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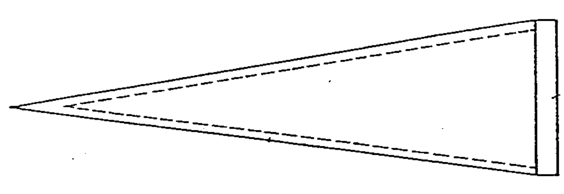
(54) BODY FOR ABSORBING ELECTROMAGNETIC WAVE.

(57) A body for absorbing electromagnetic waves having a good absorption characteristic in a wide frequency band. This body is provided with a ferritic tile body (12) for absorbing electromagnetic waves and a dielectric body for absorbing radio waves (10) having a physical taper and/or an electric taper provided on the front surface of the ferritic tile body. This dielectric body for absorbing electromagnetic waves is hollow.

Fig. 1



EP 0 485 635 A1

FIELD OF THE INVENTION

The present invention relates to a radio wave absorber which has excellent absorption characteristics in a wide frequency band.

BACKGROUND AND PRIOR ART OF THE INVENTION

For radio wave absorbers, dielectric radio wave absorbers and ferrite tile radio wave absorbers are known.

If a drastic change in impedance occurs at the surface of a radio wave absorber when radio waves propagated in the air or in a vacuum impinge on the radio wave absorber, the radio waves are reflected and are not properly absorbed thereinto.

For this reason, dielectric radio wave absorbers are usually constructed so as to be physically and/or electrically tapered so that the impedance varies gradually.

Although the dielectric radio wave absorbers are capable of displaying excellent absorption characteristics in a wide frequency band, they need to be extremely tall (thick) if it is desired that they should exhibit good performance at low frequencies.

Ferrite tile radio wave absorbers, on the other hand, have excellent absorption characteristics in a narrow frequency band, but even those which are effective at low frequencies are characterized in that they are low in height (thin in thickness).

To utilize the advantages of the above two types of radio wave absorbers, it is conceivable to combine a dielectric radio wave absorber with a ferrite tile radio wave absorber, as explained below.

First, for example, it is conceivable to combine a solid pyramidal radio wave absorber with a ferrite tile radio wave absorber. In this case, however, reflection at their interface becomes so excessive that the characteristics of the ferrite tile radio wave absorber cannot be utilized.

The reason for that is as follows. The solid pyramidal radio wave absorber contacts with the ferrite tile radio wave absorber at its base. The impedance at the tip of the solid pyramidal radio wave absorber is nearly as high as that of air or a vacuum, but the impedance gradually decreases toward the base and is reduced to an extremely small value at the base. On the other hand, the impedance on the surface of the ferrite tile radio wave absorber is high. Thus, the value of impedance greatly changes at the interface of the solid pyramidal radio wave absorber and ferrite tile radio wave absorber; consequently, impedance matching cannot be fulfilled and radio waves are reflected at said interface. The radio waves reflected at the interface are not propagated into the ferrite tile radio wave absorber, and the ferrite tile radio wave absorber fails to absorb radio waves. Accordingly, in case a solid pyramidal radio wave absorber is combined with a ferrite tile radio wave absorber, the characteristics of the solid pyramidal radio wave absorber are predominantly displayed and those of the ferrite tile radio wave absorber cannot be utilized.

Secondly, in order to improve said impedance matching between the ferrite tile radio wave absorber and the solid pyramidal radio wave absorber, it is conceivable to reduce the amount of carbon powder, etc., contained in the solid pyramidal radio wave absorber, which would cause electrical loss, so as to increase the impedance at the base of the solid pyramidal radio wave absorber. By doing so, the impedance matching between the two radio wave absorbers can be improved, whereby radio waves can be propagated into and efficiently absorbed by the ferrite tile radio wave absorber. However, an increase in impedance at the base of the solid pyramidal radio wave absorber due to a reduction in the amount of carbon, etc., causes the absorption characteristics of the solid pyramidal radio wave absorber to be markedly deteriorated, which makes it impossible to utilize the favorable characteristics of the two radio wave absorbers, i.e., the solid pyramidal radio wave absorber and ferrite tile radio wave absorber.

The above explanation pertaining to pyramidal radio wave absorbers can also apply to other physically tapered dielectric radio wave absorbers, such as dielectric wedge-shaped radio wave absorbers, to electrically tapered dielectric radio wave absorbers, and to physically and electrically tapered dielectric radio wave absorbers.

Thus, one cannot utilize the favorable characteristics of a dielectric radio wave absorber and of a ferrite tile radio wave absorber, simply by combining the two according to prior art.

SUMMARY OF THE INVENTION

According to the present invention, the above-problems can be solved by providing a radio wave absorber which comprises a ferrite tile radio wave absorber and a physically and/or electrically tapered dielectric radio wave absorber disposed on a front face of the ferrite tile radio wave absorber and which is characterized in that said dielectric radio wave absorber is hollow.

For ferrite tile radio wave absorbers, those which are commonly available and designed so as to have the maximum effect to the impedance of free space can be used in the present invention.

For dielectric radio wave absorbers, those physically tapered, those electrically tapered, and those physically and electrically tapered can be used in the present invention.

Physically tapered dielectric radio wave absorbers include pyramidal radio wave absorbers, wedge-shaped radio wave absorbers and the like.

The dielectric radio wave absorber is disposed on the front face of the ferrite tile radio wave absorber.

The dielectric radio wave absorber is hollow. The word "hollow" here implies 'electrically hollow,' and hollow dielectric radio wave absorbers include those stuffed with materials having low permittivity, such as foamed materials.

A hollow dielectric pyramidal radio wave absorber has radio wave-absorption characteristics which parallel those of an ordinary solid dielectric pyramidal radio wave absorber.

Because of its hollow structure, the impedance at the base of the hollow dielectric pyramidal radio wave absorber is higher than that of the solid dielectric pyramidal radio wave absorber; in other words, said impedance is closer to the characteristic impedance of free space (120 π ohms).

Because of these features of the hollow dielectric pyramidal radio wave absorber, a radio wave absorber formed by combining a hollow dielectric pyramidal radio wave absorber with a ferrite tile radio wave absorber have good impedance matching at the interface between them; consequently, an overall combination effect can be produced to the fullest extent and a high-performance wideband radio wave absorber can be obtained.

Also, said combination effect can be sufficiently obtained by using a commonly available ferrite tile radio wave absorber designed to have the maximum effect to the impedance of free space.

As stated above, the present invention can provide a radio wave absorber which has excellent absorption characteristics in a wide frequency band.

It can also provide a radio wave absorber which is relatively low in height (thin in thickness) and which has excellent absorption characteristics even at low frequencies.

Furthermore, a radio wave absorber in accordance with the present invention comprises a ferrite tile radio wave absorber and a dielectric radio wave absorber, and the latter can be a commonly available one which is designed to have the maximum effect to the impedance of free space; thus, it is easier to design the ferrite tile radio wave absorber and to obtain high performance.

Moreover, according to the present invention, a hollow dielectric radio wave absorber is used; therefore, it is possible to substantially reduce the weight of the absorber, as compared with the case of a conventional radio wave absorber wherein a solid dielectric radio wave absorber is used.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a side view of a radio wave absorber in accordance with embodiment 1 of the present invention.

Figure 2 shows the absorption characteristics of the radio wave absorber in accordance with embodiment 1 shown in Figure 1.

Figure 3 shows the absorption characteristics of a radio wave absorber in comparative example 1-1.

Figure 4 shows the absorption characteristics of a radio wave absorber in comparative example 1-2.

Figure 5 shows the absorption characteristics of a radio wave absorber in comparative example 1-3.

Figure 6 shows the absorption characteristics of a radio wave absorber in comparative example 1-4.

Figure 7 shows the absorption characteristics of a radio wave absorber in accordance with embodiment 2 of the present invention.

Figure 8 shows the absorption characteristics of a radio wave absorber in comparative example 2-1.

Figure 9 shows the absorption characteristics of a radio wave absorber in comparative example 2-2.

Figure 10 shows the absorption characteristics of a radio wave absorber in comparative example 2-3.

Figure 11 shows the absorption characteristics of a radio wave absorber in accordance with embodiment 3 of the present invention.

Figure 12 shows the absorption characteristics of a radio wave absorber in accordance with embodiment 4 of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Next, radio wave absorbers in accordance with the preferred embodiments of the present invention will be explained by reference to the attached drawings and by comparison with comparative examples.

Embodiment 1

A radio wave absorber in accordance with the first embodiment will be explained by reference to Figure 1.

This radio wave absorber is composed of a hollow dielectric pyramidal radio wave absorber 10 and a ferrite tile radio wave absorber 12.

The hollow dielectric pyramidal radio wave absorber 10 is hollow and pyramid-shaped and has a square base without a lossy dielectric. It is comprised of polyurethane foam containing media for electrical loss. This hollow dielectric pyramidal radio wave absorber 10 is 2.5 m high, and a side of the square base is 61 cm long.

Such a hollow dielectric pyramidal radio wave absorber 10 is available from Grace Japan K.K., under the trade name of HPY-100.

The ferrite tile radio wave absorber 12 is available from W. R. Grace and Company, under the trade name of "ECCOSORB (trademark) FT."

Figure 2 shows the absorption characteristics of the radio wave absorber constructed as stated above, in accordance with embodiment 1, at the frequencies of 20 to 120 MHz.

As is seen from Figure 2, this radio wave absorber has excellent radio wave-absorption characteristics at the frequencies of 20 to 120 MHz.

Comparative example 1-1

Figure 3 shows the radio wave-absorption characteristics of the ferrite tile radio wave absorber 12 alone used in embodiment 1.

It is seen that the radio wave-absorption characteristics shown in Figure 3 are less excellent than those in Figure 2, in the entire radio wave band measured.

Comparative example 1-2

Figure 4 shows the radio wave-absorption characteristics of the hollow dielectric pyramidal radio wave absorber 10 alone used in embodiment 1.

It is seen that the radio wave-absorption characteristics shown in Figure 4 are less excellent than those in Figure 2, especially in a low-frequency radio wave band.

Comparative example 1-3

Figure 5 shows the radio wave-absorption characterisitcs of a solid dielectric pyramidal radio wave absorber which is of the same size as the hollow dielectric pyramidal radio wave absorber 10 used in embodiment 1.

The radio wave-absorption characteristics shown in Figure 5 are more excellent than those shown in Figure 4, in a frequency band of 80 to 90 MHz. In other words, in this radio wave band, the solid dielectric pyramidal radio wave absorber is superior in radio wave-absorption characteristics to the hollow dielectric pyramidal radio wave absorber.

The radio wave-absorption characteristics shown in Figure 5 are less excellent than those of the radio wave absorber in accordance with embodiment 1, which are shown in Figure 2, especially in a low-frequency band.

Comparative example 1-4

Figure 6 shows the radio wave-absorption characteristics of a radio wave absorber constructed by combining ferrite tile radio wave absorber mentioned in comparative example 1-1 with the solid dielectric pyramidal radio wave absorber mentioned in comparative example 1-3.

The radio wave-absorption characteristics shown in Figure 6 are almost the same as those shown in Figure 5. This indicates that the radio wave-absorption characteristics of a radio wave absorber constructed by combining a ferrite tile radio wave absorber with a solid dielectric pyramidal radio wave absorber are not much different from those of the solid dielectric pyramidal radio wave absorber alone; hence, the above combination fails to enable the radio wave absorber to have more excellent absorption characteristics.

Embodiment 2

The radio wave absorber of this embodiment is constructed in the same manner as embodiment 1 except that the hollow dielectric pyramidal radio wave absorber as used in this embodiment is 3 m high. In other words, it is composed of a hollow dielectric pyramidal radio wave absorber having a height of 3 m and a ferrite tile radio wave absorber.

Such a hollow dielectric pyramidal radio wave absorber 10 is available from Grace Japan K.K., under the trade name of HPY-120.

Figure 7 shows the absorption characteristics of this radio wave absorber at the frequencies of 20 to 120 MHz.

As is seen from Figure 7, this radio wave absorber has excellent radio wave-absorption characteristics at the frequencies of 20 to 120 MHz.

It is seen that the radio wave-absorption characteristics shown in Figure 7 are more excellent than those of the ferrite tile radio wave absorber alone, which are shown in Figure 3, in the entire radio wave band measured.

Comparative example 2-1

Figure 8 shows the absorption characteristics of the hollow dielectric pyramidal radio wave absorber alone used in embodiment 2.

It is seen that the radio wave-absorption characteristics shown in Figure 8 are less excellent than those in Figure 7, especially in a low-frequency radio wave band.

Comparative example 2-2

Figure 9 shows the absorption characteristics of a solid dielectric pyramidal radio wave absorber alone, which is of the same size as the hollow dielectric pyramidal radio wave absorber used in embodiment 2.

The radio wave-absorption characteristics shown in Figure 9 are less excellent than those of the radio wave absorber in accordance with embodiment 2, which are shown in Figure 7, especially at low frequencies.

Comparative example 2-3

Figure 10 shows the radio wave-absorption characteristics of a radio wave absorber constructed by combining the ferrite tile radio wave absorber mentioned in comparative example 1-1 with the solid dielectric pyramidal radio wave absorber mentioned in comparative example 2-2.

The radio wave-absorption characteristics shown in Figure 10 are almost the same as those shown in Figure 9. This indicates that the radio wave-absorption characteristics of a radio wave absorber constructed by combining a ferrite tile radio wave absorber with a solid dielectric pyramidal radio wave absorber are not much different from those of the solid dielectric pyramidal radio wave absorber alone; hence, the above combination fails to enable the radio wave absorber to have more excellent absorption characteristics.

Embodiment 3

The radio wave absorber of this embodiment is constructed in the same manner as embodiment 1 except that the hollow dielectric pyramidal radio wave absorber as used in this embodiment is 1.5 m high. In other words, it is composed of a hollow dielectric pyramidal radio wave absorber having a height of 1.5 m and a ferrite tile radio wave absorber.

Figure 11 shows the absorption characteristics of this radio wave absorber at the frequencies of 20 to 120 MHz.

Such a hollow dielectric pyramidal radio wave absorber 10 is available from Grace Japan K.K., under the trade name of HPY-60.

It is indicated that the radio wave-absorption characteristics of the radio wave absorber in accordance with this embodiment are more excellent than those of the ferrite tile radio wave absorber alone, which are shown in Figure 3, in the entire radio wave band measured.

As in the case of comparison of embodiment 2 with comparative examples 2-1 to 2-3, the radio wave absorber of embodiment 3 exhibits excellent radio wave-absorption characteristics, as compared with an example using a dielectric pyramidal radio wave absorber having a height of 1.5 m.

Embodiment 4

The radio wave absorber of this embodiment is constructed in the same manner as embodiment 3 except that it has a dielectric base which is 8 mm thick and flat-plate shaped. In other words, it is composed of a hollow dielectric pyramidal radio wave absorber 1.5 m high having a base and a ferrite tile radio wave absorber.

Figure 12 shows the absorption characteristics of this radio wave absorber at the frequencies of 20 to 120 MHz.

It is indicated that the radio wave-absorption characteristics of the radio wave absorber in accordance with this embodiment are more excellent than those of the ferrite tile radio wave absorber alone, which are shown in Figure 3, in the entire radio wave band measured.

As in the case of comparison of embodiment 2 with comparative examples 2-1 to 2-3, the radio wave absorber of embodiment 4 exhibits excellent radio wave-absorption characteristics, as compared with an example using a dielectric pyramidal radio wave absorber having a height of 1.5 m.

In the radio wave absorbers in accordance with embodiments 3 and 4, the dielectric radio wave absorbers are hollow and have high impedance, as compared with solid dielectric radio wave absorbers, which conduces to good impedance matching with the ferrite tile radio wave absorbers; consequently, excellent radio wave-absorption characteristics can be obtained.

As is apparent from the comparison of Figure 11 with Figure 12, the radio wave-absorption characteristics of a radio wave absorber without a base in accordance with embodiment 3 are more excellent than those of a radio radio wave absorber with a base in accordance with embodiment 4.

This is ascribed to the fact that a hollow dielectric pyramidal radio wave absorber with a base still causes the impedance to drop to some extent even if the base is only 8 mm thick, thereby reducing the effect which is produced by combination with a ferrite tile radio wave absorber, in contrast to the case of a hollow dielectric pyramidal radio wave absorber without a base. Since the direction of the base is in parallel with an electric field which exists on a plane perpendicular to the direction in which radio waves are propagated, it is understood that the base, no matter how thin it is, affects the above combination effect.

Claims

1. A radio wave absorber comprising a ferrite tile radio wave absorber and a physically and/or electrically tapered dielectric radio wave absorber disposed on a front face of the ferrite tile radio wave absorber, said dielectric radio wave absorber being hollow.

Fig. 1

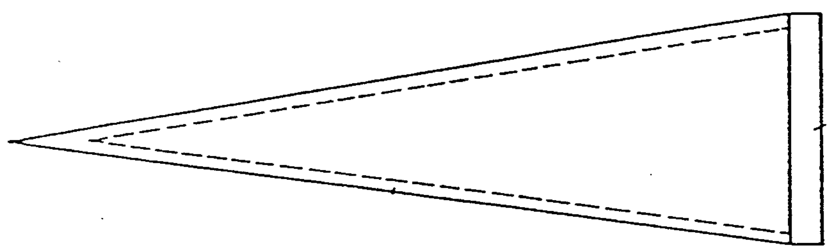
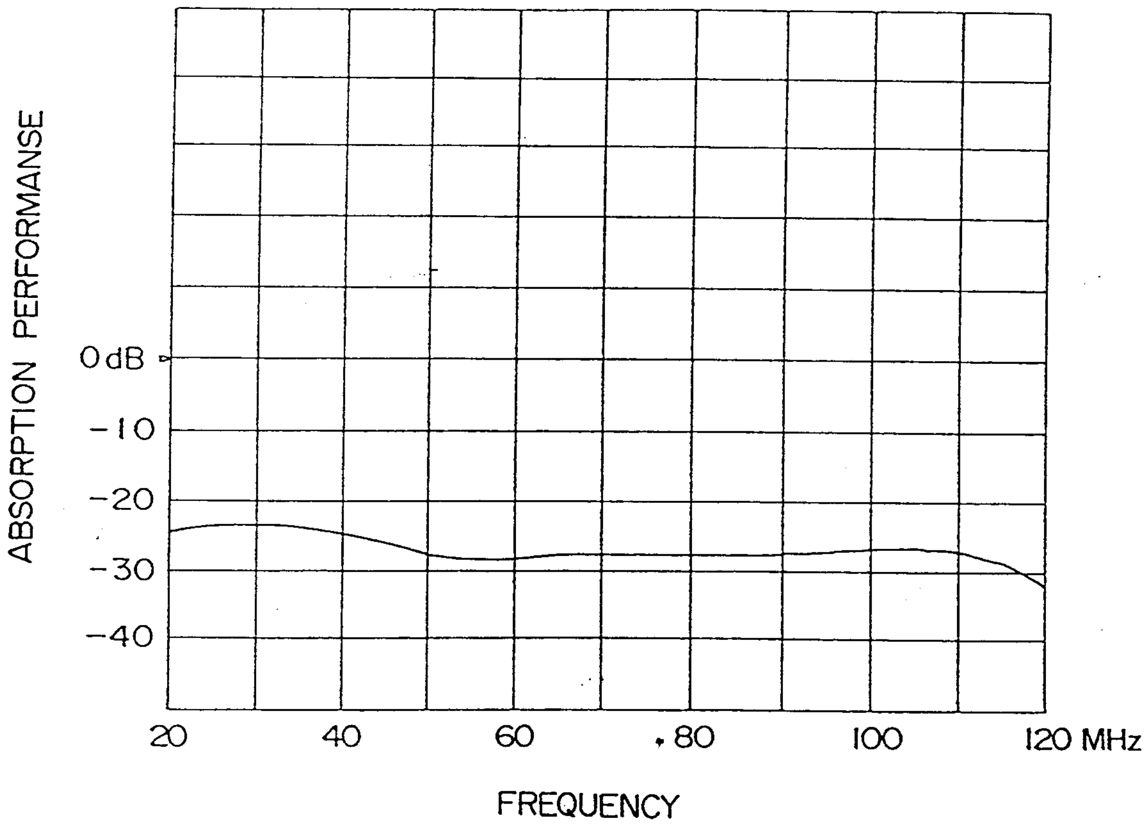


Fig. 2


ABSORPTION PERFORMANSE
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-10
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-30
-40
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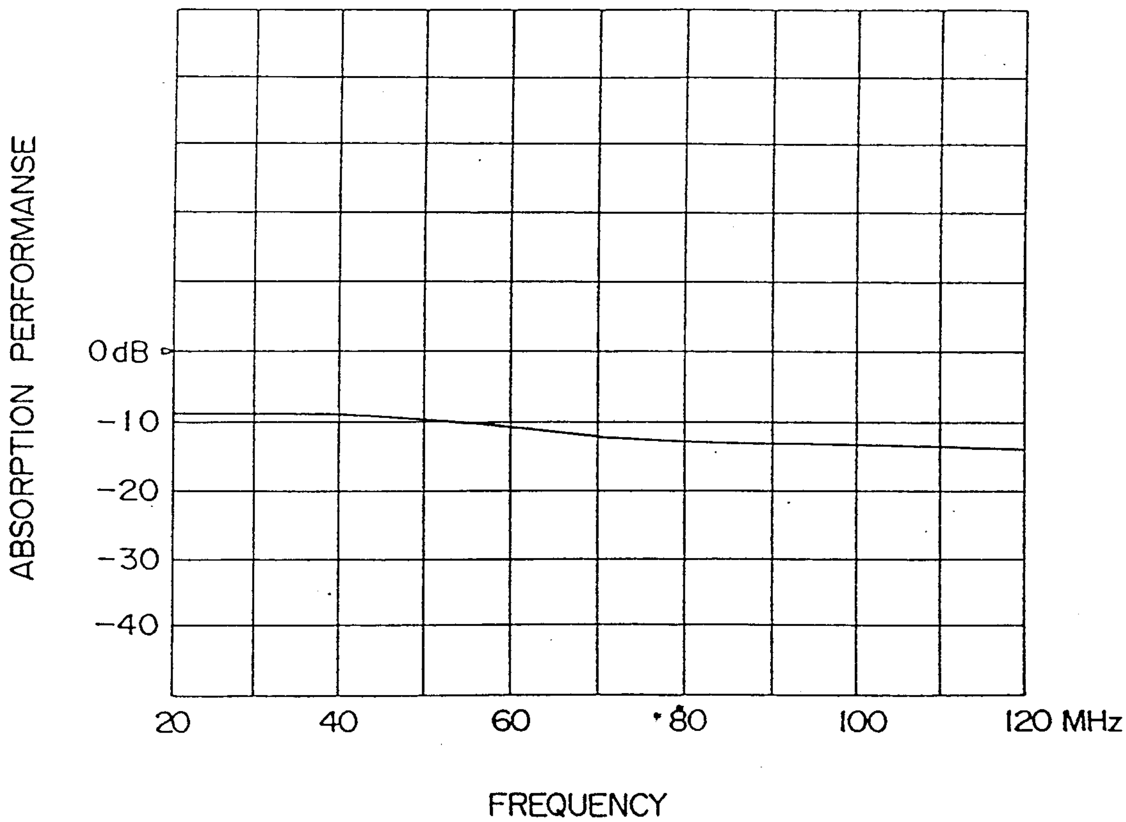
120 MHz
FREQUENCY

Fig. 3


ABSORPTION PERFORMANSE
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-20
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20
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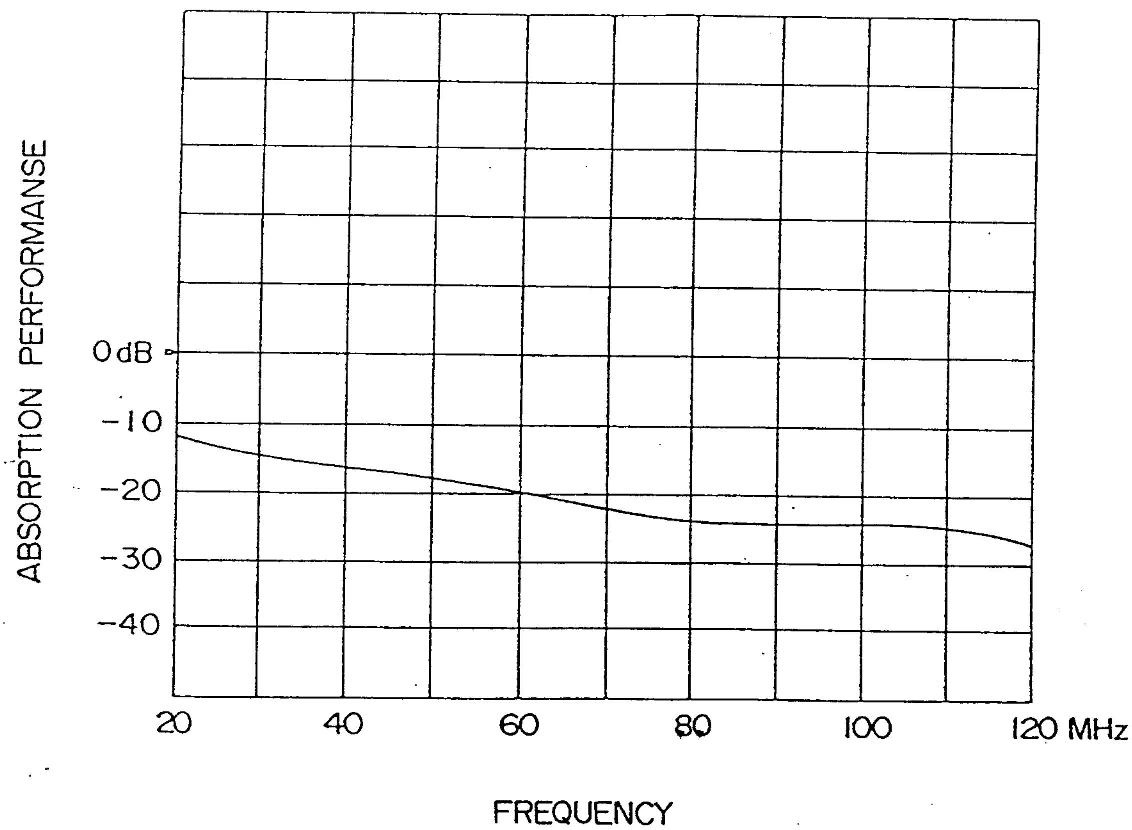
100
120 MHz
FREQUENCY

Fig. 4


ABSORPTION PERFORMANSE
0dB
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-20
-30
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20
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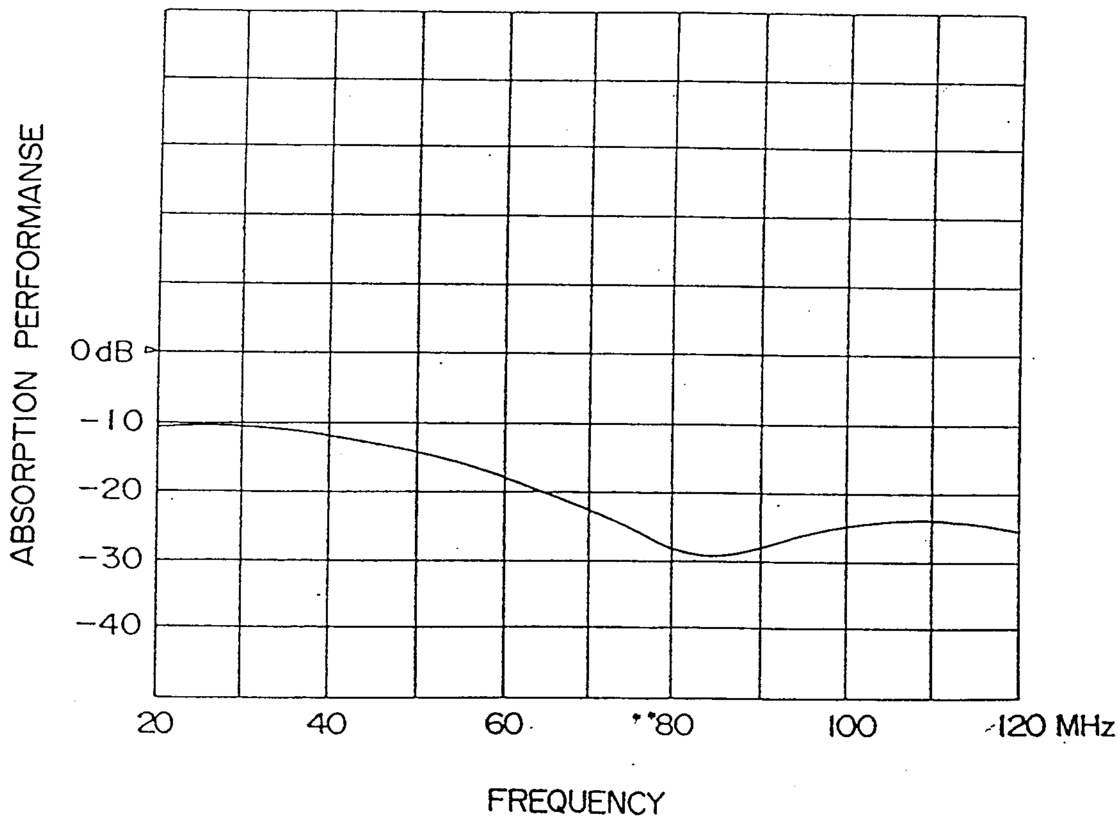
60
80
100
120 MHz
FREQUENCY

Fig. 5


ABSORPTION PERFORMANSE
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-20
-30
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20
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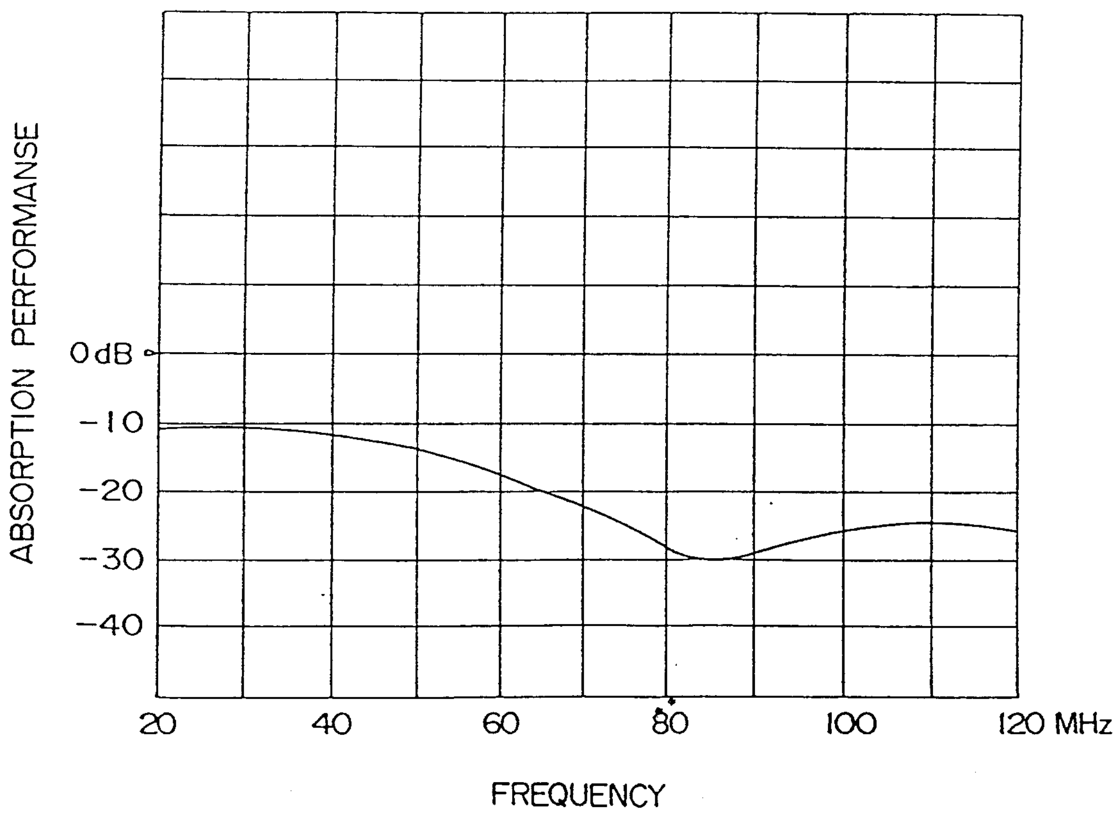
FREQUENCY

Fig. 6


ABSORPTION PERFORMANSE
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-20
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20
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FREQUENCY

Fig. 7

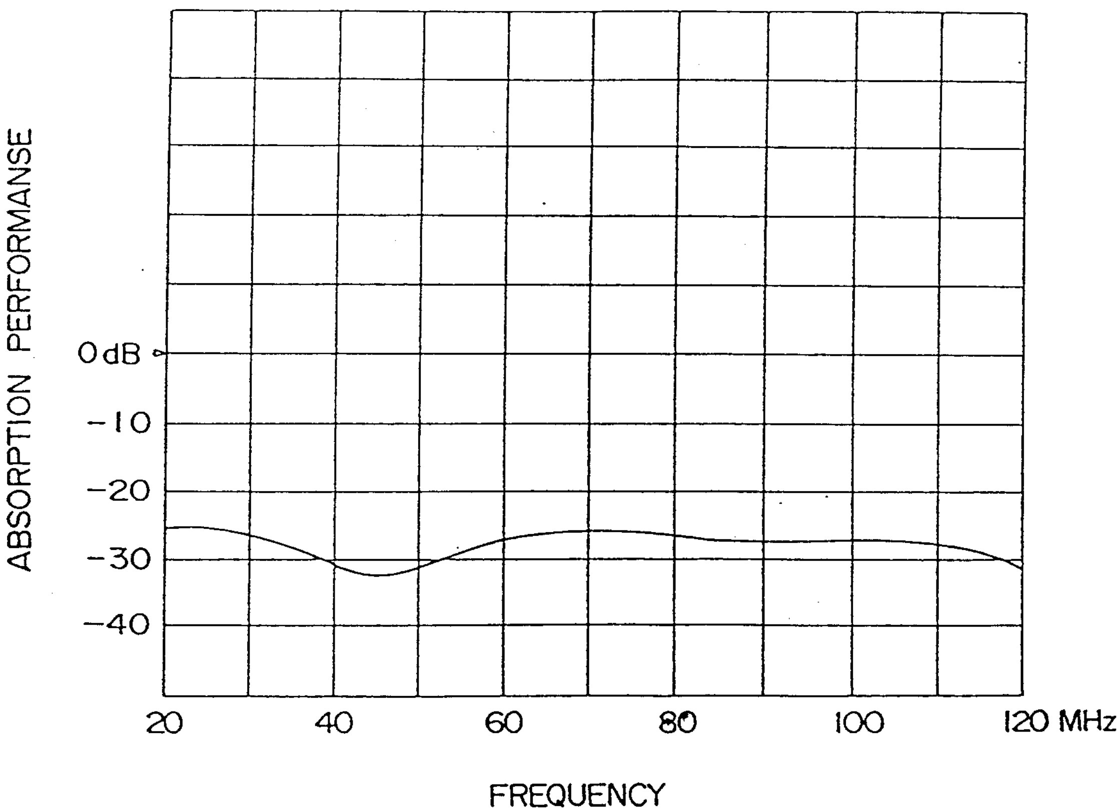
ABSORPTION PERFORMANSE
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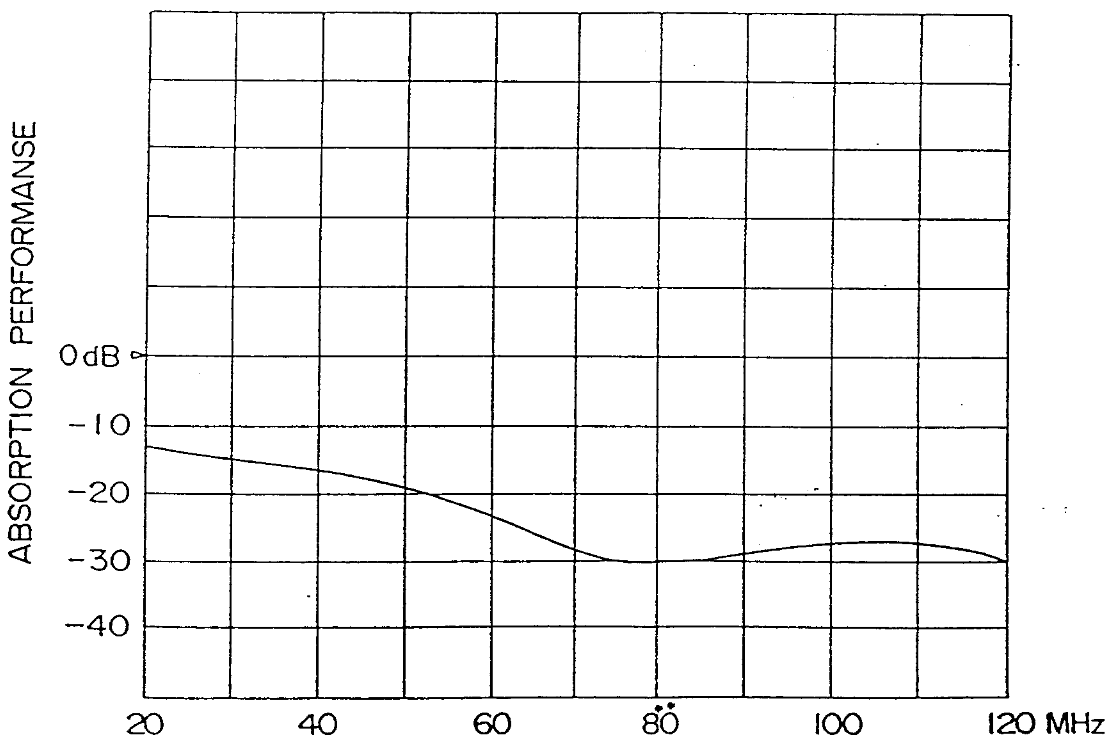
Fig. 8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FREQUENCY

Fig. 9

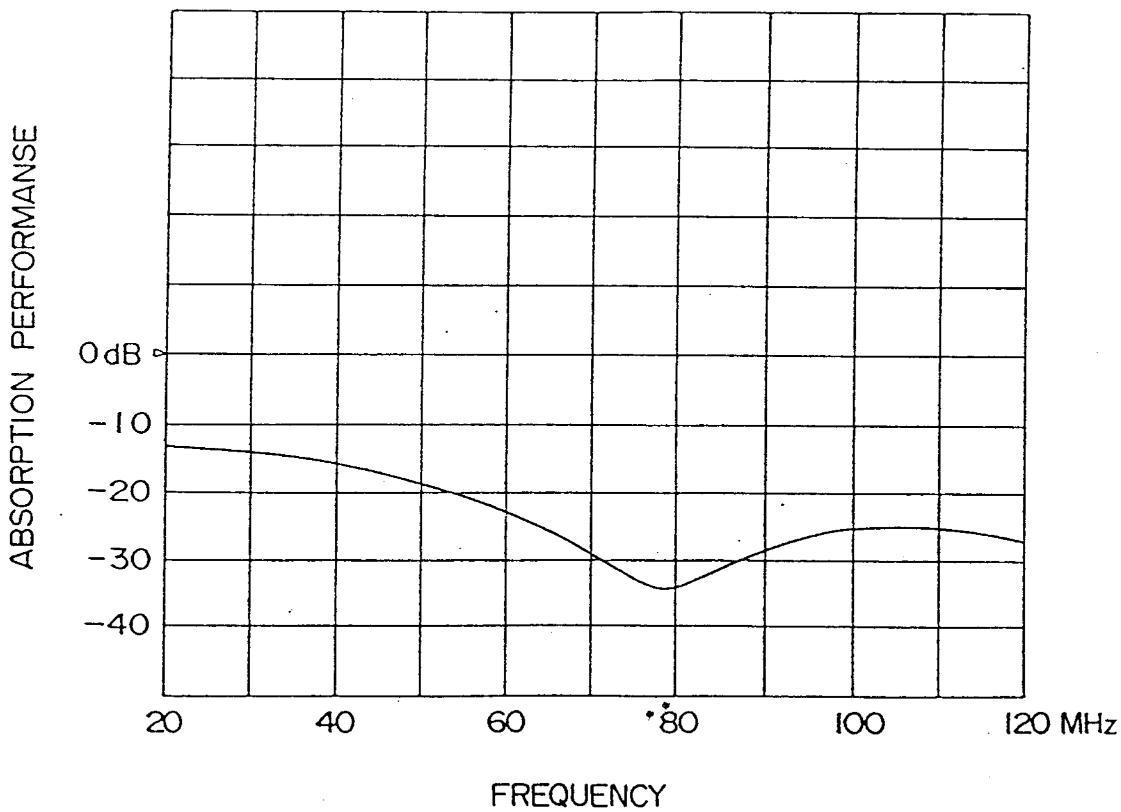
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Fig. 10

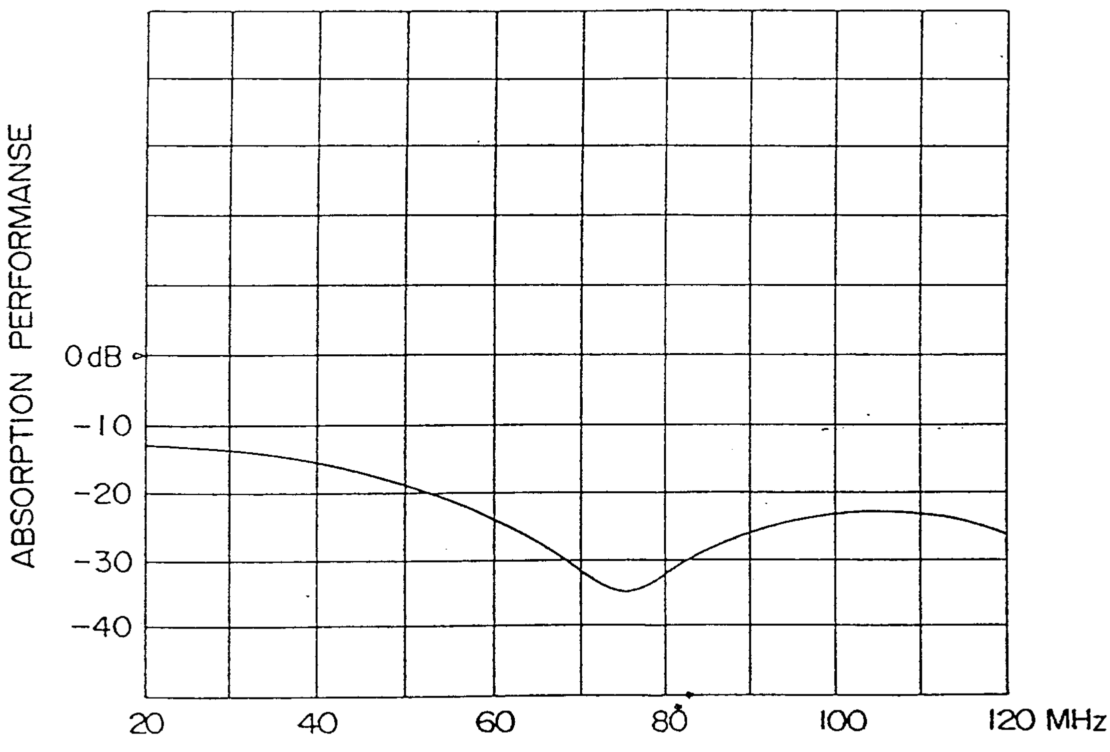
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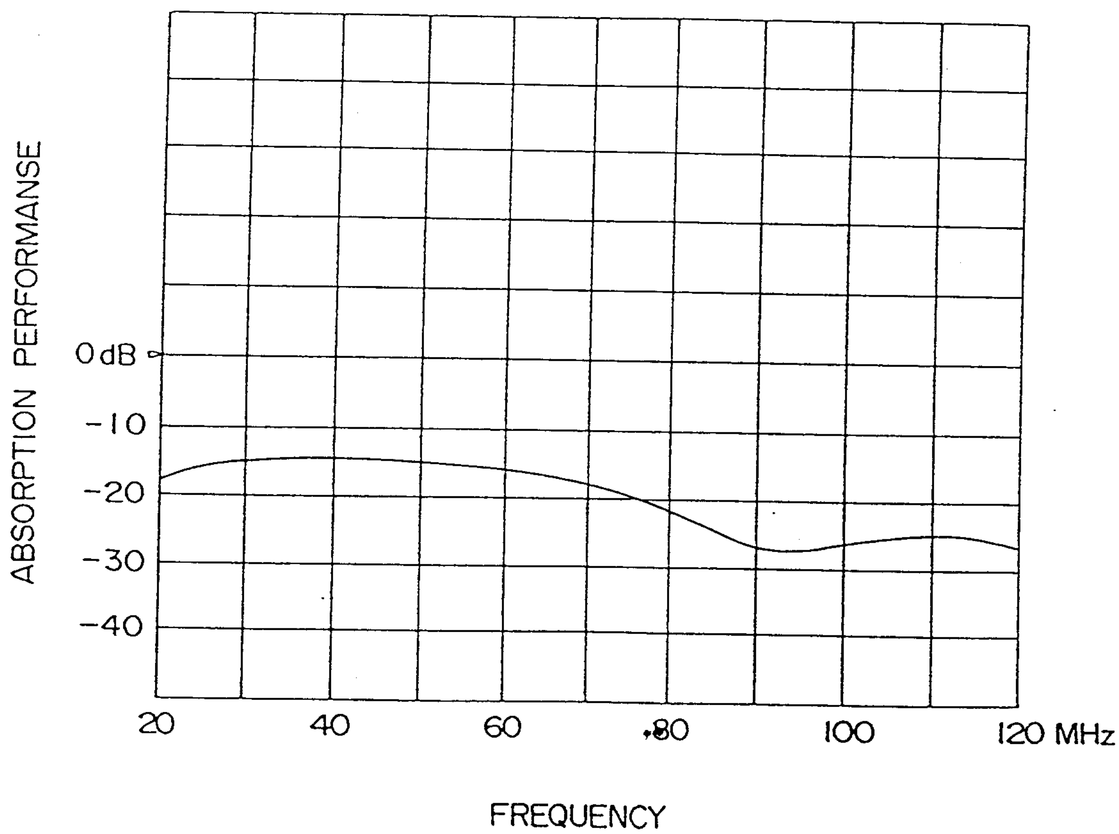
Fig. 11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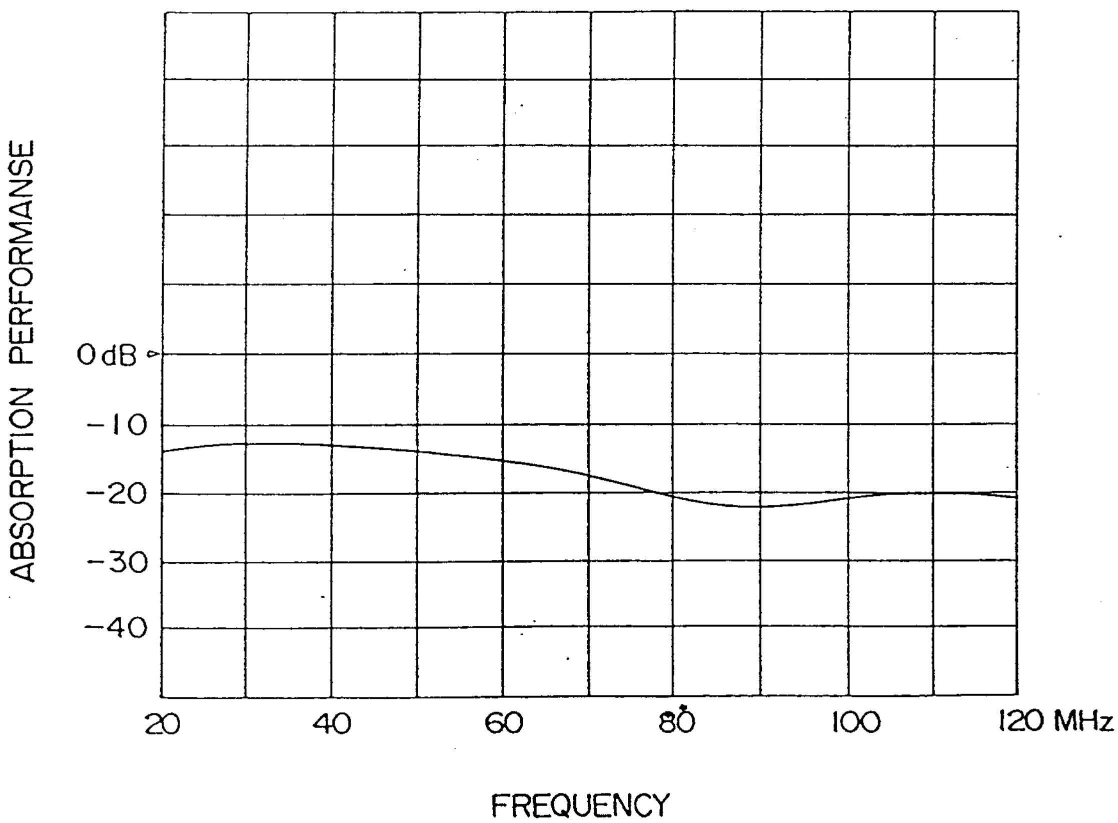
FREQUENCY

Fig. 12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INTERNATIONAL SEARCH REPORT

International Application No PCT/JP91/00788

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

Int. Cl[5] H05K9/00

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC	H05K9/00

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

Jitsuyo Shinan Koho 1926 - 1990
Kokai Jitsuyo Shinan Koho 1971 - 1990

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	JP, B1, 46-12228 (TDK Corp.), March 29, 1971 (29. 03. 71), Lines 9 to 24, column 2 (Family: none)	1
X	JP, A, 2-111099 (TDK Corp.), April 24, 1990 (24. 04. 90), Line 14, column 3 to line 11, column 4 (Family: none)	1

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

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"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)

"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

"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

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"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

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
August 1, 1991 (01. 08. 91)	September 17, 1991 (17. 09. 91)
International Searching Authority	**Signature of Authorized Officer**
Japanese Patent Office	