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TELLING THE STORY THROUGH YOUR MEASUREMENTS - POST MEASUREMENT DATA ANALYSIS USNG STANDARD SOFTWARE TOOLS

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1. Advantages of Computer Aided Measurements

Computer aided techniques have improved the power and versatility of measurement tools, removing much of the laborious manual recording and interpretation which used to be required. Measurement accuracy, resolution and speed have been improved. Today we can rapidly produce reams of test results with eight figure resolution where one page of measurement results with two or three digit resolution would have been the norm a few years ago.

Instruments (or their controllers) also provide computational and analytical resources which are integrated into their control software - making post processing and display functions easy to perform. MLS or other FFT/impulse response based techniques can allow a multiplicity of results to be extracted from one measurement. The Audio Precision System One makes it easy to produce custom scaled graphs relating almost any two measurement parameters using conventional or digital technologies. IVIE provide a software package which allows measurement data obtained with their PC40 Real Time Analyzer to be easily viewed with respect to each other or to NR/NC octave band curves.

Sometimes, indeed we find often, the analysis tools which come with our instrument are inadequate to clearly show the relationships which we require. Additionally, to aid us in communication, we want to take source data which we are trained to interpret and massage it into a form which a lay person can understand. A further advantage of computer aided instruments is that the data are frequently available in a form which can be translated more or less automatically - to serve as input to other software packages. This paper will discuss practical applications requiring post-measurement analysis and techniques which can be applied using standard software tools to effectively perform this analysis. The software tools used at Sam Wise Associates are the Borland Quattro Pro spreadsheet, Wordperfect 5.1, FastCAD CAD package, and Aldus Pagemaker desk top publishing system.

2. Macro Languages

A feature which is common to all of these software packages (except Pagemaker) is a macro language. Macro languages typically consist of commands which replicate the users keyboard and mouse functions and allow them to be automatically repeated. Quattro Pro and Wordperfect along with measurement systems such as the Audio Precision System One and MLSSA allow automatic recordings of the keyboard entries to be made. This sequence of commands can then be named, assigned to a function to key or ALT- combination and instantly replayed when required. This looks easy, and generally is, except that each software package has a personality and there is a period of 'getting acquainted' required before efficient results can be obtained.For the future the Windows and Macintosh operating environments are expected to provide a greater uniformity of behaviour.

Macro languages also typically include a set of commands which are not readily available to the user, but allow programming structures to be imposed. This allows error trapping, decision based flow control, Go No-Go result printing and other benefits.

3. Practical Application - Sound System Tuning

3.1 The initial tuning process

Enough for introduction and theory, let's look at a practical measurement problem and an approach to overcoming it. For this example we will use the Borland Quattro-Pro spreadsheet and the IVIE PC40 1/3 octave analyzer, two of our most liked tools.

In the sound system tuning and commissioning process there are several stages. After ensuring that everything is hooked up as intended and functions properly, the first step is usually a rough coverage check and level set. This is necessary prior to cluster signal alignment since re-pointing devices will often result in shifts in mechanical alignment, undoing much of our signal alignment. So we 'walk' the system, initially a device at a time (Fig. 1), with ears and possibly a level meter or real-time analyzer. If required, some spot measurements can be stored for future reference and/or an automatic time and space average can be made. During this phase a first pass level and spectrum balance throughout the room can be made.

Once coverage is checked, groups of devices are turned on (Fig. 2) and signal alignment/equalisation begins. In most rooms our experience is that properly interpreted 1/3 octave analysis and click measurements with ears/scope will provide sufficient information for this job. A few TDS type measurements in the device overlap zones can be helpful, but for overall sound system analysis, TDS methods are time consuming, requiring the setup to be altered as distance from the source changes. The TDS type measurement shows lots of detail, but the steady state measurement usually provides enough information to do the alignment job, though fine detail HF comb filtering may not be visible. For overall response measurements in rooms exhibiting reasonable speech articulation at a T60 of up to 2.5 seconds, comparison of 50 msec and 80 msec time window analysis (direct plus early reflections) with a steady-state 1/3 octave analysis reveals only small differences.

POST MEASUREMENT DATA ANALYSIS

Sorting out problems due to room/device interaction or room acoustics are probably best examined by TDS techniques (Fig. 3 and 4).

Having done a first pass tuning including level balance, signal alignment and equalisation (and often some further system debugging), it is time to examine the whole room again and look at the overall result. Unfortunately, getting to this point is tiring and it is often very early in the morning after a night of work. Exhaustion can take over and the tuning process can end with a bit of wandering around is done with our 1/3 octave analyzer while observing the display, coat is donned, and we are off to an all night eating establishment and long drive home or we collapse into a local hotel bed.

However, tired or not, our desire is to know how close we have really come to our objective - a room response meeting our house curve requirement with no SPL variation over the space. We also want to compare the room response with the area around the mix position and to examine the sound spilling into unwanted areas such as the stage. If there are unacceptable deviations we want to obtain enough detail from our measurements to identify the problem and do something about it. Here is where our trusty computer and hours spent tuning up our software begin to pay off.

As stated earlier, the sound level measuring instrument used most frequently by Sam Wise Associates is the IVIE PC40. This provides 20 directly accessible storage memories with additional backup memories in battery backed RAM if required.

3.2 Measurement Point Pre-Selection

A little advance planning can prove to be useful in improving site efficiency. Before tuning, it is a good idea to preselect measurement points including perhaps 10 measurements in positions which are not expected to be a problem and which cover most of audience area (Fig. 5). A further 10 measurements can be made in marginal zones. The measurement point selection process should also be linked to device coverage areas to allow the results to lead easily to correction. Preselection also allows the commissiong engineer to sit drinking coffee, while his assistant climbs around the building (Fig. 6). The measurement process in a typical two or three tier concert hall or theatre will take 10-15 minutes. After this, while sitting at your computer enjoying your coffee, the measurements can be transferred, loaded into the spreadsheet and the results considered. At SWA, we have automated this process by building a spreadsheet model which calculates the average and standard deviation of the room measurements. This will then automatically display the results in graph form along with the individual measurement curves if required. Let us examine this process step-by-step.

POST MEASUREMENT DATA ANALYSIS

The steps are as follows:-

1) Transfer the data from instrument to PC. This is done using the transfer software on both machines.
2) Translate data to suitable form for a spreadsheet - This is done with PC-PC40 software package available from IVIE.
3) Input data into the spreadsheet - To simplify this we have written macros which select the correct import command, prompt for source filename, load the data and reformat it to fit our pre-defined tabular structure.
4) Some data selection may be required manually within the spreadsheet.
5) View pre-defined graphs.

The whole process takes only about 3-5 minutes.

3.3 A typical sound system - applying results

Here is an example of a typical sound system (Fig. 7). This one is not of SWA design, but we were asked to test, rectify and tune it.

The graphs (Fig. 8) show the results of first stage tuning. Notice that in this installation there is only one equaliser on the whole complex cluster assembly. There is also only one crossover on the system. No alignment delay is provided, so the only correction available at device overlap frequencies is crossover phase adjustment. Therefore, variations in frequency response with respect to various room areas can only be adjusted by relative balance adjustments between bass, mid and high devices using the power amplifier level controls. Since there is only one equaliser, it is genuinely only affecting the average room response provided by the whole cluster. Referring to the measurement data, the shape of the average curve gives us a good approximation to the average steady state room response. The +/- standard deviation curve gives us an indicator as to what might be called the coherence of the average measurements. I.E., a widening of the standard deviation at a particular band of frequencies may well indicate the average is not a very reliable measure across a range of seating. The individual curves allow identification of individual seating areas and therefore cluster components which might need adjustment to narrow the standard deviation before equalisation begins.

The next graph (Fig. 9) shows the results for further adjustment to device drive levels, crossover phase adjustment and two passes at equalisation. There is a vast improvement over the original result obtained following our 'rough' alignment. This improvement process took about two hours in total, including a trip into the roof to alter amplifier gain settings.

It is easy to see that a day or two spent structuring and programming a spreadsheet can pay dividends in both speed and quality.

4. Application Example - Noise Control

Here is another example. In this case we are trying to convey to an architect the requirements of wall performance for noise control. First, the site is surveyed to determine ambient noise. This particular room is acoustically dry, so corrections to SWL have been disregarded, however it would be easy to import T60 results and let the spreadsheet automatically calculate these corrections.

A limitation of the present release of the Quattro spreadsheet is the ability to display only six sets of data at a time. However, the fact that there can be a large number of graphs pre-programmed and named means that this is a minor inconvenience.

In this design, our requirement is to meet NC 20 performance, so we select the NC 20 graph, select the series of measurements we want to examine and then graph the result. Fig. 10 shows the tabulated results of the performance required from the wall, and Fig. 11 shows the same information in graphical form, suitable for discussion with an architect.

Fig. 12 goes one stage further and shows the performance of various standard wall constructions compared to our ideal requirement. We have also used these techniques to calculate and display design criteria using room-to-room attenuation requirements from people like the BBC and to compare these with proposed construction techniques.

To improve our presentation, which is often the point of these activities, Quattro includes an annotating package which allows comments, etc. to be added to graphs to clarify points.

The ability to load data back into the PC40 means that this design performance can be stored in the PC40 for instant on-site comparison with realised performance using the built in curve difference function within the PC40.

5. Application Example - Loudspeaker Polar Plots

As a final example, we will look at the production of loudspeaker polar performance data using PC40 as a 1/1 and 1/3 octave measurement device and Fastcad as a graphics presentation tool. Like Quattro, FastCAD has a macro language which allows the automation of a process, in this case, the construction of a polar grid, importation of data, and automatic plotting of the data. Drawing a polar grid is presently beyond Quattro, although it is useful for calculating things like device "Q" from polar data. At present, at SWA we have a short basic programme which converts a series of angular single point 1/3 octave measurement data made by the PC40 into a form suitable for FastCAD. In development is a routine for use with our Audio Precision System One which will control an automatic turntable, perform a 1/3 octave bandwidth measurement over a series of 1/3 octave frequencies in the analogue domain, then perform the same measurement using TDS techniques. An automatic Quick Basic routine will convert and save the data from within an Audio Precision procedure (macro sequence), then prepare for a further series of measurements. This technique can be used to map a loudspeaker device, or modified somewhat it could be used to perform sound power measurements.

Fig. 13 shows standard output from the present equipment and software routines.

The appendix gives our recommendations for structuring spreadsheets and their macro programmes.

While not having time to discuss uses of Wordperfect, it will probably suffice to say that at SWA we have produced several professional user and technical manual using nothing but Wordperfect 5.1, and importing graphics into it from our spreadsheet and CAD packages.

6. Summary

As acoustics engineers, we now have available a set of hardware and software tools which allow for fast, accurate and useful measurements. A little effort applied to the customization of these tools can produce very useful and presentable information in graphic and tabular form which speeds up the work we do in unsocial hours and improves our customer profile.

7. Appendix

Recommended spreadsheet macro programming practice.

Programming using macros is identical in its disciplines to any competent programming practice. It is easy to sloppily construct a collection of macros, but the best results are achieved when the data is structured and the required operation designed carefully.

In addition, like other programming techniques, it is important to document the program. Below is an example of practice at SWA. In Quattro, pressing the HOME key immediately takes the user to the top of the spreadsheet, so this is a good place to locate an explanation of what the programme does and what special functions are included. Therefore, any staff member can use any macro program created by any other, preventing re-invention of the wheel.

Below the explanation is stored the macro programs themselves. You will note, that just as in other good programming practice, structuring using sub-routines or procedures is used. A column on the left contains labels, the next column contains the program, and a column to the right contains explanatory comments. Although possible 30 extra minutes may be required to complete this process, it is paid for as soon as a staff member leaves, or a program requires modification or debugging at a later date.

Space is left both vertically and horizontally within the spreadsheet structure. This allows the macros and comments to be editing, including the insertion or deletion of rows or columns, with accidentally destroying other parts of the spreadsheet.

Then tables containing data on things like NC/NR curves, standard wall construction performance, etc. is stored in tabular form, labelled to allow its easy access. Below this is our principal calculation area in the spreadsheet. Finally, at the bottom is the spreadsheet load area. Here is where the unformatted instrument data comes in. It can be reformatted and automatically loaded into the table structure above, then this section can be cleared for future use. Placing this area at the bottom is again a safety measure, rows can be deleted without any risk at all.

Determining Single Device Performance

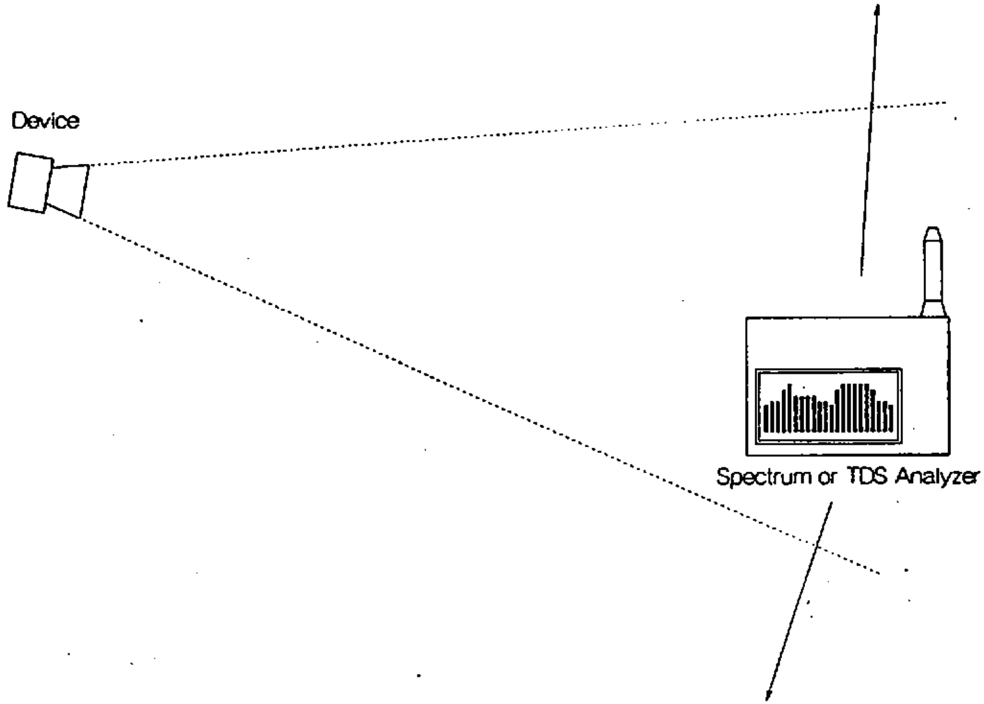


Fig. 1

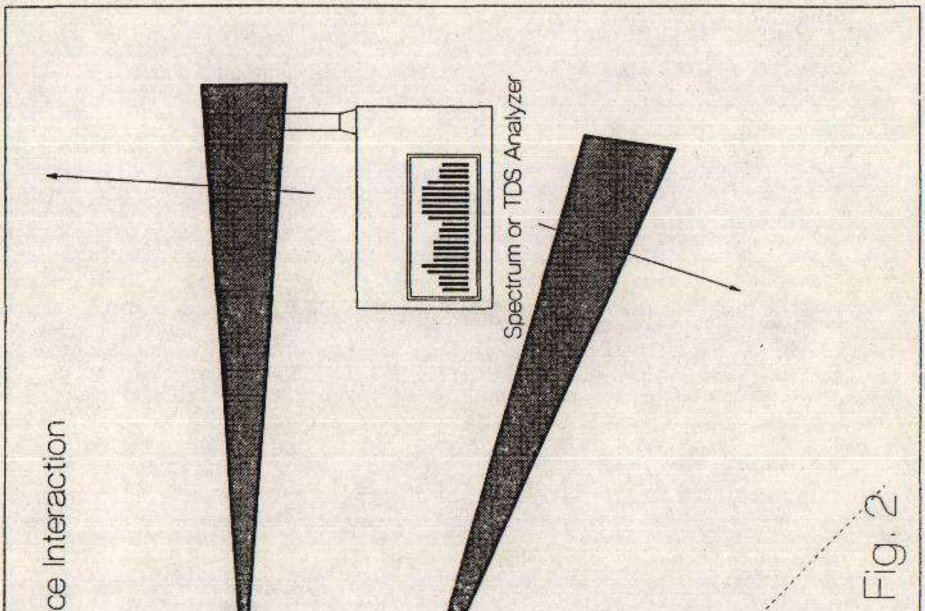

Device Interaction
Spectrum or TDS Analyzer
Cluster
Overlap Zones
Check Signal Alignment Here

Fig. 2

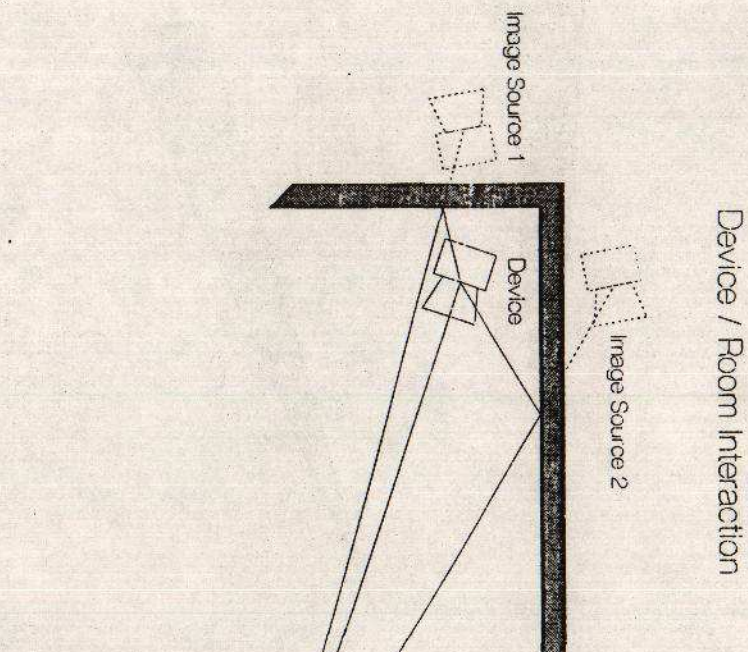
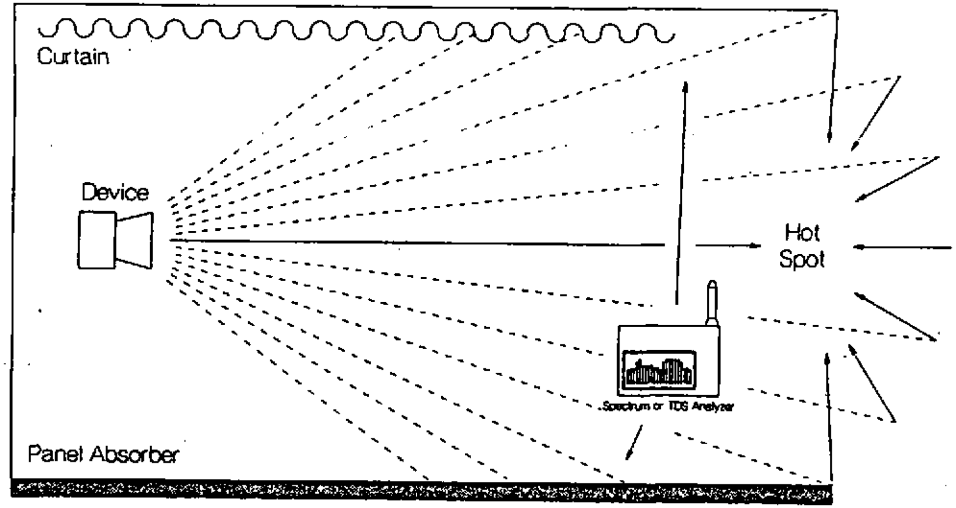

Device / Room Interaction
Image Source 1
Image Source 2
Device
Spectrum or TDS Analyzer

Fig. 3

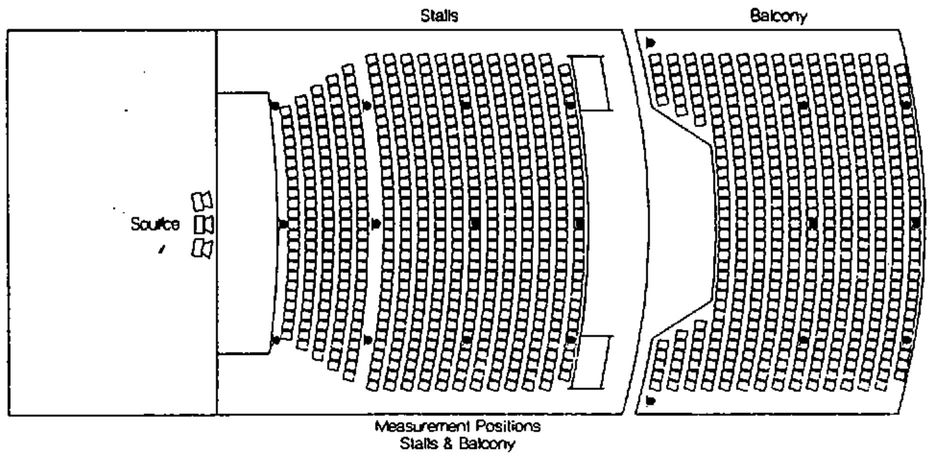
Determining The Effects of Room Characteristics



Using a panel absorber as a wall will create a bass loss.
Putting a curtain across a wall will create a treble loss.
The 'hot spot' is cause by the focussing of reflections off the curved rear wall.

Fig. 4

Auditorium Showing Multiple Measurement Positions



Preselecting Measurement Points

Fig. 5

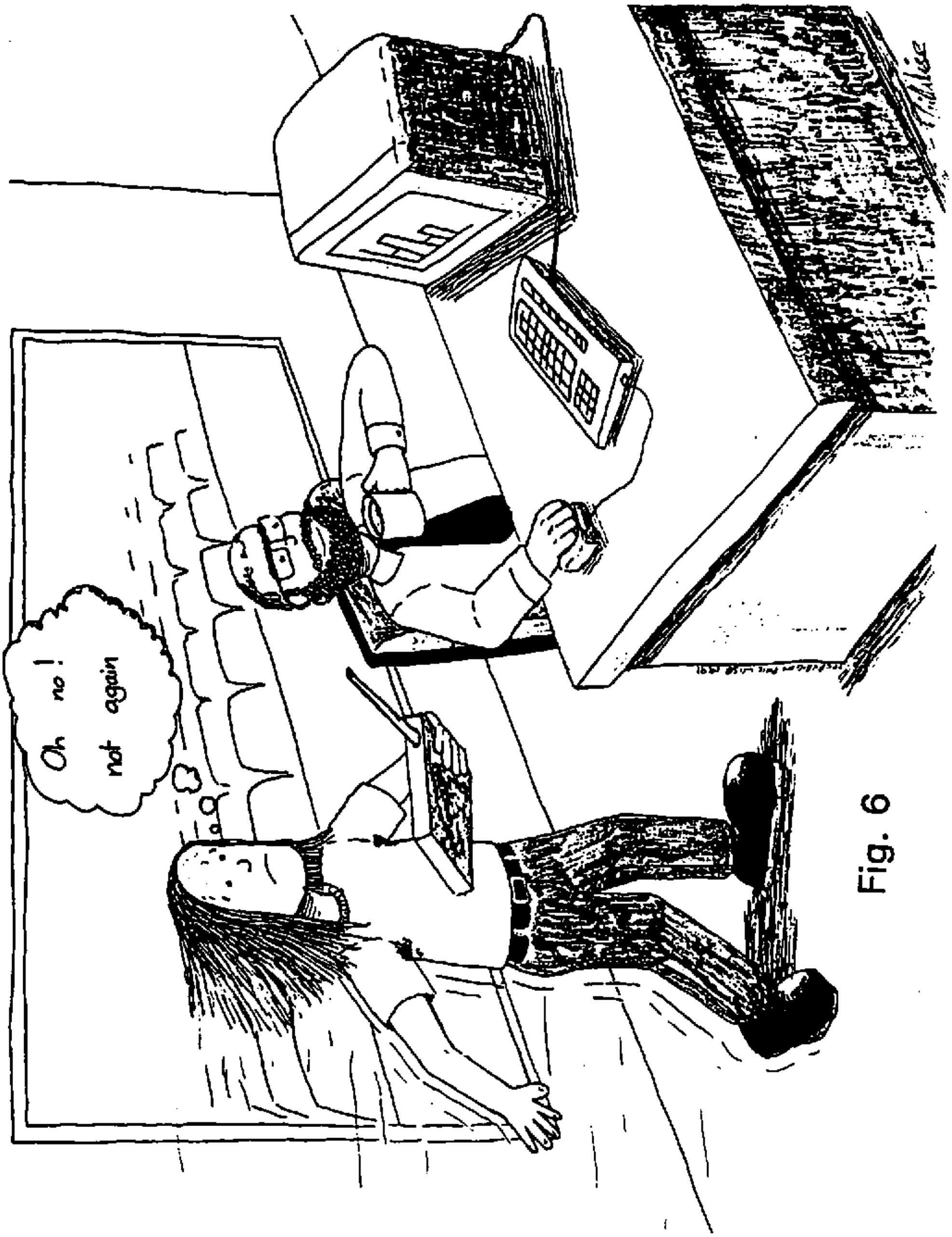
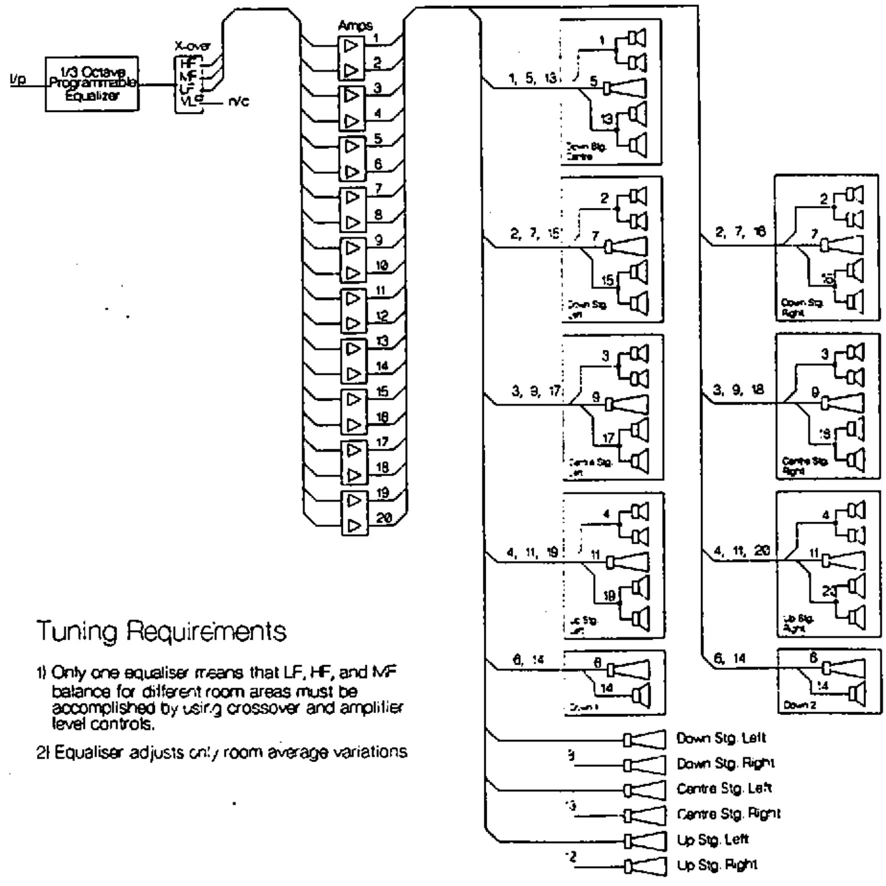


Fig. 6

Sample Sound System

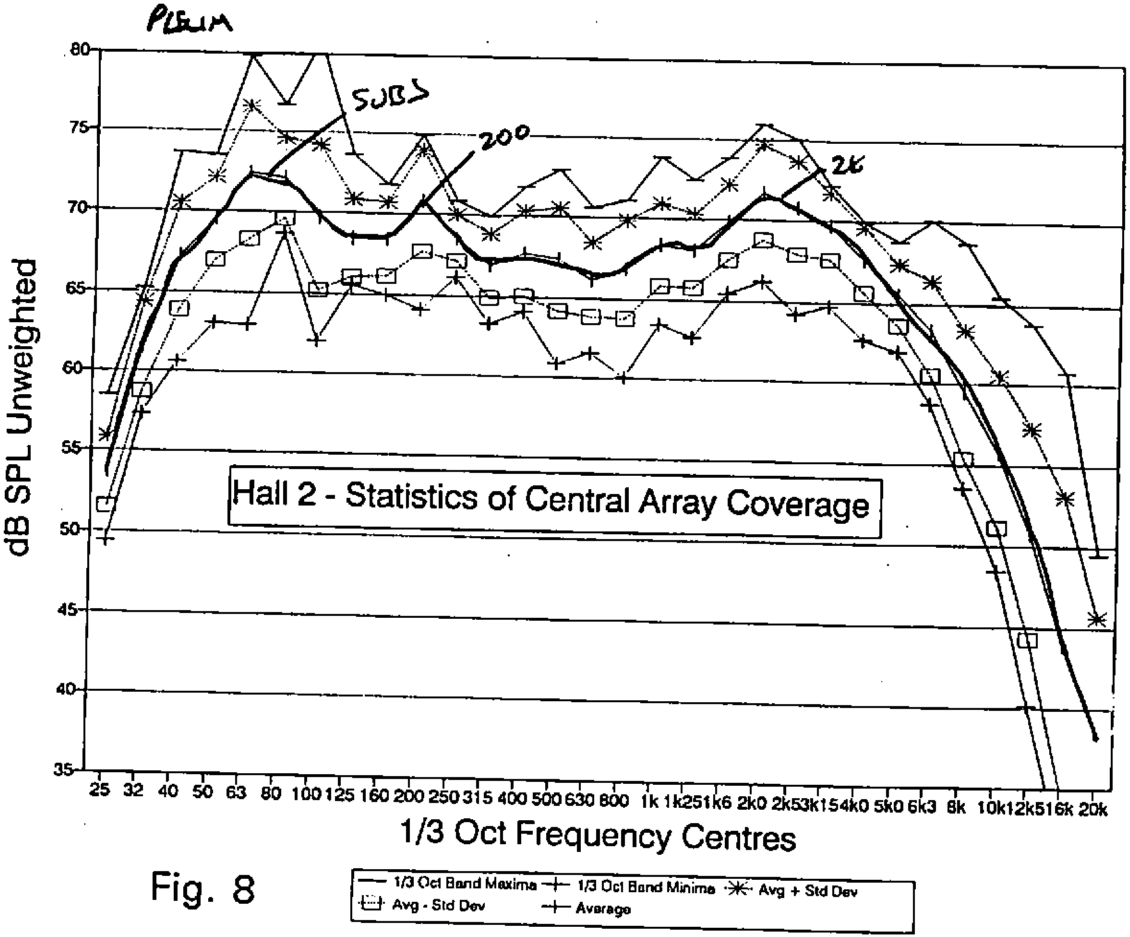


Tuning Requirements

1) Only one equaliser means that LF, HF, and MF balance for different room areas must be accomplished by using crossover and amplifier level controls.

2) Equaliser adjusts only room average variations

Fig. 7



Hall 2 - Statistics of Central Array Coverage
dB SPL Unweighted
80
75
70
65
60
55
50
45
40
35
25 32 40 50 63 80 100 125 160 200 250 315 400 500 630 800 1k 1k25 1k6 2k0 2k5 3k15 4k0 5k0 6k3 8k 10k 12k5 16k 20k
1/3 Oct Frequency Centres
SUBS
200
2K
1/3 Oct Band Maxima
1/3 Oct Band Minima
Avg + Std Dev
Avg - Std Dev
Average

Fig. 8

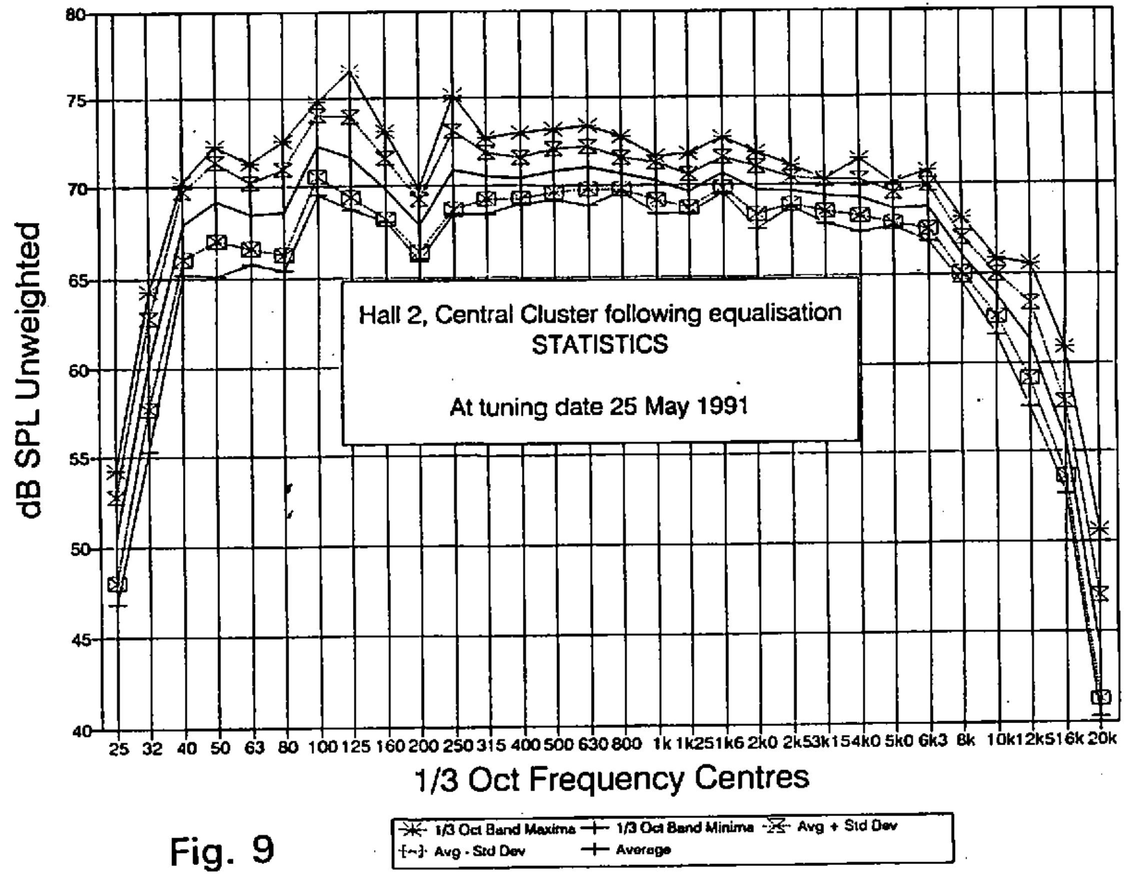

Hall 2, Central Cluster following equalisation
STATISTICS
At tuning date 25 May 1991
dB SPL Unweighted
80
75
70
65
60
55
50
45
40
25 32 40 50 63 80 100 125 160 200 250 315 400 500 630 800 1k 1k25 1k6 2k0 2k5 3k15 4k0 5k0 6k3 8k 10k 12k5 16k 20k
1/3 Oct Frequency Centres
1/3 Oct Band Maxima
1/3 Oct Band Minima
Avg + Std Dev
Avg - Std Dev
Average

Fig. 9

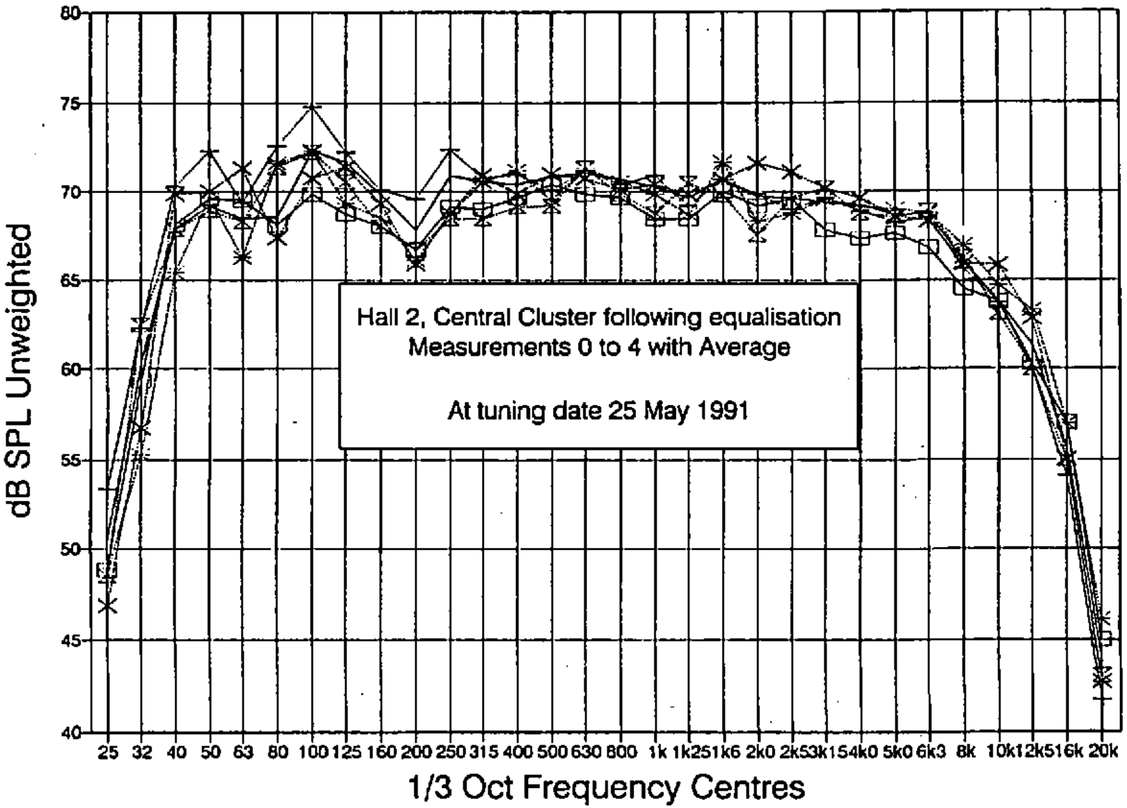

Hall 2, Central Cluster following equalisation
Measurements 0 to 4 with Average
At tuning date 25 May 1991
dB SPL Unweighted
1/3 Oct Frequency Centres
80
75
70
65
60
55
50
45
40
25 32 40 50 63 80 100 125 160 200 250 315 400 500 630 800 1k 1k25 1k6 2k0 2k5 3k15 4k0 5k0 6k3 8k 10k 12k5 16k 20k
Curve 0
Curve 1
Curve 2
Curve 3
Curve 4
Average

Fig. 9a

PREFERRED NOISE CRITERIA (PNC) CURVES

PNC	dB SPL in 1/3 Octave Band Centres (Hz)																								
VALUE	25	31.5	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1k	1k25	1k6	2k0	2k5	3k15	4k0	5k0	6k3
PNC65		74.0	73.0	72.0	71.0	70.0	69.0	68.0	67.0	66.0	65.0	64.0	63.0	62.0	61.0	60.0	59.0	58.0	57.0	56.0	55.0	54.0	53.0	53.0	53.0
PNC60		71.0	70.0	69.0	68.0	66.7	65.3	64.0	63.0	62.0	61.0	60.0	59.0	58.0	56.7	55.3	54.0	53.0	52.0	51.0	50.0	49.0	48.0	48.0	48.0
PNC55		68.0	67.0	66.0	65.0	63.7	62.3	61.0	59.7	58.3	57.0	56.0	55.0	54.0	52.7	51.3	50.0	48.7	47.3	46.0	45.0	44.0	43.0	43.0	43.0
PNC50		65.0	63.7	62.3	61.0	59.7	58.3	57.0	55.7	54.3	53.0	51.7	50.3	49.0	47.7	46.3	45.0	43.7	42.3	41.0	40.0	39.0	38.0	38.0	38.0
PNC45		62.0	60.7	59.3	58.0	56.3	54.7	53.0	51.7	50.3	49.0	47.7	46.3	45.0	43.3	41.7	40.0	38.7	37.3	36.0	35.0	34.0	33.0	33.0	33.0
PNC40		59.0	57.3	55.7	54.0	52.3	50.7	49.0	47.7	46.3	45.0	43.3	41.7	40.0	38.3	36.7	35.0	33.3	31.7	30.0	29.3	28.7	28.0	28.0	28.0
PNC35		57.0	54.7	52.3	50.0	48.3	46.7	45.0	43.3	41.7	40.0	38.3	36.7	35.0	33.3	31.7	30.0	28.3	26.7	25.0	24.3	23.7	23.0	23.0	23.0
PNC30		56.0	53.0	50.0	47.0	46.0	43.0	41.0	39.3	37.7	36.0	34.0	32.0	30.0	28.3	26.7	25.0	23.3	21.7	20.0	19.3	18.7	18.0	18.0	18.0
PNC25		55.0	51.3	47.7	44.0	42.0	40.0	38.0	36.0	34.0	32.0	30.0	28.0	26.0	24.0	22.0	20.0	18.3	16.7	15.0	14.3	13.7	13.0	13.0	13.0
PNC20		54.0	49.7	45.3	41.0	38.7	36.3	34.0	31.7	29.3	27.0	25.0	23.0	21.0	19.0	17.0	15.0	13.3	11.7	10.0	9.3	8.7	8.0	8.0	8.0
PNC15		53.0	48.0	43.0	38.0	35.3	32.7	30.0	27.7	25.3	23.0	20.7	18.3	16.0	14.0	12.0	10.0	8.3	6.7	5.0	4.3	3.7	3.0	3.0	3.0

Title: National Gallery Video Studio - New Option in Gallery A
Spreadsheet Function: 1/3 Octave Noise Criteria (PNC) Analysis
Engineer: Sam Wise
Test Eq: IVIE PC40 Serial No. 0680A339
Date of Print: 22 May 1991

Ref No.	dB SPL at 1/3 Octave Band Centres (Hz)																								
	25	31.5	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1k	1k25	1k6	2k0	2k5	3k15	4k0	5k0	6k3
0	64.5	61.6	61.6	60.4	45.5	46.1	46.2	44.6	44.9	42.5	40.0	39.3	38.4	38.6	36.2	33.4	31.7	29.9	27.9	26.7	26.0	26.0	23.1	20.6	18.6
1	78.3	78.8	78.7	83.8	93.4	90.1	94.0	95.2	92.1	90.1	88.3	88.8	87.4	84.9	86.0	88.8	89.9	89.4	88.3	89.6	88.3	88.0	86.6	84.4	81.8
2	64.6	61.0	62.2	60.0	56.6	60.3	60.9	48.7	47.1	46.1	43.0	42.0	41.0	38.6	37.8	35.9	35.4	33.8	34.3	30.4	32.7	29.7	28.2	26.2	24.7
3	64.6	61.5	63.7	53.8	48.4	48.8	50.3	45.6	46.6	43.3	41.2	40.3	38.6	38.5	36.8	34.3	33.0	31.2	28.4	27.4	26.2	22.8	20.3	18.8	16.8
4	66.9	64.5	56.6	58.6	64.3	61.3	49.7	46.6	45.9	44.1	42.0	40.2	40.5	40.0	37.8	34.5	32.6	30.7	28.4	25.8	27.3	18.8	17.1	16.8	14.5
5	66.8	66.6	58.3	64.7	65.3	48.6	48.6	42.6	43.2	39.8	40.2	38.5	37.6	39.8	34.9	32.8	31.3	29.9	26.6	25.6	22.9	20.8	21.6	19.0	15.6
SPL eff	34.6	29.0	25.0	30.1	44.0	43.3	43.7	49.4	49.5	46.8	47.1	46.3	47.8	49.4	49.4	54.6	60.0	60.7	60.9	62.1	61.1	63.4	65.9	64.8	63.2
BAND MAX		78.8	78.7	83.8	93.4	90.1	94.0	95.2	92.1	90.1	88.3	88.8	87.4	84.9	86.0	88.8	89.9	89.4	88.3	88.5	88.3	88.0	86.6	84.4	81.8
PNC20		54.0	49.7	45.3	41.0	38.7	36.3	34.0	31.7	29.3	27.0	25.0	23.0	21.0	19.0	17.0	15.0	13.3	11.7	10.0	9.3	8.7	8.0	8.0	8.0
LEVEL DIFF		26.6	29.0	38.8	52.4	51.4	57.7	61.2	60.4	60.8	61.3	63.8	64.4	63.9	67.0	71.8	74.9	78.1	78.6	79.6	77.0	77.3	78.5	76.4	73.8

Fig. 10

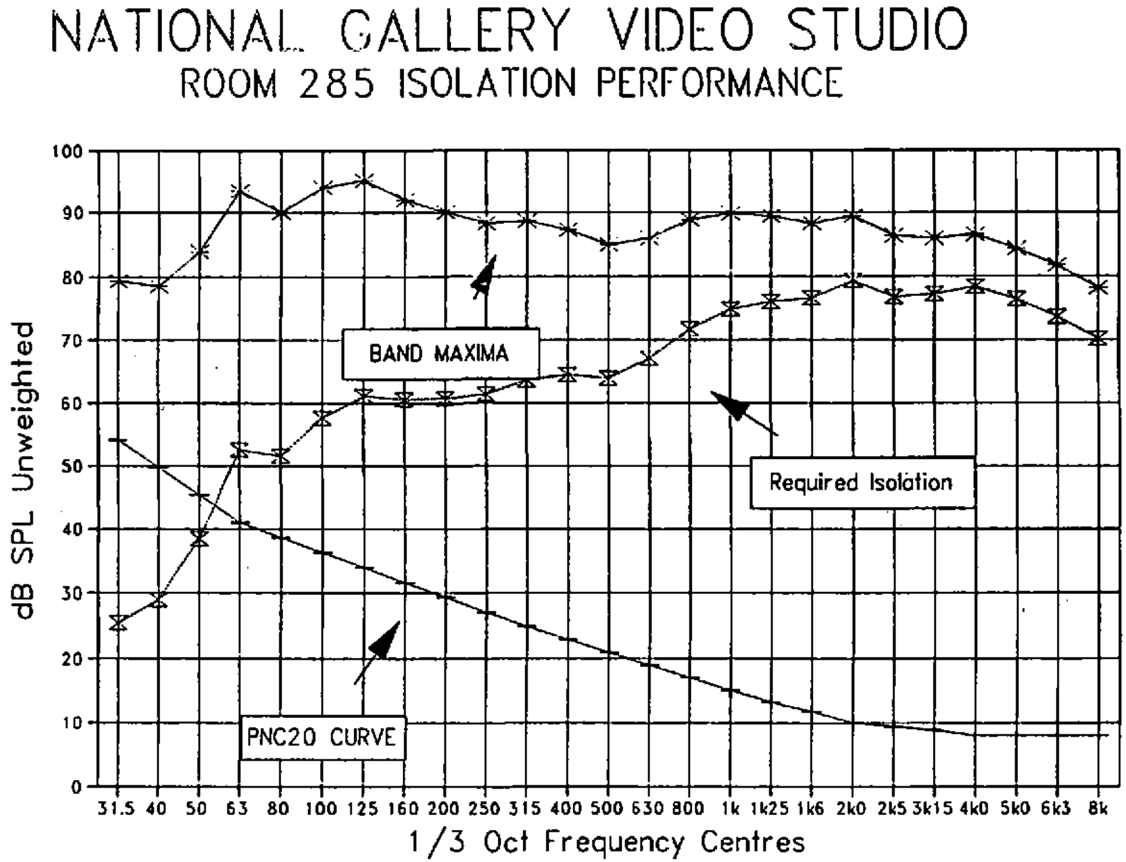

NATIONAL GALLERY VIDEO STUDIO
ROOM 285 ISOLATION PERFORMANCE
BAND MAXIMA
Required Isolation
PNC20 CURVE
dB SPL Unweighted
0
10
20
30
40
50
60
70
80
90
100
31.5 40 50 63 80 100 125 160 200 250 315 400 500 630 800 1k 1k25 1k6 2k0 2k5 3k15 4k0 5k0 6k3 8k
1/3 Oct Frequency Centres

Fig. 11

Typical examples of airborne sound pressure level differences for different wall constructions

	Sound Level Difference at 1/3 Octave Band Centres (Hz)																		
	25	31.5	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1k	1.25k	1.6k
BRICK WALLS																			
Triple leaf				49	48	60	48	53	62	64	66	69	68	62	64	66	69	72	73
Double leaf-flexi ties				28	32	34	36	38	41	48	47	61	63	68	63	64	64	67	71
Double leaf-rigid ties				28	31	33	33	37	39	40	42	44	48	52	67	68	60	62	83
single leaf, 215mm							37	39	40	46	47	48	60	62	63	64	58	58	60
BLOCKWORK WALLS																			
Triple leaf				26	33	36	34	40	45	48	50	49	53	58	60	63	64	67	70
Double leaf				23	28	28	31	33	34	37	40	42	44	47	62	67	69	61	63
CAMDEN WALLS(type a)																			
Triple leaf				30	28	31	39	48	68	68	76	81	87	82	95				
Double leaf				20	19	27	31	37	30	43	49	48	48	60	60	66	67	71	74
Single leaf						30	21	24	27	31	35	34	33	32	37	38	38	43	45
COMPOSITE WALL STRUCTURES																			
TRANSMISSION LOSS FIGURES (in the case of studios they vary very little from SPL differences)																			
Concrete, 14"cavity	✓						66	67	68	68	68	66	69	68	68	67	71	73	77
Brick-plast-110mm	✓							31	32	34	36	37	39	41	44	47	50	52	53
Brick-plast-220mm								41	42	44	45	46	48	50	52	54	56	58	61
MIXED WALLS																			
Brick-Camden(type b)							28	28	32	33	36	38	42	46	47	48	57	63	66
brick-brick							29	30	32	34	36	38	42	45	47	50	53	64	67
type 68a								38	42	44	47	47	48	48	49	49	56	60	58
type 68b								39	43	46	50	52	63	64	56	57	59	62	64
type 78							40	42	44	47	49	49	50	51	62	52	65	59	67

NOTES

Camden(a), see BBC Guide to Acoustic practice, p.66

Camden(b), see Acoustics for radio & television studios, p.[illegible] & p.70

Camden(a) is superior to Camden (b)

**Normalized level difference

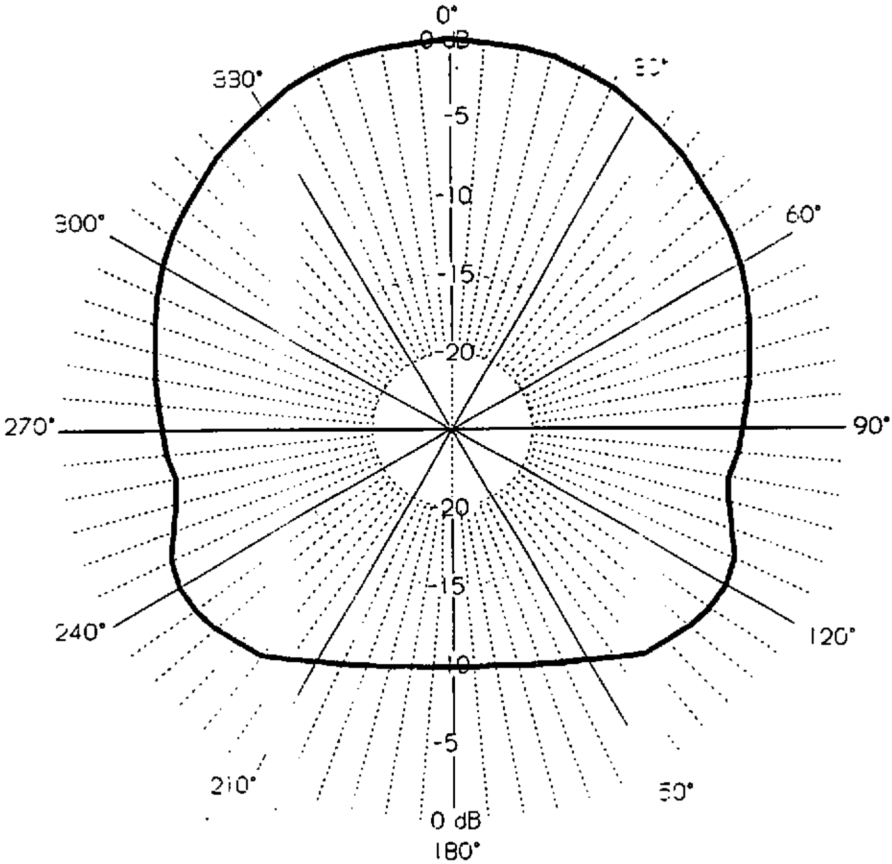
Fig.12

	2k0	2k5	3k15	4k0	5k0	6k3	8k	SOURCE
BRICK WALLS								
Triple leaf	78	80	82	84	86			BBC-Guide to Acoustics, P.62
Double leaf-flexi ties	73	76	77	80	78	78	80	
Double leaf-rigid ties	63	65	66	68	70	70	74	
single leaf, 215mm	58	58	60					Detailing for acoustics**
BLOCKWORK WALLS								
Triple leaf	73	76	80	82				BBC Guide to Acoustics, P.63
Double leaf	64	66	68	67	68			
CAMDEN WALLS(type a)								
Triple leaf								BBC Guide to Acoustics, P.66
Double leaf	78	78	78	77				
Single leaf	47	48	48	51	49	49	53	
COMPOSITE WALL STRUCTURES								
TRANSMISSION LOSS FIGURES (in the case of								
Concrete, 14"cavity	80	86	92	98				Acoustical Designing in Architecture, P438
Brick-plast-110mm	56	57	59	61				Audio System Designer
Brick-plast-220mm	63	63	62	62				
MIXED WALLS								
Brick-Camden(type b)	64	68						Acoustics for Radio & TV Studios, P70
brick-brick	64	68						
type 68a	70	73	76	78				
type 68b	67	70	73	77				
type 75	66	69	72					

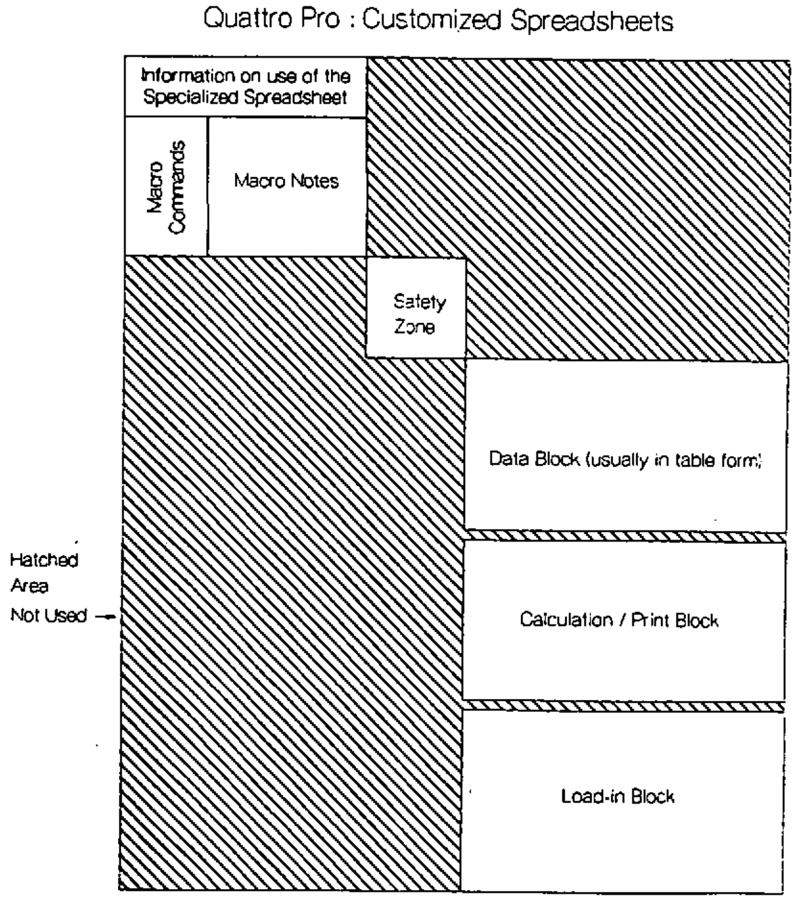
NOTES
Camden(a), see BBC Guide to Acou
Camden(b), see Acoustics for radio
*Camden(a) is superior to Camden(

**Normalized level difference

Fig.12 cont'd



EV S200 @ 1 kHz
Fig. 13



Appendix Fig.1

Title:
Spreadsheet Fu
Engineer:

PC40 1/3OCT Input and Graphing Utility
Version 2 of 21 March 1991 by Sam Wise

This Quattro Pro File contains a Table Form for inputting data from the IVIE PC40.

In this version, Alt-I imports a file, Alt-C clears the table
Alt-T prints the data out in text form

5 preset graphs are available, these are found in PRINT/NAMES

The spreadsheet has a statistical calculation function which may need to be altered to pick-up the correct table entries
It is intended that that function is automated in later versions

KEY ADDRESSES

FORM	A cell above the data in the Table Form
TOPFORM	The location for entry of essential global table info
LOADPT	A cell above the desired raw file data load-in point
DATA	All of the imported material in the spreadsheet
TABLE	Numeric data only in the spreadsheet

MACRO FILES ARE GIVEN BELOW

tidy	{GOTO}loadpt~{DOWN}~	21 Loadpt is one cell above the desired file load i
	{FOR Count1, 1, 20, 1, lineup}	Execute "lineup" 20 times
	{order}	Delete the Date and Time file labels and form
	{TABLELOAD}	Move the file into the table form
	{GOTO}form~	Goto the top of the form
	{QUIT}	
lineup	{/ Block;Move}{ESC}	This subroutine moves the second line of file
	{DOWN}.{RIGHT 4}~	to the end of the first line, then deletes th
	{BIGRIGHT 3}{RIGHT 6}~	
	{DOWN}	
	{/ Row;Delete}~	
	{RETURN}	
order	{GOTO}loadpt~{DOWN}~	This subroutine deletes the
	{RIGHT 37}	Date and Time file labels by copying
	{/ Block;Move}.	the date and time data over them.
	{DOWN 19}~{LEFT}~	
	{GOTO}{RIGHT 2}~	

Appendix Fig. 2

Title:
Spreadsheet Fu
Engineer:

```
          {/ Block;Move}.
          {DOWN 19}{RIGHT}~
          {LEFT 2}~{GOTO}
          {LEFT 3}~
          {/ Block;Format}~0~          It them formats the date and
          .{DOWN 19}{RIGHT}~           time data with no decimals
          {LEFT 5}                     and the SPL data with one decimal
          {/ Block;Format}~1~
          .{DOWN 19}{LEFT 30}~
          {RETURN}

erase     {GOTO}loadpt~{DOWN}~         This subroutine deletes the file
          {/ Block;Erase}.             input data
          {DOWN 19}{BIGRIGHT 4}~
          {RETURN}

                                       This is currently no-go, but should
load      {GOTO}loadpt~{DOWN}~         automatically load the correct
          {/ File;ImportNumbers}       type of file into the area one below
          {CLEAR}                      LoadPt
          D:\ARTEC\ICCB\ACOU\ICCBILS.PRN~
          {RETURN}

tableload {GOTO}loadpt~{DOWN}          This subroutine uses the "Edit/Value" comm
          {/ Block;Values}.            to move the data of the tidied up
          {DOWN 19}{BIGRIGHT 4}~       file input into the Table Form
          {UP 28}~
          {/ Block;Erase}.
          {DOWN 19}{BIGRIGHT 4}~
          {GOTO}form~
          {RETURN}

tableclear {GOTO}form~{DOWN}           This subroutine can clear the
Alt-C     {/ Block;Erase}.             table form while leaving the form
          {DOWN 19}{BIGRIGHT 4}~       intact.
          {RETURN}

print-text {GOTO}form~             32  This macro shrinks the spreadsheet width
Alt-t     {squeeze}                    to allow it to be printed mostly on one
          {/ Print;OutputHQ}           sheet, then expands it again afterwards
          {/ Print;Align}
          {/ Print;Go}
          {GOTO}form~
          {Stretch}
          {GOTO}form~
```

Appendix Fig. 2A