United States Patent

[11] 3,586,783

[72] Inventor **David R. Brickner**
17423 N. 20th Avenue, Phoenix, Ariz. 85023

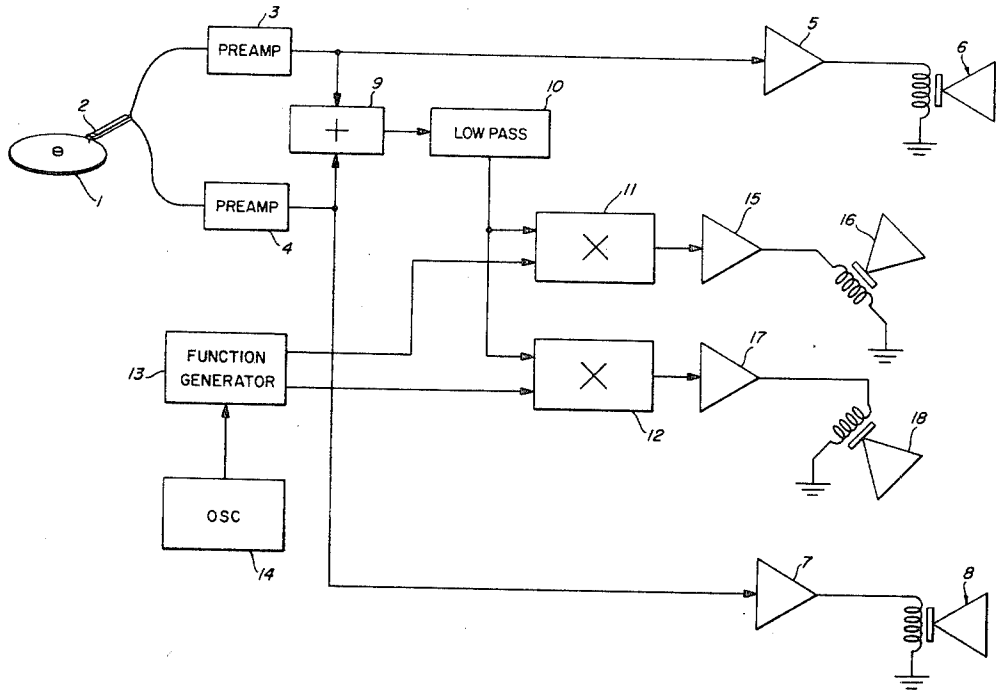
[21] Appl. No. **834,261**
[22] Filed **June 18, 1969**
[45] Patented **June 22, 1971**

[54] **SOUND SYSTEM WITH ENHANCED LOW-FREQUENCY DISTRIBUTION**
8 Claims, 2 Drawing Figs.

[52] **U.S. Cl.** ..... **179/16 A,** 179/1 J
[51] **Int. Cl.** **H04r 5/02**
[50] **Field of Search** ..... 179/1 J, 16 A, 1 GP, 1 G, 1 AT

Primary Examiner—Kathleen H. Claffy
Assistant Examiner—Horst F. Brauner
Attorney—Drummond, Cahill & Phillips

ABSTRACT: In order to achieve an augmented apparent bass in a sound system, a pair of low frequency speakers are oriented at a predetermined angle with respect to one another and each is energized by a function of the angle between the speakers such that the resultant sound vector sweeps through an arc at a subsonic rate.



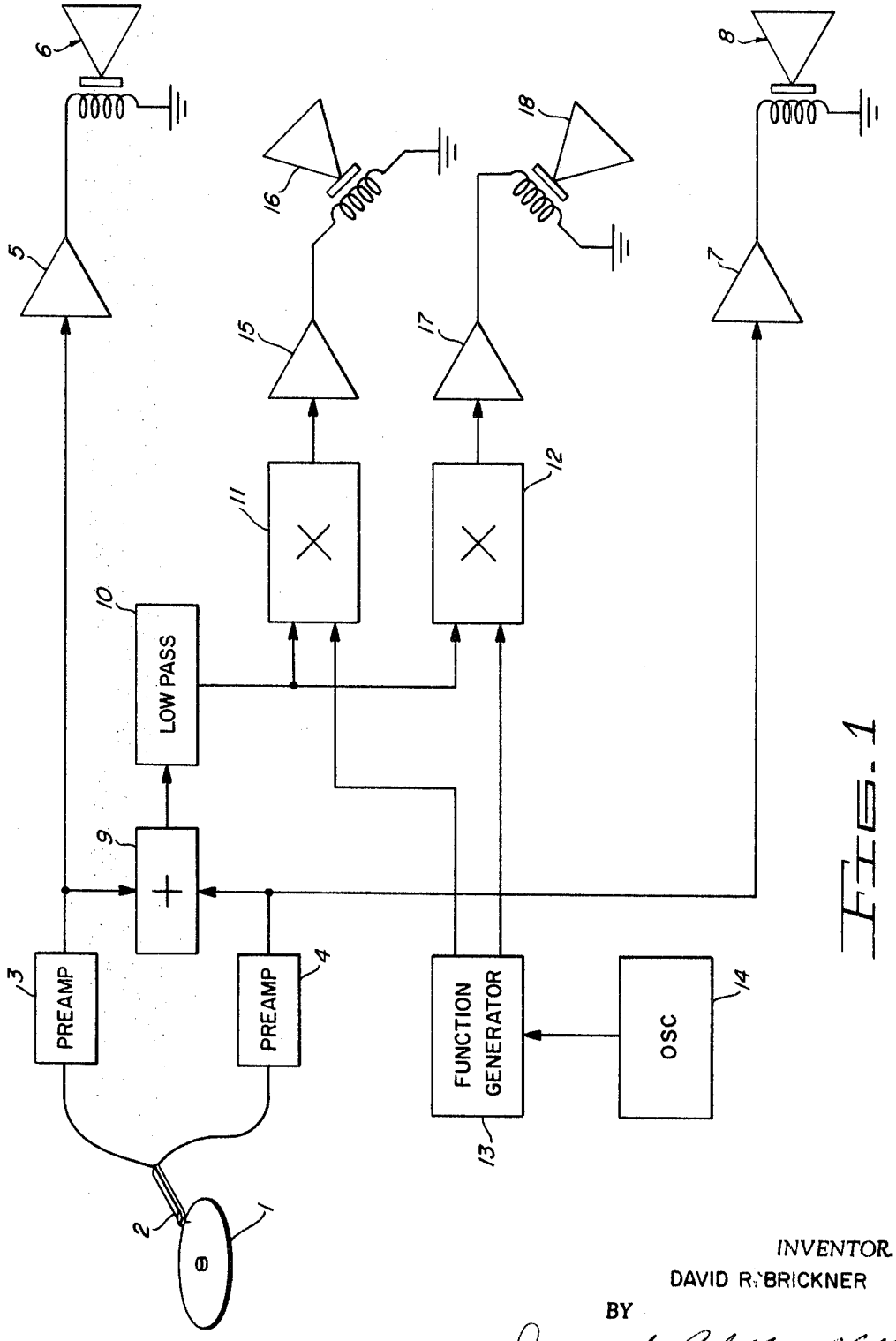


FIG. 1

INVENTOR.
DAVID R. BRICKNER
BY
Drummond, Cahill & Phillips
ATTORNEYS

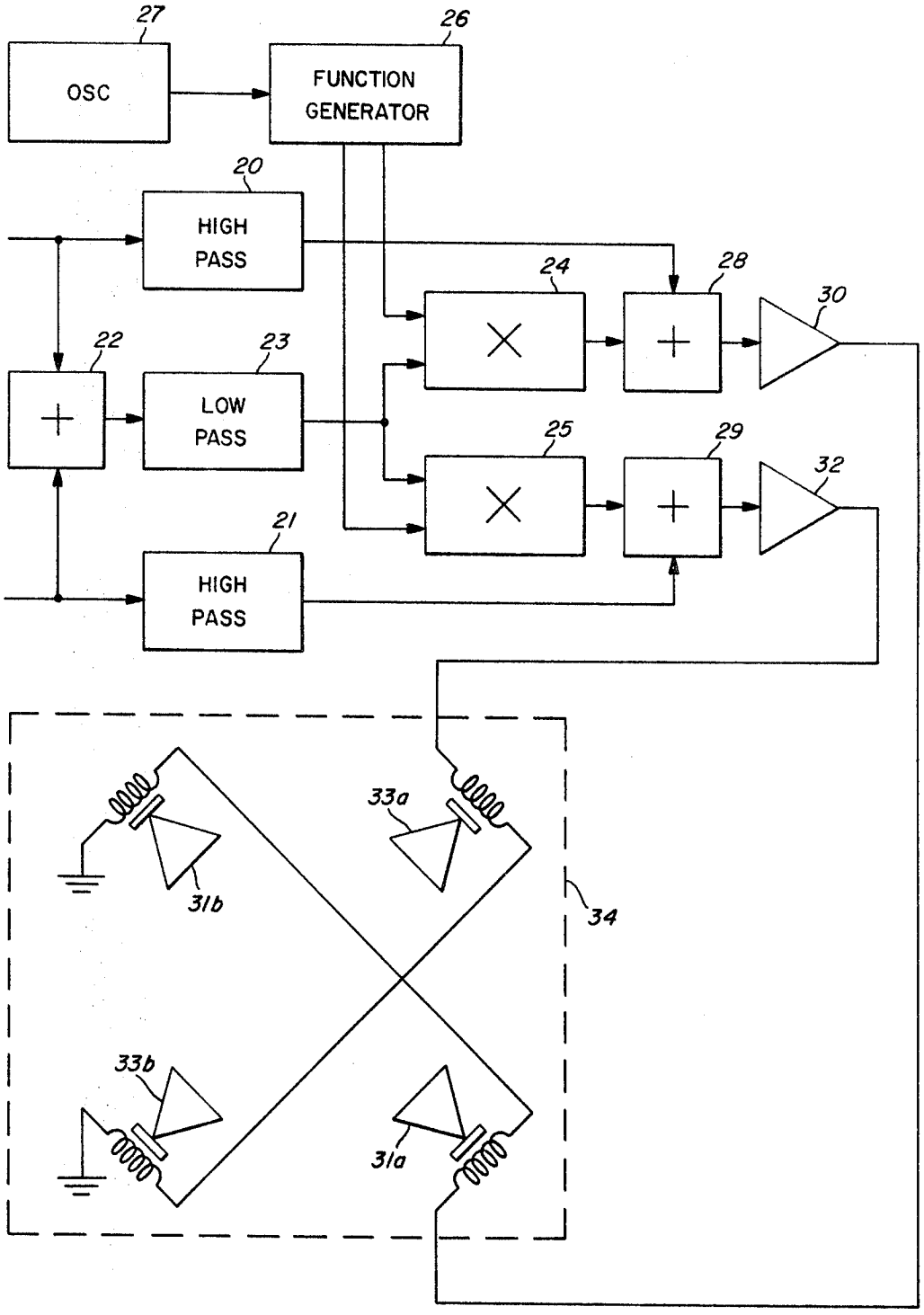


Fig. 2

INVENTOR.
DAVID R. BRICKNER
BY
Drummond, Cahill & Phillips
ATTORNEYS

SOUND SYSTEM WITH ENHANCED LOW-FREQUENCY DISTRIBUTION

This invention relates to sound systems and, more particularly, to apparatus for achieving an apparently enhanced bass.

In the development of electronic musical instruments, particularly electronic organs, the duplication of the powerful bass tones of the classical pipe organ has posed a significant problem. Further, sound reproduction systems in general have been less than satisfactory in their ability to reproduce the lower frequencies which are available at the source and are properly amplified and impressed on the speaker terminals. This follows from the manifest consideration that there are practical limits to the size and expense of the electronic-to-acoustical transducers which can be used with a given system. It has been found that the low frequency sound of such systems can be enhanced by rotating the low frequency speakers at a subsonic rate or, as a functional alternative, by rotating baffles disposed immediately adjacent the low frequency speakers at a subsonic rate. In both instances, the resulting sweeping beam containing the bass content of the program material gives the impression of enhanced bass response because of the physiological impact on the listener. While this effect is not fully understood, its effectiveness is recognized and appreciated.

In prior art enhanced bass systems utilizing rotating speakers or baffles, the mechanical realization has been inordinantly clumsy, necessitating the use of motors, speed reduction gear trains, slip rings, and the like. It would, therefore, be highly desirable if the positive results of a sweeping low frequency beam could be achieved while eliminating the mechanical drawbacks of the prior art.

It is thus a broad object of this invention to provide a sound system with improved low frequency characteristics.

It is a more specific object of this invention to provide an improved sound system utilizing a sweeping beam comprising the low frequency program content.

It is another object of this invention to provide apparatus for achieving a sweeping low frequency beam without the use of mechanically rotating or gyrating components.

The subject matter of the invention is particularly pointed out and distinctly claimed in the concluding portion of the specification. The invention, however, both as to organization and method of operation, may best be understood by reference to the following description taken in connection with the accompanying drawings, of which:

FIG. 1 is a block diagram representing a first preferred embodiment of the invention; and

FIG. 2 is a block diagram representing a second preferred embodiment of the invention as it might be utilized in a specific environment.

Referring now to FIG. 1, a two-channel sound system utilizing the present invention is illustrated. Information from a two-channel source, such as a stereophonic record 1, is translated in the conventional manner by the cartridge 2 into left and right low-level electrical signals which are applied to a left-channel preamplifier 3 and a right-channel preamplifier 4 respectively. The signals are voltage amplified through the preamplifiers 3 and 4 in a manner well known in the art to become available as so-called high-level signals at the output of the preamplifiers. It will be understood that this signal source is merely exemplary and that such other sources as organ tone generators, tuners, tape decks, etc., are contemplated and are equally applicable to the present invention.

The output signal from the left-channel preamplifier 3 is applied to the input terminals of a left-channel power amplifier 5 which drives a full-frequency left-channel speaker system 6. Similarly, the output signal from the right-channel preamplifier 4 is impressed on the input terminals to a right-channel power amplifier 7 which energizes a full-frequency right-channel speaker system 8.

The signals from 100 left-channel preamplifier 3 and the right-signal preamplifier 4 are each also applied to separate

input terminals of a conventional mixer 9. Thus, the output signal from the mixer 9 represents left plus right information, and this composite signal is applied to the input terminals of a low-pass filter 10 which may typically have a nominal cutoff frequency of 100 hertz or less. The signal issuing from the low-pass filter, representing the composite lower frequency spectrum of the source signals, is applied in parallel to first input terminals respectively of a first electronic multiplier 11 and a second electronic multiplier 12. The first electronic multiplier 11 and the second electronic multiplier 12 are each provided with second input terminals for receiving multiplier signals within a range representing values between the limits −1 and 1. It will therefore be understood that the voltage gain through the first and second electronic multipliers 11 and 12 will correspond in direct proportion to the amplitude of the multiplier signal appearing at the respective second input terminals.

The multiplier signals applied to the second input terminals to the first electronic multiplier 11 and the second electronic multiplier 12 are developed in a function generator 13. The function generator 13 is driven, in turn, by a very low frequency oscillator 14 which may be of any well known type capable of providing relatively stable performance at subsonic frequencies.

The function generator 13 comprises two similar "two quadrant" sections, each driven by the output signal from the low frequency oscillator 14. One function generator section responds to its input signal by generating a sine function signal proportional to the absolute value of the sine function of the angle of the input signal. Similarly, the second function generator section responds to the input signal by generating a cosine function signal proportional to the absolute value of the cosine function of the input signal. The sine function signal is applied to the second input terminal of the first electronic multiplier 11, and the cosine function signal is applied to the second input terminal to the second electronic multiplier 12. As a result, it will be apparent that the multiplied signals appearing at the output terminals of the electronic multipliers 11 and 12 will represent orthogonal vectors, each identical in content but varying in amplitude in accordance with a function of the angle of the low frequency oscillator output signal. It will be understood that the function generator 13 may be provided with two "four quadrant" sections rather than two "two quadrant" sections such that coordinated phase reversals will periodically occur at the output terminals of the electronic multipliers 11 and 12. The effect of such substitution will be noted below.

Assuming the function generator 13 is provided with "two quadrant" sections, the sine vector signal issuing from the electronic multiplier 11 is amplified through a low frequency power amplifier 15 which drives a sine vector low frequency speaker system 16. In a like manner, the cosine vector signal issuing from the second electronic multiplier 12 is amplified through a second low frequency power amplifier 17 which drives a cosine vector low frequency speaker system 18. It will be observed that the sine vector low frequency speaker system 16 and the cosine vector low frequency speaker system 18 are orthogonally disposed with respect to one another. This physical arrangement, in conjunction with the methodically shifting amplitudes of the sounds issuing from the speaker systems 16 and 18 result in a low frequency beam sweeping through the 90° described by the placement of the speaker systems 16 and 18. If "four quadrant" sections are utilized in the function generator 13, certain periodically recurring cancellation effects in the sounds issuing from the speaker systems 16 and 18 impart an altered character to the low frequency beam which the listener interprets as rotation.

An easily realized alternative arrangement, not shown, may be achieved by substituting the function sine-plus-120° for the cosine function applied to the second input terminal to the second electronic multiplier 12 and orienting the low frequency speaker systems 16 and 18 at an angle of 120° with respect to one another. The resultant low frequency beam will then sweep through 120°, the wider swept angle being more suita-

ble for relatively wide rooms. Further, it will be understood by those skilled in the art that it is entirely feasible to utilize three low frequency speaker systems arranged at 120° with respect to one another, the three low frequency systems being driven by signals modulated by values proportional to the respective functions sine, sine-plus-120°, and sine-plus-240° to achieve a continuously rotating low frequency beam.

Referring now to FIG. 2, an alternative preferred embodiment of the invention is presented. Left and right channel signals are applied to left- and right-channel high pass filters 20 and 21, respectively. The nominal cutoff frequency of the high pass filters 20 and 21 may be on the order of 100 hertz with the specific value determined by the environment, a larger room generally requiring a lower nominal cutoff frequency. Additionally, the left- and right-channel information signals are each applied to separate inputs of a mixer 22, and the resultant composite output signal from the mixer 22 is applied to the input terminals of a low-pass filter 23. The nominal cutoff frequency for the low-pass filter 23 should be approximately the same as that of the high pass filters 20 and 21. The signal issuing from the low-pass filter 23 representing the composite lower frequency spectrum of the source signals, is applied in parallel to first input terminals respectively of a first electronic multiplier 24 and a second electronic multiplier 25. Like the electronic multipliers 11 and 12 of the FIG. 1 embodiment, the electronic multipliers 24 and 25 are each provided with second input terminals for receiving multiplier signals within a range representing values between the limits −1 and 1 such that the output signals from the multipliers 24 and 25 will correspond in direct proportion to the amplitude of the multiplier signal appearing at the respective second input terminals. The multiplier signals applied to the second input terminals to the first electronic multiplier 24 and the second electronic multiplier 25 are developed at a function generator 26 which corresponds to the function generator 13 of the FIG. 1 embodiment. Similarly, the function generator 26 is driven by a very low frequency oscillator 27 which corresponds to the very low frequency oscillator 14 of the FIG. 1 embodiment. Thus, it will be apparent that the multiplied signals appearing at the output terminals of the electronic multipliers 24 and 25 represent orthogonal vectors, each identical in content but varying in amplitude in accordance with a function of the angle of the low frequency oscillator output signal.

The output signal from the left-channel high pass filter 20 and the sine vector multiplier 24 are applied to separate input terminals of a left-channel mixer 28. In a like manner, the output signals from the right-channel high pass filter 21 and the cosine electronic multiplier 25 are applied to separate input terminals to a right channel mixer 29. Therefore, the output signals from the mixers 28 and 29 will represent, respectively, the information above the nominal cutoff frequency of the left- and right-channel high pass filters 20 and 21 and the composite low frequency information varying in amplitude according to the angle of the output signal from the low frequency oscillator 27.

The output signal from the left-channel mixer 28 is applied to the input terminals of a left-channel power amplifier 30 which drives a pair of full-frequency left-channel speaker systems 31*a* and 31*b*. Similarly, the output signal from the right-channel mixer 29 is applied to the input terminals of a right-channel power amplifier 32 which drives a pair of full-frequency right-channel speaker systems 33*a* and 33*b*. While the speaker systems 31*a* and 31*b* and the speaker systems 33*a* and 33*b* are depicted as driven in series, it will be obvious to those skilled in the art that it may be necessary to drive the speakers in parallel to achieve a proper impedance match between the power amplifiers and their speaker system loads.

It will be seen from a study of the placement of the several speaker systems in the room 34 that a listener will perceive a stereophonic effect from almost any position within the room although the effect will be reversed in approximately half the area. For nearly all purposes, this does not constitute a significant drawback; particularly where the system is utilized in commercial establishments for background music or other types of music which do not require critical listening. Inasmuch as the low frequency content in each channel varies methodically in accordance with the subsonic output signal from the low frequency oscillator 27, the low frequency information sweeps across the entire listening area to achieve the enhanced bass sought as discussed above.

As with the embodiment of FIG. 1, alternative arrangements, not shown, are contemplated; for example, the use of a function other than cosine to modulate the low frequency content of one channel with a commensurate rearrangement of the usual angles between the several speaker systems as well as the use of "four quadrant" function generator sections. By these means, optimum results can be obtained in any room which is not square.

While the principles of the invention have now been made clear in an illustrative embodiment, there will be immediately obvious to those skilled in the art many modifications of structure, arrangement, proportions, the elements, materials, and components, used in the practice of the invention which are particularly adapted for specific environments and operating requirements without departing from those principles.

I claim:

1. Apparatus for issuing a sweeping sonic beam comprising:

A. a low frequency oscillator for issuing a signal representing a continually changing angle;

B. a function generator including means for generating first and second function signals representing first and second functions of said continually changing angle;

C. first and second electronic multipliers, each of said electronic multipliers having a plurality of inputs for accepting a corresponding plurality of input signals to be multiplied, each of said electronic multipliers having an output for issuing a product signal representing the product of the input signals;

D. means for applying said first function signal to a first one of said plurality of inputs to said first electronic multiplier and means for applying said second function signal to a first one of said plurality of inputs to said second electronic multiplier;

E. a source of first and second information signals representing sound;

F. means for applying said first information signal to a second one of said plurality of inputs to said first electronic multiplier and means for applying said second information signal to a second one of said plurality of inputs to said second electronic multiplier;

G. first and second speaker systems mutually disposed at an angle approximating the angular distance described between said first and second functions; and

H. first and second amplifiers for driving said first and second speaker systems respectively in response to the respective product signals from said first and second multipliers.

2. The apparatus of claim 1 in which said angle is continually increasing.

3. The apparatus of claim 1 in which said angle is continually decreasing.

4. The apparatus of claim 1 in which said first and second information signals are identical.

5. The apparatus of claim 4 which includes a source of first and second audio signals and in which said first and second information signals are derived by mixing said first and second audio signals and passing the resultant mixed signal through a low-pass filter.

6. The apparatus of claim 5 which further includes means for separately amplifying and sonically reproducing said first and second audio signals, respectively.

7. The apparatus of claim 6 in which said first function is sine and said second function is cosine.

8. The apparatus of claim 6 in which said first function is the absolute value of sine and said second function is the absolute value of cosine.