
Technical Contributions

Airbus Aircraft Acoustic Fatigue Certification

L C Chow MIOA & R J Cummins

Radiation Impedance Calculation by Finite
Element Analysis

Julian R Wright MIOA

Consultancy Spotlight

Investigation of an Electric Motor Noise and
Vibration Problem

Andrew H Middleton FIOA

Engineering Division

Unification of the Engineering Profession

Institute Affairs

Citation: Roger K Moore FIOA

Branch News

Conference and Meeting Reports

Reproduced Sound 10, Windermere

Sound Power Measurement, London

Current Issues in Standardisation, London

Miniature Microphones, Salford

Publications

Report: NATO CCMS Studies into Aircraft Noise

Acta Acustica

News from the Industry

New Products

News Items

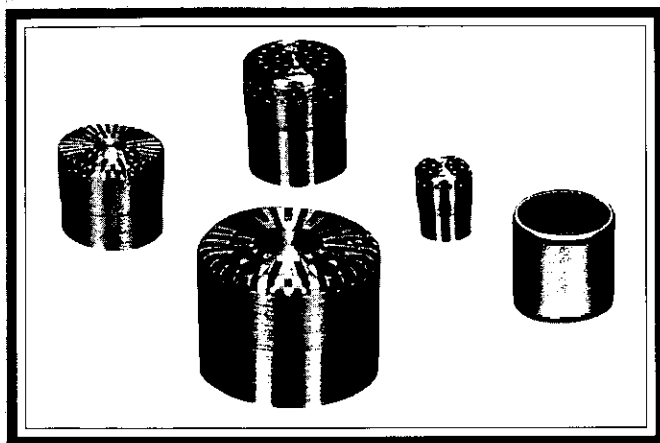
Letters to the Editor

M E Delaney HonFIOA, V Krylov FIOA,

N Shibanova & R E Challis

The Cirrus MK:224

EXCHANGE MICROPHONES AT A 40% DISCOUNT?



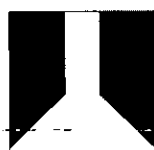
The Cirrus range of Permacharge© precision electret microphones are fully compatible with devices fitted to many leading makes of sound level meters.

If you have suffered one of those inconvenient microphone failures check out the Cirrus exchange programme. The 40% service exchange allowance is granted on the return of defective microphones from a wide range of leading sound level meters.

Full details of the Cirrus Permacharge© range and applications notes are available on request.

The Cirrus MK:224 is the "standard" precision measurement microphone and is listed at £495. It is one of a range that will cover many applications. Makes an ideal front end for DAT recorders.

Send for full information



Cirrus
Research plc



Acoustic House, Bridlington Road, Hunmanby, North Yorkshire, YO14 0PH. England. Tel: (01723) 891-655 Fax: (01723) 891-742

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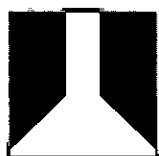
The Cirrus CR:245

ENVIRONMENTAL NOISE ANALYSER

The Cirrus Research pedigree in acoustic instrumentation has been applied to produce the CR:245. An Environmental Noise Analyser for the monitoring of civil engineering projects, transportation systems and the investigation of noise nuisance complaints.

- Fully weather protected and self contained.
- 110 dB measurement range.
- Solar and external power options.
- Processed results and raw data stored.
- Up to 1 year unattended operation.
- Full data analysis software available.

Send for full information



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1995 International Auditoria Conference

Opera and Concert Hall Acoustics

Organised by the Building Acoustics Group of the UK Institute of Acoustics

Forte Crest Hotel London Gatwick Airport 10 – 12 February 1995

Conference Organiser: Jeff Charles FIOA, Bickerdike Allen Partners

Delegate registration:

Please register me as a delegate for the above conference as:-

- ☐ An author who is a member of the Institute (Conference fee £180 + VAT)
- ☐ An author who is not a member of the Institute (Conference fee £210 + VAT)
- ☐ A non-author who is a member of the Institute (Conference fee £210 + VAT)
- ☐ A non-author who is not a member of the Institute (Conference fee £250 + VAT)

The conference fee covers all conference papers including the proceedings, lunches, dinner on Friday, the conference banquet on Saturday and the visit to Glyndebourne.

Hotel Accommodation:

Please reserve:-

- ☐ A single room ☐ A twin/double room for the night(s) of
 - ☐ Thursday 9 February ☐ Friday 10 February ☐ Saturday 11 February ☐ Sunday 12 February
- The cost (bed and breakfast) is £60 per night + VAT (single room) or £70 per night + VAT (twin/double room): An accompanying persons' programme is being arranged.

Proceedings

- ☐ I am unable to attend. Please send a copy of the Proceedings and invoice me at the address below. Price ☐ £40 (members) or ☐ £50 (non-members) including post and packing.

Method of Payment

- ☐ Please invoice me for the full amount at the address below. (All accounts are to be settled for the full amount in sterling prior to, or at, the conference)

Please note that under current UK regulations VAT has to be added at the rate of 17.5% by all including overseas delegates

Name:

Name for badge:

Organisation:

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Please post or fax this form as soon as possible to

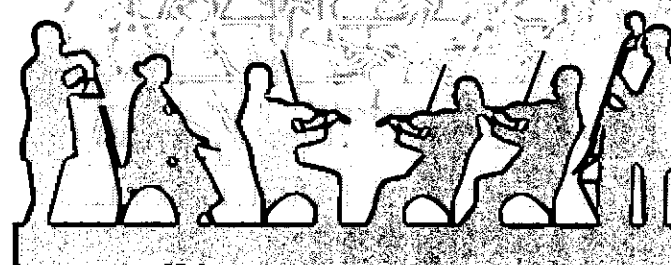
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Opera and Concert Hall Acoustics

**Forte Crest Hotel at
London Gatwick Airport
and
Glyndebourne Opera House**

10 – 12 February 1995



Friday, 10 February 1995

Morning: Technical Session 1:

Chairman: A Burd

INVESTIGATIONS INTO PROBLEMS OF AUDITORIUM ACOUSTICS

P Mapp, Consultant

LISTENING TO THE SOUND OF A PUBLIC PLACE BEFORE IT IS BUILT

K D Jacob, Bose Corporation, Framingham, USA

SPATIAL INFORMATION OF SOUND FIELDS FOR AUDITORIA DIAGNOSTICS

R Guy & A Abdou, Centre for Building Studies, Montreal, Canada

THE IMPORTANCE OF DIFFUSE REFLECTION IN
COMPUTERISED ROOM ACOUSTIC PREDICTION &
AURALIZATION

B-I Dalenbäck, Chalmers University, Sweden

FURTHER INVESTIGATION INTO THE SUBJECTIVE
LOUDNESS OF RUNNING REVERBERATION

D Griesinger, Lexicon, USA

Afternoon: Technical Session 2:

Chairman: J G Charles

THE ACOUSTIC DESIGN OF THE EDINBURGH
FESTIVAL THEATRE

L Haslam, Sandy Brown Associates

THE ACOUSTIC DESIGN OF THE ANVIL CONCERT
HALL, BASINGSTOKE

R Cowell, Arup Acoustics

ACOUSTIC PROBLEMS OF THE SALLE PLEYEL (PARIS)
& THE 1994 MODIFICATIONS

A Y Xu, Xu-Acoustique, France

THE ACOUSTIC DESIGN OF THE YORK BARBICAN

N Spring, Sandy Brown Associates

THE WOODEN CONCERT HALL FOR THE MUSIC FESTIVAL OF EVIAN,
'LA GRANGE AU LAC'

A Y Xu, Xu-Acoustique, France

STUDIES OF OPERA HOUSE ACOUSTICS

M Barron, University of Bath

Sunday, 12 February 1995

Morning: Technical Session 3:

Chairman: D Sugden

ELECTROACOUSTIC CORRECTION OF AUDITORIA WHICH HAVE POORLY
COUPLED SPACES USING A SIAP SYSTEM, A CASE STUDY

W Prinssen, Systems for Improved Acoustic Performance BV, The Netherlands

ACOUSTICS CONDITIONS IN ORCHESTRA PITS &
PROSCENIUM ARCH THEATRES

J O'Keefe, Aercoustics Engineering Ltd, Toronto, Canada

QUANTIFYING THE SENSITIVITY OF MODERN STAGE ACOUSTICS MEASUREMENTS

J O'Keefe, Aercoustics Engineering Ltd, Toronto, Canada

THE SOUND OF LIGHT

A Russell, Theatre Projects Consultants

ACOUSTIC RECOVERY OF A 200 YEARS OLD
NATIONAL OPERA HOUSE:

THE TEATRO S CARLOS IN LISBON

D Commins, Commins Acoustics Workshop, France

THE NEW OPERA HOUSE IN CAGLIARI

R Pomoli, A Farina & P Fausti, University of Ferrara, Italy

Afternoon: Technical Session 4:

Chairman: M F Barron

ACOUSTIC CHARACTERISATION & RESTORATION
OF THE GOLDONI THEATRE IN LIVORNO

*G Licitra, G Giusti, M Cerchiai, P Paoli, B Pisani &
C Rini, Unita 'Sanitaria Locale, Livorno, Italy*

THE ACOUSTIC CONDITIONS OF THE SAN
FRANCISCO OPERA HOUSE & REHEARSAL &
WORKSHOP FACILITIES

*D Paoletti, K Graffy & L Tedford, Paoletti Associates Inc,
USA*

THE ACOUSTICAL DESIGN OF THE NEW PRINCESS OF WALES
THEATRE IN TORONTO, CANADA

J O'Keefe, Aercoustics Engineering Ltd, Toronto

LISTENING AND LOOKING - THE CONCERT HALL AND OPERA HOUSE

D Sugden, Arup Acoustics

Saturday, 11 February 1995

Visit to Glyndebourne Opera House

THE ORIGIN & ANTECEDENTS OF THE
GLYNDEBOURNE AUDITORIUM

I Mackintosh, Theatre Projects Consultants

THE ACOUSTIC DESIGN OF
THE GLYNDEBOURNE OPERA HOUSE

R Harris, Arup Acoustics

OPERA HOUSE DESIGN - TO HEAR, TO SEE OR TO BE SEEN?

Anne Minors, Theatre Projects Consultants

Evening

A musical event is being arranged in conjunction
with the conference banquet

WINDOWS ON

Acoustics

A NEWSLETTER FROM AcSoft

WINTER 1994/1995

YOU HUM IT, WE'LL PLAY IT!

Over the Christmas period, you can't have failed to notice the advertising for home computers, extolling the virtues of 'multimedia' systems. But what is multimedia, and does it have any impact on our world of acoustics?

Multimedia is a combination of sound and vision into a PC environment, for applications ranging from commercial presentations, education or just plain entertainment. The last year has seen an explosion in hardware and software for these applications, and high quality audio cards are commonplace, along with CD-based storage (CD-ROM) for providing the pictures and sounds.

A whole shelf load of encyclopædia(e) can now be fitted on to one CD-ROM, and the subject matter comes to life, with film clips, and sounds at the click of a mouse button.

This boom in the consumer world has meant that 16-bit quality hardware is available at high street prices, offering performance once the exclusive domain of the specialist manufacturers.

01dB, specialists in computer-integrated acoustic analysis systems, has capitalised on this by interfacing their suite of Windows-based software to the dominant sound card format (WAV to the experts), which means their powerful software is now available on lower priced systems.

For example, if you buy a 16-bit 'SoundBlaster compatible' card for your computer (some are now coming with this feature built-in), you can now use **dBENV** for environmental noise analysis, **dBATI** for building acoustics, along with the new **dBFA** frequency analysis software previewed elsewhere in this issue.

The system is called **Sonata** and complements the established **Aria** and **Concerto** systems by becoming the new entry point to the range.

Sonata will find a big application with those who prefer to take DAT recordings of noise, and then come back to the office and analyze the recordings at their leisure, and some new features of **dBENV** make this process even easier. The low price also makes the system ideal for educational institutions, where budgets are very restricted, but educational needs seem to expand all the time.

For portable applications, we have even found a tiny SoundBlaster compatible PCMCIA card which can plug into your notebook. This makes a very cost-effective system for building acoustics, for example!

Ultimately, the performance of the system depends on the speed of your computer, and the type of

This issue of Windows on Acoustics sees the software from 01dB being integrated on to a standard multimedia platform, for low-cost applications in environmental noise and building acoustics. Also, a new frequency analysis package is added to the suite, giving not just octave and third octave bandwidths, but also narrow band FFT, with very fine resolution for diagnosing tonal components in noise & vibration.

GRAS in Denmark also release a new economically priced outdoor microphone unit, aimed at the Environmental Health market.

AcSoft is also pleased to announce the addition of a new product to our expanding line, from a British company specialising in data visualisation software. nVision offers direct support for some frequency analyzers, but accepts any standard format data from, for example, the X-YS range of analyzers from Ziegler Instruments.

Finally, we would like to wish all our readers a Happy and Prosperous New Year!

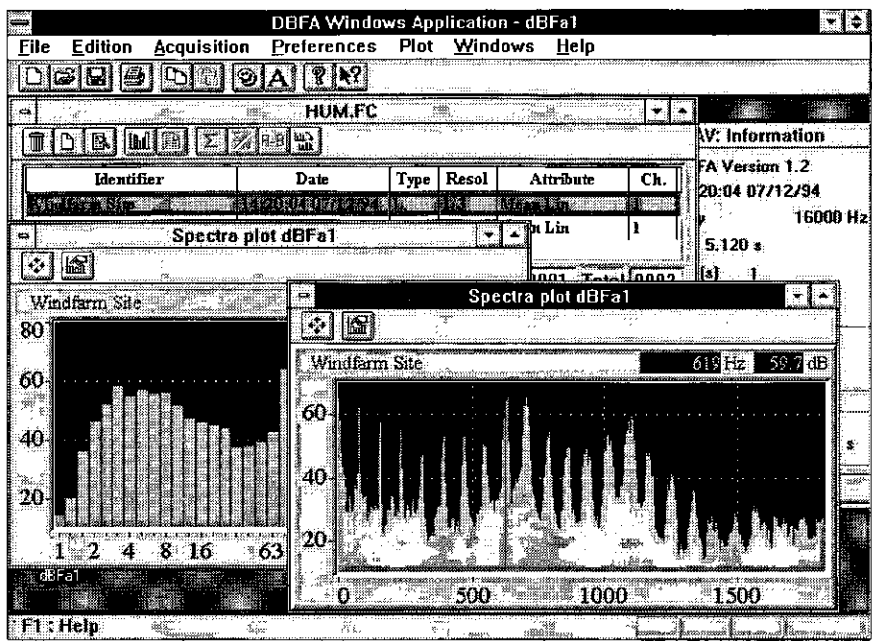
card, but we recommend the superb SoundBlaster 16 Pro AdSP card from Creative Labs, which we can supply as part of a configured system.

For the even more impecunious, there will shortly be a new version of **dBENV** called **dBENV Lite**, which cuts out the audio recording capabilities of **dBTRIG**, and hence the frequency analysis, but gives you an excellent low cost PC-based level recorder, with a full version of **dB-TRAIT**, for around £1,000 + VAT!

So now you have an even wider choice, based on the ever popular Windows user interface (love it or hate it, it's here to stay!) and either the top specification Type 1 2-channel **Aria** (pictured here), the portable Type 1 **Concerto** or multimedia **Sonata**.

For more details, Circle 1 on the fax-form on the back page.

GET AT THE DETAILS



01dB has just released the next software module in their expanding range of applications for noise & vibration analysis. The oddly named **dBFA** (the FA stands for Frequency Analysis!) allows you to acquire audio signals, and then view and edit the raw signal, before performing frequency analysis in octaves, third octaves or narrow bands. The recordings can be calibrated using a similar automatic calibration routine found in the **dBENV** and **dBBA1** software, and therefore your spectra can then be traced back to a reference.

As well as viewing the raw data, like an oscilloscope, the signal can also be analyzed as a Short Leq time history, which is ideal for examining short term fluctuations in the signal, especially with impulsive noise sources.

As the raw audio signal is stored on computer disk, it can be played back for listening, or re-analyzed as many times as you like, using different analysis parameters.

Signals can be acquired manually, or triggered from the

input level, and a choice of recording bandwidths is provided. However, the signal can always be re-sampled digitally to a different bandwidth if the original bandwidth was too high.

On the frequency analysis side, octaves and third octaves can be calculated either from FFT synthesis, or from Class 0 digital filters, operating right down to 1 Hz for low frequency noise investigations. Again, as the signal is on disk, the analysis is always in real-time, and no data is lost.

Narrow band FFT can be performed to a resolution of up to 3200 lines, with a choice of overlap processing and time windows.

The results can be stored as spectrum files, with annotation and calibration data, and many spectra can be saved in one spectrum file.

Spectrum arithmetic is available, for determining performance of noise control measures, using averaging if required.

For more advanced users, an option is available for editing the signal file by low-, high- or band-pass filtering the signal, which can then be played back through a speaker.

Finally, if you are an Aria or Concerto user, the analysis part of dBFA is available separately, so you can narrow band analyse your existing audio records. Ideal for tonal components in environmental noise!

Don't settle for 'just' third octaves! dBFA provides much more insight into your noise signals, and is available as a stand-alone application on Aria, Concerto or Sonata systems, or as an upgrade to the **dBENV** environmental noise software suite.

So you see, despite its name, dBFA is actually rather useful!

For more details, Circle 2 on the fax form.

Notebook Price Crash!

This autumn has seen a price war between the large computer vendors, giving some dramatic reductions in prices of notebook computers, which can be used as the host for a **Concerto** noise

analysis system. This can only be a good thing for the impecunious acoustician, and is an example of how sensible it is to base a noise analyzer on standard computers.

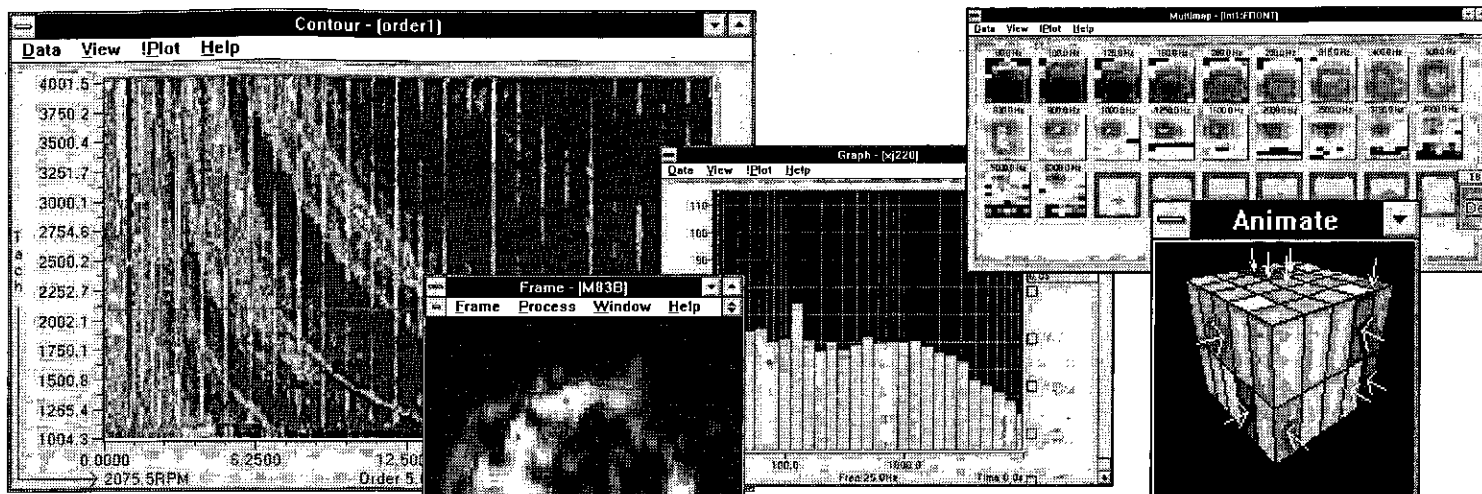
For example, the amazing Compaq Concerto notebook

(nice name that!) can now be snapped up for around £800, and that's for a 486DX processor, and a wonderful pen-driven user interface. It's certainly the first time I've used a sound level meter, where I can write on the display, and it recognises my handwriting!

Other offers included a *Colour* screen Contura notebook for less than £1,200!

As notebook technology improves, it becomes cheaper still, and the variety of options is now staggering, with PCMCIA memory cards and modems and removable disk drives. Now it makes even more sense to switch to a computer-based system.....

Bring your Noise & Vibration data to life!



An exciting new package is now available from AcSoft, for visualising noise and vibration data in a variety of dimensions. Developed by Scarborough-based company *Index Data Systems*, **nVision** brings new levels of data post-processing to the PC. Operating under Windows, **nVision** is a modular system, which accepts data in many formats, including Universal File Format, which is generated by many analyzers, including the PC based **Spectralys** FFT analyzer.

Files can be visualised in two or three dimensions, moreover, animations can be built up from time-varying data, and a 'movie' can be created, showing how acoustic radiation, for example, varies over the cycle of a machine. Options include visualisation of intensity data, with a novel 'multimap' display, which gives an excellent overview of

intensity radiation over a surface with frequency.

Extensive tools can be used to customize an application, using Visual C/C++, and interfaces are provided for transfer of data to/from Microsoft Excel and other spreadsheets. This allows changes made in one application to be automatically updated in another.

As well as import of data from files, the program can also control IEEE-488 and RS-232C interfaces for more conventional analyzers.

If you have a special requirement, IDS can also provide a custom built application for you.

A glorious colour brochure describes some of the capabilities of nVision, and you can book your copy, along with a demo disk by circling Number 3 on the fax form.

dBENV upgraded to v 1.2

The powerful environmental noise software from 01dB has now been upgraded, and includes many features requested by the growing band of users. dBTRIG, the acquisition software, which can acquire audio data as well as noise samples, now has a DDE interface for external control, as well as an intelligent autoranging facility which selects the dynamic range according to the noise level, and STILL meets Type 1. dBTRAIT now includes the option to edit the file header information, making it ideal for users of DAT recorders, where the date/time needs to be adjusted, along with calibration data. Frequency analysis now includes digital filters, down to 1Hz lowest centre frequency, and many other useful features. All going to prove that we try to listen. For a data sheet, circle 4.

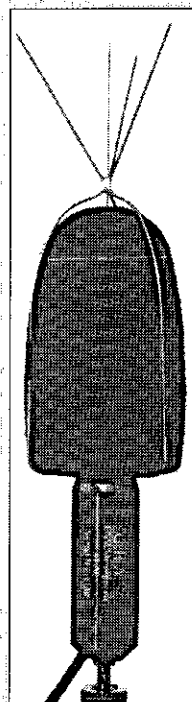
Microphone Range Expands

Earlier in 1994, we introduced a new microphone manufacturer, GRAS from Denmark. After the first wave of products comes a new range of measuring microphones, including a pre-polarised capsule, the 40AE, and a smaller outdoor microphone, the 41AL.

The 41AL (pictured here) is a development of its bigger brother, the 41AM, but designed for occasional outdoor use, for periods less than a year, but more than a few days.

It features the same super-stable microphone capsule, with integrated rain cover and windscreen, and calibration can be done with a regular calibrator, without the risky manoeuvre of removing the rain cap. Cables can be supplied for connection to a variety of systems.

For more details, circle 5 on the fax form



Urgent Fax to AcSoft on 01296 661 400

From: Name:
Dept:
Company
Address

Post Code:

Telephone:

Fax:

Please send me further information on the following:

- 1 **Sonata** multimedia acoustic analysis system
- 2 **dBFA** Frequency Analysis software
- 3 **nVision** Data Visualisation software with demo disk (3½")
- 4 **dBENV** Environmental Noise Analysis software
- 5 **System 41AL** Environmental Microphone system
- 6 Other
- 7 Please contact me to arrange a demonstration

CUT AND PASTE

And finally we come to the back page where we can tell you briefly about snippets of new product information and general gossip.

GRAS also offers a miniature hydrophone **10CS** in its range, for high frequency underwater measurements to +/-2dB @ 100kHz, with high voltage sensitivity. Also

available are some miniature ¼" microphone preamplifiers, originally developed for the **50AI Sound Intensity Probe**, which offer excellent performance in a compact

package. The outdoor microphones from GRAS are now also available with alternative reference directions, and boast a very low noise floor (<20dBA). *Phantom Calibration* allows remote calibration of microphones and preamplifiers, giving better stability than charge injection techniques.

01dB have developed a new two channel signal conditioner **dBCS2** which has microphone, charge and ICP in-

puts, with gain and filtering. The unit is ideal for portable use with a DAT recorder, and accepts direct connection of accelerometers and microphones.

01dB has also delivered some custom systems, for applications such as automotive drive-by testing. If you have a specific system requirement, we'd like to know.

Our noise annoyance recorder **Marvin** is now in great demand, and we have developed a data sheet giving the details. Including Type 1 sound level meter and DAT recorder, prices start at around £2,000.

Concerto was recently in action measuring the noise from a pub. There's something unnerving about hearing Jeff Beck at high volume being played

back from your computer hard disk!

Comments from **Concerto** users include "How did I ever do without it? I tried using a sound level meter the other day, and I didn't know what the heck was going on!". Remember, because our systems are based on computers, we can offer PCMCIA cards, removable disk drives, digital I/O, upgradeable software, etc at high street prices.

Ask for data sheets on any of the above items.

*Question of the month:
What makes more sense? Using a
computer for noise measurements
or trying to run Windows on a sound
level meter? Correct answers receive
a classical music CD free**

Windows on Acoustics IS PUBLISHED BY **AcSoft**, 6 CHURCH LANE, CHEDDINGTON, LEIGHTON
BUZZARD, BEDS. LU7 0RU TELEPHONE 01296 662 852 FAX 01296 661 400

Windows, Excel and Visual C/C++ are trademarks of the Microsoft Corporation, SoundBlaster is a trademark of Creative Labs, Inc.

**subject to availability*

- **Inputs:**
Mic (B&K socket), Line (BNC socket)
- **Polarization voltage:**
0 or 200 V
selectable
- **Preamp voltage:**
120 V
- **Measurement range:**
22–135 dBA
(with a 50 mV/Pa microphone)
- **Outputs:**
AC and DC
- **Weighting networks:**
A, B, C, Lin, Flat according to IEC 65
Human vibration networks when of
14 is installed
- **Filters:**
Serial or parallel
- **Filter bandwidth:**
8-pole Butterworth filters in the frequency range from 1 Hz to 20 kHz with 1/3
1/1 octave bandwidth
- **Time constants:**
Parallel detection of F, S, and I
- **Peak detection:**
Parallel detection of Peak (+) and Peak (-) for selected networks, plus additional
wideband Peak
- **Measurement duration:**
Selectable from 1 sec to 99 hours
(from 2 ms in Time mode)
- **Measured parameters:**
Leq, Leq(I), Lmin(F), Lmin(S), Lmin(I),
Lmax(F), Lmax(S), Lmax(I), SEL, Peak
Peak(-), PeakW, Tmax3, Tmax5, SPL
SPL(S), SPL(I), Ln (0.1%–99%)
- **Display:**
Back-lit graphical LCD with 240 x 64
- **Interface:**
2 pcs. RS-232 with max 9600 baud
- **Storage:**
191 kbyte non-volatile memory, stores
more than 100.000 measurement values
and measurement set-ups.
- **Battery:**
Approx. 4 hour battery life time using
rechargeable NiCd battery pack
type 316

Cumulative distribution

This graph shows the cumulative distribution of sound pressure levels. The y-axis is 'Cum. distr. [%]' from 0.0 to 100.0. The x-axis is 'Class [dBS]' from 40.0 to 85.0. The curve shows that approximately 90% of the sound energy is below 60 dB, and 100% is below 85 dB.

Frequency analysis

This bar chart shows the frequency analysis of the sound. The y-axis is 'Level [dB]' from 10.0 to 90.0. The x-axis is 'Freq. [Hz]' with markers at 63, 250, 1.0k, and 4.0k. The chart shows a peak level of approximately 70 dB at 1.0 kHz.

Level vs. time

This graph shows the level of the sound over time. The y-axis is 'Level [dB]' from 30.0 to 110.0. The x-axis is 'Rel. time' from 0:00:00.000 to 0:01:00.000. The graph shows a fluctuating level with several peaks reaching up to 90 dB.

Probability distribution

This graph shows the probability distribution of sound pressure levels. The y-axis is 'Prob. distr. [%]' from 0.0 to 5.0. The x-axis is 'Class [dBS]' from 20.0 to 80.0. The distribution is bell-shaped, peaking at approximately 4.5% around 60 dB.

Summary Data:

Parameter	Value
Trig time	94:03:22 14:42:44
End time	94:03:22 14:50:52
Mode	LEV TC: FAST
Sens	-26.0
Trig	START
F.0	100dB
Dur.	5.30
Band	A net
OL	0.1%
LMINP	28.6
LMAXP	92.4
LMINS	30.3
LMAXS	84.0
LMINI	34.8
LMAXI	97.0

- Self-contained: Acquisition, processing and analysis of data
- Simultaneous detection of all time constants (F, S, I)
- Simultaneous detection of Peak and RMS values (SPL, Max, Min, Leq, SEL)
- Type 1 in accordance to IEC 651/804/225
- Real-time frequency analysis
- Human vibration network
- Narrow band filters (1/12, 1/6, 1/3, 1/1)
- Battery or 12 Vdc operation
- Extensive trigger facilities
- A-, B-, C-, Lin-, Flat and human vibration networks
- 1 Hz–20 kHz real-time frequency range
- 90dB dynamic range
- Short period Leq from 2 ms
- LCD display with backlight
- Video output for use of large colour monitor
- Logical and self-explanatory display and push buttons
- Graphical and alphanumerical presentation and print-out of data
- Large and well-organized non-volatile internal memory (up to 100.000 values)
- Modular design with internal optional extensions (no external modules needed)
- Two RS-232 interfaces for PC, printer, noise generator
- Software program for transfer of data to PC available
- Digital signal processing (DSP)
- Dimensions: 56 x 380 x 168 mm (DxWxH)
- Weight: 2.2 kg incl. batteries

GRACEY &
ASSOCIATES

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Northants NN9 6AS

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£5565 - complete with
Real Time - 1Hz to 20kHz
Sequence - multi-tasking
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Time Mode - 8 values

REAL-TIME ANALYSIS



**Norsonic Sound Analyser SA 110
– combining advanced technology
with user-friendliness**



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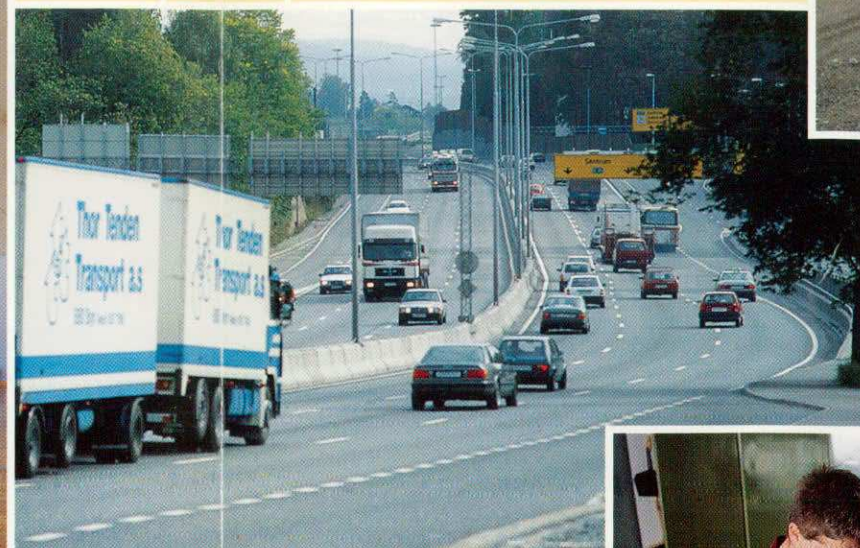


AVAILABLE EXTENSIONS

- **Real-time mode**
1/1- and 1/3-octave filters in the frequency range 1 Hz–20 kHz, plus serial frequency scan. Graphical presentation of frequency spectra. Automatic control of Noise Generator type 230.
- **Reverberation mode**
RT measurements and calculation based on noise or impulse excitation and automatic serial scanning through the pre-selected frequency range. Graphical display of the decay curves. Automatic control of Noise Generator type 230.
- **Time mode**
Electronic level recorder with graphical level vs. time presentation of the running measurement. Possible to record up to 8 parameters (Leq, Lmax, Lmin, Peak, Ln, etc.) over pre-selected sub-periods down to 2 ms resolution. Markers (0–9) may be set by operator during the measurement and used as indicators in the partial integration feature.
- **Sequence mode**
Programmable measurement sequences with store/print/check features. Excludes the need for a PC during noise monitoring.
- **Event mode**
Normal level measurements with additional event detection and automatic store/print after each event.
- **Narrow band mode**
Manual selectable 1/1, 1/3, 1/6, 1/12 octave filters with free selectable center frequencies.
- **Statistic mode**
Statistics calculations in Level, Time and Event modes based on 0.2dB class width with 62.5 Hz sampling rate. Graphical presentations of probability and cumulative distribution functions. Calculation of any percentile in the 0.1–99 % range.
- **Human vibration mode**
Human vibration networks including presentations and print-outs of all numerical results in absolute units.



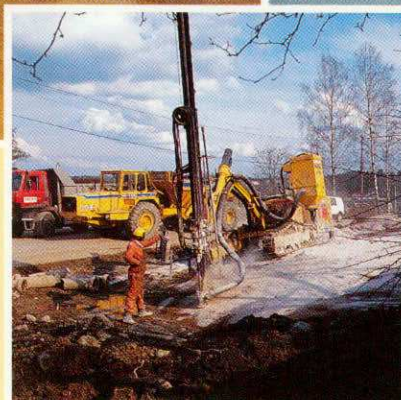
Building- and room acoustics



Traffic noise



Industry noise



Environmental noise



Human vibration

Norsonic Sound Analyser SA 110 is a real-time precision instrument for measuring sound, noise and human vibration. This instrument makes the measurement task easy, yet an advanced technology level is maintained.

Norsonic Sound Analyser SA 110 is well-suited for most acoustic measurements, including real-time frequency analysis, outdoor noise monitoring, occupational health and safety and building acoustics – or even human vibration measurements. Thus, this instrument can be used by safety engineers, acoustic consultants, R&D engineers in industry, in acoustic laboratories, in the Public Service sector etc.

Norsonic Sound Analyser SA 110 has a logical interface which guides you through your measurement task without any use of manuals or function keys. All measurement results are up-dated and presented simultaneously – even during the measurement.

Following to Norsonic's proven philosophy, Norsonic Sound Analyser SA 110 can be tailored to special applications. So, the customer does not buy features never used. As new applications emerge, the

instrument may be quickly adapted for them by simply up-dating the software.

We are constantly developing new features for Norsonic Sound Analyser SA 110, the latest being real-time frequency analysis and human vibration networks. So, the customer always have a state-of-the-art instrument, even if it was bought several years ago.

By using Norsonic Sound Analyser SA 110 in conjunction with Norsonic's various software packages, a complete measurement system can be created. Such a system provides easy and convenient – yet high precision – acquisition, processing and analysis of data. Reports presenting your results in graphical and alphanumeric format are also easily made.

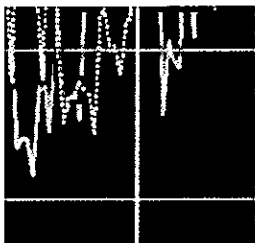
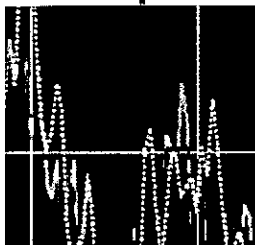
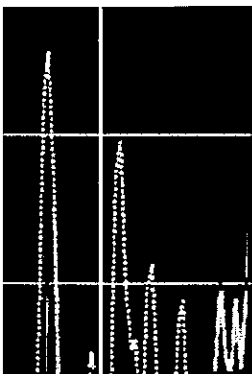
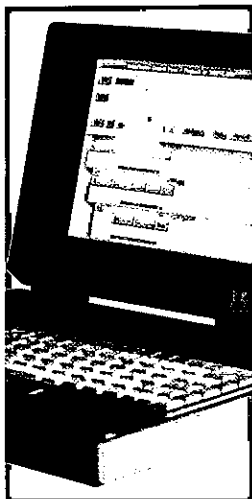
Norsonic Sound Analyser SA 110 has been sold in large numbers all over the world. The success of the instrument is mainly due to the combination of an advanced analyser's power and performance with a handheld sound level meter's flexibility and user-friendliness.

SUGGESTED SOLUTIONS TO MEASUREMENT TASKS

- **Building acoustics:**
SA 110, Reverberation mode, Real-time mode, Mic system, Oscillating mic boom 231, Tapping machine 211, Noise generator 230, Dodecahedron loudspeaker 229, Power amplifier 235, NOR-SIC 1005.
- **Outdoor noise monitoring system:**
Up to eight Noise Monitoring Terminals (SA 110, Time mode, Outdoor mic 1291, Weatherproof cabinet), NOR-MONIT 1006, Meteorology station, Modem.
- **Environmental monitoring:**
SA 110, Time mode, Sequence mode, Statistics mode, Event mode, Mic system.
- **Community noise:**
SA 110, Statistics mode, Time mode, Mic system.
- **Occupational health and safety:**
SA 110, (Real-time if fluctuating sound), Mic system.
- **Industrial R&D:**
SA 110, Real-time mode, Mic system.
- **Type approval:**
SA 110, Real-time mode, Mic system.
- **Ear protection selection:**
SA 110, Real-time mode, Mic system.
- **Acoustic phenomena:**
SA 110, Narrow band mode, Mic system.
- **Machine labelling (sound power):**
SA 110, Real-time mode, Mic system.
- **Impulsive noise:**
SA 110, Mic system.
- **Human vibration:**
SA 110, Human vibration mode, Accelerometer kit 1505.

Mic system: Mic 1220, Preamp 1201, Gooseneck/Cables

Accessories: Windshield 1434, Tripod 1307, Printer, Video interface 234, Mains adapter 314, Suitcases 1301/1316, Leather bag 1303, Calibrator 1251 (type 1), Cable to printer 1416, Cable to PC 1418, Cable to video monitor 1419, Cable to noise generator 1422.



See the sound

- several sound level meters
- an environmental noise analyser
- a frequency analyser
- an occupational noise analyser
- an automatic tape analyser
- a vibration meter
-

eNVi

environmental Noise & Vibration instrumentation

See the sound

eNVi is:

- several sound level meters
- an environmental noise analyser
- a frequency analyser
- an occupational noise analyser
- an automatic tape analyser
- a vibration meter
-

integrated as a single low cost, versatile and highly portable system

eNVi converts notebooks or desktop PCs into any or all of the above

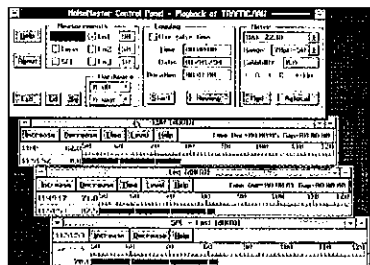
eNVi upgrades existing meters or uses a dedicated microphone / accelerometer

eNVi is uniquely easy to use as it is based on a new idea - Wysiwym -

What you see is what you Measure

What is eNVi?

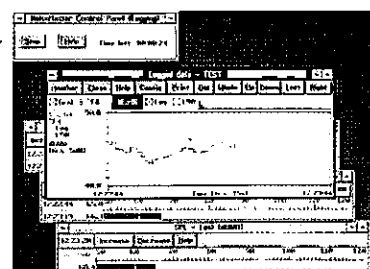
eNVi is delivered either ready installed on the notebook PC of your choice or ready to be installed on your own portable or desktop machine. The system consists of a single software disk, a lead that plugs into the printer port of the computer and battery powered pocket hardware. eNVi combines the facilities of several sophisticated noise and vibration meters and analysers in a single, low cost virtual instrument. eNVi is backed by exceptional technical support from experienced users.



Display several meters simultaneously

Setting Up

Installing the system is simplicity itself. Fit the batteries, plug the cable into the printer port, copy the contents of the disk to the PC and away you go - under 10 minutes from opening the box to displaying live data on screen. Input can be either from an existing SLM or vibration meter (immediately upgrading all that old equipment in the cupboard) or alternatively you can plug in a microphone or accelerometer directly. Instrument functions are all controlled using either a mouse or the keyboard - since everything is "live" you can see the results of your actions immediately on screen. Coupled with the simultaneous display of as many parameters as you wish, this makes eNVi very intuitive to use. Everything behaves exactly as you would expect - a spin off from the fact that the system has been designed by experienced users rather than academics or instrumentation engineers. You'll find that the well written manual is rarely opened and that the system lives up to its wysiwym description.



Logging to graph and to disc

In Use

The system defaults to a number of virtual meters with analogue and digital displays of the live data. In SLM mode (NoiseMaster module) this is SPL fast, Leq, and L90, each displayed simultaneously in its own window which can be moved and resized at will. The various measurements are all switched on or off from the control panel which also handles automatic calibration. The displays can be "locked" together (all using the same settings) or run independently (different time or level based events in each). When logging data, a graphical window is opened, plotting all selected values live. Other windows can be spun-off during capture to display selected plots separately. For frequency analysis (FrequencyMaster module), the same principles apply - only in this case different frequency plots can be displayed in multiple windows. Graphs can be printed directly (with thoughtful provision of dotted lines for monochrome printers) or exported. Measurement and display setups can all be saved and recalled for future use - as can raw data for subsequent re-analysis.

Environmental Application

Complaints about fan tones from a factory require a number of environmental noise measurements. eNVi used on a basic notebook PC to upgrade existing meter (with simultaneous feed to DAT recorder) outside the complainant's premises. Set up to plot Leq, L10, short term L90 (gaps between traffic), medium term L90 (all sources) and cumulative L90. Rearrange and format the live plots ready for the report whilst data capture continues. Octave and narrow band spectra captured between vehicles to allow the problem fan tone to be identified and the noise reduction required estimated. All data stored ready to be imported directly into report. Leave system to analyse tape automatically (for archive) over lunch.

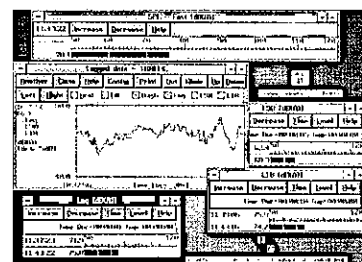
eNVi

environmental Noise & Vibration instrumentation



Industrial Application

Diagnostic measurements required on a high noise machine for both hearing protection and noise control assessments. eNVi (full colour notebook PC) used to obtain both octave band (linear) and narrow band ("A" weighted) spectra in parallel. Pulled back stored octave band attenuations for company issue hearing protectors for instant read-out of protection afforded to the operator of the machine in each case. Edit fan tones to see the effect of silencing extract fan on overall dB(A) level. Save all results for review back in office.



Hear all, see all, measure all

Verdict

eNVi is a simple, low cost way either to upgrade old instrumentation or, by adding a microphone or accelerometer, you have a new and enormously versatile portable measurement and analysis system. Ease of use is a major feature; the What You See is What You Measure concept works very well for the occasional user whilst providing more than enough facilities and customisation options for even the most sophisticated expert. Even if you purchase a powerful notebook PC just for eNVi, the complete system would still cost less than many sound level meters with a fraction of the capabilities.

Technical Summary

Type 1, 90dB dynamic range, c 8 hour battery life or external DC in, built-in microphone/accelerometer power supply, trigger in, software controlled gain, connects to PC printer (parallel) port, AC out for recording.

NoiseMaster Facilities (Summary)

Simultaneous SPL (fast), Leq, LMAX, 3 user defined LN, SEL as virtual sound level meter and analyser. Event logging of any or all parameters by time or level or any combination. Data export in ASCII or spreadsheet format. "Text" mode supported for modest PCs. Raw data can be stored for re-analysis.

FrequencyMaster Facilities (Summary)

Simultaneous 1/1 octave, 1/3 octave, narrow band (500-4000 lines), "A", "C", "Linear" and user defined weightings (e.g. hearing protector or structural attenuations), live display of spectra during capture, single and harmonic cursors, peak list, peak edit.

Note: detailed specifications subject to change.

For more information or to try eNVi for yourself, contact:

Industrial Noise and Vibration Centre
Burnham House, 267 Farnham Road
Slough, Berks SL2 1HA U.K.
Tel: 01753 570044 Fax: 01753 570311

Distributor

Editor:

J W Tyler FIOA

Features Editor:

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Contributions and letters to:

The Editor, 11 Colwyn Close, Yateley,

Camberley, Surrey GU17 7QH

Tel: 0252 871298

Books for review to:

A J Pretlove FIOA, Engineering Depart-

ment, University of Reading,

Whiteknights, Reading RG6 2AY

Information on new products to:

J W Sargent MIOA

Building Research Establishment

Garston, Watford WD2 7JR

Advertising:

Keith Rose FIOA

Brook Cottage, Royston Lane,

Comberton, Cambs. CB3 7EE

Tel: 0223 263800. Fax: 0223 264827

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The Institute of Acoustics was formed in 1974 through the amalgamation of the Acoustics Group of the Institute of Physics and the British Acoustical Society and is the premier organisation in the United Kingdom concerned with acoustics. The present membership is in excess of two thousand and since 1977 it has been a fully professional Institute. The Institute has representation in many major research, educational, planning and industrial establishments covering all aspects of acoustics including aerodynamic noise, environmental, industrial and architectural acoustics, audiology, building acoustics, hearing, electroacoustics, infrasound, noise, physical acoustics, speech, transportation noise, underwater acoustics and vibration. The Institute is a Registered Charity no. 267026.

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Dear Fellow Member

The Windermere conferences have come and gone - successful once more both technically and socially. Reproduced Sound reached its tenth anniversary and is a regular feature in many diaries. The programme this year included a one day symposium on network control of audio, video and other signals in multi-media events and a repeat of the training course for sound system engineers. This issue carries a full report of the event.

The Autumn Conference this year was organised by the Speech Group and was on 'Speech and Hearing'. Much of the subject matter was new to me and many of the possible applications of speech recognition and production opened interesting vistas. I enjoyed this conference and made new friends.

Most of the activities of the Institute rely on the energy of a number of enthusiastic individuals and this is particularly true of the Regional Branches. It was a great pleasure, therefore, to be invited to the resurrection or extension of two of our Branches recently. The Southern Branch organised a well attended evening meeting in Basingstoke and many of those present showed interest in assisting with the organisation of future activities. The Midlands Branch has expanded the territory of the former East Midlands branch and another well attended meeting took place in Rugby.

For those of us who see ourselves as engineers – whether by membership of other Institutes or simply in the application of our acoustic technology – the moves towards a unified Engineering Profession are of interest. This issue of the Bulletin carries further details on this important topic. It is to be hoped that the more democratic election of a governing body for the new Engineering Council will strengthen its ability to represent the profession.

We have given some details on the contents of recent issues of Acta Acustica to remind members that this is a late opportunity to take out a personal members' rate subscription for 1995.

I hope that you all enjoy the festive season with family and friends and that 1995 will be a prosperous and exciting year for you and for the Institute.

Sincerely yours

A handwritten signature in cursive script that reads "Alex Burd".

Alex Burd

A

A

T

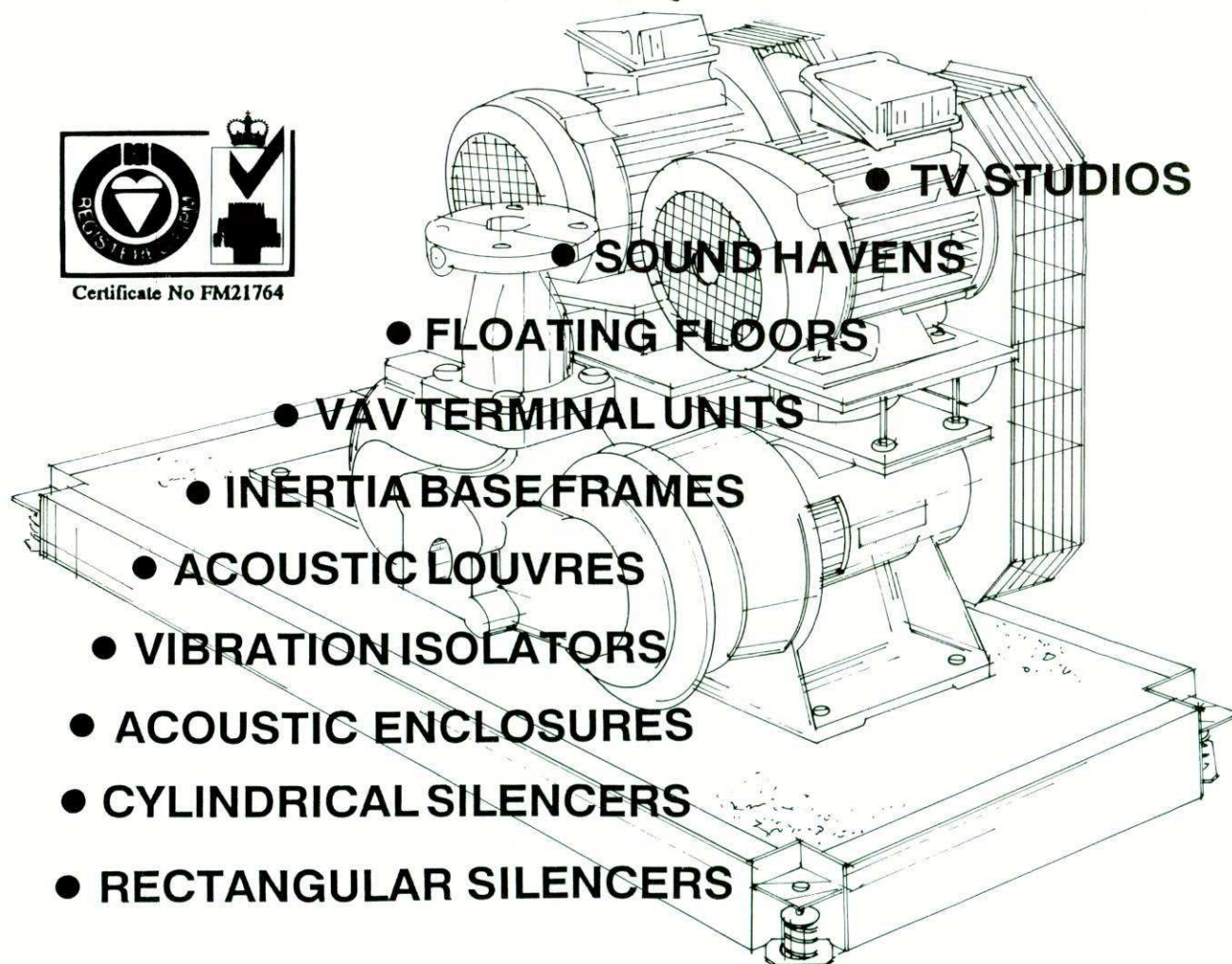
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AIRBUS AIRCRAFT ACOUSTIC FATIGUE CERTIFICATION

L C Chow MIOA & R J Cummins

Introduction

Acoustically induced fatigue failures in aircraft have been a design consideration for over thirty years. The problem was introduced with the advent of turbojet engines and the resulting high intensity acoustic pressure levels experienced on the aircraft structure. Acoustic fatigue failures can substantially increase the maintenance burden and life cycle cost of the aircraft. The certification of the aircraft structure includes the acoustic fatigue justification of those components likely to be affected by acoustic excitation. These components should also meet the normal structural damage tolerance requirements (threshold and damage growth) for the whole aircraft design life. The justification includes prediction, flight, ground and laboratory tests.

The History of British Involvement in Airbus Development

The launch of the first Airbus aircraft A300, a twin engined wide body aircraft was in September 1967 when the French, British and Germans signed a memorandum of understanding to develop the aircraft. The work was shared 37.5% each for France and Britain, 25% for Germany. The British government subsequently withdrew from the project; the share was rearranged as 50% each for French and Germans. It was because of the decision of Hawker Siddeley Aviation of UK to remain in the consortium as a subcontractor and contribute by

themselves towards hardware such as machine tools and in intellectual development that the project proceeded with British continued involvement. Hawker Siddeley had overall responsibility for the design of the wing but manufactured only the wing box. The equipping of the wing went to Germans in Bremen.

Fokker joined the Airbus programme in December 1970 as an associate partner. One year later CASA of Spain took a 4.2% stake and became a full partner with the French and Germans having shares reduced to 47.9% each. CASA was responsible for the design and manufacture of the tailplane. It was not until 1979 when the British government agreed to rejoin Airbus that Hawker Siddeley (by then incorporated into British Aerospace) secured a 20% stake share in the consortium with the French and Germans having their share further reduced to 37.9% each. British Aerospace were given overall responsibility for wing design and manufacture for the A310, the second twin engined wide body Airbus aircraft type. Belairbus of Belgium also joined as an associate partner and was responsible for the slats manufacturing.

It was not until the development of the twin engined narrow body A320 aircraft that BAe secured the design, manufacture and equipping of the wing including the control surfaces. On the A321, a stretched A320 twin engined narrow body aircraft, BAe are responsible for the wing and one of the two fuselage extensions. For the

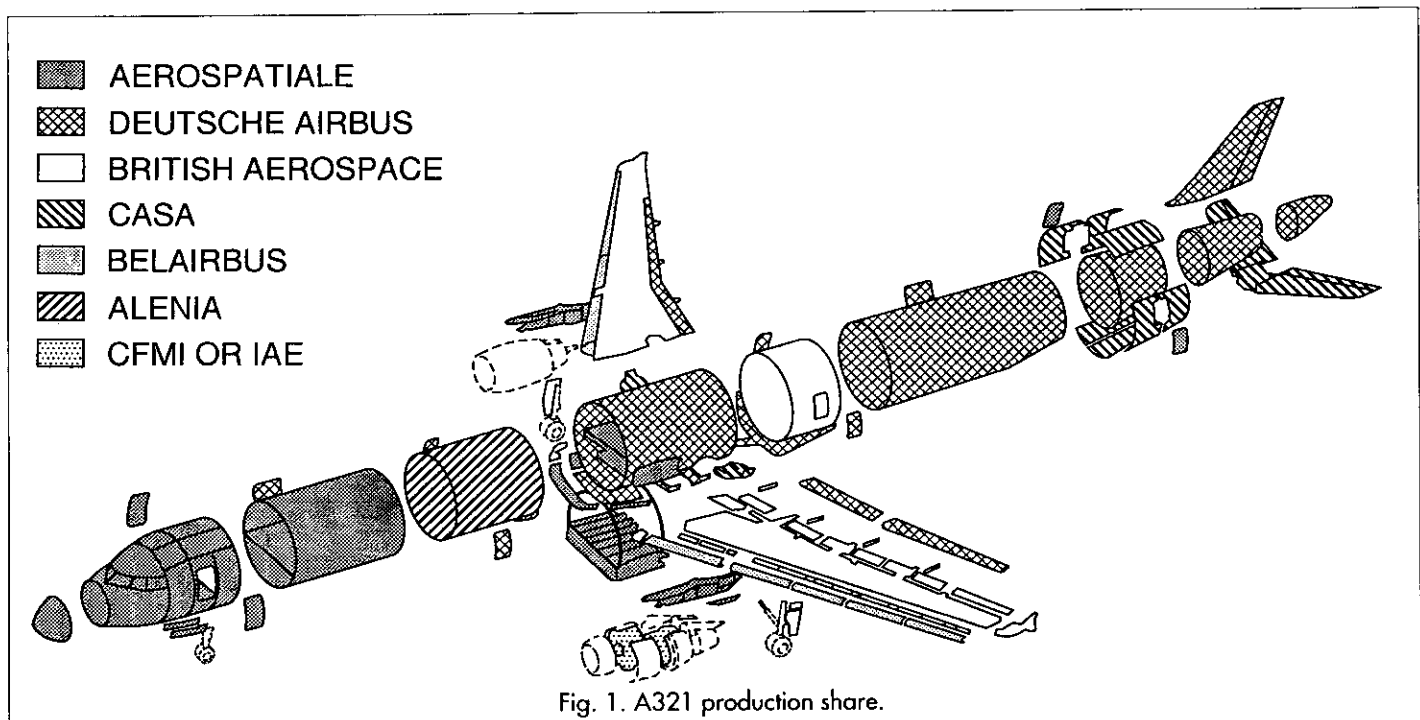


Fig. 1. A321 production share.

A330 (twin engined wide body aircraft) and the A340 (four engined wide body aircraft), BAe are again responsible for the wing design and manufacture of the wing box. Alenia of Italy have also joined the consortium as an associate partner during the A330/A340 programme. A typical work share diagram for A321 aircraft is given in Figure 1.

Joint Airworthiness Authorities

To design and build aircraft to different certification requirements may cause the aircraft manufacturer either to build to the envelope of the requirements or build to different standards, with the associated additional costs and spares complications. The extra costs to the operators may have to cover the direct cost of the modifications, a contribution to the extra development and certification costs, and possibly extra fuel consumption and perhaps restricted payload, if the aircraft weight is increased. The operational penalties from different requirements may be considerable. In the case of maintenance, the mutual acceptance of approvals and other bilateral arrangements depend on acceptably similar requirements.

The Joint Airworthiness Authorities (JAA) is a body representing the civil aviation regulatory authorities of a number of European states who have agreed to co-operate in developing and implementing common safety regulatory standards and procedures. This co-operation is intended to provide high and consistent standards of safety and a 'level playing field' for competition in Europe. Much emphasis is also placed on harmonising JAA regulations with those of the Federal Aviation Administration (FAA), the Authority in the USA. Membership is open to states who are members of the European Civil Aviation Conference (ECAC), which currently has 32 member countries, and JAA are an associated body of ECAC. JAA has a two stage membership system. New authorities join JAA as candidate members and can fully participate in meetings etc, but have no voting rights and there is no obligation on other JAA states to accept their approvals. After a satisfactory conclusion to a process of evaluation and assessment they will become full members. There are at present 17 full members and 6 candidate members.

JAA work was started in 1970 with objectives to produce common certification codes for large aeroplanes and for engines. This was to meet the needs of European industry, particularly for products manufactured by international consortia such as Airbus. Since 1987 its work has been extended to operations, maintenance, licensing and certification/design standards for all classes of aircraft. Common procedures and the approval of design, production and maintenance organisations are covered. A single Joint Certification team working on behalf of all JAA countries is used for certification of new aircraft and engines. After the successful completion of the evaluations Type Certificates are issued simultaneously, and on a common basis by all states. Since January 1992, JAA codes are referenced in the European Community Regulation on harmonised technical standards and became law in the EC states.

The British Sonic Fatigue Certification Responsibility

The overall acoustic fatigue certification responsibility of A300 and A310 aircraft is with Aerospatiale and Deutsche Aerospace Airbus respectively. BAe are responsible for the justification of the wings. Since then, the overall acoustic fatigue certification responsibility for all other Airbus aircraft, namely A319, A320, A321, A330 and A340, is with BAe. BAe is also responsible for the justification of components such as main wing box, wing fixed leading edges and spoilers.

Acoustic Fatigue Certification Requirements

The complete aircraft structure has to be considered for its susceptibility to acoustic fatigue. The structural components which are most likely to be affected by acoustic excitation are agreed with the certifying Airworthiness Authority. The components typically selected for an Airbus aircraft configuration are:

- Rear fuselage and auxiliary power unit (inlet region);
- Main wing box, fixed leading edge, slats, inboard and outboard landing flaps, inboard and outboard ailerons, spoilers;
- Fin, rudder, horizontal tailplanes and elevators.

The Joint Airworthiness Requirement (JAR) to be met in order to cover the acoustic fatigue strength is JAR 25.561 (d). This requirement states that it must be shown by analysis, supported by test evidence, or by the history of aeroplanes of similar structural design and acoustic excitation environment, that:

- (a) acoustic fatigue cracks are not probable in any part of the flight structure subjected to acoustic excitation; or
- (b) catastrophic failure caused by acoustic cracks is not probable assuming that the loads prescribed by the damage-tolerance evaluation are applied to all areas affected by those cracks.

One or more of the following Means of Compliance (MC) have been used to clear each component against the JAR 25.571 (d) requirements. They are:

- Description: For a component in a noise environment it may be possible to demonstrate by comparison, with other aircraft or structure in similar environments, that acoustic fatigue will not be a problem.
- Calculation/Analysis: The component is covered by analysis based on calculation. Established methods such as those presented in the Engineering Science Data Unit (ESDU) data sheets have been used.
- Laboratory Tests: Certain components require the demonstration of structural response (to support calculations) or of acoustic fatigue endurance by the use of ground test facilities such as a high intensity noise siren.

Ground Tests: Ground test measurements are normally conducted on aircraft with different engine variants to obtain sound pressure levels and structural response measurements for comparison with those obtained for basic certified aircraft.

- Flight Tests: Flight test measurements are usually carried out on the basic aircraft to be certified to obtain sound

pressure levels and structural response measurements (strain and acceleration) to validate the levels used for calculation and test demonstration. Relevant flight test data from other aircraft may also be used for this purpose.

The primary structure of an aircraft refers to the fuselage pressure shell, wing, fin and tailplane boxes and associated attachment structure. Other components are usually referred to as secondary structure or removable items. A removable item may be designed to accept, at low probability, replacement or repair at a stage where it is considered more economical than designing to the full life requirement. All the components should meet the normal structural damage tolerance requirements (threshold and damage growth). However, due to the difficulty of demonstrating damage growth under acoustic loading, the primary structure should be able to accept a complete local failure unless a damage free life is shown.

Acoustic Loading

The comparable near field noise generated by the high by-pass ratio turbofan engines used to power Airbus aircraft is generally less than that of the turbojet and low by-pass powerplants of the early jet era. The maximum overall sound pressure level recorded during flight test is less than 150 dB for the enroute and rarely higher than 155 dB for the landing flaps.

The typical exposure times to noise are based on the flight plan for the fatigue mission, see Figure 2. The levels given for each mission stage are the maximum levels assumed to occur and are taken to hold throughout the quoted exposure time. Flight test measurements have shown that the acoustic level may vary during a mission stage and this variation is most noticeable during the take off and landing stages. Hence the acoustic loading chosen to represent take off and landing phases is usually estimated conservatively.

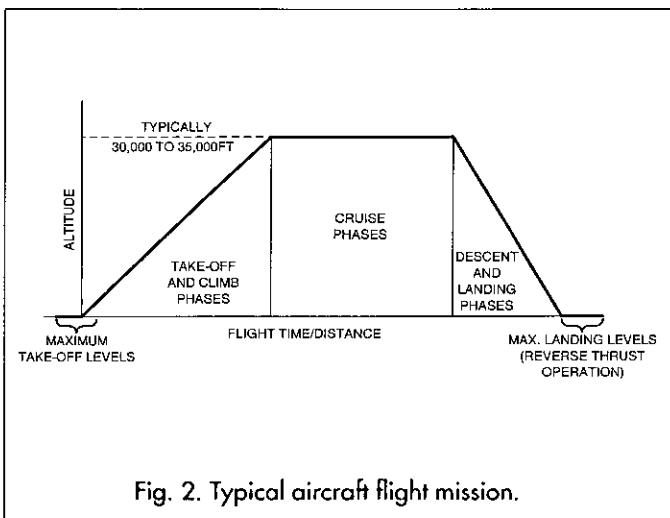


Fig. 2. Typical aircraft flight mission.

For the initial design work acoustic loading data is provided for each component required for certification. This allows the Airbus partner responsible for an individual component to allow for the acoustic loading during design and to produce the justification predictions and later to be able to compare with measurements from

ground or flight test. BAe have provided this data for the A320 and subsequent aircraft. Much of the important near field noise for the A320 was gathered from a scaled jet/wing/flap noise rig. Measured acoustic loading data from A300 and A310 aircraft were also used to aid the prediction of the A320 levels. The loading data for the subsequent aircraft, A321, A330, A340 and A319 (1996 certification) have been based on information gathered from:

- i) model scaled test data of the previous certified Airbus aircraft such as the above mentioned A320 jet/wing/flap noise rig;
- ii) flight test data of the A300, A310 and A320 aircraft;
- iii) engine noise predictions based on the engine performance information of each aircraft type;
- iv) jet noise prediction methods.

A typical flight test installation comprising microphones, accelerometers and strain gauges is given in Figures 3 and 4. Measurements are made during a typical flight mission although for most components the maximum noise loading will occur during the take-off and climb-out phases and also during the landing phase covering the use of engine reverse thrust operation.

Acoustic Laboratory Testing

In some cases it has been necessary to conduct an acoustic fatigue endurance test in a laboratory facility using either a whole aircraft component or a representative portion of the component. This means of compliance is adopted where a new or novel type of structure has been used in a high noise area where there may not be sufficient data to allow clearance completely by calculation. There may be additional considerations to be addressed for composite structures as explained in the following section.

The normal high intensity noise siren used is a progressive wave tube (PWT) with a controllable air modulator (siren) as the sound source. There are several types of suitable siren modulators produced by specialist manufacturers and currently sirens exist at the BAe Structural Test Facility at Brough and at the IABG Acoustic Facility at Ottobrunn, Germany, although several other manufacturers have smaller facilities. The specimens are usually tested at grazing incidence in the PWT, with the structural surface receiving the highest noise excitation in aircraft operation mounted facing into the PWT duct, see Figure 5. The excitation characteristics of the PWT may differ to that of the aircraft near field noise excitation due to jet efflux. It is therefore preferable to have some knowledge of the response of the test structure to the appropriate excitation field and to simulate this response by adjusting the siren modulator input. Failing this the estimated simulation of the aircraft noise excitation has to be established in the PWT and allowance made for a test or scatter factor.

In order to demonstrate the acoustic fatigue endurance in a reasonable timescale recourse will frequently be made to 'accelerated' testing. In this case the component is subjected to acoustic loading at levels higher than the expected 'real life' levels and an allowance

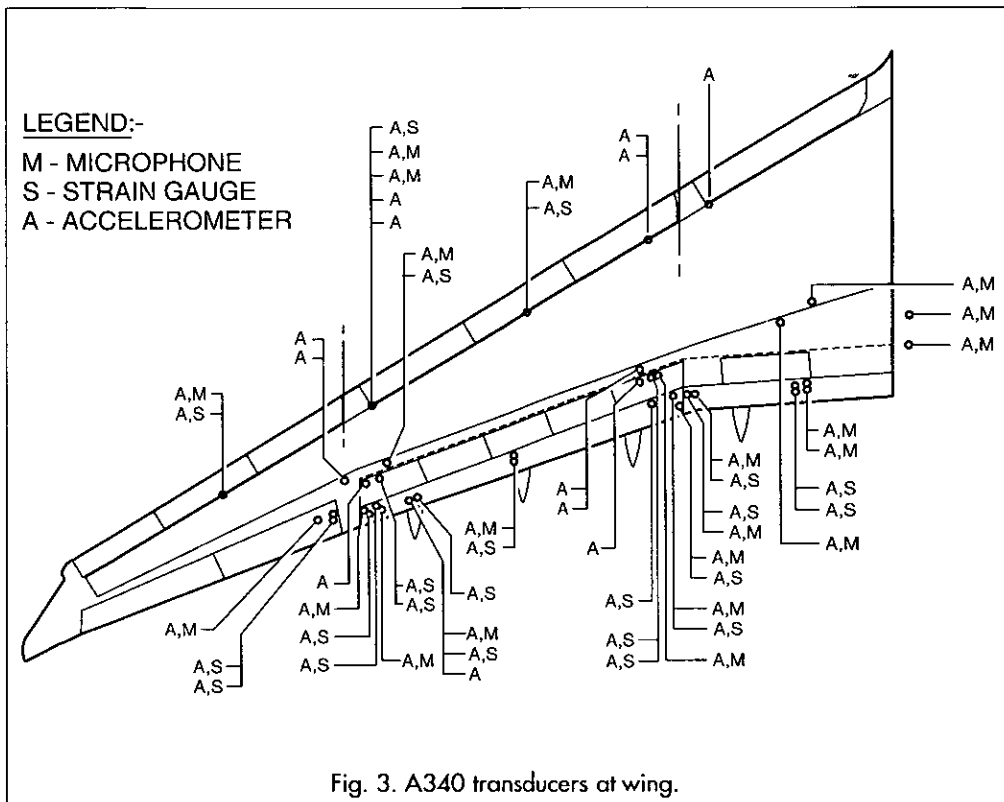


Fig. 3. A340 transducers at wing.

made to the change in fatigue endurance by means of established S-N data.

Acoustic Fatigue Certification of Composite Material Components

From the outset the Airbus consortium saw the attraction of composite materials as a means to reduce aircraft weight. Therefore extensive research and development took place into the properties and technology of these composite materials. After in-service experience of the composite materials in secondary structures such as leading edge fairing panels, spoilers, air brakes and inspection panels, the Airbus consortium became, in the spring of 1985, the first manufacturer of large commercial aircraft to use composite materials for the series production of primary structures when it began to assemble the A310 aircraft with fins built of carbon fibre reinforced plastic (CFRP). They are now in advance of all the other manufacturers in the use of composites which have revealed a number of advantages in cost and weight saving including the elimination of corrosion. A typical distribution layout of composite materials on the A340

dropped tools, or ground handling equipment. As the name suggests BVID is characterised by having only very small surface indentations but with an unknown amount of damage to the interior structure or to the rear (non-impacted) face. This type of damage was incorporated at an early stage, at various locations on the composite spoiler by using a mechanical device which could control the impact force. Several levels of impact force were used

aircraft is shown in Figure 6.

It was mainly due to the lack of the appropriate S-N data that many of the early Airbus composite components were subjected to acoustic endurance laboratory tests rather than being cleared by calculation or analysis techniques. A typical example was that of an A320 composite spoiler being tested for almost 300 hours with an overall sound pressure level of 150 dB. No detectable damage occurred to the basic structure due to the noise loading during the course of the test. However, there was also a need to prove that BVID (Barely Visible Impact Damage) and any applied repairs on a composite component would also survive the loading without any undue deterioration. In practise BVID could be caused by impact from stones or tyre debris,

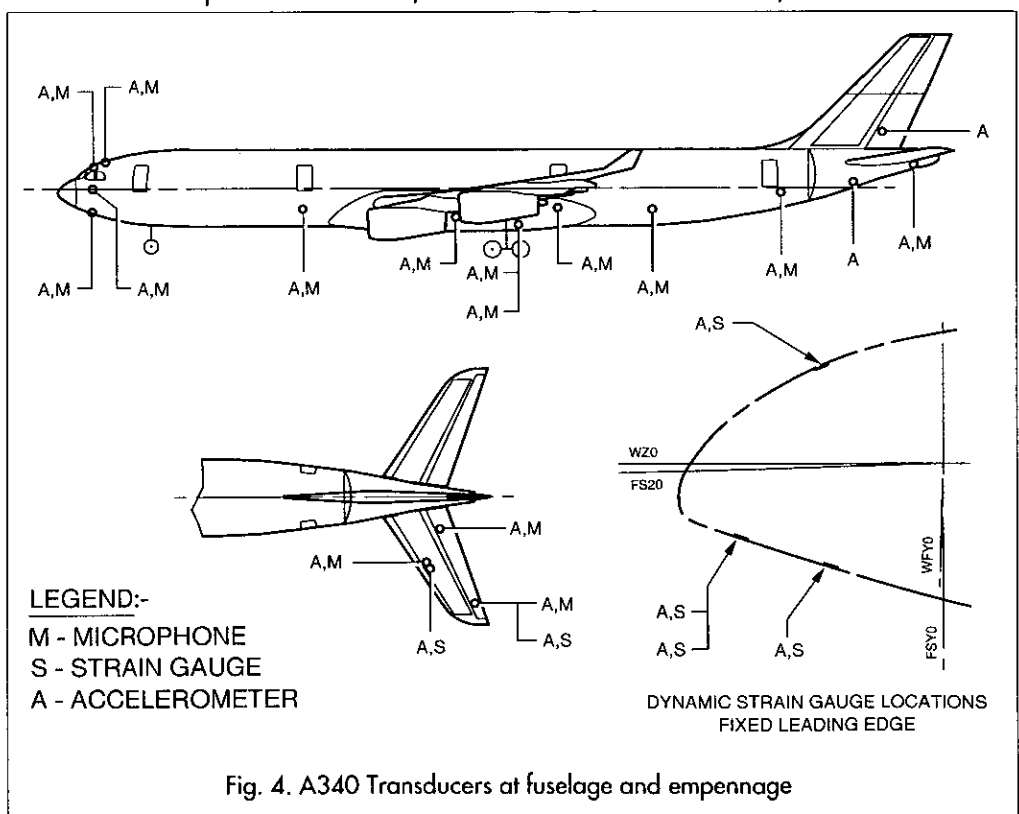


Fig. 4. A340 Transducers at fuselage and empennage

at separate locations on the surface of the structure.

In addition several repairs were applied to artificial damage. No detectable damage propagation occurred from the BVID or in the vicinity of the repairs demonstrating a high reserve factor in the fatigue design life. Other composite components tested in the laboratory included the A310 elevator, fin box, rudder and the A320 inner flap and horizontal tailplane.

Recent Airbus Aircraft Acoustic Fatigue Certification

Recent Airbus aircraft being certificated include the A321, A330, A340. The A321 is a twin engine single aisle short to medium range airplane with 186 seating capacity. It differs from the A320 aircraft by the addition of two fuselage sections, a new double slotted flap design and a modified centre fuselage. For certification purposes, the A321 is regarded as a stretched A320 aircraft rather than as a new type. Two basic engine types have been certificated, the CFM56 and V2530 from the two collaborative powerplant manufacturers, with variants producing nominal take-off thrust in the range of 30,000 to 31,000 lbs.

The A340 is a four engine wide bodied aircraft with twin aisles and designed for long range operations. There are two basic fuselage lengths the -300 having 8 additional fuselage frames compared to the -200 variant and giving a typical seating capacity of 296 in a three class configuration. There are several versions of the CFM56-5 engines available for the A340 variants ranging in nominal take off power rating from about 31,000 lbs to 34,000 lbs thrust. There is a small increase in near field noise levels due to the increase in thrust.

The A330 is a twin turbofan version of the same basic aircraft structure designed for short to medium range operations with a higher seating capacity. In a single class configuration this could be typically 440 seats. There are several airframe variants with options for engine choice from all the big three manufacturers, General Electric, Pratt and Whitney and Rolls-Royce. These powerplants range in nominal take off power rating from 64,000 lbs to 72,000 lbs thrust. There are variations in the near field noise levels due to the different manufacturer's engine configurations and geometries as well as the thrust rating. The initial entry-into-service variants have completed or nearly completed certification while for additional airframe/engine options certification will be a continuing process.

A new model, the A319 twin engine narrow body, which is a shortened version of the A320 will be certifi-

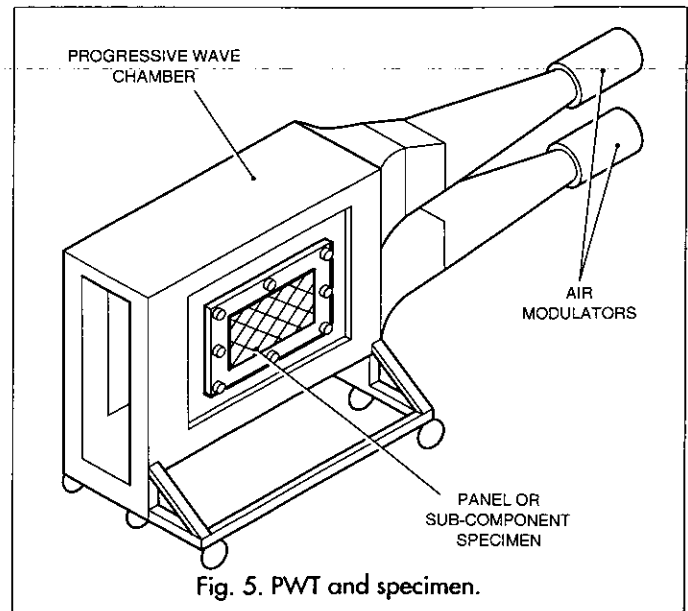


Fig. 5. PWT and specimen.

icated at the beginning of 1996. This is typically a 124 seating capacity aircraft when in a two class configuration.

Flight tests are carried out at the Airbus Industrie site in Toulouse, France. The microphone, strain gauge and accelerometer measurements are subsequently analysed



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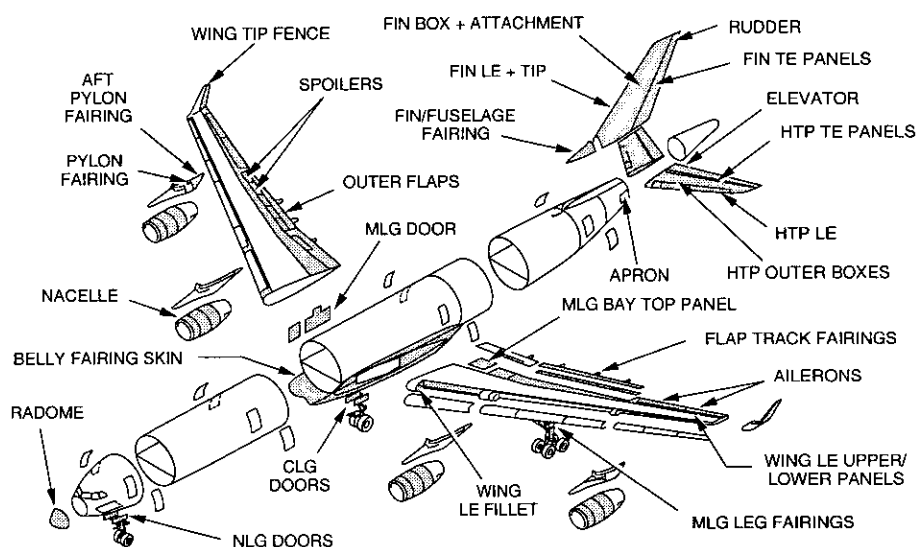


Fig. 6. A340 composite structures.

and made available for comparison with predictions and/or laboratory tests.

For major engine upgrades or thrust changes the measurements may be made with an aircraft ground test using microphones which are not permanently fixed to

the lead A300 flying is still only just past 80% of its design life goal.

L C Chow MIOA and R J Cummins are with British Aerospace Airbus Ltd, Filton, Bristol

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RADIATION IMPEDANCE CALCULATION BY FINITE ELEMENT ANALYSIS

Julian R Wright MIOA

Foreword

The advent of commercially available Finite Element Analysis (FEA) software which permits the solution of coupled mechanical-acoustical problems will have a profound effect on the acoustics world. Complex problems with no analytical solution can now be solved with useful precision. One such real-world problem is that of the radiation impedance acting upon a loudspeaker diaphragm. For several decades designers have resorted to classical theory of vibrating discs [1] to provide an approximate model for this radiation impedance. It will be shown that, in the modern context, this approximation can be inadequate. A simple coupled FEA model of a cone piston provides an immediate improvement.

Introduction

Acoustic FEA is a burgeoning field [2-6]. It is important, however, to distinguish between *coupled* models (where the fluid has a loading effect upon the structure) and *uncoupled* models (where the structural vibration is solved in vacuo and the resultant displacements used as an input into a separate model of the fluid). In many situations the uncoupled model is quite acceptable, eg radiation in air from machines or vehicles. However, in cases where the acoustic impedance (or *radiation impedance*) of the fluid is significant in comparison with the mechanical impedance of the structure a coupled model is essential. The loudspeaker is a good example of such a system. Many Finite Element programs support uncoupled

models by virtue of a separate acoustics module, but those which provide an integrated (and therefore coupled) mechanical/acoustical solver are few. One such integrated system is PAFEC-FE: the following study illustrates the potential of such software.

Finite Element Analysis Theory

For detailed discussions of FEA theory, the reader is referred to the works of Petyt [7] and Macey [8,9]. However, there follows a brief summary of the general principles.

In a generalised single-degree-of-freedom mechanical system, a body of mass M is coupled to an inert point by a stiffness K , and caused to move by an external force F .

The motion is damped by a damping element C (Figure 1).

The equation of motion of this system is

$$M \frac{d^2x}{dt^2} + C \frac{dx}{dt} + Kx = F \quad (1)$$

or

$$M \ddot{x} + C \dot{x} + Kx = F \quad (2)$$

where x is the displacement of the body and t is the time variable.

The natural frequency of vibration of the system is found by setting F and C to zero and assuming sinusoidal motion:

$$x = |x| e^{i\omega t} \quad (3)$$

where ω is angular frequency ($= 2\pi f$ where f is frequency), hence

$$(K - \omega^2 M)x = 0 \quad (4)$$

In a practical mechanical system there will be many degrees of freedom with multiple variants of F , M , K and C . The Finite Element approach is to discretize the system into constituent *elements* of *finite* size. The surface of an element is defined by *nodes*, and the result is a mesh representing the complete system. This produces a typically large number of simultaneous equations, which can be represented in matrix form:

$$[M][\ddot{x}] + [C][\dot{x}] + [K][x] = [F] \quad (5)$$

The equivalent matrix equation for the natural frequencies is then

$$([K] - \omega^2 [M])[x] = [0] \quad (6)$$

where ω represents a series of frequencies ω_n .

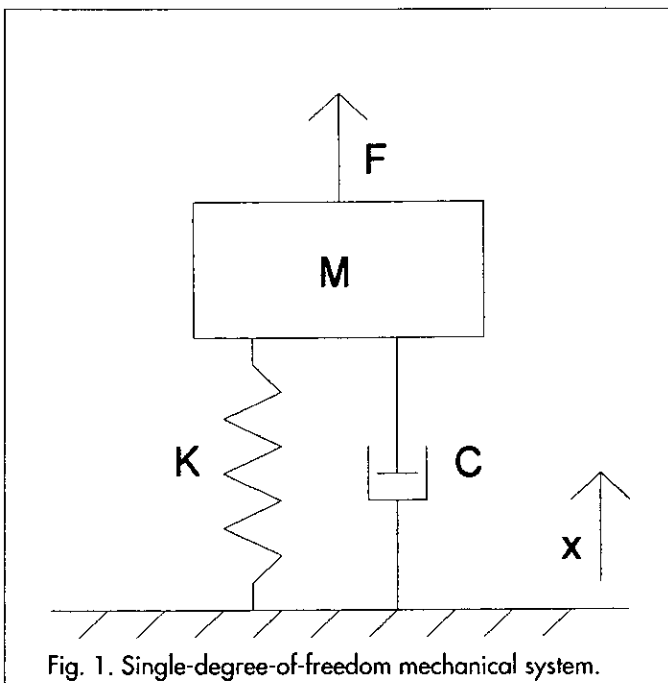


Fig. 1. Single-degree-of-freedom mechanical system.

If the material properties are defined, the above equations can be solved for $\{x\}$ (or $\{F\}$) and ω respectively.

For an undamped coupled structure-fluid problem with harmonic excitation, equation (5) becomes

$$([K] - \omega^2 [M])\{x\} + [T_a^T]\{p\} = \{F\} \quad (7)$$

and

$$([K_a] - \omega^2 [M_a])\{p\} + \omega^2 [T_a]\{x\} = \{0\} \quad (8)$$

where

ρ is the density of the fluid, $\{p\}$ are the pressures at nodes in the fluid, $[K_a]$ is proportional to $1/\rho$, $[M_a]$ is proportional to $1/B$ (where B is bulk modulus) and $[T_a]$ represents the coupling between structural and fluid elements according to their 'shape functions', ie the functions representing variation of displacement or pressure across an element.

In the case where the fluid region is not finite, a different approach is required whereby the infinite fluid can be reduced to a finite model. Here the *boundary element* technique is employed [2,8]. A boundary is defined by a continuous mesh of surface elements such that radiation from each node on this surface is of the form

$$p \propto \frac{1}{4\pi r} e^{-ikr} \quad (9)$$

where k is the wave number ($= \omega/c$ where c is the velocity of sound in the medium).

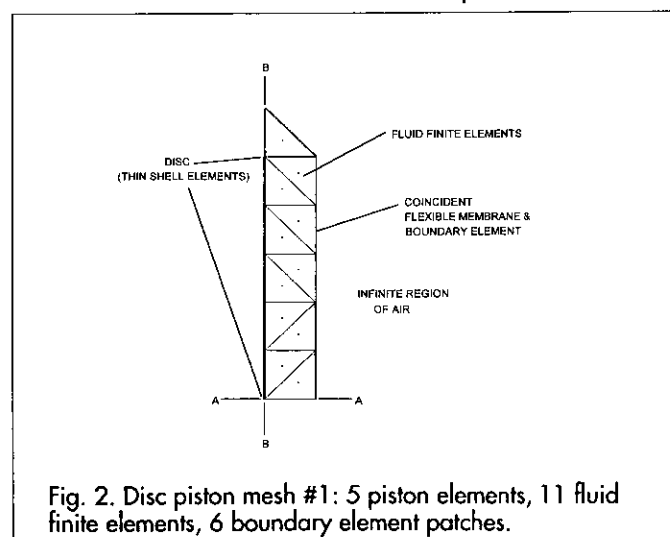
Note that this is a highly simplified description, and that the interested reader should consult the references.

There are a number of difficulties with the implementation of this technique, but these problems have largely been overcome [10,11].

Models

Radiation Impedance of a Disc Piston

To validate the method the radiation impedance of a disc piston, for which there exists an analytical solution, was calculated. To ensure adequate accuracy in the solution the finite-element mesh density was gradually increased and results compared with the previous set until appropriate convergence was achieved. Figures 2 and 3 show the finite-element meshes used for the disc piston.

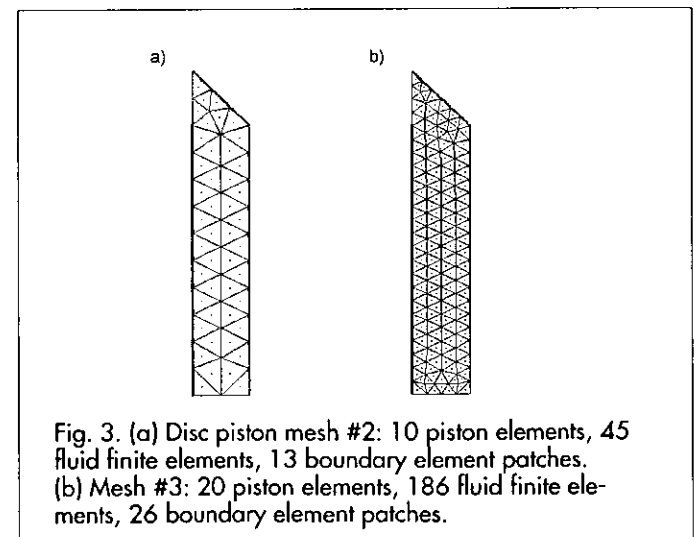


Consider Figure 2. The disc is represented by five thin-shell structural elements. The model is axisymmetric about the line A-A and the piston lies in an acoustic plane of symmetry (infinite baffle) along the line B-B. The air immediately in front of the piston is modelled by triangular fluid finite elements and the infinite fluid beyond them is represented by an acoustic boundary element (comprised of a contiguous series of patches). The fluid finite elements are necessary because the boundary element technique cannot model the entire fluid space – there must be an excluded volume. Note that the nature of FEA allows us conveniently to isolate any effects on the rear of the disc – essentially there is air on the front face and a (mathematical) vacuum on the rear!

In order to represent the acoustic field with sufficient accuracy at least three elements per wavelength are required. To enable modelling up to normalised frequency $ka = 10$ (where a is the radius of the disc) we require a minimum element dimension given by $\lambda/3 = 2\pi a/30$, ie approximately $a/5$. Hence mesh #1 must be the most coarse mesh.

Unfortunately the current version of the PAFEC software does not permit direct coupling of axisymmetric fluid finite elements with axisymmetric boundary element patches, so it is necessary to interpose a light, flexible *coupling membrane* of structural elements whose nodes are coincident with both sets of fluid elements. This introduces additional difficulties which must be carefully monitored throughout the analysis: each coincident pair of fluid element and boundary element nodes should exhibit the same acoustic pressure, ie pressure should be continuous across the (artificial) membrane. Any resonances in this coupling membrane must therefore lie outside the frequency band of interest or be of negligibly small amplitude. This situation must be attained by trial and error, as merely solving for the natural frequencies of the coupling membrane will be useless because this assumes that vibration occurs *in vacuo*: fluid loading due to the medium (air) will significantly affect the vibrational behaviour of a light structure.

To calculate the radiation impedance acting upon the disc, a sinusoidally varying force F is applied to the centre of the disc (at the intersection of A-A and B-B). To



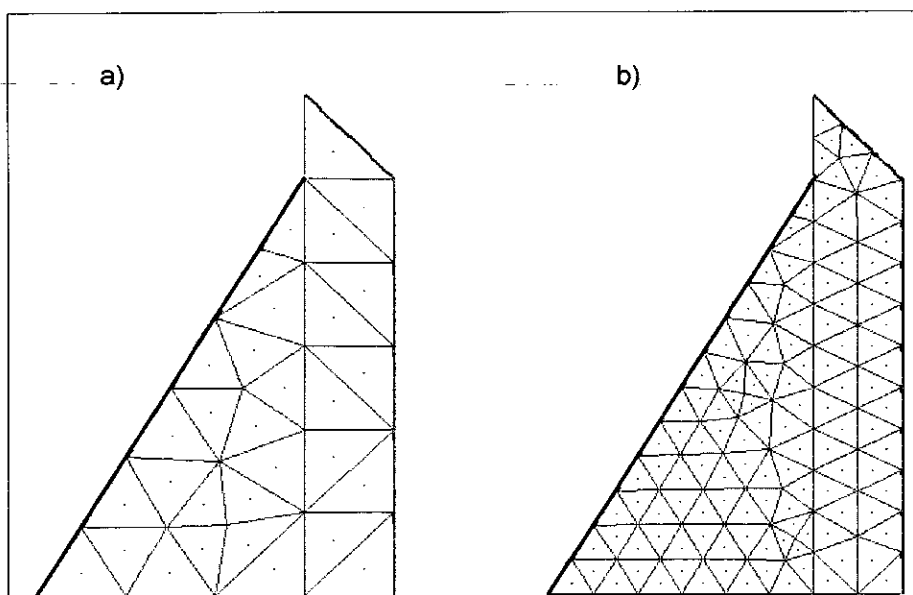


Fig. 4. (a) Concave Cone piston mesh #4: 6 piston elements, 31 fluid finite elements, 6 boundary element patches.
(b) Mesh #5: 12 piston elements, 113 fluid finite elements, 13 boundary element patches.

enforce piston motion, all degrees of freedom (DOFs) on this structure are made identical. The model is then solved for the displacement x of the piston. The total mechanical impedance Z_m acting upon the disc is given by

$$Z_m = F/u \quad (10)$$

where u is the velocity of the piston. So

$$Z_m = F/j\omega x \quad (11)$$

This impedance comprises two components: the actual mechanical impedance due to the mass M of the piston and the mechanical equivalent of the radiation impedance Z_r . Then

$$Z_r = (Z_m - j\omega M)/S^2 \quad (12)$$

where S is the area of the piston.

Thus, having solved for the displacement, radiation impedance is easily obtained.

Radiation Impedance of a Cone Piston

The majority of real loudspeaker diaphragms are not planar discs: they are non-planar cones. This three-dimensional geometry has hitherto posed severe problems – there is no known solution for the radiation impedance of a cone piston (although Suzuki & Tichy have shown a solution for dome pistons [12]).

In order to model the behaviour of a loudspeaker, we need the radiation impedance acting upon *both* faces of

the diaphragm. If the diaphragm is a disc, we can simply use the radiation impedance as per section 4.1, multiplied by a factor of 2. However, for a cone we must obtain two different solutions – one for the *concave* face and one for the *convex* face. Note that here the required displacement is the component which is parallel to the applied force.

Concave Cone: Figure 4 shows the two finite-element meshes used to obtain the radiation impedance acting upon a concave cone. The included angle at the cone apex throughout this work was 120° , which is typical of real loudspeakers. The approach is precisely as described for the disc, with merely a change in geometry.

Convex Cone: Figure 5 shows two meshes for the convex face. In this case there is an alternative solution method. The convex cone inherently provides an excluded volume for the boundary element, thus allowing direct coupling between piston and boundary element.

This has two major advantages – the artificial membrane and the fluid finite elements are eliminated, leading to improved solution accuracy and much reduced computation time. Using this approach, mesh #8 comprised five coincident piston elements and boundary element patches and mesh #9 comprised 15 coincident elements and patches.

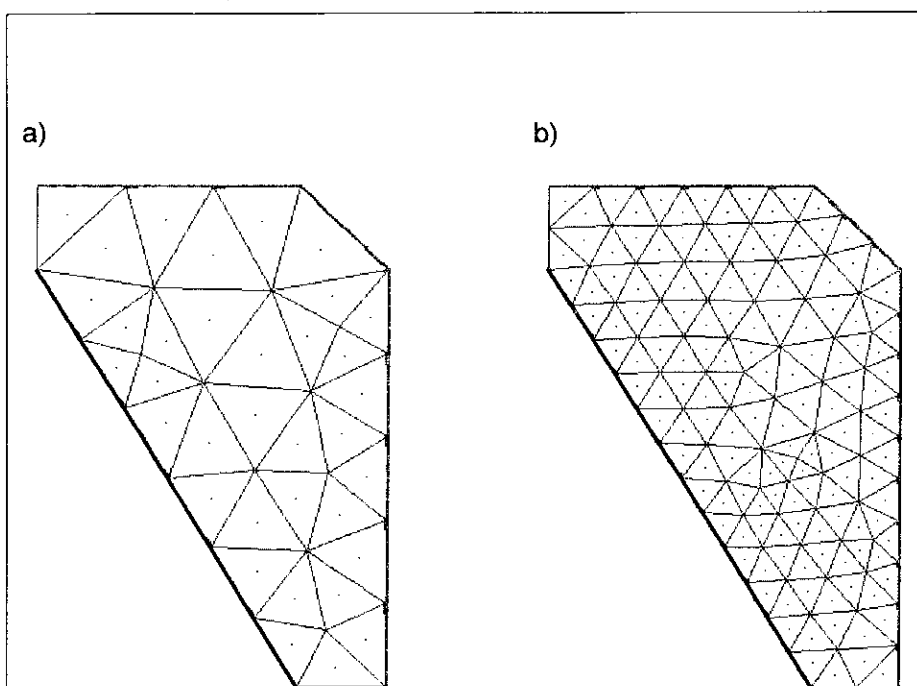


Fig. 5. (a) Convex Cone piston mesh #6: 6 piston elements, 35 fluid finite elements, 9 boundary element patches.
(b) Mesh #7: 12 piston elements, 143 fluid finite elements, 19 boundary element patches.

Computer Hardware

All calculations were carried out using a PC-compatible 486DX 50 MHz system running MS-DOS 5, with 32Mbytes of RAM and a 200 Mbyte hard disk.

Results

Radiation Impedance of a Disc Piston

Figure 6 shows the calculated radiation impedance from disc mesh #3. The abscissa shows normalised frequency ka . The ordinate shows radiation impedance normalised by $\rho c S$. This presentation is the convention for radiation impedance data, and provides a generalised data set which can be applied to any combination of k , a , ρ , c and S .

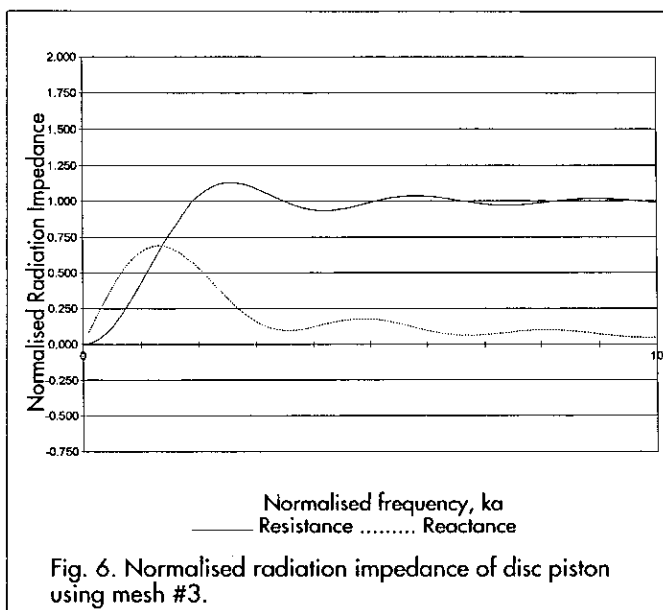


Figure 7 shows the absolute error between the values derived from mesh #2 and from mesh #1. The reliability of the computation decreases with increasing frequency, as would be anticipated. The discontinuities in the curves around $ka = 0.3$ are due to resonance in the coupling membrane. The resultant error is negligible.

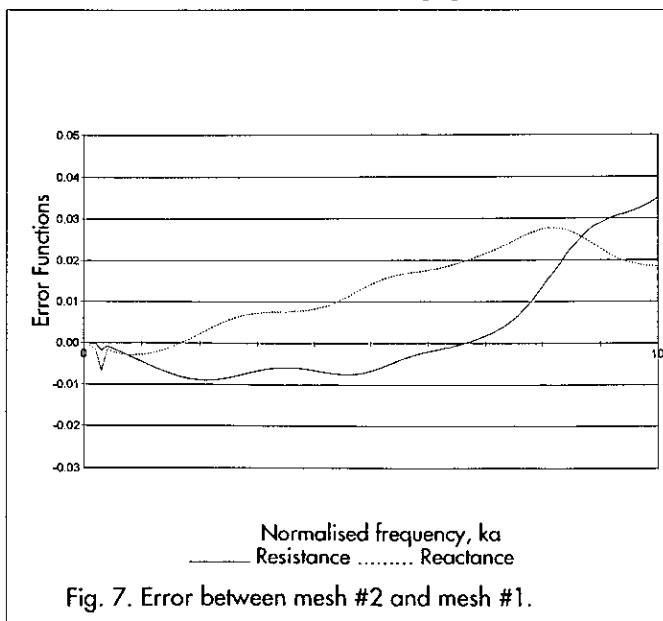
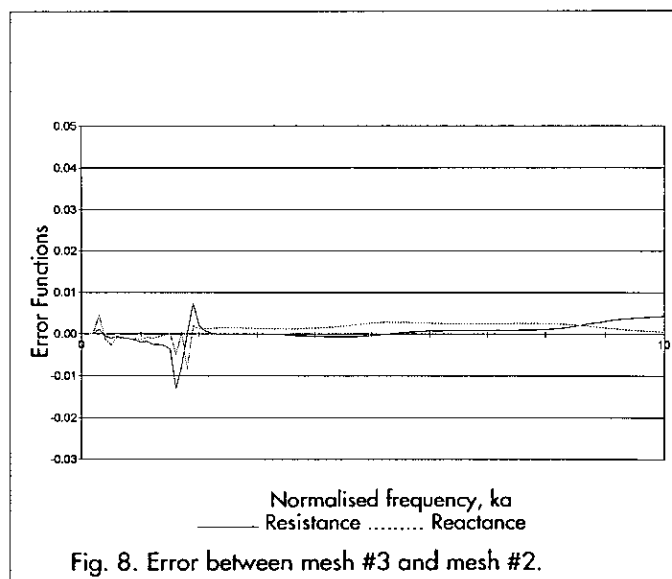


Figure 8 shows the error between the values derived from mesh #3 and from mesh #2. The tendency to convergence as the model is refined is clearly illustrated. More discontinuities have appeared, due to the increased number of DOFs in the coupling membrane giving rise to an increase in the number and bandwidth of resonance frequencies. The errors remain insignificant.

On the basis of Figure 8, mesh #3 is deemed to provide adequate accuracy for the computation. Hence the data shown in Figure 6 is taken as the definitive data for the radiation impedance of the disc piston. The values are

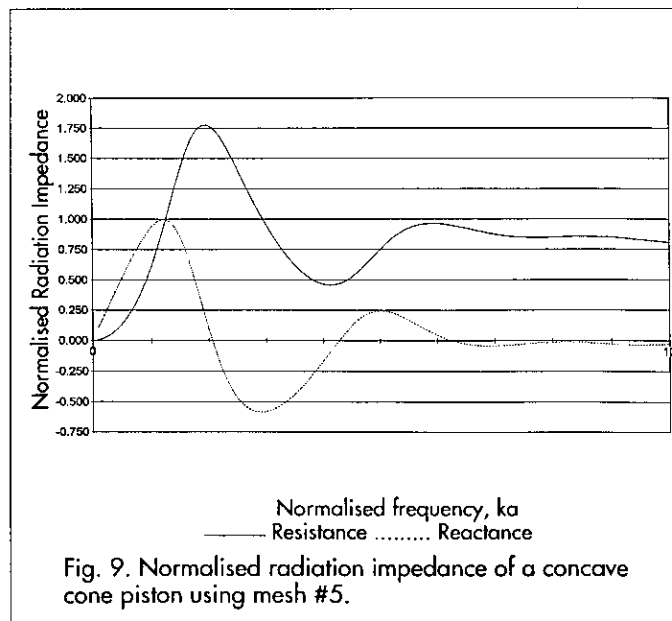


given in Appendix Table A and comparison with those published by Kinsler & Frey [1] is highly favourable – all values lie within 2% and most lie within 0.2%. On this evidence, we can proceed to analyse the results for the cone pistons.

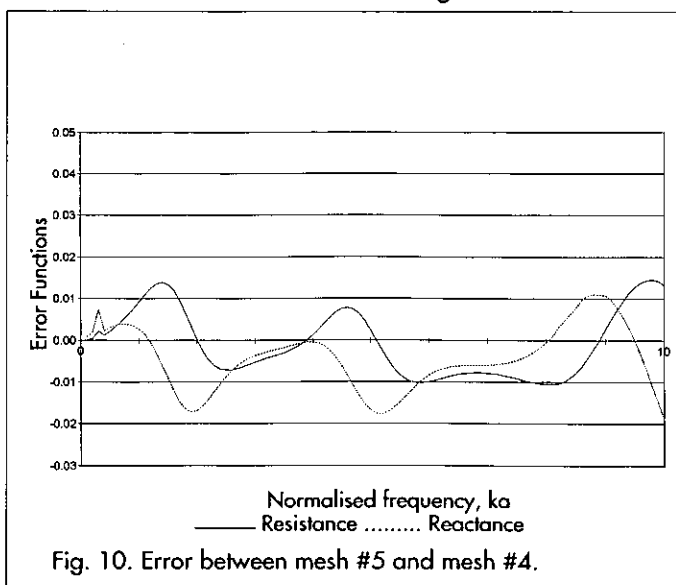
Radiation Impedance of a Cone Piston

Concave Cone: Figure 9 shows the normalised radiation impedance of a concave cone piston obtained using concave mesh #5.

Note that the radiation impedance is normalised by

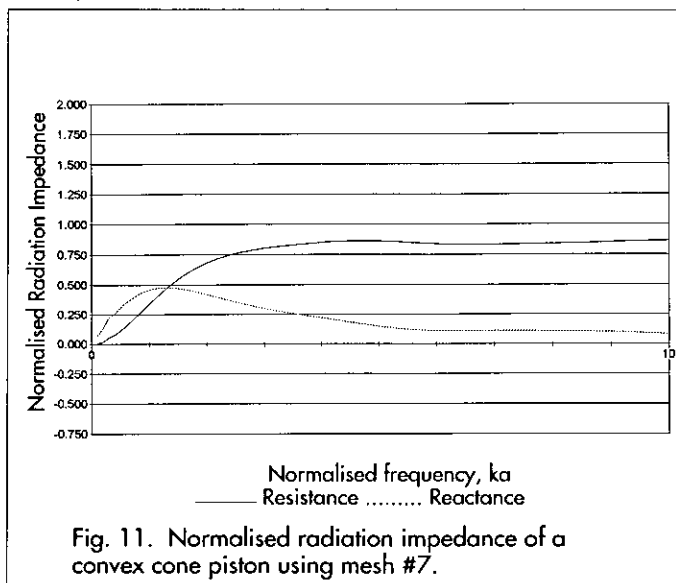


the projected area of the cone (ie still pcS). Numerical data is given in Appendix Table B. The error between mesh #5 and mesh #4 is shown in Figure 10.



Convex Cone: Figure 11 shows the normalised radiation impedance of a convex cone piston obtained using convex mesh #7. The error between mesh #7 and mesh #6 is shown in Figure 12.

Figure 13 shows the normalised radiation impedance of a convex cone piston obtained using convex mesh #9. The error between mesh #9 and mesh #8 is shown in Figure 14. The large error 'glitch' near $ka=9$ is due to inadequate mesh density near the discontinuities at the baffle and apex in mesh #8.



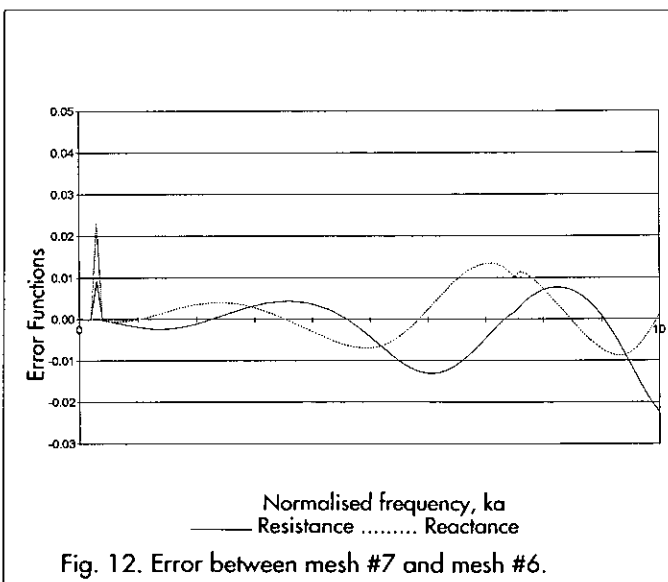
The error between mesh #9 and mesh #7 is shown in Figure 15, illustrating that the two alternative methods produce very similar results. The absence of fluid finite elements in the mesh #9 approach is superior in terms of computational efficiency, and is therefore the preferred method. Numerical data for Figure 13 is given in Appendix Table C.

Pressure Continuity Checks

A small sample was taken of pressure continuities across

	Errors in continuity	
	Re (p)	Im (p)
DISC MESH #4		
$ka=1$	0.49%	0.23%
	0.07%	0.04%
	1.85%	6.64%
$ka=10$	0.01%	0.05%
	0.01%	0.00%
	0.20%	0.05%
CONCAVE MESH #5		
$ka=1$	0.00%	0.00%
	0.03%	0.08%
	0.00%	0.00%
$ka=10$	0.01%	0.00%
	0.00%	0.00%
	0.00%	0.00%
CONVEX MESH #7		
$ka=1$	0.00%	0.00%
	0.00%	0.00%
	0.03%	0.09%
$ka=10$	0.00%	0.00%
	0.00%	0.00%
	0.03%	0.19%

Table 1. Pressure continuity checks.



the coupling membrane. Table 1 shows the results for three nodes at each of two frequencies, $ka=1$ and $ka=10$. Results are generally acceptable, although one node in the disc mesh indicates some resonant behaviour in the membrane.

Discussion

The practical significance of radiation impedance should not be underestimated. Let us consider, as an illustration, the case of a direct-radiating cone loudspeaker. The acoustic output of this device can be modelled by treating its properties as lumped parameters and analysing an equivalent electrical circuit [13]. The radiation impedance (front and back) appears as (frequency-dependent) components in this circuit.

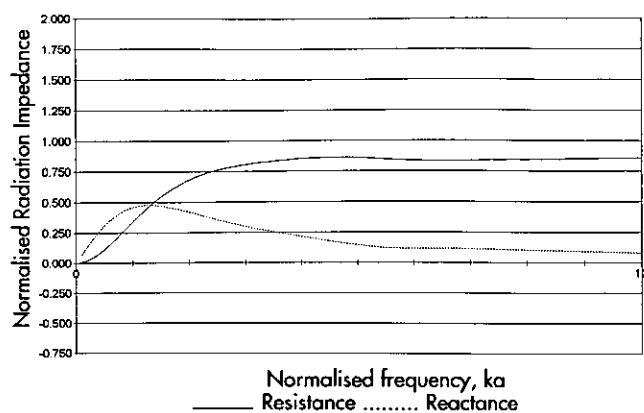


Fig. 13. Normalised radiation impedance of a convex cone piston using mesh #9.

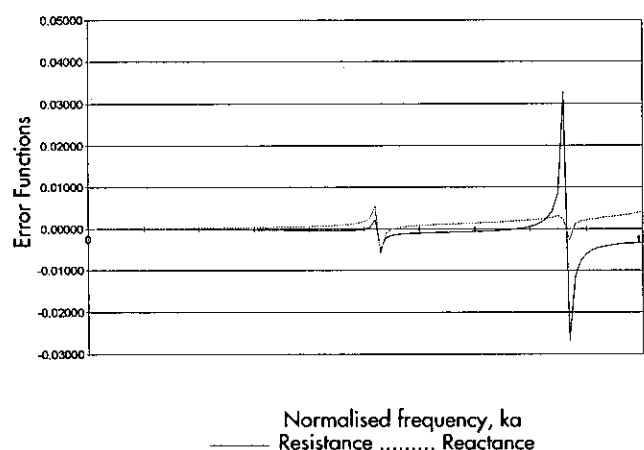


Fig. 14. Error between mesh #9 and mesh #8.

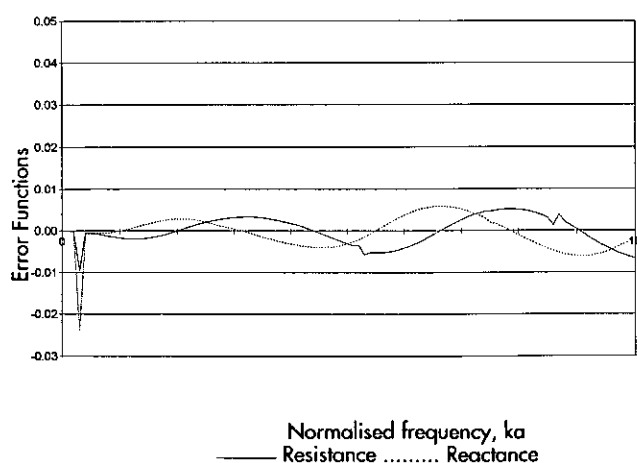


Fig. 15. Error between mesh #9 and mesh #7.

Consider a conical loudspeaker of average mechanical mass ($a=106$ mm, mass=14 g). The traditional approach is to model the radiation impedance using the available data for the disc. Now we can replace this data with the above data for concave and convex cones.

Figure 16 compares the predicted infinite baffle on-

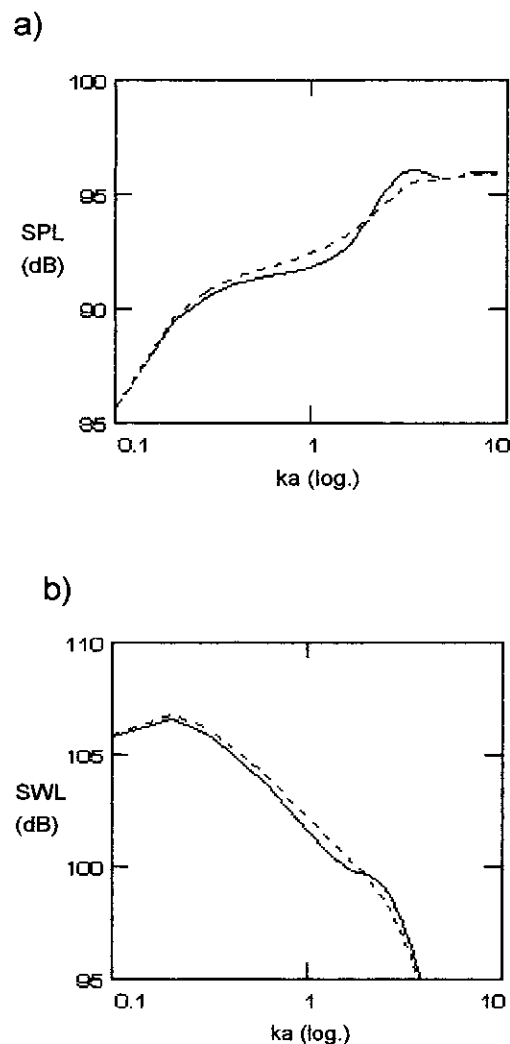


Fig. 16. Comparison of cone and disc infinite baffle models: (a) on-axis SPL; (b) SWL. Solid line : cone, broken line: disc.

axis Sound Pressure Level (SPL) and the Sound Power Level (SWL) assuming that (a) the diaphragm is a disc, and (b) the diaphragm is a cone. The latter is a much more realistic assumption. The difference between the predictions exceeds 0.6 dB at some frequencies – this for a *typical* loudspeaker. Lighter diaphragms would be susceptible to greater modelling errors if the traditional 'disc approximation' were used.

Conclusions

This paper has discussed the application of Acoustic Finite Element Analysis to practical problems which have hitherto remained unsolved. The technique was validated by comparing results with a known analytical solution, and radiation impedance data for cone pistons has been obtained. The importance of this data is illustrated by a typical example of prediction of the acoustic output of a loudspeaker.

ka	Zre	Zim	ka	Zre	Zim	ka	Zre	Zim	ka	Zre	Zim	ka	Zre	Zim	ka	Zre	Zim
0.1	0.005	0.085	5.1	0.999	0.173	0.1	0.005	0.104	5.1	0.793	0.241	0.1	0.005	0.069	5.1	0.857	0.140
0.2	0.020	0.168	5.2	1.008	0.168	0.2	0.021	0.208	5.2	0.834	0.230	0.2	0.020	0.136	5.2	0.855	0.135
0.3	0.044	0.248	5.3	1.017	0.161	0.3	0.047	0.311	5.3	0.870	0.213	0.3	0.043	0.199	5.3	0.851	0.130
0.4	0.078	0.325	5.4	1.024	0.153	0.4	0.085	0.414	5.4	0.899	0.192	0.4	0.074	0.257	5.4	0.849	0.127
0.5	0.119	0.395	5.5	1.030	0.145	0.5	0.135	0.515	5.5	0.923	0.168	0.5	0.112	0.309	5.5	0.847	0.124
0.6	0.170	0.462	5.6	1.034	0.135	0.6	0.198	0.613	5.6	0.940	0.142	0.6	0.154	0.353	5.6	0.844	0.121
0.7	0.226	0.520	5.7	1.036	0.125	0.7	0.277	0.707	5.7	0.952	0.117	0.7	0.199	0.390	5.7	0.842	0.119
0.8	0.288	0.571	5.8	1.037	0.115	0.8	0.371	0.793	5.8	0.960	0.092	0.8	0.246	0.420	5.8	0.839	0.118
0.9	0.354	0.613	5.9	1.037	0.105	0.9	0.482	0.870	5.9	0.963	0.068	0.9	0.293	0.443	5.9	0.837	0.117
1.0	0.423	0.646	6.0	1.035	0.096	1.0	0.610	0.933	6.0	0.962	0.046	1.0	0.340	0.459	6.0	0.835	0.116
1.1	0.495	0.670	6.1	1.031	0.088	1.1	0.754	0.977	6.1	0.958	0.026	1.1	0.385	0.470	6.1	0.834	0.116
1.2	0.566	0.685	6.2	1.027	0.080	1.2	0.912	0.996	6.2	0.952	0.009	1.2	0.429	0.476	6.2	0.833	0.116
1.3	0.638	0.691	6.3	1.021	0.074	1.3	1.078	0.985	6.3	0.944	-0.006	1.3	0.470	0.478	6.3	0.832	0.116
1.4	0.707	0.689	6.4	1.015	0.069	1.4	1.245	0.941	6.4	0.935	-0.018	1.4	0.508	0.476	6.4	0.832	0.116
1.5	0.773	0.679	6.5	1.008	0.065	1.5	1.405	0.860	6.5	0.925	-0.028	1.5	0.544	0.472	6.5	0.832	0.116
1.6	0.826	0.656	6.6	1.002	0.063	1.6	1.546	0.745	6.6	0.914	-0.035	1.6	0.577	0.464	6.6	0.832	0.116
1.7	0.889	0.636	6.7	0.995	0.062	1.7	1.658	0.601	6.7	0.904	-0.040	1.7	0.607	0.455	6.7	0.832	0.116
1.8	0.949	0.597	6.8	0.989	0.063	1.8	1.735	0.438	6.8	0.894	-0.043	1.8	0.634	0.445	6.8	0.833	0.116
1.9	1.003	0.572	6.9	0.984	0.064	1.9	1.773	0.267	6.9	0.884	-0.045	1.9	0.659	0.433	6.9	0.834	0.116
2.0	1.037	0.533	7.0	0.979	0.067	2.0	1.774	0.099	7.0	0.875	-0.044	2.0	0.681	0.421	7.0	0.835	0.115
2.1	1.068	0.491	7.1	0.975	0.070	2.1	1.741	-0.057	7.1	0.867	-0.043	2.1	0.701	0.408	7.1	0.836	0.115
2.2	1.094	0.448	7.2	0.973	0.074	2.2	1.683	-0.195	7.2	0.861	-0.040	2.2	0.719	0.395	7.2	0.837	0.114
2.3	1.112	0.405	7.3	0.971	0.078	2.3	1.605	-0.310	7.3	0.855	-0.037	2.3	0.735	0.382	7.3	0.838	0.114
2.4	1.125	0.362	7.4	0.971	0.083	2.4	1.515	-0.403	7.4	0.851	-0.033	2.4	0.749	0.369	7.4	0.839	0.113
2.5	1.131	0.320	7.5	0.971	0.087	2.5	1.419	-0.474	7.5	0.848	-0.029	2.5	0.761	0.356	7.5	0.840	0.112
2.6	1.132	0.281	7.6	0.973	0.091	2.6	1.320	-0.525	7.6	0.846	-0.025	2.6	0.772	0.344	7.6	0.841	0.111
2.7	1.127	0.244	7.7	0.976	0.095	2.7	1.223	-0.559	7.7	0.846	-0.021	2.7	0.782	0.332	7.7	0.842	0.109
2.8	1.119	0.211	7.8	0.979	0.098	2.8	1.129	-0.577	7.8	0.846	-0.018	2.8	0.790	0.321	7.8	0.843	0.108
2.9	1.106	0.182	7.9	0.983	0.100	2.9	1.040	-0.583	7.9	0.847	-0.015	2.9	0.798	0.310	7.9	0.844	0.107
3.0	1.091	0.157	8.0	0.987	0.101	3.0	0.956	-0.578	8.0	0.848	-0.013	3.0	0.805	0.300	8.0	0.845	0.106
3.1	1.074	0.137	8.1	0.992	0.101	3.1	0.878	-0.564	8.1	0.850	-0.012	3.1	0.811	0.290	8.1	0.846	0.105
3.2	1.055	0.120	8.2	0.997	0.101	3.2	0.806	-0.541	8.2	0.851	-0.011	3.2	0.817	0.281	8.2	0.846	0.104
3.3	1.037	0.109	8.3	1.002	0.099	3.3	0.739	-0.512	8.3	0.853	-0.012	3.3	0.822	0.272	8.3	0.847	0.102
3.4	1.018	0.101	8.4	1.006	0.097	3.4	0.679	-0.476	8.4	0.854	-0.013	3.4	0.827	0.264	8.4	0.847	0.101
3.5	1.000	0.097	8.5	1.010	0.094	3.5	0.625	-0.434	8.5	0.855	-0.015	3.5	0.832	0.256	8.5	0.848	0.100
3.6	0.983	0.097	8.6	1.013	0.090	3.6	0.578	-0.388	8.6	0.855	-0.016	3.6	0.837	0.248	8.6	0.847	0.099
3.7	0.969	0.099	8.7	1.015	0.086	3.7	0.538	-0.337	8.7	0.854	-0.019	3.7	0.841	0.240	8.7	0.851	0.098
3.8	0.957	0.105	8.8	1.017	0.081	3.8	0.505	-0.282	8.8	0.853	-0.022	3.8	0.845	0.232	8.8	0.851	0.097
3.9	0.947	0.112	8.9	1.018	0.076	3.9	0.480	-0.224	8.9	0.851	-0.025	3.9	0.848	0.224	8.9	0.851	0.096
4.0	0.940	0.120	9.0	1.018	0.071	4.0	0.464	-0.164	9.0	0.849	-0.028	4.0	0.852	0.216	9.0	0.852	0.094
4.1	0.936	0.130	9.1	1.017	0.067	4.1	0.457	-0.102	9.1	0.846	-0.031	4.1	0.854	0.209	9.1	0.853	0.093
4.2	0.934	0.139	9.2	1.016	0.062	4.2	0.460	-0.041	9.2	0.842	-0.033	4.2	0.857	0.201	9.2	0.853	0.092
4.3	0.935	0.148	9.3	1.014	0.058	4.3	0.472	0.018	9.3	0.838	-0.035	4.3	0.859	0.193	9.3	0.854	0.091
4.4	0.938	0.157	9.4	1.011	0.054	4.4	0.493	0.074	9.4	0.833	-0.036	4.4	0.860	0.186	9.4	0.855	0.089
4.5	0.944	0.164	9.5	1.008	0.051	4.5	0.524	0.124	9.5	0.829	-0.036	4.5	0.861	0.178	9.5	0.855	0.088
4.6	0.951	0.170	9.6	1.004	0.049	4.6	0.561	0.167	9.6	0.824	-0.036	4.6	0.862	0.171	9.6	0.856	0.086
4.7	0.960	0.175	9.7	1.001	0.048	4.7	0.605	0.201	9.7	0.819	-0.034	4.7	0.862	0.164	9.7	0.856	0.085
4.8	0.969	0.177	9.8	0.997	0.047	4.8	0.652	0.225	9.8	0.815	-0.033	4.8	0.861	0.157	9.8	0.856	0.083
4.9	0.979	0.178	9.9	0.993	0.047	4.9	0.700	0.240	9.9	0.810	-0.030	4.9	0.860	0.151	9.9	0.857	0.081
5.0	0.989	0.176	10.0	0.990	0.048	5.0	0.748	0.244	10.0	0.806	-0.027	5.0	0.859	0.145	10.0	0.857	0.080

Table A. Normalised radiation impedance of a disc piston

Table B. Normalised radiation impedance of a concave cone piston

Table C. Normalised radiation impedance of a convex cone piston

Key to Tables: ka =Normalised frequency, Zre =Normalised radiation resistance, Zim =Normalised radiation reactance

References

- [1] L E KINSLER & A R FREY, Fundamentals of Acoustics, Wiley, New York, 1962 (2nd edition).
- [2] E GEDDES, J PORTER & Y TANG, A Boundary-Element Approach to Finite-Element Radiation Problems, J Audio Eng Soc, Vol 35 (4), 1987.
- [3] Y KAGAWA, T YAMABUCHI, K SUGIHARA & T SHINDOU, A Finite Element Approach to a Coupled Structural-Acoustic Radiation System with Application to Loudspeaker Characteristic Calculation, J Sound Vib, Vol 69 (2), 1980.
- [4] S SAKAI, Y KAGAWA & T YAMABUCHI, Acoustic Field in an Enclosure and Its Effect on Sound-Pressure Responses of a Loudspeaker, J Audio Eng Soc, Vol 32 (4), 1984.
- [5] G BANK, Advances in Computer Modelling of Ribbon Loudspeakers, Audio Eng Soc Preprint #3837, 1994.
- [6] J R WRIGHT, An Exact Model of Acoustic Radiation in Enclosed Spaces, Audio Eng Soc Preprint #3848, 1994.
- [7] M PETYT, Introduction to Finite Element Vibration Analysis,

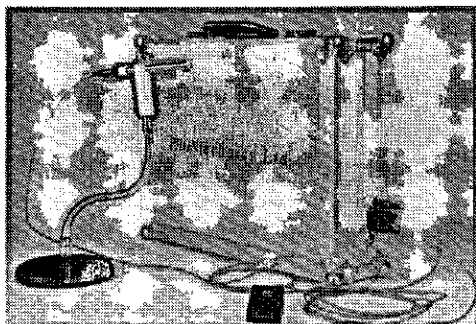
Cambridge Univ Press, Cambridge, 1990.

- [8] P C MACEY, Acoustic and Structure Interaction Problems using Finite and Boundary Elements, Ph D Thesis, Nottingham University, 1987.
- [9] P C MACEY & D J W HARDIE, Acoustic Scattering by Shielded Obstacles, Proc Inst Acoust, Vol 13 (3), 1991.
- [10] L G COPLEY, Fundamental Results Concerning Integral Representations in Acoustic Radiation, J Acoust Soc Am, Vol 44 (1), 1968.
- [11] H A SCHENCK, Improved Integral Formulation for Acoustic Radiation Problems, J Acoust Soc Am, Vol 44 (1), 1968.
- [12] H SUZUKI & J TICHY, Sound Radiation from Convex and Concave Domes in an Infinite Baffle, J Acoust Soc Am, Vol 69 (1), 1981.
- [13] R H SMALL, Direct Radiator Loudspeaker System Analysis, J Audio Eng Soc, Vol 20 (5), 1972.

Julian R Wright MIOA is with Celestion International Ltd, Ipswich IP3 8JP

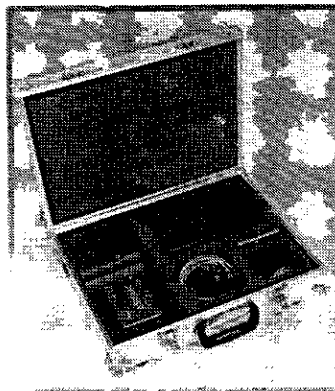
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INVESTIGATION OF AN ELECTRIC MOTOR NOISE AND VIBRATION PROBLEM

Andrew H Middleton FIOA

Introduction

As well as solving a problem for a client, this project was noteworthy because it involved so many elements of the vibration engineer's art and science. It forms an excellent tutorial project for electric motor engineers and vibration engineers.

The client was an electric motor manufacturer with a mystery on his hands. A series of 'identical' motors had been returned to the plant for overhaul, which had been done successfully on all but the last one. After overhaul, all the motors were 'checked for noise' by listening to them and checked for off-load vibration by measuring overall vibration level against speed using an accelerometer on the bearing housings.

The problem motor gave excessive noise and vibration. Dismantling showed no reasons for the vibration and re-balancing had only a marginal effect.

The motors were normally vibration tested off load when hanging from the overhead crane or resting on the steel stand used to support them during overhaul.

Frequency analysis of the vibration gave the first confirmation that the vibration was not an out of balance problem, although the two attempts at balancing should have shown this to a sufficient extent. Frequency analysis showed that there were strong components of vibration at three times per revolution and many harmonics of this plus some vibration at once and twice per revolution. The immediate thought was that the three phase electrical supply might be to blame. It was simple to test the validity of this by running the motor up to maximum speed then turning the power off. It took several minutes for the motor to stop rotating, but the three times per revolution vibration components continued to be as bad with the power off.

The cause of the problem was obviously not electrical. It was decided to use order locked analysis to investigate how much of the problem was caused by forced vibration and how much by resonant response. Resonances obviously played a large part in the problem because the vibration was much worse at some speeds. In normal operation this motor cycles over a wide speed range, so intermediate speed range vibration peaks could not be ignored.

Order locked analysis uses a pulse train derived from the rotating shaft of a machine to act as the digitization clock for the vibration signals. The spectra that are produced by this technique have the abscissa in units of orders (number of times per revolution that events occur) rather than in units of frequency (number of times per second that events occur). The main advantages of order locked analysis are that vibration components occurring

at, say, three times per revolution occur on the spectra at order 3 exactly, regardless of speed and that the amplitude shown at order 3 is the correct average vibration level occurring during the time of acquisition of data for that spectrum, even if the machine is changing in speed. This is in contrast to frequency analysis, where a change of speed during a spectrum acquisition can cause a spreading of the spectral energy along the frequency axis.

The frequency and true amplitude of the resultant peak are therefore uncertain. It is therefore very easy to be misled into thinking that a spectral component occurs at order 3, when in fact it occurs at a slightly different order.

Order locked analysis is not without its own problems however. The greatest problem is in obtaining the required pulse train at a repetition rate of at least 2.56 times the maximum order of interest. On this project there was less of a problem than usual. A once per revolution pulse was available from an optical pickup looking at a piece of retroreflective tape on the shaft. It is often not good practice to use a once per rev pulse because there could be torsional speed oscillations occurring between pulses that could obscure the true results. It is usually much better to use a shaft pulse rate closer to the digitisation rate, but this often requires special preparations.

In this case the motor inertia was high and the acceleration and deceleration rates low so it was reasonable to use the phase locked loop multiplier in the CED1401 computer interface to multiply the pulse train up to the desired rate. Serious errors can occur if the pulse train is not accurately multiplied, but they can usually be spotted from the jitter that can occur on narrow band signals on waterfall plots.

The order locked analysis over the speed range from 600 to 3600 rpm gave results similar to Figure 1. A Campbell diagram with an order range of 0 to 25 orders is shown at the left. At the top right is one of the order spectra that make up the Campbell diagram and at the lower right is the order track showing how vibration at the most prominent order varies with speed. This turned out to be order 3.125, not order 3.0 and was a crucial clue to the cause of the problem. The resolution of the analysis was 0.125 orders.

Vibration measurements were made at four positions on the motor, three on the drive end bearing housing and one on the base frame.

To home in more clearly on the exact order of the vibration the orders nearest to 3.125 were plotted on Figure 2. This shows that the vibration component was actually very close to order 3.07. (The units on these

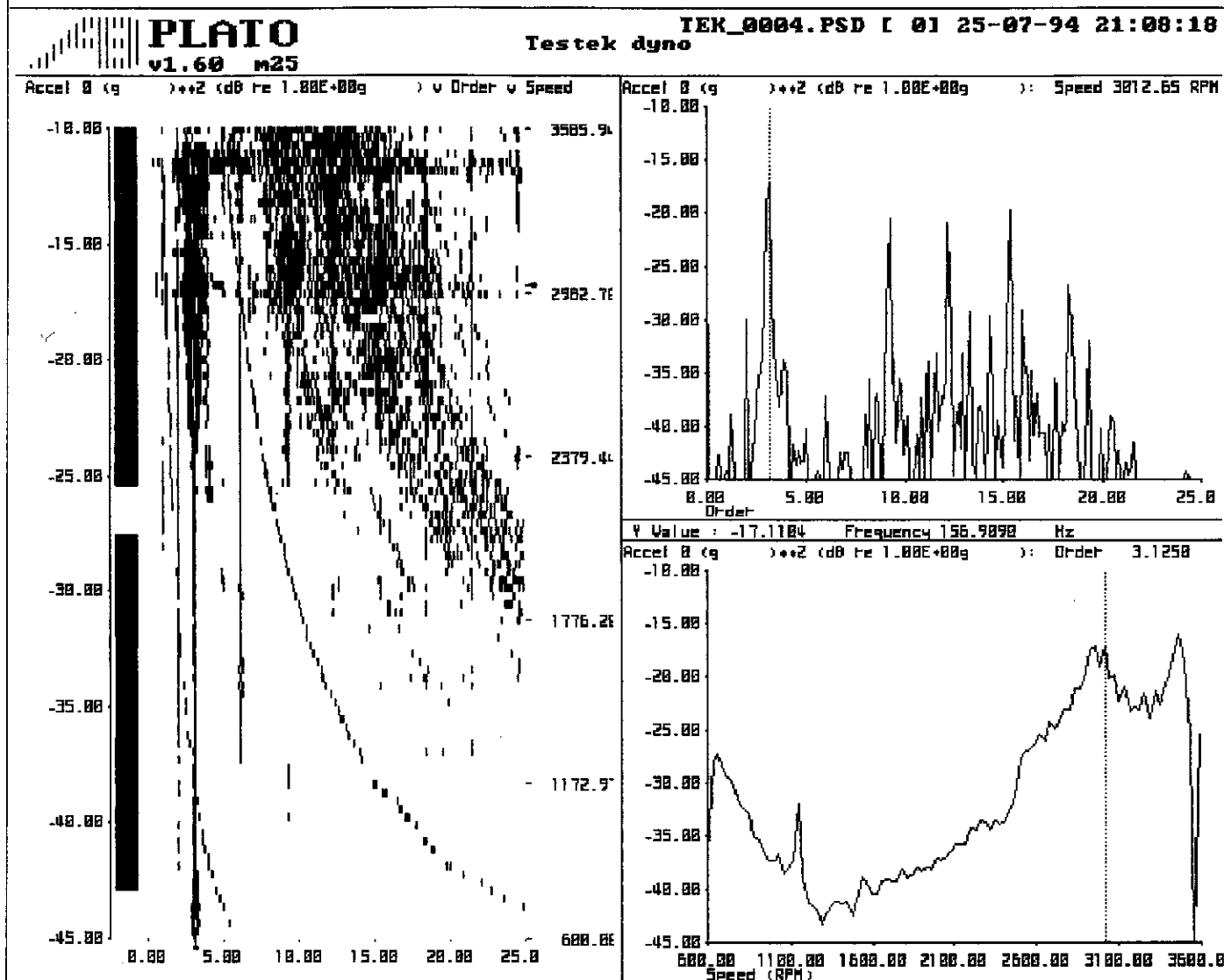


Fig. 1. Axial Vibration at drive end bearing housing during acceleration.

graphs are dB re 1g).

The motor exhibited some extremely unpleasant harsh vibrations. Two of the speeds at which this occurred can be seen from the horizontal bars of high vibration on Figure 1. The effect is more prominent on Figure 3, which was the vibration of the motor base. The base consisted of two steel beams attached to the motor body at each end. The beams were very lightly damped and of no structural consequence. The motor would have been better without them. Figure 3 shows the presence of several resonances that have a major influence on the resulting vibration. Order 3.1 runs through resonances at 2690 rpm (139 Hz) and again at 3435 rpm (177 Hz) but these are not the most prominent resonances on the Campbell diagram. The most prominent is at 220 Hz but is never

excited at its centre frequency by the greatest excitation component, (order 3.1). The 220 Hz resonance is only excited by harmonics of order 3.1 at the lower speeds and 'off tune' by order 3.1 close to maximum frequency. This can be seen in the top right spectrum on Figure 3. The cursor is on order 3.13 and the 220 Hz resonance is the peak to its right.

The spectral shapes of the vibration components at the rough speeds can be seen in the waterfall of Figure 4. At lower speeds they are variants of the theme of once per revolution transient excitation of the 220 Hz resonance. At the upper end of the speed range the spectra embrace a wide range of spectral components.

Resonances do not affect the order 3.1 component at all positions. Figure 5 shows how order 3.1 increases

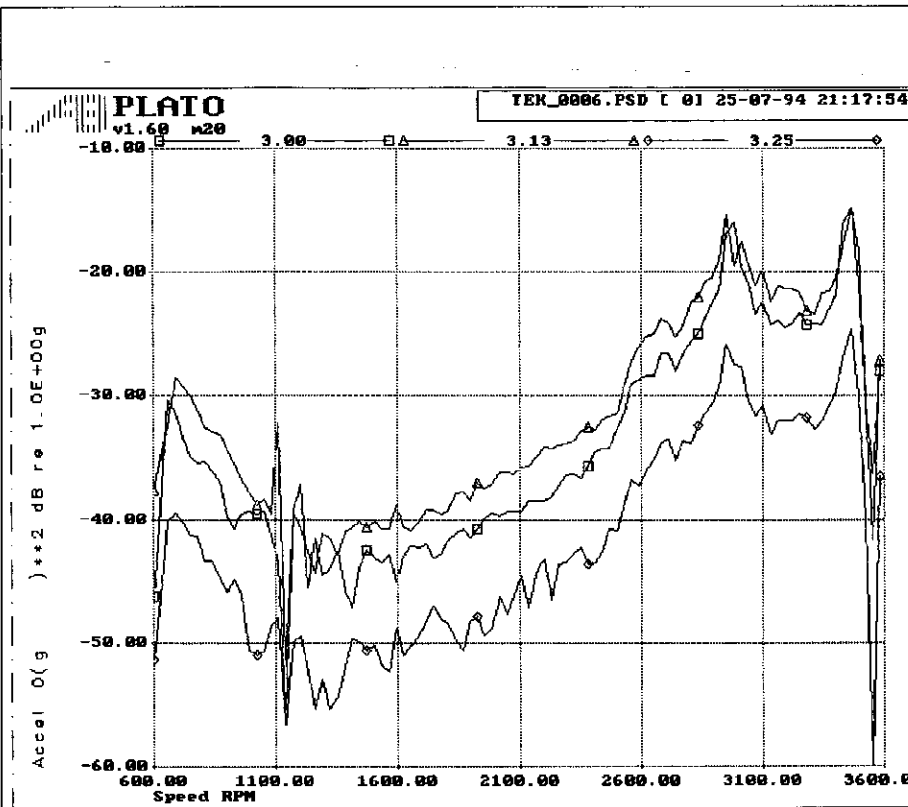


Fig. 2. Order tracks of the three orders close to order 3.

more or less uniformly up to about 2200 rpm – a forced response only. The same slope and amplitude was visible on power off run down. Power on acceleration and power off run down results at order 3.1 agree very well up to about 2500 rpm. Between 2600 and 3300 rpm on the motor base the power off run down results were higher than power on. This was believed to be due to the motor having been lifted off its stand and replaced in a slightly different position between the two sets of results. This affected the influence of the lightly damped 220 Hz resonance on the off tune order 3.1 component.

Deductions About the Causes of the Problem

When repairing a motor (as opposed to developing it) there is no opportunity to change any of the resonances of the structure, although in this case we suggested that the non functional parts of the motor frame should be cut off. There was no response to this suggestion.

The cure to the problem must therefore be found in the forcing functions. If electricity was not the problem then

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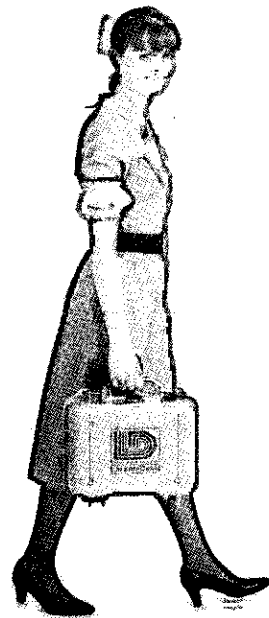
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CALL FOR PAPERS

Noise in Building Services

(Organised by the London Branch and the Industrial Noise Group)

Church House Conference Centre, London

Wednesday 15 March 1995

It is some years since the Institute held a meeting on noise in building services. This lack of activity may suggest that design engineers are confident that long-standing design tools, such as the CIBSE Guide and the ASHRAE Handbook, provide all that is required for the accurate prediction of noise levels and the selection and evaluation of noise control methods. There are, however, those who take the view that current prediction methods are conservative and that considerable uncertainty surrounds the prediction of regenerated noise at diffusers, end reflection losses at duct terminations and the break-out of noise from externally-lagged ducts, to name but a few. Ambiguous specifications can give rise to uncertainty as to the design targets, who is responsible for meeting them and under what conditions measurements of noise of completed installation should be made. In consequence, differences of opinion can arise as to whether a system meets the specification.

Against this background of apparent uncertainty in traditional design procedures and the increasing commercial exploitation of active noise control methods, the London Branch and the Industrial Noise Group invite contributions to this meeting, in any of the following subject areas:

- Design criteria and the specification of noise control targets
- Noise prediction methods
- Noise control methods, including active noise control and vibration isolation
- Testing of completed installations

Intending authors should send a 100-word abstract to the address below, indicating whether the paper is to be refereed. Abstracts should be received by 18 January.

Meeting organisers: S W Turner FIOA, TBV Science and Dr R J Peters FIOA, NESCOL

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18-20 December 1995

Send your 100 - word abstracts, and address any questions regarding the conference programme, to Professor J W R Griffiths, Dept of Electronic and Electrical Engineering, Loughborough University of Technology, Loughborough, Leicestershire LE11 3TU, UK.

INSTITUTE DIARY 1995

- 5 JAN**
Speech Group mtg
Links Between Speech
Technology, Speech
Science and Hearing
Sheffield
- 10 JAN**
Reproduced Sound 11
Organising Committee
St Albans
- 18 JAN**
London Branch mtg
Design of Underground
stations
London
- 20 JAN**
Engineering Division
Committee
St Albans
- 2 FEB**
IOA Publications,
Meetings Committee
St Albans
- 10 FEB**
IOA CofC in Workplace
Noise Assessment exam
Accredited Centres
- 10-12 FEB**
**1995 International
Auditorium
Conference: Opera &
Concert Hall Acoustics**
(organised by the
Building Acoustics
Group)
*Gatwick &
Glyndebourne*
- 15 FEB**
London Branch visit to
Browns of Canterbury
- 16 FEB**
IOA Membership,
Education Committee
St Albans
- 23 FEB**
CEng Interviews
St Albans
- FEB**
Southern Branch mtg
Tour of Anvil Centre
Basingstoke
- 2 MAR**
IOA Medals & Awards,
Council
St Albans
- 3 MAR**
IOA CofC in Env Noise
M'ment exam
Accredited Centres
- 10 MAR**
IOA CofC in W'place
Noise Ass't Advisory
Committee
St Albans
- 15 MAR**
London Branch mtg:
Building Services Noise
London
- 16 MAR**
CEng Interviews
St Albans
- 30 MAR**
Physical Acoustics
Group mtg
Telford
- 31 MAR**
IOA CofC in
Environmental Noise
Mm'nt Advisory
Committee
St Albans
- MAR**
Southern Branch mtg
Railway Noise
Calculations
Gatwick
- 3-5 APR**
**Sonar Transducers '95:
Underwater Acoustics
Group Conference**
Birmingham
- 26 APR**
London Branch mtg:
Acoustic Intensity
St Albans
- 27 APR**
IOA Publications,
Meetings Committee
St Albans
- 4 MAY**
IOA Membership,
Education Committee
St Albans
- 9-11 MAY**
**ACOUSTICS '95
Spring Conference:
Environmental Noise
& Vibration**
Liverpool
- 10 MAY**
IOA 1995 AGM and
Annual Dinner
Liverpool
- 19 MAY**
IOA CofC in
Workplace Noise
Assessment exam
Accredited Centres
- 25 MAY**
London Branch mtg
Noise and Statutory
Nuisance Act
London
- 25 MAY**
IOA Medals & Awards,
Council
St Albans
- MAY**
Southern Branch mtg
User Perspectives on
PPG24
Oxford
- 9 JUN**
IOA CofC in Env Noise
M'ment exam
Accredited Centres
- 15-16 JUN**
IOA Diploma
Examinations
Accredited Centres
- 21 JUN**
London Branch mtg
Occupational Noise
NESCOT, *Epsom*
- 23 JUN**
IOA CofC in W'place
Noise Ass't Advisory
Committee
St Albans
- 30 JUN**
IOA CofC in
Environmental Noise
Mm'nt Advisory
Committee
St Albans
- 21 SEP**
IOA Publications,
Meetings Committee
St Albans
- 28 SEP**
IOA Membership,
Education Committee
St Albans
- SEP**
Southern Branch mtg
Lesser Known
Techniques in
instrumentation/measu
rement
ISVR Southampton
- 5 OCT**
IOA Medals & Awards,
Council
St Albans
- 13 OCT**
IOA CofC in
Workplace Noise
Assessment exam
Accredited Centres
- 26-29 OCT**
Autumn Conference
Windermere
- 3 NOV**
IOA CofC in Env Noise
M'ment exam
Accredited Centres
- 10 NOV**
IOA CofC in W'place
Noise Ass't Advisory
Committee
St Albans
- 16 NOV**
IOA Membership,
Education Committee
St Albans
- 20 NOV**
IOA Publications,
Meetings Committee
St Albans
- 23-26 NOV**
Reproduced Sound 11
Windermere
- NOV**
Southern Branch mtg
Environmental Noise
Barriers
Winchester
- 1 DEC**
IOA CofC in
Environmental Noise
Mm'nt Advisory
Committee
St Albans
- 7 DEC**
IOA Medals & Awards,
Council
St Albans
- 18-20 DEC**
**Underwater Group
Conference - Sonar
Signal Processing**
Loughborough

MEMBERSHIP

The following were elected at the Council Meeting held on 8 December 1994

Member	Delaney, D J	Rogers, I E	Davis, N R	Wright, D S
Anderson, T M	Gelat, P N	Rogers, P J	Fosker, J A	Wright, G C
Arnold, C	Hennissen, W		Furssedonn, P	Young, G J
Cooper, A J	Hewett, M D	Associate	Gentry, M A	
Duce, D O	Hubbard, P F	Allan, J	Glasson, A N	Student
Kettlewell, D R	Jewell, E T	Batchelor, C L	Hollingsworth, J A	Golley, S M
Owen, R W	Johnston, R A	Blay, S R	James, R	Hargreaves, T J
Russell, M J	King, P	Bowmer, A	King, K A	Hutt, R
Staveley, P W	Majumani, J Z	Brett, V A	Metcalfe, K J	Jordan, S E
Trinder, M C	Methold, R H	Butler, T J	Osler, C J	Kang, J
	Milne, A D	Cains, S E	Pembroke, S J	Marsh, D W
Associate Member	Nicholas, A R	Canavon, M A	Robinson-Ferras, I	Simpson, K D
Attwood, P E W	Perkins, R A	Chabot, T J	Whyman, G D	Stone, M J
Dawson, P G	Petrie, J E	Daniel, T M	Williams, C M	

Certificate of Competence in Workplace Noise Assessment

The following were successful in the 17th examination held in October 1994

Amber	Billcliff, A D
Yarnell, R	Carter, P R
	Chamberlain, Y
Bristol	Cracknell, T S
Belger, T	Crane, J A
Bilsborough, K P	Davies, A M
Hulme, J	Day, P J
Lynch, J C	Farr, M
Poole, N D	Hall, N M
Turley, P	Higgs, M
Yerbury, K R	Lingard, E
	McCullough, K
Colchester	Pratt, C B
Clifton, P R	Woods, A K
Hopton, J M	
Knight, R J	NESCOT
Platt, M J	Buckley, T S A
Ruxton, P J	Clark, A M
Wilkinson, C D	Gonis, K
Williams, G	Siddall, K G
Derby	Newcastle
Franklin, J E	Carran, A D
Hickey, J P	Coates, D G
	Cook, A J
Glasgow	Dillon, C
Draper, C	Dyson, P A
Maciver, J M	Jefford, P J
Purdon, D E	Lloyd, M
Quigley, J	Millican, A I
Waddell, T	Wilkes, A
Wilson, G A	Wilkie, G S
Young, C G	Wood, J
Liverpool	Salford
Hart, M	Fone, C
Kavanagh, L	
Wassell, C J	South Bank
	Boyton, P
Loughborough	Ede, P
Amis, J A	

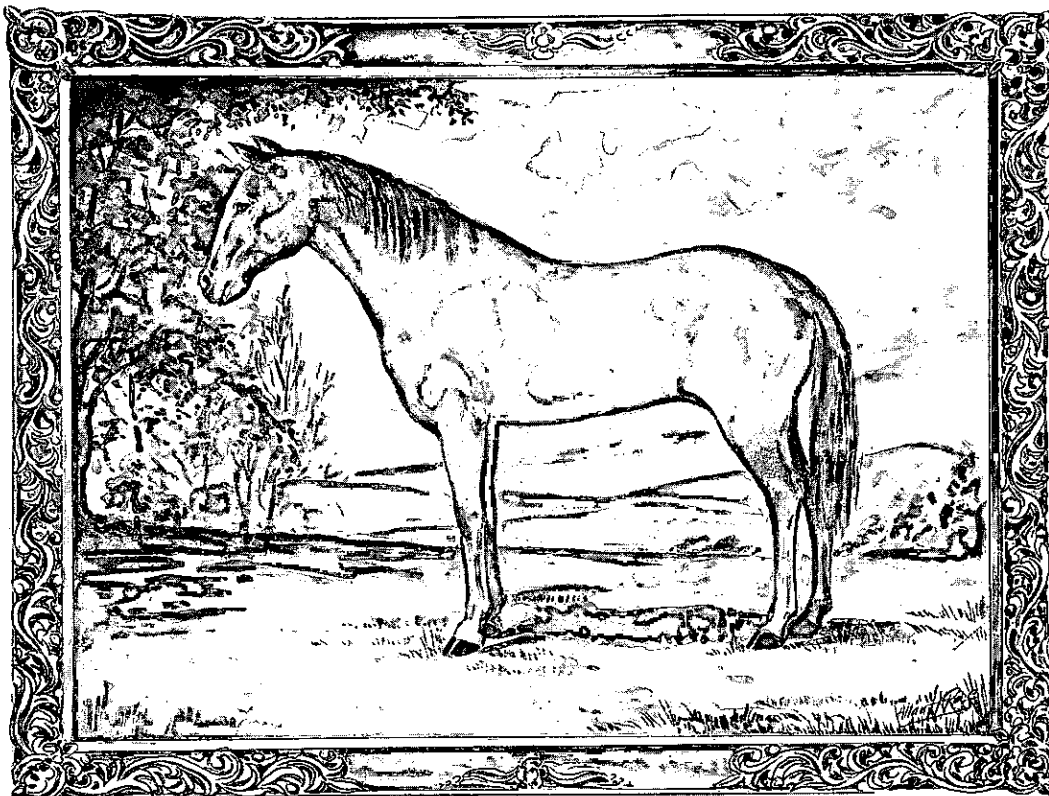
Certificate of Competence in Environmental Noise Measurement

The following were successful in the 5th examination held in November 1994

Bristol	Newton, A J
Gray, R D	Payne, J
Parker, A J	Slater, A
Potten, C L	Wakeford, A J
Rogers, P J	Walsh, P
	Wood, C R
Colchester	
Chaffey, M B	South Bank
Davidson, S	Colley-Davies, B J
Edwards, P	Harker, R J
Farquhar, T	Rogan, P
Rust, M C	Silva Rosa, M de L
Wood, B C	Stokes, D J
	Wood, A M
Derby	
Grosse, K	
Harris, P	
Hornby, G	
Housley, R J	
Norman, G	
Roby, D J	
Staite, M A	
Liverpool	
Brown, P D	
Crawshaw, A	
Davis, M T	
Harte, J	
Packer, N	
Picken, J S	
NESCOT	
Aylott, S L	
Brown, P	
Drayan, A K	
Flook, S	
Gregory, C	
Jefferson, K M	
McEvoy, R P	
Narramore, G	

I am told by our sales force that some readers of this journal tell them that they have never heard of Larson*Davis noise and vibration instrumentation and they have asked me to look into the problem. I am a little puzzled as to what to do next as we take a full page of space in every IOA Bulletin and have done for some time now. We also exhibit at the major IOA seminars and conferences and advertise in many other journals and magazines.

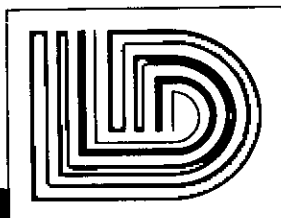
So, just in case we need to change our approach to advertising I have decided to display a rather nice picture of a horse so that the next time you require noise and vibration instrumentation you'll remember the horse and hopefully Larson*Davis.



A RATHER NICE PICTURE OF A HORSE

By the way, the L*D range includes sound level meters, environmental noise analysers, condenser microphones and real time spectrum analysers incorporating digital fractional octaves and narrow band FFT.

For further information on our range of superior quality instruments, NOT THE HORSE, why not telephone us to discuss your requirements.



And if you're wondering what the horse and Larson*Davis instruments have in common, the answer is simple – they're both thoroughbreds.

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REDCAR STATION BUSINESS CENTRE, STATION ROAD, REDCAR, CLEVELAND, TS10 2RD
Telephone: 0642 471777 & 491565 Fax: 0642 490809

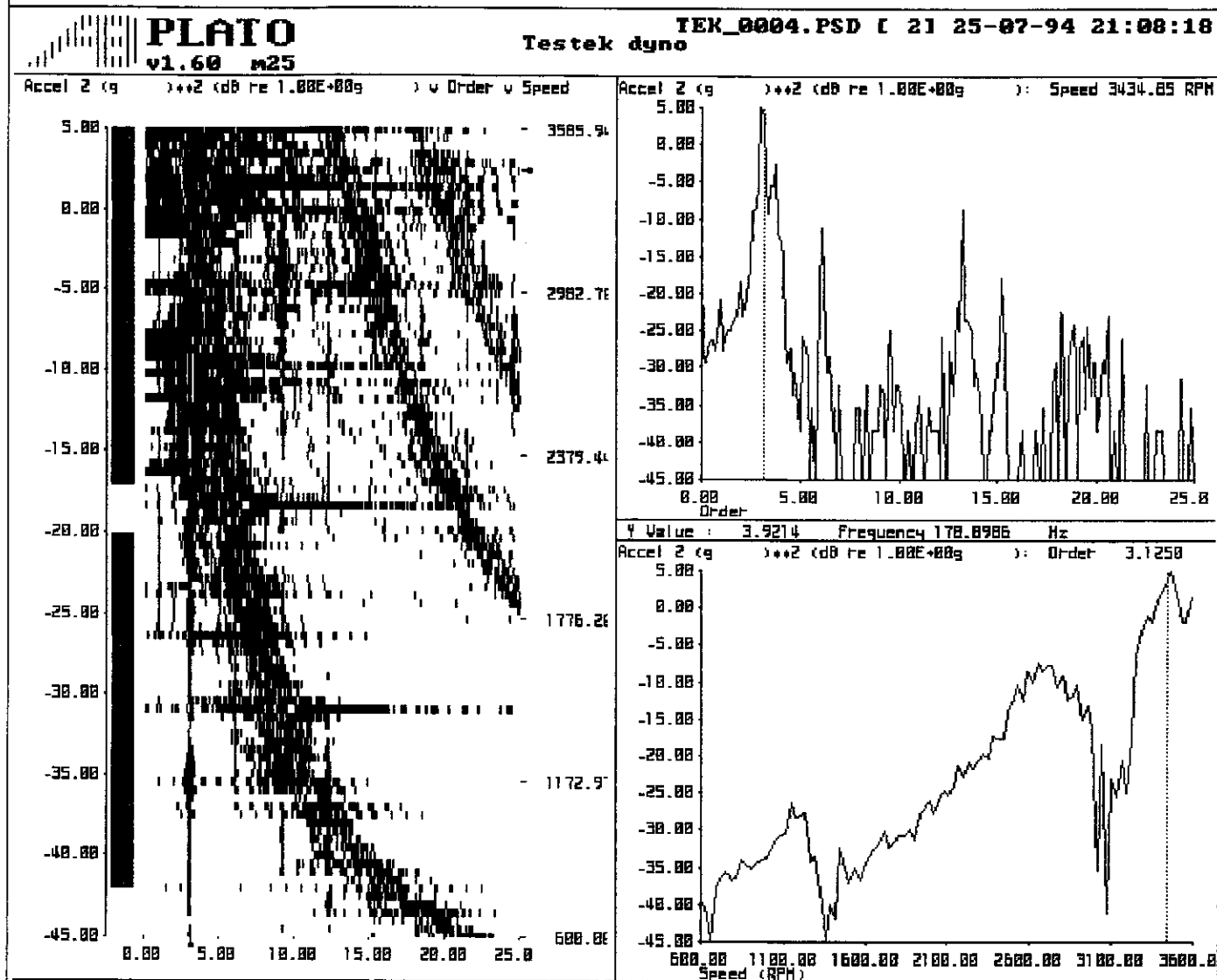


Fig. 3. Motor base vibration during acceleration.

mechanics must have been. Mechanics are as foreign to electrical engineers as electrical things are to mechanical engineers, hence the need for noise and vibration engineers with multi-disciplinary outlooks!

The only possible mechanical source of vibration at a non integer order of rotation was something that was effectively geared to rotation at a ratio of 3.07, but there was nothing driven by the motor during these tests. The only things that are effectively geared to the motor are the bearing balls and their cages. Using well known techniques for calculating bearing induced vibration orders it was found that the calculated orders were as follows:

- For
- irregularities of the cage or balls – order 0.38
 - irregularities of the balls impacting the races – order

2.04 or 4.08

- damage or irregularity of the inner race – order 4.93
- damage or irregularity of the outer race – order 3.07.

From this the area to search is immediately obvious. Dismantling the motor showed that the outer race of one bearing had been fitted carelessly causing a sliver of metal to be sheared off the bearing housing bore. This sliver of metal had caused distortion of the outer race.

After rebuilding, the vibration measurements were repeated and showed large reductions in vibration level at most speeds, although order 3.1 was still prominent (compare Figures 5 and 6). In fact from 2700 to 2900 rpm order 3.1 was higher than before repair.

This was caused by it exciting a 160 Hz resonance that became prominent after repair, because the motor

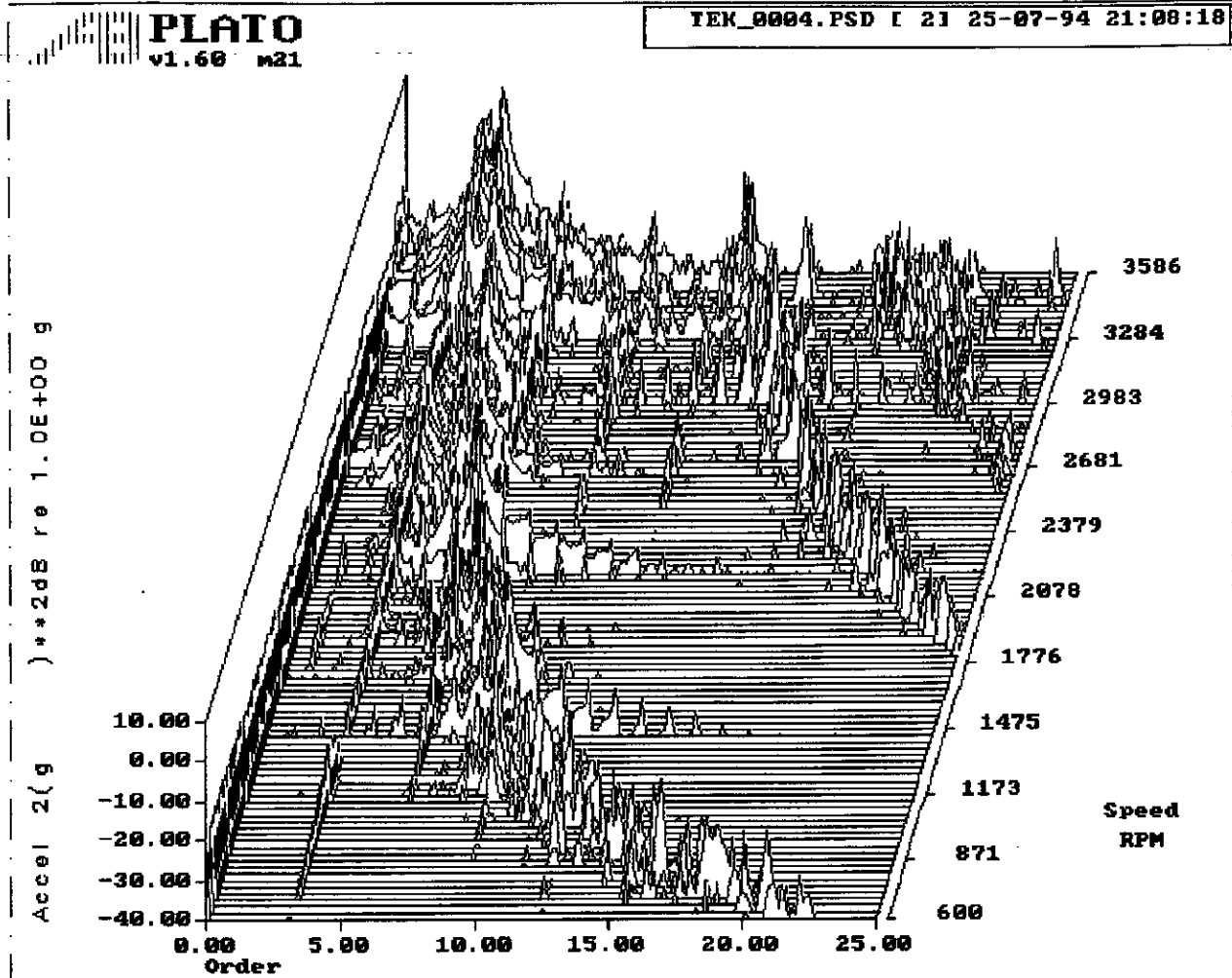


Fig. 4. Replot of motor base vibration as a waterfall.

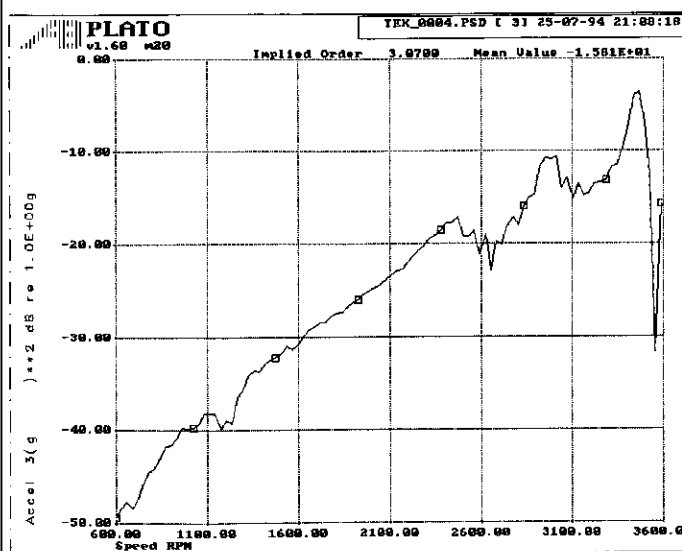


Fig. 5. Order 3.07 component before repair.

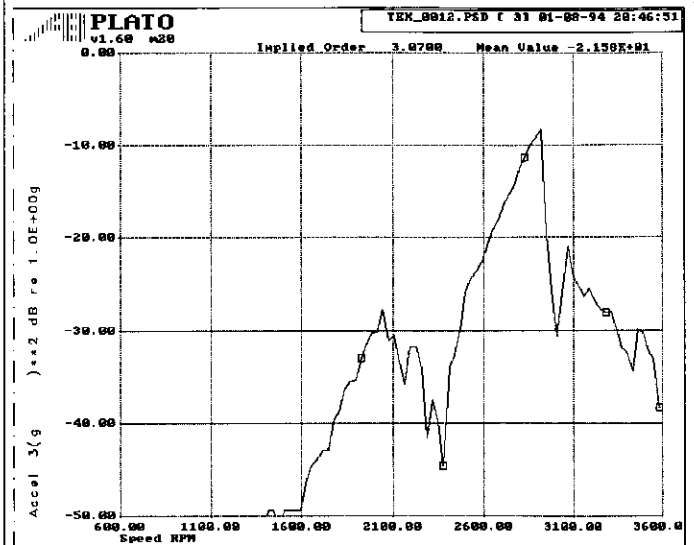


Fig. 6. Order 3.07 component after repair.

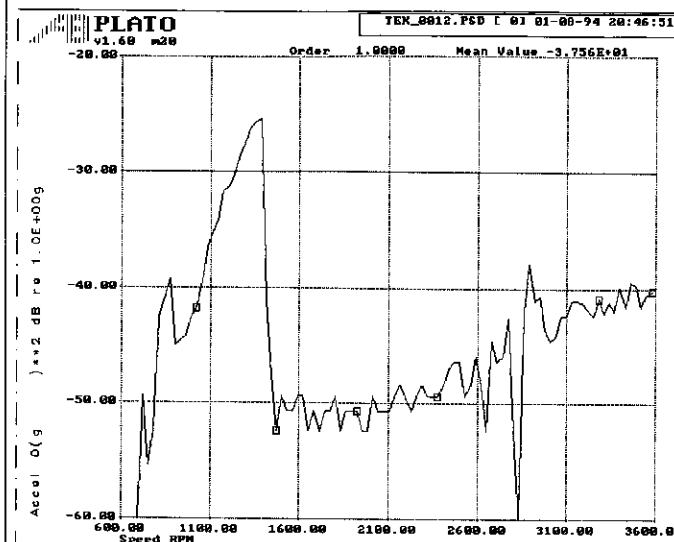


Fig. 7. Out of balance component of vibration on acceleration.

was again lifted off its stand and replaced between the two measurement sessions. In none of the tests was it bolted down.

Throughout the speed range after repair the order 3.1 component fluctuated in amplitude as it was affected by the resonances of the system. It no longer showed the very strong forced vibration character that had been seen before repair.

The results also showed the clearest illustration we have seen of the classical effects of stiffening spring resonant response. One reads about this in text books but rarely sees it clearly in practice. Figure 7 show an asymmetric peak in order 1.0 during acceleration. Order 1.0 (out of balance) reaches a peak at 1360 rpm. The corresponding curve measured during run down is on Figure 8, this time measured without disturbing the motor between tests.

Order 3.07 behaved very similarly on acceleration and deceleration, but order 1.0 gave a peak at 1200 rpm on deceleration instead of 1360 rpm – another mystery to the electrical men. Below 1200 rpm both acceleration and run down are almost the same. This is exactly what the text book reader should expect from a single degree of freedom system with a spring whose stiffness increases with increasing deflection. In the case of the motor we deduce that the stiffening spring effect was given by variation of the contact area between the motor and its base as it was excited by the out of balance vibration. It would probably not have occurred if the motor had been bolted down properly.

The Morals of This Story

- You can easily be fooled by frequency analysis.
- Order analysis under acceleration and deceleration

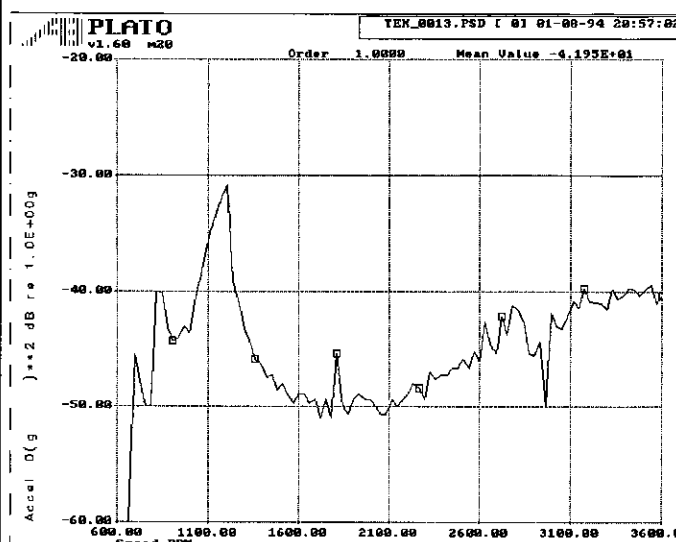


Fig. 8. Out of balance component of vibration on deceleration.

gives a lot more useful information.

- As with all investigative tasks make sure that you investigate in enough detail. The availability of an analysis system which is very flexible in operation helps enormously.
 - Do not be fooled into thinking that resonances are only significant when they coincide with forced vibration components. Offtune excitation of resonances can cause high vibration.
 - Do not be fooled into thinking that the most obvious resonances on waterfalls and Campbell diagrams are the ones you need to worry about. Lesser resonances can take over if the forced vibration input is strong enough.
 - Do not test electric motors without bolting them down.
 - Be very careful when assembling rolling element bearings. It is the bearing housings and shaft journals that control the fitted shape of bearings races.
- All the above 'morals' are obvious and well known, but easily ignored or forgotten when you are tempted to take shortcuts.

Andrew Middleton FIOA is with Anthony Best Dynamics Ltd, Holt Road, Bradford-on-Avon, Wilts, BA15 1AJ. Anthony Best Dynamics is a member of the Association of Noise Consultants

To advertise in
Acoustics Bulletin

contact

Keith Rose RIBA FIOA

Tel 01223 263800 Fax 01223 264827

UNIFICATION OF THE ENGINEERING PROFESSION

A Proposal by the Stage II Policy Group

Sir John Fairclough announced on the 25 October a proposed plan to unite Britain's engineering profession. Sir John, who started the unification initiative three years ago, presented the plan at a meeting of the Council of Presidents of the Engineering Institutions on the previous day, 24 October. The proposals have been developed by a policy group that was set up in September last year after the publication of the report 'Engineering into the Millennium'. The proposals will now be considered by the two bodies concerned – The Engineering Council and the Council of Presidents. Under the plan a new body would be formed to bring together the views of the institutions, industry and academe and would provide a single voice for the profession. The new body would consist of a democratically elected senate with 24 members elected by institute councils from their past and present council members, 24 members elected by the engineers and technicians registered with the Engineering Council and six members appointed by the Privy Council.

The Senate would be the focal point for the engineering profession. It would discharge its responsibilities through two boards; one for the regulation of the profession, the other for the promotion of the profession. Members of the two boards would be selected from the Senate. Sir John said that it was hoped to have the new arrangements in place by mid 1995.

Background

The Interim Report of the Council of Presidents Steering Group, 'Engineering into the Millennium', proposed a new relationship between The Engineering Council and the Institutions. In September 1993 a Stage II Policy Group was set up to establish a proposal that would:

- provide leadership and vision for the profession as a whole;
- speak with a powerful single voice to those outside the profession, in the UK and internationally;
- provide a framework for harnessing the resources of the profession to the best effect;
- regulate the profession to high standards, thereby serving the public interest in wealth creation, health, safety and the environment;
- meet the needs of engineers to develop their skills, knowledge and competence;
- to best effect ensure a supply of engineers, which in quality and quantity meets the future needs of industry, commerce, Government and society;
- ensure that the importance of engineering is understood in the community so that the profession exerts its proper influence on society.

The Stage II Policy Group has now completed its task

and the proposal to meet all of these objectives is set out below.

The Way Ahead

The Policy Group has agreed unanimously a proposal which will forge a partnership between all those who seek to represent and promote the profession of engineering. The proposal, which will bring together the views of The Engineering Council, the Institutions, industry and academe, will for the first time provide a single voice for the profession. The Stage II Policy Group is united in the belief that its proposal will give the profession the leadership and vision that is required for the next millennium.

The New Body will be responsible for those issues that are profession-wide. It will provide leadership, founded on a partnership, which draws on the strengths of all the participants and has clear definitions of the responsibility and authority of its constituent parts. Ownership of the arrangements by the profession is made real and visible by the way in which people are elected to serve on the New Body and the way in which it is structured such that all partners can work in unity to ensure that it serves the needs of the profession as well as of society at large.

The Constitution of the New Body

The New Body will consist of a Senate and two executive Boards: one for the regulation of the profession, the other for the promotion of the profession. The responsibility and sphere of action of each of these three constituents of the New Body are clearly defined.

THE SENATE will be the focal point for the engineering profession and will be ultimately responsible for all the activity of the new arrangements. It will be the focus for all issues, both national and international, that have a pan-profession dimension. It will generally operate through its two executive Boards. It will approve the budgets and business plans of the Boards and will periodically review their activities.

THE BOARD FOR ENGINEERING REGULATION (BER) will be responsible for maintaining the register of engineers and technicians and will define, review, monitor and enforce standards for education, training and continuing professional development. It will have the authority to nominate and authorise Institutions to process applications for those engineers and technicians who wish to be registered at any of the three phases of education, training and responsible experience.

THE BOARD FOR THE ENGINEERING PROFESSION (BEP) will be responsible for matters concerning the promotion of the profession and will respond to those issues on which the profession needs to have a single voice. It

will have the authority to establish joint projects and ventures and to implement initiatives on behalf of the participating Institutions.

Election to the New Body

The majority of Senate members will be democratically elected either directly by all registrants or by Institution councils. Twenty four members will be elected by registrants from a list approved by the Senate which can include nominations by Institutions, nominations by groups of registrants and nominations by the Senate. Twenty four members will be elected by Institution councils from present or past members of their councils. Finally, to reflect the wide role played by engineering in society, six members will be appointed by the Privy Council.

To facilitate the election procedures an electoral college structure has been devised. There will be four electoral colleges each embracing similar numbers of registrants. Each college will elect six members to the Senate via the registrant-elected route and six via the Institution-council elected route. A formula has been devised that produces a balanced distribution across the Institutions: the three largest Institutions with 52% of the total registrants get 10 seats; the nine medium-sized with 31% of the registrants also get 10 seats; the smaller Institutions with 17% of the registrants get 4 seats.

The number of seats on the Senate allocated to an Institution for election by Institution councils will depend upon the number of members registered with the New Body who wish to practice in the UK. Of those eligible, 95% should be registered within three years of the new

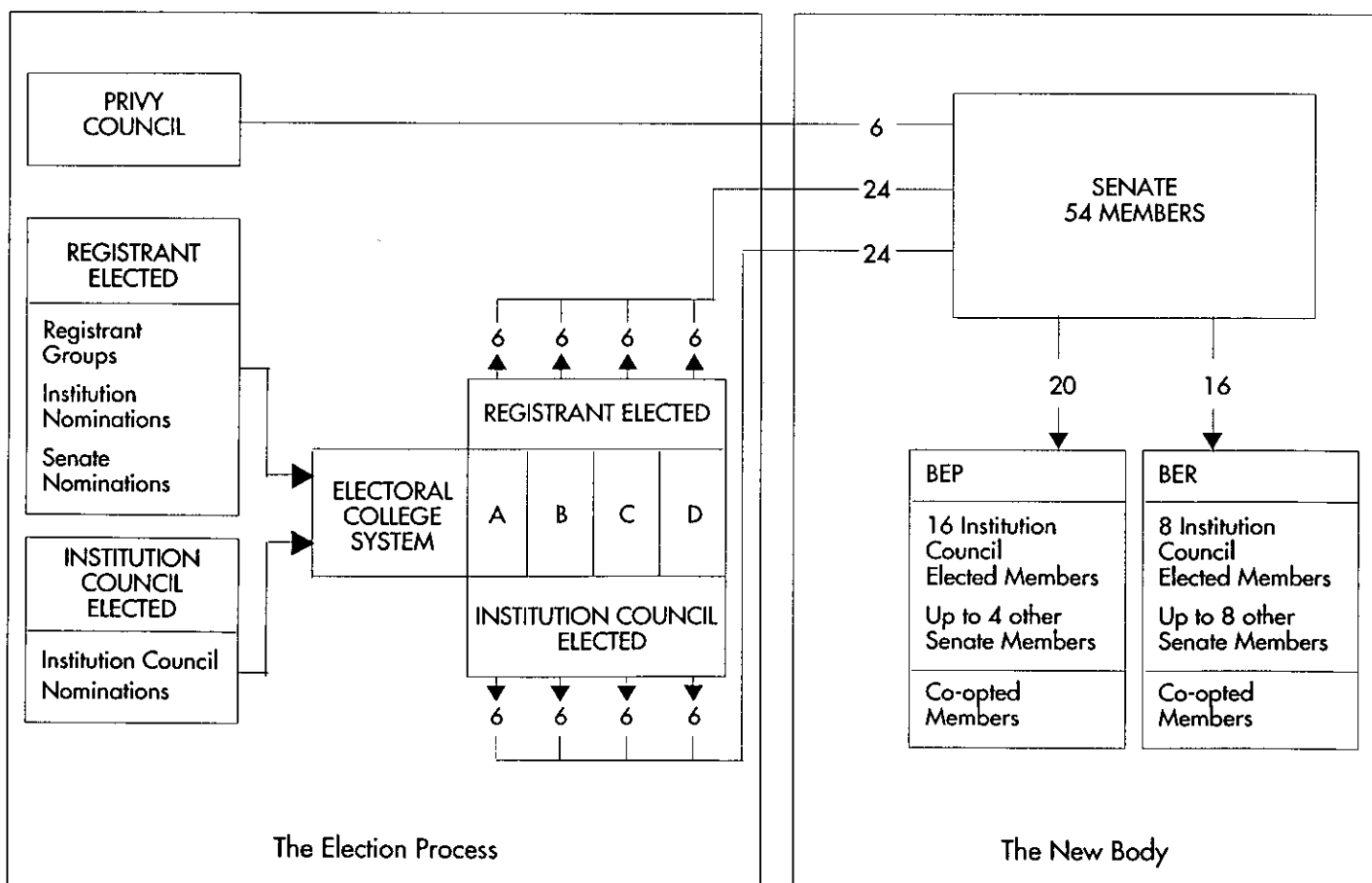
arrangements being put in place. This requirement will re-enforce the democratic nature of the Institution council elections as well as strengthening the essential partnership between the New Body and the practising engineer.

The organisational structure of the bodies that make up the corporate structure are shown in the Figure below. Members of the two Boards will be selected from the Senate by a committee consisting of the Chairman of the Senate, the chairmen of the BEP and the BER and the Director General of the New Body. Provision is made for the addition of co-opted members to the two Boards where there is a need to augment the range of the Boards specialist expertise.

Recommendation

The Stage II Policy Group has considered the options and we conclude, unanimously, that this proposal will create a more effective relationship between the fragmented parts of the profession so that the whole becomes greater than the sum of the parts. It will enable the profession to speak with a single voice on those matters that are of general concern and provide the leadership to take us into the next century with a new found relevance and sense of purpose. An enormous amount of time and energy has been expended in debating these issues and reaching this point. It is time now to decide. We commend this proposal to you and ask for your support.

This matter will be considered by the Institute's Engineering Division Committee who would welcome any comments from members ❖



Citation

Tyndall Medal 1994

Roger K Moore

Roger Moore is a research leader in the area of speech technology and his expertise in the subject is recognised in the UK and overseas.

Roger was awarded a degree in Computer and Communications Engineering at the University of Essex in 1973. He subsequently received the MSc and PhD degrees from the same University in 1975 and 1977, with investigations into the analysis and design of speech recognition systems. Following a short period of research at University College London he joined the Royal Signals and Radar Establishment (now the Defence Research Agency) and is currently a Senior Principal Scientific Officer and Head of the Speech Research Unit. He acts as leader and co-ordinator for a range of programmes related to strategic speech research and the development of communication systems.

He still finds time to pursue personal research in his main subject areas of speech technology applications, algorithms and assessment. He has authored or co-authored over 50 papers in these topics and contributed to several books.

Roger Moore is visiting Professor in the Department of Phonetics and Linguistics at University College London. He is a Fellow of the Institute of Acoustics and has been a member of the Council of the Institute. He has also strongly supported the Speech Group of the Institute and was Chairman from 1984 to 1990. At present he is member of the Editorial Board of the journals *Computer Speech and Language* and *Natural Language Engineering*.

He has acted on many Committees dealing with the development of speech research and technology including the NATO Research Study Group on Speech Processing. Currently he is Chairman of the European Expert Advisory Group on Language Engineering Standards working party on spoken language resources and has recently been elected as Vice-President of the European Speech Communication Association (of which he was a founding member).

The Institute of Acoustics is pleased to award the Tyndall Medal for 1994 to Roger Moore for his work in the field of speech research and technology.



Branch News

London Branch

A new session of London Evening Meetings commenced on 21 September at the London offices of TBV Science. Mark Southwood of Union Railways and Alec Glendinning of Ashdown Environmental gave a talk on the environmental impact of the Channel Tunnel railway routes before a packed house. They described the methodology used to rate the environmental impact of the various alternative route proposals – noise being only one of many factors which had to be considered. They explained how properties along the route were categorised as 'residential', 'noise sensitive' and 'noise critical' and presented the noise criteria which they used to rate the impact – both in terms of changes to the 24-hour L_{Aeq} and the resulting L_{Amax} . For the route which was finally chosen 25 properties were found to be eligible for sound insulation treatment.

On 19 October, for the first time, we held a meeting at the well-appointed new offices of TBV Science in Lansdowne Road, Croydon and were rewarded by an encouragingly large turn-out. Steve Fisher gave a talk on the Design Manual for Roads and Bridges (DMRB), Volume 11 Environmental Assessment, published by the Department of Transport in 1993. Steve summarised the background to this document, starting with the Noise Insulation Regulations and Calculation of Road Traffic Noise and compared it with the document it replaces, namely the Department of Transport's Manual of Environmental Appraisal. Amongst a number of changes which include limited guidance on vibration assessment and sleep disturbance, the DMRB includes a new procedure for assessing the percentage of people bothered by traffic noise following an abrupt change in traffic conditions, such as might occur after the opening of a new road. This appears to show that an increase as small as 1 dB(A) can result in a very large change in the percentage of people bothered and appears to challenge the widely-held view in environmental acoustics that a 3 dB(A) change is 'just perceptible'.

The Branch Annual Dinner was held at Plummer's restaurant in Covent Garden on 16 November. Derek Percy gave an entertaining and informative after-dinner speech, drawing from his 30-years experience in the noise control industry world-wide with IAC.

Our final event of 1994 takes place on 14 December when Julian Wright of Celestion International Ltd will give a talk entitled the 'Wonderful World of Loudspeakers'. The meeting will be held at TBV Science, Great Guildford House, Great Guildford Street, London SE1 and will commence at 6 pm. Our programme for the first half of 1995 is in preparation and will be circulated to Branch members in the near future.

John Miller MIOA

Midlands Branch

More than 50 people attended the inaugural meeting of the Midlands Branch on the evening of 7 December 1994 at Herbert Gray College in Rugby. The meeting was

organised by John McGrath (Rugby BC), John Hinton (Birmingham CC) and Ken Dibble (Ken Dibble Acoustics) who will act as an ad hoc branch committee until elections can be held at the first AGM next year.

At the start of the meeting the Institute President, Mr Alex Burd, welcomed the formation of the new branch and wished it success. There then followed a programme of three very topical and highly informative talks relating to the investigation of noise problems. The first speaker was Bernard Berry of NPL who gave details of the latest position concerning the update of BS 4142. Nicole Porter, also of NPL, then gave a presentation entitled the Assessment of Environmental Noise, suggesting that BS 4142 should be only one part in a framework approach to environmental noise problems and described a model which emphasises the investigation of the acoustic features of the noise. The final presentation was an authoritative but light hearted talk by Steve Turner of TBV Science on presenting evidence at public inquiries.

The meeting concluded with a buffet and informal discussion among delegates in comfortable and congenial surroundings. Details of the programme of future meetings for 1995 will appear in the next Bulletin.

R J Peters FIOA

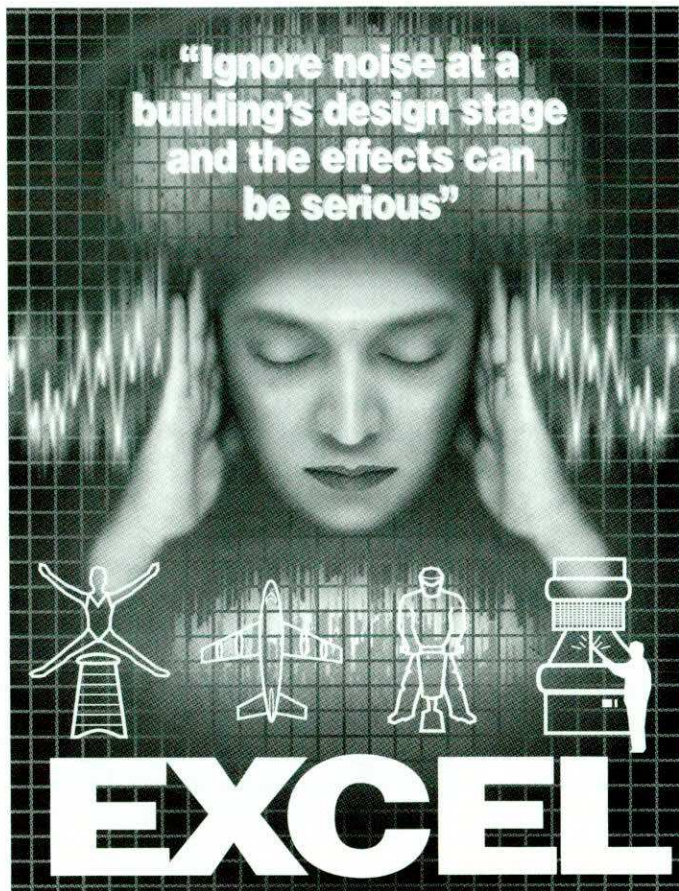
South-West Branch

The revival of the South-West Branch continued apace with an evening meeting, on the topic of underwater acoustics, held at the new British Aerospace Welfare Association sports centre in Bristol on 10 November.

Underwater acoustics is regarded by many as a somewhat esoteric branch of the art, and the meeting was aimed at showing that it is not the acoustics that is special, but the environment. The plan was to give an understandable overview of underwater acoustics and how the marine environment differs from the atmosphere in its influence on sound propagation. It was clearly of interest as it attracted an audience of nearly 30.

After a buffet, by courtesy of BAeSEMA, Peter Dobbins gave a general introduction to the subject and some of the more common applications of sound in the sea, and then Mike Denney described the principles of sonar system operation. This was followed by Peter Dobbins again talking about the temperature structure of the ocean and how it produces sound channels, shadows, and convergence zones. At a more practical level, John Oswin then gave some insights into the design of underwater acoustic transducers and Mike Baker described how they are tested and calibrated. Unfortunately, two other presenters, Dave Hart and Derek Beattie, were unable to attend but Mike Denney made the most of his background as an ex-Naval schoolie by producing at very short notice a concluding presentation about some real-world applications of underwater sound in the form of mines, torpedoes and the counter measures against such weapons. The discussion that followed suggested that the audience found the evening both enjoyable and stimulating; it is hoped that the South-West Branch can continue with the momentum that the new committee has built up over the past nine months.

P F Dobbins MIOA



Acoustic Solutions

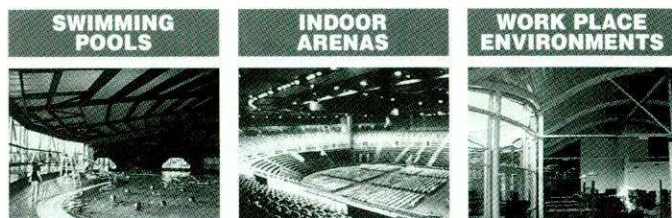
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3 – 6 November 1994, Windermere

Introduction

The numbers of delegates, totalling 104, was down on last year but this statistic did not apply to the variety of subjects covered, the technical quality of the presentations and the general enthusiasm of all concerned.

As usual the conference was organised in collaboration with the Sound and Communication Industries Federation, the Audio Engineering Society, the Association of Professional Recording Services, the Association of British Theatre Technicians, the Professional Lighting and Sound Association and the International Association of Forensic Phonetics.

The technical programme was compiled by an inter-association committee, chaired as usual by Ken Dibble of Ken Dibble Acoustics, comprising James Angus of the University of York, Peter Barnett of AMS Acoustics, Guy Hawley from Harman Audio, Allen Mornington-West of Quad, Andy Munro of Andy Munro Associates, David Trevor-Jones of Fleming and Barron and Tony Woolf from the BBC.

The range of topics covered this year included Audio-Video Network Control, Speech Intelligibility, Loudspeaker Developments and Sound In Spaces while there was a varied Open Session. Workshop discussions were held on Aspects of Bit Rate Reduction and Radio Microphones and Audio links. Invited papers were given by Professor Richard Guy on sound intensity and its use in assessing the sound quality in a space, by H J M Steeneken on subjective and objective speech intelligibility measures and by John Watkinson on the future of digital recording.

Dr Roy Lawrence, Peter Barnett and Dr Paul Darlington presented a revised version of the 1993 training course entitled Acoustics for Sound System Engineers. The additions and changes which were based on

the previous years experience proved popular. Although the number participating was down on last year, it was said to have demonstrated again the need for such training.

On Saturday evening after a reviving boat trip on Windermere Lake, a November 5th firework party and the conference dinner, a demonstration of new loudspeakers was given by Eastern Acoustic Works of USA; some very impressive sounds were heard including a repeat performance of the recording of the Challenger battle tank gun, last heard at RS9 when it was used in the demonstration by Tannoy. Perhaps it should be included in a performance of Tchaikovsky's 1812 overture next year!

Two workshop sessions took place during the conference. On the Friday night after dinner John Watkinson led a discussion on aspects of bit rate reduction. Following this, at a time of night when only Windermere conferences continue to function, Brian Copsey from ASP FM Ltd chaired a workshop on the topic of Radio Microphones and Audio Links. The attendance at each was particularly encouraging.

Reports on the invited lectures and the technical sessions follow, based mainly on the notes of the session chairmen.

Invited Lectures

Subjective and objective speech intelligibility measures by H J M Steeneken & T Houtgast. The paper was presented by H J M Steeneken. Subjective measurements by a panel of listeners was once the only possible method for the determination of speech intelligibility. Over the years many variations in the tests have been developed and were described, with those using phoneme combinations giving the greatest degree of discrimination. Word and sentence tests are generally found to be usable over a

restricted range of signal to noise ratio but speech reception threshold in which the noise level for 50% intelligibility is obtained, has been shown to be repeatable for some types of test. Objective methods utilising the modulation transfer function at fourteen modulation frequencies over eight octave bands of a speech-like signal from which a Speech Transmission Index is derived have been shown to correlate well with subjective appraisal. Examples of the use of subjective and objective results were given in a paper which provided an excellent overview of an important subject.

Sound intensity and its use in assessing the sound quality in a space by R W Guy and A Abdou.

The paper was presented by R W Guy. The field of room acoustics has developed many objective measurements with which to assess quality. With the advent of intensity measurements directional qualities in stationary fields were added.

Now Professor R Guy and Dr A Abdou using the large amounts of computing power currently available have extended the field enormously to develop Intensity Impulse Response.

Combining the information from three mutually perpendicular intensity microphone pairs allows a complete time, energy, directional representation of the sound field at a point to be drawn. The system can provide information for diagnostic purposes in auditoria but the enormous amount of data makes the discovery of the useful bits difficult.

The future of digital recording by John Watkinson. The conference was fortunate to have enlisted the services of John Watkinson, an internationally renowned expert on digital techniques and author of many books, to talk on Digital Recording Techniques in Acoustics and to point to its use in the future. His paper described the principles of digital recording using pulse code modulation and, through steps of increasing complexity of data handling, the provision of methods of error correction using redundancy and concealment.

In essence the recording process

is now well nigh perfect and sound recording or reproduction is limited only by the transducers, the microphone and loudspeaker. The user is free to define what he wants to do with the recorded material. The lifetime of a recording is no longer limited by the recording medium since the reconstitution of the signal can be automatic and is indistinguishable from the original.

This was an interesting and informative paper attractively presented with his usual dry humour.

Technical Sessions

Network control of audio and video equipment. This session, which ran throughout the Friday, was chaired by Allen Mornington-West of Quad Electroacoustics who also organised the programme. The opening presentation, by the chairman, set out some of the key requirements for network systems which could be used in professional audio, video and lighting control (PAVI). A good starting point in network systems design is the Open Systems Interconnection (ISO) seven layer model as this helps to ensure that undue focus is not placed on the simpler problems associated with the physical and data link layers. A network for PAVI use would probably be open, licence free and involve an incremental equipment cost below ten pounds sterling but it is the requirements of the higher layers of protocol which are exercising the minds of those involved in the standards meetings. This is because it is envisaged that the protocol should be capable of being carried on a variety of transports and a brief review of some of them was presented.

Vic Dobbs from Glantre Engineering shared his experience of practical installations by describing the problems which his company has had to solve when installing a complex system. One example of a theatre on a cruise liner showed that some seven different protocols were involved though this was chosen from nearly 20 common ones. These include the RS232, MIDI and ethernet types. In a bigger environment Siemens' engineers have been

active in installing comprehensive signal and control systems in places as diverse as Leipzig Oper, Gottlieb Daimler stadium and a new high speed passenger train. Geor Mundle from Siemens AG set out the scope of the engineering skills required to solve some of the engineering problems which arose.

Blackpool's Pleasure Beach is known by most people for having the largest big dipper ride but engineers will recognise the site as having one of the largest arrays of distributed network control of amplifier systems in the UK. Steve Simpkins is its chief engineer and he has been responsible for installing the system and integrating it into other parts of the business operation. The original target of the array was to be able to control the environmental noise spillage and over the three years so far the scope of the Nexsys system has increased. Wind direction, speed, crowd density are all used to adjust the amplifier gains and the system is able to carry out impedance checks which allow missing and failed loudspeaker units to be readily identified.

Steve Clarke of University College Salford devised the MIDI PLC (Programmable Logic Controller) idea as a way of providing his students with a test bed for a variety of projects in machine control. It is based on using industry standard PLC chips and driving them with MIDI control codes using relatively simple extensions to the existing codes.

Andrew Stirling from C&C Electronics introduced the IEC1030 or D2B approach for control and monitoring. Though this system was originally envisaged as a domestic control bus by Philips it is seeing wider application in vehicles as extensions permit programme and control signals to be carried on the same optical fibre. Echellon's Rob Warden presented his company's LonWorks networking approach by noting that its current applications include aircraft throttle control and building energy management. Echellon's approach has been to provide as much as possible of the layers of the OSI model to its customers thus

allowing them to concentrate on their detailed application even to the extent of being able to provide them with simple plug-in repeaters and a wide range of interfaces to the physical world.

RS 232 can be described as a standard for confusion whilst the world has seen many examples of standards which have not been adopted. Lone Wolf's approach to providing a commercial network solution was explained by Dave Scheirman. He is able to approach the issue with the rare attribute of being a musician and a well respected sound system designer. He stressed the need for chip-wise integration of much of the protocol in order that the knowledge required to implement the protocol did not have to be replicated and could thus be relied on. Amortising the cost of coding intellect on silicon inevitably raises the cost of entering the market with new technology. Lone Wolf's approach extends across all of the OSI layers to providing the complete solution including a customised version of their man machine interface for a client's equipment.

There is a number of transport protocols in use in areas far removed from the world of professional audio and video systems. Many of them are intended for use in buildings, vehicles or industrial process control but, with a wider perspective, they may prove to be suitably powerful for PAVI use. One such system, Controller Area Networks (CAN), was introduced by Richard McLaughlin from the University of Warwick. CAN was originally devised by Robert Bosch for use in vehicles but it has since been used in applications as varied as lift control, lighting and industrial process control.

In a true CAN system the intelligence is distributed at the node where the information is received and the network conforms to the producer/consumer model. CAN could be adapted for use in PAVI applications and thoughts as to how it could be adapted for a more general use could be provided by studying the DeviceNet protocol which is carried on CAN.

Speech Intelligibility. The programme for this part of the proceedings was organised by Peter Barnett of AMS Acoustics, who also chaired the session. The session was opened by Dr Steneken's keynote lecture, which is reported above. The next paper was written by Andy Munro of Andy Munro Associates and provided details of the findings of a speech intelligibility investigation at NEC Birmingham. Intelligibility results from various loudspeaker heights and spacing were presented.

Sam Wise and Tony Barns provided the following paper on some of the problems and data gathering methods required on very large sites. The area in question was a naval site some 1.6 km x 1.3 km.

Two papers followed before lunch; the first was given by Arup Acoustics' Raf Orłowski on scale modelling for London Underground. Raf, in addition to presenting a video clip from 'Tomorrow's World', explained some of the difficulties encountered and the results obtained in a model of a new proposed ticket hall for Canary Wharf on the Jubilee Line Extension project.

Ken Jacobs of Bose and Peter Barnett then gave a combined paper on the new PA installation at Tottenham Hotspur Football Club. The predicted and measured intelligibility performance was found to be in close agreement.

An open forum discussion was held prior to lunch and much of the discussion returned to Dr Steneken's presentation. The morning ended one of the most lively sessions to date.

Finally, the paper by Peter Barnett and Richard Knight was squeezed in at the end of the day. The paper examined the effect of frequency bandwidth on speech intelligibility.

It was demonstrated that in general terms decreasing the system bandwidth decreases the attainable speech intelligibility.

Loudspeaker developments. This year's well attended session on loudspeaker developments focused on loudspeaker system design, with

papers addressing system directivity, loudspeaker/room interaction and the practicalities of transconductance power amplifiers and was chaired by Salford University's Dr Paul Darlington.

The opening paper, presented by John Woodgate and co-authored by Dr John Bowsher, reminded us that a dipole or spaced dipole loudspeaker system can produce a directional response at low frequencies from a compact enclosure. It was suggested that such directionality could be usefully exploited in Public Address applications.

In a later paper, Mike Chamness, of Eastern Acoustic Works, explained the difficulties of assessing system directivity for some practical sources and made some proposals for techniques for estimating coverage angles. James Angus of York University used models of the frequency response of sources operating near room boundaries to show why some systems with a flat free field response are bass heavy when used in a practical domestic listening room. Dr Angus then suggested how to partly compensate for this effect, exploiting an unusual tuning of a bass-reflex system.

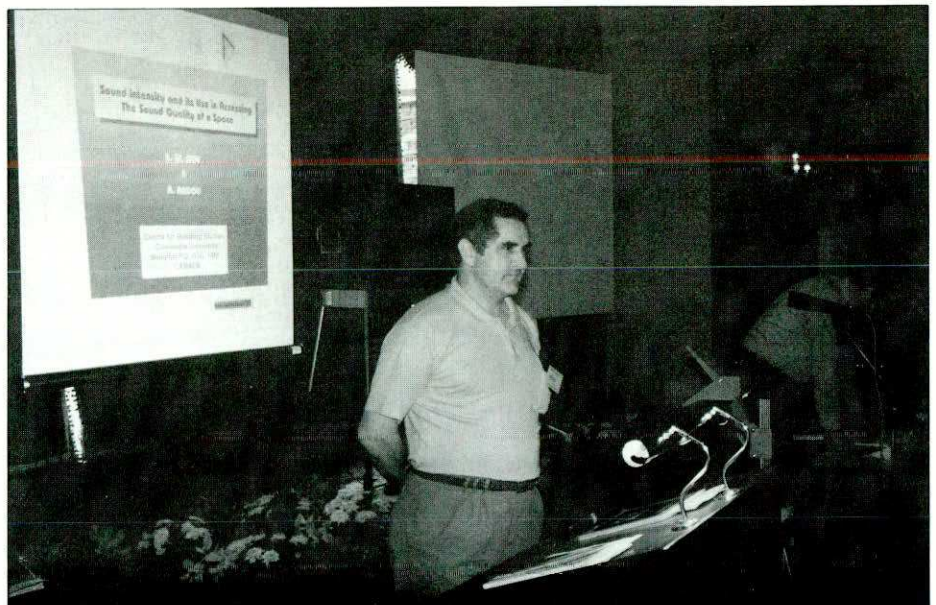
In an interesting presentation by Paul Mills, Tannoy's approach to the practical implementation of loudspeaker systems with current drive was discussed. Dr Mills explained how a real loudspeaker electrical

load influences transconductance power amplifier performance and introduced some novel techniques to improve system linearity in extended bandwidth 'error feedforward' transconductance power amplifiers.

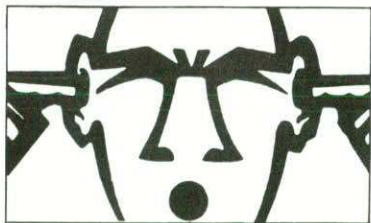
In the final paper of the session, Cliff Hendricksen from Bose Corporation began a description of the developments which have culminated in the horn loaded Bose systems used in the new Tottenham Hotspur Football Stadium installation. This attracted so much attention it continued at 11pm on the Saturday after the EAW demonstration!

Sound in Spaces The chairman was Neil Spring of Sandy Brown Associates and Dr James Angus of the University of York started this session with a paper on amplitude gratings as acoustic diffusers. A new compact tool for the acoustic designer's armoury was described, consisting of strips of absorber arranged in a pseudorandom pattern. This device produces controllable diffusion and absorption without the penalty of excessive thickness.

Phil Pyatt then presented Andy Munro's extensive results of MLSSA measurements of the Royal Albert Hall that were done to provide data for the design of electroacoustic systems. It was pointed out that improvements in intelligibility would probably be limited by the requirements of English Heritage.



Professor R Guy of Concordia University, Canada, presenting an Invited Lecture.



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SIAP's Ben Kok presented a paper co-authored by Wim Prinssen on the electronic modification of acoustic spaces. The characteristics of modern systems were described and some recent installations of SIAP were discussed. Complete details of the technical design of the system will be disclosed as soon as European patents have been granted.

The long-standing problems of specifying and achieving suitable and consistent acoustics for control rooms were addressed by three papers in this session. Robert Walker from the BBC Research & Development Department described the development of a method of control room design called Controlled Image Design. This is based on a design target of reducing the sound energy components to 15 dB below, and within 15 ms of, the direct sound. Four installations based on the technique exhibit excellent stereo image quality and measurements show that the design targets have essentially been achieved. The importance of controlling reflections from the mixing desk was emphasized.

P R Newell, an independent consultant, argued strongly for a design in which the reverberation is minimized but the floor and loudspeaker wall are allowed to be reflective. He claimed that, from experience of many such rooms, excellent and consistent listening conditions were achieved.

Uncoloured sound with good stereo imaging over a wide listening area could be obtained without the unpleasant effects generally associated with near-anechoic listening rooms. It was also beneficial that recordings controlled in such rooms also sounded similar when reproduced at home.

In his second paper, Bob Walker described the work of the EBU and other international bodies in preparing recommendations over many years for standardising control rooms and listening rooms. The importance of this work was emphasized, not only for the problems of programme interchange but for the more recent problems of assessing

impairments introduced by bit rate reduction schemes in digital coding. It was pointed out that, in the international broadcasting community, progress was limited by the ability of poorer countries to make rapid changes to their facilities. Some harmonization had been achieved, but there was likely to remain a fundamental difference between the EBU and the ITU as opposed to the AES and the IEC as the objectives of the two groups differed.

Dr Paul Darlington of the University of Salford described the use of an active absorber to suppress low frequency modes in rooms. Using an analogy based on catching a cricket ball, Paul explained the principles behind active absorption. A practicable implementation employing a single eight-inch loudspeaker was shown to have reduced the reverberation time at 44 Hz in a reverberation chamber to almost one half.

During the discussion, sceptics who questioned the ability of a single loudspeaker to have an absorption cross-section comparable with the wall of a room were invited to assess the system in person at Salford. The system is relatively inexpensive and is being exploited commercially.

A lively discussion on the papers followed, curtailed only by the imminence of lunch.

Open Session. James Angus from the University of York was chairman and the session provided an eclectic mix of subjects. It started with Tony Woolf of the BBC who reviewed the problems of measuring the acoustic level of headphones for the purposes of controlling noise exposure from them, his conclusion being that a flat plate measurement system provides the best compromise except for balanced armature transducers.

There were then two papers on power amplifiers. The first by Ben Duncan of Ben Duncan Research discussed realistic tests for power amplifiers and the second by Ken Dibble and Allen Mornington-West dealt with the EMC performance of several amplifiers. Most of them failed to meet the new European regulations but a surprising result was that the amplifiers using linear power supplies were worst.

The session concluded with two papers on sound system design and intelligibility. Peter Mapp discussed the problems of measuring the effect on audiences of PA system performance and presented a method for doing this. In the final paper Peter Barnett investigated the effect of band limiting on speech intelligibility. His results seemed to indicate that 250 Hz to 8 kHz was an acceptable compromise for such systems.

J W Tyler FIOA

Sound Power Measurement

London, 30 November 1994

This one-day meeting was organised by NEL under the auspices of the Industrial Noise Group and held at the Commonwealth Conference Centre in London. There were seven technical presentations, a discussion forum at the end of the day and a brief meeting of the Industrial Noise Group, in what was a very informative and busy day.

Over forty delegates from a number of different areas, including government, academia, consultancies and manufacturers and suppliers of a wide variety of equipment attended the meeting which was

focused on the need for sound power measurements primarily as a result of the Machinery Directive which comes into effect on the 1st January 1995.

The first paper by Dick Whitson of NEL introduced the concept of sound power, and tried to dispel the confusion that sometimes exists within industry between sound power and sound pressure. A number of questions then followed on the context of Dick's presentation, in particular a comment on the use of units, dBs and BELs giving rise to some lively discussion.

Dr Andrew Small of Brüel & Kjær Ltd then presented a paper on the instrumentation required for sound power measurement and highlighted the standards applicable to instrumentation and the accuracies inherent within them. He also discussed instrumentation for sound intensity type approaches, the technique being further discussed in a later paper. A number of questions were then addressed to Andrew, with an emphasis on calibration of the sound intensity probe being raised.

The paper by Roger Higginson of Higginson Acoustics Ltd on standards for sound power measurement gave a comprehensive review of the currently available documents. Roger also highlighted the areas currently being revised together with anticipated dates for these revisions. Again a number of questions were forthcoming, addressing the uncertainty aspects of the standards and how they had been evaluated, and the concepts of repeatability and reproducibility.

The last paper in the morning session was presented by Harry Lester of Health and Safety Executive and addressed the subject of Legislation with an emphasis on the Machinery Directive. Harry received a number of questions from the floor and in particular on the use of the CE mark and how the Executive would be enforcing the Directive as of 1 January 1995.

Martin Williams, a Trading Standards Officer from Kent County Council opened the afternoon session with a paper on the role of Trading Standards, LACOTS and their powers of enforcement in terms of product safety with regard to the Directive.

Martin highlighted that although most Officers would not be expert in acoustics, they did have major powers in terms of product safety and would use them if an independent testing body could prove that a machine failed to meet the necessary requirements.

The penultimate paper of the day was presented by Paul Guckien of

AT&T GIS Dundee. Paul illustrated the need that a manufacturer has to understand the use of sound power and sound pressure and to be able to educate his customer base. He emphasised the importance of meeting the requirements of the legislation and the barrier to trade that failure to comply inevitably brings. He illustrated an acoustic signature reduction policy that had given his company a significant competitive edge.

Ian Benson of NEL delivered the final paper of the day on sound intensity case studies, the benefits of the technique and some of the pitfalls for the unwary. A question on the pass criteria for the various field indicators used in the intensity standard ISO 9614-1 raised a number of interesting points, the discussion that followed confirming the need for a comprehensive understanding of the technique.

A final discussion period offered an opportunity to raise any outstanding issues.

A Mackinnon MIOA

Workshop on Current Issues in Standardisation

London, 11 November 1994

This workshop, organised by Roger Higginson, was scheduled shortly before London sessions of acoustics technical committees ISO TC43 and IEC TC29. The standards committees have established numbered working groups, each of which considers a particular topic. Some of these groups were also meeting in London. European Standardisation Committee CEN TC211 also has responsibility for acoustics.

The workshop opened with a presentation by Susan Dowson of NPL who talked about standards for sound level meters and sound-calibrators. TC29 WG4 is looking to a new single standard to supersede IEC 651 and IEC 804 (BSEN 60651 and BSEN 60804), and a thorough overhaul of sound level meter performance and usage stan-

dards is intended. Among topics which are under review are the tolerances for the A-weighting and the question of whether the much criticised 'impulse' time weighting should be kept at all. The opportunity is being taken to reduce the present four 'type' classifications to two new classes.

Verification procedures similar to BS 7580 may be incorporated into the new standard, as well as methods for use with an associated calibrator. It was felt that the verification period should be contingent on degree of usage rather than at fixed intervals. The recent calibrator norm IEC 942 is thought to be deficient in that it lacks detail in pattern evaluation and verification, and it is expected to be shortly updated.

Mike Martin, who is with the UK delegation to IEC, spoke on audiometry and hearing aids. He grouped the standards into audiometers – principally the new IEC 645, audiometric techniques, eg ISO 6189 & ISO 8253 (part 3 of 8253 to do with speech audiometry is being finalised), and hearing aids eg IEC 118. Diagnostic audiometry has expanded beyond tonal audiometry covered by the old BS 5966, and IEC 645 now encompasses equipment for pure tone (645-1), speech (645-2:1993), use of test signals of short duration for audiometric and neuro-otological purposes (645-3:1994) and extended high frequency audiometry (645-4:1994).

Calibration of audiometers is the subject of ISO 389 which is being updated and is now to incorporate a revised version of the fundamental ISO 226:1987 – normal equal loudness level contours. The scope of ISO 226 has been subdivided into (i) the reference threshold of hearing for free field and diffuse field listening conditions, which will

become part 7 of ISO 389; and (ii) the proposed part 8 of ISO 389 covering contours at higher levels.

Peter Wheeler talked on hearing protectors, beginning with an overview of the differing groups responsible for testing methods and product standards within ISO, CEN and BSI. Hearing protectors fall within the personal protective equipment (PPE) directive 89/686/EEC, and are considered to be mid-category products for which an approved type examination is required. A brief description of test and rating methods was given, with mention of the difficulties in the rating in ISO 4869-2:1994 (referred to in *Acoustics Bulletin* Sept/Oct 1993). Following a short transition period the 'CE' mark will become compulsory, to show conformity with attenuation tests and type approval by an accredited body.

Product standards are always improving, and on the cards may be a comfort index and a value for minimum assured attenuation. The assessment of level dependent ear muffs is a recent issue, as electronic sound restoration may lead to sound levels in excess of 85 dB(A). These products are to be addressed by EN 352 part 4, at present in draft.

Standards for machinery noise

measurement was the topic of Roger Higginson's talk after lunch. The ISO 3740 series of standards (3740 - 3747) for the determination of sound power has been reconsidered to take account of European needs. The future series will be completely updated, including the new ISO 3743 part 1 which has relaxed requirements for the test site and a simpler test method applicable to reverberant fields.

Intensity meters are now capable of sound power determination of machinery in situ. Measurement method is standardised by ISO 9614-1:1993 dealing with sound intensity measurements at discrete points, and the forthcoming ISO 9614-2 dealing with scanning, a less onerous technique than computation from discrete point measurements. A proposed new series of standards ISO 11200 - 11204 will deal with measurement of sound pressure levels at workstations, and 12001 will give guidance on the drafting of noise test codes. The procedure for noise labelling of machinery and equipment, covered by the old ISO 4871:1984 is being updated, taking account of the important Machinery Directive (89/392/EEC with amendments 91/368 and 93/44).

Finally, Harry Lester from the HSE spoke on noise reduction and the Machinery Directive. This is implemented in Britain under the Supply of Machinery (safety) Regulations 1992 and Supply of Machinery (safety) (amendment) Regulations 1994. He explained the standards categories used by CEN: type A is fundamental and giving basic concepts and principles; type B for particular safety aspects or mechanisms eg interlocking devices, safety temperatures, noise; and type C to do with machine specific requirements. CEN TC211 has adopted B type standards dealing with noise, which will govern C standard makers for individual machines. The Machinery Directive has requirements for minimising noise and is being supported by a new series of international standards ISO 11688 - 11690 which should provide a detailed framework for recommended practice.

The HSE has been sceptical of the noise aspects of the recent European Commission proposals for a Directive on physical agents. A study from ISVR relating to damage from lower noise levels has been completed and the findings are expected to be published early next year.

J Silverman

Workshop on Miniature Microphones Salford, 9 November 1994

This one-day Engineering Division Workshop was hosted by the Department of Applied Acoustics at the University of Salford. Fifteen members discussed the use of miniature microphones for measuring hearing protection attenuation and noise immission. Participants included members involved in pre-standardisation research, delegates from HSE, MOD and DRA, BSI and CEN Working Group members, test laboratories, instrumentation manufacturers and specialists from the fields of broadcasting and microphone calibration.

With the trend towards the use of miniature microphones to measure the sound pressure level and spec-

trum at a subject's ear, issues of reproducibility and practicability have arisen. Reports in the literature have suggested that the most repeatable measurements are obtained when the microphone is placed in close proximity to the eardrum. Discussion focused on the practicality of using probe tube techniques for this purpose in research, standards testing and field measurement, and the design criteria for microphones for such work.

Correction of in-ear data for microphone placement, and the use of 'transfer function of the open ear' reference measurements to allow comparison of sound pressure levels under an ear-muff with the Action

Levels prompted lively debate.

The meeting addressed the imminent ISO TC43/SC1/W17 meeting in London and reviewed the ISO Committee draft for the measurement of the attenuation of level-dependent ear-muffs.

Participants were able to share their views with the UK delegate to the ISO Working Group, allowing a coordinated input into this international work. Assessment techniques for ANR muffs were discussed and a review of hearing protector standards under development in Europe were presented.

The day concluded with a session in the Department's laboratories.

Delegates expressed interest in further collaborative experimental work to assist the UK input in standardisation, and in the holding of future workshops.

Peter Wheeler FIOA ❖

Report

NATO CCMS Studies Into Aircraft Noise

Final report of the working group study into the effects of topography on propagation of noise in the vicinity of airfields

Most current aircraft noise models assume that the terrain surrounding the runway is flat and has normal impedance properties. This assumption is adequate in most cases, but for airports situated in hilly terrain or close to acoustically hard surfaces it could give misleading results.

With increasing computing power facilities and access to digital maps, there is now the possibility of automatically including terrain effects in calculations. This NATO CCMS working group undertook to investigate these possibilities.

The report reviews current practices in the handling of topographic effects and describes the main building blocks – slant range adjustment, ground attenuation and noise barriers. The majority of the work was carried out by three laboratories under national contracts; The Danish Acoustical Institute, SINTEF DELAB Norway, USAF Armstrong Laboratory/Nyle Laboratory. Each laboratory has approached the problem in different ways and this report summarises the individual reports (which are fully referenced). The group came to a number of conclusions. These include the fact that topographical effects can have significance for airfield noise calculations. Of greater importance, in my opinion, is the conclusion that the improved propagation models do not agree with lateral

attenuation computed by SAE AIR 1751.

The report gives an excellent overview of the work carried out and gives recommended procedures to any reader who wants to include topographic effects in their models. However, I recommend that members with a serious interest obtain copies of the individual reports.

Subsequent to this work the working group carried out a validation trial at Narvik airport, Norway in June 1994. The results from this trial have not yet been fully evaluated but will be the subject of a subsequent report.

The one aspect missing from this work is the meteorological effects on the propagation of sound in these situations. This was a deliberate decision at the outset but is the subject of a further study by this working group.

Note: NATO CCMS stands for the COMMITTEE ON THE CHALLENGES OF MODERN SOCIETY. It was set up by President Nixon to tackle environmental issues and since its inception has studied a wide range of subjects. In the noise field it conducted a large pilot study into aircraft noise and sponsored a number of international conferences, the most recent one being held in Baltimore in May 1994. Currently the working group on helicopter noise modelling is finalising its report and, in addition to the work on meteorological effects already mentioned, a working group has been formed to assess the possibilities of creating an international database on noise from weapons and sonic booms and their impact on wildlife, domestic animals, humans and structures. Further information may be obtained from the author of this note, Ralph Weston MIOA, RAF Institute of Health and Medical Training, Royal Air Force Halton, Aylesbury, Bucks HP22 5PG. ❖

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Acta Acustica is the journal of the European Acoustics Association, of which the Institute of Acoustics is a founding member.

Six issues of the journal are published per year and the cost to members for a personal subscription is currently £38.00 which can be arranged through the Institute office.

As well as technical papers, the journal includes abstracts of doctoral theses, book reviews, society news, congress reports and a list of forthcoming events in acoustics.

The following is a sample of the articles and correspondence that have appeared in the last two issues to give a flavour of the breadth of topics covered.

Sound propagation from a point source over a two-impedance surface.

European developments in prediction models for building acoustics.

Materials characterization and nondestructive testing.

The cumulative spectral probability diagram: theory and experiments.

Acoustic radiation from finite cylindrical shell containing flowing fluid.

Describing the coupling between vibrating walls and fluid-filled enclosures: a method based on a modal analysis.

Diffraction impulse response of arbitrary polygonal plane transducers.

Sea-bed identification using echo-sounders signals.

Measurement and prediction of the surface impedance of a resonant sound absorbing structure.

Theory and implementation of a broadband active noise control system using a fast RLS algorithm.

An experimental investigation of mode coupling

On the relations between the long-wave characteristics of an optoacoustic pulse and the moments of bubble size distribution in the upper ocean layer.

An equivalent network modelling the strong coupling between a vibrating membrane and a fluid film

New Products

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The new Peters Medical RA500 Audiometer delivers capabilities that on most others are extra cost options. The powerful operating software enables an operator to customise the system to fit individual testing requirements.

True multi tasking capability allows the RA500 to process data and conduct tests simultaneously. It also has extra value features such as a built-in talk over microphone, dual RS232C communications ports and internal storage of up to 400 audiograms all as standard. The RA500's large 'tactile' feel alphanumeric keyboard makes operation fast and positive.

Audiograms print out on an integral graphics style printer. The RA500 fully complies with all the latest OSHA testing requirements. For further information contact: Simon Bull, Sales Manager, Peters Medical Equipment Ltd, Salter Road, Cayton Low Road Industrial Estate, Scarborough, North Yorkshire YO11 3UZ Tel: 0723 584250 Fax: 0723 583728.

CEL INSTRUMENTS

CF-5220 FFT Analyser Options

The new, super fast, CF-5220 FFT analyser from Ono Sokki can now be made even more powerful with a comprehensive range of optional extras.

These options include the CF-0582 tracking card which enables the analyser to complete high speed measurements of the acoustic characteristics of engine noise during 'run-up' tests as well as for gearbox performance assessments. The CF-0585 module adds Real Time Octave Band Analysis and the CF-0552 Acoustic Intensity Software makes the analyser the ideal tool for many applications including product noise testing. Other options for the CF-5220 include a built-in printer, CMOS memory card, Parallel and Audio I/O with the CF-0583 Signal output card, external DC power module and Wigner software.

The CF-5220 is notable for its variety of high speed analysis options including real time octave band, RPM tracking and Sound Intensity measurements. A 16-bit converter guarantees highly accurate results and contributes to a high 90 dB dynamic range by combining 32-bit calculations. The instrument also has a 9.4" TFT high definition colour screen and a floppy disc drive.

Information on the CF-5220 FFT analyser and accessories can be obtained from CEL Instruments Ltd, 35-37 Bury Mead Road, Hitchin, Herts SG5 1RT Tel: 0462 422411 Fax: 0462 422511.

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OCTOBER DEVELOPMENTS

Waveform Library Version 1

October Developments, personal computer test systems specialists, announce the release of 'The Waveform Library', a C++ class library for the generation and processing of standard and complex waveforms.

Features include:

- A comprehensive range of waveform filter, modulation and sweep classes
- Complex waveform creation and processing
- Intuitive class interfaces
- Classes for interfacing to output drivers
- Advanced memory and heap management techniques
- Disk I/O, including direct creation of waveforms from disk.

Whether involved in development, research or education The Waveform Library is said to provide an excellent solution for those involved in waveform processing applications. Its familiar classes and intuitive interfaces ensure speedy development, whilst advanced techniques enable efficient memory management.

Applications areas include waveform generation, automatic test, acoustic/vibrational test, process control, signal processing. For further information call 081 968 3586: October Developments, 101 St Marks Road, London W10 6JW.

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The PHONdat is a fully self-contained, tamper proof noise recording system intended for use by noise complainants who operate the system using a single button remote control. The system is supplied complete on a 'switch on and go' basis with no external SLM or pre-amplifier required. A time/date stamping digital audio tape recorder and microphone with all supporting electronics is integrated into a single, portable, ruggedised unit. The microphone and related electronics are built to give performance equivalent to type 1 (IEC 651) standard. Other features include simultaneous linear and A-weighted recording, battery power option, sleep mode for battery saving and a user indicator for standby/record status. The DAT recorder is removed easily from the (unlocked) case for replay and the system can be calibrated using the optional acoustic calibrator. A single price includes all equipment for the complete system excluding a tripod or microphone stand which can be provided as options.

Further information is available from PHONtechnics Ltd, Enterprise House, Cherry Orchard Lane, Salisbury, Wiltshire SP2 7LD, Tel: 01722 415068, Fax: 01722 414165

FLEMING & BARRON

Railway noise calculation

The publication in 1993 of the Noise Insulation (Railways and Other Guided Transport Systems) Regulations (draft) saw also the publication of the Department of Transport draft for public comment titled 'Calculation of Railway Noise'.

The final version of the Calculation is eagerly awaited; in the meantime the draft Calculation has been used, for want of any other official method, to calculate current and future noise for several railways. In connection with this work FLEMING & BARRON have developed a computer program for the purpose and have accumulated many examples of its use. In outline, the draft Calculation calls for the railway to be divided into straight line segments,

relative to selected noise receiving points (ie on building facades) and intervening barriers. These are entered into the computer program from Ordnance Survey maps on an A3 size digitising tablet, together with the track type, geometric information about barriers, intervening ground conditions and reflecting surfaces opposite the receiving point. Currently, three barrier types are handled.

The program also provides for train files to be generated containing the type of vehicle (diesel/coach/wagon, disc or tread braked, etc) its speed, number of units (engines/coaches/wagons) and the numbers of train movements during the day, evening and night. This information is gleaned from timetables for freight and passenger movements, together with train speed profiles and knowledge of the railway, all of which require experienced interpretation.

Finally, before the trains can be run, a file is created containing the heights at which calculated noise levels are required at each receiver

position. When run, the program calculates the L_{Aeq} at each receiver position and height for all relevant segments of the line and for the batch of trains which run during the day, evening and night.

Thus, by running the program for current trains and track, and again for future trains and track, comparison can be made with qualification standards for railway noise mitigation such as those in the Draft Noise Insulation Regulations (1993) or the Kent/Surrey/Essex Joint Standard on Railway Noise and Vibration.

The program contains various options, for instance, to insert, modify or delete barriers and test their effect, to extend segments beyond the edge of A3 drawings, to run single trains or modify train files and to rotate coordinates for checking barrier geometry and attenuation. It is written in BASIC and runs on the Acorn RiscPC using the facilities and power of the windows, menus, filing system and operating system of that machine. This is a purpose designed, user friendly program – not a spread sheet.

Enquiries to David Fleming, Fleming & Barron, Opera Omnia Design Centre, 69 Caversham Road, London NW5 2DR, Tel: 071 485 7611, Fax: 071 284 0412.

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HBM UK

New digital amplification system

HBM claims to have combined the best of analogue and digital technologies in a new amplification system. The MGC Measurement Amplifier System uses gate array technology to implement a patented analogue to digital conversion (ADC) technique and flexible digital signal processing to carry out a substantial part of the signal conditioning. HBM claim that the most important aspect of the ADC is capability to digitise the signal at high speed and with high resolution, giving error-free signal processing across the entire frequency range of the amplifier, improving measurement accuracy by a factor of three compared with analogue amplifiers. Compatible with all commonly used transducers, the MGC can be used for simultaneous measurement of many different parameters in applications such as monitoring systems, quality assurance, test rigs and process control. It can also be battery driven for mobile applications.

For further information contact Chris Kitiris, HBM United Kingdom Ltd, Harrow Weald Lodge, 92 Uxbridge Road, Harrow, Middx HA3 6BZ. Tel: 0181 420 7170, Fax: 0181 420 7336.

News Items

IAC Ltd

New ground run-up test facility for British Airways

Currently nearing completion is a

new ground run-up pen for British Airways at London Heathrow Airport. Designed and built by UK aero engine test facility specialist Industrial Acoustics Company (IAC), the pen will enable the airline to carry out important aircraft engine checks without creating a noise pollution problem in the local community. IAC states that it is capable of testing all of BA's Boeing 767, 757, 747 and 737 aircraft, including the 747-400 and will also accommodate the new 777. The pen occupies an area 75 metres wide and 67 metres deep and its side and rear walls are 12 metres high. Situated on the edge of a BA maintenance base at the airport, it is designed to reduce noise levels to 73 dB(A) at the fringes of a nearby residential area.

IAC is a Sponsor Member of the Institute.

International Conferences & Exhibitions Ltd

Britain in the Gulf '95, 24-27 April 1995

British exporters have another opportunity to project themselves in the Arab world following the announcement that the 'Britain in the Gulf' exhibition is to return to Dubai.

It is strongly supported by the Department of Trade and Industry which fully recognises the importance of the event and provides generous subsidies and travel grants for

exhibitors. Over 37,000 visitors came in 1994, generating millions of pounds worth of business.

For further information contact David Domoney or John Fletcher at: International Conferences & Exhibitions Ltd, 2 Churchgates, The Wilderness, Berkhamstead, Herts HP4 2UB. Tel: 01442 878222 Fax: 01442 879998.

HBB

Real-Time hiss removal without encoding/decoding

HBB Communications have launched the DH-1 from Cedar Audio, a rack mounted device which removes broadband noise in real-time without using filters and without the need for encoding and decoding.

Controlled by a simple user interface, HBB claim that the DH-1's advanced processes accurately differentiate between hiss and the genuine signal, removing hiss and restoring the signal virtually instantaneously. The DH-1 joins the range of rack mounted real-time audio restoration devices that includes the DC-1 De-Clicker, CR-1 Crackle Remover and the AZ-1 Azimuth Corrector.

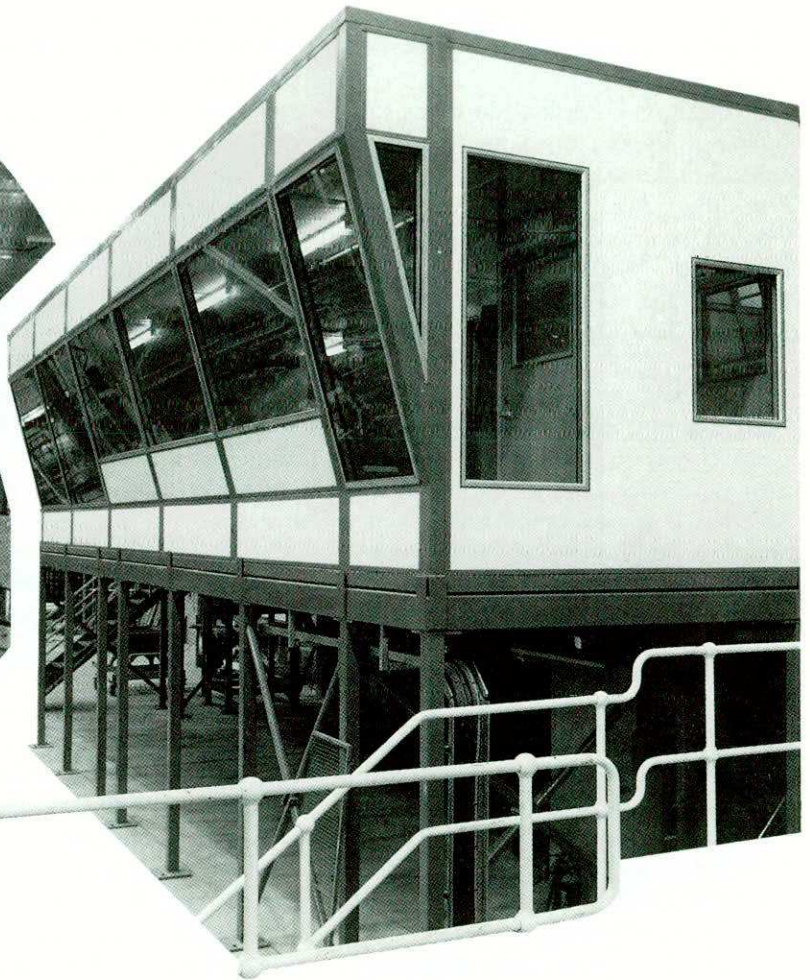
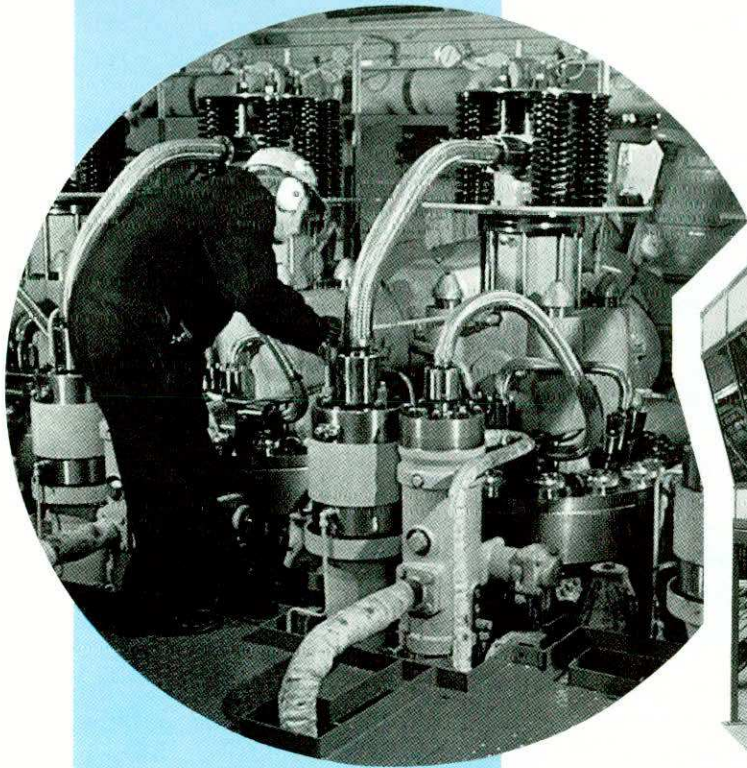
For further information contact Steve Angel, Sales Director, 73-75 Scrubs Lane, London, NW10 6QU. Tel: 0181 960 2144, Fax: 0181 960 1160. ♦



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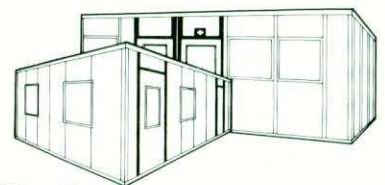
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Letters to the Editor

Views expressed in Letters to the Editor are not necessarily shared by the Editor or the Institute. Letters may be shortened for space reasons or at the discretion of the Editor.

The Editor
Acoustics Bulletin

Sir,
I trust that the pre-history of the IOA will NOT be re-written along the lines proposed by William Allen in the September/October issue of the Bulletin, for the history given in the recently-published Institute Register is substantially correct as it stands.

In 1946 Alan Pickles and others set up the so-called Acoustics Group under the aegis of the Physical Society, and it continued as a Subject Group when the latter amalgamated with the Institute of Physics; our current President Alex Burd and myself served as joint Honorary Secretaries of this Group in the early 1960s. However, some apparently felt that the more engineering aspects of noise and acoustics were not being fully covered and established the Society of Acoustic Technology alongside the continuing Acoustics Group. Then in 1966 SAT ceased operation and the British Acoustical Society was set up, still operating alongside the Acoustics Group.

The fragmentation of acoustics in Britain, with consequent duplication of meetings etc, was unfortunate and in 1974, with the approach of the International Congress on Acoustics scheduled for London, the Acoustics Group and BAS came together to form the Institute of Acoustics, which has flourished ever since.

Yours sincerely

Michael E Delany HonFIOA

The Editor
Acoustics Bulletin

Sir,
In the recently published paper of N N Shibanova 'Physics and techniques of ultrasound in Moscow' (Acoustics Bulletin, 19, No 5, p25-28, September/October 1994) there are so many distortions and crude mistakes that the reader may gain a grossly misleading picture of the acoustic activities in Moscow and in Russia generally. As a person who, before moving to the UK, was closely connected with acoustics research in Moscow, I feel obliged to make some corrective remarks.

First of all, the allegation that research in ultrasonics in Russia is mainly concentrated in the Moscow region is far from the truth. Excellent institutions dedicated to acoustics and ultrasonics research may be found in St Petersburg, Novosibirsk, Nizhny Novgorod (formerly Gorky), Kazan, Vladivostok, and other major cities. But even speaking about Moscow alone, to reduce all acoustics activities to just three leading institutions, as the author does, is equivalent to representing the diverse acoustic work in London by referring only to three or four academic departments without taking into account the work of numerous acoustics consultancies and industrial laboratories.

Despite the presence of the word 'techniques' in the title, the contents of the paper relate mainly to physics of ultrasound. However, in this field the picture is also unbalanced, some very advanced research schools being completely ignored. In particular, it is difficult to imagine international research into propagation of acoustic waves in crystals without the fundamental results obtained in the Institute of Crystallography of Russian Academy of Science (Prof V I Alshitz, Dr A L Shuvalov, et al), or investigations of surface acoustic waves on rough surfaces and propagation of ultrasound in media with relaxation without the achievements of theoreticians from the Moscow Engi-

neering Physics Institute (Dr V V Kosachev, Dr G Maximov, et al).

It is also clear from the paper that the author is completely unaware of research into ultrasonic nondestructive testing which is undertaken in numerous academic and research institutes in Moscow. One can mention, for example, the Moscow Bauman Technical University which coordinates research into ultrasonic nondestructive testing in all Russian higher education institutes (Prof N P Aleshin), the Kurchatov Atomic Energy Institute carrying out research into acoustic emission with regard to reactor safety (Dr K B Vakar), the Central Research Institute of Technology for Machinery (Prof I N Ermolov), etc.

In describing the achievements of some eminent scientists N N Shibanova often makes inappropriate emphasis. Thus, speaking about the results of the world renowned acoustician and holder of the IOA Rayleigh medal, L M Brekhovskikh, the author does not mention his direct relation to the discovery of a deep ocean sound canal providing waveguide propagation of sound for very long distances (this canal was independently discovered by scientists in the USA). Instead, she emphasises the discovery of synoptic vortices in the ocean which represent not acoustic but purely hydrodynamic phenomenon. From the paragraph on the acoustic microscope, the reader may imagine that this device was first built in Russia. In fact, the Americans, R A Lemons and C F Quate designed the first acoustic microscope at Stanford University.

Especially upsetting are unforgivable mistakes in basic facts concerning some well known scientists. For many years I worked at the Department of Acoustics of Moscow State University. This is why I was unpleasantly surprised to see, among the names of supposedly active researchers, the name of V E Lyamov, an outstanding and much respected scientist and once my older colleague and friend. Regretfully, Dr Lyamov died of cancer at the age of 45 in November 1980. Similarly, another famous scientist, I A Victorov, who worked at the N N Andreyev Acoustical Institute and who was a world renowned expert in surface acoustic waves (and the author of the pioneering book 'Rayleigh and Lamb Waves', 1967), died of a heart attack in April 1981. I wonder how N N Shibanova, whose purposed aim was 'to provide a review of the wide range of scientific and technical activity in the field, and to identify the principal scientists and institutes involved', could not know these obvious facts.

It would be a waste of time to rehearse all the other errors and infelicities that are present in Shibanova's paper. Let me just mention arbitrary use of academic titles before certain names. In particular, the author unjustly deprives Professorial titles from some persons and yet attaches them to others.

I cannot know for sure what was the real aim of Dr Shibanova's writing the above paper. Perhaps it was to exploit interest in current Russian reforms and their effect on science and technology, although the paper reads as if it had been written ten years ago.

I suggest that in future review papers on current issues of acoustics activity overseas should be submitted to the normal refereeing procedure.

Yours sincerely

Victor Krylov FIOA
Professor of Acoustics
The Nottingham Trent University

The Editor
Acoustics Bulletin

Sir,
I would like to reply to Victor Krylov's letter which comments on my recently published article 'Physics and Techniques of Ultrasound in Moscow' (Acoustics Bulletin, 19(5), pp 2528, September/October 1994). First, I would like to emphasize the fact that the final version of this article was written after long discussions with leading Moscow scientists including Aca-

demician Yu V Gulyaev and Professor Yu D Mansfeld. The facts given in the article were obtained from interviews with researchers recommended to me by well-known scientists, who have been working in acoustics for a long time: V I Pustovoyt, V F Kazantsev, N A Dubrovsky, O V Rudenko, etc. When I began the survey it soon became clear that such an article would contain delicate issues – in that to find agreement between the many scientists involved, especially belonging to the different scientific schools would be an extremely difficult task. There could have been as many differences of opinion, as there were scientists, both about the relative importance of the various scientific aspects of their research and of the relative importance of scientific achievements. The flow of opinions on the importance of ideas and results could have continued long after the review was prepared. The situation of Russian scientists at the moment is one of great financial stringency. Many seek employment abroad, often in the form of short-term contracts, and consequently many movements of personnel are difficult to follow. While writing the article in Moscow I attempted many times to contact Victor Krylov, but his colleagues were unable to inform me as to his movements and therefore I could not contact him, as well as a number of other scientists whose work should have been included in the review. It was important to avoid misunderstandings in an article that was to be written in a style which depended on personal interview, and so it was decided not to attempt to include the achievements of some contemporary scientists, whom I could not access. Unfortunately Victor Krylov was one of them.

I would now like to address specific points raised by Dr Krylov.

(1) I did not intend to write about the activity in the whole of Russia. I was asked by Acoustics Bulletin (Professor R E Challis, Editorial Board Member) to write about ultrasonics activity in Moscow (see the title), with the accent on the research there. This is why I did not mention the excellent ultrasonics groups at St Petersburg, Nizhny Novgorod, etc. The reader cannot have been given a misleading picture of acoustics activity of the whole of Russia as this was not implied by the title of the article.

(2) I did not reduce the acoustics activity to just three leading institutes as Victor Krylov has stated – the article contained major sections on work in other institutes and on research in biology and medicine which discussed the major efforts of other groups. In my concluding remarks I stressed that I had limited space available for the article; I could not therefore include many of the ultrasonics groups which I would have liked to.

(3) I feel that Professor Krylov has seized upon relatively minor points and amplified them out of proportion to their significance. For example it was the choice of Academician L M Brekhovskikh himself during the interview, as to which of his numerous achievements should be recorded. In the point about the acoustic microscope I was merely discussing the developments of the microscope in Russia and not giving a world view.

(4) In the paragraph about I A Victorov I do not suggest that he might continue to influence the technology concerning SAWs, but that his investigations done in the past might continue to do so. I stressed in the introduction that I A Victorov and V E Lyamov were very influential in the history of the field, and in a small space it was not possible to give a biography of each, or the dates of their untimely deaths.

(5) As to the misapplications of the term 'Professor' in the article, I checked as many titles as was possible in Moscow in August 1994. I suggest that Professor Krylov's information may be inaccurate due to his very long absence from Russia. But I should also add that, because of the dramatic changes in Russian society in general and in the scientific community particularly during recent years (the article was submitted to the journal in 1992), it was very difficult to follow the changing status and title of many people, and of organisations, and even new scientific results in some cases.

Finally I very much regret that some very respectable sci-

entists have not been included and that the work of some has not been emphasized adequately. I do hope that Victor Krylov would feel able to seize this opportunity to take a broad view of this subject in Russia, and produce an article of his own to enlighten and inform us.

Yours truly

Dr Natalia Shibanova
Senior Research Assistant
Moscow Institute of Physics and Technology

The Editor Acoustics Bulletin

Sir,

As the Editorial Board member responsible for Dr Shibanova's article I feel that I must offer a few words in reply to Professor's Krylov's letter. I asked Dr Shibanova if she would write the article in 1991, recognising at the time that it would be a difficult task. It was important to restrict the length of the review, so I specified that the article should be limited to activity in Moscow, and that it should emphasise scientific research rather than developments in technology. I recognise that the boundaries between these two are rather fuzzy. The article was to give our readers a 'flavour' of the significant research effort rather than provide an indepth account. I am grateful to Dr Shibanova for achieving what I still believe to be a not unreasonable balance in a field that is now undergoing fundamental change in its scientific, technological, economic, and political aspects.

Although there has been a delay between my receipt of the original manuscript in 1992 and its final submission to the journal, I am of the opinion that the article gives a reasonable picture of research activity in Moscow. However, in my editorial task a few phrases were altered in the interests of written style and some of these may have brought about a slightly misleading emphasis – for example the fact that the article was intended to concentrate on 'science' rather than 'technology' was not adequately emphasised at the beginning of the review, although it had been more clearly stated in the original manuscript.

Having read Professor Krylov's letter I am of the opinion that he would be well placed to write a complementary article, giving a review of research in acoustic technology in Moscow, or even in the broader context of Russia as a whole. Then we would all be much the wiser.

Yours truly

Professor R E Challis
Ultrasonics and Digital Signal Processing Laboratory
University of Keele

The Editor Acoustics Bulletin

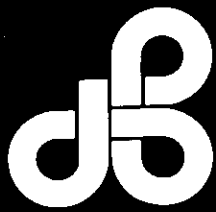
Sir,

In response to the above letters of Professor R Challis and Senior Research Assistant Dr N Shibanova, I must say that it is not clear to me why so much attention is being paid in Dr Shibanova's reply to her unsuccessful attempts to contact me while writing the article in Moscow. Does it mean that the article would have been of a better quality if she had managed to find me? As to the specific points touched in my critical comments, I am not entirely satisfied by the author's explanations. I do not wish, however, to continue the dispute, being sure that careful readers (if interested) will be able to draw their own conclusions having read Dr Shibanova's paper along with all above correspondence.

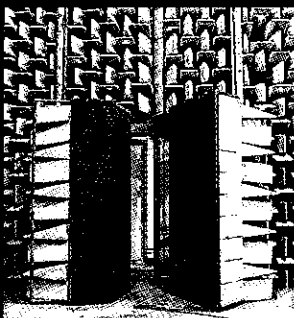
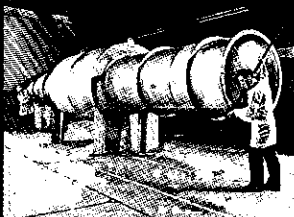
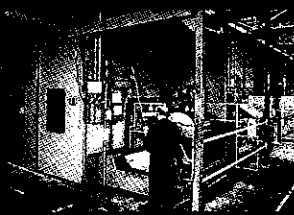
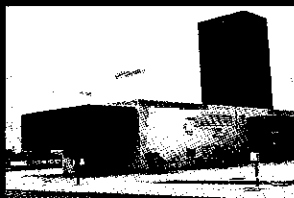
Yours sincerely

Victor Krylov FIOA
Professor of Acoustics
The Nottingham Trent University





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