

1 PHASE CORRECTING CANALPHONE SYSTEM AND METHOD

2 CROSS-REFERENCE TO RELATED APPLICATIONS

3 **[0001]** This application is a continuation-in-part of
4 copending U.S. Patent Application No. 13/315,610, filed 9
5 December 2011 (Agent Docket No. JH02), and this application
6 also claims the benefit of copending U.S. Provisional
7 Application No. 61/683,614, filed 15 August 2012 (Agent
8 Docket No. JH05(P)). The present application and both
9 applications identified above include identical
10 inventorship and ownership.

11 BACKGROUND

12 **[0002]** The embodiments relate to the field of
13 canalphones and/or similar listening devices.

14 Description of Background

15 **[0003]** There are many different types of personal
16 listening devices such as headphones, earbuds, canalphones,
17 and/or the like. Headphones are personal listening devices
18 that are held in close proximity to the ear by some
19 support system. Earbuds are small personal listening
20 devices that are positioned directly in front of the ear
21 canal and are substantially smaller than a person's outer
22 ear. Similarly, canalphones are personal listening devices
23 that are substantially smaller than a person's outer ear,
24 but they differ from earbuds in that they are placed
25 directly in one end of the ear canal. Both earbuds and

1 canalphones are held in positioned by friction between the
2 ear and the device rather than the support system found in
3 most headphones. Canalphones may also be held in place by
4 retainers that engage a portion of the listener's head.

5 **[0004]** Canalphones are also referred to as in-ear
6 monitors due to how the canalphone is worn by a listener.
7 In other words, a canalphone housing is worn in the ear of
8 the user and not over and/or around the ear of the user.
9 Some canalphones also serve as earplugs due to the way the
10 canalphone limits noise external to the canalphone from
11 entering the ear canal.

12 SUMMARY

13 **[0005]** According to one embodiment, a canalphone system
14 may include a high frequency sound bore carried within a
15 canalphone. The system may also include a low frequency
16 sound bore carried within the canalphone that is adjacent
17 to the high frequency sound bore to form a single unit
18 prior to the sound bores being introduced to the
19 canalphone, the low frequency sound bore and the high
20 frequency sound bore being sized so that the low frequency
21 sound bore and the high frequency sound bore each deliver
22 sound with correct time and phase. The system may further
23 include a high acoustical driver carried within the
24 canalphone where the high acoustical driver delivers sound
25 through the high frequency sound bore. The system may
26 additionally include a low acoustical driver carried within

1 the canalphone where the low acoustical driver delivers
2 sound through the low frequency sound bore.

3 **[0006]** The low acoustical driver may comprise two low
4 acoustical drivers. The high acoustical driver may comprise
5 two high acoustical drivers.

6 **[0007]** The low frequency sound bore and/or the high
7 frequency sound bore may carry an acoustical damper. The
8 acoustical damper may be positioned without any rubber
9 boot.

10 **[0008]** The low frequency sound bore and/or the high
11 frequency sound bore may have extended lengths to reduce
12 each sound bore's diameter. The high frequency sound bore's
13 extended length may be greater than 3 millimeters.

14 **[0009]** The single unit may aid in the assembly of the
15 canalphone. The single unit may be positioned at an angle
16 between 30 degrees and 65 degrees with respect to the high
17 acoustical driver and the low acoustical driver. The system
18 may further include a resistor on the high acoustical
19 driver to tune the high acoustical driver.

20 **[0010]** In another embodiment, the system may include a
21 high frequency sound bore carried within a canalphone. The
22 system may also include a low frequency sound bore carried
23 within the canalphone that is adjacent to the high
24 frequency sound bore to form a single unit prior to the
25 sound bores being introduced to the canalphone, the low
26 frequency sound bore and the high frequency sound bore

1 being sized so that the low frequency sound bore and the
2 high frequency sound bore each deliver sound with correct
3 time and phase, and where the low frequency sound bore and
4 the high frequency sound bore have extended lengths to
5 reduce each sound bore's diameter. The system may further
6 include a high acoustical driver carried within the
7 canalphone where the high acoustical driver delivers sound
8 through the high frequency sound bore. The system may
9 additionally include a low acoustical driver carried within
10 the canalphone where the low acoustical driver delivers
11 sound through the low frequency sound bore, and the single
12 unit is positioned at an angle between 30 degrees and 65
13 degrees with respect to the high acoustical driver and the
14 low acoustical driver.

15 **[0011]** Another aspect of the embodiments is a method.
16 The method may include positioning a high acoustical driver
17 within a canalphone. The method may also include
18 positioning a low acoustical driver within the canalphone
19 adjacent to the high acoustical driver. The method may
20 further include positioning a single unit comprising a low
21 frequency sound bore adjacent to a high frequency sound
22 bore within the canalphone where the low frequency sound
23 bore and the high frequency sound bore are sized so that
24 the low frequency sound bore and the high frequency sound
25 bore each deliver sound with correct time and phase, and

1 the single unit adjoins both the high acoustical driver and
2 low acoustical driver.

3 **[0012]** The method may additionally include inserting an
4 acoustical damper within at least one of the low frequency
5 sound bore and the high frequency sound bore. The method
6 may also include inserting the acoustical damper within the
7 sound bore without any rubber boot. The method may further
8 include reducing the low frequency sound bore's diameter
9 and the high frequency sound bore's diameter by extending
10 the lengths of each sound bore.

11 **[0013]** According to another embodiment, a canalphone
12 system may include a high audio driver carried by a
13 canalphone housing, and a low audio driver carried by the
14 canalphone housing adjacent to the high audio driver. The
15 system may also include an acoustical-timer to phase
16 correct a high audio signal from the high audio driver
17 directed to the outside of the canalphone housing with
18 delivery of a low audio signal from the low audio driver
19 directed to the outside of the canalphone housing.

20 **[0014]** The acoustical-timer further includes a low audio
21 sound-tube to carry a low audio signal from the low audio
22 driver to outside of the canalphone housing, and a high
23 audio sound-tube to carry a high audio signal from the high
24 audio driver to the outside of the canalphone housing, the
25 high audio sound-tube phase corrected with respect to the
26 low audio sound-tube by sizing it to be longer than the low

1 audio sound-tube. The low audio sound-tube may be sized
2 based upon its time response for the low audio signal to
3 pass through the low audio sound-tube.

4 **[0015]** The high audio sound-tube may be longer to slow
5 down the high audio signal's arrival to the outside of the
6 canalphone housing so that it is closer in time to the low
7 audio signal from the low audio driver arrival to the
8 outside of the canalphone housing. The arrival of the high
9 audio signal's to the outside of the canalphone housing is
10 less than .05 milliseconds difference than the low audio
11 signal from the low audio driver arrival to the outside of
12 the canalphone housing.

13 **[0016]** The system may additionally include a mid audio
14 driver carried by the canalphone housing adjacent to the
15 high audio driver, and a mid audio sound-tube to carry a
16 mid-audio signal from the mid audio driver to the outside
17 of the canalphone housing, the mid audio sound-tube phase
18 corrected by sizing it to be longer than the low audio
19 sound-tube and shorter than the high audio sound-tube. The
20 acoustical-timer may include a processor to phase correct a
21 high audio signal from the high audio driver to the outside
22 of the canalphone housing with delivery of a low audio
23 signal from the low audio driver to the outside of the
24 canalphone housing.

25 **[0017]** The processor may use digital signal processing
26 to control the high audio signal's arrival at the outside

1 of the canalphone housing to be closer in time to the low
2 audio signal from the low audio driver's arrival to the
3 outside of the canalphone housing. The arrival of the high
4 audio signal's to the outside of the canalphone housing is
5 less than .05 milliseconds difference than the low audio
6 signal from the low audio driver arrival to the outside of
7 the canalphone housing.

8 **[0018]** The acoustical-timer may use a time response for
9 the low audio signal to pass through the canalphone housing
10 as a control point to set all other audio signals' phase in
11 the system. The system may also include a mid audio driver
12 carried by the canalphone housing adjacent to the high
13 audio driver, the mid audio driver to provide a mid-audio
14 signal to the outside of the canalphone housing based upon
15 the low audio driver.

16 **[0019]** Another aspect of the embodiments is another
17 method. The method may include providing a high audio
18 driver carried by a canalphone housing, and a low audio
19 driver carried by the canalphone housing adjacent to the
20 high audio driver. The method may also include phase
21 correcting a high audio signal from the high audio driver
22 directed to the outside of the canalphone housing with
23 delivery of a low audio signal from the low audio driver
24 directed to the outside of the canalphone housing.

25 **[0020]** The method may further include carrying a low
26 audio signal from the low audio driver to outside of the

1 canalphone housing via a low audio sound-tube, and carrying
2 a high audio signal from the high audio driver to the
3 outside of the canalphone housing via a high audio sound-
4 tube phase corrected with respect to the low audio sound-
5 tube by sizing it to be longer than the low audio sound-
6 tube. The method may additionally include sizing the low
7 audio sound-tube based upon its time response for the low
8 audio signal to pass through the low audio sound-tube.

9 **[0021]** The method may also include selecting the low
10 audio sound-tube's size to be acoustically proper and as
11 short as can be readily fit into the canalphone housing.
12 The method may further include slowing down the high audio
13 signal's arrival to the outside of the canalphone housing
14 so that it is closer in time to the low audio signal from
15 the low audio driver arrival to the outside of the
16 canalphone housing by making the high audio sound-tube
17 longer.

18 **[0022]** The method may additionally include timing the
19 arrival of the high audio signal to the outside of the
20 canalphone housing compared to the low audio signal from
21 the low audio driver arrival to the outside of the
22 canalphone housing is within .05 milliseconds of each
23 other. The method may also include using digital signal
24 processing to phase correct a high audio signal from the
25 high audio driver directed to the outside of the canalphone
26 housing with delivery of a low audio signal from the low

1 audio driver directed to the outside of the canalphone
2 housing.

3 **[0023]** The method may further include timing the arrival
4 of the high audio signal to the outside of the canalphone
5 housing compared to the low audio signal from the low audio
6 driver arrival to the outside of the canalphone housing is
7 within .05 milliseconds of each other. The method may
8 additionally include using a time response for the low
9 audio signal to pass through the canalphone housing as a
10 control point to set all other audio signals' phase in the
11 system.

12 **[0024]** The method may also include standardizing high
13 audio sound-tube lengths based upon at least two low sound-
14 tube lengths. The method may further include fabricating an
15 assembly of a standardized high audio sound-tube length
16 with a respective one of the two low audio sound-tube
17 lengths to make installation in the canalphone housing
18 easier and to provide repeatable acoustic characteristics.
19 The method may additionally include aligning the
20 standardized high audio sound-tube length's end with the
21 respective one of the two low audio sound-tube lengths'
22 end.

23 **[0025]** Another embodiment is computer readable program
24 codes coupled to tangible media to provide canalphone phase
25 correction. The computer readable program codes may be
26 configured to cause the program to provide a high audio

1 driver carried by a canalphone housing, and a low audio
2 driver carried by the canalphone housing adjacent to the
3 high audio driver. The computer readable program codes may
4 also be configured to cause the program to phase correct a
5 high audio signal from the high audio driver to the outside
6 of the canalphone housing with delivery of a low audio
7 signal from the low audio driver to the outside of the
8 canalphone housing. The computer program product may
9 further include program code configured to phase correct a
10 high audio signal from the high audio driver to the outside
11 of the canalphone housing with delivery of a low audio
12 signal from the low audio driver to the outside of the
13 canalphone housing.

14 BRIEF DESCRIPTION OF the DRAWINGS

15 **[0026]** FIG. 1 is a schematic block diagram of a system
16 in accordance with the embodiments.

17 **[0027]** FIG. 2 is a flowchart illustrating method aspects
18 according to the embodiments.

19 **[0028]** FIG. 3 is a flowchart illustrating method aspects
20 according to the method of FIG. 2.

21 **[0029]** FIG. 4 is a flowchart illustrating method aspects
22 according to the method of FIG. 3.

23 **[0030]** FIG. 5 is a flowchart illustrating method aspects
24 according to the method of FIG. 2.

25 **[0031]** FIG. 6 is a schematic block diagram of a system
26 in accordance with various embodiments.

1 **[0032]** FIG. 7 is an exemplary graph of a phase corrected
2 response of the system in FIG. 6.

3 **[0033]** FIG. 8 is a flowchart illustrating other method
4 aspects according to the embodiments.

5 **[0034]** FIG. 9 is a flowchart illustrating method aspects
6 according to the method of FIG. 8.

7 **[0035]** FIG. 10 is a flowchart illustrating method
8 aspects according to the method of FIG. 9.

9 **[0036]** FIG. 11 is a flowchart illustrating method
10 aspects according to the method of FIG. 10.

11 **[0037]** FIG. 12 is a flowchart illustrating method
12 aspects according to the method of FIG. 9.

13 **[0038]** FIG. 13 is a flowchart illustrating method
14 aspects according to the method of FIG. 9.

15 **[0039]** FIG. 14 is a flowchart illustrating method
16 aspects according to the method of FIG. 8.

17 **[0040]** FIG. 15 is a flowchart illustrating method
18 aspects according to the method of FIG. 8.

19 **[0041]** FIG. 16 is a flowchart illustrating method
20 aspects according to the method of FIG. 8.

21 **[0042]** FIG. 17 is a flowchart illustrating method
22 aspects according to the method of FIG. 9.

23 **[0043]** FIG. 18 is a flowchart illustrating method
24 aspects according to the method of FIG. 16.

25 **[0044]** FIG. 19 is a flowchart illustrating method
26 aspects according to the method of FIG. 17.

1 DETAILED DESCRIPTION

2 **[0045]** Embodiments will now be described more fully
3 hereinafter with reference to the accompanying drawings, in
4 which preferred embodiments are shown. Like numbers refer
5 to like elements throughout.

6 **[0046]** With reference now to Fig. 1, a dual bore
7 canalphone system 10 is initially described. The system 10
8 is carried by a canalphone housing 12 that frictionally
9 engages the ear of a user (not shown) in its usage position
10 as will be appreciated by those of skill in the art.

11 **[0047]** In one embodiment, the system 10 includes a high
12 frequency sound bore 14 carried within the canalphone 12.
13 The system 10 also include a low frequency sound bore 16
14 carried within the canalphone 12 that is adjacent to the
15 high frequency sound bore 14 to form a single unit 15 prior
16 to the sound bores being introduced to the canalphone, the
17 low frequency sound bore and the high frequency sound bore
18 being sized so that the low frequency sound bore and the
19 high frequency sound bore each deliver sound 18 with
20 correct time and phase.

21 **[0048]** For example, the sizing of the low frequency
22 sound bore 16 and the high frequency sound bore 14 involves
23 selecting the diameter and/or length of each sound bore to
24 provide the correct time and phase of sound 18 through the
25 two sound bores with respect to each other. In other words,
26 correct time and phase of the sound 18 through the low

1 frequency sound bore 16 and the high frequency sound bore
2 14 as acoustically perceived by one using the system 10.

3 **[0049]** The system 10 further includes a high acoustical
4 driver 20 carried within the canalphone where the high
5 acoustical driver delivers sound 18 through the high
6 frequency sound bore 14. The system 10 additionally include
7 a low acoustical driver 22 carried within the canalphone 12
8 where the low acoustical driver delivers sound 18 through
9 the low frequency sound bore.

10 **[0050]** In one embodiment, the low acoustical driver 22
11 comprises two low acoustical drivers. In another
12 embodiment, the high acoustical driver 20 comprises two
13 high acoustical drivers.

14 **[0051]** In one embodiment, the low frequency sound bore
15 16 and/or the high frequency sound bore 14 carry an
16 acoustical damper 24a and 24b. In another embodiment, the
17 acoustical damper 24a and 24b is positioned without any
18 rubber boot (not shown).

19 **[0052]** In one embodiment, the low frequency sound bore
20 16 and/or the high frequency sound bore 14 have extended
21 lengths to reduce each sound bore's diameter. Stated
22 another way, the acoustical characteristics of either bore
23 is preserved when reducing the bore's diameter by extending
24 the bore's overall length. An advantage of the reduction of
25 the two bores' diameter is that a user of system 10 can
26 have a physically smaller ear canal. Stated another way, a

1 physically smaller person usually has a smaller ear canal
2 than a physically larger person, and system 10 can properly
3 fit the physically smaller ear canal because of its reduced
4 bore diameters while other canalphone systems currently
5 available do not fit such individuals. In another
6 embodiment, the high frequency sound bore's 14 extended
7 length is greater than 3 millimeters.

8 **[0053]** In one embodiment, the single unit 15 aids in the
9 assembly of the canalphone. Stated another way, because the
10 single unit 15 is one piece, the installation of the single
11 unit into the canalphone 12 is easier than trying to
12 install the low frequency sound bore 16 and the high
13 frequency sound bore 14 as separate components. In another
14 embodiment, the single unit 15 is positioned at an angle
15 between 30 degrees and 65 degrees with respect to the high
16 acoustical driver 20 and the low acoustical driver 22. In
17 another embodiment, the system 10 includes a resistor 26 on
18 the high acoustical driver 20 to tune the high acoustical
19 driver.

20 **[0054]** In another embodiment, the system 10 includes a
21 high frequency sound bore 14 carried within the canalphone
22 12. The system also includes a low frequency sound bore 16
23 carried within the canalphone 12 that is adjacent to the
24 high frequency sound bore 14 to form a single unit 15 prior
25 to the sound bores being introduced to the canalphone, the
26 low frequency sound bore and the high frequency sound bore

1 being sized so that the low frequency sound bore and the
2 high frequency sound bore each deliver sound 18 with
3 correct time and phase, and where the low frequency sound
4 bore and the high frequency sound bore have extended
5 lengths to reduce each sound bore's diameter. The system
6 further includes a high acoustical driver 20 carried within
7 the canalphone 12 where the high acoustical driver delivers
8 sound 18 through the high frequency sound bore 14. The
9 system additionally include a low acoustical driver 22
10 carried within the canalphone 22 where the low acoustical
11 driver delivers sound 18 through the low frequency sound
12 bore 16, and the single unit 15 is positioned at an angle
13 between 30 degrees and 65 degrees with respect to the high
14 acoustical driver 14 and the low acoustical driver.

15 **[0055]** Another aspect of the embodiments is a method,
16 which is now described with reference to flowchart 28 of
17 FIG. 2. The method begins at Block 30 and may include
18 positioning a high acoustical driver within a canalphone at
19 Block 32. The method may also include positioning a low
20 acoustical driver within the canalphone adjacent to the
21 high acoustical driver at Block 34. The method may further
22 include positioning a single unit including a low frequency
23 sound bore adjacent to a high frequency sound bore within
24 the canalphone where the low frequency sound bore and the
25 high frequency sound bore are sized so that the low
26 frequency sound bore and the high frequency sound bore each

1 deliver sound with correct time and phase, and the single
2 unit adjoins both the high acoustical driver and low
3 acoustical driver at Block 36. The method ends at Block 38.

4 **[0056]** In another method embodiment, which is now
5 described with reference to flowchart 40 of FIG. 3, the
6 method begins at Block 42. The method may include the steps
7 of FIG. 2 at Blocks 32, 34, and 36. The method may further
8 include inserting an acoustical damper within at least one
9 of the low frequency sound bore and the high frequency
10 sound bore at Block 44. The method ends at Block 46.

11 **[0057]** In another method embodiment, which is now
12 described with reference to flowchart 48 of FIG. 4, the
13 method begins at Block 50. The method may include the steps
14 of FIG. 3 at Blocks 32, 34, 36, and 44. The method may also
15 include inserting the acoustical damper within the sound
16 bore without any rubber boot at Block 52. The method ends
17 at Block 54.

18 **[0058]** In another method embodiment, which is now
19 described with reference to flowchart 56 of FIG. 5, the
20 method begins at Block 58. The method may include the steps
21 of FIG. 2 at Blocks 32, 34, and 36. The method may further
22 include reducing the low frequency sound bore's diameter
23 and the high frequency sound bore's diameter by extending
24 the lengths of each sound bore at Block 60. The method ends
25 at Block 62.

1 **[0059]** With reference now to Fig. 6, a phase corrected
2 canalphone system 10 is further described. In one
3 embodiment, the system 10 includes a canalphone housing 12
4 that frictionally engages the ear of a user (not shown) in
5 its usage position.

6 **[0060]** In one embodiment, the system 10 includes a high
7 audio driver 20 carried by the canalphone housing 12, and a
8 low audio driver 22 carried by the canalphone housing
9 adjacent to the high audio driver. In another embodiment,
10 the system 10 also includes an acoustical-timer 17a and/or
11 17b to phase correct a high audio signal from the high
12 audio driver 20 directed to the outside of the canalphone
13 housing 12 with delivery of a low audio signal from the low
14 audio driver 22 directed to the outside of the canalphone
15 housing.

16 **[0061]** In one embodiment, the acoustical-timer 17a
17 includes a low audio sound-tube 16 to carry a low audio
18 signal from the low audio driver 22 to the outside of the
19 canalphone housing 12. In another embodiment, the
20 acoustical-timer 17a further includes a high audio sound-
21 tube 14 to carry a high audio signal from the high audio
22 driver 20 to the outside of the canalphone housing 12, the
23 high audio sound-tube phase corrected with respect to the
24 low audio sound-tube 16 by sizing it to be longer than the
25 low audio sound-tube.

1 **[0062]** In one embodiment, the low audio sound-tube 16 is
2 sized based upon its time response for the low audio signal
3 to pass through the low audio sound-tube. In another
4 embodiment, the high audio sound-tube 14 is longer to slow
5 down the high audio signal's arrival to the outside of the
6 canalphone housing 12 so that it is closer in time to the
7 low audio signal from the low audio driver's 22 arrival to
8 the outside of the canalphone housing.

9 **[0063]** In one embodiment, the arrival of the high audio
10 signal to the outside of the canalphone housing 12 is less
11 than .05 milliseconds difference than the low audio signal
12 from the low audio driver's 22 arrival to the outside of
13 the canalphone housing. In another embodiment, the
14 difference is less than .02 milliseconds difference.

15 **[0064]** In one embodiment, the system 10 additionally
16 includes a mid audio driver 23 carried by the canalphone
17 housing 12 adjacent to the high audio driver 20, and a mid
18 audio sound-tube 25 to carry a mid-audio signal from the
19 mid audio driver to the outside of the canalphone housing,
20 the mid audio sound-tube phase corrected by sizing it to be
21 longer than the low audio sound-tube 16 and shorter than
22 the high audio sound-tube 14.

23 **[0065]** In one embodiment, the acoustical-timer 17b
24 includes a processor 27 to phase correct a high audio
25 signal from the high audio driver 20 directed to the
26 outside of the canalphone housing 12 with delivery of a low

1 audio signal from the low audio driver 22 directed to the
2 outside of the canalphone housing. In another embodiment,
3 the processor 27 uses digital signal processing to control
4 the high audio signal's arrival at the outside of the
5 canalphone housing 12 to be closer in time to the low audio
6 signal from the low audio driver's 16 arrival to the
7 outside of the canalphone housing.

8 **[0066]** In one embodiment, the arrival of the high audio
9 signal to the outside of the canalphone housing 12 is less
10 than .05 milliseconds difference compared to the low audio
11 signal from the low audio driver's 16 arrival to the
12 outside of the canalphone housing. In another embodiment,
13 the acoustical-timer 17a and 17b uses a time response for
14 the low audio signal to pass through the canalphone housing
15 12 as a control point to set all other audio signals' phase
16 in the system 10. In another embodiment, the system 10
17 further includes a mid audio driver 23 carried by the
18 canalphone housing 12 adjacent to the high audio driver 20,
19 and the mid audio driver provides a mid-audio signal to the
20 outside of the canalphone housing based upon the low audio
21 driver 22.

22 **[0067]** Fig. 7 illustrates an example of the phase
23 corrected response of the system 10. The red line in the
24 upper graph is the phase corrected response compared to an
25 uncorrected response in the lower graph.

1 **[0068]** Another aspect of the embodiments is another
2 method, which is now described with reference to flowchart
3 68 of FIG. 8. The method begins at Block 70 and may include
4 providing a high audio driver carried by a canalphone
5 housing, and a low audio driver carried by the canalphone
6 housing adjacent to the high audio driver at Block 72. The
7 method may also include phase correcting a high audio
8 signal from the high audio driver directed to the outside
9 of the canalphone housing with delivery of a low audio
10 signal from the low audio driver directed to the outside of
11 the canalphone housing at Block 74. The method ends at
12 Block 76.

13 **[0069]** In another method embodiment, which is now
14 described with reference to flowchart 78 of FIG. 9, the
15 method begins at Block 80. The method may include the steps
16 of FIG. 8 at Blocks 72 and 74. The method may further
17 include carrying a low audio signal from the low audio
18 driver to outside of the canalphone housing via a low audio
19 sound-tube at Block 82. The method may additionally include
20 carrying a high audio signal from the high audio driver to
21 the outside of the canalphone housing via a high audio
22 sound-tube phase corrected with respect to the low audio
23 sound-tube by sizing it to be longer than the low audio
24 sound-tube at Block 84. The method ends at Block 86.

25 **[0070]** In another method embodiment, which is now
26 described with reference to flowchart 88 of FIG. 10, the

1 method begins at Block 90. The method may include the steps
2 of FIG. 9 at Blocks 72, 74, 82, and 84. The method may also
3 include sizing the low audio sound-tube based upon its time
4 response for the low audio signal to pass through the low
5 audio sound-tube at Block 92. The method ends at Block 94.

6 **[0071]** In another method embodiment, which is now
7 described with reference to flowchart 96 of FIG. 11, the
8 method begins at Block 98. The method may include the steps
9 of FIG. 10 at Blocks 72, 74, 82, 84, and 92. The method may
10 also include selecting the low audio sound-tube's size to
11 be acoustically proper and as short as can be readily fit
12 into the canalphone housing at Block 100. The method ends
13 at Block 102.

14 **[0072]** Acoustically proper means that the audio sound
15 tube does not promote distortion due to its length. As
16 short as can be readily fit into the canalphone housing 12
17 refers to the fact that the physical dimensions of the
18 canalphone housing creates placement issues with regards to
19 the low audio driver 22 and the other system 10 components
20 such as the high audio driver 20 and respective sound
21 tubes.

22 **[0073]** In another method embodiment, which is now
23 described with reference to flowchart 104 of FIG. 12, the
24 method begins at Block 108. The method may include the
25 steps of FIG. 9 at Blocks 72, 74, 82, and 84. The method
26 may also include slowing down the high audio signal's

1 arrival to the outside of the canalphone housing so that it
2 is closer in time to the low audio signal from the low
3 audio driver's arrival to the outside of the canalphone
4 housing by making the high sound-tube longer at Block 108.
5 The method ends at Block 110.

6 **[0074]** In another method embodiment, which is now
7 described with reference to flowchart 112 of FIG. 13, the
8 method begins at Block 114. The method may include the
9 steps of FIG. 9 at Blocks 72, 74, 82, and 84. The method
10 may also include timing the arrival of the high audio
11 signal to the outside of the canalphone housing is within
12 .05 milliseconds when compared to the low audio signal from
13 the low audio driver arrival to the outside of the
14 canalphone housing at Block 116. The method ends at Block
15 118.

16 **[0075]** In another method embodiment, which is now
17 described with reference to flowchart 120 of FIG. 14, the
18 method begins at Block 122. The method may include the
19 steps of FIG. 8 at Blocks 72 and 74. The method may further
20 include using digital signal processing to phase correct a
21 high audio signal from the high audio driver directed to
22 the outside of the canalphone housing with delivery of a
23 low audio signal from the low audio driver directed to the
24 outside of the canalphone housing at Block 124. The method
25 ends at Block 126.

1 **[0076]** In another method embodiment, which is now
2 described with reference to flowchart 128 of FIG. 15, the
3 method begins at Block 130. The method may include the
4 steps of FIG. 8 at Blocks 72 and 74. The method may further
5 include timing the arrival of the high audio signal to the
6 outside of the canalphone housing is within .05
7 milliseconds when compared to the low audio signal from the
8 low audio driver arrival to the outside of the canalphone
9 housing at Block 132. The method ends at Block 134.

10 **[0077]** In another method embodiment, which is now
11 described with reference to flowchart 136 of FIG. 16, the
12 method begins at Block 138. The method may include the
13 steps of FIG. 8 at Blocks 72 and 74. The method may further
14 include using a time response for the low audio signal to
15 pass through the canalphone housing as a control point to
16 set all other audio signals' phase in the system at Block
17 140. The method ends at Block 142.

18 **[0078]** In another method embodiment, which is now
19 described with reference to flowchart 144 of FIG. 17, the
20 method begins at Block 146. The method may include the
21 steps of FIG. 9 at Blocks 72, 74, 82, and 84. The method
22 may also include standardizing high sound-tube lengths
23 based upon at least two low sound-tube lengths at Block
24 148. The method ends at Block 150.

25 **[0079]** In another method embodiment, which is now
26 described with reference to flowchart 152 of FIG. 18, the

1 method begins at Block 154. The method may include the
2 steps of FIG. 16 at Blocks 72, 74, and 140. The method may
3 also include fabricating an assembly of a standardized high
4 sound-tube length with a respective one of the two low
5 sound-tube lengths to make installation in the canalphone
6 housing easier and to provide repeatable acoustic
7 characteristics at Block 156. The method ends at Block 158.

8 **[0080]** In another method embodiment, which is now
9 described with reference to flowchart 160 of FIG. 19, the
10 method begins at Block 162. The method may include the
11 steps of FIG. 17 at Blocks 72, 74, 82, 84, and 148. The
12 method may also include aligning the standardized high
13 sound-tube length's end with the respective one of the two
14 low sound-tube lengths' end at Block 164. The method ends
15 at Block 166.

16 **[0081]** Another aspect of the embodiments are computer
17 readable program codes coupled to tangible media to provide
18 canalphone phase correction. The computer readable program
19 codes may be configured to cause the program to provide a
20 high audio driver carried by a canalphone housing, and a
21 low audio driver carried by the canalphone housing adjacent
22 to the high audio driver. The computer readable program
23 codes may also phase correct a high audio signal from the
24 high audio driver to the outside of the canalphone housing
25 with delivery of a low audio signal from the low audio
26 driver to the outside of the canalphone housing.

1 **[0082]** The computer readable program codes may further
2 phase correct a high audio signal from the high audio
3 driver to the outside of the canalphone housing with
4 delivery of a low audio signal from the low audio driver to
5 the outside of the canalphone housing. The computer
6 readable program codes may additionally use a time response
7 for the low audio signal to pass through the canalphone
8 housing as a control point to set all other audio signals'
9 phase in the system.

10 **[0083]** Since a canalphone housing 12 is very small, it
11 is very difficult to achieve any of the preceding
12 embodiments. However, system 10 overcomes the technical
13 hurdles of providing more components in less space,
14 providing superior sound reproduction, and provides a user
15 a phase corrected canalphone system.

16 **[0084]** As will be appreciated by one skilled in the art,
17 aspects may be embodied as a system, method, and/or
18 computer program product. Accordingly, embodiments may take
19 the form of an entirely hardware embodiment, an entirely
20 software embodiment (including firmware, resident software,
21 micro-code, etc.) or an embodiment combining software and
22 hardware aspects that may all generally be referred to
23 herein as a "circuit," "module" or "system." Furthermore,
24 embodiments may take the form of a computer program product
25 embodied in one or more computer readable medium(s) having
26 computer readable program code embodied thereon.

1 **[0085]** Any combination of one or more computer readable
2 medium(s) may be utilized. The computer readable medium may
3 be a computer readable signal medium or a computer readable
4 storage medium. A computer readable storage medium may be,
5 for example, but not limited to, an electronic, magnetic,
6 optical, electromagnetic, infrared, or semiconductor
7 system, apparatus, or device, or any suitable combination
8 of the foregoing. More specific examples (a non-exhaustive
9 list) of the computer readable storage medium would include
10 the following: an electrical connection having one or more
11 wires, a portable computer diskette, a hard disk, a random
12 access memory (RAM), a read-only memory (ROM), an erasable
13 programmable read-only memory (EPROM or Flash memory), an
14 optical fiber, a portable compact disc read-only memory
15 (CD-ROM), an optical storage device, a magnetic storage
16 device, or any suitable combination of the foregoing. In
17 the context of this document, a computer readable storage
18 medium may be any tangible medium that can contain, or
19 store a program for use by or in connection with an
20 instruction execution system, apparatus, or device.

21 **[0086]** A computer readable signal medium may include a
22 propagated data signal with computer readable program code
23 embodied therein, for example, in baseband or as part of a
24 carrier wave. Such a propagated signal may take any of a
25 variety of forms, including, but not limited to, electro-
26 magnetic, optical, or any suitable combination thereof. A

1 computer readable signal medium may be any computer
2 readable medium that is not a computer readable storage
3 medium and that can communicate, propagate, or transport a
4 program for use by or in connection with an instruction
5 execution system, apparatus, or device.

6 **[0087]** Program code embodied on a computer readable
7 medium may be transmitted using any appropriate medium,
8 including but not limited to wireless, wireline, optical
9 fiber cable, RF, etc., or any suitable combination of the
10 foregoing.

11 **[0088]** Computer program code for carrying out operations
12 for aspects of the embodiments may be written in any
13 combination of one or more programming languages, including
14 an object oriented programming language such as Java,
15 Smalltalk, C++ or the like and conventional procedural
16 programming languages, such as the "C" programming language
17 or similar programming languages. The program code may
18 execute entirely on the user's computer, partly on the
19 user's computer, as a stand-alone software package, partly
20 on the user's computer and partly on a remote computer or
21 entirely on the remote computer or server. In the latter
22 scenario, the remote computer may be connected to the
23 user's computer through any type of network, including a
24 local area network (LAN) or a wide area network (WAN), or
25 the connection may be made to an external computer (for

1 example, through the Internet using an Internet Service
2 Provider).

3 **[0089]** Aspects of the embodiments are described above
4 with reference to flowchart illustrations and/or block
5 diagrams of methods, apparatus (systems) and computer
6 program products according to the embodiments. It will be
7 understood that each block of the flowchart illustrations
8 and/or block diagrams, and combinations of blocks in the
9 flowchart illustrations and/or block diagrams, can be
10 implemented by computer program instructions. These
11 computer program instructions may be provided to a
12 processor of a general purpose computer, special purpose
13 computer, or other programmable data processing apparatus
14 to produce a machine, such that the instructions, which
15 execute via the processor of the computer or other
16 programmable data processing apparatus, create means for
17 implementing the functions/acts specified in the flowchart
18 and/or block diagram block or blocks.

19 **[0090]** These computer program instructions may also be
20 stored in a computer readable medium that can direct a
21 computer, other programmable data processing apparatus, or
22 other devices to function in a particular manner, such that
23 the instructions stored in the computer readable medium
24 produce an article of manufacture including instructions
25 which implement the function/act specified in the flowchart
26 and/or block diagram block or blocks.

1 **[0091]** The computer program instructions may also be
2 loaded onto a computer, other programmable data processing
3 apparatus, or other devices to cause a series of
4 operational steps to be performed on the computer, other
5 programmable apparatus or other devices to produce a
6 computer implemented process such that the instructions
7 which execute on the computer or other programmable
8 apparatus provide processes for implementing the
9 functions/acts specified in the flowchart and/or block
10 diagram block or blocks.

11 **[0092]** The flowchart and block diagrams in the Figures
12 illustrate the architecture, functionality, and operation
13 of possible implementations of systems, methods and
14 computer program products according to various embodiments.
15 In this regard, each block in the flowchart or block
16 diagrams may represent a module, segment, or portion of
17 code, which comprises one or more executable instructions
18 for implementing the specified logical function(s). It
19 should also be noted that, in some alternative
20 implementations, the functions noted in the block may occur
21 out of the order noted in the figures. For example, two
22 blocks shown in succession may, in fact, be executed
23 substantially concurrently, or the blocks may sometimes be
24 executed in the reverse order, depending upon the
25 functionality involved. It will also be noted that each
26 block of the block diagrams and/or flowchart illustration,

1 and combinations of blocks in the block diagrams and/or
2 flowchart illustration, can be implemented by special
3 purpose hardware-based systems that perform the specified
4 functions or acts, or combinations of special purpose
5 hardware and computer instructions.

6 **[0093]** The terminology used herein is for the purpose of
7 describing particular embodiments only and is not intended
8 to be limiting. As used herein, the singular forms "a",
9 "an" and "the" are intended to include the plural forms as
10 well, unless the context clearly indicates otherwise. It
11 will be further understood that the terms "comprises"
12 and/or "comprising," when used in this specification,
13 specify the presence of stated features, integers, steps,
14 operations, elements, and/or components, but do not
15 preclude the presence or addition of one or more other
16 features, integers, steps, operations, elements,
17 components, and/or groups thereof.

18 **[0094]** The corresponding structures, materials, acts,
19 and equivalents of all means or step plus function elements
20 in the claims below are intended to include any structure,
21 material, or act for performing the function in combination
22 with other claimed elements as specifically claimed. The
23 description of the embodiments has been presented for
24 purposes of illustration and description, but is not
25 intended to be exhaustive or limited to the embodiments in
26 the form disclosed. Many modifications and variations will

1 be apparent to those of ordinary skill in the art without
2 departing from the scope and spirit of the embodiments. The
3 embodiment was chosen and described in order to best
4 explain the principles of the embodiments and the practical
5 application, and to enable others of ordinary skill in the
6 art to understand the various embodiments with various
7 modifications as are suited to the particular use
8 contemplated.

9 **[0095]** While the preferred embodiment has been
10 described, it will be understood that those skilled in the
11 art, both now and in the future, may make various
12 improvements and enhancements which fall within the scope
13 of the claims which follow. These claims should be
14 construed to maintain the proper protection for the
15 embodiments first described.
16

1 CLAIMS

2

3 What is claimed is:

4

5 1. A system comprising:

6 a high audio driver carried by a canalphone
7 housing;8 a low audio driver carried by the canalphone
9 housing adjacent to the high audio driver; and10 an acoustical-timer to phase correct a high audio
11 signal from the high audio driver directed to the outside
12 of the canalphone housing with delivery of a low audio
13 signal from the low audio driver directed to the outside of
14 the canalphone housing.

15

16 2. The system of claim 1 wherein the acoustical-
17 timer includes:18 a low sound-tube to carry a low audio signal from
19 the low audio driver to outside of the canalphone housing;
20 and21 a high audio sound-tube to carry a high audio
22 signal from the high audio driver to the outside of the
23 canalphone housing, the high audio sound-tube phase
24 corrected with respect to the low audio sound-tube by
25 sizing it to be longer than the low audio sound-tube.

26

1 3. The system of claim 2 wherein the low audio
2 sound-tube is sized based upon its time response for the
3 low audio signal to pass through the low audio sound-tube.
4

5 4. The system of claim 2 wherein the high audio
6 sound-tube is longer to slow down the high audio signal's
7 arrival to the outside of the canalphone housing so that it
8 is closer in time to the low audio signal from the low
9 audio driver's arrival to the outside of the canalphone
10 housing.
11

12 5. The system of claim 4 wherein the arrival of
13 the high audio signal's to the outside of the canalphone
14 housing is less than .05 milliseconds difference than the
15 low audio signal from the low audio driver arrival to the
16 outside of the canalphone housing.
17

18 6. The system of claim 1 wherein the acoustical-
19 timer includes a processor to phase correct a high audio
20 signal from the high audio driver to the outside of the
21 canalphone housing with delivery of a low audio signal from
22 the low audio driver to the outside of the canalphone
23 housing.
24

25 7. The system of claim 6 wherein the processor
26 uses digital signal processing to control the high audio

1 signal's arrival at the outside of the canalphone housing
2 to be closer in time to the low audio signal from the low
3 audio driver's arrival to the outside of the canalphone
4 housing.

5
6 8. The system of claim 7 wherein the acoustical-
7 timer uses a time response for the low audio signal to pass
8 through the canalphone housing as a control point to set
9 all other audio signals' phase in the system.

10
11 9. A method comprising:
12 providing a high audio driver carried by a
13 canalphone housing, and a low audio driver carried by the
14 canalphone housing adjacent to the high audio driver; and
15 phase correcting a high audio signal from the
16 high audio driver directed to the outside of the canalphone
17 housing with delivery of a low audio signal from the low
18 audio driver directed to the outside of the canalphone
19 housing.

20
21 10. The method of claim 9 further comprising:
22 carrying a low audio signal from the low audio
23 driver to outside of the canalphone housing via a low audio
24 sound-tube; and
25 carrying a high audio signal from the high audio
26 driver to the outside of the canalphone housing via a high

1 audio sound-tube phase corrected with respect to the low
2 audio sound-tube by sizing it to be longer than the low
3 audio sound-tube.
4

5 11. The method of claim 10 further comprising
6 sizing the low audio sound-tube based upon its time
7 response for the low audio signal to pass through the low
8 audio sound-tube.
9

10 12. The method of claim 11 further comprising
11 selecting the low audio sound-tube's size to be
12 acoustically proper and as short as can be readily fit into
13 the canalphone housing.
14

15 13. The method of claim 10 further comprising
16 slowing down the high audio signal's arrival to the outside
17 of the canalphone housing so that it is closer in time to
18 the low audio signal from the low audio driver's arrival to
19 the outside of the canalphone housing by making the high
20 audio sound-tube longer.
21

22 14. The method of claim 10 further comprising
23 timing the arrival of the high audio signal's to the
24 outside of the canalphone housing compared to the low audio
25 signal from the low audio driver arrival to the outside of

1 the canalphone housing is within .05 milliseconds of each
2 other.

3

4 15. The method of claim 9 further comprising
5 using digital signal processing to phase correct a high
6 audio signal from the high audio driver directed to the
7 outside of the canalphone housing with delivery of a low
8 audio signal from the low audio driver directed to the
9 outside of the canalphone housing.

10

11 16. The method of claim 15 further comprising
12 timing the arrival of the high audio signal's to the
13 outside of the canalphone housing compared to the low audio
14 signal from the low audio driver arrival to the outside of
15 the canalphone housing is within .05 milliseconds of each
16 other.

17

18 17. The method of claim 9 further comprising
19 using a time response for the low audio signal to pass
20 through the canalphone housing as a control point to set
21 all other audio signals' phase in the system.

22

23 18. The method of claim 10 further comprising
24 standardizing high audio sound-tube lengths based upon at
25 least two low audio sound-tube lengths.

26

1 19. The method of claim 17 further comprising
2 fabricating an assembly of a standardized high audio sound-
3 tube length with a respective one of the two low audio
4 sound-tube lengths to make installation in the canalphone
5 housing easier and to provide repeatable acoustic
6 characteristics.

7
8 20. The method of claim 18 further comprising
9 aligning the standardized high audio sound-tube length's
10 end with the respective one of the two low audio sound-tube
11 lengths' end.

12
13 21. A computer program product embodied in a
14 tangible media comprising:
15 computer readable program codes coupled to the
16 tangible media to provide canalphone phase correction, the
17 computer readable program codes configured to cause the
18 program to:

19 provide a high audio driver carried by a
20 canalphone housing, and a low audio driver carried by the
21 canalphone housing adjacent to the high audio driver; and
22 phase correct a high audio signal from the
23 high audio driver to the outside of the canalphone housing
24 with delivery of a low audio signal from the low audio
25 driver to the outside of the canalphone housing.

26