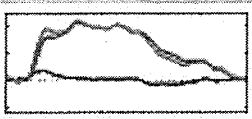
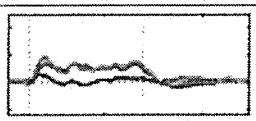
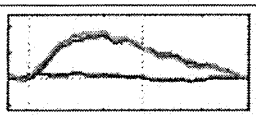
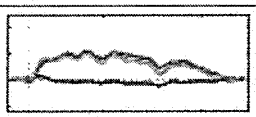
表　NIRSで捉えた精神疾患の前頭葉機能(模式図)

	NIRS波形	賦活反応性
健常者		明瞭
うつ病		減衰
双極性障害		遅延
統合失調症		非効率

平均して，ウィンドウ中央の時点におけるNIRSデータとする．アーティファクトなどに基づく高周波数成分を除去する目的としている．

2．視察によるデータの判定(表，図3)

得られたデータのうち特にoxy-Hbに注目し，その波形データを視察により検討し，また補助としてトポグラフィー表示を参考にする．注目するのは前頭部から得られるデータで，①全体的な賦活の大きさ(積分値)，②課題全体を通じた賦活のタイミング(重心値)，③課題初期の賦活のスムーズさ(初期賦活)，の3点についてである．

前頭部における賦活が大きい場合には，前頭葉の賦活反応性が十分であることを示し，気分障害や統合失調症の状態にはない可能性を示唆する．うつ状態の双極性障害では賦活が大きいこともあるが，この後に述べるピークが後半となることが多い．

前頭部における課題全体を通じた賦活のタイミングとは，賦活の大きい時点が課題前半/課題後半/課題終了後のいずれかという点である．波形が滑らかな場合にはピークとして認められるが，波形が不規則な場合にはピークとして捉えにくいこともある．健常者では，課題前半から課題中盤にピークを認めることが多い．ピークが課題終了前後あるいは課題終了後にあったり，あるいはピークが明瞭でなく課題終了前後や課題終了後の賦活が大きい場合は，統合失調症や双極性障害であることが多い．

課題初期の賦活のスムーズさは，波形の最初の部分の傾き(立ち上がり方)として表れる．うつ病では賦活の大きさは小さくても，この部分の傾きは速やかであることが多いので，細かな観察が重要である．この傾きが小さく全体の賦活も小さい場合には統合失調症を，傾きは小さいが賦活の増加が緩やかに続いて全体として大きい場合には双極性障害を考える．双極性障害の躁状態では，この傾きが急峻だが間もなく低下してしまうパターンを示すことがある．

3．自動解析の試み(図4)

上記の結果は各疾患についての群平均データの特徴をもとにした判定であるが，個別データについて定量的で自動的な特徴抽出の試みを進めている．具体的には，①前頭前野背外側面にほぼ対応する前頭部11チャンネルの平均波形を算出し，②得られたoxy-Hb平均波形について，課題区間におけるoxy-Hb増加の累積(積分値)と課題開始前～課題終了後の区間におけるoxy-Hb増加の時間軸上の中心位置(重心値)の2パラメータを自動抽出し，③積分値と重心値の2パラメータの組み合わせにより，波形パターンを5分類する，という手順である．

二つのパラメータのうち，積分値は脳賦活の大きさを表す指標である．光路長の個人差や部位差があるため，チャンネル間の平均波形を求めることや個人間で比較することは望ましくないとされるので，それを含んだ一つの近似値としての指標である．もう一つの重心値は，脳賦活のタイミングを表す指標であり，時間分解能が高いNIRSの特徴を生かした指標である．この2指標を用いると，波形を5パターンに分類でき，この5パターンが疾患ごとに異なる分布を示すという予備的な結果を得ている．

こうしたパラメータの自動抽出に基づく解析においては，①複数チャンネルを平均した波形に基づくもので，チャンネルごとの波形の相違を考慮していない，②上記の二つのパラメータ以外の特徴を考慮していないなどのことがあるため，視察判定を併用することで疾患ごとの特徴をより捉えやすくなる印象がある．

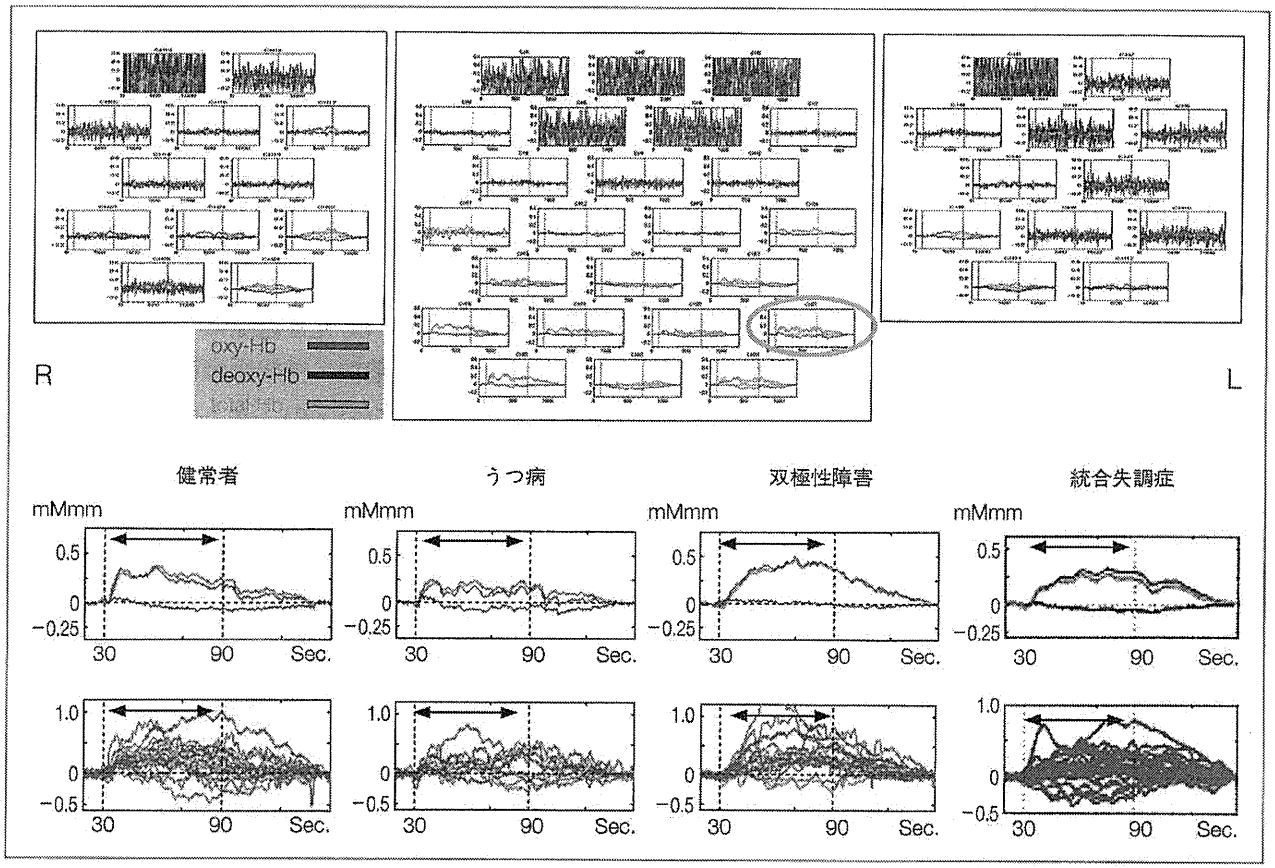


図3　NIRS で捉えた精神疾患の前頭葉機能

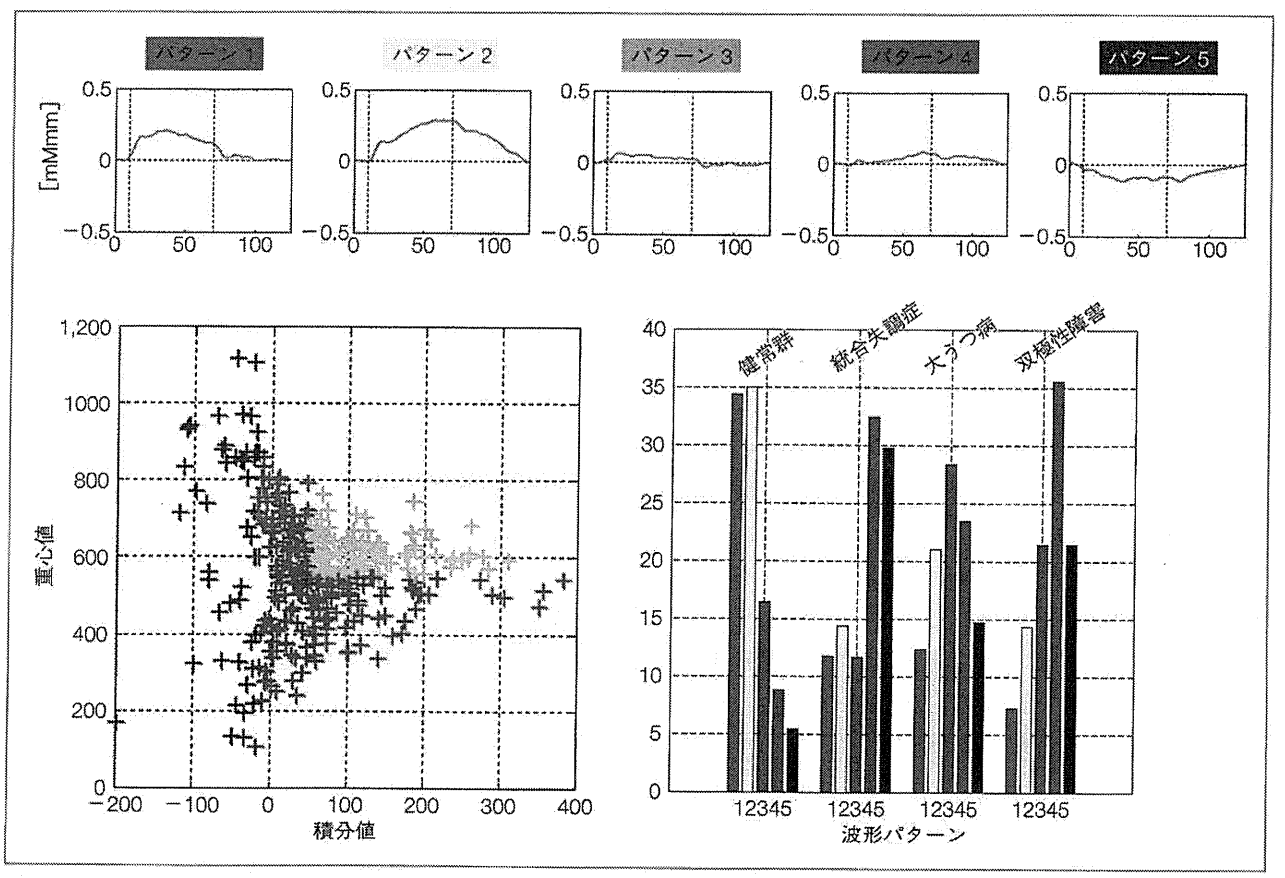


図4　NIRS データの自動解析と疾患ごとの分布

精神疾患のための臨床検査

1．精神疾患の診断の現状

精神疾患は予想以上に多い疾患である．認知症や統合失調症を除いても，わが国の一般人口における精神疾患の1年有病率8.8%，生涯有病率24.4%という報告がある．生命に及ぼす影響や障害の原因としても重要で，WHOが用いている障害調整生命年(disability-adjusted life years, DALY)を指標にすると，わが国では精神神経疾患がその20.7%を占め第1位で，悪性新生物や循環器疾患を上回っている．医療機関を受診する患者はその一部にすぎないが，厚生労働省の患者調査ではわが国の受診患者数は149万人(1990年)→218万人(1996年)→258万人(2002年)→323万人(2008年)と増加を続けている．そのため2011年には，癌・脳卒中・急性心筋梗塞・糖尿病とならび，医療法に基づいて厚生労働省が定める5大疾病の一つに指定された．

こうした精神疾患の診断や治療は，主に臨床症状と病歴とに基づいて行われており，多くの精神疾患の診断や治療に有用な臨床検査は現在のところ確立されていない．そのため，一般外来を受診する患者における精神疾患についての内科医と精神科医の診断一致率は19.3%に過ぎず，患者5人のうち4人は見逃されるか誤診されているという現状がある(WHO調査)．また，臨床検査が未確立であることが，予防や早期診断を困難にしている側面がある．

2．精神疾患のための臨床検査の意義

脳画像検査法の進歩などにより精神疾患における脳の微妙な変化が捉えられるようになり，脳科学の対象が「理性脳→感情脳→社会脳→自我脳」と精神疾患に近づいてきたことなどから，今後は精神疾患についての臨床検査の実現が期待されている．NIRSのような検査で「こころの病を目に見えるようにする」ことは，問診に基づく診断や治療の客観性や確実性や定量性を高めるための補助検査として医療者にとって役立つばかりでなく，そのデータを当事者や家族にも見てもらうことで，当事者中心の精神科医療を進めるうえでも有用と考えられる．

なお，本稿で述べた先進医療についての研修の機会として，国立精神・神経医療研究センター病院が，検査技術についての「光トポグラフィー講習会」と，データ判読についての「光トポグラフィー判読セミナー」を開催している．また，NIRSによる脳機能測定の情報交換の場として日本光脳機能イメージング研究会があり，毎年200名以上の参加者がある(http://jofbis.umin.jp)．

謝　辞

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(12) **United States Patent**
Oohashi et al.

(10) **Patent No.: US 8,167,826 B2**
(45) **Date of Patent: May 1, 2012**

(54) **VIBRATION GENERATING APPARATUS AND METHOD INTRODUCING HYPERSONIC EFFECT TO ACTIVATE FUNDAMENTAL BRAIN NETWORK AND HEIGHTEN AESTHETIC SENSIBILITY**

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(73) Assignee: **Action Research Co., Ltd.**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 115 days.

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A61H 1/00 (2006.01)

(52) **U.S. Cl.** **601/2**
(58) **Field of Classification Search** 601/2
See application file for complete search history.

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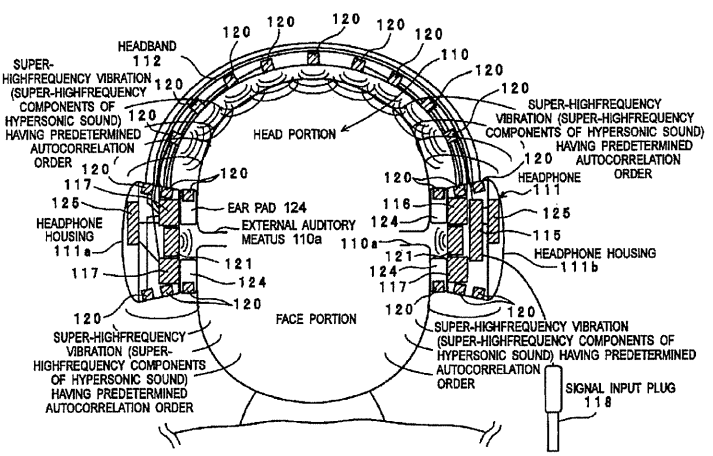
Primary Examiner — Tse Chen
Assistant Examiner — Hien Nguyen
(74) *Attorney, Agent, or Firm* — Wenderoth, Lind & Ponack, L.L.P.

(57) **ABSTRACT**

A means is provided for generating a vibration or a vibration signal, which contains audible range components that are vibration components in the audible frequency range and super-high-frequency components within a range exceeding the audible frequency range up to a predetermined maximum frequency, and which has an autocorrelation order represented by at least either one of a first property and a second property. By applying the vibration or an actual vibration generated from the vibration signal to a human being, a fundamental brain activation effect activating the fundamental brain network system constituted of a fundamental brain including the brain stem, thalamus and hypothalamus that are regions to bear the fundamental function of the human being and the fundamental brain network of neuronal projection from the fundamental brain to various brain regions is introduced.

24 Claims, 90 Drawing Sheets



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VIBRATION GENERATING APPARATUS AND METHOD INTRODUCING HYPERSONIC EFFECT TO ACTIVATE FUNDAMENTAL BRAIN NETWORK AND HEIGHTEN AESTHETIC SENSIBILITY

TECHNICAL FIELD

The present invention relates to a vibration generating apparatus and method for generating a vibration that can introduce an effect (hereinafter referred to as a hypersonic effect) of comprehensively enhancing mental activity and physical activity by increasing the regional cerebral blood flow of the fundamental brain including the brain stem, thalamus and hypothalamus, which are the regions that bear the fundamental functions of the brain, and the neuronal projection from the fundamental brain to various areas in the brain (these are hereinafter collectively referred to as a fundamental brain network system) and by activating these regions with a hypersonic sound, which is a sound having a non-stationary structure that abundantly contains super-high-frequency components exceeding the human audible frequency upper limit, and relates also to a vibration discriminating apparatus and method for discriminating the vibration. That is, the present invention relates, in concrete, to a vibration generating apparatus and method for generating a vibration that can introduce the effects of increasing α rhythm power of the brain wave, heightening the aesthetic sensibility to general sensory inputs inclusive of receiving of sounds pleasantly, beautifully and movingly, thereby heightening the sensibility effects of composite sensory information including sounds, intensifying a sound listening behavior, and adjusting the activities of the emotional system, the behavior control system, the autonomic nervous system, the endocrine system and the immune system located in the fundamental brain network system, thereby reducing stress and comprehensively improving lifestyle-related diseases of metabolic syndromes such as hypertension, hyperlipidemia and diabetes, cancer, cerebrovascular disorder and cardiopathy, immune abnormalities including pollinosis and atopic dermatitis, various mental disorders such as depression, schizophrenia, dementia, chronic fatigue syndrome and attention-deficit hyperactivity disorder, behavioral abnormalities such as suicide and self-injurious behaviors, abnormal exaltation of aggressiveness and so on, which are caused by the abnormality of the fundamental brain activity and pose serious problems, in the modern society, and relates to a vibration discriminating apparatus and method for discriminating the vibration.

BACKGROUND ART

The present inventor and others discovered that a hypersonic sound, which was a non-stationary sound abundantly containing super-high-frequency components exceeding the audible frequency upper limit, introduced a fundamental brain activation effect of increasing the regional cerebral blood flow of the fundamental brain, including the brain stem, thalamus and hypothalamus, and the fundamental brain network (fundamental brain network system) of a human being listening to the sound and boosting α rhythm of the brain wave power of an index of the fundamental brain activation, and had the effects of heightening the aesthetic sensibility inclusive of receiving of sounds pleasantly, beautifully and movingly, reducing stress, rationalizing the activities of the autonomic nerve system, the endocrine system and the immune system, and comprehensively improving the mental and physical states, i.e., a hypersonic effect, by contrast to

which the fundamental brain activity was more deteriorated than in a background noise state when he or she was listening to a sound containing no super-high-frequency component (See, for example, the Patent Documents 1 to 4 and the Non-Patent Documents 1 and 2).

In addition, the present inventor and others have revealed that, by contrast to the fact that the natural environmental sounds of the tropical rain forests, which are the most powerful candidate of the environments where the human genes had been formed through evolution, abundantly contained super-high-frequency components that largely exceeded 20 kHz at the human audible frequency upper limit and had a complicatedly changing structure capable of introducing the fundamental brain activation effect, environmental sounds in cities where the modern people lived contained almost no such super-high-frequency components and deteriorated the fundamental brain activity (See, for example, the Patent Document 5 and the Non-Patent Documents 3 and 4).

The fundamental brain activated by the hypersonic sound serves as an important base of the neural circuit inclusive of the monoamine nerve system and the opioid nerve system closely related to the control of human emotions and behaviors. Therefore, it has been discovered that the activity disorder of the fundamental brain and the neural network projected on the entire brain from there leads to various mental and behavioral disorders. Further, the fundamental brain, which is the ultimate center of the autonomic nerve system and the endocrine system, controls the immune system via them and bears a function to maintain the homeostasis of the whole body through these and a biophylactic function. Therefore, the disorder of the fundamental brain activity has a close relation to the induction of the lifestyle-related diseases that are rapidly increasing in the modern society by incurring breakdown of the homeostatic function and the biophylactic function.

Therefore, paying attention to the fact that the aforementioned mental and behavioral disorders and the lifestyle-related diseases and the like are increasing specifically and rapidly in the modern society, it is highly possible that a cause is ascribed to the fact that the sound environments surrounding the modern people largely deviate from the specific sound structure characterizing the environmental sounds of the tropical rain forests, which are the most powerful candidate of the environments where the human genes have been evolutionally formed, and particularly the complicatedly changing super-high-frequency components drop out, consequently causing the disorder of the fundamental brain activity.

On the other hand, reproducing the tropical rain forest natural environment as it is in the modern cities does not become a realistic solution method counterbalancing the urgency of the aforementioned problems that the modern societies confront in terms of climate and biological conditions and also in the aspect of the needed time and the amount of a social investment cost. Accordingly, a method for solving the aforementioned problems in the aspects of psychosomatic health that the modern people confront is proposed by using a vibration signal having a specific structure to introduce the fundamental brain activation effect and a vibration generating apparatus capable of generating it, generating a vibration to introduce the fundamental brain activation effect in a manner similar to that of the tropical rain forest environmental sounds suited to the design of the human genes and applying the same to the modern people, thereby introducing the fundamental brain activation effect (See, for example, the Patent Document 5).

However, almost all of the audio signals in the digital formats outputted from compact discs (CD), mini discs (MD) and those recorded in solid memories of portable players, which are audio information media widely popularized in the

http://ip.com/patent/US8167826

modern society, and the audio signals in the digital formats distributed and delivered via broadcastings and telecommunications can neither record nor reproduce super-high-frequency components, and therefore, they are unable to generate a hypersonic sound and to activate the fundamental brain.

On the other hand, it is recently becoming possible to use digital media, which have formats capable of recording, transmitting and reproducing to a range that largely exceeds the audible range upper limit, such as super audio CD (SACD), DVD audio, soundtracks of blu-ray disc (BD) and network distribution by high-speed optical communications or the like. However, the vibration signals recorded in the recording media, i.e., the contents contain no super-high-frequency component in these due to limitations in the vibration generating function owned by the sound sources and limitations in the capability of the recording and editing apparatuses and the like, and therefore, it is customary that the hypersonic sound cannot be generated and the fundamental brain activation effect cannot be introduced.

Further, the present inventor and others revealed that, when an artificial signal of a white noise or the like was applied as super-high-frequency components to a listener with the audible range components, or the vibration components in the audible frequency range, the hypersonic effect was not induced even if sufficient super-high-frequency components are contained (See, for example, the Non-Patent Document 2). Moreover, none of a sine-wave-like signal having a peak at a specific frequency, its harmonic sound and super-high-frequency components of a quantization noise entailed by a high-speed sampling 1-bit quantization system or the like similarly produce the hypersonic effect. Further, it is recently revealed that super-high-frequency components, which are composed of a sine-wave-like signal having a peak at a specific frequency and are generated from artificial objects of electronic equipment and the like, introduce negative effects of unpleasant sensation, escape behavior and so on in human beings and animals to which they are applied, and they are used as an apparatus for rejecting young people and an apparatus for repulsing mice (See, for example, the Non-Patent Documents 5 and 6).

These findings suggest that, in order to introduce the fundamental brain activation effect by the hypersonic effect, it is not proper to merely apply super-high-frequency components exceeding the audible range upper limit, but it is necessary that those super-high-frequency components have a certain specific structural feature, whereas the vibration of the super-high-frequency components having a certain peculiar structure different from it has a risk of possibly exerting a negative influence on the physiological states of human beings and animals. However, such a structural feature that the super-high-frequency components of the vibration that can introduce the fundamental brain activation effect should have has not been clarified thus far. Therefore, even if the digital formats capable of recording, transmitting and reproducing super-high-frequency components in a manner similar to that of the super audio CD (SACD), soundtracks of blu-ray disc (BD) and network distribution utilizing high-speed optical communications and the like are made usable, it is unclear what sort of structural feature should be owned by the vibration signals recorded and transmitted there in order to introduce the fundamental brain activation effect.

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Non-Patent Document 5: Kaoru Ashihara, "Factual survey of Super-high-frequency Sounds Existing in Surroundings", Journal of Acoustical Society of Japan, Vol. 65, pp. 23-28, January, 2009;
Non-Patent Document 6: Tomomi Yamada, "Super-high-frequency Sounds Generated from Dental Instruments", Journal of Acoustical Society of Japan, Vol. 65, pp. 52-57, January, 2009; and
Non-Patent Document 7: Mikio Hino, "Spectrum Analysis", Asakura Shoten, pp. 210-217, October, 1977.

DISCLOSURE OF INVENTION

Problems to be Solved

First of all, there is such a problem that, since the structural feature of super-high-frequency components that can introduce the fundamental brain activation effect has not been conventionally identified, it is impossible to estimate whether a sound applied to a listener can actually introduce the fundamental brain activation effect from the structure itself of the vibration signal even if it contains super-high-frequency components as observed in an example in which super-high-frequency components artificially synthesized from, for example, a white noise or the like do not introduce the hypersonic effect. That is, as to whether a certain vibration introduces the fundamental brain activation effect, it is necessary to actually observe whether the fundamental brain is activated by applying the vibration to the listener in each case and measuring the activation of the fundamental brain of the listener by a strict physiological experiment using advanced functional brain measuring means such as a positron emission tomography or an electroencephalograph. It is unreal to carry out such a physiological experiment for every vibration, measure the fundamental brain activation and thereafter link them to practical use. Therefore, it is necessary to specify the structural features of the vibration signal that can introduce the fundamental brain activation effect in order to estimate whether a specified vibration can introduce the fundamental brain activation effect without carrying out a physiological experiment.

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Secondly, there is such a problem that a vibration containing super-high-frequency components that can introduce the fundamental brain activation effect cannot be artificially synthesized since the structural feature of the super-high-frequency components that can introduce the fundamental brain activation effect has not been conventionally identified. In particular, considering the uncovered existence of a problem in the safety aspect such that a definite kind of artificial super-high-frequency components produces a negative effect in the physiological states of human beings and animals, a vibration generated from a specific inartificial natural vibration generating source of which the effectiveness and safety have been proven by the past results, such as the environmental sounds of tropical rain forests and a definite kind of native musical instrument sound are to be recorded and used as the vibration that can introduce the fundamental brain activation effect. However, the kinds and the amount of inartificial natural vibration generating sources that can introduce such a fundamental brain activation effect are limited, and collection and recording of them are frequently accompanied by immense difficulties and sometimes even risks. Therefore, in order to artificially abundantly synthesize various kinds of vibrations that can introduce the fundamental brain activation effect without relying on the limited inartificial natural vibration generating sources, it is necessary to identify the structural feature of the vibration that can introduce the fundamental brain activation effect.

Thirdly, there is such a problem that, since the structural feature of the super-high-frequency components that can introduce the fundamental brain activation effect has not been conventionally identified in spite of a variety of past proposals of band expanding methods as one method for complementing a vibration signal from which the super-high-frequency components drop out with super-high-frequency components, it is necessary to carry out a physiologic experiment in each case and confirm every vibration whether the super-high-frequency components artificially expanded by such a conventional band expanding method introduce the fundamental brain activation effect. In particular, considering the reported examples in which the hypersonic effect does not occur or conversely produce a negative effect in the case of a definite kind of artificially synthesized super-high-frequency components as described above, it is very important to discriminate whether the structure of the super-high-frequency components artificially expanded by the band expanding method is able to introduce the fundamental brain activation effect, i.e., whether it is effective and safe for human beings.

Fourthly, due to the existence of such wide variety of problems, there is such a problem that the vibration generated by the vibration sources of the existent vast amount of record library and the vibration generating apparatus not only significantly impair the sensuous artistic value but also rather invite various modern diseases due to a deterioration in the fundamental brain activity failing in introducing the fundamental brain activation effect, and this leads to a high possibility of significantly threatening the comfort and safety of modern people. There is a growing demand for a technique to overcome such limitations and prevent the risks.

Fifthly, there is such a problem that, in contents comprehensively working on multiple sensory systems of visual sensation, auditory sensation and so on, such as video and audio contents recorded in a large-capacity package media of DVD, Blu-ray Disc and the like popularized recently rapidly and video and audio distributed and delivered by using high-speed large-capacity communication lines such as high-definition television and high-speed optical communications, the recording media have restrictions in the recordable information capacity and restrictions in the information transfer rate (transmittable information capacity per unit time) in the case of reading the recorded information from the recording media and transmitting through communication lines, which therefore leads to a trade-off relation between the information capacity usable for video and the information capacity usable for audio, resulting in an antinomy between the image quality and the sound quality of the contents. That is, data volume assigned to audio data is reduced when a large information capacity is assigned to video giving priority to the image quality, and therefore, it is necessary to perform processing such as limitation or compression of the sound frequency domain, reducing the sensuous artistic value like impairment of an expressive effect as a consequence of a deterioration in the sound quality. Conversely, data volume assigned to image data is reduced when a large information capacity is assigned to sound information giving priority to the sound quality, and therefore, it is necessary to perform processing such as a reduction in resolution by saving or compressing images, reducing the sensuous artistic value like impairment of an expressive effect as a consequence of a deterioration in the image quality.

Sixthly, there is a problem of the phenomenon of an antinomy between the fact that "necessary information cannot be caught unless sound volume is increased" and the fact that "the sound becomes bothersome and unpleasant when the sound volume is increased" on the other hand when a sound aimed at information transmission such as sound-reinforcement broadcasting coexists with another sound that disturbs the transmission such as a significant background noise. Problems resembling this exist under various situations, and, for example, sound effects of audio and video contents and sound effects of theatrical performance have the problem of an antinomy between the fact that "the intended artistic effect cannot be obtained unless sound volume is increased" and "sound becomes unpleasant when the sound volume is increased" on the other hand.

It is an object of the present invention to solve the aforementioned problems by clarifying the detailed structural feature of a vibration that can introduce the fundamental brain activation effect and thereby provide an apparatus and method for generating a vibration that can introduce hypersonic effect and an apparatus and method for discriminating the vibration. It is a further object to provide an apparatus and method capable of enhancing the aesthetic sensibility to sensory inputs other than sounds and heightening the expressive effect in the entire sensory system by generating a vibration that can introduce the hypersonic effect in complex sensory information generating means for comprehensively working on multiple sensory systems and activating the fundamental brain including the reward system (fundamental brain network system) as its application. It is a further object to provide an apparatus and method for developing or intensifying both sensitization and comforting of sound perception in a coexistent state by applying the effect of enhancing the activity of the entire fundamental brain network system.

Means for Solving the Problems

A vibration generating apparatus according to a first aspect of the present invention includes means for generating a vibration or a vibration signal, which contains audible range components that are vibration components in an audible frequency range and super-high-frequency components within a range exceeding the audible frequency range up to a predetermined maximum frequency and has an autocorrelation order, which is the internal correlation property which is

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widely contained in natural conformation, represented by at least either one of a first property and a second property. The vibration generating apparatus is able to introduce a fundamental brain activation effect for activating a fundamental brain network system of a human being into a fundamental brain including brain stem, thalamus and hypothalamus that are regions to bear the fundamental brain function and a fundamental brain network of neuronal projection from the fundamental brain to various brain regions by applying the vibration or an actual vibration generated from the vibration signal to the human being.

The first property has a fractal nature such that a shape of a three-dimensional power spectrum array of time, frequency and power of the components exceeding the audible frequency range is a complexity having a self-similarity. A local exponent of fractal dimension is a value obtained, upon calculating the fractal dimension of a curved surface of the three-dimensional power spectrum array by using a box-counting method, by inverting the sign of an inclination of a straight line that interconnects two mutually adjacent points when logarithms of a necessary minimum number of reference boxes for covering the curved surface are plotted with respect to a logarithm of a size of each one side of the reference boxes. The local exponent of fractal dimension is a value that represents a self-similarity of the shape, and the local exponent of fractal dimension has a value of not smaller than 2.2 and not greater than 2.8 in a range in which a spectro-temporal index defined by normalizing one side of the reference box is 2^{-1} to 2^{-5} and a fluctuation range of the local exponent of fractal dimension within 0.4 when the spectro-temporal index changes in a range of 2^{-1} to 2^{-5}.

The second property is defined such that a degree of one of predictability and irregularity of time series of the vibration signal changes with time except for the time series of the vibration signal that are completely predictable and regular and for the time series of the vibration signal that are completely unpredictable and random. An information entropy density representing the irregularity of time series data has a value in a range of not smaller than −5 and smaller than zero, and an entropy variation index (Entropy Variation Index; EV-index), which is a variance of the information entropy density and represents a degree of time variance, has a value of not smaller than 0.001 for 51.2 seconds.

A vibration generating space apparatus according to a second aspect of the present invention generates a vibration having the autocorrelation order by radiating the vibration generated by at least one vibration generating apparatus installed in a space into the space or by making the vibrations become added together or mutually interfere in the space or by making things constituting the space resonate with the vibrations.

A vibrating object or body according to a third aspect of the present invention is a vibrating object in a vibrational state generated by at least one vibration generating apparatus.

A vibration generating method according to a fourth aspect of the present invention includes a step of generating a vibration or a vibration signal, which contains audible range components that are vibration components in an audible frequency range and super-high-frequency components within a range exceeding the audible frequency range up to a predetermined maximum frequency and has an autocorrelation order represented by at least either one of a first property and a second property. The vibration generating method is able to introduce a fundamental brain activation effect for activating a fundamental brain network system including a fundamental brain including brain stem, thalamus and hypothalamus that are regions to bear the fundamental brain function of a human being and a fundamental brain network of neuronal projection from the fundamental brain to various brain regions by applying the vibration or an actual vibration generated from the vibration signal to the human being.

The first property has a fractal nature such that a shape of a three-dimensional power spectrum array of time, frequency and power of the components exceeding the audible frequency range is a complexity having a self-similarity. A local exponent of fractal dimension is a value obtained, upon calculating the fractal dimension of a curved surface of the three-dimensional power spectrum array by using a box-counting method, by inverting the sign of an inclination of a straight line that interconnects two mutually adjacent points when logarithms of a necessary minimum number of reference boxes for covering the curved surface are plotted with respect to a logarithm of a size of each one side of the reference boxes. The local exponent of fractal dimension is a value that represents a self-similarity of the shape, and the local exponent of fractal dimension has a value of not smaller than 2.2 and not greater than 2.8 in a range in which a spectro-temporal index defined by normalizing one side of the reference box is 2^{-1} to 2^{-5} and a fluctuation range of the local exponent of fractal dimension within 0.4 when the spectro-temporal index changes in a range of 2^{-1} to 2^{-5}.

The second property is defined such that a degree of one of predictability and irregularity of time series of the vibration signal changes with time except for the time series of the vibration signal that are completely predictable and regular and for the time series of the vibration signal that are completely unpredictable and random. An information entropy density representing the irregularity of time series data has a value in a range of not smaller than −5 and smaller than zero, and an entropy variation index (Entropy Variation Index; EV-index), which is a variance of the information entropy density and represents a degree of time variance, has a value of not smaller than 0.001 for 51.2 seconds.

The vibration generating apparatus of the first aspect of the present invention further includes addition means for adding a complementing vibration signal that has the autocorrelation order and is generated by the vibration generating apparatus, to an original vibration signal not having the autocorrelation order, and outputting a vibration signal of an addition result is included.

Moreover, the vibration generating apparatus further including band expanding means and addition means. The band expanding means performs band expanding so that a band of the original signal exceeds the audible frequency range with respect to the original vibration signal not having the autocorrelation order, and outputting a band-expanded vibration signal that contains the band exceeding the audible frequency range and the band of the original vibration signal. The addition means adds a complementing vibration signal that has the autocorrelation order and is generated by the vibration generating apparatus, to the band-expanded vibration signal, and outputting a vibration signal of an addition result.

Further, the vibration generating apparatus further includes high-pass filter means, which is provided between the vibration generating apparatus and the addition means, for performing high-pass filtering of the complementing vibration signal having the autocorrelation order.

Furthermore, the vibration generating apparatus further includes attenuation means for comparing the signal level of the original vibration signal or the band-expanded vibration signal with a predetermined threshold value, and attenuating by a predetermined attenuation amount the complementing vibration signal that has the autocorrelation order and is

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inputted to the addition means or its high-pass filtered signal, when the signal level is smaller than the threshold value.

Further, the vibration generating apparatus further includes level changing means for detecting the absolute value of the signal level of the original vibration signal or the band-expanded vibration signal and performing amplification or attenuation of the signal level of the complementing vibration signal that has the autocorrelation order and is inputted to the addition means or its high-pass filtered signal, in accordance with the magnitude of the absolute value of the signal level.

Further, in the vibration generating apparatus, the complementing vibration signal, that has the autocorrelation order and is inputted to the addition means, contains a plurality of kinds of vibration signals each having the autocorrelation order. The vibration generating apparatus further includes control means for selecting at least one kind of complementing vibration signal from among the plurality of kinds of complementing vibration signals in correspondence with at least one of the original vibration signal and the band-expanded vibration signal, and outputting the signal to the addition means.

Furthermore, the vibration generating apparatus further includes first processing means for calculating an autocorrelation coefficient of a reference vibration signal having the autocorrelation order, and performing convolution calculation of the original vibration signal not having the autocorrelation order with the calculated autocorrelation coefficient, thereby generating a vibration signal having the autocorrelation order.

Furthermore, the vibration generating apparatus further includes second processing means for calculating a transfer function of the reference vibration signal having the autocorrelation order, and multiplying the original vibration signal not having the autocorrelation order by the calculated transfer function, thereby generating a vibration signal having the autocorrelation order.

Further, the vibration generating apparatus includes an elastic vibrating object, first transducing means, and second transducing means. The first transducing means transduces the vibration signal having the autocorrelation order or a vibration signal not having the autocorrelation order, into a vibration and applying the vibration to the elastic vibrating object. The second transducing means transduces the vibration of the elastic vibrating object into an electric signal. At least either one of the first property and the second property on the autocorrelation order in the vibration signal is enhanced or imparted by processing the applied vibration using a vibration characteristic owned by the elastic vibrating object, and vibration components not introducing the fundamental brain activation effect and being existable as an electric signal but not existable in the natural elastic vibrating object are attenuated or removed, thereby emphasizing or imparting the effect of a vibration that can introduce the fundamental brain activation effect.

Furthermore, in the vibration generating apparatus, the elastic vibrating object is installed in a container filled with a predetermined vibration transmission medium.

Furthermore, in the vibration generating apparatus activates a fundamental brain network system including a fundamental brain including a reward system neural circuit that is a brain function region being unitarily comprehensively responsible for the generation of all reactions of pleasure, beauty and emotion and a fundamental brain network in a human being by applying a vibration generated by the vibration generating apparatus to the human being while applying predetermined information to the human through at least one of visual sensation, gustatory sensation, somatic sensation and olfactory sensation other than auditory sensation, thereby enhancing also an aesthetic sensibility to sensory inputs from other than auditory sensation and heightening expressive effects of sensory information other than auditory sensation.

Furthermore, the vibration generating method activates a fundamental brain network system including a fundamental brain including a reward system neural circuit that is a brain function region being unitarily comprehensively responsible for the generation of all reactions of pleasure, beauty and emotion and a fundamental brain network in a human being by applying a vibration generated by the vibration generating apparatus to the human being while applying predetermined information to the human through at least one of visual sensation, gustatory sensation, somatic sensation and olfactory sensation other than auditory sensation, thereby enhancing also an aesthetic sensibility to sensory inputs from other than auditory sensation and heightening expressive effects of sensory information other than auditory sensation.

A computer-readable recording medium according to a fifth aspect of the present invention records the vibration signal generated by the vibration generating apparatus.

A communication apparatus according to a sixth aspect of the present invention includes communication means for transmitting the vibration signal generated by the vibration generating apparatus via a communication medium.

A vibration discriminating apparatus according to a seventh aspect of the present invention includes discrimination means for discriminating whether or not an inputted vibration signal contains audible range components that are vibration components in an audible frequency range and super-high-frequency components within a range exceeding the audible frequency range up to a predetermined maximum frequency and has an autocorrelation order represented by at least either one of a first property and a second property. The discrimination means discriminates whether or not a fundamental brain network system of a human being can be introduced into a fundamental brain including the brain stem, thalamus and hypothalamus that are regions to bear the fundamental brain function and a fundamental brain network of neuronal projection from the fundamental brain to various brain regions, by applying an actual vibration generated from the vibration signal to the human being.

The first property has a fractal nature such that a shape of a three-dimensional power spectrum array of time, frequency and power of the components exceeding the audible frequency range is a complexity having a self-similarity. A local exponent of fractal dimension is a value obtained, upon calculating the fractal dimension of a curved surface of the three-dimensional power spectrum array by using a box-counting method, by inverting the sign of an inclination of a straight line that interconnects two mutually adjacent points when logarithms of a necessary minimum number of reference boxes for covering the curved surface are plotted with respect to a logarithm of a size of each one side of the reference boxes. The local exponent of fractal dimension is a value that represents a self-similarity of the shape, and the local exponent of fractal dimension has a value of not smaller than 2.2 and not greater than 2.8 in a range in which a spectro-temporal index defined by normalizing one side of the reference box is 2^{-1} to 2^{-5} and a fluctuation range of the local exponent of fractal dimension within 0.4 when the spectro-temporal index changes in a range of 2^{-1} to 2^{-5}.

The second property is defined such that a degree of one of predictability and irregularity of time series of the vibration signal changes with time except for the time series of the vibration signal that are completely predictable and regular and for the time series of the vibration signal that are com-

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pletely unpredictable and random. An information entropy density representing the irregularity of time series data has a value in a range of not smaller than −5 and smaller than zero, and an entropy variation index (Entropy Variation Index; EV-index), which is a variance of the information entropy density and represents a degree of time variance, has a value of not smaller than 0.001 for 51.2 seconds.

In the above-mentioned vibration discriminating apparatus, the discrimination means includes first, second and third partial discrimination means, and final discrimination means. The first partial discrimination means discriminates whether or not the inputted vibration signal is a vibration signal containing audible range components that are vibration components in the audible frequency range and whether or not the signal contains super-high-frequency components within a range exceeding the audible frequency range up to the maximum frequency. The second partial discrimination means discriminates whether or not the inputted vibration signal has the autocorrelation order represented by the first property. The third partial discrimination means discriminates whether or not the inputted vibration signal has the autocorrelation order represented by the second property. The final discrimination means discriminates whether or not the inputted vibration signal has the feature of a hypersonic sound based on the discrimination results of the first to third discrimination means.

A vibration monitoring system according to an eighth aspect of the present invention includes the vibration discriminating apparatus. The vibration monitoring system includes at least one of alarm generating means, and addition means. The alarm generating means outputs an alarm when the discrimination result of the discrimination means indicates that the inputted vibration signal cannot introduce the fundamental brain activation effect. The addition means adds the complementing vibration signal, that has the autocorrelation order and is generated by the vibration generating apparatus, to the inputted vibration signal when the discrimination result of the discrimination means indicates that the inputted vibration signal cannot introduce the fundamental brain activation effect.

A vibration discriminating method according to a ninth aspect of the present invention includes a discrimination step of discriminating whether or not an inputted vibration signal contains audible range components that are vibration components in an audible frequency range and super-high-frequency components within a range exceeding the audible frequency range up to a predetermined maximum frequency and has an autocorrelation order represented by at least either one of a first property and a second property. The discrimination step discriminating whether or not a fundamental brain network system of a human being can be introduced into a fundamental brain including the brain stem, thalamus and hypothalamus that are regions to bear the fundamental brain function and a fundamental brain network of neuronal projection from the fundamental brain to various brain regions, by applying an actual vibration generated from the vibration signal to the human being.

The first property has a fractal nature such that a shape of a three-dimensional power spectrum array of time, frequency and power of the components exceeding the audible frequency range is a complexity having a self-similarity. A local exponent of fractal dimension is a value obtained, upon calculating the fractal dimension of a curved surface of the three-dimensional power spectrum array by using a box-counting method, by inverting the sign of an inclination of a straight line that interconnects two mutually adjacent points when logarithms of a necessary minimum number of reference boxes for covering the curved surface are plotted with respect to a logarithm of a size of each one side of the reference boxes. The local exponent of fractal dimension is a value that represents a self-similarity of the shape, and the local exponent of fractal dimension has a value of not smaller than 2.2 and not greater than 2.8 in a range in which a spectro-temporal index defined by normalizing one side of the reference box is 2^{-1} to 2^{-5} and a fluctuation range of the local exponent of fractal dimension within 0.4 when the spectro-temporal index changes in a range of 2^{-1} to 2^{-5}.

The second property is defined such that a degree of one of predictability and irregularity of time series of the vibration signal changes with time except for the time series of the vibration signal that are completely predictable and regular and for the time series of the vibration signal that are completely unpredictable and random. An information entropy density representing the irregularity of time series data has a value in a range of not smaller than −5 and smaller than zero, and an entropy variation index (Entropy Variation Index; EV-index), which is a variance of the information entropy density and represents a degree of time variance, has a value of not smaller than 0.001 for 51.2 seconds.

In the above-mentioned vibration discriminating method, the discrimination step includes first, second and third partial discrimination steps and a final discrimination step. The first partial discrimination step discriminates whether or not the inputted vibration signal is a vibration signal containing audible range components that are vibration components in the audible frequency range and whether or not the signal contains super-high-frequency components within a range exceeding the audible frequency range up to the maximum frequency. The second partial discrimination step discriminates whether or not the inputted vibration signal has the autocorrelation order represented by the first property. The third partial discrimination step discriminates whether or not the inputted vibration signal has the autocorrelation order represented by the second property. The final discrimination step discriminates whether or not the inputted vibration signal has the feature of a hypersonic sound based on the discrimination results of the first to third discrimination steps.

A computer-executable program according to a tenth aspect of the present invention includes the steps of the above-mentioned vibration discriminating method.

A computer-readable medium according to an eleventh aspect of the present invention stores the above-mentioned program.

Effects of the Invention

According to the present invention, by clarifying the detailed structural feature of the vibration that can introduce the fundamental brain activation effect, the apparatus and method for generating a vibration that can introduce a hypersonic effect, i.e., a hypersonic sound, and the apparatus and method for discriminating the vibration can be provided.

As an advantageous effect, in order to first know whether a certain vibration introduces the fundamental brain activation effect, it is not necessary to apply the vibration to a listener in each case and to examine the activation of the listener's fundamental brain by a strict physiological experiment as conventionally performed, and it becomes possible to know whether the vibration introduces the fundamental brain activation effect by only examining the structural feature of the super-high-frequency components of the vibration.

Secondly, it becomes possible to artificially synthesize various kinds of vibrations that can introduce the fundamental brain activation effect without relying on the inartificial natu-

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ral vibration generating sources, of which the effectiveness and safety have been proven by the past results, in order to generate a vibration that can introduce the fundamental brain activation effect.

Thirdly, in order to know whether the super-high-frequency components, which are artificially expanded by the conventional band expanding method that hardly expects prevention of the deterioration in the fundamental brain activity and cannot deny the possibility of causing a safety problem depending on circumstances, are safe and possible to introduce the fundamental brain activation effect, it is not necessary to apply the vibration to a listener in each case as conventionally performed and examine the activation of the listener's fundamental brain by a strict physiologic experiment, and it becomes possible to know whether the vibration is safe and able to introduce the fundamental brain activation effect by only examining the structural feature of the super-high-frequency components of the vibration.

Fourthly, by activating the fundamental brain network system responsible for the generation of all reactions of pleasure, beauty and emotion by generating a vibration to which the super-high-frequency components having the feature of the autocorrelation order are added or enhanced, it becomes possible to increase the expressive effects, heighten the sensuous artistic value and concurrently promote the safety of the already accumulated record library of sound sources, which are currently voluminously accumulated in terms of both quality and quantity and are unable to introduce the fundamental brain activation effect because they contain utterly or almost no super-high-frequency component having the feature of the autocorrelation order.

Fifthly, in the contents comprehensively working on multiple sensory systems such as video and audio contents recorded in large-capacity package media that are rapidly popularized in recent years and video and audio that are distributed and delivered by using Internet and the like, there is the problem of a trade-off relation between the information capacity usable for video and the information capacity usable for audio, and consequently, this leads to the problem of an antinomy between image quality and sound quality. Against the problems, by heightening the activity of the fundamental brain network system being unitarily responsible for the generation of all reactions of pleasure, beauty and emotion by generating a vibration to which the super-high-frequency components having the feature of the autocorrelation order are added or enhanced, it becomes possible to enhance also the aesthetic sensibility to sensory inputs other than sounds in parallel and heighten the expressive effects in the entire sensory system.

Sixthly, in order to solve the problem of the antinomy occurring in information transmitting sounds in spaces having significant background noises, the sound effects of artistic productions and so on, i.e., such a problem that "necessary information cannot be caught unless sound volume is increased" whereas "the sound becomes bothersome and unpleasant when the sound volume is increased" on the other hand without contradiction, by complementing a vibration containing super-high-frequency components having the feature of the autocorrelation order, it becomes possible to heighten the activity of the entire fundamental brain network system and activate the thalamus and the brain stem that is included in this system and have operation to sensitize the sensibility to general sensory information inputs (excluding olfactory sensation) and concurrently activate the reward system neural circuit that is included in the same system and has operation to generate pleasant sensation and alleviate the unpleasant sensation in parallel, thereby allowing both the sensitization and comforting of sound perception to be developed or reinforced in a coexistent state.

If the above is generalized, it becomes possible to generate vibrations that can introduce the fundamental brain activation effect voluminously and easily in terms of both quality and quantity, and by applying them to a human being, activation of the fundamental brain network system constituted of the fundamental brain and the fundamental brain network including the reward system neural circuit of the brain being unitarily comprehensively responsible for the generation of reactions of pleasure, beauty and emotion in the human being is induced, consequently making it possible to enhance the aesthetic sensitivity to various general sensory inputs inclusive of sounds and heighten the sensuous artistic value of input information. In addition, an effect of heightening the physical activation such as homeostatic maintenance and biophylaxis of the whole body managed by the fundamental brain network system is introduced, and it consequently becomes possible to introduce the effects of comprehensively remedying lifestyle-related diseases of metabolic syndromes such as hypertension, hyperlipemia and diabetes, cancer, cerebrovascular disorder and cardiopathy, immune abnormalities including pollinosis and atopic dermatitis, various mental disorders such as dementia, depression, schizophrenia, chronic fatigue syndrome and attention-deficit hyperactivity disorder, behavioral abnormalities such as suicide and self-injurious behaviors, abnormal exaltation of aggressiveness and so on, which are caused by the abnormality of the fundamental brain activity and pose serious problems in the modern society.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a spectral diagram showing a frequency spectrum of a vibration that contains audible range components of vibration components in the audible frequency range and super-high-frequency components exceeding the audible frequency range;

FIG. **2** is a chart showing a three-dimensional power spectrum array of a gamelan instrument sound;

FIG. **3** is a chart showing a three-dimensional power spectrum array of a tropical rain forest environmental sound;

FIG. **4** is a graph showing an example of a local exponent of fractal dimension of a spectro-temporal structure of a vibration that satisfies a first property on an autocorrelation order according to the present invention;

FIG. **5** is a table showing a local exponent of fractal dimension of a vibration that satisfies the first property on the autocorrelation order of the present invention within a range in which the spectro-temporal index (ST-index) is 2^{-1} to 2^{-5};

FIG. **6** is a graph showing an example of the local exponent of fractal dimension of the spectro-temporal structure of a vibration that does not satisfy the first property on the autocorrelation order of the present invention;

FIG. **7** is a table showing a local exponent of fractal dimension of a vibration that does not satisfy the first property on the autocorrelation order within a range in which the spectro-temporal index (ST-index) is 2^{-1} to 2^{-5};

FIG. **8** is a graph showing an example of the information entropy density and its time change of a vibration that satisfies a second property on the autocorrelation order of the present invention;

FIG. **9** is a graph showing an example of the information entropy density and its time change of a vibration that does not satisfy the second property on the autocorrelation order of the present invention;

FIG. **10** is a graph showing an example of the entropy variation index (EV-index) of vibrations that satisfy the sec-

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ond property on the "autocorrelation order" of the present invention and vibrations that do not satisfy it according to the present invention;

FIG. **11** is a spectral diagram of the average power spectrum of the gamelan instrument sound;

FIG. **12** is a graph showing a local exponent of fractal dimension of the gamelan instrument sound;

FIG. **13** is a graph showing an information entropy density of the gamelan instrument sound;

FIG. **14** is a graph showing an entropy variation index (EV-index) of the gamelan instrument sound;

FIG. **15** is a block diagram of a vibration generating apparatus including a configuration of a positron emission tomography (PET) and a brain wave measurement apparatus used in the first preferred embodiment of the present invention and a perspective view showing a room for generating a vibration by the vibration generating apparatus;

FIG. **16** is a projection chart showing brain regions where the regional cerebral blood flow in an FRS condition is significantly increased by contrast to an LFC alone condition, in which (a) is a projection chart (sagittal projection chart) along the sagittal suture of a human cranium, (b) is a projection chart (coronal projection chart) along the coronal suture, and (c) is a horizontal plane projection chart of them, or experimental results measured by the apparatus of FIG. **15**;

FIG. **17** is a graph showing a normalized electric potential of spontaneous a rhythm of brain wave band components normalized to each frequency component, or the experimental results measured by the apparatus of FIG. **15**;

FIG. **18** is a chart showing a cross section of a fundamental brain network image extracted as a second principal constituent by a principal component analysis of regional cerebral blood flow data, or the experimental results measured by the apparatus of FIG. **15**;

FIG. **19** is a chart showing a scalp distribution of a correlation coefficient between the normalized electric potential of spontaneous brain wave $\alpha 2$ band component and changes in the activity intensity of the fundamental brain network, or the experimental results measured by the apparatus of FIG. **15**;

FIG. **20** is a block diagram showing a configuration of a vibration generating apparatus that is an earphone experimental apparatus used in the first preferred embodiment;

FIG. **21** is a graph showing a deep brain activity index (DBA-index) of each case, or experimental results measured by the system of FIG. **20**;

FIG. **22** is a perspective view and a sectional view showing an example of a vibration generating apparatus that generates a vibration (hypersonic sound) capable of introducing the fundamental brain activation effect by using a liquid current according to the first preferred embodiment;

FIG. **23** is a sectional view showing examples of the shape of protrusions served as an obstacle of the liquid current of FIG. **22**;

FIG. **24** is a sectional view of an example in which the position control of the protrusion is systematized and interrelated according to the first preferred embodiment;

FIG. **25** is a perspective view showing an example in which the arrangement of protrusions served as the obstacle of the liquid current is not regular according to the first preferred embodiment;

FIG. **26** is a perspective view and a sectional view showing an example in which a structure served as the obstacle of the liquid current has a bump shape or a dimple shape according to the first preferred embodiment;

FIG. **27** is a perspective view showing an example in which a protrusion structure served as the obstacle of the liquid current has an irregular configuration and is irregularly arranged according to the first preferred embodiment;

FIG. **28** is a perspective view and a sectional view showing an example (horizontal path) of a vibration generating apparatus that generates a vibration (hypersonic sound) capable of introducing the fundamental brain activation effect by using a liquid current according to the first preferred embodiment;

FIG. **29** is a block diagram showing an example of a vibration generating apparatus that generates a vibration (hypersonic sound) capable of introducing the fundamental brain activation effect by dripping water according to the first preferred embodiment;

FIG. **30** is a perspective view showing an example of a vibration generating apparatus that generates a vibration (hypersonic sound) capable of introducing the fundamental brain activation effect by an airflow passing through gaps according to the first preferred embodiment;

FIG. **31** is a side view showing an example of a vibration generating apparatus that generates a vibration (hypersonic sound) capable of introducing the fundamental brain activation effect by flipping a metal piece according to the first preferred embodiment;

FIG. **32** is a block diagram of an apparatus that amplifies an input signal in a vibration signal amplifier and generates a vibration from a vibration generating mechanism according to the first preferred embodiment;

FIG. **33** is a block diagram of an apparatus that amplifies a vibration signal reproduced by using a vibration signal recording and reproducing apparatus in a vibration signal amplifier and generates a vibration from a loudspeaker according to the first preferred embodiment;

FIG. **34** is a block diagram showing an example of a vibration generating apparatus having a function to adjust the generated vibration by using a reproduction vibration characteristic adjuster according to the first preferred embodiment;

FIG. **35** is a side view showing an example of an apparatus that applies from a body surface a vibration (hypersonic sound) capable of introducing the fundamental brain activation effect via a solid vibration generating mechanism according to the first preferred embodiment;

FIG. **36** is a block diagram of an apparatus that generates a vibration (hypersonic sound) capable of introducing the fundamental brain activation effect via a plurality of vibration generating mechanisms from signals diverging from a single vibration signal according to the first preferred embodiment;

FIG. **37** is a front view of a headphone type vibration generating apparatus according to the first preferred embodiment;

FIG. **38** is a diagram of an accessory type vibration generating apparatus according to the first preferred embodiment, in which (a) is its front view, (b) is its right side view, and (c) is its rear view;

FIG. **39** is a diagram of a clothes embedded type vibration generating apparatus according to the first preferred embodiment, in which (a) is its external view, and (b) is its internal view;

FIG. **40** is a sectional view and a block diagram of a body surface attachment type vibration generating apparatus according to the first preferred embodiment;

FIG. **41** is a block diagram showing an example in which audible range components are presented from a portable music player or the like by an earphone or the like, and super-high-frequency components provided for a vibration signal separately from the audible range components are presented by a loudspeaker or the like, according to the first preferred embodiment;

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FIG. **42** is a block diagram showing an apparatus according to a modified preferred embodiment of FIG. **41**;

FIG. **43** is a perspective view and a sectional view of a portable terminal plus pendant type vibration generating apparatus according to the first preferred embodiment;

FIG. **44** is a perspective view showing an example of a sauna type vibration presenting apparatus according to the first preferred embodiment;

FIG. **45** is a side view showing an example of a vibration presenting apparatus in a vehicle according to the first preferred embodiment;

FIG. **46** is a side view showing an example of a vibration presenting apparatus in a driver's seat or a cockpit of public transportation according to the first preferred embodiment;

FIG. **47** is a perspective view showing an example in which the walls themselves constituting a space vibrate to generate super-high-frequency components according to the first preferred embodiment;

FIG. **48** is a plan view showing an example of a space in which portable players are combined with a vibration generating apparatus that simultaneously applies a super-high-frequency to a plurality of persons according to the first preferred embodiment;

FIG. **49** is a plan view showing a modified preferred embodiment of the apparatus of FIG. **48**;

FIG. **50** is a perspective view showing a shower type vibration presenting apparatus according to the first preferred embodiment;

FIG. **51** is a spectral diagram of the average power spectrum of an urban district environmental sound and a tropical rain forest environmental sound for complementing, measured in the first preferred embodiment;

FIG. **52** is a graph showing a local exponent of fractal dimension of the tropical rain forest environmental sound applied to an urban district space, measured in the first preferred embodiment;

FIG. **53** is a graph showing an information entropy density of the tropical rain forest environmental sound applied to the urban district space, measured in the first preferred embodiment;

FIG. **54** is a graph showing an entropy variation index (EV-index) of the tropical rain forest environmental sound applied to the urban district space, measured in the first preferred embodiment;

FIG. **55** is a block diagram showing a method for generating a vibration (hypersonic sound) capable of introducing the fundamental brain activation effect in an urban district space according to the first preferred embodiment;

FIG. **56** is a graph showing a deep brain activity index (DBA-index) in a case where only the urban district environmental sound is applied and a case where the tropical rain forest environmental sound capable of introducing the fundamental brain activation effect is added to it, measured in the first preferred embodiment;

FIG. **57** is a side view showing an example of a vibrating object in a vibrational state satisfying the feature of a predetermined autocorrelation order according to the first preferred embodiment by vibrating air surrounding persons in the super-high-frequency band exceeding the audible range according to the first preferred embodiment;

FIG. **58** is a sectional view showing an example of a vibrating object in a bathtub according to the first preferred embodiment;

FIG. **59** is a block diagram of an apparatus that generates an output signal (hypersonic sound signal) capable of introducing the fundamental brain activation effect by adding a vibration signal, which has a predetermined autocorrelation order and can introduce the fundamental brain activation effect, to an original vibration signal that does neither have the predetermined autocorrelation order nor introduce the fundamental brain activation effect according to a second preferred embodiment of the present invention;

FIG. **60** is a block diagram showing a modified preferred embodiment of the apparatus of FIG. **59**;

FIG. **61** is a perspective view showing an example of a vibration complementing apparatus to add a vibration signal that can introduce the fundamental brain activation effect to an original vibration that does not introduce the fundamental brain activation effect according to the second preferred embodiment;

FIG. **62** is a perspective view showing an example of a vibration complementing apparatus to add a vibration signal (hypersonic sound signal) that can introduce the fundamental brain activation effect to an original vibration that does not introduce the fundamental brain activation effect and is outputted from a portable player or the like according to the second preferred embodiment;

FIG. **63** is a perspective view showing an example of a vibration complementing apparatus to add a vibration signal (hypersonic sound signal) that can introduce the fundamental brain activation effect to an original vibration signal that does not introduce the fundamental brain activation effect and is outputted from a broadcasting receiver or the like according to the second preferred embodiment;

FIG. **64** is a block diagram showing an example of a vibration complementing apparatus using the band expanding means of the existing technology together with addition means of a vibration (hypersonic sound) capable of introducing the fundamental brain activation effect according to the second preferred embodiment;

FIG. **65** is a block diagram showing an example of a vibration complementing apparatus that generates a vibration signal capable of introducing the fundamental brain activation effect as an output signal by adding a signal obtained by extracting the super-high-frequency components of a vibration signal (hypersonic sound signal) capable of introducing the fundamental brain activation effect to an original vibration signal according to the second preferred embodiment;

FIG. **66** is a block diagram showing an example of a complementing type vibration signal generating apparatus capable of introducing the fundamental brain activation effect concurrently using the circuits of a band expander, a high-pass filter, a gate apparatus and a voltage-controlled amplifier (VCA) according to the second preferred embodiment;

FIG. **67** is a block diagram showing an example of a vibration complementing apparatus that can add a plurality of vibrations (hypersonic sound) capable of introducing the fundamental brain activation effect according to the second preferred embodiment;

FIG. **68** is a block diagram showing a vibration signal generating apparatus that imparts the predetermined autocorrelation order of a vibration (hypersonic sound) capable of introducing the fundamental brain activation effect by performing processing based on an autocorrelation coefficient representing the property of the autocorrelation order owned by a reference vibration signal capable of introducing the fundamental brain activation effect to a vibration signal that does not introduce the fundamental brain activation effect according to the second preferred embodiment;

FIG. **69** is a block diagram showing a modified preferred embodiment of the vibration signal generating apparatus of FIG. **68**;

FIG. **70** is a block diagram showing an example of an apparatus that generates a vibration (hypersonic sound)

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capable of introducing the fundamental brain activation effect by processing the 1-bit quantization noise owned by a high-speed sampling 1-bit quantization system according to the second preferred embodiment;

FIG. **71** is a block diagram showing a vibration signal generating apparatus that imparts the predetermined autocorrelation order owned by a vibration (hypersonic sound) capable of introducing the fundamental brain activation effect by performing processing based on a transfer function representing the property of the autocorrelation order of a reference vibration signal capable of introducing the fundamental brain activation effect to a vibration signal that does not introduce the fundamental brain activation effect according to the second preferred embodiment;

FIG. **72** is a block diagram showing a vibration (hypersonic sound) generating apparatus (exemplified apparatus employing a moving magnet type fluctuation detector device) capable of introducing the fundamental brain activation effect using an elastic vibrating object according to the second preferred embodiment;

FIG. **73** is a block diagram showing a vibration (hypersonic sound) generating apparatus (exemplified apparatus employing a capacitor type fluctuation detector device) capable of introducing the fundamental brain activation effect using an elastic vibrating object according to the second preferred embodiment;

FIG. **74** is a block diagram showing a vibration (hypersonic sound) generating apparatus capable of introducing the fundamental brain activation effect using a spiral spring shaped elastic vibrating object according to the second preferred embodiment;

FIG. **75** is a block diagram showing a vibration (hypersonic sound) generating apparatus (exemplified apparatus that makes an elastic vibrating object function as a fluctuation detecting coil) capable of introducing the fundamental brain activation effect using an elastic vibrating object according to the second preferred embodiment;

FIG. **76** is a block diagram showing a vibration (hypersonic sound) generating apparatus (exemplified apparatus that makes an elastic vibrating object as a fluctuation detecting coil) capable of introducing the fundamental brain activation effect using an elastic vibrating object according to the second preferred embodiment;

FIG. **77** is a block diagram showing a vibration (hypersonic sound) generating apparatus (exemplified apparatus that concurrently uses a plurality of vibration generating apparatuses each employing an elastic vibrating object) capable of introducing the fundamental brain activation effect using an elastic vibrating object according to the second preferred embodiment;

FIG. **78** is a spectral diagram showing a power spectrum of a vibration signal recorded on the soundtracks of a "DVD version AKIRA" and a "Blu-ray Disc version AKIRA" measured in the second preferred embodiment;

FIG. **79** is a graph showing a local exponent of fractal dimension of the vibration signal of the "Blu-ray Disc version AKIRA soundtrack" measured in the second preferred embodiment;

FIG. **80** is a graph showing an information entropy density of the vibration signal of the "Blu-ray Disc version AKIRA soundtrack" measured in the second preferred embodiment;

FIG. **81** is a graph showing an entropy variation index (EV-index) of the vibration signal of the "Blu-ray Disc version AKIRA soundtrack" measured in the second preferred embodiment;

FIG. **82** is a graph showing a deep brain activity index (DBA-index) recorded from a listener under a high-cut sound condition and a full-range sound condition generated by using the "Blu-ray Disc version AKIRA soundtrack" measured in the second preferred embodiment;

FIG. **83** is a graph and a table showing an impression evaluation of sounds evaluated by a listener on the high-cut sound condition and the full-range sound condition generated by using the "Blu-ray Disc version AKIRA soundtrack" measured in the second preferred embodiment;

FIG. **84** is a perspective view showing an example of an apparatus that leads to an increase in the impression of image representation and an improvement in image quality by using a hypersonic sound as a sound to be recorded on the soundtrack in a video-and-audio complex package media such as a Blu-ray Disc according to a third preferred embodiment;

FIG. **85** is a graph and a table showing an impression evaluation of screen images evaluated by a listener on the high-cut sound condition and the full-range sound condition generated by using the "Blu-ray Disc version AKIRA soundtrack" according to a third preferred embodiment;

FIG. **86** is a perspective view showing an improvement in aesthetic sensibility at the time of watching TV by the fundamental brain activation effect according to the third preferred embodiment;

FIG. **87** is a flow chart showing a derivation control process of the fundamental brain activation effect according to a fifth preferred embodiment;

FIG. **88** is a block diagram showing a structural example of a circuit for performing the derivation control process of the fundamental brain activation effect according to the fifth preferred embodiment;

FIG. **89** is an external view showing an example of a vibration generating apparatus installed in a station yard according to a modified preferred embodiment of the second preferred embodiment;

FIG. **90** is a graph showing a regional cerebral blood flow rate normalized to each frequency component, or the experimental results measured by the apparatus of FIG. **15**, in which (a) is a graph showing a regional cerebral blood flow rate in the position of the brain stem, and (b) is a graph showing a regional cerebral blood flow rate in the position of the left thalamus region;

FIG. **91** is a perspective view showing an example of a vibration generating apparatus provided with a function to generate a hypersonic sound or the vibration of its super-high-frequency components by only giving an independent vibration generating function to a loudspeaker system itself and connecting it to certain equipment or by itself according to the first preferred embodiment;

FIG. **92** is a block diagram of a vibration generating apparatus applied to portable equipment or a distribution network to it according to the first preferred embodiment;

FIG. **93** is a perspective view of a vibration generating apparatus applied to a portable telephone according to the first preferred embodiment;

FIG. **94** is a perspective view of a vibration generating apparatus applied to a portable music player according to the first preferred embodiment;

FIG. **95** is a perspective view of a vibration generating apparatus solely of an earphone according to the first preferred embodiment;

FIG. **96** is a perspective view showing an example in which a vibration (hypersonic sound) capable of introducing the fundamental brain activation effect because it has a predetermined autocorrelation order and contains super-high-frequency components at a close distance to audiences in the

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space of a theater, a hall, an auditorium, or the like according to the first preferred embodiment;

FIG. **97** is a perspective view showing an ordinary prior art 4-channel surround loudspeaker arrangement;

FIG. **98** is a perspective view showing a double helical matrix loudspeaker arrangement according to the first preferred embodiment;

FIG. **99** is a perspective view showing an arrangement such that the double helical matrix loudspeaker arrangements are consecutively arranged in two directions according to the first preferred embodiment;

FIG. **100** is a perspective view showing a six-dimension consecutive matrix loudspeaker arrangement according to the first preferred embodiment;

FIG. **101** is a perspective view showing an arrangement such that six-dimension consecutive matrix loudspeaker arrangements are consecutively arranged in two directions according to the first preferred embodiment;

FIG. **102** is a table showing major differences between a hypersonic therapy according to the first preferred embodiment and the conventional musicotherapy;

FIG. **103** is a block diagram showing an example of a vibration complementing apparatus to add a vibration signal (hypersonic sound signal) that can introduce the fundamental brain activation effect to an original vibration signal that does not introduce the fundamental brain activation effect and is outputted from an electronic musical instrument or the like inclusive of a digital synthesizer according to the second preferred embodiment;

FIG. **104** is a perspective view showing an example of a vibration complementing apparatus to add a vibration signal (hypersonic sound signal) that can introduce the fundamental brain activation effect to an original vibration signal that does not introduce the fundamental brain activation effect and is outputted from an electronic musical instrument or the like inclusive of a digital synthesizer according to the second preferred embodiment;

FIG. **105** is a graph showing an effect of making a listener more clearly recognize sensory information of a sound and the like by sensitizing the sensibility to a sensory information input by heightening the activities of the thalamus and the brain stem included in the listener's fundamental brain network system among the two effects of the hypersonic sound, or psychological experimental results according to a fourth preferred embodiment;

FIG. **106** is a graph showing an effect of making a listener feel a vibration input of a large sound volume comfortable by increasing the aesthetic sensibility to sensory information by inducing activation of the reward system nerve circuit included in the listener's fundamental brain network system among the two effects of the hypersonic sound, or the psychological experimental results of the fourth preferred embodiment;

FIG. **107** is a graph indicating that the effect of increasing the aesthetic sensibility to sensory information and thereby making the listener feel the vibration input of a large sound volume comfortable appears more intensely when the super-high-frequency components contained in the hypersonic sound are heightened by inducing activation of the reward system nerve circuit included in the listener's fundamental brain network system among the two effects of the hypersonic sound, or the psychological experimental results of the fourth preferred embodiment;

FIG. **108** is a block diagram showing an example in which a transmission sound (audible sound) and a hypersonic sound or its super-high-frequency components are recorded in mixture by a predetermined balance, and the signal is reproduced by using a public-address system having a faithful response performance according to the fourth preferred embodiment;

FIG. **109** is a block diagram showing an example in which a transmission sound (audible sound) and a hypersonic sound or its super-high-frequency components are generated by using different public-address systems with different sound sources according to the fourth preferred embodiment;

FIG. **110** is a block diagram showing an example in which a transmission sound (audible sound) and a hypersonic sound or its super-high-frequency components are synthesized on the spot and generated from one public-address system according to the fourth preferred embodiment;

FIG. **111** is a block diagram showing an example in which a background noise (audible sound) is collected by a microphone, the feature of the background noise (audible sound) is measured based on the collected vibration signal, and a transmission sound (audible sound) and a hypersonic sound or its super-high-frequency components are adjusted in conformity to measured data according to the fourth preferred embodiment;

FIG. **112** is a perspective view showing an example in which the vibration generating apparatus of the fourth preferred embodiment is installed in a station yard;

FIG. **113** is a perspective view showing an example of an application to an electric vehicle according to the fourth preferred embodiment;

FIG. **114** is a perspective view showing an example of a vibration monitoring system that performs adjustment of vibration generating setting by feedback to the vibration generating apparatus by using a judgment result on the autocorrelation order owned by a vibration according to the fifth preferred embodiment; and

FIG. **115** is a block diagram showing an example of a vibration monitoring system that performs adjustment of vibration generating setting by feedback to the vibration generating apparatus by using the judgment result on the autocorrelation order owned by the vibration according to the fifth preferred embodiment.

BEST MODE FOR CARRYING OUT THE PRESENT INVENTION

Preferred embodiments of the present invention will be described below with reference to the drawings. It is noted that like components are denoted by like reference numerals in the following preferred embodiments.

First Preferred Embodiment

In the first preferred embodiment of the present invention, a vibration generating apparatus and method are described below.

The vibration generating apparatus and method of the first preferred embodiment is characterized in that it generates a natural vibration, an artificial vibration, a synthesized vibration and the like, which are vibrations having the essential conditions that they contain the audible range components of the vibration components within a range of 20 Hz to 15 kHz or 20 kHz in the audible frequency range perceivable as a sound by human beings and super-high-frequency components within a range exceeding the audible frequency range up to a predetermined maximum frequency (e.g., 88.2 kHz, 96 kHz, 100 kHz, 176.4 kHz, 192 kHz, 200 kHz, 300 kHz, 500 kHz or 1 MHz), and the vibrations have an "autocorrelation order" (i.e., internal correlation property which is widely contained in natural conformation) represented by at least either one of a first property and a second property

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described in detail hereinbefore and immediately hereinafter, and therefore, they can introduce the effect (fundamental brain activation effect) of activating the fundamental brain including the brain stem, thalamus and hypothalamus, which are the regions to bear the fundamental functions of the human brain and the neural network (fundamental brain network) projected from the fundamental brain to the various other brain regions.

The first property has the feature of the following fractal nature such that the shape of the three-dimensional power spectrum array of the components exceeding 20 kHz of a vibration signal has a complexity with a self-similarity. That is, a "local exponent of fractal dimension" that represents the self-similarity of the shape consistently has a value of not smaller than 2.2 and not greater than 2.8 unlike the number of dimensions two of the "topological dimension" of a plane and also unlike the number of dimensions three of the "topological dimension" of a cube within a range in which a "spectro-temporal index" serving as a scale for measuring local exponent of fractal dimension is within a range of 2^{-1} to 2^{-5}, and the local exponent of fractal dimension does not largely change and falls within a fluctuation range of 0.4 even when the spectro-temporal index changes in the range of 2^{-1} to 2^{-5}.

In this case, it is assumed that the three-dimensional power spectrum array of a vibration signal is obtained by digitizing a signal for 51.2 seconds of a vibration served as a candidate of the vibration that can introduce the fundamental brain activation effect with a sampling frequency of 192 kHz and a quantization bit count of 24 bits or 12 bits, normalizing the variance of the whole signal, dividing the whole into a unit analysis interval duration of 200 milliseconds and a unit analysis interval overlap of 50%, performing power spectrum estimation by an autocorrelation model of ten dimensions for each interval by using the Yule-Walker method, extracting band components ranging from 20 kHz to 96 kHz exceeding the human audible range upper limit from the obtained power spectrum and three-dimensionally extracting its time change with the transverse axis (from left to right) served as linear representation of frequency, the anteroposterior axis (from this side to the depth) served as linear representation of time, and the vertical axis (from downside to upside) served as logarithmic representation of power at each time point of each frequency component.

Moreover, the "local exponent of fractal dimension" is a value obtained by inverting the sign of the inclination (i.e., local inclination of the graph) of a straight line that interconnects two mutually adjacent points when the logarithm of the length of one side of a reference box (i.e., a cube or rectangular parallelepiped serving as a "measure") for use upon calculating the fractal dimension of a curved surface by using the box-counting method is plotted on the transverse axis, the logarithm of a necessary minimum number of reference boxes for covering a three-dimensional power spectrum array curved surface with the reference boxes of the size is plotted on the vertical axis, and the necessary number of reference boxes is plotted with respect to the reference box of a different size.

Further, the "spectro-temporal index" is a normalized representation of the length of one side of the reference box used upon calculating the local exponent of fractal dimension of the three-dimensional power spectrum array curved surface by using the box-counting method as a ratio to the entire frequency bandwidth (transverse axis) and the entire time (anteroposterior axis) of the three-dimensional power spectrum array of the analysis object.

The second property means that the time series of a vibration signal is neither completely predictable and regular nor completely unpredictable and random, and the degree of the predictability or the irregularity changes with time. That is, it means that the "information entropy density" representing the irregularity of time series data has neither a value smaller than −5 expressed by a completely determinate regular signal like a sine wave nor zero expressed by a completely random signal like a white noise but consistently has a value within a range of not smaller than −5 and not greater than zero, and in addition, the value does not have a temporally constant value like a sine wave and a white noise, whereas the "entropy variation index" (hereinafter abbreviated as EV-index), which represents the degree of time change of the information entropy density, has a value of not smaller than 0.001 for 51.2 seconds.

In this case, the "information entropy density" of the time series data of a vibration signal is defined as obtained by digitizing a signal for 51.2 seconds of a vibration served as a candidate of the vibration that can introduce the fundamental brain activation effect by a sampling frequency of 192 kHz and a quantization bit count of 24 bits or 12 bits, dividing the whole into a unit analysis interval duration of 200 milliseconds and a unit analysis interval overlap of 50%, performing power spectrum estimation by an autocorrelation model of ten dimensions for each interval by using the Yule-Walker method, and being calculated from the obtained power spectrum. Moreover, the "entropy variation index (EV-index)" is the variance of all the analysis object intervals of the information entropy density for each unit analysis interval.

Also, the first preferred embodiment is characterized by being configured so that a vibration having the feature of the autocorrelation order is generated by radiating the vibration generated by one or more vibration generating apparatuses existing in a space into the space or by making the vibrations become added together or mutually interfere in the space or by making the entire space resonate with the vibrations. Moreover, the first preferred embodiment provides a vibrating object, or body, that is gas, liquid, solid or a complex of them in a vibrational state having the feature of the autocorrelation order. Further, the generated vibration signal that can introduce the fundamental brain activation effect is recorded preferably in, for example, a recording medium such as an optical disk, a memory or a hard disk, a network server or the like, which can be read by a computer or transmitted by a communication apparatus, a communication system, a broadcasting system or the like preferably by wire, wirelessly or infrared-ray communications.

Next, an implemental example of fundamental brain activation by a vibration generated to have a predetermined property is described below. First of all, the super-high-frequency components of the essential condition is described below.

FIG. **1** is a spectral diagram showing a frequency spectrum of a vibration that contains audible range components of vibration components in the audible frequency range and super-high-frequency components exceeding the audible frequency range. That is, with regard to an example of a vibration having components in the audible frequency range from 20 Hz to 15 kHz or 20 kHz perceivable as a sound by human beings and super-high-frequency components within a range exceeding the audible frequency range up to a predetermined maximum frequency (the maximum frequency is 100 kHz in FIG. **1**), its power spectrum obtained by the FFT method is shown in FIG. **1**.

Reference is next made to the "autocorrelation order". An additive set of elements inclusive of atoms and molecules constituting the inorganic material world has such a feature that the thermal entropy, i.e., "randomness" unidirectionally increases with time in conformity to the second law of ther-

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modynamics. On the other hand, complex structures existing in the natural world including lives are ingenerated as a consequence that the elements including atoms and molecules having such features are self-organized according to a certain "order" different from the deterministic regularity represented by the Euclidean geometry and the Cartesian mathematics. Such a feature is typically observed in the vital phenomena of cells and the living bodies constituted based on the mechanisms of, for example, the hierarchies of biomolecules, control of vital activities by genes and energy utilization using adenosine triphosphate and structures generated by them. Similar tendencies can be found in, for example, the compositions of rocks, geographic formations and crystal structures also in the native structures besides the vital phenomena. Further, similar structures can be found also in artificial objects highly adaptive to the senses and sensibilities of "human beings as living matters" ingenerated as one of the self-organized native structures, such as Japanese gardens of high naturalness and folk instrument sounds.

The concept representing such a "structurized order that is complex but not random" widely seen in the structures of high naturalness concerning the vital phenomena is referred to as an "autocorrelation order". This is a concept comprehensively representing the universal phenomena of organizing in accordance with the correlation internally contained or ingeneration of a structure by organizing. The structure ingenerated by the autocorrelation order possibly represents the features of, for example, self-similarity expressed by a fractal dimension, a time series structure representing the information entropy density in a moderate range that is neither completely random nor completely regular, and further a temporal structural transformation and chaos. The autocorrelation order is the concept that includes the features owned by these complex systems.

Reference is next made to the first property on the autocorrelation order. The intricate complex structures owned by the native structures of the natural world often exhibit shapes, when its details are magnified, quite similar to the unmagnified shapes (e.g., branches of trees, veins of leaves, coastlines, human internal blood vessel distribution, and pulmonary alveolus distribution in the lung). As described above, in a case where resembling structures are recurrently duplicated from a rough level to a detailed level within a definite range, a fractal dimension that represents the configurational complexity and self-similarity within the range has a constant value different from the topological dimension.

The present inventor and others discovered that, when the spectro-temporal structure of a vibration signal in the super-high-frequency range exceeding the upper limit at 20 kHz of the human audible range was indicated as a three-dimensional power spectrum array curved surface, the structure had a recurrent complexity in a manner similar to that of the native structures, and therefore, when the fractal dimension was obtained by using a "measure" having a size within a definite range, the vibration capable of introducing the fundamental brain activation effect had a property that the local exponent of the fractal dimension fell within a definite range even if the size of the "measure" changed.

On the other hand, the fractal dimension of the three-dimensional power spectrum array of a vibration not having the fundamental brain activation effect, such as the vibration signals of a white noise or a sine wave has a value of two, which is the topological dimension of a plane, or a value close to it, and the local exponent of the fractal dimension largely varies depending on the size of the "measure".

In this case, the "local exponent of fractal dimension" is a value obtained by inverting the sign of the inclination of a straight line that interconnects two mutually adjacent points when the logarithm of the length of one side of a reference box (i.e., a cube or rectangular parallelepiped serving as the "measure") for use upon calculating the fractal dimension of a curved surface by using the box-counting method is plotted on the transverse axis, the logarithm of a necessary minimum number of reference boxes for covering a three-dimensional power spectrum array curved surface with the reference boxes of the size is plotted on the vertical axis, and the necessary number of reference boxes is plotted with respect to the reference box of a different size.

In general, when the fractal dimension is obtained by using the box-counting method, the value obtained by inverting the sign of the inclination of a regression line obtained from the aforementioned graph becomes the fractal dimension. Therefore, the local exponent of fractal dimension becomes the local inclination (i.e., derivative) of the graph. The derivative value is obtained from a difference in the case of discretized data.

FIG. **2** is a chart showing a three-dimensional power spectrum array of a gamelan instrument sound, and FIG. **3** is a chart showing a three-dimensional power spectrum array of a tropical rain forest environmental sound. In this case, FIGS. **2** and **3** show examples of three-dimensional power spectrum arrays ranging from the human audible range upper limit of not lower than 20 kHz up to 96 kHz produced for examining the first property on the autocorrelation order of a vibration having super-high-frequency components. These are obtained by digitizing a signal for 51.2 seconds of a vibration by a sampling frequency of 192 kHz and a quantization bit count of 24 bits or 12 bits, normalizing the variance of the whole signal, dividing the whole into a unit analysis interval of 200 milliseconds and a unit analysis interval overlap of 50%, performing power spectrum estimation by an autocorrelation model of ten dimensions for each interval by using the Yule-Walker method, extracting band components ranging from 20 kHz to 96 kHz exceeding the human audible range upper limit from the obtained power spectrum and three-dimensionally extracting its time change with the transverse axis (from left to right) served as the linear representation of frequency, the anteroposterior axis (from this side to the depth) served as the linear representation of time, and the vertical axis (from downside to upside) served as the logarithmic representation of power at each time point of each frequency component.

FIG. **4** is a graph showing an example of a local exponent of fractal dimension of a spectro-temporal structure of a vibration that satisfies the first property on the autocorrelation order according to the present invention. In this case, the local exponent of fractal dimension of the obtained three-dimensional power spectrum array curved surface is calculated by using the box-counting method. It is noted that a calculation method is described in a "supplementary explanation of the calculating formula" described later. Referring to FIG. **4**, regarding these vibrations, the local exponent of fractal dimension that represents the complexity and self-similarity of the shape of the three-dimensional power spectrum array of the components exceeding 20 kHz consistently has a value of not smaller than 2.2 and not greater than 2.8, which is greater than the dimension number two of the topological dimension owned by a plane-like figure even when the "spectro-temporal index" (ST-index) that serves as a reference to measure it changes within a range of 2^{-1} to 2^{-5}, and its fluctuation range falls within 0.4. The local exponent of fractal dimension within a range in which the "spectro-temporal index" (ST-index) of the vibration that satisfies the first property on the autocorrelation order is 2^{-1} to 2^{-5} is shown in FIG. **5**.

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Although the maximum value of the data exemplified in this case is 2.709, the value changes depending on how to take a sample to be analyzed and possibly has a value up to 2.8.

In this case, the "spectro-temporal index" (ST-index) represents the length of one side of a reference box used upon calculating the local exponent of fractal dimension of the three-dimensional power spectrum array curved surface by using the box-counting method, the length being normalized as a ratio to the entire frequency bandwidth (transverse axis) and the entire time (anteroposterior axis) of the three-dimensional power spectrum array of the analysis object.

FIG. **6** is a graph showing an example of the local exponent of the fractal dimension of the spectro-temporal structure of a vibration that does not satisfy the first property on the autocorrelation order according to the present invention. As is apparent from FIG. **6**, examples of vibrations that do not satisfy the first property on the autocorrelation order among vibrations having the super-high-frequency components are shown. In these examples, the local exponent of fractal dimension has a value smaller than 2.2 when the spectro-temporal index is within the range of 2^{-1} to 2^{-5}. That is, the local exponent of fractal dimension has a value smaller than 2.2 when the spectro-temporal index is 2^{-1} in the case of a white noise, when the spectro-temporal index is 2^{-1} and 2^{-2} in the case of a pink noise and a 1-bit noise or when the spectro-temporal index is 2^{-1}, 2^{-3}, 2^{-4} and 2^{-5} in the case of a sine wave. Further, in the case of the white noise, the fluctuation range of the local exponent of fractal dimension indicates a value greater than 0.4. Moreover, the local exponent of fractal dimension of the vibration that does not satisfy the first property on the autocorrelation order when the spectro-temporal index is within the range of 2^{-1} to 2^{-5} is shown in FIG. **7**.

Reference is next made to the second property on the autocorrelation order. Many of time series having the autocorrelation order observed in the natural world exhibit a structure that is neither completely random nor completely regular. That is, they are neither the time series that are completely random and have no predictability like a white noise nor the time series that are completely predictable and have a determinate regularity like a sine wave, and they coexistently have inherent predictability and irregularity commensurate with the autocorrelation order.

The present inventor and others discovered that the vibration capable of introducing the fundamental brain activation effect had its signal coexistently having moderate predictability and irregularity and the autocorrelation structure changed with time. In contrast to this, a vibration of which the time series is completely irregular and which does not have predictability at all, such as a white noise, does not introduce the fundamental brain activation effect. Likewise, a vibration of which the time series is completely regular and the predictability is determinate, such as a sine wave, does not introduce the fundamental brain activation effect.

Therefore, when the "information entropy density" that is the index of the irregularity of the signal is obtained, the vibration that can introduce the fundamental brain activation effect indicates a value within a definite range between the vibration like, for example, a white noise that is completely irregular and unpredictable and the vibration like, for example, a sine wave that is completely regular and determinate. In contrast to this, the information entropy density theoretically consistently has a maximum value in the case of a vibration constituted of a completely irregular signal like, for example, a white noise among the vibrations that do not introduce the fundamental brain activation effect, and likewise, it theoretically consistently has a minimum value in the case of a vibration constituted of a completely determinate signal like, for example, a sine wave among the vibrations that do not introduce the fundamental brain activation effect. Further, in contrast to the fact that the information entropy density indicates fluctuations temporally in excess of a definite range since the autocorrelation structure changes with time in the case of the vibration that can introduce the fundamental brain activation effect, it consistently indicates a constant value in the case of the vibration like, for example, a white noise that does not introduce the fundamental brain activation effect.

FIG. **8** is a graph showing an example of the information entropy density and its time change of a vibration that satisfies the second property on the autocorrelation order of the present invention. In this case, the information entropy density of a vibration are obtained by digitizing a signal for 51.2 seconds of a vibration served as an analysis object by a sampling frequency of 192 kHz and a quantization bit count of 24 bits or 12 bits, dividing it into a unit analysis interval of 200 milliseconds and a unit analysis interval overlap of 50%, performing power spectrum estimation by an autocorrelation model of ten dimensions of the time series signal for each interval by using the Yule-Walker method, and being calculated from the obtained power spectrum based on a predetermined calculating formula (See the "supplementary explanation of the calculating formula" described later). It is noted that the signal capable of introducing the fundamental brain activation effect has its information entropy density consistently assuming a value within a range of not smaller than −5 and smaller than zero and has a large time change as described in detail later with reference to FIG. **10**.

FIG. **9** is a graph showing an example of the information entropy density and its time change of a vibration that does not satisfy the second property on the autocorrelation order of the present invention. As is apparent from FIG. **9**, among the vibrations that do not introduce the fundamental brain activation effect, the information entropy density of the white noise consistently has a value of zero, and that of the sine wave consistently has a value of not greater than −5, also exhibiting flat forms with no time change. The pink noise and the 1-bit quantization noise have a value of not smaller than −5 and smaller than zero and exhibit almost no time change.

Regarding the vibrations shown in FIGS. **8** and **9**, the "entropy variation index" (EV-index) that represents the degree of temporal change of the information entropy density is indicated by the graph of FIG. **10** where the vertical axis represents the logarithm. That is, FIG. **10** is a graph showing an example of the entropy variation index (EV-index) of vibrations that satisfy the second property on the "autocorrelation order" of the present invention and vibrations that do not satisfy it according to the present invention. The entropy variation index (EV-index) is the variance of the information entropy densities for the unit analysis intervals across all the analysis intervals. In contrast to the fact that the entropy variation index (EV-index) has a value of not smaller than 0.001 in the case of the vibrations that satisfy the second property shown in FIG. **8**, the entropy variation index (EV-index) has a value smaller than 0.001 in the case of the vibrations that do not satisfy the second property shown in FIG. **9**. It is noted that the theoretical upper limit value of the entropy variation index (EV-index) is observed in such a case that the information entropy density alternately has the values of −5 and zero and it is 6.2622 under the conditions described above.

As described above, the vibration has such essential necessary conditions as having audible range components of vibration components in the audible frequency range perceivable as a sound by the auditory sensation of human beings,

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and as having super-high-frequency components within a range exceeding the audible frequency range up to a predetermined maximum frequency. The vibration also has the feature represented by at least either one of the first property and the second property, can introduce the effect (fundamental brain activation effect) of activating the fundamental brain including the brain stem, thalamus and hypothalamus, which are the regions that bear the fundamental functions of the human brain to which the vibration is applied, and then, can introduce the same effect of activating the neural network (fundamental brain network) projected from the fundamental brain to the various other brain regions. Therefore, the vibration has the same meanings as a hypersonic sound.

Next, an implemental example, in which the gamelan instrument sound of a percussion instrument made of bronze in Bali of Indonesia, or a typical aerial vibration that satisfies the essential conditions and the first property and the second property on the autocorrelation order is applied to a human being to introduce the fundamental brain activation effect is described below.

FIG. **11** shows the average power spectrum of the aerial vibration of the gamelan instrument sound, obtained by the FFT method. The sound sufficiently has super-high-frequency components having an upper limit reaching 100 kHz and satisfies the essential conditions of the present invention with regard to the frequency components.

FIG. **12** shows the local exponent of fractal dimension obtained by a predetermined method with regard to the first property on the autocorrelation order of the gamelan instrument sound. Since the local exponent of fractal dimension consistently has a value of not smaller than 2.2 and the fluctuation range is not greater than 0.4, the first property is satisfied.

FIG. **13** shows the information entropy density obtained by a predetermined method with regard to the second property on the autocorrelation order of the gamelan instrument sound. As is apparent from FIG. **13**, the information entropy density consistently has a value of not smaller than −5 and smaller than zero. FIG. **14** shows the entropy variation index (EV-index) obtained by a predetermined method. As is apparent from FIG. **14**, the entropy variation index (EV-index) has a value greater than 0.001. For the above-mentioned reasons, the gamelan instrument sound satisfies the second property on the autocorrelation order.

FIG. **15** is a block diagram of a vibration generating apparatus including a configuration of a positron emission tomography (PET) and a brain wave measurement apparatus used in the present implemental example and a perspective view showing a room **20** for generating a vibration by the vibration generating apparatus.

As shown in FIG. **15**, an instrument sound obtained by giving a performance with a gamelan **1** is collected by a microphone **2**. The microphone **2** transduces the inputted instrument sound into an analog electric signal, and outputs the transduced analog electric signal to an AD converter **4** via a preamplifier **3**. The AD converter **4** performs AD conversion of the inputted analog electric signal into a digital signal by a sampling frequency of 1.92 MHz by, for example, a high-speed sampling 1-bit quantization system devised by Dr. Yoshio Yamasaki, and outputs the resulting signal to a magnetic recording part **11**.

A magnetic recording and reproducing device **10** is a so-called digital signal recorder that includes a magnetic recording part **11**, a magnetic recording head **12**, a magnetic reproducing head **14** and a magnetic reproducing part **15** to record a digital signal on a magnetic tape **13** or to reproduce and output the digital signal recorded on the magnetic tape **13**. In this case, the magnetic recording and reproducing device **10** has a uniform frequency characteristic in a frequency domain reaching 150 kHz with a prior art DAT in which a digital signal having undergone AD conversion by the high-speed sampling 1-bit quantization system devised by Dr. Yoshio Yamasaki is recorded. The magnetic recording part **11** modulates a carrier wave signal in accordance with the digital signal inputted from the AD converter **4** by a predetermined digital modulation system and records the modulated signal on the magnetic tape **13** running in the predetermined direction **16** indicated by the arrow by using the magnetic recording head **12**. Meanwhile, the magnetic reproducing part **15** reproduces the modulated signal recorded on the magnetic tape **13** by using the magnetic reproducing head **14**, demodulates the reproduced modulated signal by a digital demodulation system reverse to the aforementioned digital modulation system and takes out the digital signal.

The demodulated digital signal is subjected to DA conversion into the original analog signal by a DA converter **5** and thereafter outputted via a reproducing amplifier **6**. An output analog signal from the reproducing amplifier **6** is inputted to a right side loudspeaker **9***aa* and a left side loudspeaker **9***ab* capable of generating a signal in a frequency domain of 20 kHz to 150 kHz via a switch SW**1**, a high-pass filter **7***a* having a cutoff frequency of 22 kHz and a power amplifier **8***a* and also inputted to a right side loudspeaker **9***ba* and a left side loudspeaker **9***bb* capable of generating a signal of not higher than 20 kHz via a switch SW**2**, a low-pass filter **7***b* having a cutoff frequency of 22 kHz and a power amplifier **8***b*. Therefore, the crossover frequency of the two filters **7***a* and **7***b* is 22 kHz.

The loudspeakers **9***aa*, **9***ab*, **9***ba* and **9***bb* are placed in the room **20** of a sound insulation room that is acoustically shielded, and the loudspeakers **9***aa*, **9***ab*, **9***ba* and **9***bb* are applied to a listener **30** who is the test human subject by transducing the inputted signal into a vibration.

Detection electrodes are placed at, for example, twelve scalp points (Fp1, Fp2, F7, Fz, F8, C3, C4, T5, Pz, T6, O1, O2) conforming to the International 10-20 method on the scalp of the listener **30**, and a brain wave detecting and transmitting apparatus **32** connected to the detection electrodes convert the brain waves detected by the detection electrodes into a wireless signal and transmit it from an antenna **33** toward an antenna **34**. The wireless signal of the brain waves is received by the antenna **34** and thereafter outputted to a brain wave data receiving and recording apparatus **31**. In the brain wave data receiving and recording apparatus **31**, the received wireless signal of the brain waves is converted into a brain wave signal and recorded in a magnetic recording apparatus. Further, the brain wave signal is analyzed by an analysis computer, while changes in the brain wave are recorded and outputted by using an output device such as a CRT display and a pen recorder. On the other hand, the head portion of the listener **30** is placed held between two detecting parts of a tomographic detector apparatus **42**, and a detection signal from the tomographic detector apparatus **42** is transmitted to a tomographic apparatus **41**. Subsequently, the tomographic apparatus **41** executes predetermined tomographic analysis processing based on the inputted detection signal and displays a tomographic chart of the analysis result on a built-in CRT display.

In the vibration generating apparatus and the room **20** configured as above, when the switches SW**1** and SW**2** are both turned on, an instrument sound performed by using the gamelan **1** is recoded on the magnetic tape **13** in the magnetic recording and reproducing device **10**. Subsequently, when it is reproduced, the reproduced vibration substantially identi-