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(54) **Resonating microwave cavity with double dielectric resonator and tunable resonance frequency**

Mikrowellen-Resonanzhohlraum mit zwei dielektrischen Resonatoren und abstimmbarer Resonanzfrequenz

Cavité résonnante pour hyperfréquences avec double résonateur diélectrique et fréquence de résonance réglable

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- **PATENT ABSTRACTS OF JAPAN vol. 11, no. 59 (E-482)(2506) 24 February 1987 & JP-A-61 218 202 (NIPPON SOKEN INC) 27 September 1986**

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Description

The present invention relates to a resonant microwave cavity with double dielectric resonator and tunable resonance frequency.

As is known, resonant cavities with dielectric resonator are devices used as a filtering element for example in local oscillators and microwave filters.

Since the dielectric resonator has a high Q-factor unloaded and a high dielectric constant, oscillators with good performance, low phase noise and high frequency stability can be made.

For some applications, for example in microwave oscillators with dielectric resonator, the need arises for resonance frequency tuning which can be done mechanically and/or electronically.

If it is desired to perform the tuning electronically, there is ordinarily used a varactor diode coupled to the dielectric resonator, but there are obtained narrow tuning bands to avoid excessively degrading the Q-factor of the resonator since the varactor diode has a low Q-factor, e.g. Q-20 at 10GHz, for a GaAs (gallium arsenide) varactor.

If it is desired to perform the tuning mechanically there is ordinarily used a metal screw, ending optionally with a washer, in the cavity with adjustable distance from the dielectric resonator, as in the EP-A-0 337 371 patent application. But in this case the tuning frequency cannot be varied much since it would be necessary to draw the screw much closer to the dielectric resonator, wherein is confined the greater part of the energy, causing an excessive increase in the induced currents in the screw and hence a decrease in the Q-factor. In addition variation of the tuning frequency is not linear with the distance between the screw and the dielectric resonator but increases exponentially with the decrease in said distance, thus creating problems of gauging and sensitivity to mechanical vibrations especially at short distances.

To achieve tuning of the resonance frequency there is known, as described in United States patent 4565979, the use of a second dielectric resonator mounted on a screw which adjusts the distance and the coupling between the second resonator and the fixed primary one and hence the total resonance frequency of the resonant cavity. By the insertion of a second resonator with adjustable distance from the first, there is obtained better theoretical behaviour as regards the overall Q-factor which does not vary significantly and remains high with the variation of the distance.

But the following shortcomings are still present: variation of resonance frequency with the distance between the two resonators is not linear, but increases with the decrease in said distance, i.e. where the projecting part of the screw and of the second resonator from the screw support is greater, creating problems of excessive sensitivity to the stresses and mechanical vibrations which give rise to movements of the second resonator in relation to the first, and hence to excessive variations of the

resonance frequency.

In addition, to obviate the problem of the variation of relative humidity of the resonator, under the different possible ambient operating conditions, which affect resonance frequency value, the entire cavity should be sealed off, with obvious manufacturing problems such as for example sealed embodiment of the tuning screw housing and of the openings for coupling the cavity with the outside.

Therefore the purpose of the present invention is to overcome the above shortcomings and indicate a resonant microwave cavity with double dielectric resonator and tunable resonance frequency, wherein the primary dielectric resonator is sealed in a quartz support which holds up a secondary dielectric resonator and keeps it at a fixed distance from the primary resonator. Tuning is achieved by means of a metal screw with adjustable distance from the secondary resonator.

There is obtained a strong structure which minimizes the negative effects of mechanical vibrations on resonance frequency, whose adjustment is linear with the distance of the screw from the resonator. In addition the Q-factor of the cavity remains constant with variation of the tuning frequency.

To achieve said purposes the object of the present invention is a resonant microwave cavity with double dielectric resonator and tunable resonance frequency as described in claim 1.

Additional purposes and advantages of the present invention will become clear from the detailed description given below of an embodiment thereof and the annexed drawings given merely by way of nonlimiting example wherein:-

FIG. 1 shows a side cross section of an example of embodiment of the resonant microwave cavity with double dielectric resonator which is the object of the present invention,

FIGS. 2 and 3 show the trends of the resonance frequency variation obtained with the cavity which is the object of the present invention and with known cavities respectively,

FIG. 4 shows the trend of the Q-factor Q_s for the cavity which is the object of the present invention and for known cavities,

FIGS. 5 and 6 show the trends of the sensitivity in frequency for the cavity which is the object of the present invention and for known cavities respectively.

In FIG. 1 SM indicates a metal shield which delimits the resonant cavity and encloses all its components. SM has one or more openings IR for electromagnetic coupling with the outside activated in a known manner and termed irises and which allow input and output of the electromagnetic signal. SM is made in a known manner in any appropriate number of parts among which are identified at least one base SM1 and one cover SM2.

RDP indicates a primary dielectric resonator held up by a quartz support, indicated by SQP, integral with the base SM1. RDP and SQP can be for example of cylindrical form with diameter and height determined in a known manner and are fixed by sticking.

RDS indicates a secondary dielectric resonator, for example of cylindrical form, whose dimensions are calculated in a known manner.

SQS indicates a second quartz support provided for example in the form of an overturned glass and whose side surface is fixed to the base SM1 by means of airtight sticking. SQS has the double function of supporting the secondary resonator RDS a fixed distance from the primary resonator RDP and of enclosing the latter hermetically.

VS indicates a tuning screw which consists of the following elements:

- a hollow threaded body CSC which screws in a special through-passing threaded groove present in the cover SM2 of the metal shield SM, in the part opposite the base SM1;
- a metal washer TM constituting the terminal part of the hollow body CSC and facing the secondary resonator RDS; TM has a central through-passing hole;
- a fine tuning screw VSF which screws into a special through-passing threaded groove embodied inside the hollow body CSC and inside the hole of the washer TM, and can through-pass the hole;
- a ring ASS consisting of absorber material for the upper resonating modes and placed around the screw near the washer TM.

The screw VS is held in the cover SM2 by means of a lock nut CD.

Tightening or loosening the screw VS changes the distance of the metal washer TM from the secondary resonator RDS and hence the resonance frequency of the resonant cavity. Turning the screw VSF fine tunes said resonance frequency.

There will now be explained the principles on which is based the innovative concept expressed in the present invention.

In a resonant cavity with a single resonator and a resonance frequency adjustment screw the lowest or fundamental resonance frequency is called frequency f_r of the fundamental mode TE_{01d} and the electromagnetic field generated from the resonator has a trend of the type generated by a loop through which current runs.

If to the first resonator, termed primary resonator, is brought near a second resonator, termed secondary resonator and similar to the primary one, placing it on the same axis, there are obtained two resonance frequencies of the fundamental mode TE_{01d}, $f_{r1} < f_r$ and $f_{r2} > f_r$ respectively. This is true because the secondary resonator generates an electromagnetic field with two components respectively in-phase and phase opposi-

tion with respect of that generated by the primary resonator.

The frequency $f_{r1} < f_r$ is the resonance frequency for a resulting electromagnetic field when the electromagnetic field generated by the secondary resonator is the component in-phase with the field of the primary one.

The frequency $f_{r2} > f_r$ is the resonance frequency for a resulting electromagnetic field when the electromagnetic field generated by the secondary resonator is the component in phase opposition with respect to the field of the primary one.

The values of f_{r1} and f_{r2} depend basically on:

- the resonance frequency f_r of the primary resonator when considered as the only resonator in the cavity,
- the resonance frequency f_r of the secondary resonator when considered as the only resonator in the cavity, and
- the coupling between the two resonators.

In addition the resonance frequency f_r of each of the resonators depends on the dimensions and relative dielectric constant of the resonator whereas the coupling depends on the distance between the two resonators.

Normally in known systems there is used the frequency f_{r1} ; the frequency f_{r1} is regulated in known systems, as in that described in U.S. patent 4565979, changing the coupling and hence the distance between the two resonators, causing the shortcomings described above.

The salient characteristic of the present invention is regulation of the frequency f_{r1} by changing the resonance frequency f_r of the secondary resonator, and hence the distance x between the washer TM and said resonator, by means of the tuning screw VS, while holding constant the distance and hence the coupling between the two resonators.

This results in advantages and improvements in performance described below and more readily understood by referring to FIGS. 2 to 6, wherein d_{max} indicates the maximum distance to which can be taken the washer TM in relation to the secondary resonator RDS.

As shown in FIG. 2, there is obtained an adjustment of the linear frequency with the distance x of the washer TM from the secondary resonator in a broad range of frequencies between f_{r1} and f_{r2} .

For small distances x , i.e. when the washer TM (FIG. 1) draws near the secondary resonator RDS, the frequency f_r tends toward the value f_{r1} very slowly and tends to cancel out the contribution of the secondary resonator to determination of the resonance frequency f_r . Under these conditions any mechanical vibrations of the tuning screw which cause the distance to oscillate are maximal, but have little influence in terms of variations of resonance frequency because they influence only the secondary resonator which makes no appreci-

able contribution to the value of f_r . This is also clear from an analysis of the trend of sensitivity to mechanical vibrations S_n , FIG. 5, given by the derivative of the trend f_r of FIG. 2 in relation to the distance x : it tends to zero for small distances x .

The washer can even touch the secondary resonator, cancelling out the influence thereof on the frequency f_r , which becomes equal to f_{r1} , while when moving away the washer said influence increases and the value of f_r decreases toward f_{r2} . In any case the mechanical stresses never influence highly the resonance frequency since the greater part of the electromagnetic energy is confined to the region of the cavity in which all the parts are rigidly mounted.

What happens in known systems is shown in FIGS. 3 and 6. In FIG. 3 it is seen that the variation of resonance frequency f_r with the distance x is maximal for small x , i.e. when the secondary resonator draws close to the primary one and elongation of the tuning screw is maximal, whether with metal screw (curve f_{rm}) or dielectric screw (curve f_{rd}).

As appears in FIG. 6, under these conditions, sensitivity to the mechanical vibrations S is maximal, both for the metal screw (curve S_m) and for the dielectric screw (curve S_d).

In accordance with the present invention, it is possible to predetermine readily the range of variation of the resonance frequency, it being given by the values of f_{r1} and f_{r2} , and hence obtain by the tuning screw a linear variation of the resonance frequency with the distance x of the screw from the secondary resonator in a broad range of values between f_{r1} and f_{r2} , where the derivative curve S_n (FIG. 5) has an approximately constant value.

With variation of the resonance frequency f_r and hence distance d , the Q-factor Q_s of the resonant cavity remains substantially unchanged since the distance between the two resonators remains constant. This is also clear from FIG. 4 in which Q_{sd} indicates said trend, which is also what occurs in known systems which use a dielectric tuning screw; but Q_{sm} indicates the trend of the Q-factor in known systems using mechanical tuning screws.

The quartz glass SQS makes airtight the zone of the cavity where the greater part of the electromagnetic energy is concentrated, i.e. the only zone around the primary resonator RDP of real interest from the viewpoint of sensitivity to the variation of relative humidity of the surroundings. In this manner the rest of the resonant cavity can be provided without airtightness with obvious reduction of problems and costs.

Numerous variants of the embodiment described by way of example in FIG. 1 are possible without thereby going beyond the scope of the innovative principles contained in the inventive idea.

Claims

1. Resonant microwave cavity delimited by a metal shield (SM) which includes and sustains a double dielectric resonator and also supports tunable resonance frequency means made of a metal washer (TM) held up by a metal tuning screw (VS) which screws from the outside of said metal shield in a groove made therein, **characterized in that** it comprises a primary dielectric resonator (RDP) with associated quartz support (SQP) both enclosed hermetically in a second quartz support (SQS) which holds up a secondary dielectric resonator (RDS) and keeps it at a fixed distance from the primary resonator, tuning being performed by means of a metal washer (TM) at an adjustable distance from the secondary resonator.
2. Resonant microwave cavity as in claim 1, characterized in that said second quartz support (SQS) is provided in the form of an overturned glass, whose side surface is fixed to said metal shield (SM).
3. Resonant microwave cavity as in claim 1, characterized in that said tuning screw (VS) and said washer (TM) are hollow for housing a fine tuning screw (VSF).
4. Resonant microwave cavity as in claim 1, characterized in that it comprises a ring (ASS) consisting of absorber material, for upper resonating modes, placed around said tuning screw (VS) near the metal washer (TM).
5. Resonant microwave cavity as in claim 1, characterized in that said primary dielectric resonator (RDP) and associated quartz support (SQP) and said secondary dielectric resonator (RDS) are made in cylindrical form.

Patentansprüche

1. Ein in eine metallische Abschirmung (SM) eingeschlossener Mikrowellen-Resonanzhohlraum, der einen doppelten dielektrischen Resonator beinhaltet und außerdem eine Vorrichtung zur Abstimmung der Resonanzfrequenz trägt, die aus einer an einer Abstimmschraube (VS) befestigten Metallscheibe (TM) besteht, die von der Außenseite in eine Öffnung der genannten metallischen Abschirmung eingeschraubt wird, **dadurch gekennzeichnet**, daß diese einen dielektrischen Primärresonator (RDP) mit zugehörigem Quarzträger (SPQ) enthält, die beide hermetisch in einem zweiten Quarzträger (SQS) eingeschlossen sind, der seinerseits einen dielektrischen Sekundärresonator (RDS) trägt und diesen in einem festem Abstand von dem Pri-

märresonator hält, wobei die Abstimmung mit Hilfe einer Metallscheibe (TM) in einstellbarem Abstand vom Primärresonator vorgenommen werden kann.

2. Ein Mikrowellen-Resonanzhohlraum wie in Anspruch 1, **dadurch gekennzeichnet**, daß der genannte zweite Quarzträger (SQS) in der Form eines auf den Kopf gestellten Glasbechers hergestellt wird, dessen Seitenwand an der genannten Metallabschirmung (SM) befestigt ist. 5
3. Ein Mikrowellen-Resonanzhohlraum wie in Anspruch 1, **dadurch gekennzeichnet**, daß die genannte Abstimmungsschraube (VS) und die genannte Scheibe (TM) hohl sind, sodaß sie eine Schraube zur Feinabstimmung (VSF) aufnehmen können. 10
4. Ein Mikrowellen-Resonanzhohlraum wie in Anspruch 1, **dadurch gekennzeichnet**, daß dieser einen aus Absorptionsmaterial bestehenden Ring (ASS) für höhere Resonanzmoden enthält, der die genannte Abstimmungsschraube (VS) umschließt und nahe der Metallscheibe (TM) angebracht ist. 15
5. Ein Mikrowellen-Resonanzhohlraum wie in Anspruch 1, **dadurch gekennzeichnet**, daß der genannte dielektrische Primärresonator (RDP) samt zugehörigem Quarzträger (SQP), sowie der genannte Sekundärresonator (RDS) in zylindrischer Form hergestellt werden. 20

3. Cavit  resonnante pour hyperfr quences selon la revendication 1, caract ris e en ce que ladite vis d'accord (VS) et ladite rondelle (TM) sont creuses pour qu'une vis d'accord fin (VSF) puisse s'y loger.
4. Cavit  resonnante pour hyperfr quences selon la revendication 1, caract ris e en ce qu'elle comprend une bague (ASS) compos e d'un mat riel amortisseur, pour les modes de r sonance sup rieurs, plac e autour de ladite vis d'accord (VS) pr s de la rondelle m tallique (TM).
5. Cavit  resonnante pour hyperfr quences selon la revendication 1, caract ris e en ce que ledit r sonateur di lectrique primaire (RDP) et le support de quartz associ  (SQP) et ledit r sonateur di lectrique secondaire (RDS) sont faits sous forme cylindrique.

Revendications

1. Cavit  resonnante pour hyperfr quences, d limit e par un blindage m tallique (SM) qui comporte et soutient un double r sonateur di lectrique et supporte  galement un moyen pour fr quence de r sonance r glable constitu  d'une rondelle m tallique (TM) retenue par une vis d'accord m tallique (VS) qui se visse de l'ext rieur dudit blindage m tallique dans une gorge pratiqu e dans celle-ci, **caract ris e en ce qu'elle** comprend un r sonateur di lectrique primaire (RDP) avec un support de quartz associ  (SQP), tous deux enferm s herm tiquement dans un second support de quartz (SQS) qui retient un r sonateur di lectrique secondaire (RDS) et le maintient   une distance fixe du r sonateur primaire, le r glage  tant r alis  au moyen d'une rondelle m tallique (TM)   une distance ajustable depuis le r sonateur secondaire. 35
2. Cavit  resonnante pour hyperfr quences selon la revendication 1, caract ris e en ce que le second support de quartz (SQS) est pr vu sous la forme d'un verre renvers  dont la surface lat rale est fix e audit blindage m tallique (SM). 40

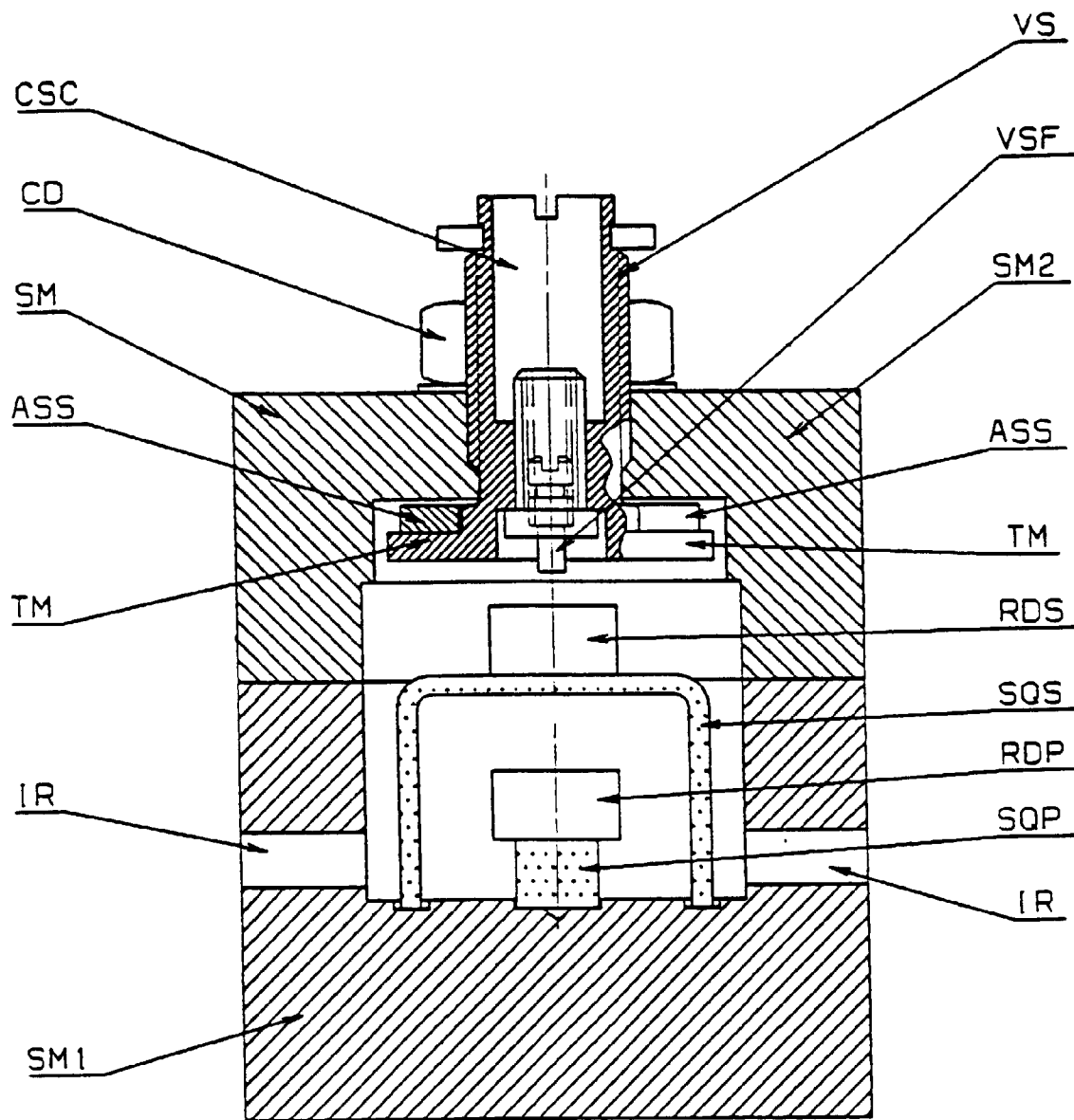


FIG. 1

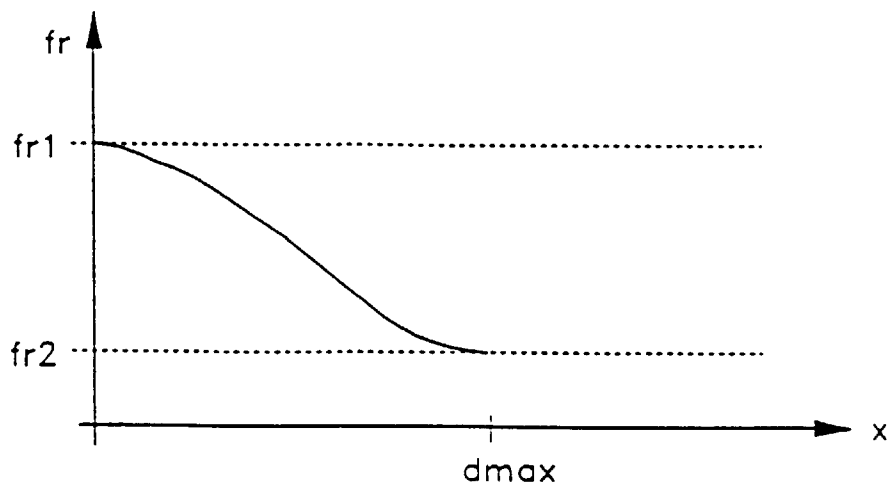


FIG. 2

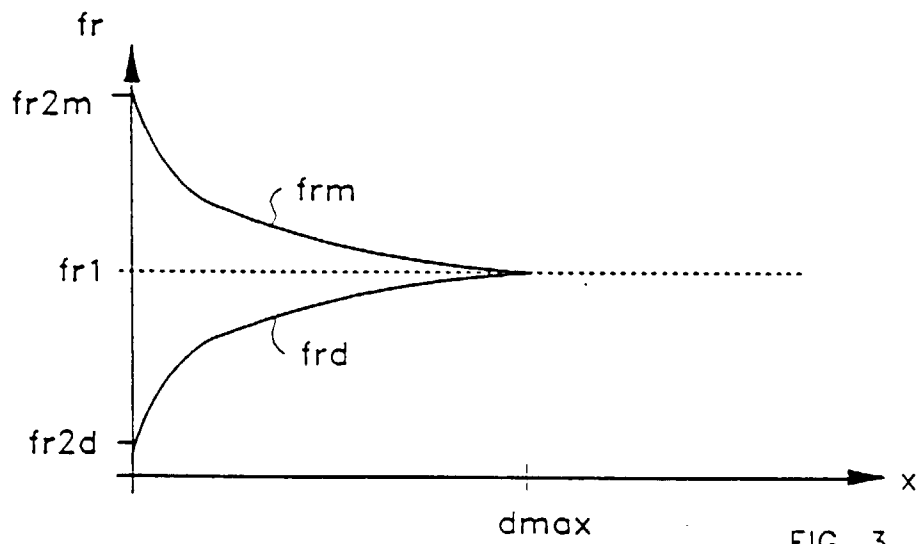


FIG. 3

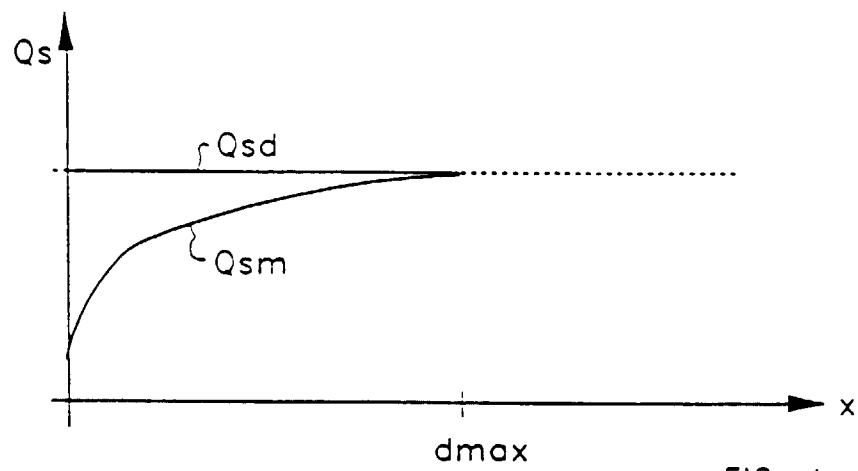


FIG. 4

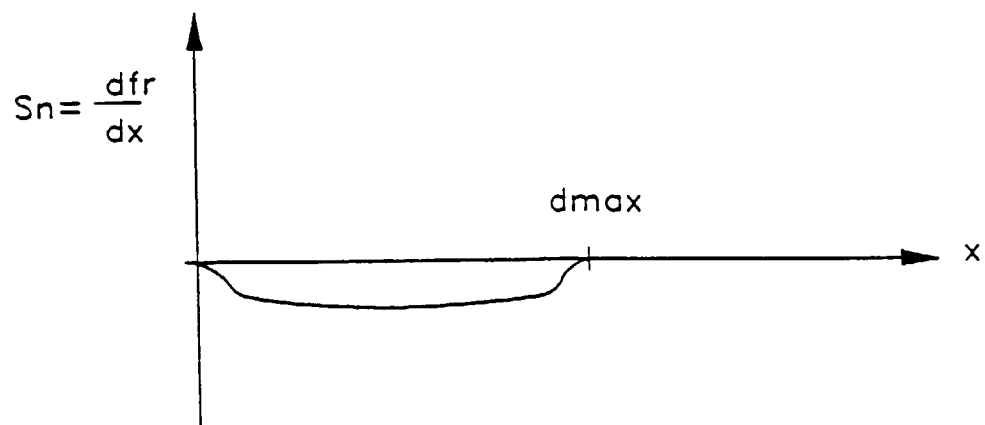


FIG. 5

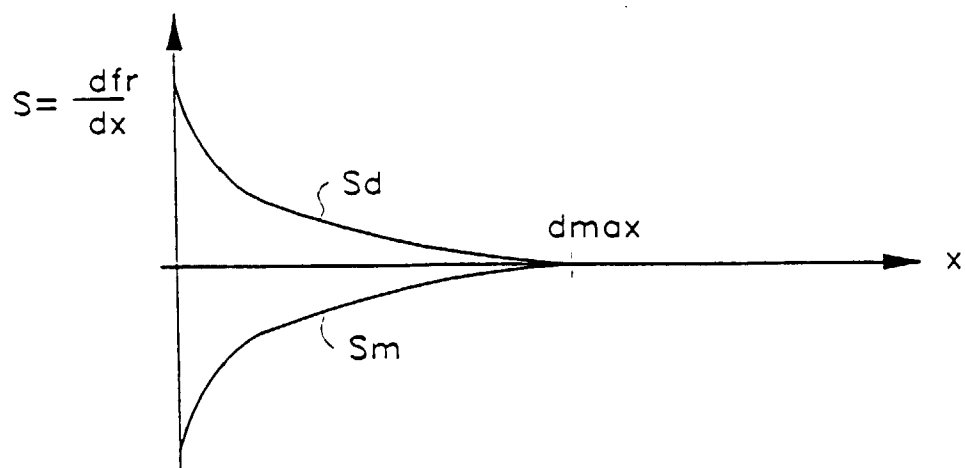


FIG. 6