Proceedings of The Institute of Acoustics

DISCO DEAFNESS - THE MYTH?

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INTRODUCTION

Let it be clear that it is not the object of this paper to show that exposure to loud music will not be ultimately harmful or that it will not lead to hearing impairment. It is however intended to suggest some of the reasons why research has failed to substantiate the widely held belief that all rock musicians and all who attend rock music performances and discotheques will be deaf by the time they reach the age of thirty and to question the validity of the exposure level values presently assigned to Damage Risk Criteria or Equal Energy Concept methods of assessment after Burns and Robinson (1) Robinson & Shipton (2) or BS5330 (3) for this application.

ABOUT THE AUTHOR

The author of this paper is not an audiologist and makes no claim to be an expert in hearing conservation other than to the extent necessary in the everyday practice of noise exposure assessment and the specification and implementation of appropriate noise control measures. The author is however an acoustician with an alert sense of hearing and some 25 years experience of the pop and rock music business, first as a sound system installation contractor and rock concert sound engineer, for the last 12 years as a consultant in sound system engineering, building acoustics and noise control and as a practising musician throughout that period. The precepts of this paper are thus based initially on observation, which has lead to certain experimentation and thence to a study of the available research data.

OVERVIEW

The hypothesis is put that whilst for exposure to industrial noise audiometry has indeed been able to substantiate the criteria used this is not the case in studies carried out on those who engage in or are spectators to, modern music making. The situation is aptly stated by Fletcher (4), who, following an audiometric study in which the pure tone thresholds of 100 rock musicians and 100 rock music spectators were compared with that of 400 normal hearing control subjects concluded:-

"....Knowing the levels and durations of exposure these persons receive in that pastime it is almost unbelievable that no clearly observable losses could be found."

Simply stated, the concern is that any new codes of practice proposals aimed at volume regulation in this arena and any industry sector agreements (5)(6) which might be entered into with the Health & Safety Commission regarding the implementation of EEC Directive 86/188 (7) should be based on substantive criteria rather than on an assumed relationship which on present evidence does not stand up to objective measurement.

without peak clipping. Not only will one's reaction to the programme content be completely altered but the two sensations of loudness will be quite different.

Now test the latter symptom by listening to broad band pink noise at 90dB(A) and then listen to music at the same SPL. Which is louder? Which is more unpleasant? Whilst engaged in a survey project on a nuclear power station site (12) the author recorded virtually broad band pink noise at 96dB(A) throughout the turbine hall and would not entertain entering that building without the use of hearing protection. Yet this same author will relish a 5 hour session in a nightclub commissioning a new sound system reproducing music at some 6/8dB higher.

Such observations are not entirely without foundation, scant though this may be at the present time. The discussion on the subject to be found in the MRC Review Report (10) clearly recognises the stress element in unwanted sound and observes that:-

"....loud music appears to be somewhat less damaging than noise of a supposedly equivalent energy...."

In a study intended to test this hypothesis Barry & Thomas (13) subjected ten volunteer students to 60 minutes exposure to music and 60 minutes of noise at similar levels, measuring the effects of Temporary Threshold Shift after each exposure. The results show that the noise-induced TTS exceeded music-induced TTS by about 9dB over the midrange, whilst Chuden & Strauss (14) found that:-

"...disc jockeys developed less TTS after exposure to music then to noise of equal intensity and spectral form."

(summary extract from (10))

Clearly then subjectivity is not to be dismissed as an element to the debate.

SOUND LEVELS & SPECTRA

Much work has been carried out to study the volume levels at which rock music is played, in both a live performance and discotheque situation, much of which (up to 1980) is summarized in Fig 1 taken from the MRC Literature Review (10). Comparison with more recent data recorded by the author (15) during 1988 as shown in Fig 2 confirms that not much has changed during the 20 year period for which data is available.

What has changed however is the spectral distribution. Referring again to the MRC Literature Review (10) gives the bargraph chart of Fig 3 based on Bickerdike & Gregory 1979 (8) and Cabot, Genter & Lucke (16). However, this data is very different from that recorded by the author (15)(17) as shown by the 1/3rd octave RTA plot of Fig 4, the general pattern of which can be verified by many similar RTA plots taken in venues throughout the UK over an 8 year period (18).

THE DATA AVAILABLE

Of the earlier studies undertaken in the wake of the Burns and Robinson report (1), the outstanding work in terms of its quantity and zeal is by Fearne (19 thru 26) who, based on the results of his investigations, in 1973 submitted a report to Leeds City Council recommending that volume limi of 90 dB(A) and 93dB(A) be imposed as a condition of license. As a result a limit of 96dB(A) peak was accepted and predictably, popular music in Leeds died on its feet.

In order to protect their interests the Association of Ballrooms retained consultants to investigate the matter and as a result of a report by Burd (27) coupled with a public outcry the restrictions were eventually revised in 1975 by a new condition of license:-

"During any period of time in which music is played....the equivalent continuous noise level, Leq, shall not exceed a reasonable level. An interim code of practice will be sent in the near future....this will be based on the industrial code and will permit an Leq of 90dB(A) or the equivalent noise emission level."

As a result of this furore the Acoustics Group at the National Physical Laboratory were asked by the DoE to:

"Review the various studies....to collate the available information....and to produce a best estimate of the probability and extent of damage to hearing using the latest methods of assessment (2)...."

Therefore the ensuing report by Whittle & Robinson (28) remains firmly based on Robinson & Shipton's DRC method but does introduce a 3dB correction to the recorded LAeq level to take into account the variability and intermittency of music. This study concluded that one group of "live pop" attenders exposed to a corrected LAeq of 104DB for 4hrs per week would be unlikely to reach the low fence impairment level after 8 years exposure, but that 5% of musicians, exposed to 108dB corrected LAeq for 10hrs per week would reach the low fence level after just 2 years.

The Whittle & Robinson report provided the starting line for what is probably the most extensive study of the subject yet undertaken, in which the sound levels in 49 discotheques were monitored and the habits of 4166 attenders studied. The survey was carried out as a course project at Leeds Polytechnic School of Constructional Studies with John Bickerdike as the Project Leader. Again the conclusions reached (8) are based on DRC after Burns & Robinson (1) and Robinson & Shipton (2):

"...Although the ranges of possible exposure to sound levels in discotheques is large the risk of noise induced hearing loss....is small. Out of an estimated 6 million regular attenders some 0.025% might be expected to reach the low fence impairment level....at the end of their attendance period."

Yet the MRC consider this to be a seven-fold over estimate (10).

Turning then to actual audiometric evidence, in a study carried out in the USA by Rintlemann & Borus in 1968 (29) it was found that of 42 otologically screened rock and roll musicians aged between 16 and 23 years, exposed on average to 105dB (Lin) for 11.4hrs per week for 2.9 years, only 5% showed any symptom that could be diagnosed as noise induced hearing loss (NIHL) when tested by conventional pure tone air conduction and by bone conduction audiometry. Four years later 10No of the original subjects were still actively playing in rock and roll bands and follow-up tests showed that their hearing thresholds had not changed. 3½ years later - ie 7½ years from the date of the original study, 6No of these were still playing and further tests showed no substantial differences between the 1968, 1971 and 1974 results. The findings are shown in Fig 5, from which it can be seen that the thresholds are within normal limits on each occasion. However one musician from this group, following 9 years as a rock and roll drummer, suffered a 35dB loss at 3KHz and although this one case was considered atypical it was concluded (30):-

"Since one musician demonstrated a loss in hearing it can be said that our findings to date support the notion that there are some individuals who are seemingly susceptible to noise-induced hearing loss when exposed to levels of music commonly encountered today. However, the majority of individuals in this study could be exposed to high levels of rock music without suffering substantial changes in their auditory thresholds."

In another pure tone air conduction study, this time involving attenders rather than musicians (31) 120 college students with an average age of 20 years were divided into two groups, each group comprising 30 males and 30 females. The first group comprised those who listened to rock music for less than 2 hours per week, the second, for more than 2 hours per week. The actual exposure periods averaged out at 41 minutes for Group 1 and 5hrs for Group 2. The results showed that out of the total sample of 120 subjects, only five showed a loss of hearing, and that the occurrences of low fence impairment were equally divided between the two groups with all the 36dB Hearing threshold loss subjects in Group 1, as shown in Fig 6. The authors conclude:-

"....there was no evidence to suggest that audience members who listen to rock music frequently had poorer pure-tone thresholds than audience members who listen to rock music infrequently".

And then of course we have the study carried out for the National Institute for Occupational Safety & Health, US Dept of Health, Education & Welfare, by Fletcher in 1972 (4) as earlier cited. To fill in some of the details, the 400 control subjects, 100 rock musicians and 100 attenders were all aged between 18 and 21 and were tested using both high frequency and conventional air conduction audiology. Whilst no change was noticed between the two groups overall, either as a function of age or exposure to rock music, in the 20 year old group the rock musicians showed slightly lower thresholds than the control subjects, whilst for the 18, 19 and 21 year old groups the position was reversed. The rock music attenders are reported as attending 2/3 performances per month as well as listening to loud recorded music played over hi-fi stereo equipment at home for "several hours per day". Thus the conclusions quoted in the Overview section of this paper would appear justified and having regard to the importance of this work some surprise must be expressed that the study is not more widely known.

To return to the UK, Fearne (19 thru 26) has been active in this arena for many years, his work apparently motivated by a concern that young people should not suffer premature hearing loss from exposure to leisure activities. Along with Hanson (32) he carried out a well structured study in 1975 in which otologic history, otologic examination and reliable audiometric serial examinations were used to select 29 control subjects and 50 young adults who attended rock concerts or discotheques on a regular basis from a total of 505 volunteers. Although the results of pure tone audiometric testing showed little difference between the two groups - typically less than 5dB, the authors concluded that exposure to rock music is associated with sensorineural hearing impairment.

In two more recent studies (33)(34), again following rigourous otological screening and careful age matching, the hearing thresholds of 83 9-12 year old children who do not attend discotheques or "pop concerts" were compared to those of 61 children of the same age group who do, and 135 teenagers aged between 13 and 16 who do attend were compared with 88 who don't. The merged results of the two studies - taken from a summary in the MRC Literature Review (10) - are shown in the table of Fig 7 and again it can be seen that the differences between the two groups are of marginal significance. Yet the authors conclude that amplified music is the cause of hearing losses in children.

Given a low fence impairment level of 30dB and a minimum audiometer step of 5dB Fearne's results seem almost insignificant and certainly do not appear to support the conclusions being drawn. This scepticism is supported by Rintlemann & Bienvenue (35), the MRC Literature Review (10) and by Knight (32) and a study of Fearne's titles (19 thru 26, 32 and 33) suggest increasing fervour bordering on obsession, even though his motives are not in doubt.

The final study to be considered was conducted by Martinez and Gilman at the 83rd AES Convention, held in LA in November 1986 on the basis that many AES members would be exposed to high levels of reproduced sound in their occupations (37). A random sample of 229 volunteers were given pure tone air conduction audiometry to establish their hearing thresholds. The volunteers were divided into five age groups and four occupational groups and results analysed accordingly. Fig 8a shows the tabulated results of the survey, Fig 8b the associated table of standard deviations and Fig 8c the mean results by age group. Fig 8d shows the results after the application of Spoor's Correction (38) and Fig 8e the corrected results by occupation.

From Fig 8c the authors conclude that as the Spoor Correction has failed to normalise the curves, the residual 4KHz dip shown in respect of the 40-49yr group in particular and the 10dB or so loss at higher frequencies shown for the 50-59yr group demonstrates NIHL at a level beyond that to be expected in a normal population. They also express concern over the wide variability in the results as shown in the Standard Deviation table of Fig 8b and the trend towards greater deviation at the higher frequency test tones and upper age groups.

Yet this conclusion appears to be contradicted by the results shown in Fig 8e. Surely, if occupational noise were the cause then the recording engineers group would show greater NIHL than the other groups with managers the least affected - but this is not the case and the authors do not address this discrepancy at all in the formulation of their conclusions.

OTHER STUDIES

There have been many further studies carried out and those of uncertain reliability or not directly relevant have been omitted from this review. Also, those study methods based on histology have been omitted partly because the author is sceptical of the relationship between the hearing characteristics of animals with those of human beings and partly because of a general disapproval of the practice per se.

Also those studies involving TTS and whose predictions are based on a relationship between TTS and PTS have been omitted because it is considered that the assumed relationship is not proven (10, p65) & (35). So whilst all the available evidence as summarised in Fig 9, coupled with subjective experience, confirms that TTS is certain to result after exposure to loud music, its relevance to permanent PTS and NIHL is at present unclear.

CONCLUSIONS

It has been shown that for each study that might be cited to support the case for the inclusion of "music" within the scope of the Burns & Robinson (1) and Robinson & Shipton (2) criteria, there is another which will suggest otherwise with equal conviction. It has also been shown that conclusions reached by certain authors do not always stand up to scrutiny and it is suggested that a number of papers which would appear to support the case for DRC assessment can equally be interpreted to make a better case the other way. There also appears to be some evidence to support the widely held supposition that sounds which are pleasing are less stressful and therefore less damaging, than unwanted noise.

No one wishes to see the hearing of future generations being eroded through exposure to dangerous levels of noise or music, and at the same time, there is no virtue in regulation for its own sake. Most responsible people will react positively to regulation which is seen to be necessary and accepted as reasonable, otherwise opposition is certain and enforcement becomes impossible - as for example the outdated 70mph speed limit on an open motorway.

The following conclusions are thus drawn from this review paper:-

i) The DRC values cannot be justified on the present evidence .

ii) There is a clear need for further properly conducted and rigorously controlled research on a much larger scale and on all fronts before realistic exposure criteria for music can be determined.

iii) Based on a balance of the presently available data an interim value for Lep,d should be established to be used in the enforcement of the Health & Safety at Work Act Regulations where the principle exposure is to "music" rather than to "noise". Alternatively exposure to music should be excluded from the scope of the Regulations until a proper basis for its inclusion can be established.

iv) Interim codes of practice for the performance of live music, for discotheques and for the recording industry should be formulated to alert operators to the dangers of excessive volume levels and to set realistic maxima based on a balance of the presently available data.

v) Provision should be made for (iii) and (iv) to be revised periodically in the light of experience and of new information arising from (ii).

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TABLE 5 SOUND LEVELS FROM LIVE POP/ROCK GROUPS USING AMPLIFICATION

Authors	Year & IHR no.		Comments	LIN	dB(A)
Lebo & Oliphant	1968 145 + 154	USA	Hall "A"	109	106
			Hall "B"	118	111
Rintelmann & Borus	1968 80	USA	5 groups read 5-20 ft from stage	106	100
				106	102
				108	103
				104	97
				107	104
			group 40-60ft from stage	98	90
Flugrath	1968 148		10 groups	108	106
				98	97
				102	99
				103	102
			1 ft from stage	98	95
				105	104
				105	103
				105	104
				99	99
				105	104
Lipscomb	1969 155	USA		122	114
Rice	1969 159	UK	Dance floor	-	105
Dey	1970 242	USA	30 ft from loud-speakers	108	100
Abrol, Nath Sahai	1970 105	New Delhi		104	100
				106	101
Hickling	1970 245	New Zealand		104	99
Speaks, Nelson Ward	1970 81	USA	10 groups, 15 measures each, table shows max. and min. values	116	111
				101	95
Fearn	1972 261	UK		112	109
Flottorp	1973 127	Norway		113	111
				112	110
				110	106
				115	110
Rupp, Banachowski, Kiselwich	1974 250	USA			102
					116
					104
Ulrich, Pinheiro	1974 251	USA	Figures read off small chart		90/95
Barry, Thomas	1972 83	USA	Figures inconsistent		105
Bickerdike, Gregory	1980 39	UK	Unlicensed:	119-121	116
			Licensed:	95-126	89-119

Fig 1 FROM MRC LITERATURE REVIEW (10)

TABLE 1: Venue Volume Levels

Measurement Location	Mean SPL	Mean Devn	Max SPL	Min SPL	No Smpls
Dance Floor:	103dB(A)	1.5	107	99	12
DJ Console:	99dB(A)	1.6	104	98	12
Bar Serveries:	90dB(A)	4.2	100	73	36
Lounges:	90dB(A)	4.5	98	75	32
Restaurants:	84dB(A)	6.1	89	70	10

Fig 2 FROM THE 1986 BEDA SURVEY REPORT (DIBBLE 16)

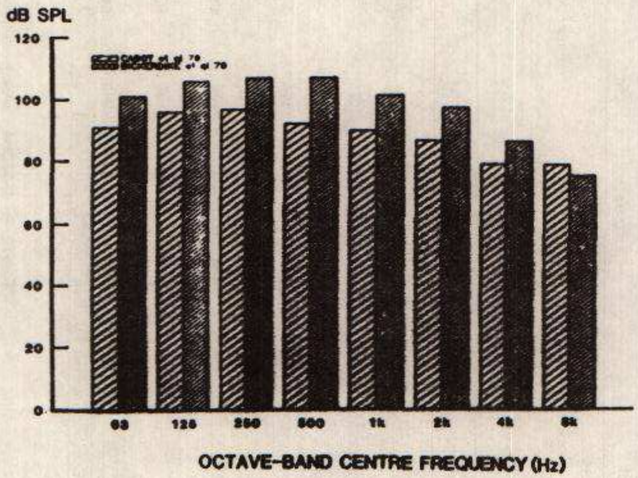

Fig 3 FROM MRC LITERATURE REVIEW (10)

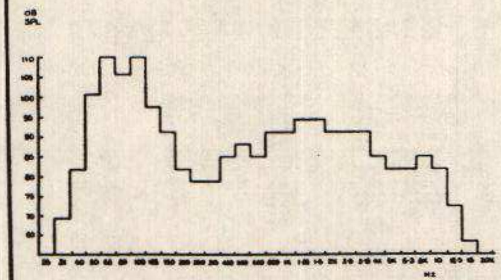

Figure 1 Typical 1/3rd Octave Band Analysis of Discotheque Music; Measured Level 96dB(A). Dance Floor - 1987

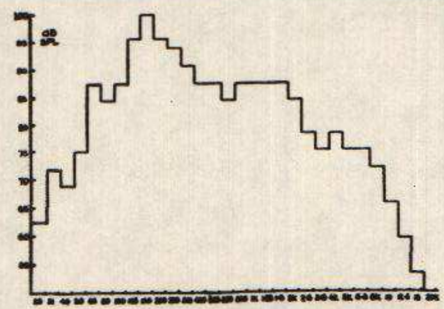

Figure 2 Typical 1/3rd Octave Band Analysis of Rock Concert Performance ; Measured Level 96dB(A). Theatre Circle Front 1986

Fig 4 FROM ACOUSTICS INDEX REVIEW PAPER 3.6 (Dibble 17)

Table III. Number of Instances by Frequency (kHz) in which Thresholds Among the Four Groups of Rock Music Audience Members Exceeded Limits of Normal Hearing * (N=120)

Group Exposure Time	26-35 dB HTL					N**	36 dB HTL or Poorer					N**
	Frequency in kHz						Frequency in kHz					
	2	3	4	6	8		2	3	4	6	8	
Less than 2 hrs.												
Males	1		1	2	3		1	2	1	1	2	
Females				1					1	1	2	
						8						13
More than 2 hrs.												
Males				2	1							
Females				1	3							
						7						0

*Poorer than 25 dB Hearing Threshold Level (re ANSI 1969 Norm).
**N = total by group

Fig 6 FROM RINTLEMANN & SMITELY 1971 (31)

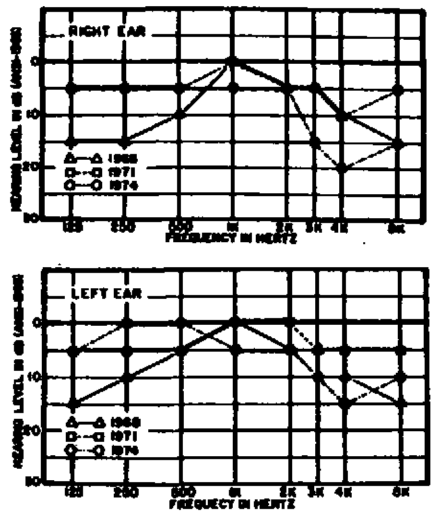

Fig. 5 A comparison of the mean pure-tone air-conduction audiograms from 1968 to 1974, rounded to the nearest five decibels, for the six musicians' right and left ears respectively.

[*from Rintelmann and Johnson (1975)*].

DISCO DEAFNESS - THE MYTH?

TABLE 27 TEMPORARY THRESHOLD SHIFT REPORTED AFTER EXPOSURE TO ROCK/POP MUSIC

Reported by	Year & IHR no.	No. of subjects	Age range	Noise level	Exposure time	Freq. of max. shift	TTS dB	TTS statistic	Time of start of testing after exposure
Rupp & Koch	1969:244	5 musicians	19-20	120-130 dB(C)	2½ hrs.	4 kHz	25	median	"immediate"
Hickling	1970:245	4 lab subjects	?	107 dB(C)	20 mins	4 kHz	8	mean	2 mins
Speaks, Nelson, Ward	1970:81	25 musicians	?	90-110 dB(A)	2½ hrs.	4 kHz	8	mean	20-40 mins.
Day	1970:242	15 male	18-25	range 100 dB(A) for	30 mins	2 kHz	14	mean	up to 10 mins or longer. Corrected to TTS_2
Jerger & Jerger	1970:152	5 musicians	17-23	104-124 (dB, octave band)	4 hrs	3 kHz	22	mean	within 60 mins
		4 musicians	14-15	108-116 dB(C)	4 hrs	6 kHz	15	mean	
Cohen, Anticaglia, Jones (quoted in Whittle & Robinson 1974:128)	1970:107	6	teenage High School	112 dB(A)	3 hrs	3 & 4 kHz	17	mean	Immediate
		5		105 dB(A)	1½ hrs	4 kHz	6	mean	
Smitley & Rintelmann	1971:246	40	18-24	110 dB average peak SPL	1 hr (continuous)	4 kHz	27	mean	2 mins
					1 hr (with 12x30sec off periods)		25		
Flugrath, Irwin, Wolfe Krone & Parnell	1971:149	7M	13-20	96-113 dB(A)	10 mins	6 kHz	4		
		19F				"	12		
		6M			20 mins	"	7		
		18F				"	5		
		8M			30 mins	"	4		
		13F				"	15	mean	2-5 mins.
		6M			40 mins	"	10		
		9F				"	15		
		6M			50 mins	"	3		
		10F				"	3		
		7M			60 mins	"	11		
		2F				"	5		
Rintelmann, Lindberg & Smitley	1971:31	20 female	20-22	110 dB(C) continuous	60 mins	4 kHz	26	mean	2 mins
				3 mins on, 1 min off		4 kHz	23		
Redell & Lebo (quoted from Whittle & Robinson 1974:128)	1972:158	7	22	108 dB(A) estimated	1 hr	6 kHz	21	mean, at 6kHz	"immediate"
Ulrich & Pinheiro	1974:251	14	teens	110-115 dB SPL	3½ hrs	4 kHz	18 (R)	mean, at 4kHz	30 min
						4 kHz	15 (L)		
Axelsson & Lindgren	1978:37	30 musicians		95-110 dB(A)	50-240 mins	4 kHz	1 to 22	Range for 1-8 kHz average	Mostly 2-15 min
		18 audience		88-110 dB(A)	45-180 mins	4 kHz	-6 to 21		

Fig 9 FROM MRC LITERATURE REVIEW (10)

TABLE 33

HEARING THRESHOLDS OF VARIOUS GROUPS OF OTOLOGICALLY NORMAL

(from Fearn 1981:259 (Table 2) and Fearn and Hanson 1983:515)

(a) Those who do not attend discotheques/pop concerts:

ages	N	dB HL 500Hz	1kHz	2kHz	3kHz	4kHz	6kHz	8kHz
9-12	83	4.2	3.0	0.8	1.3	2.1	3.8	2.5
13-16	135	6.8	1.3	0.9	0.1	2.4	6.8	5.3

(b) Those who attend discotheques/pop concerts (same sources)

9-12	61	7.9	4.8	1.6	2.8	4.8	8.1	7.2
13-16	88	8.2	3.8	1.7	2.0	4.2	7.9	7.0

(c) Differences between above two sets of data

9-12	3.7	1.8	0.8	1.5	2.7	4.3	4.7
13-16	1.4	2.5	0.8	1.9	1.8	1.1	1.7

ADAPTED FROM FEARNE (83) & FEARNE & HANSON (84)

Fig 7 FROM MRC LITERATURE REVIEW (10)

Table 1. Mean hearing thresholds (dB re: ANSI, 1969), uncorrected for age.

	Number in group	Frequency (Hz) 500	1000	2000	3000	4000	6000	8000
Occupation								
Recording engineer	100	5.3	2.7	0.9	7.1	12.3	14.0	11.5
Manager	34	5.0	1.5	−1.4	5.1	9.3	13.6	12.7
Vendor	49	7.3	3.8	3.1	8.3	16.1	19.5	19.3
Other	46	6.8	6.5	3.7	10.7	14.8	17.1	17.0
Age								
<30	53	5.2	2.6	−0.6	2.3	4.9	7.2	6.4
30−39	107	4.2	0.7	−2.3	3.1	7.1	9.7	8.4
40−49	37	7.1	4.7	5.4	12.9	21.8	21.8	19.8
50−59	12	10.6	11.0	8.1	20.8	33.3	39.2	38.5
>60	20	13.3	14.8	17.3	30.0	40.5	45.2	45.0

8a

Table 2. Standard deviations from threshold

8b

	Frequency (Hz) 500	1000	2000	3000	4000	6000	8000
Occupation							
Recording engineer	4.5	5.4	7.5	9.4	11.8	11.6	11.9
Manager	4.8	5.3	7.3	9.1	11.3	16.6	16.6
Vendor	6.8	6.2	7.9	10.8	12.4	13.6	15.8
Other	5.2	9.7	10.3	12.6	13.8	12.7	12.0
Age							
<30	4.1	4.1	5.9	7.0	8.5	8.1	7.7
30−39	4.1	4.5	6.1	8.3	9.9	10.3	10.5
40−49	4.7	5.9	8.3	13.3	15.3	18.5	19.3
50− 59	9.2	10.2	13.0	18.1	20.6	20.4	18.5
>60	9.5	15.0	14.8	15.1	16.6	17.1	20.4

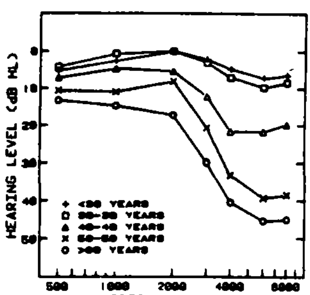

Fig. 2. Mean results of 1986 AES audiometric survey categorized by age groupings.

8c

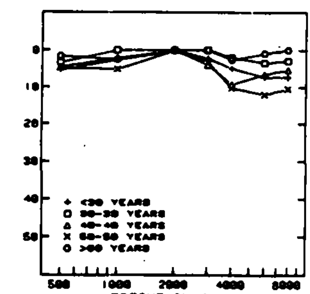

Fig. 3. Mean results of 1986 AES audiometric survey after application of Spoor's [5] correction for aging. Groupings are as in Fig. 2.

8d

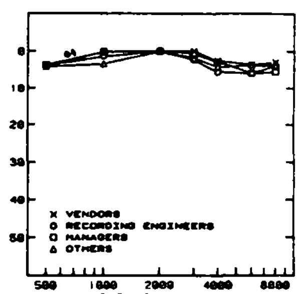

Fig 4. Age-corrected results of survey with membership grouped according to occupational categories.

8e

Fig 8 FROM THE 1986 AES AUDIOMETRIC SURVEY (MARTINEZ & GILMAN 37)