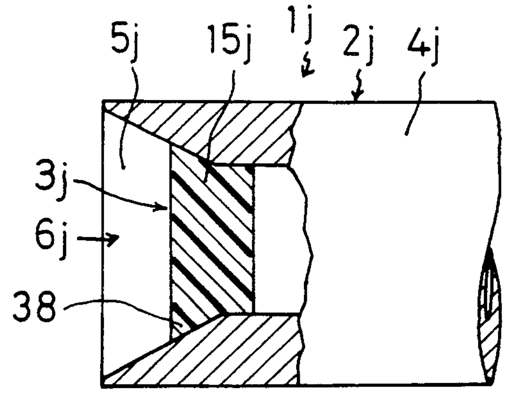


FIG.12

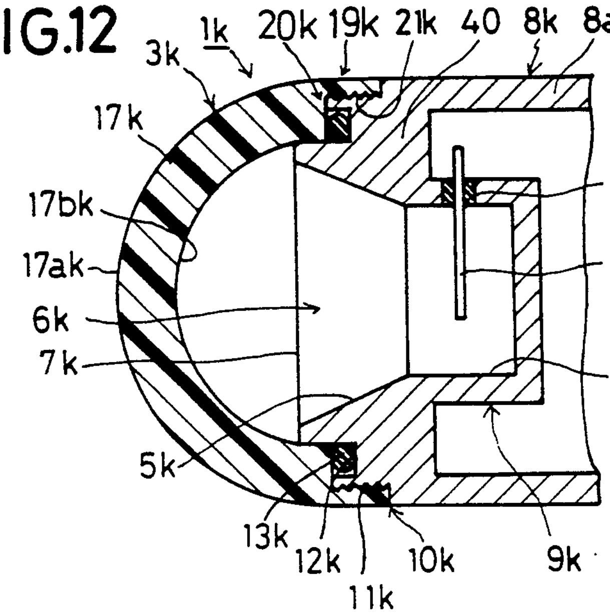
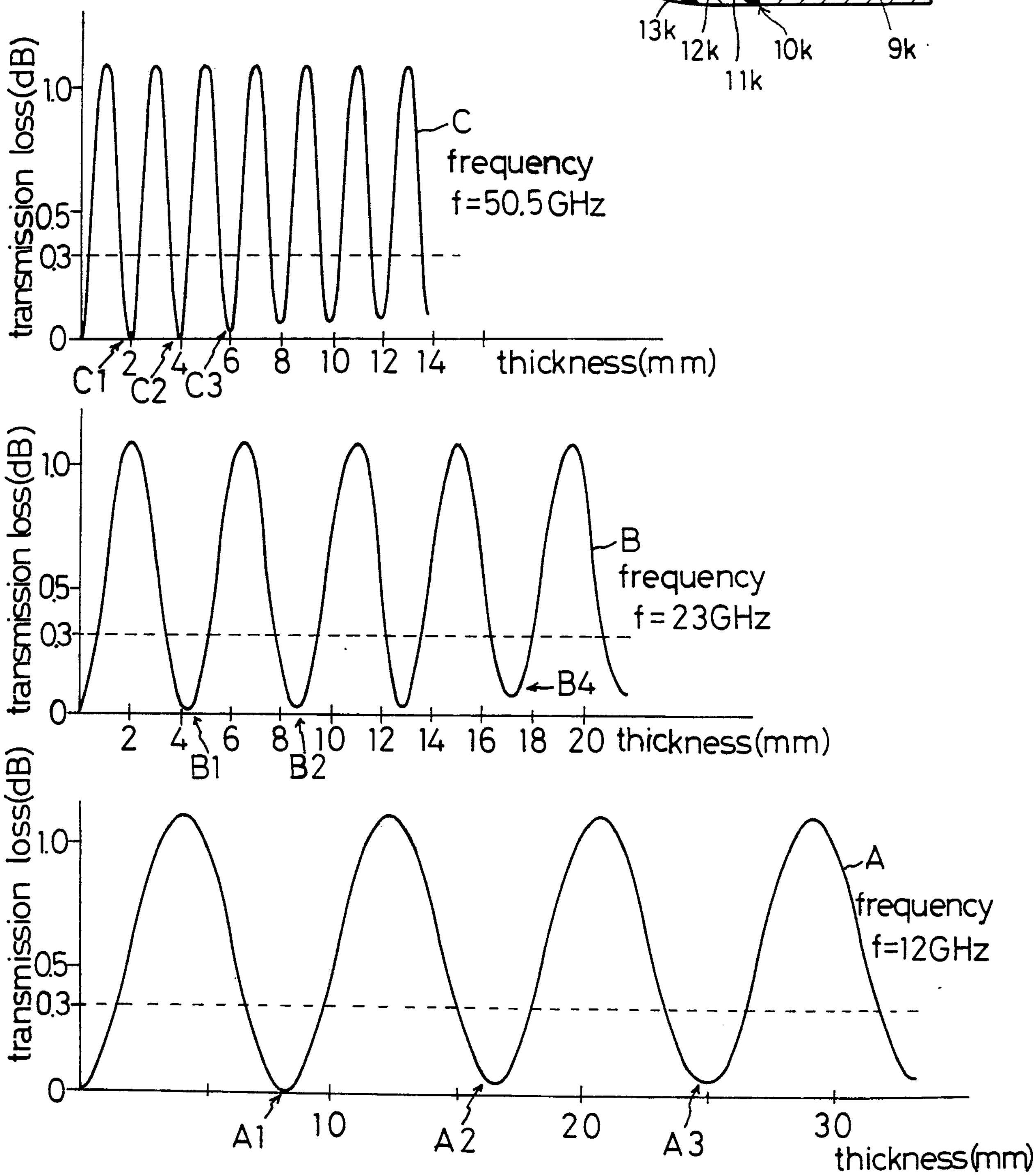

1k
3k
20k
19k
21k
40
8k
8ak
17k
17bk
17ak
6k
7k
5k
9ck
9bk
9ak
13k
12k
11k
10k
9k

FIG. 2


transmission loss(dB)
1.0
0.5
0.3
0
C1
C2
C3
2
4
6
8
10
12
14
thickness(mm)
C
frequency
f=50.5 GHz
B
frequency
f=23GHz
B4
B1
B2
16
18
20
A
frequency
f=12GHz
A1
A2
A3
30