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Development of a historic hearing devices exhibit

Monique Carraway

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**DEVELOPMENT OF A HISTORIC HEARING
DEVICES EXHIBIT**

by

Monique Carraway

**An independent study submitted in partial
fulfillment of the requirements for the degree of**

Master of Science in Speech and Hearing

Emphasis in Audiology

**Washington University
Department of Speech and Hearing**

May 25, 2001

Approved by: Rosalie Uchanski, Ph.D., Independent Study Advisor

Development of a Historic Device/Exhibit

INTRODUCTION

The purpose of this project is to examine historical perspectives on hearing devices and their benefit to users. Hearing loss is an invisible disability that interferes with quality of life in all societal groups and classes. Over the last three centuries, hearing devices have been used to amplify sound to alleviate the effects of one's hearing loss. Hearing devices have changed in size and technology from generally large mechanical devices in the 18th and 19th centuries to electronic devices that are the size of a coin in the 20th and 21st centuries. Examples of early mechanical devices are acoustic chairs & thrones, and ear trumpets.

Society's negative attitudes toward hearing loss and deafness introduced pressure on the deaf to hide their deafness and their devices. This pressure to conceal the devices affected design, cost and acoustic benefit of hearing devices. According to Murdy (2000), the trend of designing devices for concealment or camouflaged purposes started in the 19th century with . . .cosmetically acceptable or inconspicuous trumpets (Stephens, 1984, p.221). The widespread attitudes toward hearing loss and hearing devices of the 19th century is the motivation for developing hearing devices that conceal despite the limited acoustic benefit. Therefore, the focus on marketing inconspicuous or concealed devices serves to ameliorate the social stigma to having a hearing loss or wearing a hearing device (Hawksley, 1895).

For this study, two devices were chosen to examine the interaction between acoustic benefit and aesthetics of design. The two devices are the London Dome and the Aurollese Phone. The former is a large device that does not appear to have been designed

with regard to ease of portability or for disguise or concealment. The latter device, the Aurolase Phone, is designed to look like a flower worn in a woman's hair. The aesthetics and acoustic benefit for these two devices will be examined in this study. For comparison, the acoustic benefit of the very portable cupped hand will be examined also.

METHODS & MATERIALS

Three devices were chosen for acoustic gain measurements using a Knowles Electronics Manikin for Acoustic Research (KEMAR). The three devices are 1) the cupped hand, 2) the London Dome, and 3) the Aurolase Phone.

Measurements of acoustic gain were made using the following set-up. KEMAR was placed in the CID anechoic chamber 88 inches from an audio speaker. KEMAR's right ear contained a Zwislocki coupler fitted with a pressure microphone.

One-third octave bands of noise were generated and played out via the loud speaker. The level of the 1/3-octave noise band at the microphone in KEMAR's ear was recorded using a B & K 4134 pressure microphone. Twenty-six bands of noise were used ranging in center frequency from 63 to 20000 Hz. The noise level at each center frequency was measured at the ear both with and without the device placed appropriately in KEMAR's right ear (see Figure 1).

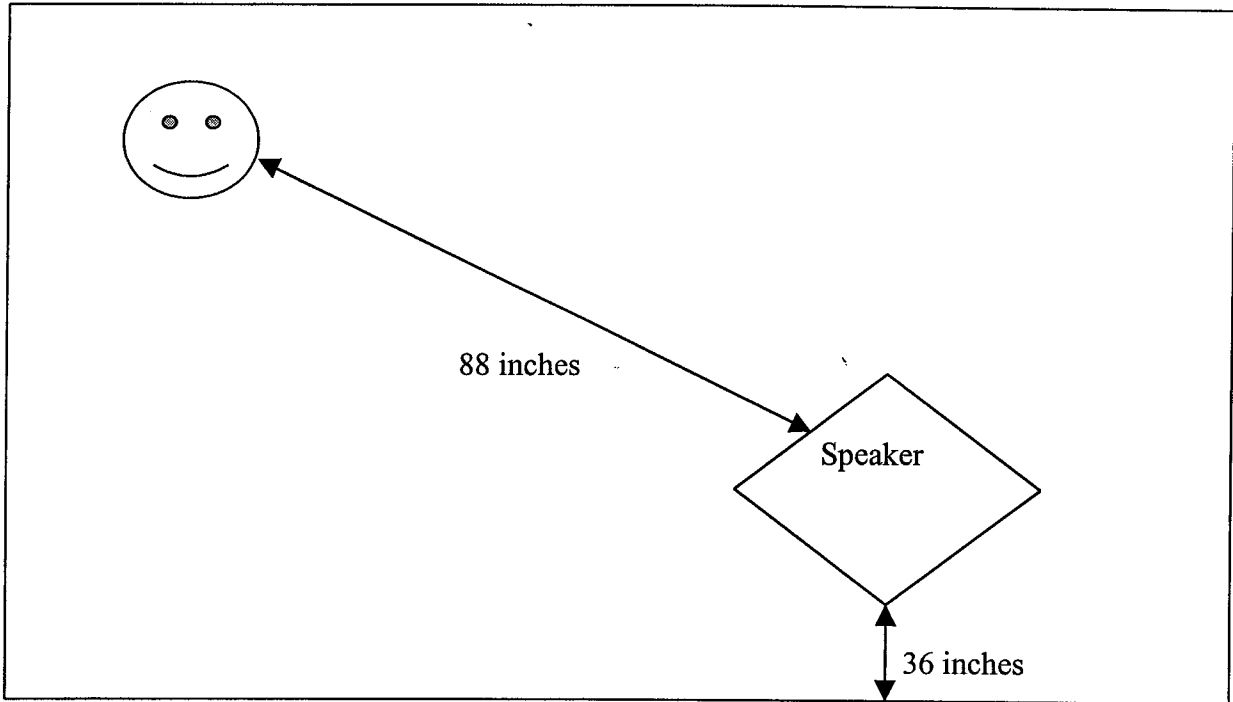


Figure 1

The cupped hand is a timeless natural hearing device used to amplify sound. An artificial cupped hand was constructed with a latex surgical glove and CRAYOLA Model Magic molding clay. It was approximately the size of a large man's hand -- about 9.5 inches long and 4 inches wide across the palm (see Figures 2 a and b).

The London Dome is an ear trumpet (see Figure 3) from the turn of the 19th Century manufactured by Frederick Charles Rein in 1800 in London, England. The trumpet has a bell-shaped sound collector and its name comes from its resemblance to a London church dome. This device is 9.5 inches high and weighs 2 pounds. The circular opening of the sound collector is 8.5 inches in diameter, and has a handle for holding the device to the ear with hearing loss.

The Aurolese phone (or Floral Receptor) was invented and manufactured by Frederick Charles Rein ca.1802-1810 in London. This metal device has a sound collector in the shape of a flower with a funnel-shaped tube that is inserted into the ear canal (see Figure 4). The circular opening of the sound collector is 3 in diameter. The flower is held in place with a wire headband.

RESULTS

The results of the measurements of acoustic gain are shown in Figures 5, 6, & 7, for the Cupped Hand, London Dome, and Aurolese Phone, respectively. In each figure, the top graph shows individual data from repeated measurements while the bottom graph shows the gain averaged across measurement repetitions.

The average gain in the 300-3000 Hz region is 5, 16, and 3.5 dB for the Cupped Hand, London Dome, and Aurolese Phone, respectively. In general, the gain functions are not flat, but tend to have several peaks. There are primary peaks in the 500-2000 Hz region, which can be considered very desirable for speech perception. There are also peaks in the gain functions at very high frequencies (7000-8000 Hz). These peaks may not be particularly useful for speech perception.

Based on the average gain in the 300-3000 Hz region, important for speech communication, one might consider the London Dome to be useful for listeners with moderate hearing losses. Moderate hearing loss is defined as a 3-tone threshold average of 40-55 dB hearing level (dB HL). Analogously, the Cupped Hand and Aurolese Phone

might be beneficial for listeners with slight to mild hearing losses. Mild hearing loss is defined as a 3-tone pure tone average of 25-40 dB HL.

DISCUSSION

Of the three devices used in this project the cupped hand is the most convenient to use whenever you need a few decibels of amplification. According to these results, however, in the Victorian Era, those persons with mild hearing loss will benefit from the Aurolese Phone. The range of hearing loss varies according to how much a person is handicapped by the hearing loss. A person with a mild hearing loss would have difficulty detecting certain speech sounds such as “s” as in sun, “sh” as in shoe, and “v” as in violin; as well as having trouble hearing soft sounds, for example, a watch ticking. A moderate hearing loss, and with this magnitude of hearing loss would cause a person to have trouble understanding speech in noise and hearing certain speech sounds such as “m” as in monkey, “ng” as in king, and “r” as in run. A severe hearing loss is defined as a 3-tone threshold average of 70-90 dB, which makes it difficult for a person to hear all speech sounds and piano playing or a telephone ring. A profound hearing loss is defined as a 3-tone threshold average of greater than 90 dB, and this magnitude of hearing loss makes it difficult to hear a lawn mower, chainsaw, or jet engine. A person with a profound hearing loss is considered Deaf today.

Barr-Hamilton (1983) and Stephens & Goodwin (1984) also performed experiments using the cupped hand as a hearing aid; measuring the amplification provided by an actual and artificial cupped hand, respectively. As seen in Figure 5, Barr-

Hamilton and Stephens obtained 8-10 dB of amplification in the mid- to high-frequency region (500-2000 Hz) produced by the cupped hand. Each of these studies shows peak gain in the frequency regions important for speech, and there is essentially no difference between the amounts of amplification between each set of data. A possible explanation for the amplification measured in the mid- to high-frequency region is that the hand, artificial or real, seems to modify the natural resonance of the ear canal.

In 1984, Koelkebeck, Detjen, & Calvert (1984) published frequency gain data for the London Dome. In comparison to our current data, the London Dome would be suitable for a person with a moderate to severe hearing loss with maximum gain values in the mid- to high-frequency regions (see Figure 6).

No other data for the Aurollese Phone are available/published. Data are available for other mechanical devices including a recent study, performed by Bentler & Duve (2000), comparing a variety of 20th century hearing aids. In this study, the real-ear gain of an early 20th century speaking tube was measured. Similar to our London Dome device, there is approximately 10-15 dB of gain in the frequency region of 1000-3000 Hz, according to the data in Figure 6.

Depending on the magnitude of hearing loss a person has, there is a definite sacrifice of acoustic benefit for design consideration, especially when aesthetics or concealment is a priority. Today, there continues to be an overwhelming demand for concealment with hearing loss and hearing devices as it was in the 19th century.

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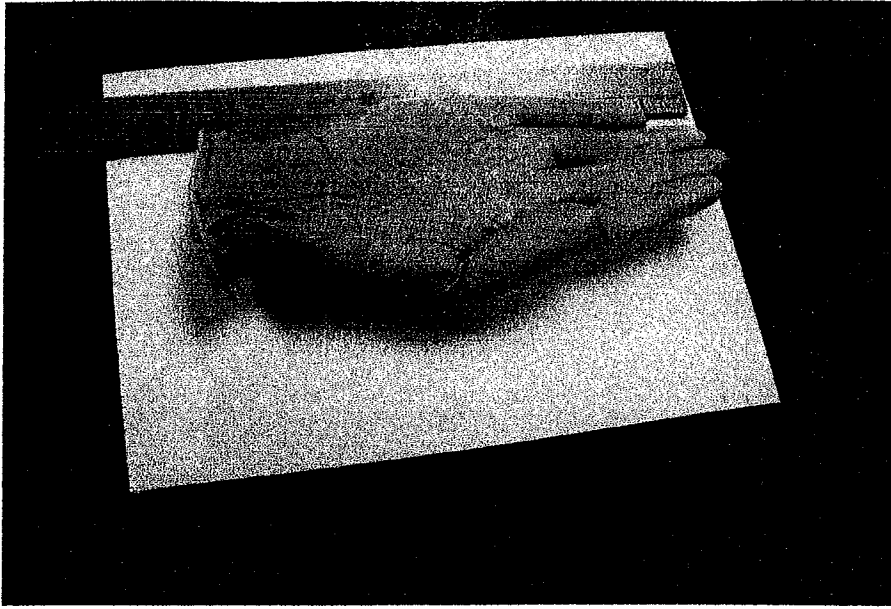


Figure 2 (a)

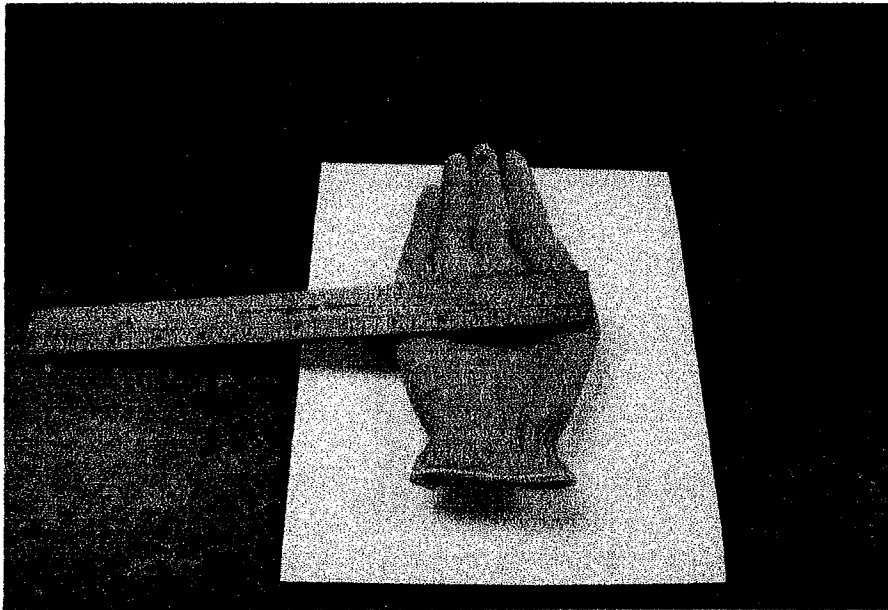


Figure 2 (b)



Figure 3

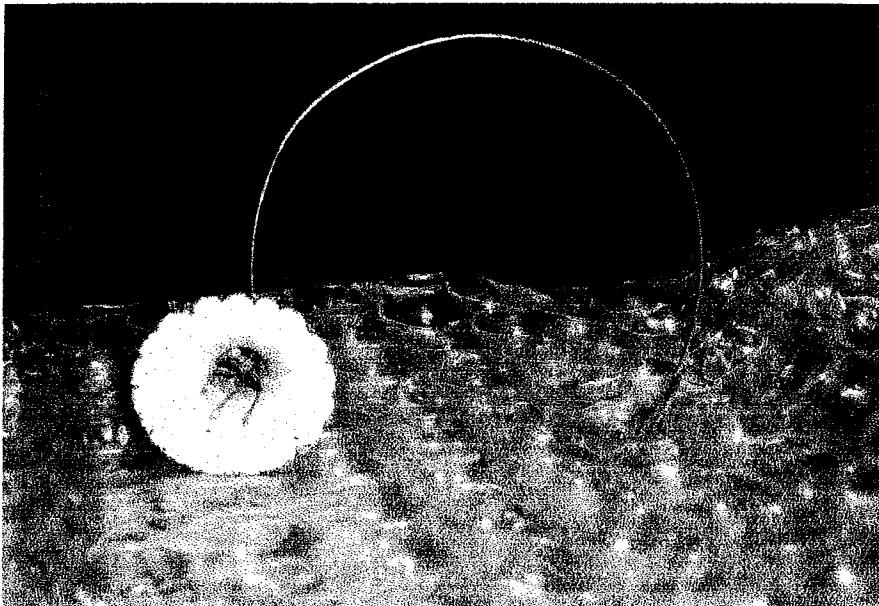


Figure 4

Cupped Hand

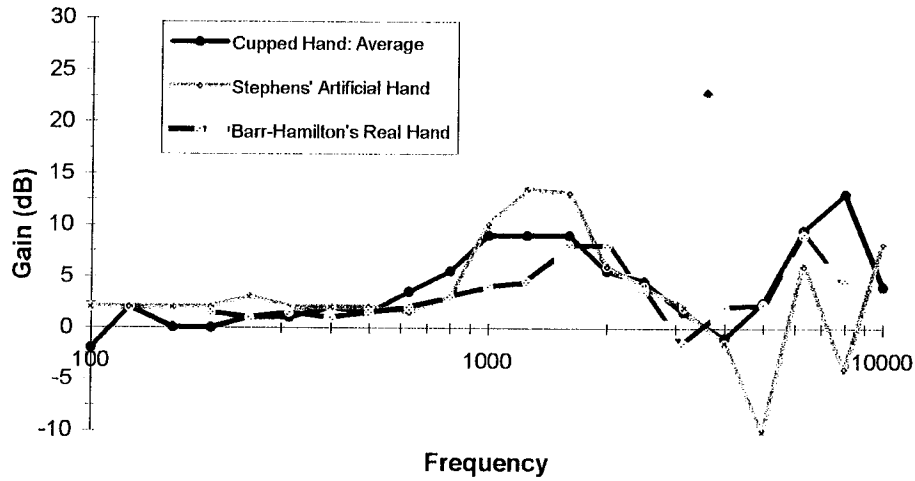
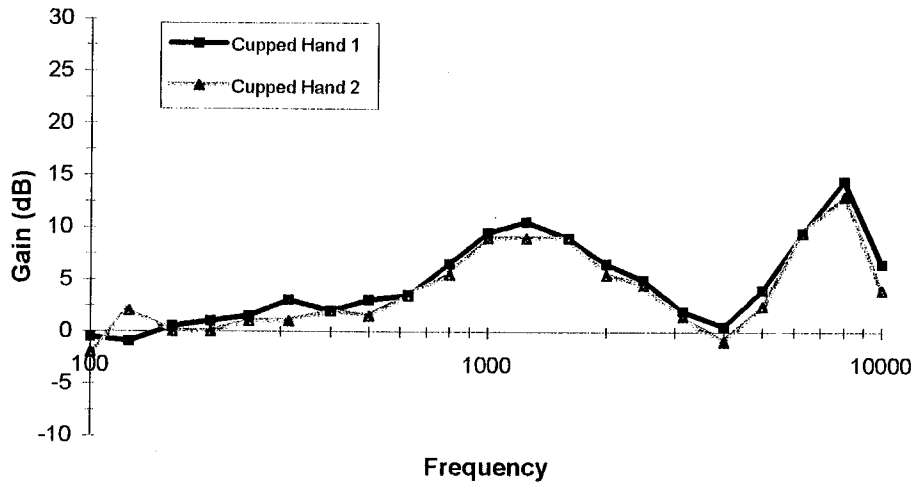
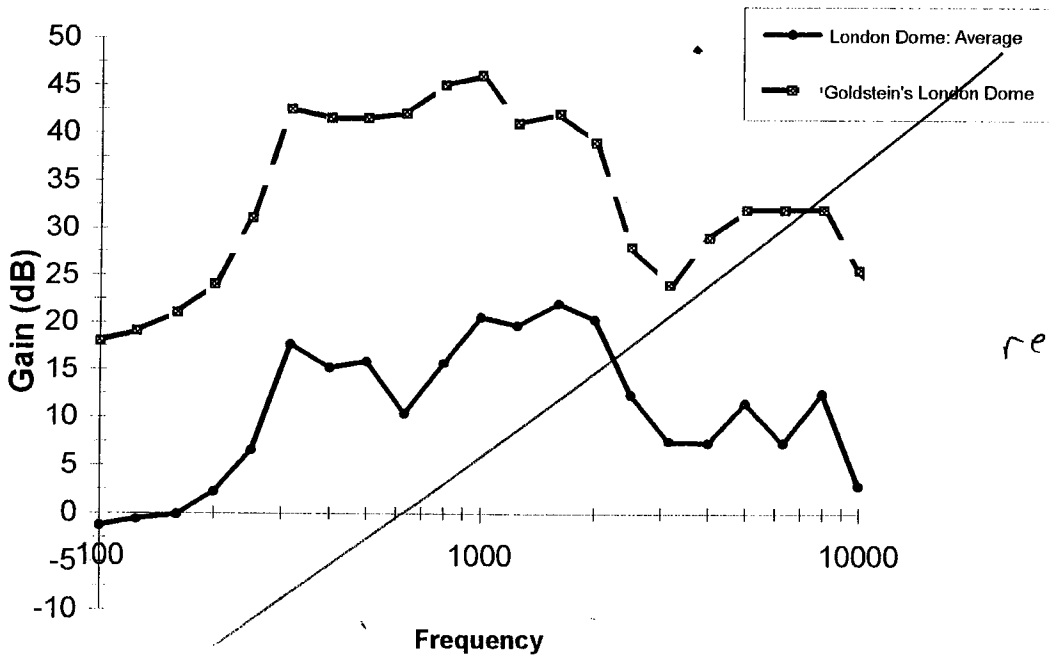
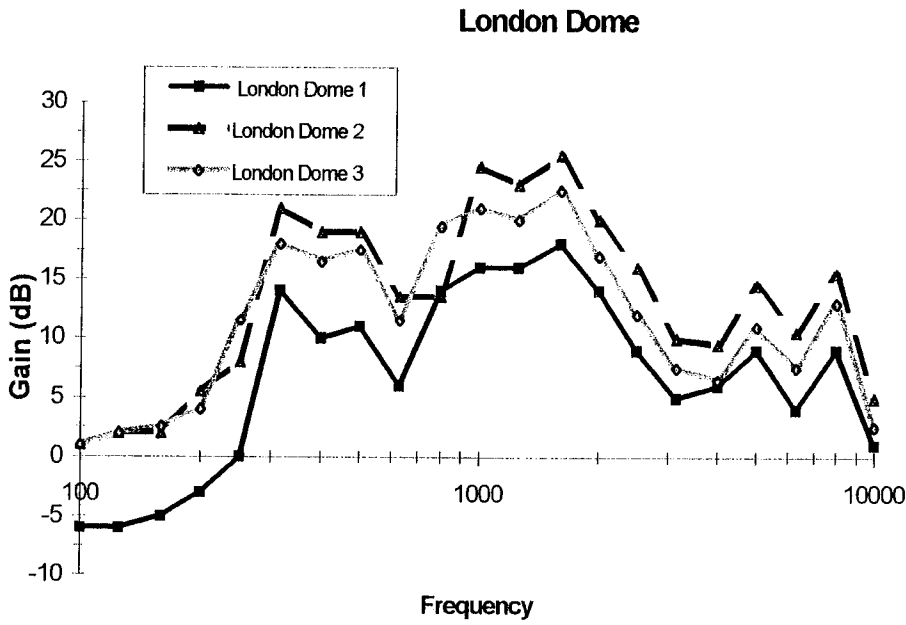
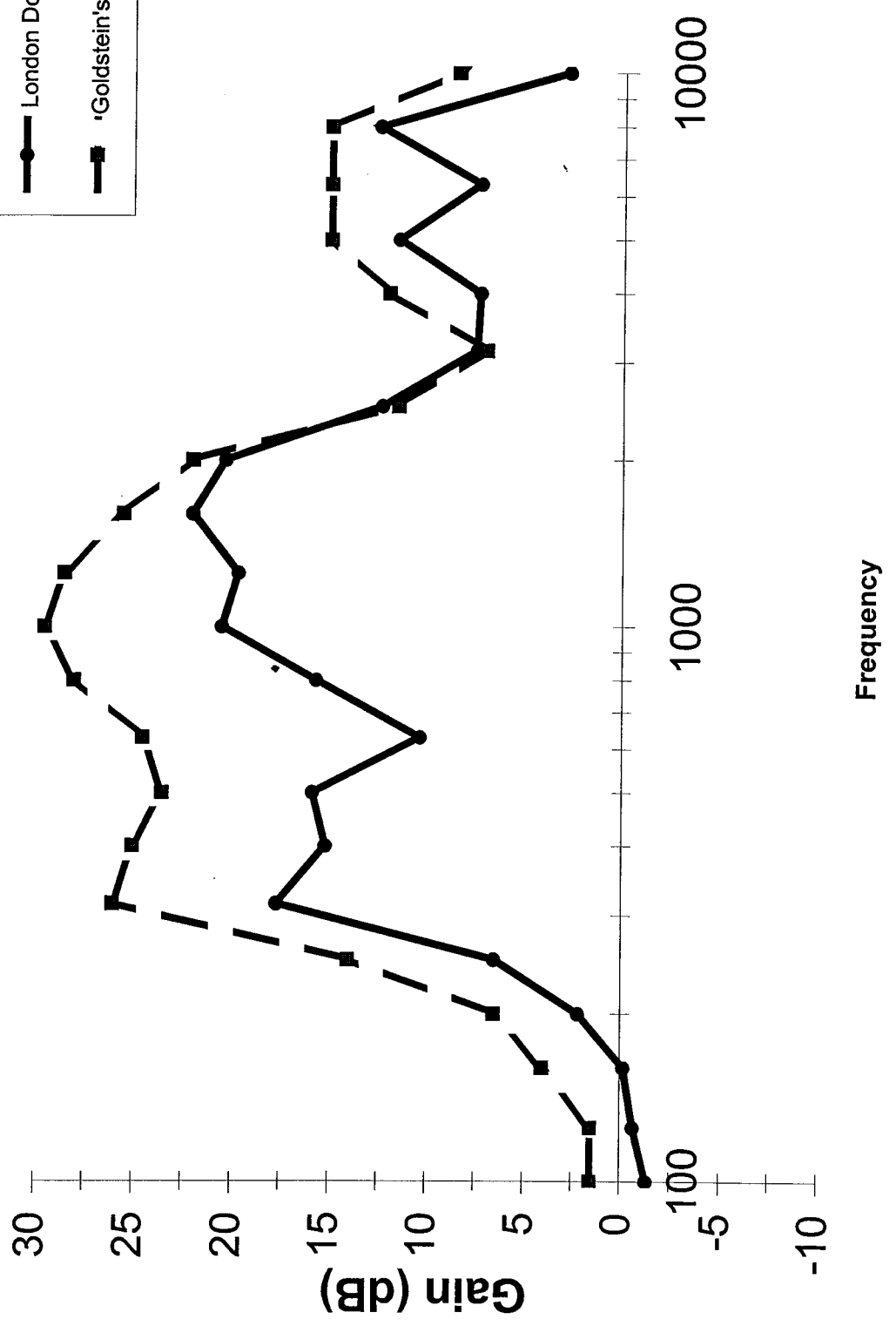
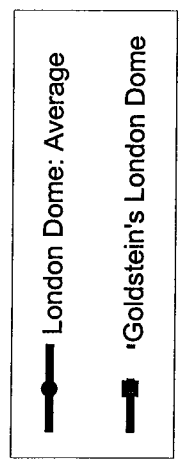


Figure 5



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Figure 6



Aurolese Phone

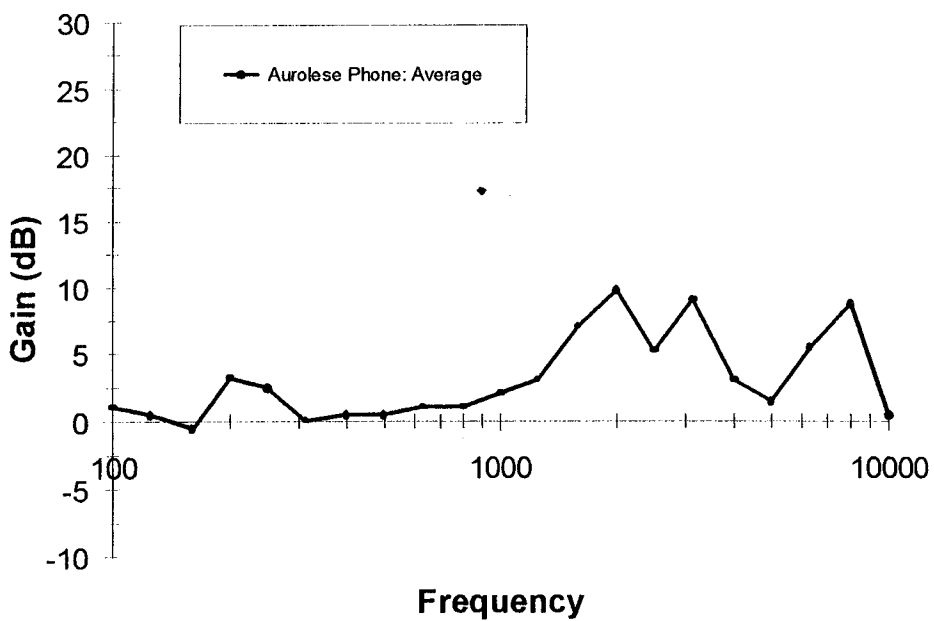
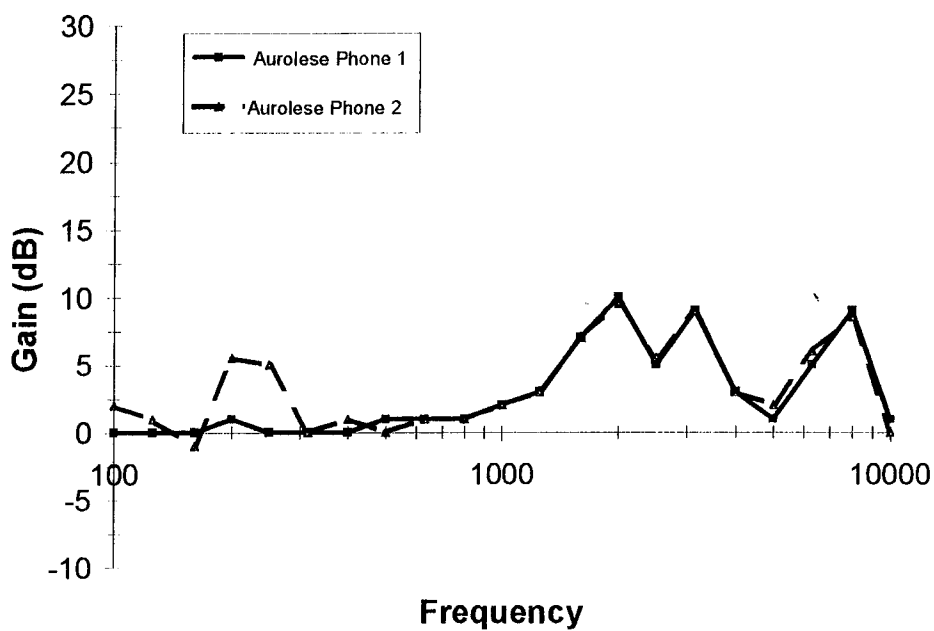


Figure 7

Appendix

device = Cupped Hand, Meas #1

<u>(Hz)</u> <u>center freq</u>	<u>(dB)</u> <u>w/o device</u>	<u>(dB)</u> <u>with device</u>	<u>(dB)</u> <u>gain</u>
63	67	68	1
80	74	75	1
100	77.5	77	-0.5
125	73	72	-1
160	70.5	71	0.5
200	73	74	1
250	73.5	75	1.5
315	73.5	76.5	3
400	75	77	2
500	75	78	3
630	75.5	79	3.5
800	76	82.5	6.5
1000	75.5	85	9.5
1250	78	88.5	10.5
1600	81	90	9
2000	89	95.5	6.5
2500	96	101	5
3150	95	97	2
4000	94	94.5	0.5
5000	90	94	4
6300	84.5	94	9.5
8000	78.5	93	14.5
10000	86.5	93	6.5
12500	84	89.5	5.5
16000	83	85.5	2.5
20000	71	72	1
max			14.5
min			-1

device = Cupped Hand. Meas #2

(Hz) center freq	(dB) w/o device	(dB) with device	(dB) gain
63	68	67	-1
80	75	75	0
100	79	77	-2
125	72	74	2
160	71	71	0
200	74	74	0
250	73	74	1
315	75	76	1
400	75	77	2
500	76	77.5	1.5
630	76	79.5	3.5
800	76.5	82	5.5
1000	76	85	9
1250	79	88	9
1600	81	90	9
2000	89.5	95	5.5
2500	96	100.5	4.5
3150	95.5	97	1.5
4000	95	94	-1
5000	91	93.5	2.5
6300	84.5	94	9.5
8000	80	93	13
10000	89	93	4
12500	84.5	90.5	6
16000	83	85.5	2.5
20000	73	72	-1
max			13
min			-2

device = Cupped Hand, avg Meas

(Hz) center freq	meas #1 gain(dB)	meas #2 gain (dB)	avg gain (dB)	Stephens Bar-Hamilton	
63	1	-1	0		
80	1	0	0.5		
100	-0.5	-2	-1.25	2	
125	-1	2	0.5	2	
160	0.5	0	0.25	2	
200	1	0	0.5	2	1.5
250	1.5	1	1.25	3	1
315	3	1	2	2	1.5
400	2	2	2	2	1
500	3	1.5	2.25	2	1.5
630	3.5	3.5	3.5	1.5	2
800	6.5	5.5	6	3	3
1000	9.5	9	9.25	10	4
1250	10.5	9	9.75	13.5	4.5
1600	9	9	9	13	8
2000	6.5	5.5	6	6	8
2500	5	4.5	4.75	4	3.5
3150	2	1.5	1.75	2	-1.5
4000	0.5	-1	-0.25	-1.5	2
5000	4	2.5	3.25	-10	2.3
6300	9.5	9.5	9.5	6	9
8000	14.5	13	13.75	-4	4.5
10000	6.5	4	5.25	8	10
12500	5.5	6	5.75		
16000	2.5	2.5	2.5		
20000	1	-1	0		
max			13.75	13.5	10
min			-1.25	-10	-1.5

device = London Dome, Meas #1

(Hz)	(dB SPL)	(dB SPL)	(dB SPL)
<u>center freq</u>	<u>w/o device</u>	<u>with devic</u>	<u>gain</u>
63	75	69	-6
80	82	76	-6
100	85	79	-6
125	80	74	-6
160	77	72	-5
200	79	76	-3
250	79	79	0
315	80	94	14
400	80	90	10
500	80	91	11
630	80	86	6
800	81	95	14
1000	80	96	16
1250	82	98	16
1600	85	103	18
2000	92	106	14
2500	99	108	9
3150	98	103	5
4000	96	102	6
5000	92	101	9
6300	87	91	4
8000	82	91	9
10000	89	90	1
12500	84	88	4
16000	83	77	-6
20000	73	69	-4
max			18
min			-6

device = London Dome, Meas #2

(Hz)	(dB SPL)	(dB SPL)	(dB SPL)
center freq	w/o device	with devic	gain
63	71	73	2
80	79	81	2
100	82	83	1
125	77	79	2
160	75	77	2
200	75.5	81	5.5
250	76	84	8
315	77	98	21
400	78	97	19
500	78.5	97.5	19
630	79	92.5	13.5
800	79	92.5	13.5
1000	78	102.5	24.5
1250	82	105	23
1600	82.5	108	25.5
2000	91	111	20
2500	97	113	16
3150	97	107	10
4000	96	105.5	9.5
5000	91.5	106	14.5
6300	85.5	96	10.5
8000	81.5	97	15.5
10000	89.5	94.5	5
12500	85	94	9
16000	83.5	83	-0.5
20000	73	75.5	2.5
max			25.5
min			-0.5

device = London Dome, Meas #3

(Hz)	(dB SPL)	(dB SPL)	(dB SPL)
<u>center freq</u>	<u>w/o device</u>	<u>with devic</u>	<u>gain</u>
63	71	74	3
80	80	81	1
100	83	84	1
125	77	79	2
160	76	78.5	2.5
200	78	82	4
250	78	89.5	11.5
315	80	98	18
400	80	96.5	16.5
500	80	97.5	17.5
630	81	92.5	11.5
800	81.5	101	19.5
1000	81	102	21
1250	84	104	20
1600	85.5	108	22.5
2000	94	111	17
2500	101	113	12
3150	100.5	108	7.5
4000	100	106.5	6.5
5000	95.5	106.5	11
6300	89	96.5	7.5
8000	84.5	97.5	13
10000	93	95.5	2.5
12500	89.5	94.5	5
16000	88	83.5	-4.5
20000	77.5	76	-1.5
max			22.5
min			-4.5

device = London Dome, avg Meas

(Hz) center freq	meas #1 gain (dB)	meas #2 gain (dB)	meas #3 gain (dB)	avg gain	Goldstein
63	-6	2	3	-0.3	2
80	-6	2	1	-1.0	1.5
100	-6	1	1	-1.3	1.5
125	-6	2	2	-0.7	1.5
160	-5	2	2.5	-0.2	4
200	-3	5.5	4	2.2	6.5
250	0	8	11.5	6.5	14
315	14	21	18	17.7	26
400	10	19	16.5	15.2	25
500	11	19	17.5	15.8	23.5
630	6	13.5	11.5	10.3	24.5
800	14	13.5	19.5	15.7	28
1000	16	24.5	21	20.5	29.5
1250	16	23	20	19.7	28.5
1600	18	25.5	22.5	22.0	25.5
2000	14	20	27	20.3	22
2500	9	16	12	12.3	11.5
3150	5	10	7.5	7.5	7
4000	6	9.5	6.5	7.3	12
5000	9	14.5	11	11.5	15
6300	4	10.5	7.5	7.3	15
8000	9	15.5	13	12.5	15
10000	1	5	2.5	2.8	8.5
12500	4	9	5	6.0	6
16000	-6	-0.5	-4.5	-3.7	4
20000	-4	2.5	-1.5	-1.0	5
max				22.0	29.5
min				-3.7	1.5

device = Aurolase Phone, Meas #1

(Hz)	(dB SPL)	(dB SPL)	(dB SPL)
center freq	w/o device	with devic	gain
63	68	68	0
80	76	75	-1
100	78	78	0
125	74	74	0
160	72	72	0
200	73	74	1
250	74	74	0
315	75	75	0
400	75	75	0
500	76	77	1
630	76	77	1
800	77	78	1
1000	76	78	2
1250	79	82	3
1600	81	88	7
2000	89	99	10
2500	96	101	5
3150	95	104	9
4000	95	98	3
5000	91	92	1
6300	85	90	5
8000	79	88	9
10000	88	89	1
12500	84	91.5	7.5
16000	83	78	-5
20000	72	68	-4
max			10
min			-5

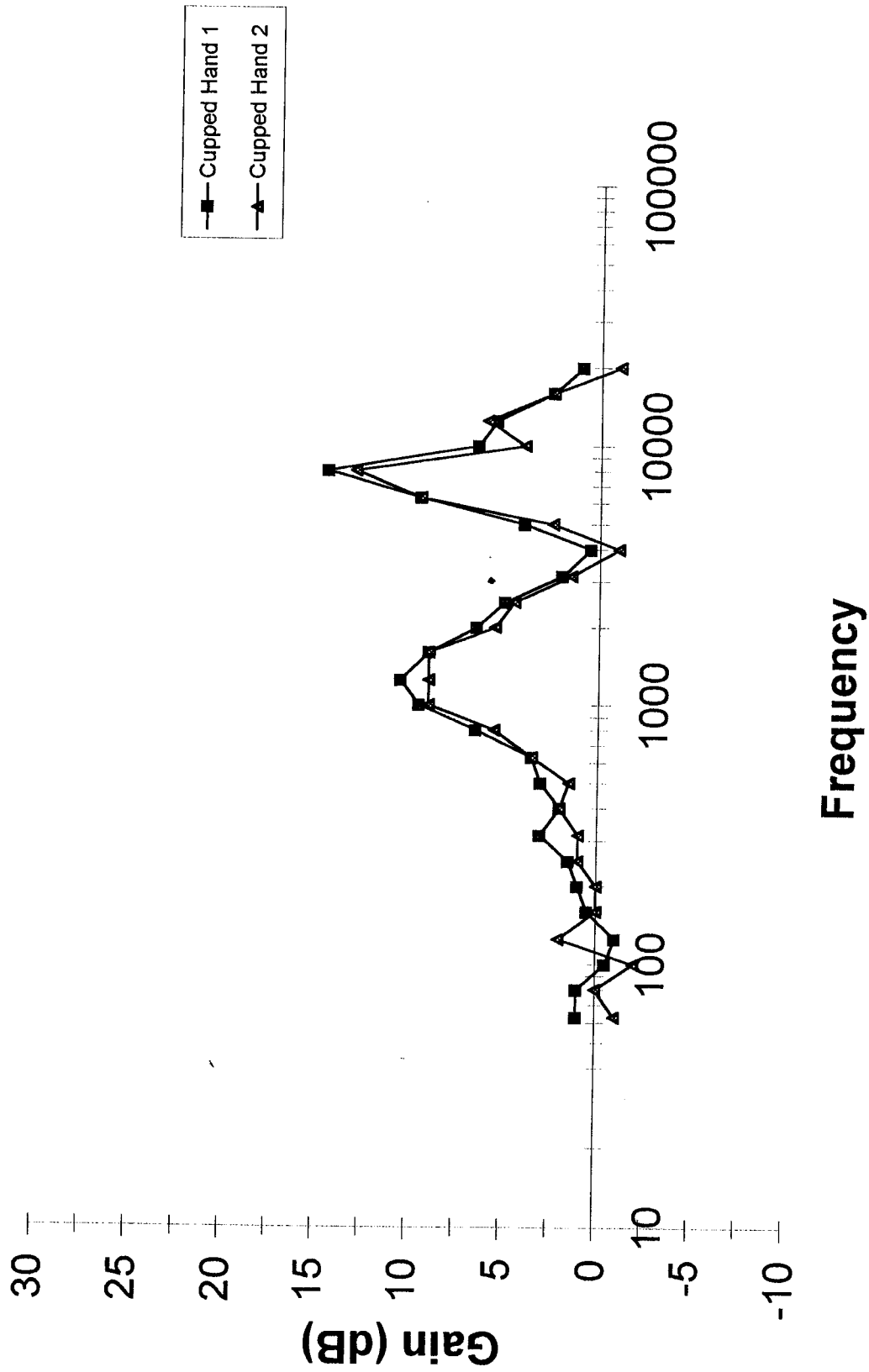
device = Aurolese Phone, Meas #1

(Hz)	(dB SPL)	(dB SPL)	(dB SPL)
center freq	w/o device	with devic	gain
63	68	68	0
80	76	75	-1
100	77	79	2
125	73	74	1
160	72	71	-1
200	73.5	79	5.5
250	74	79	5
315	75	75	0
400	75	76	1
500	76	76	0
630	76	77	1
800	77	78	1
1000	76	78	2
1250	79	82	3
1600	81	88	7
2000	89.5	99	9.5
2500	96.5	102	5.5
3150	95	104	9
4000	94.5	97.5	3
5000	90	92	2
6300	84	90	6
8000	79.5	88	8.5
10000	88.5	88.5	0
12500	85	92	7
16000	83.5	78.5	-5
20000	73	68	-5
max			9.5
min			-5

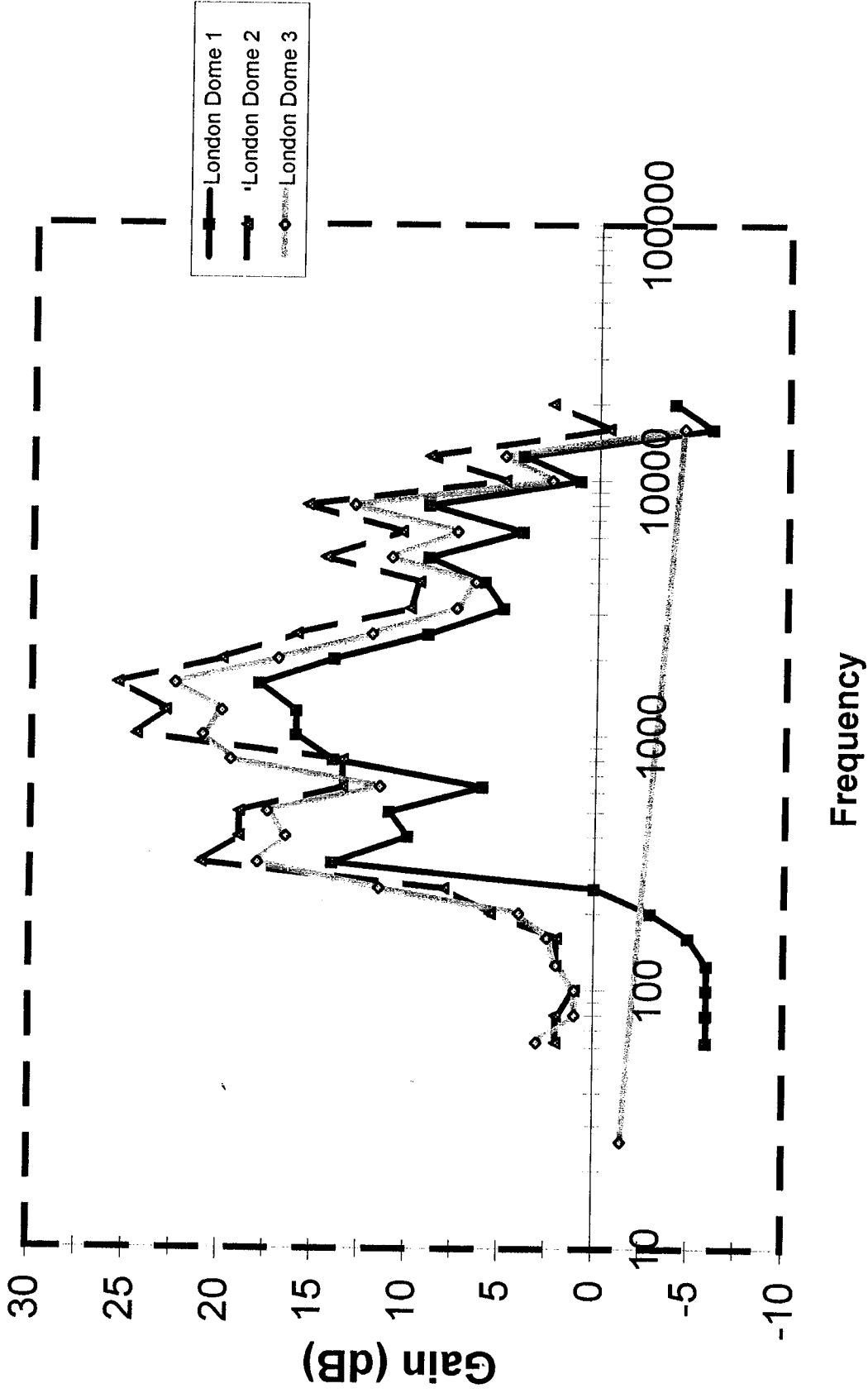
device = Aurolese Phone. avg Meas

<u>(Hz)</u> <u>center freq</u>	<u>meas #1</u> <u>gain (dB)</u>	<u>meas #2</u> <u>gain (dB)</u>	<u>avg</u> <u>gain</u>
63	0	0	0
80	-1	-1	-1
100	0	2	1
125	0	1	0.5
160	0	-1	-0.5
200	1	5.5	3.25
250	0	5	2.5
315	0	0	0
400	0	1	0.5
500	1	0	0.5
630	1	1	1
800	1	1	1
1000	2	2	2
1250	3	3	3
1600	7	7	7
2000	10	9.5	9.75
2500	5	5.5	5.25
3150	9	9	9
4000	3	3	3
5000	1	2	1.5
6300	5	6	5.5
8000	9	8.5	8.75
10000	1	0	0.5
12500	7.5	7	7.25
16000	-5	-5	-5
20000	-4	-5	-4.5
max			9.75
min			-5

Cupped Hand



London Dome



Aurolese Phone

