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(54) Title: DYNAMIC CONTOURED-SOUND/SUBWOOFER-SYNTHESIS AUDIO SYSTEM

(57) Abstract: A dynamic contoured-sound/subwoofer-synthesis system including an adjustable high pass filter coupled to the input terminal, the high pass filter being designed to provide a variety of frequency response shapes in response to adjustments thereof. A primary amplifier is coupled to receive one of the variety of frequency response shapes from the adjustable high pass filter and includes a main operational amplifier (op-amp) with the inverting input coupled to the adjustable high pass filter through a series connected input capacitor and input resistor. The primary amplifier provides low frequency signal gain and shaping of the received frequency response shape. A high frequency signal shaping circuit includes a feedback op-amp coupled to the inverting input of the main op-amp through a feedback resistor and a feedback capacitor.

1 DYNAMIC CONTOURED-SOUND/SUBWOOFER-SYNTHESIS AUDIO SYSTEM

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Field of the Invention

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This invention generally relates to analog signal conditioning in audio systems.

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Background of the Invention

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Research has shown that the response of the human ear is very dependent on the frequency content of the sound.

14

The ear has peak response around 2,000 Hz to 4,000 Hz and

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significantly less response at lower and higher

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frequencies. In other words, a sound with a frequency

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between 2,000 Hz and 4,000 Hz will be perceived as louder

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to the ear than sounds below and above this range.

19

Additionally, the ear's ability to perceive low and high

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frequencies varies with sound intensity (i.e., volume)

21

level. This explains why soft music seems to sound less

22

rich than music played at higher volume. Turning to FIG.

23

1, each curve represents a different volume level from a

24

sound source, such as a stereo system. Curves on the bottom

1 represent quieter volume levels and curves on the top
2 represent louder volume levels. By examining these curves
3 it will be observed that the quieter a volume level the
4 greater the difference in sound intensity level (sound
5 energy) required for the ear to hear low and high
6 frequencies. Thus, it is desirable for a sound system to
7 compensate for the natural inadequacies of the ear.

8

9 Furthermore, the ability of a typical speaker to
10 reproduce sound diminishes (rolls-off) at low and high
11 frequencies resulting in a reduction of sound content
12 conveyed to the ear. A significant reduction of sound
13 intensity occurs as the signal frequency decreases from 700
14 Hz down to 20 Hz and again as the frequency increases from
15 4,000 Hz to 20,000 Hz. See for example the typical speaker
16 frequency response illustrated graphically in FIG. 2. This
17 roll-off results in diminished loudness and thus audibility
18 as perceived by the human ear.

19

1 One method/apparatus of solving the low frequency
2 problem in the prior art, is to provide a subwoofer system.
3 Subwoofer systems, specifically designed to accentuate
4 lower frequencies, are incorporated with standard stereo
5 systems to compensate for the low frequency roll-off. A
6 major problem is that commonly obtainable audio subwoofer
7 systems for reproducing low frequency sound are constructed
8 in such an embodiment that their form is bulky and
9 therefore cannot be easily transported for personal use,
10 for example with an MP3 player when walking or exercising.
11 Additionally, commercially obtainable subwoofer systems
12 consume sizeable electrical current, require ventilation
13 for heat removal, can be complex and difficult to connect
14 and operate, are costly to obtain, present a potential for
15 electrical shock when exposed in damp or wet environments,
16 and as a result are not able to be proliferated widely or
17 easily.

18

19 To date, audio engineers have been unable to produce
20 extreme low frequency sound (i.e., in the subwoofer range)
21 from all speaker and earpiece types of sound devices. In
22 fact, it is commonly believed by audio engineers that it is
23 physically impossible to produce extreme low frequency
24 sound with small speakers and other audio sound devices.

1 It would be highly advantageous, therefore, to remedy
2 the foregoing and other deficiencies inherent in the prior
3 art.

4

5 Accordingly, it is an object of the present invention
6 to provide a new and improved subwoofer sound synthesizer.

7

8 It is a further object of the present invention to
9 provide a new and improved dynamic contoured sound system
10 that substantially compensates for the natural inadequacy
11 of the human ear at either or both the low frequencies and
12 the high frequencies.

13

14 It is a further object of the present invention to
15 provide a new and improved dynamic contoured sound system
16 that substantially compensates for the roll-off effects of
17 standard speakers and other sound producing devices.

18

19 It is a further object of the present invention to
20 provide a new and improved subwoofer sound synthesizer that
21 is capable of being used with substantially any sound
22 producing devices, including speakers, small speakers,
23 earpieces, hearing aids, etc.

24

1 Summary of the Invention

2

3 Briefly, to achieve the desired objects of the instant

4 invention in accordance with a preferred embodiment

5 thereof, provided is a dynamic contoured-sound/subwoofer-

6 synthesis system including an adjustable high pass filter

7 coupled to the input terminal of the system and an

8 adjustable feedback amplifier coupled to the primary

9 amplifier. The high pass filter is designed to provide a

10 variety of frequency response shapes in response to

11 adjustments of an adjustable component. A primary

12 amplifier is coupled to receive a frequency response shape

13 of the variety of frequency response shapes from the

14 adjustable high pass filter. The primary amplifier

15 includes a plurality of feedback components designed and

16 connected to produce low and high frequency signal gain and

17 shaping. The primary amplifier provides low and high

18 frequency signal gain and shaping of the received frequency

19 response shape to the output terminal.

20

21 The desired objects of the instant invention are

22 further realized in accordance with another embodiment

23 thereof, in which a dynamic contoured-sound/subwoofer-

24 synthesis system includes an input terminal designed to

1 receive an audio signal and an output terminal designed to
2 supply an output signal to an external load. An adjustable
3 high pass filter is coupled to the input terminal and
4 includes an adjustable component. The high pass filter is
5 designed to provide a variety of frequency response shapes
6 in response to adjustments of the adjustable component. A
7 primary amplifier is coupled to receive a frequency
8 response shape of the variety of frequency response shapes
9 from the adjustable high pass filter. The primary
10 amplifier includes a main operational amplifier having an
11 inverting input, a non-inverting input, and a signal
12 output. The inverting input is coupled to the adjustable
13 high pass filter through a series connected input capacitor
14 and input resistor to receive the frequency response shape
15 of the variety of frequency response shapes. The primary
16 amplifier further includes a first feedback resistor
17 coupled between the signal output of the main operational
18 amplifier and the inverting input. The primary amplifier
19 provides low and high frequency signal gain and shaping of
20 the received frequency response shape to the output
21 terminal. A high frequency signal shaping circuit includes
22 a feedback operational amplifier having an inverting input,
23 a non-inverting input, and a signal output. The high
24 frequency signal shaping circuit further includes a second

1 feedback resistor and a feedback capacitor with the
2 feedback operational amplifier coupled to the inverting
3 input of the main operational amplifier through the second
4 feedback resistor and the feedback capacitor. The
5 inverting input of the feedback operational amplifier is
6 coupled to the signal output of the main operational
7 amplifier through a first differential gain resistor, and
8 the non-inverting input of the feedback operational
9 amplifier is coupled to the signal output of the main
10 operational amplifier through a second differential gain
11 resistor with a resistance value different than a
12 resistance value of the first differential gain resistor. A
13 capacitor, resistor, and adjustable component, coupled with
14 the non-inverting input of the feedback operational
15 amplifier and output of the second differential gain
16 resistor forms an adjustable simulated inductor.

17

18 The desired objects of the instant invention are
19 further realized in accordance with a method of contouring
20 sound and synthesizing subwoofer sound in a sound producing
21 device including the step of providing an adjustable high
22 pass filter having a plurality of step settings and
23 constructed with each setting having a different frequency
24 of emphasis and the frequency of emphasis for each setting

1 occurring at a lower frequency than a prior setting and
2 each setting having a different magnitude of gain change,
3 for each setting the magnitude of gain change is greater
4 than a prior setting. The method further includes the step
5 of applying audio signals to the adjustable high pass
6 filter for controlling the amount of subwoofer synthesis of
7 the audio signals, each step setting providing a different
8 frequency response shape, and selecting a step setting of
9 the high pass filter to provide a preferred frequency
10 response shape of the different frequency response shapes.
11 The method further includes the step of receiving the
12 preferred frequency response shape of the different
13 frequency response shapes from the adjustable high pass
14 filter and amplifying the preferred frequency response
15 shape to provide low frequency signal gain and shaping of
16 the preferred frequency response shape.

17

18 The desired objects of the instant invention are
19 further realized in accordance with a method of contouring
20 sound in a sound producing device including the step of
21 providing an adjustable simulated inductor having a
22 plurality of step settings and constructed with each
23 setting having a different frequency of emphasis and the
24 frequency of emphasis for each setting occurring at a

1 higher frequency than a prior setting and each setting
2 having a different magnitude of gain change, for each
3 setting the magnitude of gain change is greater than a
4 prior setting. The method further includes the step of
5 applying audio signals from the output of the primary
6 amplifier to the adjustable simulated inductor for
7 controlling the amount of high frequency contoured sound of
8 the audio signals, each step setting providing a different
9 frequency response shape, and selecting a step setting of
10 the simulated inductor to provide a preferred frequency
11 response shape of the different frequency response shapes.
12 The method further includes the step of receiving the
13 preferred frequency response shape of the different
14 frequency response shapes from the output of the primary
15 amplifier and amplifying the preferred frequency response
16 shape to provide high frequency signal gain and shaping of
17 the preferred frequency response shape.

18

19 The method thereby controls the amount of contoured
20 sound, subwoofer synthesis, and high frequency signal
21 shaping that substantially compensates for the roll-off
22 effects of sound producing devices at low audio frequencies
23 and at high audio frequencies. Furthermore, the method
24 counterbalances the natural inadequacies of the human ear

1 and significantly compensates the ear's ability to perceive
2 low and high frequency sounds.

3

1 Brief Description of the Drawings

2

3 The foregoing and further and more specific objects
4 and advantages of the instant invention will become readily
5 apparent to those skilled in the art from the following
6 detailed description of a preferred embodiment thereof
7 taken in conjunction with the drawings, in which:

8

9 FIG. 1 is a graphical representation of the natural
10 response of the human ear, each curve in the graph
11 representing a different volume level from a sound source
12 such as a stereo system;

13

14 FIG. 2 is a graphical representation of the frequency
15 response of a typical speaker;

16

17 FIG. 3 is a schematic representation of one embodiment
18 of a dynamic contoured-sound/subwoofer-synthesis sound
19 system in accordance with the present invention;

20

21 FIG. 4 is a graphical representation of audio signal
22 shaping produced by the circuitry of FIG. 3;

23

1 FIG. 5 is a graphical representation of the audio
2 signal shaping illustrating the frequency of emphasis and
3 magnitude of gain change by controller settings;

4
5 FIG. 6 is a schematic representation similar to FIG. 3
6 illustrating functional sections of the circuitry;

7
8 FIG. 7 is a breakaway view of section A of the
9 circuitry illustrated in FIG. 6;

10
11 FIG. 8 is a graphical representation of the low
12 frequency response of the circuitry of FIG. 6, illustrating
13 the adjustability and response provided by section A;

14
15 FIG. 9 is a graphical representation of the low
16 frequency response of the circuitry of FIG. 6, without
17 section A;

18
19 FIG. 10 is a breakaway view of section B of the
20 circuitry illustrated in FIG. 6;

21
22 FIG. 11 is a breakaway view of section C of the
23 circuitry illustrated in FIG. 6;

1 FIG. 12 is a graphical representation of the high
2 frequency response of the circuitry of FIG. 6,
3 substantially as produced by the operational amplifiers;
4

5 FIG. 13 is a graphical representation of the high
6 frequency response of the circuitry of FIG. 6,
7 substantially as produced by the various coupling
8 components;
9

10 FIG. 14 is a breakaway view of section D of the
11 circuitry illustrated in FIG. 6;
12

13 FIG. 15 is a graphical representation of the high
14 frequency response of the circuitry of FIG. 6, illustrating
15 the adjustability and response provided by section D; and
16

17 FIGS. 16 and 17 are views in top plan and side
18 elevation, respectively, of the sound system, illustrating
19 the approximate size thereof.
20

1 Detailed Description of a Preferred Embodiment

2

3 Turning now to FIG. 3, a schematic representation is

4 illustrated of one embodiment of a dynamic contoured-

5 sound/subwoofer-synthesis sound system, designated 20, in

6 accordance with the present invention. Sound system 20

7 includes passive and active electronic components

8 formulated and configured to filter input signal frequency

9 and contour output signal magnitude in calculated

10 proportion with frequency characteristics of the input

11 signal. As will be understood from the description below,

12 sound system 20 further includes circuitry providing

13 adjustable filtering of the input signal frequencies and

14 thus the signal content acted upon by the contouring stage

15 resulting in the desired contoured-sound/subwoofer-

16 synthesis characteristics. It should be noted that FIG. 3

17 is a single channel representation only and in application

18 sound system 20 would be duplicated for each independent

19 signal channel (e.g. two channels for stereo application).

20

21 Referring additionally to FIG. 4, exemplary modulation

22 contours are illustrated extending from below 100 Hz on the

23 left side to above 10,000 Hz on the right side. While

24 approximately 12 contours are illustrated for this example,

1 the specific embodiment of sound system 20 is constructed
2 to provide 32 unique low frequency shapes or contours and
3 32 independent high frequency shapes or contours, resulting
4 in a total of 1024 (32^2) unique controller response shapes.
5 It will of course be understood that 32 shapes is simply
6 for purposes of explanation and more or less low frequency
7 and high frequency contours can be provided if desired.

8

9 Referring additionally to FIG. 5, it can be seen that
10 each contour or controller setting, has a different
11 frequency of emphasis, i.e. for each succeeding contour or
12 shape (beginning with the lower shape and proceeding
13 upward) the frequency of emphasis, or highest amplitude,
14 occurs at a little lower frequency. Also, it can be seen
15 that each contour or controller setting, has a different
16 magnitude of gain change, i.e. for each succeeding contour
17 or shape (beginning with the lower shape and proceeding
18 upward) the magnitude of gain change is slightly greater.
19 This is true for both the unique low frequency shapes or
20 contours and the independent high frequency shapes or
21 contours. It should also be noted that the low frequency
22 contours have a much greater effect on the overall response
23 and are a primary subject of the present invention. While
24 high frequencies are affected by both the human ear and

1 speakers, as illustrated in FIGS. 1 and 2, the effect is
2 less and therefore the high frequency shapes or contours
3 illustrated in FIG. 5 may be implemented in a sound system
4 or may be optionally left out if desired.

5

6 Turning now to FIG. 6, sound system 20 as illustrated
7 is partitioned into sections A through D, each of which
8 will be taken up in order. It will of course be understood
9 that each section influences each of the other sections but
10 for purposes of understanding the overall operation or
11 function of the sections will be discussed individually.
12 Also, throughout this disclosure it should be understood
13 that components referred to as 'a resistor' or 'a
14 capacitor' include any component or components combining to
15 form a resistance or a capacitance, respectively, such as a
16 plurality of interconnected resistors or a plurality of
17 interconnected capacitors and any other devices providing
18 an equivalent impedance.

19

20 Referring specifically to FIG. 7, the schematic
21 representation of section A is illustrated. Section A
22 includes an audio signal input device, designated V2,
23 connected between a common (in this instance ground) and
24 one end of an isolation/divider resistor R7. The opposite

1 end of resistor R7 is connected to one side of a filter
2 input capacitor C5. The opposite side of capacitor C5
3 represents the output of section A and is also connected to
4 one end of a 32 step digital potentiometer A1. The
5 adjustable tap of potentiometer A1 is also connected to the
6 output side of capacitor C1 and the opposite side is
7 connected through an isolation/divider/filter resistor R10
8 to the common or ground. Resistor R7 creates a voltage
9 divider with potentiometer A1 and resistor R10. Capacitor
10 C5, potentiometer A1, and resistor R10 form a high pass
11 filter.

12

13 Section A is a high pass filter configuration
14 responsible for controlling the amplitude of audio signals
15 passed-thru to the primary amplifier (section B). By
16 changing the value setting of digital potentiometer A1, a
17 variety of frequency response shapes are obtained, as
18 illustrated in FIG. 8. Without section A, the low
19 frequency response of sound system 20 would appear as shown
20 in FIG. 9.

21

22 Referring specifically to FIG. 10, the schematic
23 representation of section B is illustrated. Section B
24 includes an input capacitor C1, the input side of which is

1 connected to receive the output signals from section A.
2 The opposite side of capacitor C1 is connected to one side
3 of an input resistor R1. The opposite side of resistor R1
4 is connected to the inverting input of an operational
5 amplifier X2. The positive or non-inverting input of
6 operational amplifier X2 is connected to an amplifier bias
7 supply V3. Power is provided to the positive terminal of
8 operational amplifier X2 by a DC voltage supply V1 and the
9 negative terminal is connected to the common or ground. It
10 will be understood that bias supply V3 and DC voltage
11 supply V1 (along with other bias supplies included herein)
12 may be simply batteries or might be connections through a
13 voltage divider network to a common supply source, as will
14 be understood by those skilled in the art. The output of
15 operational amplifier X2 is the signal output of section B.

16

17 Section B is the primary amplifier including feedback
18 components producing low frequency signal gain and shaping.
19 The feedback components include a feedback resistor R4 an
20 input end of which receives a signal from the output of
21 operational amplifier X2 (see FIG. 6) and series connected
22 feedback capacitor C3 and feedback resistor R3. The input
23 end of resistor R3 is connected to an output of section C
24 and the output ends of resistor R4 and capacitor C3 are

1 connected to the inverting input of operational amplifier
2 X2. Capacitor C1 and resistor R1 form a band pass filter
3 that sets the bandwidth of frequencies passed to
4 operational amplifier X2. Resistors R1, R3, R4 and
5 capacitor C3 form a high pass filter that sets the voltage
6 gain of operational amplifier X2. Capacitor C3 reacts in
7 proportion to signal frequency and dynamically changes the
8 combined impedance of components forming the voltage
9 feedback loop. The circuit included in section B, by
10 itself, produces the signal shape illustrated in FIG. 9.

11

12 Referring specifically to FIG. 11, the schematic
13 representation of section C is illustrated. Section C
14 includes an operational amplifier X1 the inverting input of
15 which has an output terminal of a differential gain
16 resistor R5 connected thereto and the non-inverting or
17 positive input of which has an output terminal of a second
18 differential gain resistor R6 connected thereto. The input
19 ends of resistors R5 and R6 are connected to the output of
20 operational amplifier X2 (see FIG. 6). The input side of a
21 differential gain capacitor C4 is connected to the non-
22 inverting or positive input of operational amplifier X1 and
23 the output end is connected to the input of section D.
24 Power is provided to the positive terminal of operational

1 amplifier X1 by a DC voltage supply V4 and the negative
2 terminal is connected to the common or ground. The output
3 of operational amplifier X1 is connected directly to the
4 inverting input thereof and is also connected through a
5 high frequency shaping capacitor C6 to the junction of
6 series connected capacitor C3 and resistor R3 in section B.

7

1 Section C is a feedback servo amplifier, further
2 simulating the electrical characteristics of an inductor,
3 that produces high frequency signal shaping. The impedance
4 of capacitor C4 changes in proportion to the applied signal
5 frequency from the output of operational amplifier X2.
6 Resistor R6 and capacitor C4 form a dynamic voltage divider
7 at the non-inverting input of operational amplifier X1.
8 Operational amplifier X1 changes the output voltage thereof
9 in proportion to the difference voltage between the
10 inverting and non-inverting inputs thereof. The output
11 voltage from operational amplifier X1 is applied to the
12 inverting input of operational amplifier X2 to produce the
13 frequency response shape illustrated in FIG. 12. The
14 impedance of capacitor C6 changes in proportion to the
15 applied frequency from the output of operational amplifier
16 X1. Combined in parallel with resistor R3 of section B,
17 capacitor C6 dynamically adjusts the feedback impedance of
18 operational amplifier X2 shaping/limiting the high
19 frequency gain. Basically, the inputs of operational
20 amplifier X1 are connected to maintain operation at a mid
21 point between upper and lower limits to ensure that no
22 clipping and the consequent sound aberrations occurs. The
23 effect of this high frequency shaping/limiting is
24 illustrated in FIG. 13.

1 Referring specifically to FIG. 14, the schematic
2 representation of section D is illustrated. Section D
3 includes a 32 step digital potentiometer A2 and an
4 isolation/voltage divider resistor R11 connected in series
5 between common or ground and the output side of capacitor
6 C4 in section C. The variable tap of potentiometer A2 is
7 connected to the input end thereof (i.e. the output side of
8 capacitor C4). Basically, potentiometer A2 and resistor
9 R11 are added to the dynamic voltage divider (i.e.
10 capacitor C4 and resistor R6) of section C. Resistor R11
11 provides a fixed resistance to the dynamic side of the
12 voltage divider and sets the attainable high frequency
13 gain. Capacitor C4, potentiometer A2, and resistor R11
14 form an adjustable simulated inductor. The adjustable
15 simulated inductor has a plurality of step settings and is
16 constructed with each step setting having a different
17 frequency of emphasis, the frequency of emphasis for each
18 step setting occurring at a higher frequency than a prior
19 step setting and each step setting having a different
20 magnitude of gain change, for each step setting the
21 magnitude of gain change is greater than a prior step
22 setting. By changing the value setting of digital
23 potentiometer A2, a variety of frequency response shapes
24 are obtained, as illustrated in FIG. 15.

1 Referring again to FIG. 6, it can be seen that the
2 output from operational amplifier X2 is supplied through a
3 DC blocking capacitor C2 to an external load represented by
4 a fixed resistor R2. As will be understood by those
5 skilled in the art, the external load can be virtually any
6 type of sound producing device including speakers, small
7 speakers, earpieces, etc. or it can include subsequent
8 amplifier stages. Operation occurs when a low voltage
9 signal is applied at the input V2 of sound system 20. The
10 subwoofer synthesis signal conditioning circuitry controls
11 the filtering and contouring of the applied frequencies to
12 provide intensified low frequency signal content and
13 increase the corresponding output magnitude. In the
14 preferred embodiment, high frequency signal shaping and
15 conditioning circuitry is also included to control the
16 filtering and contouring of the applied frequencies and
17 provide intensified high frequency signal content and
18 increase the corresponding output magnitude.

19

20 Turning to FIGS. 16 and 17, top plan and side
21 elevation views, respectively, are illustrated of the
22 preferred embodiment of sound system 20, illustrating the
23 approximate physical size thereof. It will be understood
24 that the sizes are strictly for example and different sizes

1 and numbers of components will result in different sizes
2 and shapes. In this example, the length (designated L) is
3 approximately 1.65 inches, the width (designated W) is
4 approximately 1.22 inches, and the height (designated H) is
5 approximately 0.200 inches. The example is provided to
6 indicate the relatively small size that can be achieved and
7 further accentuates the difference between the present
8 invention and prior art subwoofer systems.

9

10 Thus, a new and improved dynamic contoured-
11 sound/subwoofer-synthesis system has been disclosed that
12 substantially compensates for the natural inadequacy of the
13 human ear at either or both the low frequencies and the
14 high frequencies. The dynamic contoured-sound/subwoofer-
15 synthesis system includes a new and improved subwoofer
16 sound synthesizer and preferably includes high frequency
17 signal shaping and conditioning circuitry that
18 substantially compensates for the roll-off effects of
19 standard speakers and other sound producing devices at the
20 low end and at the high end. Further a new and improved
21 dynamic contoured-sound/subwoofer-synthesis system has been
22 disclosed that is capable of being used with substantially
23 any sound producing devices, including speakers, small
24 speakers, earpieces, etc. The dynamic contoured-

1 sound/subwoofer-synthesis system produces extreme deep low
2 frequency sound (i.e. subwoofer) from all speaker and
3 earpiece types and does so without inducing noticeable
4 sound aberrations or adversely affecting/diminishing higher
5 frequency sounds. The dynamic contoured-sound/subwoofer-
6 synthesis system replaces the need for a separate subwoofer
7 speaker and associated amplification systems. Also, the
8 dynamic contoured sound system tailors audio intensity to
9 compensate for non-linearity of the human auditory system,
10 producing a balanced frequency-loudness listening
11 experience. Further, the preferred embodiment provides
12 1024 (or more) unique loudness compensation shapes or
13 contours to match the hearing needs of various listeners
14 and for non-ideal characteristics of sound reproduction
15 systems.

16

17 Various changes and modifications to the embodiment
18 herein chosen for purposes of illustration will readily
19 occur to those skilled in the art. To the extent that such
20 modifications and variations do not depart from the spirit
21 of the invention, they are intended to be included within
22 the scope of the invention which is assessed only by a fair
23 interpretation of the following claims.

1 DYNAMIC CONTOURED-SOUND/SUBWOOFER-SYNTHESIS AUDIO SYSTEM

2

3

4 What is claimed is:

5

6 1. A dynamic contoured-sound/subwoofer-synthesis
7 system comprising:

8

9 an input terminal designed to receive an audio
10 signal and an output terminal designed to supply an
11 output signal to an external load;

12

13 an adjustable high pass filter coupled to the
14 input terminal and including an adjustable component,
15 the high pass filter being designed to provide a
16 variety of frequency response shapes in response to
17 adjustments of the adjustable component; and

18

19 a primary amplifier coupled to receive a
20 frequency response shape of the variety of frequency
21 response shapes from the adjustable high pass filter,
22 the primary amplifier including a plurality of
23 feedback components designed and connected to produce
24 low frequency signal gain and shaping, the primary

1 amplifier providing low frequency signal gain and
2 shaping of the received frequency response shape to
3 the output terminal.
4
5

6 2. A dynamic contoured-sound/subwoofer-synthesis
7 system as claimed in claim 1 wherein the adjustable high
8 pass filter includes an isolation resistor, a multi-step
9 digital potentiometer, and a divider resistor connected to
10 the input terminal to form a voltage divider, a junction
11 between the isolation resistor and the multi-step digital
12 potentiometer providing the variety of frequency response
13 shapes.
14
15

16 3. A dynamic contoured-sound/subwoofer-synthesis
17 system as claimed in claim 2 wherein the adjustable high
18 pass filter further includes a filter input capacitor, the
19 filter input capacitor in circuit with the multi-step
20 digital potentiometer and the divider resistor forming a
21 high pass filter.
22
23

1 4. A dynamic contoured-sound/subwoofer-synthesis
2 system as claimed in claim 1 wherein the primary amplifier
3 includes a main operational amplifier having an inverting
4 input, a non-inverting input, and a signal output, the
5 inverting input being coupled to the adjustable high pass
6 filter through a series connected input capacitor and input
7 resistor to receive the frequency response shape of the
8 variety of frequency response shapes, the input capacitor
9 and input resistor forming a band pass filter connected to
10 set a bandwidth of frequencies passed from the adjustable
11 high pass filter to the main operational amplifier.

12
13
14 5. A dynamic contoured-sound/subwoofer-synthesis
15 system as claimed in claim 4 wherein at least one feedback
16 component of the plurality of feedback components of the
17 primary amplifier includes a first feedback resistor
18 coupled between the signal output and the inverting input
19 of the main operational amplifier.

20
21
22 6. A dynamic contoured-sound/subwoofer-synthesis
23 system as claimed in claim 5 wherein the plurality of
24 feedback components further includes a second feedback

1 resistor and a feedback capacitor, the input resistor, the
2 first feedback resistor, the second feedback resistor, and
3 the feedback capacitor being connected to form a high pass
4 filter connected to set the voltage gain of the main
5 operational amplifier.

6

7

8 7. A dynamic contoured-sound/subwoofer-synthesis
9 system as claimed in claim 4 further including a high
10 frequency signal shaping circuit coupled between the signal
11 output and the inverting input of the main operational
12 amplifier.

13

14

15 8. A dynamic contoured-sound/subwoofer-synthesis
16 system as claimed in claim 7 wherein the plurality of
17 feedback components further includes a second feedback
18 resistor and a feedback capacitor and the high frequency
19 signal shaping circuit is coupled to the inverting input of
20 the main operational amplifier through the second feedback
21 resistor and the feedback capacitor.

22

23

1 9. A dynamic contoured-sound/subwoofer-synthesis
2 system as claimed in claim 8 wherein the high frequency
3 signal shaping circuit includes a feedback operational
4 amplifier having an inverting input, a non-inverting input,
5 and a signal output.

6
7
8 10. A dynamic contoured-sound/subwoofer-synthesis
9 system as claimed in claim 9 wherein the inverting input of
10 the feedback operational amplifier is coupled to the signal
11 output of the main operational amplifier through a first
12 differential gain resistor, and the non-inverting input of
13 the feedback operational amplifier is coupled to the signal
14 output of the main operational amplifier through a second
15 differential gain resistor with a resistance value
16 different than a resistance value of the first differential
17 gain resistor.

18
19
20 11. A dynamic contoured-sound/subwoofer-synthesis
21 system as claimed in claim 10 wherein the plurality of
22 feedback components further includes a second feedback
23 resistor and a feedback capacitor, the signal output of the
24 feedback operational amplifier being coupled to the

1 inverting input of the main operational amplifier through a
2 series connection of the second feedback resistor and a
3 feedback capacitor.
4
5

6 12. A dynamic contoured-sound/subwoofer-synthesis
7 system as claimed in claim 11 further including a high
8 frequency shaping capacitor coupled in parallel with the
9 second feedback resistor.
10

11 13. A dynamic contoured-sound/subwoofer-synthesis
12 system as claimed in claim 12 further including a
13 differential gain capacitor coupled to the non-inverting
14 input of the feedback operational amplifier.
15
16

17 14. A dynamic contoured-sound/subwoofer-synthesis
18 system as claimed in claim 13 further including a multi
19 step digital potentiometer and an isolation/divider
20 resistor connected in series to the differential gain
21 capacitor, the multi step digital potentiometer and the
22 isolation/divider resistor being connected to provide a
23 different high frequency response shape at the output

1 terminal in response to changes of steps in the multi step
2 digital potentiometer.

3

4

5 15. A dynamic contoured-sound/subwoofer-synthesis
6 system comprising:

7

8 an input terminal designed to receive an audio
9 signal and an output terminal designed to supply an
10 output signal to an external load;

11

12 an adjustable high pass filter coupled to the
13 input terminal and including an isolation resistor, a
14 multi-step digital potentiometer, and a divider
15 resistor connected to the input terminal to form a
16 voltage divider, the adjustable high pass filter
17 further including a filter input capacitor coupled in
18 circuit with the multi-step digital potentiometer and
19 the divider resistor to form a high pass filter, the
20 high pass filter being designed to provide a variety
21 of frequency response shapes in response to
22 adjustments of the adjustable component;

23

1 a primary amplifier coupled to receive a
2 frequency response shape of the variety of frequency
3 response shapes from the adjustable high pass filter,
4 the primary amplifier including a main operational
5 amplifier having an inverting input, a non-inverting
6 input, and a signal output, the inverting input being
7 coupled to the adjustable high pass filter through a
8 series connected input capacitor and input resistor to
9 receive the frequency response shape of the variety of
10 frequency response shapes, the input capacitor and
11 input resistor forming a band pass filter connected to
12 set a bandwidth of frequencies passed from the
13 adjustable high pass filter to the main operational
14 amplifier; and

15
16 the primary amplifier further including a first
17 feedback resistor coupled between the signal output
18 and the inverting input of the main operational
19 amplifier, and a second feedback resistor and a
20 feedback capacitor, the input resistor, the first
21 feedback resistor, the second feedback resistor, and
22 the feedback capacitor being connected to form a high
23 pass filter connected to set the voltage gain of the
24 main operational amplifier.

1

2

3 16. A dynamic contoured-sound/subwoofer-synthesis
4 system as claimed in claim 15 further including a high
5 frequency signal shaping circuit coupled between the signal
6 output and the inverting input of the main operational
7 amplifier.

8

9

10 17. A dynamic contoured-sound/subwoofer-synthesis
11 system as claimed in claim 16 further including a second
12 feedback resistor and a feedback capacitor and the high
13 frequency signal shaping circuit is coupled to the
14 inverting input of the main operational amplifier through
15 the second feedback resistor and the feedback capacitor.

16

17

18 18. A dynamic contoured-sound/subwoofer-synthesis
19 system as claimed in claim 17 wherein the high frequency
20 signal shaping circuit includes a feedback operational
21 amplifier having an inverting input, a non-inverting input,
22 and a signal output.

23

24

1 19. A dynamic contoured-sound/subwoofer-synthesis
2 system as claimed in claim 18 wherein the inverting input
3 of the feedback operational amplifier is coupled to the
4 signal output of the main operational amplifier through a
5 first differential gain resistor, and the non-inverting
6 input of the feedback operational amplifier is coupled to
7 the signal output of the main operational amplifier through
8 a second differential gain resistor with a resistance value
9 different than a resistance value of the first differential
10 gain resistor.

11
12
13 20. A dynamic contoured-sound/subwoofer-synthesis
14 system as claimed in claim 19 wherein the plurality of
15 feedback components further includes a second feedback
16 resistor and a feedback capacitor, the signal output of the
17 feedback operational amplifier being coupled to the
18 inverting input of the main operational amplifier through a
19 series connection of the second feedback resistor and the
20 feedback capacitor.

21
22
23 21. A dynamic contoured-sound/subwoofer-synthesis
24 system as claimed in claim 20 further including a high

1 frequency shaping capacitor coupled in parallel with the
2 second feedback resistor.

3

4

5 22. A dynamic contoured-sound/subwoofer-synthesis
6 system as claimed in claim 21 further including a
7 differential gain capacitor coupled to the non-inverting
8 input of the feedback operational amplifier.

9

10

11 23. A dynamic contoured-sound/subwoofer-synthesis
12 system as claimed in claim 22 further including a multi
13 step digital potentiometer and an isolation/divider
14 resistor connected in series to the differential gain
15 capacitor, the multi step digital potentiometer and the
16 isolation/divider resistor being connected to provide a
17 different high frequency response shape at the output
18 terminal in response to changes of steps in the multi step
19 digital potentiometer.

20

21 24. A dynamic contoured-sound/subwoofer-synthesis
22 system comprising:

23

1 an input terminal designed to receive an audio
2 signal and an output terminal designed to supply an
3 output signal to an external load;

4
5 an adjustable high pass filter coupled to the
6 input terminal and including an adjustable component,
7 the high pass filter being designed to provide a
8 variety of frequency response shapes in response to
9 adjustments of the adjustable component;

10
11 a primary amplifier coupled to receive a
12 frequency response shape of the variety of frequency
13 response shapes from the adjustable high pass filter,
14 the primary amplifier including a main operational
15 amplifier having an inverting input, a non-inverting
16 input, and a signal output, the inverting input being
17 coupled to the adjustable high pass filter through a
18 series connected input capacitor and input resistor to
19 receive the frequency response shape of the variety of
20 frequency response shapes, the primary amplifier
21 further including a first feedback resistor coupled
22 between the signal output and the inverting input of
23 the main operational amplifier, the primary amplifier
24 providing low frequency signal gain and shaping of the

1 received frequency response shape to the output
2 terminal; and

3
4 a high frequency signal shaping circuit including
5 a feedback operational amplifier having an inverting
6 input, a non-inverting input, and a signal output, the
7 high frequency signal shaping circuit including a
8 second feedback resistor and a feedback capacitor, the
9 signal output of the feedback operational amplifier
10 being coupled to the inverting input of the main
11 operational amplifier through the second feedback
12 resistor and the feedback capacitor, the inverting
13 input of the feedback operational amplifier being
14 coupled to the signal output of the main operational
15 amplifier through a first differential gain resistor,
16 and the non-inverting input of the feedback
17 operational amplifier being coupled to the signal
18 output of the main operational amplifier through a
19 second differential gain resistor with a resistance
20 value different than a resistance value of the first
21 differential gain resistor.

22
23 25. A dynamic contoured-sound/subwoofer-synthesis
24 system as claimed in claim 24 further including a high

1 frequency shaping capacitor coupled in parallel with the
2 second feedback resistor.

3

4

5 26. A dynamic contoured-sound/subwoofer-synthesis
6 system as claimed in claim 25 further including a
7 differential gain capacitor coupled to the non-inverting
8 input of the feedback operational amplifier.

9

10

11 27. A dynamic contoured-sound/subwoofer-synthesis
12 system as claimed in claim 26 further including a multi
13 step digital potentiometer and an isolation/divider
14 resistor connected in series to the differential gain
15 capacitor, the multi step digital potentiometer and the
16 isolation/divider resistor being connected to provide a
17 different high frequency response shape at the output
18 terminal in response to changes of steps in the multi step
19 digital potentiometer.

20

21

22 28. A method of synthesizing subwoofer sound in a
23 sound producing device comprising the steps of:

24

1 providing an adjustable high pass filter having a
2 plurality of step settings and constructed with each
3 setting having a different frequency of emphasis and
4 the frequency of emphasis for each setting occurring
5 at a lower frequency than a prior setting, and each
6 setting having a different magnitude of gain change,
7 for each setting the magnitude of gain change is
8 greater than a prior setting;

9
10 applying audio signals to the adjustable high
11 pass filter for controlling the amount of subwoofer
12 synthesis of the audio signals, each step setting
13 providing a different frequency response shape, and
14 selecting a step setting of the high pass filter to
15 provide a preferred frequency response shape of the
16 different frequency response shapes; and

17
18 receiving the preferred frequency response shape
19 of the different frequency response shapes from the
20 adjustable high pass filter and amplifying the
21 preferred frequency response shape to provide low
22 frequency signal gain and shaping of the preferred
23 frequency response shape.

24

1

2

29. A method as claimed in claim 28 including the steps of high frequency signal shaping the preferred frequency response shape during the amplifying step to compensate for non-linearity of the human auditory system at both the auditory low frequencies and high frequencies.

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31. A method of contouring sound in a sound producing device comprising the steps of:

providing a primary amplifier;

1

2 providing an adjustable simulated inductor having a
3 plurality of step settings and constructed with each step
4 setting of the plurality of step settings having a
5 different frequency of emphasis and the frequency of
6 emphasis for each step setting occurring at a higher
7 frequency than a prior step setting and each step setting
8 having a different magnitude of gain change, for each step
9 setting the magnitude of gain change is greater than a
10 prior step setting;

11

12 applying audio signals from the output of the primary
13 amplifier to the adjustable simulated inductor for
14 controlling the amount of high frequency contoured sound of
15 the audio signals, each step setting of the plurality of
16 step settings providing a different frequency response
17 shape; and

18

19 selecting a step setting of the simulated inductor to
20 provide a preferred frequency response shape of the
21 different frequency response shapes.

22

23

1 32. A method as claimed in claim 31 further including
2 a step of receiving the preferred frequency response shape
3 of the different frequency response shapes, amplifying the
4 preferred frequency response shape, and applying the
5 amplified preferred frequency response shape to an input of
6 the primary amplifier to provide high frequency signal gain
7 and shaping of the preferred frequency response shape.

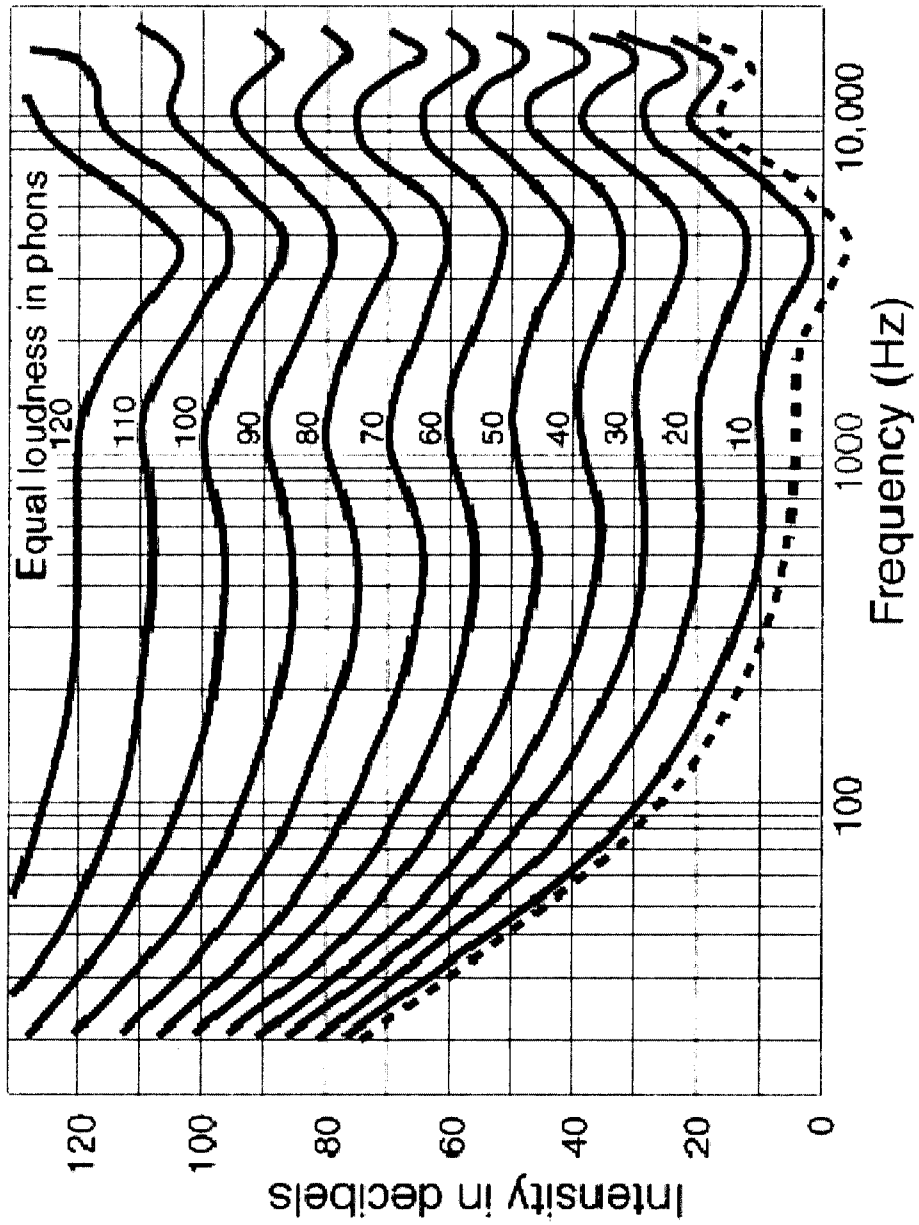


FIG. 1

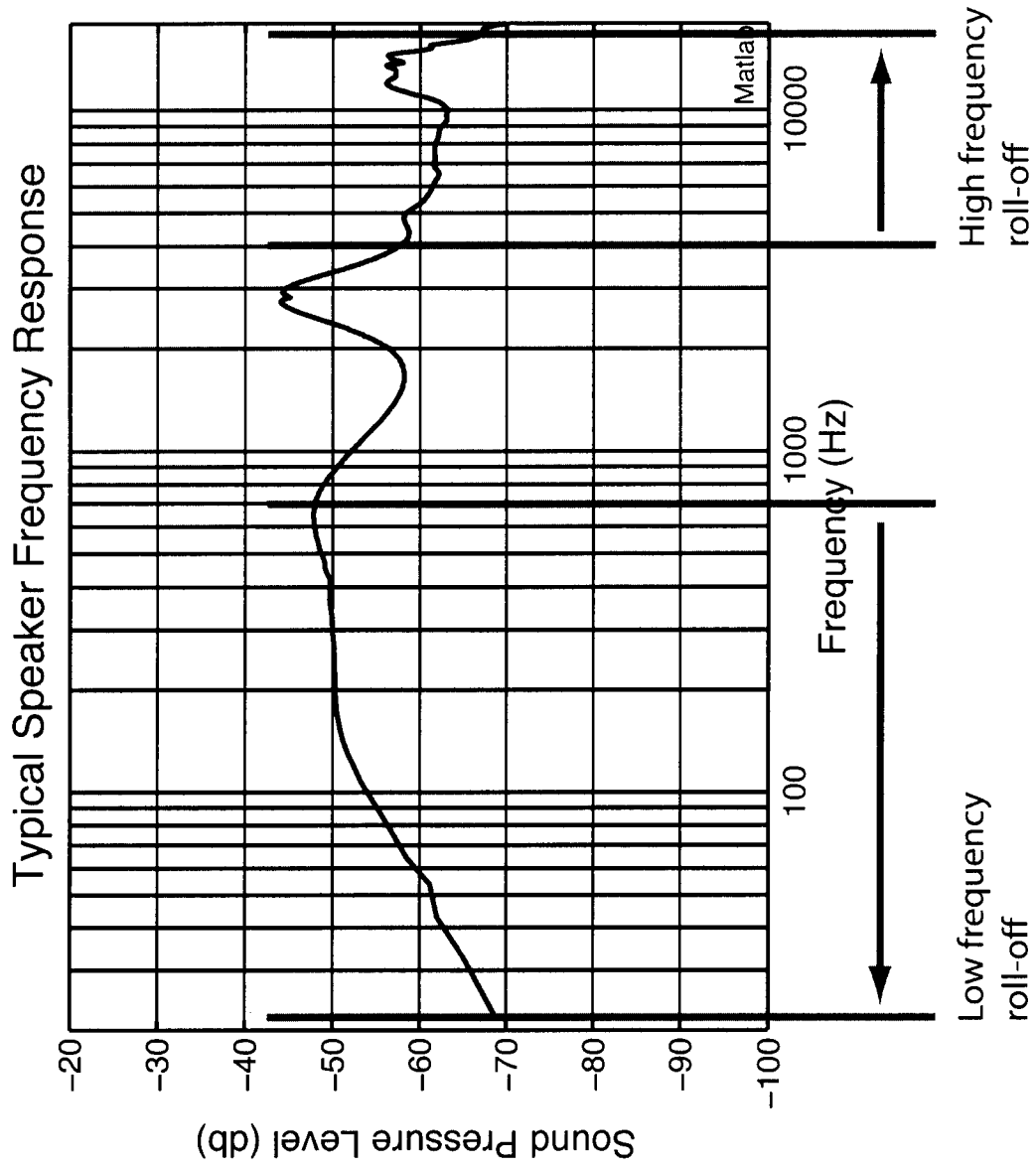


FIG. 2

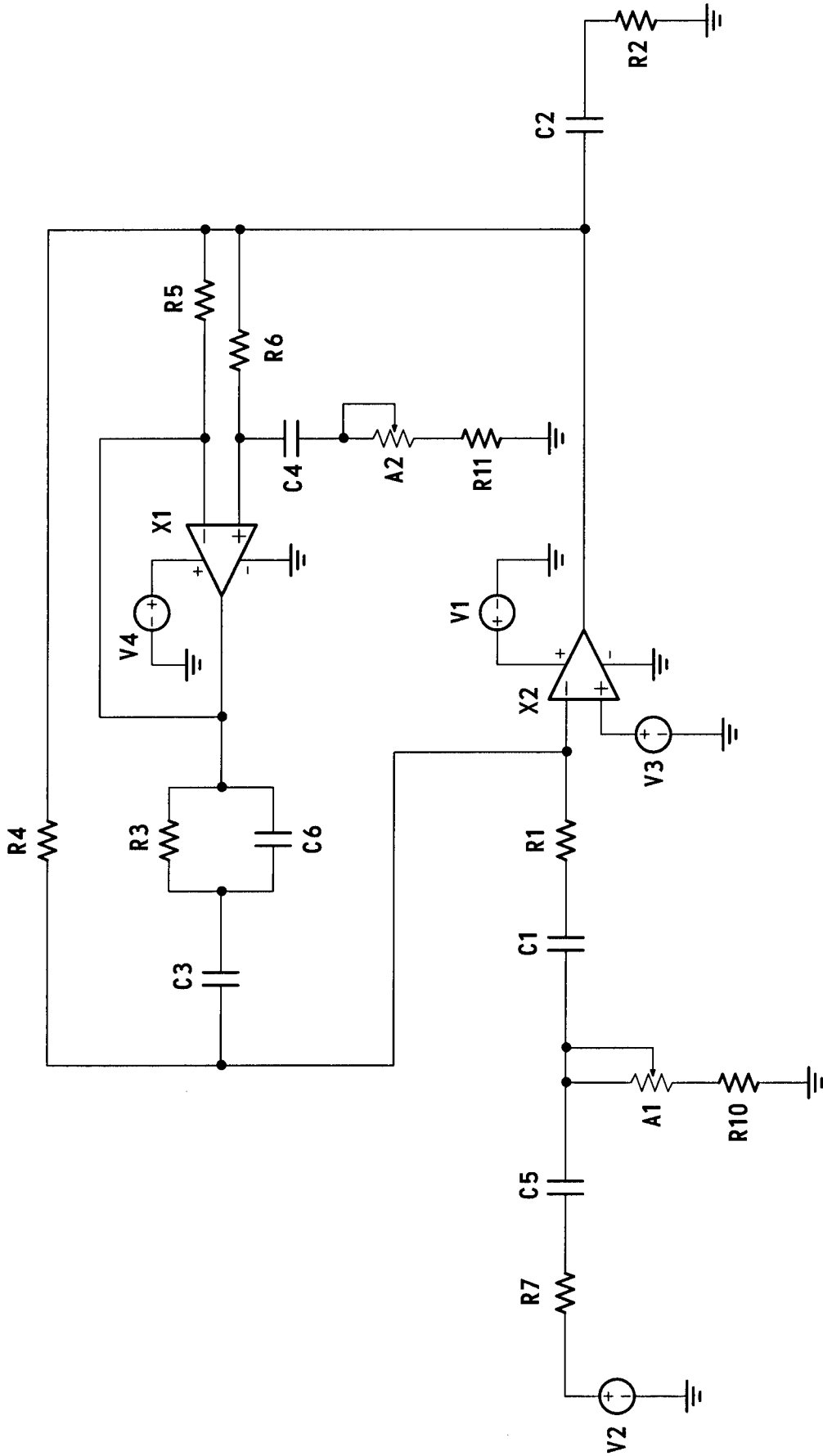


FIG. 3



FIG. 4

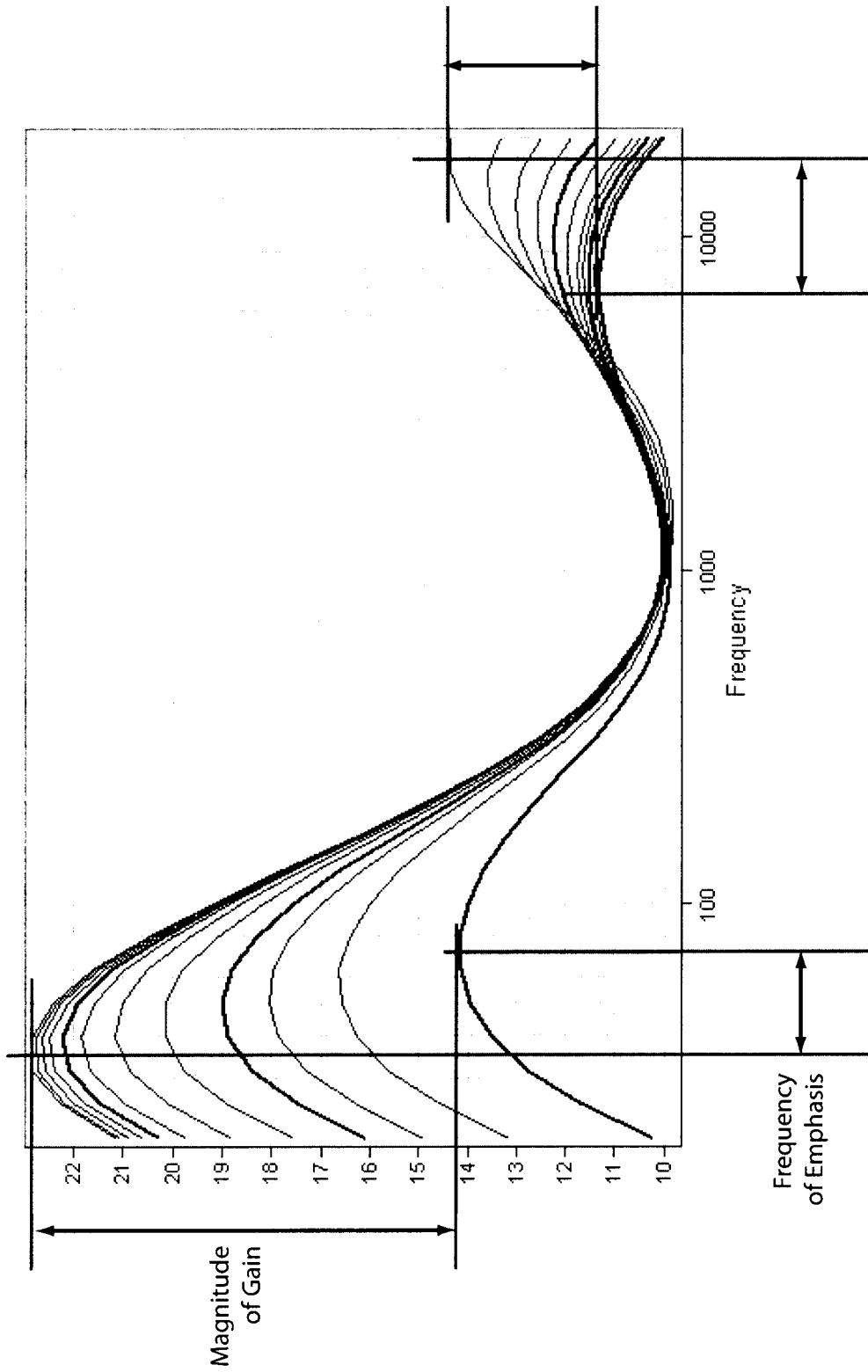


FIG. 5

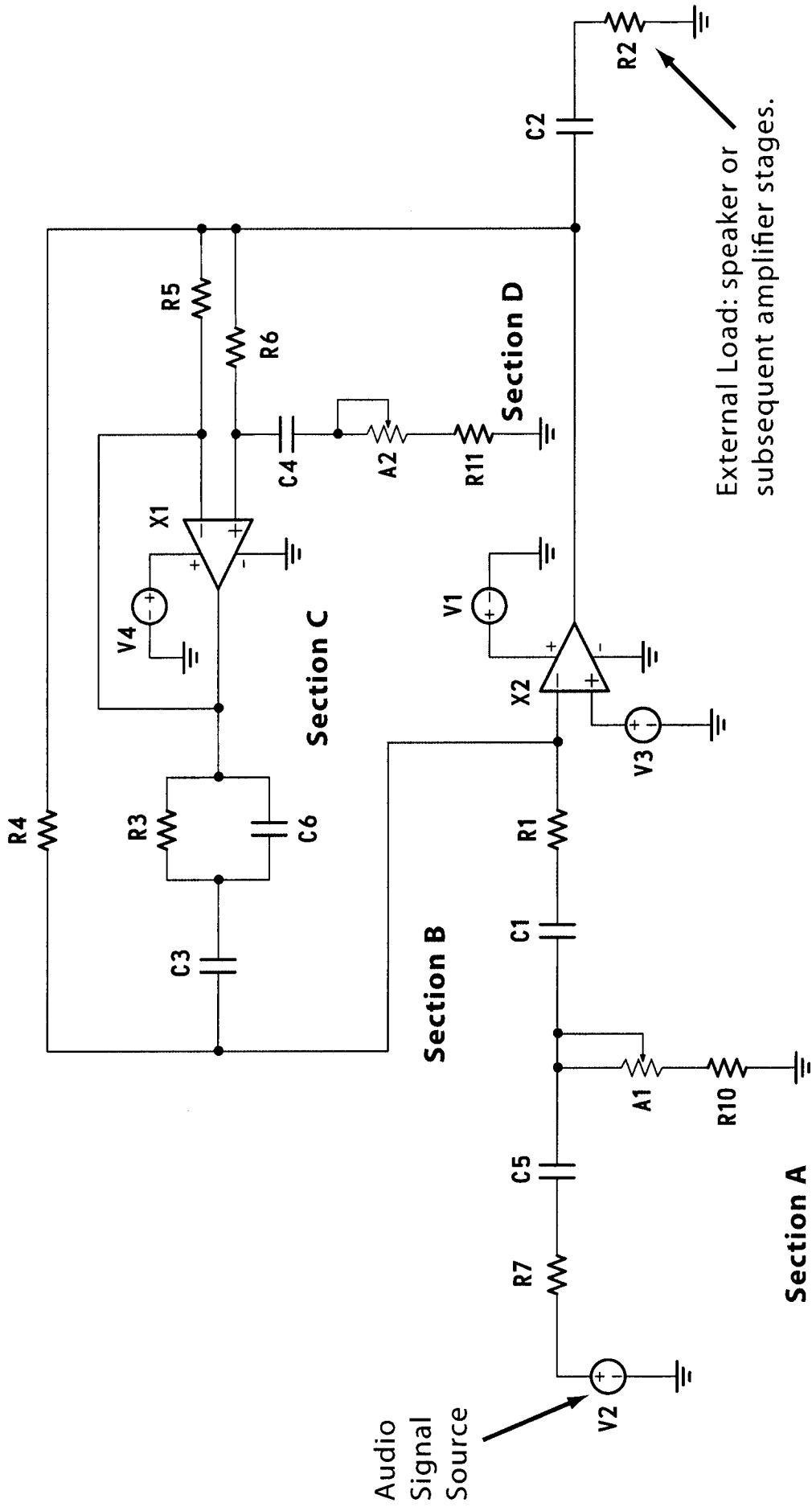


FIG. 6

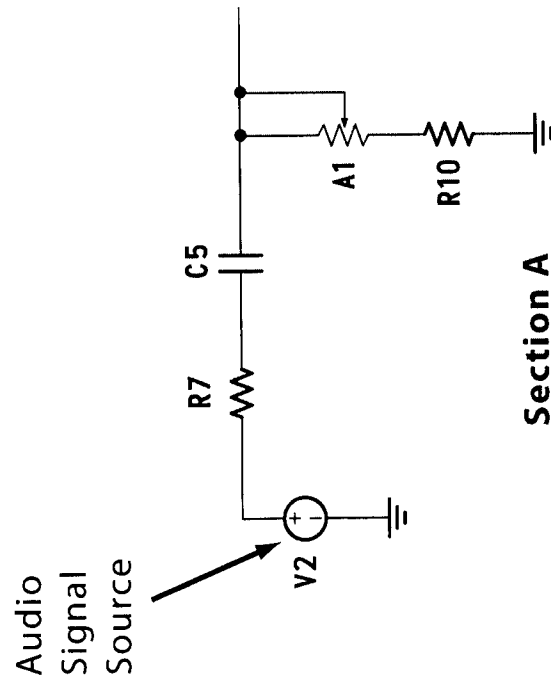


FIG. 7

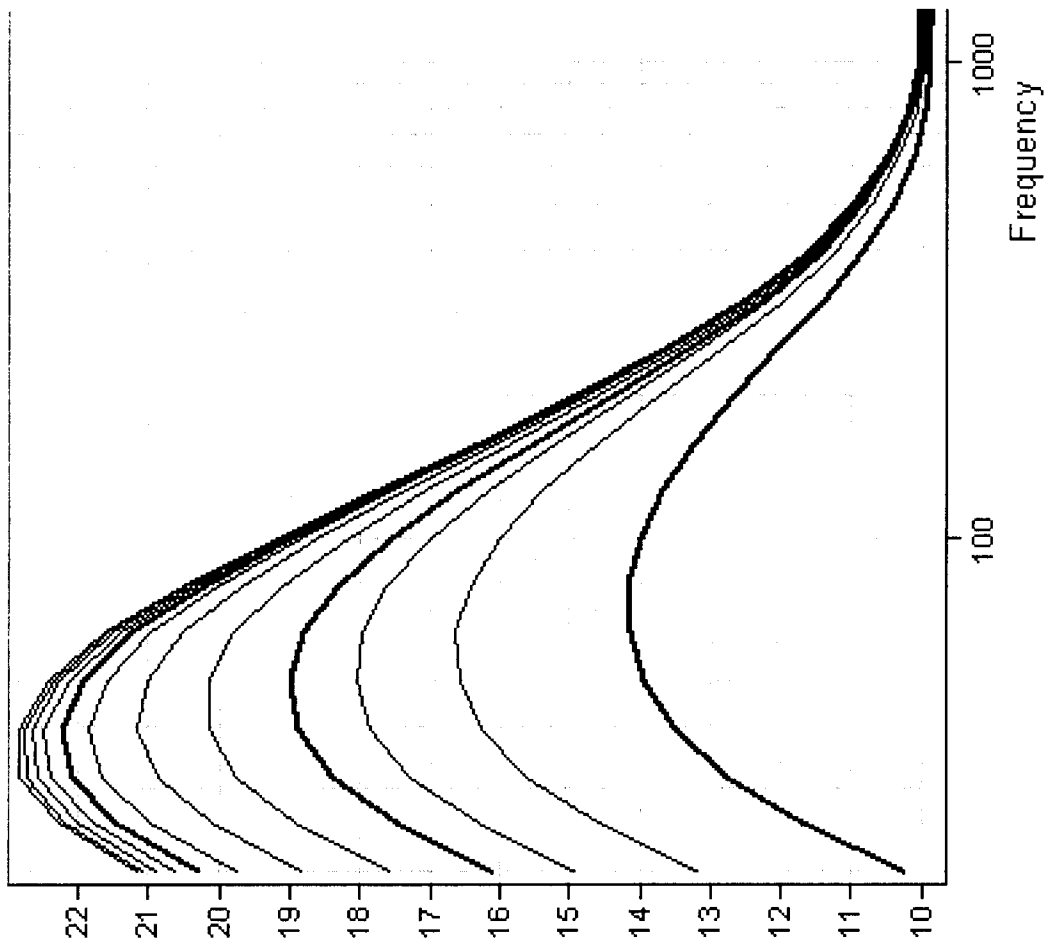


FIG. 8

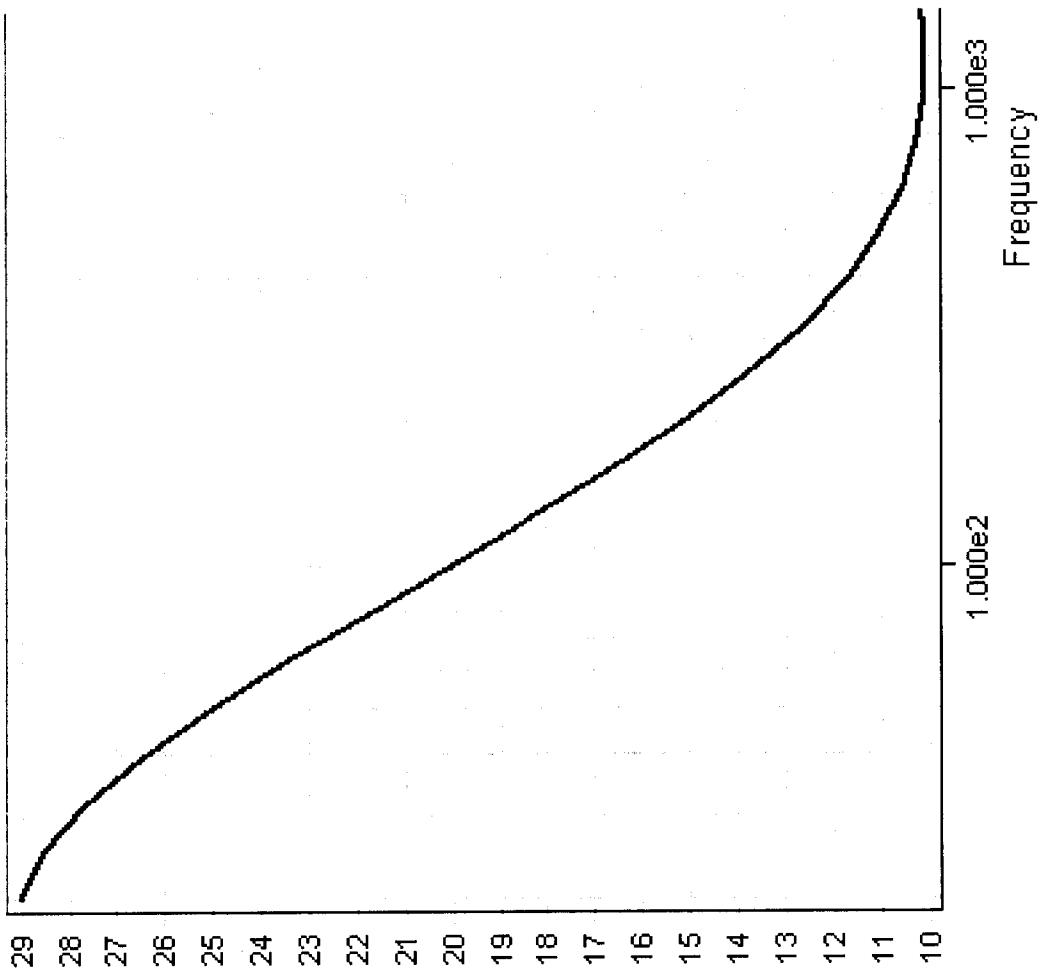


FIG. 9

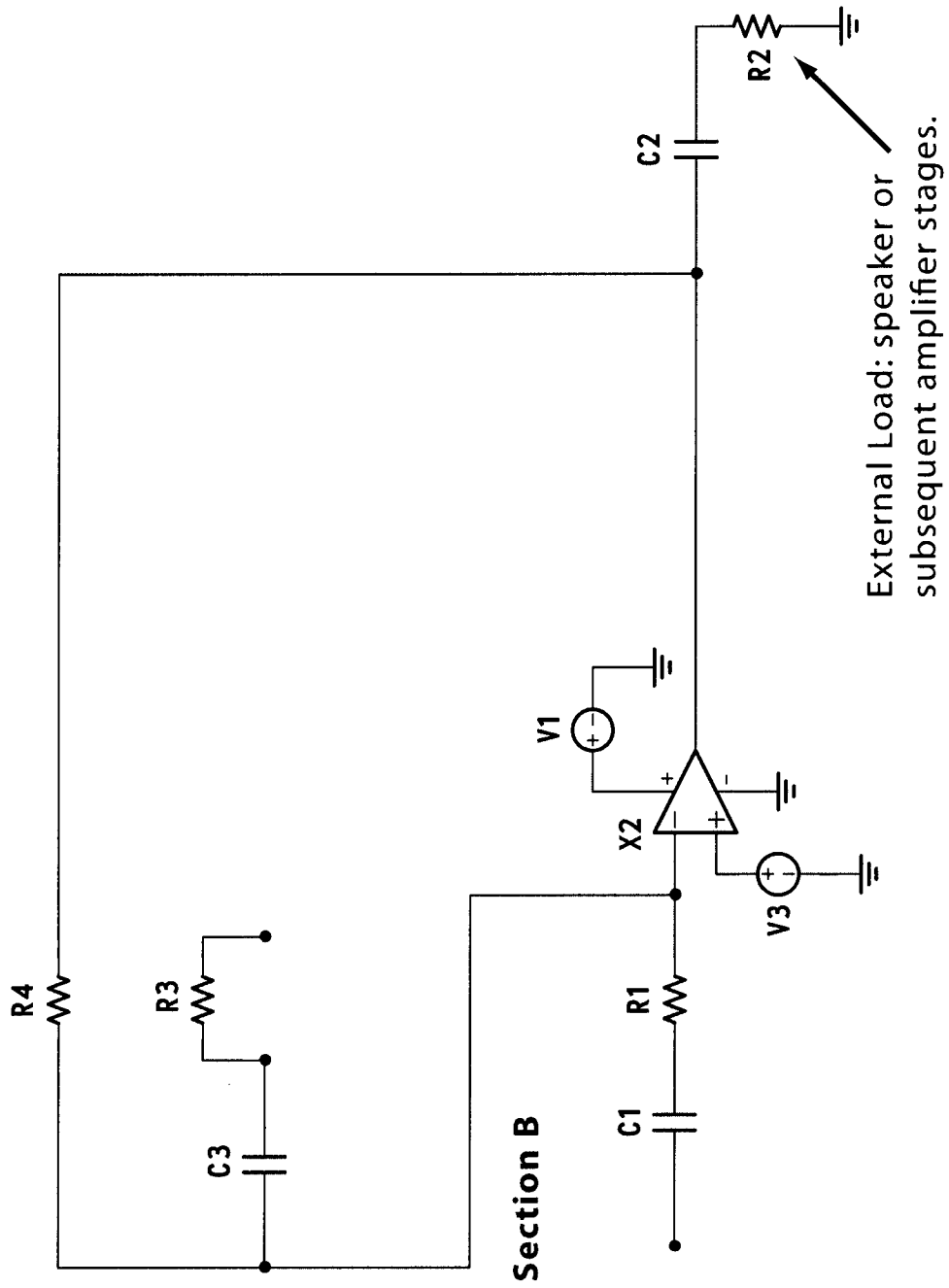


FIG. 10

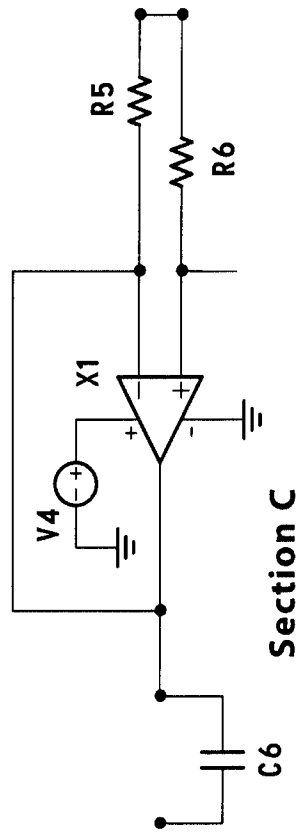


FIG. 11

FIG. 12

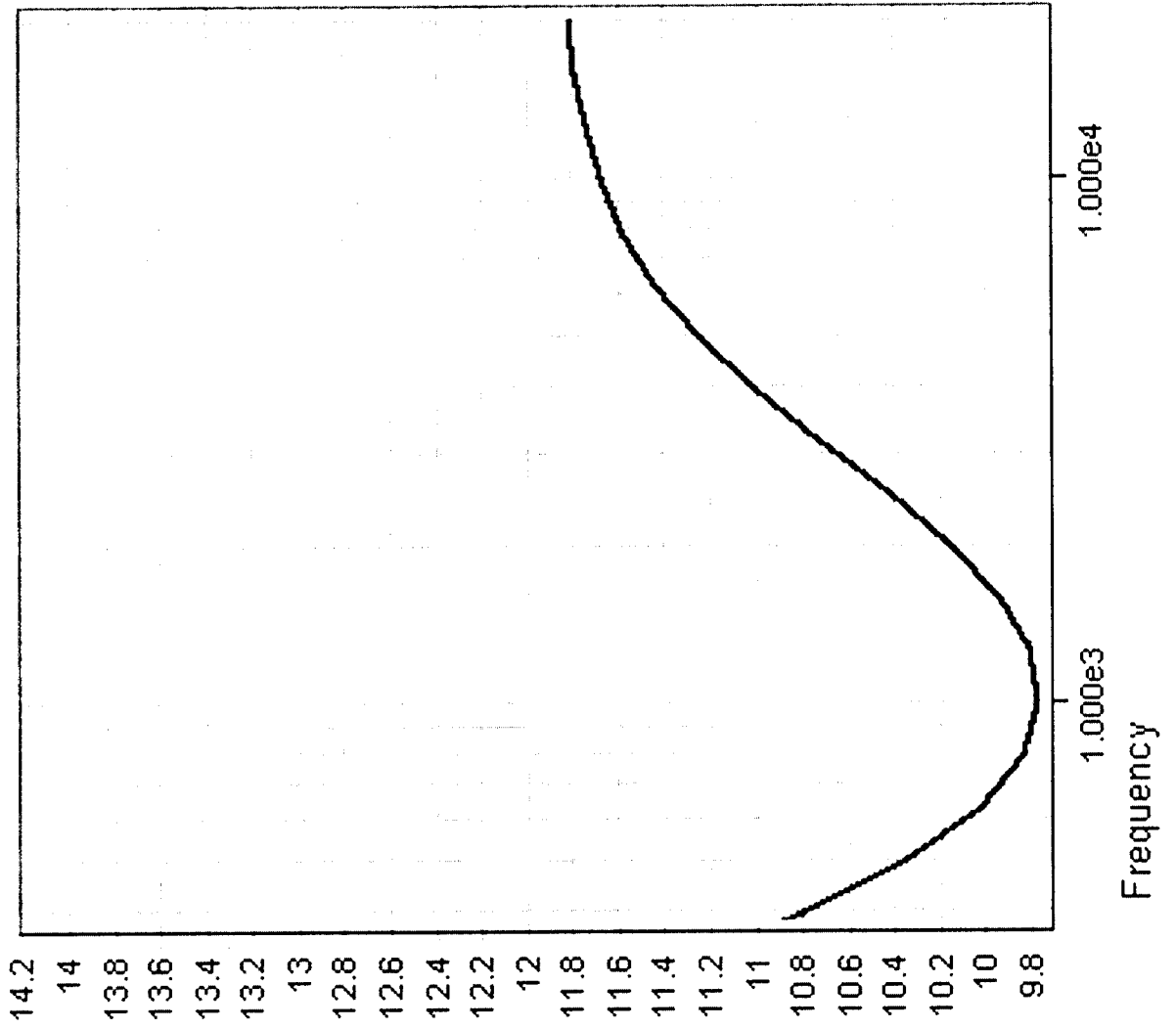


FIG. 13

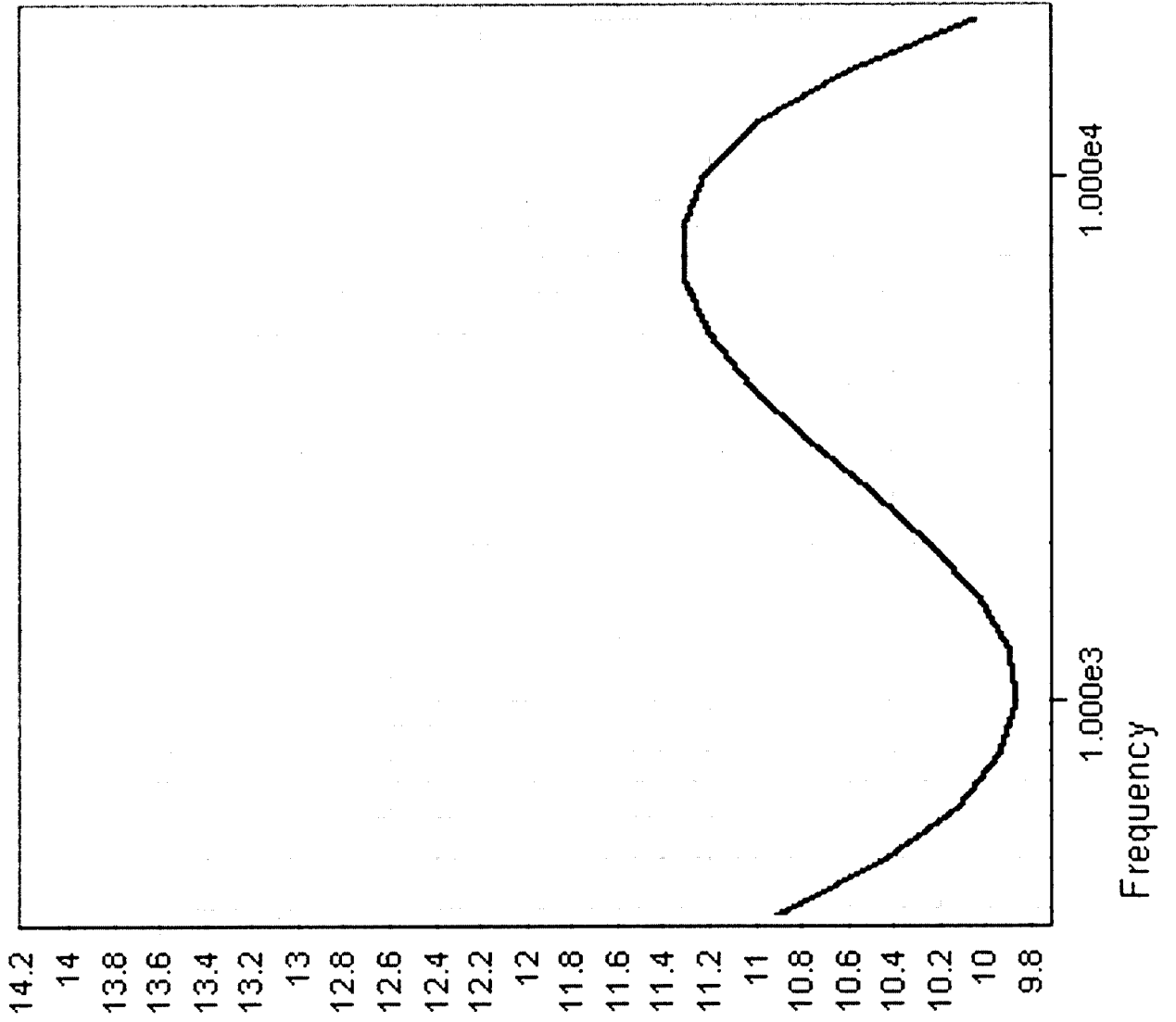


FIG. 14

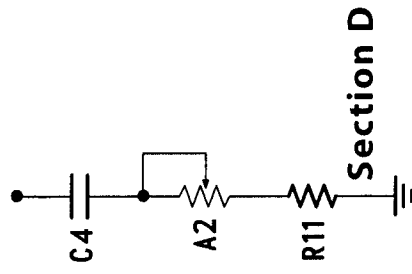
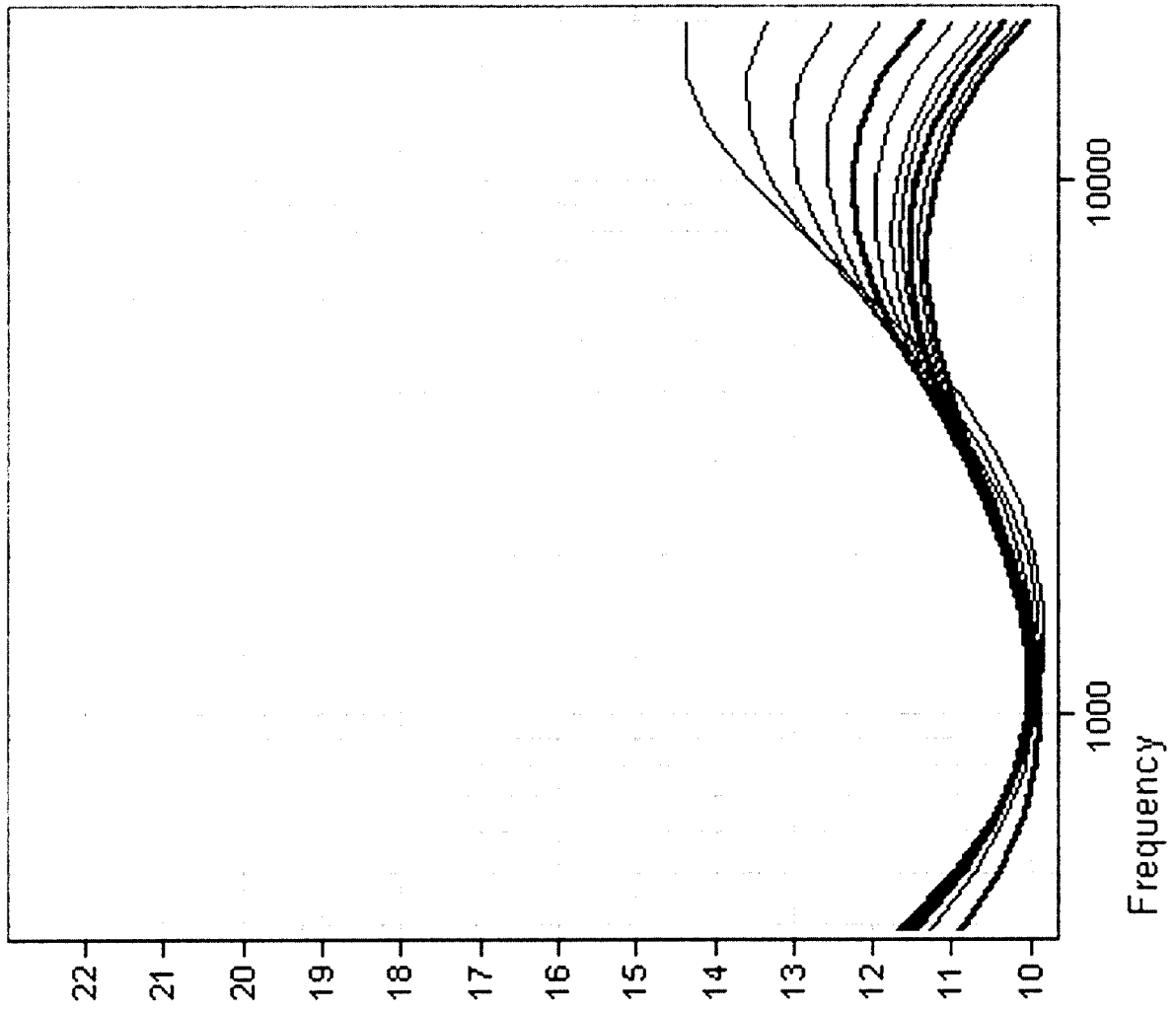


FIG. 15



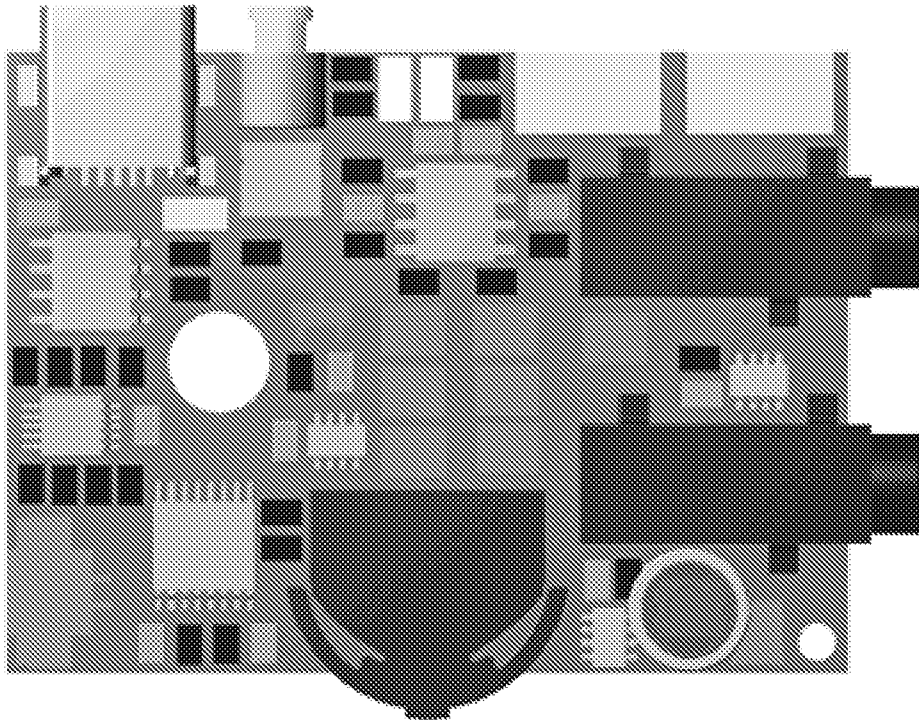


FIG. 16

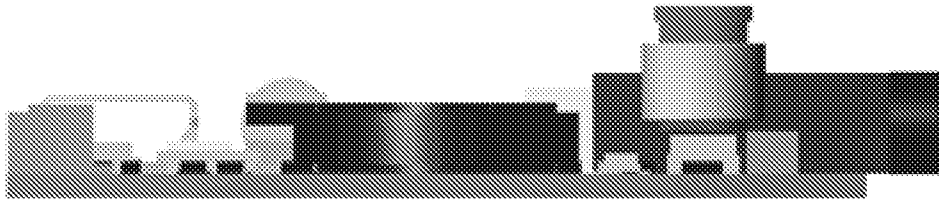


FIG. 17