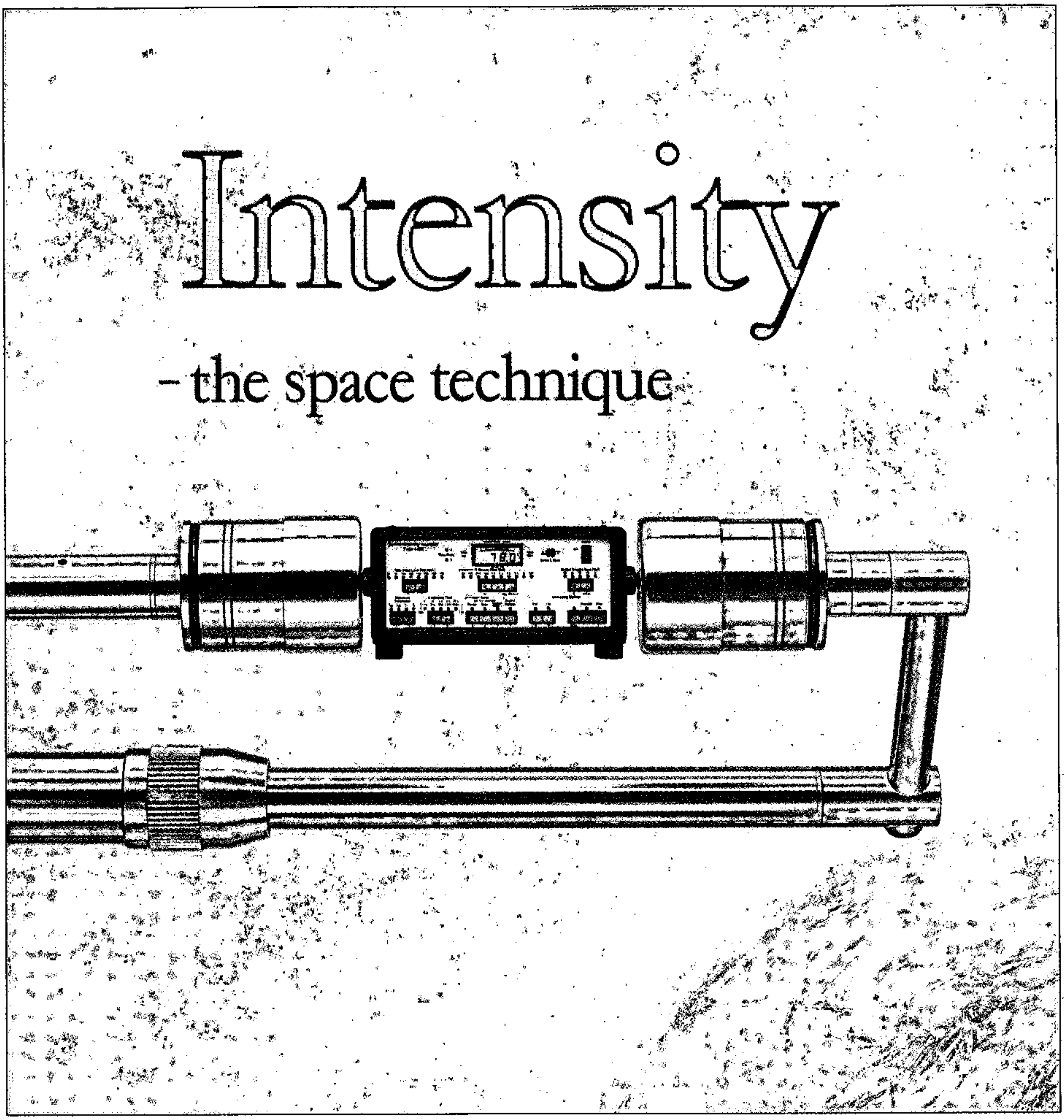
Acoustics Bulletin

January 1987 Volume 12 Number 1

INSTITUTE OF ACOUSTICS



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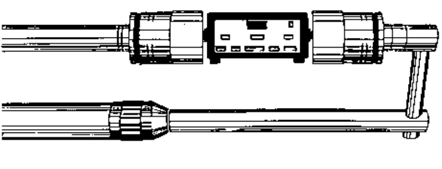

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The Institute of Acoustics was formed in 1974 by the amalgamation of the Acoustics Group of the Institute of Physics and the British Acoustical Society and is now the largest organisation in the United Kingdom concerned with acoustics. The present membership is in excess of one thousand and since the beginning of 1977 it is a fully professional Institute.

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Dear Fellow Member,

Alison Hill has resigned after seven years' valiant service as the Editor of the Acoustics Bulletin. The Council at its last meeting recorded its appreciation of her contribution to the development of the Bulletin to its present form. I would like to take this opportunity to extend best wishes to Alison for the future.

In the meantime, do spare a thought for John Tyler who, having manfully taken on the Chairmanship of the Publications Committee recently, has the additional problem of the Editorship of the Bulletin — and all that it implies.

As the publications of any learned Institute is such an important part of its activities (if for no other reason) John must have our very best wishes for success in his endeavours.

Yours sincerely,

Orhan Berktay

The Alvey Directorate

The U.K. Alvey Research Programme in Speech Technology

R N Kay (Alvey Directorate, Millbank, London)

1. The Alvey Report

Largely in response to the Japanese fifth generation computer initiative, the government set up a committee in March 1982, to report on the future of information technology in the U.K. The committee was chaired by John Alvey, Senior Director, Technology, British Telecom. Its report, known as the Alvey Report, was published later in 1982, and recommended a government sponsored programme of information technology research and associated support activities that would require £350 million over 5 years. The programme was to be divided into four main areas, which were (1) Very Large Scale Integration (VLSI); (2) Software Engineering (SE); (3) Man Machine Interface (MMI); and (3) Intelligent Knowledge Based Systems (IKBS). Today MMI has been replaced as a single entity and divided into Speech and Image Processing, Human Factors and Displays Technology. This research programme was to be a major part of an overall government strategy for supporting the information technology industry.

The main recommendations of the Alvey Report were accepted by the government in April 1983, and Brian Oakley was appointed as head of a special 'Alvey Directorate' in the Department of Trade and Industry to manage the programme. An essential feature of the Alvey Programme was that the main 'precompetitive research' projects were to be undertaken by consortia, in most cases, consisting of at least two separate companies and at least one university. The government was to provide 100% funding for the academic community, and a maximum of 50% of the costs in industry. Within the community of Alvey contractors, special arrangements have been devised to protect the intellectual property rights of individual companies, while ensuring that any results can be exploited to the maximum benefit of the U.K. by requiring licensing agreements to be given to other companies in the Alvey scheme. It was decided that a significant part of the available funding should be spent on 'Large Scale Demonstrator' projects which would draw on all of the four original 'enabling technology' fields and produce demonstrations of potential products and systems with powerful, and previously unattainable, capabilities. It was to be an important aspect of the demonstrators that they should require new research knowledge and so would 'pull' the research in the enabling technology fields.

Speech technology projects are to be found in three parts of the Alvey portfolio. Those projects that include advanced natural language processing are handled by and large within IKBS, while the projects reported on in this paper are those that formerly came under MMI and one of the Large Scale Demonstrators. (This paper does not address those projects that tackle the human factors aspects of the use of speech technology.)

Although the speech projects are spread administratively across the Directorate, the benefits of synergy have not been overlooked and intra project cross fertilisation is encouraged. In particular the Alvey Speech Club, within which research information is freely exchanged, is made up in the first instance of all organisations involved in any Alvey speech project. In addition, subject to approval by the membership, other individuals are granted membership, where it is felt that it would be mutually beneficial.

Finally the Joint Speech Research Unit, (now merged with RSRE speech research to form the RSRE Speech Research Unit) was invited to assist the Alvey Directorate with advice on coordinating, evaluating and monitoring speech projects in the Alvey Programme and to make its own research results available to Alvey contractors where appropriate.

2. Workshop

In January 1984, an Alvey-sponsored Speech Technology Workshop was held in Coventry, attended by 34 of the leading people involved in speech technology in the U.K. The workshop included 16 participants from industry, 13 from academe, and 5 from government research laboratories. Their aim was to identify the major research areas where government-supported research was necessary to put the U.K. in a good competitive position both in U.K. and world markets for products based on speech technology.

Not surprisingly, the three main types of speech technology application identified by the workshop were speech synthesis, recognition and coding, although it was recognised that these fields are closely related in that they require similar basic research and use related speech-processing techniques. For speech coding a distinction was made between coding for real time telecommunications and coding for application in voice mail, voice annotation of text etc. For telecommunications at low bit rates, where the applications so far are mainly military, it was considered that coding techniques were unlikely to give robust enough good performance within the timescale of the Alvey programme to find significant commercial application and that the military applications would be dealt with by defense sponsored research. At higher digit rates, research into low delay, high quality fixed rate systems for civil telephone networks would be driven by the telecommunication needs. On the other hand, robust medium rate coding for voice storage was accepted as having great commercial importance and as being able to exploit the permitted signal delay to save bits in a way that is impossible for real-time conversation. For this reason medium bit rate coding was identified as a proper subject for Alvey support.

For versatile speech synthesis, the workshop dismissed the widely used current techniques of replaying stored coded signals and concentrated entirely on various aspects of 'speech synthesis by rule'. In this latter area the problems have as much relevance to advanced automatic speech recognition as to voice output, in that a good synthesis-by-rule system will contain a model that relates the linguistic specification of a message to the properties of the acoustic signal. Considered in the reverse direction, such a model is an essential part of any very general speech recognition system. The main objectives of speech synthesis research were identified as:

* high intelligibility
* multiple accents
* multiple speaker types
* acceptable prosody, with discourse relevant information
* some tone of voice information
* improved naturalness
* ability to work from conventional text or directly from concept.

Concerning automatic speech recognition, it was observed that current products are unable to deal with unlimited vocabulary, a wide range of speakers, naturally spoken, fluent speech, or speech from a hostile environment. The major research objectives were listed as:

* high reliability (even in hostile environments)
* fluent speech
* single accent speaker independence
* speaker adaptibility
* nontrained vocabulary set in excess of 1000 words
* understanding limited dialogue in structured discourse
* effective use of linguistic constraints of natural language.

3. Announcement of Opportunity

An Alvey 'Announcement of Opportunity' was published in April 1984, identifying a number of speech related areas in which applications for funding were sought. These areas were coding, synthesis, recognition, algorithms and architectures, human factors aspects, and common tools (including performance assessment). As a result of the announcement, a substantial number of proposals were received. These can be divided into two general categories: a few large collaborative proposals — involving at least two companies, but also including a substantial amount of academic research — and a number of smaller proposals for more basic research which would be done entirely in universities or polytechnics. For these academic proposals, the Alvey rules require an industrial 'uncle' to be identified by the applicant. The role of the uncle is to assist in monitoring the project and to confirm the relevance of the research to eventual product development.

None of the proposals fitted entirely under any one of the headings, listed in the announcement: in general, they contained significant parts under two or three different headings. Also none of the proposals asked for support on speech coding. The consortium proposals were mostly aimed at automatic speech recognition of large vocabularies, but in general the value of a close link between synthesis by rule and automatic speech recognition was also recognised.

4. The Speech Research Programme

The projects which are currently supported are shown in Fig.1, annotated by their 'Alvey Number'. All Alvey projects connected with speech technology are represented in this figure. However projects 003, 062, and 103 essentially deal with Human Factors issues and will not be described in detail. Appendix 1 provides a list of the collaborating firms, universities, polytechnics and research institutions by project number.

A global look at the programme reveals four main areas: BASIC TECHNIQUES, SYSTEMS, SPEECH TECHNOLOGY ASSESSMENT AND STANDARDS, and THE SUPPORT TOOLS AND INFRASTRUCTURE area, which supports and supplies the other three areas. BASIC TECHNIQUES is further subdivided into two parts, Algorithms and Feature Extraction, and SYSTEMS into Synthesis, Human Factors in The Use of Speech Technology and Recognition.

4.1 Large Demonstrator

At the heart of the speech programme, in the Recognition area, is one of the major demonstrator projects (LD006). The aim is to develop a very powerful 'fifth-generation' architecture personal workstation for business use. Speech recognition, using phonetic knowledge and linguistic processing, will support machine assisted speech transcription (MAST) for office dictation etc. The leading industrial company involved is Plessey, and much of the research is to be done in three universities: Edinburgh (Linguistics, Artificial Intelligence, and Electrical Engineering), Loughborough (Human Sciences), and Imperial College, London (Computer Science).

To fit in with the Alvey structure, this project has been split up into two groups, with those parts that are clearly embodied in the demonstrator system in one group, and those parts which are 'enabling technology' in the other (see 4.2). Enabling technology research, although essential for the demonstrator, is also of value to the rest of the Alvey-funded community and will be available under license to other Alvey contractors.

The work at Imperial College is directed towards high speed parallel processing architectures for implementing the algorithms, particularly those specified in the declarative computer languages widely used in the Artificial Intelligence research community. Loughborough will be responsible for the human factors of the user interface. The enabling research directly related to the speech problems will be done in the three departments at Edinburgh University. In Linguistics, the emphasis will be on

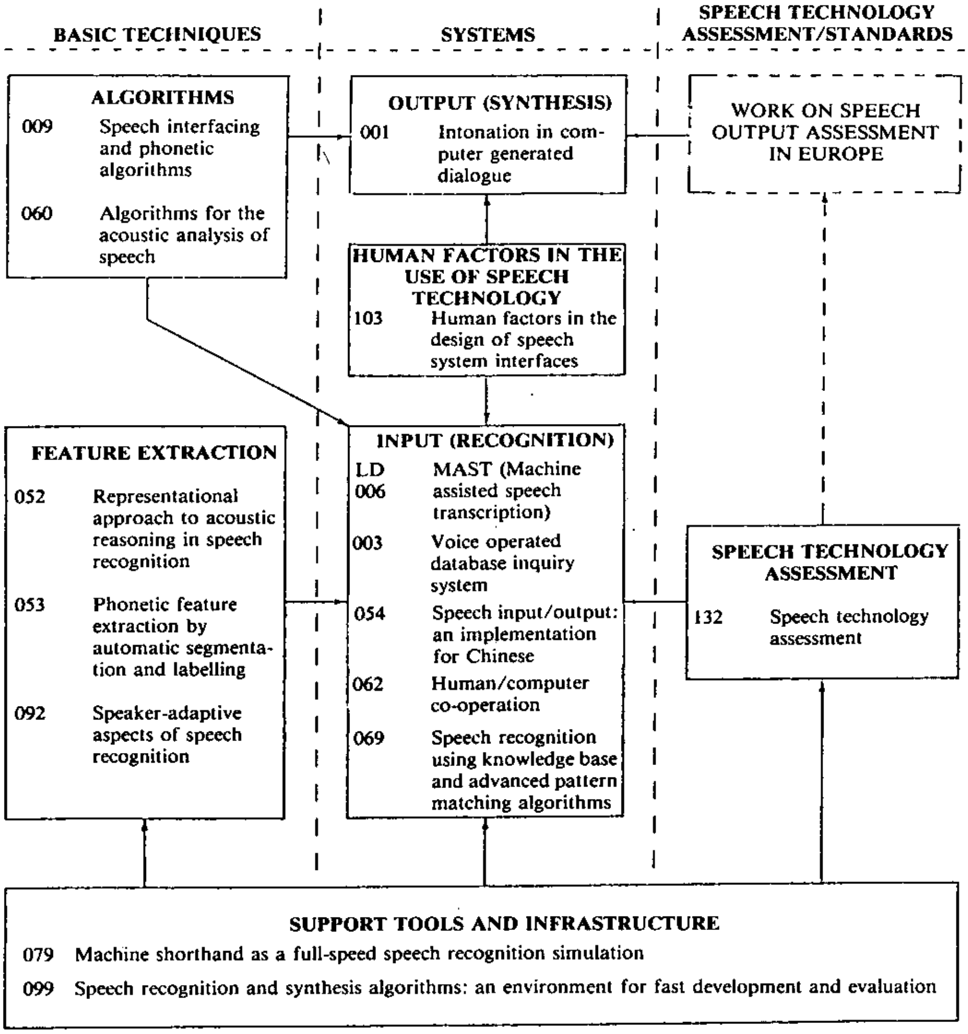

Figure 1 Speech Projects

detection and interpretation of acoustic/phonetic features, including use of expert system techniques to encode human knowledge about acoustic phonetics. This approach has much in common with the work of Cole[1] at Carnegie Mellon University. In the Artificial Intelligence department, the work will be mainly concerned with the integration of information from various levels of the knowledge base, using the Active Chart Parser of Thomson and Ritchie[2]. A principal function of this part of the work will be to ensure that the system output does not violate the syntactic constraints of English. The Electrical Engineering Department, in conjunction with Plessey, will be responsible for the acoustic signal processing techniques needed to provide the acoustic/phonetic team with the necessary acoustic information. A variety of techniques will be used for deducing the pole zero response of the vocal tract, fundamental frequency and the spectra of fricatives and plosives. Three years into the project it is planned to assess the progress of the phonetic research, to see whether it is justifiable to continue with this approach in preference to using extensions of template matching methods expected to be achieved by other Alvey research teams by that time.

4.2 Enabling Technology Research

4.2.1 Feature Extraction

The three projects which comprise the Feature Extraction area are specifically designed to provide results for the Large Demonstrator.

Project 052 — (A Representational Approach To Acoustic Phonetic Reasoning In Speech Recognition), starts from the hypothesis that current template matching technology, even at the subword level, is unsatisfactory as a general paradigm for speech recognition. It is only practical for limited task domains through the availability of powerful processing and the now long standing familiarity with the relevant algorithms.

This mechanistic approach does not correspond to the 'recognition-reasoning' done by speech scientists when examining and comparing spectral data. Here inferences are made at the level of formant transitions, fricative noise, stop bursts and so on, which are the natural and useful abstractions from the raw spectral data. Furthermore operating at this level enables explanations to be formulated for particular recognition decisions.

The project also recognises that attempts to produce representations of the acoustic waveform based on segmentation in time and subsequent labelling as a phone, phoneme or phoneme type, that are closer to what can usefully be held as stored data for the matching process, are also fraught with difficulty principally because speech is a continuous process with inertia.

Consequently what is required to facilitate the comparison between signal and memory is a set of one or more intermediate representations to bridge the gap between the different ways in which the signal and memory are expressed. It is the main aim of this project to develop a rich, descriptive, intermediate representation called the 'Speech Sketch'. (This has strong analogues with the late David Marr's work[3] on the Primal Sketch, 2.5D Sketch and 3D Model as intermediate representations for vision processing).

Project 053 — (Phonetic Feature Extraction By Automatic Segmentation and Labelling), is designed to enhance the existing Leeds segmentation and labelling system in several ways. This can already segment and classify conversational speech into gross phonetic categories. The system uses minimal acoustic information (10ms averages of energy in 4 wideband frequency channels) and relies on the phonetic experience of the designers to produce a robust output.

The main goals therefore are to make the system portable to other users by substituting digital for hardware filters and second to extend the system to allow expert knowledge about speech to be incorporated into the recognition procedure. This expert systems work is being done in close collaboration with the knowledge based systems group connected with the Large Demonstrator at Edinburgh University.

Project 092 — (Speaker Adaptive Aspects of Speech Recognition) is tackling the problem of achieving speaker independence in automatic speech recognition. In particular the team is tackling acoustic variability due to accent, phonetic context, and personal voice quality.

The method under investigation is essentially an extension of the work already done by this group on the use of acoustic spectra for recognition, that have been transferred according to a functional model of the hearing mechanism. Male-female vowel normalisation can already be coped with and now it is intended to extend the technique to other aspects of acoustic variability. In particular a computer implemented model of the peripheral auditory analysis of speech sounds, based on the Bark scale, together with an essentially psychophysical theory of speaker-normalisation, based on scaling of auditory space, will be developed to tackle:

- phonetic context differences (restricted to prosodic context)
- accent differences

4.2.2 Algorithms

Also within the BASIC TECHNIQUES area there are two projects tackling different aspects of Algorithms. This work is of course of fundamental importance to the projects of Synthesis and Recognition within the SYSTEMS area.

Project 009 — (Speech Interfacing and Phonetic Algorithms), is a major consortium project. Its thesis is based on the fact that today's commercial development in speech is aimed firmly at questions of implementation of current technology and of price. Before performance quality can be improved, a considerable amount of fundamental work has to be tackled and solved. This project has mapped out an investigation strategy that proceeds systematically from basic, simple levels of phonetic description to the incorporation of syntactic, semantic and pragmatic processing. Furthermore a parallel integrated advance is planned in all five areas of production, perception, synthesis, recognition and algorithms.

The main technical goal is to be able to apply phonetic and phonological knowledge in both synthesis and recognition procedures. To bridge the gap between the acoustic analysis and the phonetic content form of the speech signal, work is being done to derive and implement phonetic and linguistic rules that relate phonetic features to the acoustic signal.

The consortium is using phonetically selected speakers to provide material of graded complexity which defines the acoustic-auditory pattern correlates of basic speech contrasts. By the use of specially developed analysis algorithms, perceptual constraints and phonological transformations, similar to those used by the ordinary listener, are being defined and used from the outset. These results will be transferred through a single speaker then multi speaker English recognition-synthesis system, first with one accent and later several.

Project 060 — (Development and Application of Algorithms For The Acoustic Analysis of Speech), is investigating novel methods for the acoustic analysis of speech sounds, with the aim of producing a description of the acoustic events in Bark — Scale spectrograms by convolving them with masks of different shapes and sizes. The project recognises the important fact that in trying to identify linguistic units from the speech wave, current methods have problems dealing with the invariable deviation of the input signal from either the stored template or the stored description of the characteristics of the particular phonetic features. This is due to factors such as the nature of the recording conditions, the presence of extraneous sounds and the particular characteristics of the speaker's voice. Typical features of significance are the slope and frequency of the spectral peaks and the onset — time of different frequency components.

Representations are being developed to explicitly hold descriptions of the local properties (20ms) of a spectrogram and to enable grouping of local properties into temporally more extended descriptions (100ms — 200ms).

4.2.3 Synthesis

The SYSTEMS area contains projects both on Synthesis and Recognition.

Project 001 — (Intonation In Computer Dialogue) is the only project dedicated to the output side of the technology. The team is developing techniques to allow the correct words to be accented and the correct intonational gestures to be used in computer generated speech. The fundamental question under consideration, is how to make a synthetic system understand the material that is to be spoken so that it can master intonation. The goal therefore is to provide descriptive rules, couched in computational form, that associate utterance purposes, within a restricted dialogue domain, with appropriate intonation contours.

One of the main challenges of the project is to establish a suitable structure of levels and control parameters in order to take account of the intonation-contour influencing factors such as speaker dependence, the communicative intent, the phrase syntax and semantics in a rule based way and generate intonation contours automatically.

To this end the project uses a program in which two robots talk to each other in order to achieve various goals, such as moving objects around their model world. This produces purposeful discourse whose utterances require particular accent placements and intonation types. The project team has developed an abstract representation for intonation contours, compatible with the discourse program output which they are using to drive the intonation component of their English diphone synthesis system.

4.2.4 Recognition

In addition to the large demonstrator concentrating on recognition two other projects address this topic.

Project 054 — (Speech Input/Output an Implementation for Chinese), is developing a Chinese speech-to-text and text-to-speech system. Additionally the consortium aims to make a major contribution to speech technology in general through the development and implementation of their chosen techniques in the particularly fruitful forcing environment of the Chinese language. The industrial partner has already developed and successfully exploited a Chinese text editor which uses lexical lookup and morphological analysis to determine the lexical identity and hence the appropriate characters of the syllables of the input. A further advantage of this device is that it effectively removes the task of lexical identification from the recognition stage. In other words, it becomes possible to use syllables rather than lexical units for pattern matching templates.

Consequently the main objective for the recognition stage is the segmentation of speech into grouped syllables by matching against the set of syllables (approx. 1000). To reduce the template set, two techniques are being developed. One which is proving highly successful is the application of discriminative network theory[4]. The second uses the fact that Chinese is a tonal language and that ignoring lexical pitch the set of Chinese syllables is about 400. The recognition algorithm under development integrates separate track recognition of lexical pitch with pattern matching by Hidden Markov Modelling of the set of Chinese sequential syllables organised in discriminative networks.

Project 069 — (Automatic Speech Recognition Using A Speech Knowledge Base and Advanced Pattern Matching Algorithms), is attempting to introduce more speech knowledge into speech recognition, while at the same time retaining optimal pattern matching procedures. The algorithms so developed would form an integral part of a speech technology that could handle

* large vocabularies (greater than 25000 words)
* natural language syntax
* speech from many talkers

The project hopes to improve on previous attempts to incorporate knowledge into speech recognition, which showed a distinct bias towards rules that embraced the higher level aspects of speech semantics and pragmatics. In this case the speech knowledge base, which will be derived from both automatic and manual analysis of speech and from current knowledge of speech (phonetics, linguistics etc.), will include knowledge on the acoustic/phonetic transformation, the phonetic/phonemic transformation, the effects of prosody, language syntax and talker characterisation e.g. dialect, accent and physiology. The emphasis will be on the creation of general models of speech that are parameterised by the automatic analysis of naturally spoken speech.

4.2.4 Speech Technology Assessment/Standards

Project 132 — (Speech Technology Assessment), which is tackling the development of tools, methodologies and standards for the assessment of speech input technology performance, is of vital importance to the entire speech programme. The work covers short, medium and longer term goals. In the short term, existing databases are being collated, calibrated, supplemented where necessary and then made widely available. Medium term goals focus on the development of a more meaningful assessment methodology and an associated database. In the long term, fundamental work on the characterisation of normal speech and the development of standard reference details proposed.

The project aims specifically to develop techniques that utilise the best features of the two most prominent philosophies for the assessment of the performance of speech recognisers, namely field trials and lab tests with recorded speech databases. The approach is based on evidence that there are relatively few speech signal parameters which are subject to variability by a large number of sources. Errors in recognition are largely due to such variability in the speech signal, most of which is not present in existing databases. The development of a database with a carefully controlled range of variability in the speech parameters should make it possible to predict field performance from a test using manageable amounts of data.

4.2.5 Support Tools And Infrastructure

The areas described above are supported by work in two projects that provide tools and valuable knowledge of how speech technology is best used.

Project 079 — (Machine Shorthand as a Full Speed Speech Recognition Simulation), is using the indiginous U.K. system used in Law Courts and in verbatim reporting — the Palantype speech transcription system which converts speech recorded on a shorthand machine into an orthographic representation — as a working high quality speech recognition machine, albeit with a trained operator. It can thus act as a simulated speech recognition system and provide facilities for:

* investigating the uses of automatic speech recognition machines
* assessing the role of speech as an input modality
* specifying performance requirements
* developing appropriate guidelines for dialogue design
* early investigation of other post acoustic requirements in speech recognition machines.

Project 099 — (Speech Recognition and Synthesis Algorithms: An Environment for Fast Development and Evaluation), is developing an algorithm test environment (ATE) for the speech programme as a whole. The ATE will be flexible and used both to describe and automatically test speech recognition and synthesis algorithms. The problems of a menu driven approach to this task will be overcome by the development of a high level speech algorithm specification language (SASL) whose syntax reflects both the mathematical description of the algorithm and the statistical tests needed to differentiate between algorithms.

It is intended to have the SASL interpreted into a Fortran/DAP Fortran program for running on the ICL 2980/DAP or the ICL Perq/DAP. It is recognised that the software should also be portable to other computer configurations and to this end the team will ensure that the program for interpreting the SASL, developed in C, will not rely on any special features of the UNIX operating system.

5. Conclusions

In general the consortium approach to precompetitive research has greatly stimulated collaboration between the various firms and academic institutions involved. In particular as regards speech technology, although several of the projects are still at an early stage of development, interesting and useful results are beginning to emerge. This output will form the basis of a next generation of exploitable products that will keep the U.K. speech industry competitive on a world wide basis. Furthermore the spirit of cooperation engendered by the programme will enable the research community to move ahead in a more cohesive and integrated fashion to tackle the speech problems of the nineties.

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The author would like to acknowledge the advice and input of Dr John Holmes, formerly head of the Joint Speech Research Unit and now a private speech technology consultant to various bodies including the Alvey Directorate.

Appendix

Project 001 University of Sussex

Project 009 GEC Research Ltd. (Hirst Laboratory) University College, London
Imperial College, London
Plessey, Roke Manor
University of Leeds

Project 052 University of Sheffield

Project 053 University of Leeds

Project 054 Sindex Speech Technology
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University College, London

Project 006 Plessey-UK Ltd (Roke Manor)
University of Edinburgh
Husat Research Group, Loughborough
Imperial College, London

6th Symposium of the Federation of Acoustical Societies of Europe

Sopron, Hungary 2nd to 6th September, 1986

THE 6th FASE SYMPOSIUM was held in the Ferenc Liszt Cultural Centre from the 2nd to 6th of September 1986 in Sopron, north-west Hungary, a town seemingly filled with road works and school children. The subject of the Symposium was "Subjective Evaluation of Objective Acoustic Phenomena". There were 65 papers, in all three of the Official Languages, English, French and German, and six Invited Papers. They were arranged in 10 Sessions and a Poster Session. 128 delegates attended from 24 countries.

Overall, the Symposium was very well organised, everything went smoothly, after the slow Registration, and delegates were notified of programme changes as quickly as could be expected. The Organising Committee, under the Presidency of Professor Tarnóczy, is to be congratulated. Apart from the Plenary Invited Papers, meetings took place in two parallel sessions in rooms conveniently close to each other. The domestic arrangements were no less well handled: we were accommodated in the three star Hotel Lövér, about 2 km from the Cultural Centre. To avoid excessive travelling, we were given lunch in the nearby Hotel Pannónia every day. Meals were of a very acceptable quality, but three large ones every day were perhaps a little too much for those of us inclined to put on weight!

Formal proceedings began on the morning of the 3rd with a multilingual opening ceremony including welcomes from Prof. Tarnóczy and from Jószef Markó the President of Sopron Town Council. During the course of these Introductions we learnt that about 80% of the Delegates understood German, 70% English, but only 40% French. One wonders how this information was obtained! We then had a very interesting overall survey of the field of the Symposium, including recent developments, from the President of FASE, Prof. Andrés Lara-Saenz from Spain. He also reminded us that no fewer than 12 of the 80 Authors had also been to the 12th ICA in Toronto, thus emphasising the high standard of the FASE meeting.

Space does not permit a review of all the papers I attended, leaving aside those I had to miss because of parallel sessions, so I will content myself with picking out some which interested me (in the order of their appearance). A book of all the abstracts is available now and the complete proceedings will be available by next summer.

Sessions on the first day were devoted mainly to speech and to timbre problems; I attended the latter and heard Tro, from Norway, describing his interesting perception experiments using longer samples than customary; he finds that there are unexpected differences of dynamic range perception between the sexes. Miśkiewicz from Poland next described listeners' reliability in timbre measurements in an extension of work on sensory dissonance continued so thoroughly in Warsaw. Naylor from Scotland showed that MTF measurements seem to be a powerful way of predicting audibility between musicians, and Melka and his colleagues talked about their continuing work on the objective and subjective determination of the tone quality of trombones. Gabrielsson from Sweden told us about applying multidimensional scaling to the assessment of sound reproducing systems, and Zera from Poland described how phase deviations in harmonic complexes seem to be more audible than the literature leads one to expect. Finally, in this session Weiss from Canada showed that a speaker's voice effort in response to disturbing noise depends upon which ear is stimulated with the noise.

On the second day, we had the privilege of hearing Dr Brüel himself on the applications of RASTI, he mentioned particularly its usefulness in the growing problem of class room acoustics. RASTI was further discussed by Jacobsen of Denmark. I am sure, though, that the organisers will bear with me when I record that for me, the highlight of the day was the Excursion.

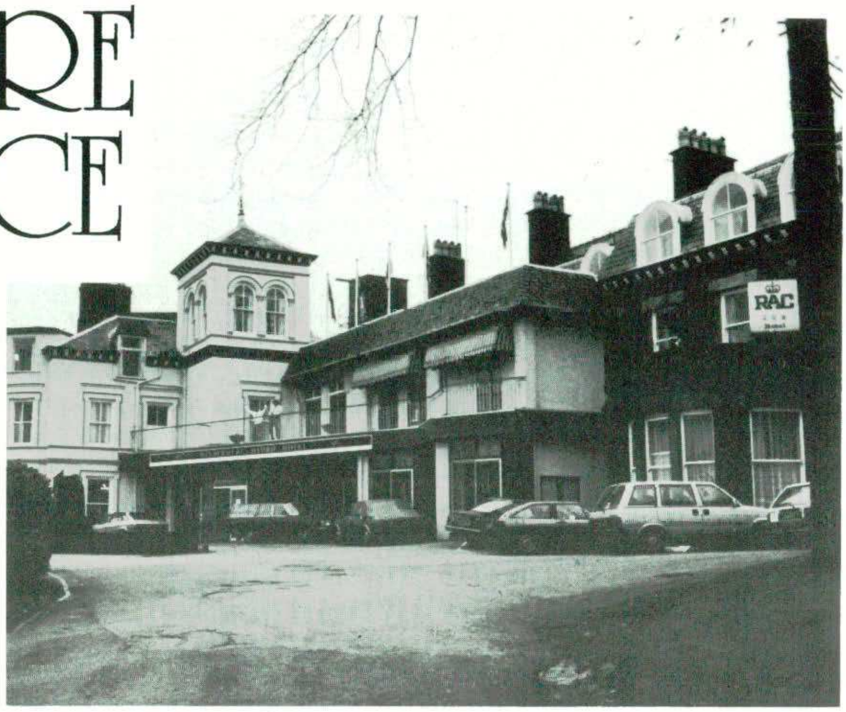
We went first to the former home of Count Széchenyi, now a museum and a splendid stud farm for thoroughbred horses. This visit was most appropriate in view of the four in hand World Championships just held in Windsor. After a short stop at a brand new Church where we were entertained by a vicar whose enthusiasm outstripped his singing skill, we went on to Fertöd, better known to us as Esterháza, where Haydn spent most of his working life. After a tour of the magnificent 18th Century residence, we settled in the famous concert hall and heard a recital of the very highest standard given on two cymbalums. It was a real ear-opener to those who associate the cymbalum with Hungarian restaurants; the two girl players displayed an exquisitely delicate *pp*, an attractively plangent *ff* and an amazing unanimity of rhythm and expression. They played three Scarlatti Sonatas, the Bach French Suite, a Haydn G major sonata, two remarkable pieces by Stravinsky (Waltz and Polka), and ended with Kolindák and Szonatina by Bartók. The beautiful room really brought home to one that music is not only acoustics; the visual aspect adds immensely to the overall ambience. Truly a concert to write home about!

At the last full day attendances fell somewhat, one talk I attended had only four listeners! Authors did not deserve this treatment and some of the work, from Romania and England, on the appropriateness of dB(A) as a measure of heavy vehicle noise seemed of considerable importance.

Overall, this was a most useful meeting to attend; there was a wide range of papers and delegates, and corridor discussions went on for many hours in the comfortable surroundings. The next meetings are next summer in Madrid and (a week later) Lisbon. □

J M Bowsher

WINDERMERE CONFERENCE



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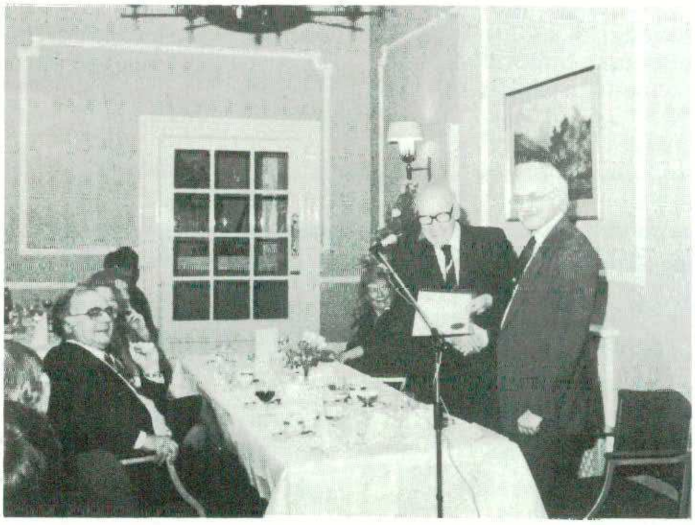

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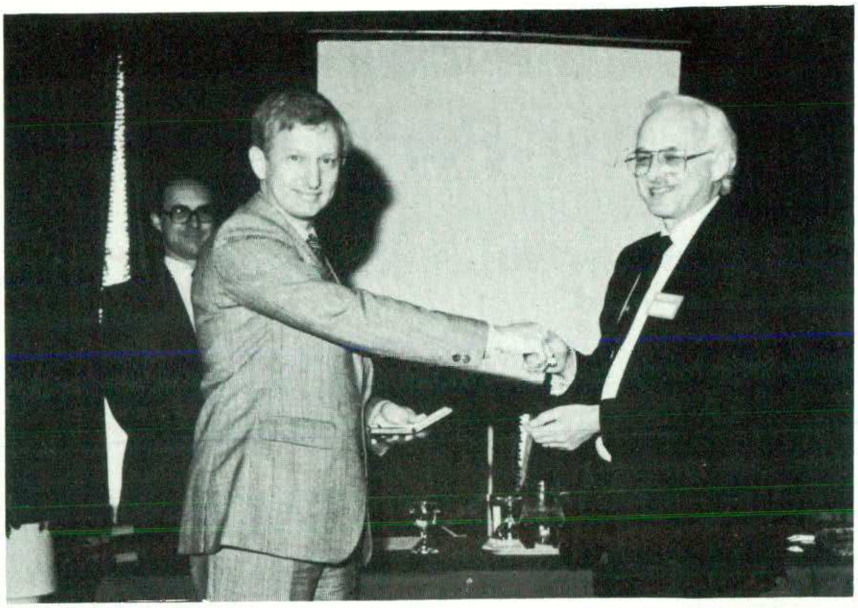


6

Reproduced Sound

WINDERMERE: 6-9 NOVEMBER 1986

Photographs by Mike Ankers.

1. We came to Windermere, to the **Hydro Hotel,** which lived up to its name — it rained outside *almost* all the time — but without the rain there would be no Lakes.

2. The captive audience inside hardly noticed the weather, so attentive were they and appreciative of the speakers during the sessions,

3. and, during the breaks, natural or otherwise, interested in the wide variety of hardware, software and salesware exhibited by our industrial and commercial supporters.

4. Coffee and tea breaks provided a welcome counterpoint to the formal sessions, some well-known figures being seen attempting to lend some additional stability to the corridor walls.

5. Even **Ken Dibble** (whose total contribution to the proceedings was nothing less than breathtaking) needed occasional lubrication and oral rest.

6. **Jeff Charles** receives the 1986 Tyndall Medal from **Geoff Leventhall,** following his lecture on "Acoustic Consultancy: Aural Craftsmanship with Scientific Pretensions"

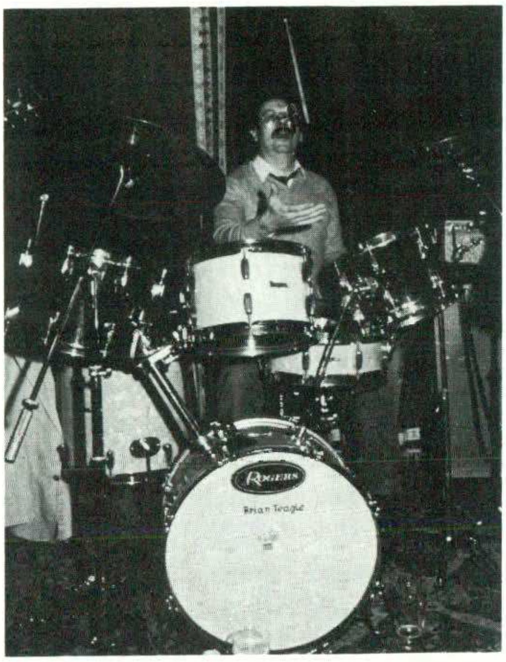
7. Eighty years young, but still remembering almost all of his (strictly business) encounters of the female kind during his long career in acoustics, **James Moir** is awarded an Honorary Fellowship after the banquet.

8. The staff looked after us attentively, although your correspondent found the odd unguarded moment. . .

9. Among the controllers and attenuators present, there were some generators, but no synthesisers; Ken is again high profile.

10. & 11. A surprising and spontaneous display of talent from people whose energies are normally directed into attempting to reduce the impact, if not the actual volume, of Reproduced Sound in the world outside this successful conference at Windermere.

10



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Noise from Paper in Computer Peripherals

Ian Carr
ISVR, Southampton

In a world where computers and office machinery are being progressively designed to be as quiet as possible, but where operating speeds are ever increasing, the noise radiated from paper being processed by such machines as line printers is becoming the limiting factor for quiet design. The Structures and Machinery Group at ISVR has been intermittently conducting a series of studies into the mechanisms by which paper noise is generated and radiated.

THE BEGINNING of our involvement with this subject was a meeting of one of the University's governing bodies in which Professor Elfyn Richards was participating. Being slightly hard of hearing, Professor Richards was having some difficulty in following the proceedings, and deduced that the problem was due in the main to the rustling noises coming from the many pieces of paper being handled by the other members at the meeting. His scientific interest was aroused, and he delegated one of his researchers to do some simple investigations into paper noise[1].

Probably the simplest experiment that can be done with paper is to rustle it with your fingers and listen. The noise generated clearly has high frequency elements and is somewhat random in time. Furthermore, the quality of the noise depends of paper type. In general, the thinner and apparently stiffer the paper, the noisier it can be, with humidity also being important. High quality computer paper seems to be one of the worst offenders, while at the other end of the scale it is impossible to coax tissue or crepe paper to generate rustling noises.

A freely hanging sheet of computer paper was then impacted by a metal ball, with a second metal ball placed behind the paper opposite to the first, to simulate a platen. When the platen ball was touching the paper, the noise from the impact was the same as for impacting spheres, apart from a 3 dB increase due to the baffle effect. As the platen ball was moved back from the paper, a second source of sound was noted, arising from the motion of the paper following the first contact. (Figure 1 shows this effect of varying clearances on the pressure time history close to the paper.) This second noise radiation began from the moment the paper was pulled, and seems random in nature and independent of the impact noise with the platen. This second source of noise developed, and by the time the clearance was large, had become the major source. A vibratory pattern was set up in the paper which radiated a random pattern of sound and which related more to the impact ball acting as a source of tension in the paper rather than establishing flexural waves as such.

When the platen ball was removed, the sound pressure next to the paper behaved as in Figure 2, which also shows the experimental set up. The impact was much slower, without the acceleration noise pulse seen with the backing ball, but the high frequency pressure perturbations still occurred.

Laser Doppler velocity measurements taken on the paper show that the paper movements on and near to the impact area (without the platen ball) were relatively smooth, but that away from this position random patterns of vibration were detected very similar in nature to the aforementioned microphone measurements. After the impact, the

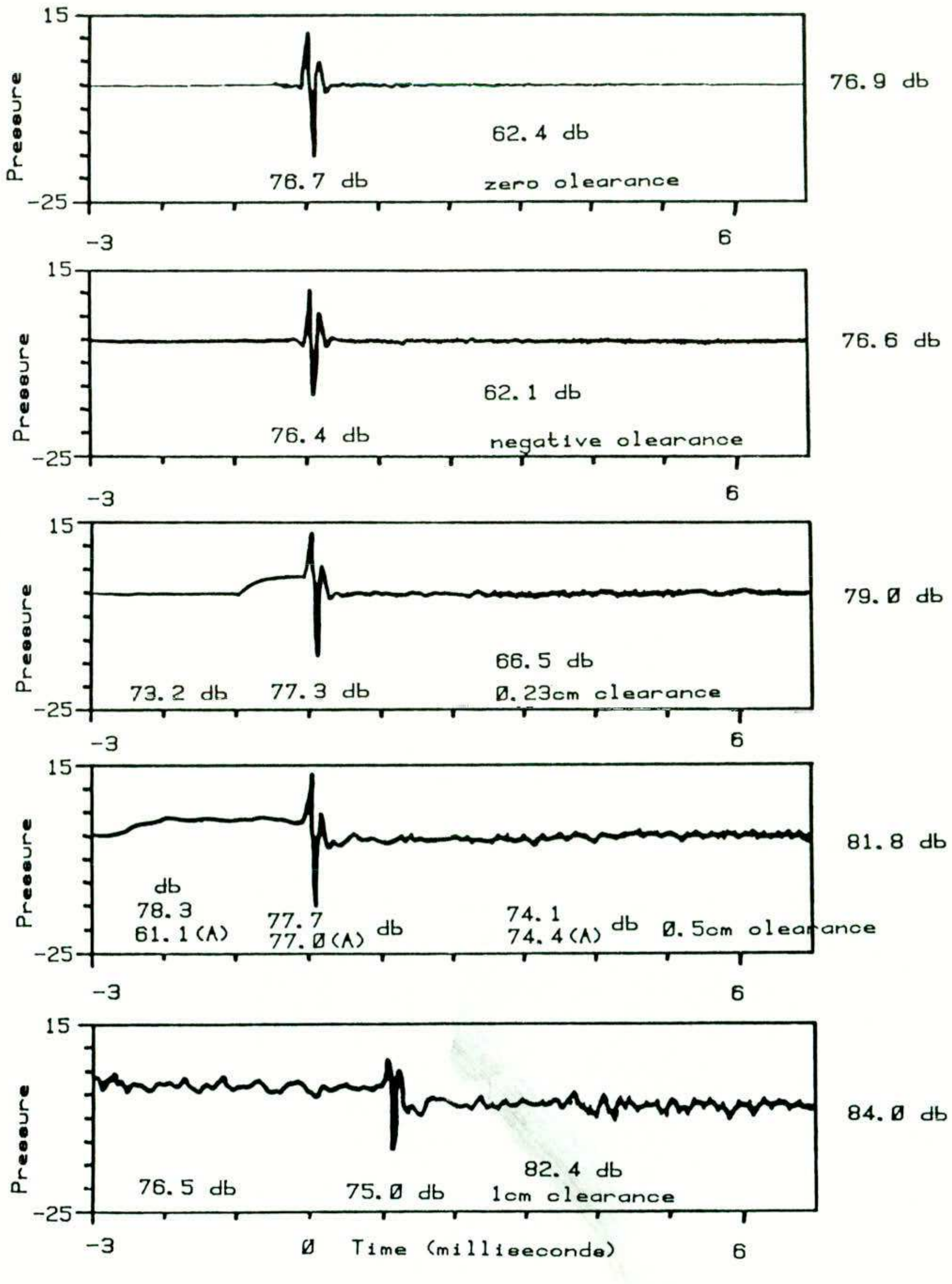

Figure 1 The effect of clearances between paper and backing ball

whole surface of the paper behaved in this manner with an exponential decay in vibration level. Frequency spectra showed that the paper had a low frequency movement at about 12 Hz, but no clear resonance occurred above this frequency, the vibration spectral content being broadband and falling steadily 30 dB per decade, with some ill-defined peaks below 200 Hz.

Paper tension had very little effect in these experiments, other than slight reductions in overall vibration levels as the tension applied to one side of the paper was increased. The paper could be made to act as a membrane by very close control of tension along the whole edge of the paper, and then only for small sheets of paper. In these conditions, the random high frequency noise content disappeared, and the paper behaved rather like a drum skin. Simply treating the paper as a membrane could not explain these results.

The same experiments were done on crepe type tissue paper. As one would expect, this type of paper did not exhibit the random high frequency characteristics of the computer paper, although the low frequency component could be detected. Aluminium foil, however, did generate the high frequencies, which

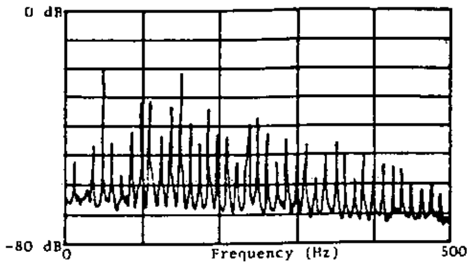

Figure 3a Drive point velocity 0.020 m/s

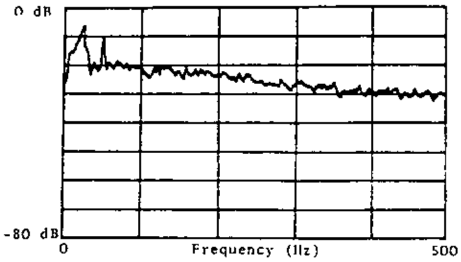

Figure 3b Drive point velocity 0.200 m/s

demonstrates that it is not the fibrous nature of paper which allows the paper to behave in this way.

At this stage, the existing theories into paper noise were investigated. Paper has stiffness and must therefore be expected to vibrate in a manner associated with flat plate bending theory. Busch-Visniac and Lyon[2] used this theory to describe paper vibration. Work at ISVR continued with an investigation into the effect of amplitude on paper noise and vibration. Smith[3] discovered that when paper amplitudes are small, i.e., below the thickness of the paper, resonant modes can develop with very low frequencies. For instance, the modes on typical print-out paper can be listed as (1,1) 2 Hz, (10,10) 230 Hz and (50,50) 5820 Hz. Thus there are a possible one hundred modes below 230 Hz and 2500 modes below 6000 Hz. Many of these modes were seen experimentally (Fig 3a) and the noise radiated agreed with Busch-Visniac and Lyon. However these amplitudes were extremely low and no audible noise occurred. When the amplitude was increased tenfold to more realistic levels a change occurred, with the clearly defined resonances being replaced by the now familiar apparently random noise spectrum (Fig 3b). The rate of increase of noise with increase in velocity of excitation exceeded the rate of 6 dB per doubling proposed by the theory, although the noise radiated was not affected by the frequency of excitation (Fig 4). The radiation efficiency of the paper was also shown to be high (although below unity) at high frequencies at the higher vibrational amplitudes.

At that stage it appeared that with finite amplitude waves (defined as being

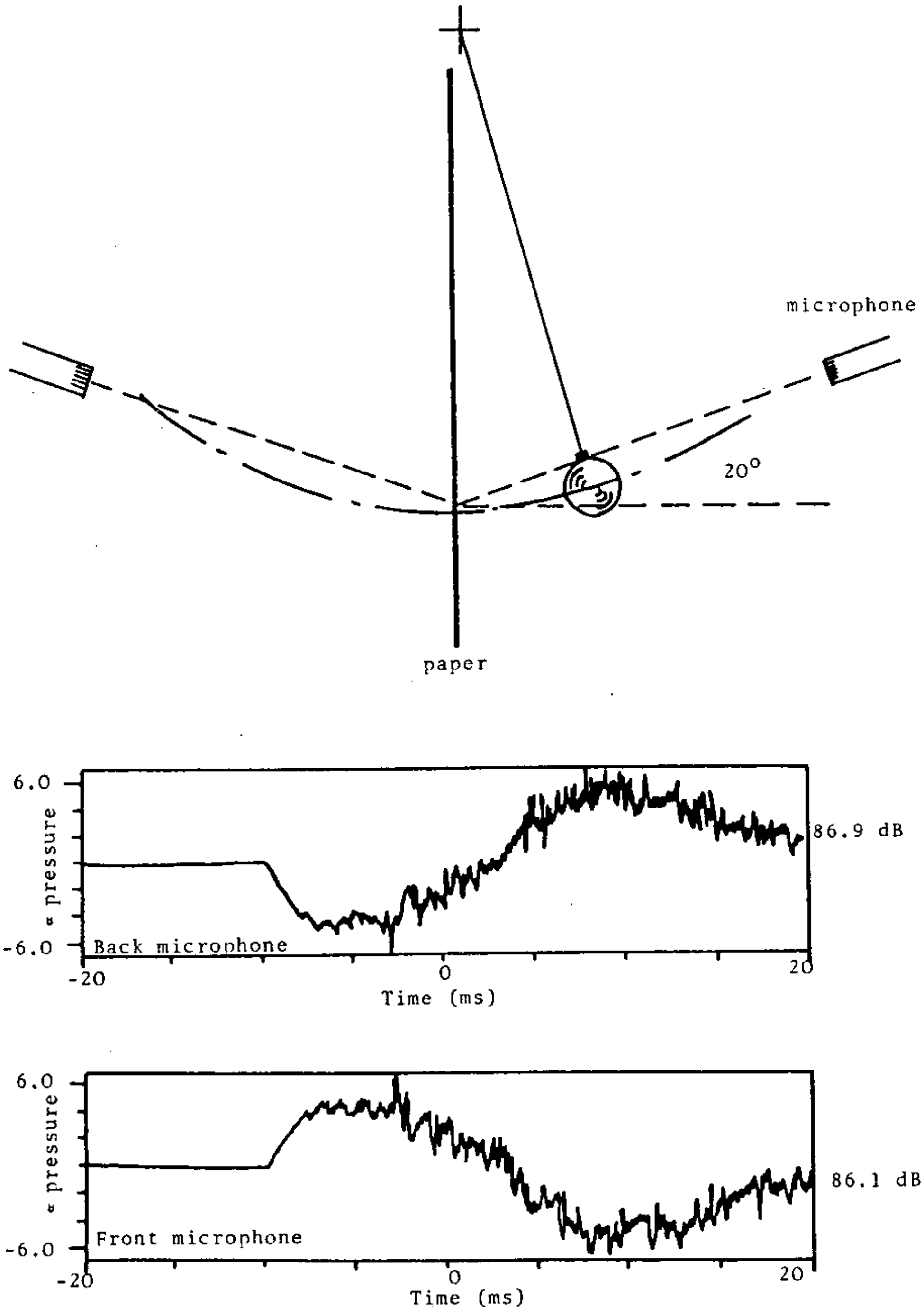

Figure 2 Impact of ball on paper — no backing ball

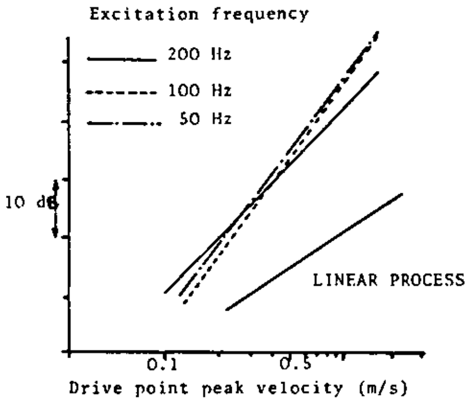

Figure 4a   Noise at 2750 Hz versus drive point velocity

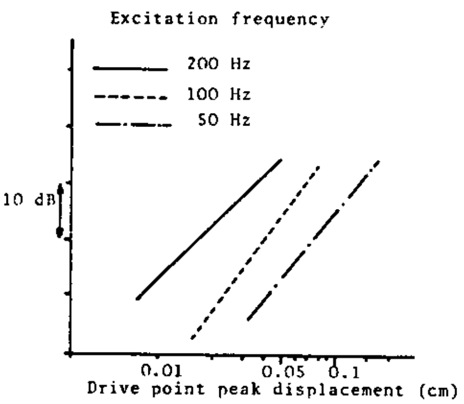

Figure 4b   Noise at 2750 Hz versus drive point displacement

greater than the thickness of the paper) much faster longitudinal waves begin to dominate the energy transfer process across the paper, and give rise to the dominating noise radiated from the paper.

Such tension dominating sound mechanisms are nearer in concept to acceleration noise[4], the non-resonant broadband noise produced by, for instance, the clashing of two billiard balls. The collapse mechanism of initially non-flat surfaces postulated by Dowling[5] also appears consistent with these observations. Dowling assumes that paper is initially bulged, and that longitudinal tension in the paper pulls the surface flat. The speed and collapse of the bulge is determined by the speed of longitudinal waves and the distance that must be pulled to flatten the bulge. The longitudinal speed of the waves is high and the radiation efficiency over the bulge area can be assumed to be unity. Small amplitudes are not assumed, the transient sound from each small vibrating element being treated as a piston as in loudspeaker theory.

Paper impact noise is important in such devices as dot matrix printers where the paper is impacted to generate high instantaneous pressure either to deposit ink on to the paper or to break ink capsules within the paper. As the quality of printing is closely related to the sharpness of the impact, quietening the machine by softening the impact is probably unsatisfactory, and is unlikely to affect the noise from the paper. These impacts also generate structural noise from the printer and as it becomes clear that quietness is a desirable selling point, manufacturers are moving towards non-impact printing systems using, for instance, ink jets. It is probably true that the problem of paper impact noise will disappear as printing methods change.

A second way in which paper noise can be generated is simply by the movement of paper as it is transported through a printing machine. Noise levels close to the recommended maximum can be generated by paper within the transport mechanisms of a high speed line printer when paper is moving but not being printed. The paper not only moves rapidly, but is subjected to high acceleration and deceleration levels when printing occurs as it has to be stationary when a line is being printed but has to move to the next line as quickly as possible. Speeds of up to 2000 lines per minute are not uncommon and the paper is subjected to several sharp tugs each second, each of which can be considered as a noise generating event cumulating to high L_{eq} readings. Thus, as operating speeds increase, the problem of paper noise increases.

Paper does not have to be tugged or impacted to generate noise. It is very easy to generate considerable high frequency noise by holding a piece of A4 sized paper at one corner and waving it at less than 5 Hz. When a wide continuous sheet of computer paper is passed through a transport mechanism as smoothly as possible with a high velocity and no significant acceleration at the drive point, and the paper has substantial unsupported areas, high noise levels are generated. Development of quiet printers with smooth paper drive systems (where possible) will not make paper noise go away, and higher speeds mean more paper noise. Therefore, more fundamental research work is needed into the noise generating mechanisms within paper, which should lead to means of noise reduction by inhibiting these mechanisms.

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4. E J Richards, M E Westcott and R K Jeyapalan 1979 *On the prediction of impact noise, I: Acceleration Noise.* Journal of Sound and Vibration 62(4), 547-575.

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6. E J Richards and N Lalor 1985 *On the noise radiated from paper.* Proc. Internoise '85.

New Elections

At its meeting on 2 October 1986 Council approved the following elections to corporate and non-corporate membership.

Fellow

R J Hawkes	Dr W W Lang	D J Oldham	

Member

R S Bleach	T Gould	A D Johnson	C J Shadle
N G Breitz	L Griffiths	A M McMillan	M J Tomlinson
L C Chow	J H Hamilton	R T Morrow	A D Wallis
R M Crossland	J R Howes	S A Ridler	J Westmoreland
J Frampton	N R Jarman	N C Sedgwick	

Associate

C F Au	J S Gibson	H A Jelvehi-McGhaddam	R Muir
R S Bloxham	J W Healy	B E Jones	M J Ryder
L Brookman	S A Heaton	A D Hart	C E Snow
D S Cunningham	S D Howells	S Khajeh	S Sivabavanandan
A Fallon	K-K Iu	D Markham	M L Wright

Student

I S Howard	K T Lambell	J McGowan	C P Stollery
R N Hunter	J R Mendies		

Sound Insulation of Buildings and Building Elements

One-day conference organised in collaboration with the Building Research Establishment at the Building Research Station, 4 December 1986

Noise Reduction of Dwellings Against Traffic Noise

W A Utley and J W Sargent
Building Research Establishment, Watford

While a considerable amount of laboratory data on window insulation has been published there is only limited data available on the noise reduction of windows in dwellings. This paper describes the results of measurements of noise insulation of dwellings against road traffic noise. The dwellings had a range of window types including single casement, replacement double glazing and double windows formed by adding a secondary inner pane. The advantages and disadvantages of the various single figure methods of describing noise insulation are considered. The extent to which the considerable quantity of laboratory data that is available may be used to predict field performance is discussed.

The Problems of Using Single Figure Indices to Describe the Acoustic Performance of Traditional and Newly Developed Windows

G Kerry (1) and C Inman (2)
(1) Salford University (2) Pilkington Flat Glass Ltd

A recently completed comprehensive test programme has been used to investigate the acoustic performance of traditional glazing and to develop new types of windows.

As new ideas are introduced the difficulties of accurately describing improvements or modifications in performance increase and single figure indices offer an attractive convenient alternative.

However selection merely on the basis of single figure indices can lead to ineffective installations and may also miss the opportunity to take advantage of recent developments in coating technology where special double glazing units can perform better, thermally, than triple glazing. Gas filling can improve the R_W index but characteristic low frequency resonances often negate this apparent advantage over air filled units of lower R_W.

This paper describes the acoustic performance of several types of recently introduced windows and considers the problems that can arise if such performance is described too briefly.

Sound Insulation of Pugged Floors in Renovated Tenement Dwellings

W N Hamilton and R McLaughlin
Glasgow College of Building and Printing Glasgow

This paper outlines the results of a field research project on sound insulation performance of timber floors in renovated tenements. The work was carried out by the Acoustics Group of Glasgow College of Building and Printing on behalf of CIRIA.

The research centred on progressive attempts in a live test bed situation to obtain a satisfactory solution within the existing floor depth and provides comparative performance of a variety of deafening (pugging) and resilient materials under the following conditions:

i) with the lath and plaster ceiling remaining intact;

ii) with a new plasterboard ceiling;

iii) with plasterboard plus a thin plywood structural membrane to take deafening directly on the ceiling;

iv) variations of above in a patch situation.

The results show that within the constraints of the test bed, considered typical of flats in Glasgow tenements, satisfactory performance of sound insulation can be achieved. Relative costs and practical advice for each construction is also considered.

The development of a sound absorbing flooring system

Robin K Mackenzie
Dept of Building, Heriot-Watt University, Edinburgh

The paper describes the development of a new design of floating raft construction for laying on top of concrete slab or timber joist structural floors. The specification comprises of chipboard flooring laid upon a timber batten to which a lamination of polyethylene and polyether foams are bonded to the underside. The specification differs from existing design by virtue of the fact that a lamination of polyether and polyethylene foam has been used instead of the more conventional single material layers. The open cell structure of the polyether foam provides sound absorption in the cavity which is not present in the case of closed cell polyethylene or polyurethane foams. Under dynamic loading e.g. footsteps, the deflection provided by the use of the new system results in a superior performance in terms of impact sound reduction compared with polyethylene or polyurethane foams. The development work involved in the system is described and results of comparative tests are given.

The sound insulation of plasterboard/mineral fibre laminates fixed to masonry walls

P E Jones
British Gypsum Ltd, East Leake, Leicestershire

Fixing plasterboard/mineral fibre laminates to a masonry wall is an attractive way of achieving increases in sound insulation (in addition to the thermal benefits). Several series of laboratory tests have been carried out in order to assess the effectiveness of such linings as remedial treatment to an existing wall or as part of a separating wall construction likely to meet the requirements of the Approved Document Part E. The level of the improvement in sound insulation is found to depend on the nature of the substrate and also whether the lining is applied to one side or both sides. Owing to the highly variable nature of masonry and blockwork ie. porosity, density and the actual configuration, then a wide variety of tests need to be undertaken in order to identify which masonry walls will prove the most amenable to this type of lining.

Finally, the results of some site measurements are presented.

Laboratory measurements of the sound insulation of building elements including flanking

R Clough
Wimpey Laboratories Ltd, Hayes, Middlesex

The sound insulation of building elements for use as party walls may be measured in a standard laboratory transmission suite. However it is well known that the sound insulation in an actual building can be much lower due to flanking transmission. The paper describes an acoustic test chamber facility which can test party wall or party floor building elements together with their associated flanking structure. The design of the chamber is discussed; the results from the chamber are compared with field results and a recent programme of testing for the Cement and Concrete Association is described.

The effect of leakage on the sound insulation of plasterboard constructions

P Royle
British Gypsum Ltd, East Leake, Leicestershire

A laboratory test on a plasterboard partition or timber joist floor will normally represent the fully sealed state ie. no leakage around the perimeter. However, in practise, this state will not usually be achieved owing to either specification or construction shortcomings. This paper looks at some results from tests on constructions with various forms of leakage. One type of leakage can be described as "line of sight leakage" such as an unsealed base track ie. the base track was simply placed on the ground with no further sealing treatment and then boarded out. A second type of leakage can be described as "cavity leakage" where a construction comprises two leaves of material separated by studs or joists and one or both leaves are not fully sealed. Sound can enter the cavity of the construction and the effect on the sound insulation spectrum is different in nature to the effect of "line of sight leakage".

Finally, the effect of fixing timber skirtings to an inadequately sealed partition is shown and also the results of using back-to-back electrical sockets are discussed.

A Guide to Flanking Transmission
Robert J M Craik

Department of Building, Heriot-Watt University, Edinburgh

Flanking transmission is often the cause of poor sound insulation in buildings but despite the many studies that have been carried out into flanking transmission it is still usually difficult to calculate the effect of flanking transmission on the overall transmission of sound between two rooms.

Fortunately, there are some very simple equations which can be used for the most common situation of flanking past a party wall. An examination of these equations shows which parameters will effect flanking transmission and which do not and can hence give some insight into flanking transmission.

It can be shown that for flanking transmission past a party wall the difference between the noise reduction of the direct path and the noise reduction of the flanking paths will be a constant and independent of frequency.

It can be shown that the area of the flanking walls have no effect on the magnitude of the flanking path and that the only dimension that is important is the length of the structural connection of the two flanking walls. This kind of information can be very useful for a designer faced with a potential flanking problem.

Measurement of Flanking Transmission between Dwellings

Tina Carmen and L C Fothergill
Building Research Establishment, Watford

Flanking transmission is a general term which covers sound transmission between rooms by paths other than the direct path through a party wall or floor. The problem has been recognised for many years but has recently become more important because the need to improve thermal performance has led to the introduction of lightweight materials which, in some cases, have imposed a limitation on sound insulation.

When planning remedial treatment or evaluating a new design it is important to be able to compare the contributions of the various transmission paths so that modifications can be made in the most cost effective way. In the Paper ways of measuring flanking transmission by the accelerometer method and by direct measurement of sound intensity are discussed. Results obtained by the sound intensity method are presented.

Reduction of Noise Nuisances from Neighbours Footsteps on Stairs and Slammed Doors

J E Savage and L C Fothergill
Building Research Station, Watford

The problems of people being disturbed by noise from neighbours using stairs and slamming doors in attached dwellings were identified as particular aspects of sound insulation needing research in a Social Survey conducted by the Building Research Establishment a few years ago. This paper reviews the findings of laboratory studies of the two problems and a field investigation of noise from slammed doors.

The laboratory study of stairs examined the effects of isolating the staircase from the building structure, repositioning the staircase within the dwelling and overlaying the treads with resilient materials. The effectiveness of soft coverings in reducing noise from impacts on a floor on the other side of the party wall was also investigated as an adjunct to the project. For doors the effects of door closing speed and buffers fitted to the door frame were examined in the laboratory. The field study of slamming doors examined effects of party wall plus partition wall construction and room layout as effecting door location together with junctions and bends in the wall.

Simple additions to both stair treads and door frames that were effective in attenuating the noise were found and are described.

Effectiveness of Party-Wall sound insulation against airborne and impact noise from stairwells and corridors in newly converted dwellings

J Anani, A Peyvandi, J Roberts and M Vuillermoz
Polytechnic of the South Bank, Borough Road, London

The British Standard Code of Practice, CP3: Chapter III: Part 2, 1972 'Sound Insulation and Noise Reduction' classifies the Standard of Structural Insulation between a flat or maisonette and a main flight or stairs or corridor in terms of Airborne Sound Insulation only. Impact Sound Insulation is considered only for those floors of common approach, balconies or corridors which are directly *over* living accommodation.

There are neither standard test procedures nor agreed criteria presently available for Airborne and Impact Noise generated within stairwells and corridors, especially for those adjacent to living rooms and bedrooms. The paper reports surveys using a Standard Tapping Machine in stairwells and shows that structures which appear, or may be deemed, to meet the higher Grade 1 standard when compared to CP3 do not necessarily give sufficient insulation to avoid noise nuisance in the relevant rooms.

It is concluded that on the basis of the present evidence, even for those buildings meeting the highest of present standards the occupants of dwellings whose living rooms and bedrooms are adjacent to stairwells and corridors are likely to be annoyed by noise generated from normal day to day use within them.

Speech Technology

This European Conference is being organised by CEP Consultants Ltd on behalf of the Centre for Speech Technology Research at the University of Edinburgh and the Institute of Acoustics is acting as co-sponsor. The themes for the conference, to be held in Edinburgh from 2 to 4 September 1987, are:

Major Speech Technologies:

1. Speech Signal Processing
2. Automatic Speech Recognition and Understanding Systems
3. Automatic Text-to-Speech Synthesis Systems
4. Automatic Speaker Identification and Verification
5. Speech Waveform Coding
6. Machine Translation
7. Ergonomic Human Factors in Speech Technology

Major Application Areas in Speech Technology

1. Telecommunications
2. Office Automation
3. Defence, Avionics and Aerospace
4. Education
5. Process Control
6. Consumer Products
7. Medical Applications
8. Access Control

Further details are available from CEP Consultants Ltd, 26 Albany Street, Edinburgh EH1 3QH Tel: 031-557-2478

Recent Advances in Structural Dynamics

The ISVR is arranging a third international conference on this topic at Southampton University from 18 to 22 July 1988.

Papers are invited on any aspect of Structural Dynamics from any branch of Engineering, including structural/acoustic and structure/fluid problems. Abstracts of approximately 500 words (two copies) should be submitted by 29 May 1987. Accepted papers of up to 10 pages will be required by 13 November 1987.

Abstracts and requests for further information should be sent to:

Dr M Petyt, ISVR, The University, Southampton SO9 5NH, England. Tel: 0703-559122, ext. 2344/2310. □

Current Research in Ultrasonics and Physical Acoustics

Physical Acoustics Group Meeting, 25 September 1986

This, now traditional, annual meeting of the Physical Acoustics Group was held at University College London. It has been the custom of the Group for one of the centres which are active in various areas of Physical Acoustics to host this meeting and to provide a major part of the programme. At this meeting half of the contributions presented were from workers at University College.

Several papers were presented on various aspects of ultrasonic wave scattering which are of importance in the development of non-destructive evaluation techniques. P Smith (UCL) discussed the problem of utilizing ultrasonic scattering data to reduce the nature of the scattering object in a medium which is viscoelastic. L J Bond (UCL) reported a recent advance in overcoming the zero-of-time problem which has led to some controversy over the application of 1-D Born Inversion techniques for sizing defects. M Punjani and L J Bond (UCL) discussed the phenomena which occur when an ultrasonic wave is scattered by a partially closed crack. The natural occurance of partially closed cracks in solids poses a major obstacle to the reliance on ultrasonic techniques for the sizing and detection of cracks. M Plant (UCL) represented the College's close involvement in the development of the acoustic microscope with a new analysis of the propagation of surface waves at the interface between the coupling fluid and the sample being investigated.

E Aristodemou (British Geological Survey, Edinburgh) demonstrated that seismologists and those engaged in ultrasonic testing have much in common by relating results obtained for wave propagation and scattering at a welded quater space to seismic data. All users of ultrasonics have an interest in transducers which made J Engelbrecht's (visiting the University of Surrey) analysis of linear and non-linear fields in the near field of an ultrasonic transducer particularly appropriate to a meeting of this kind. P J King (University of Nottingham) reported low temperature ultrasonic attenuation evidence of three distinct loss phenomena associated with vanadium centres in doped GaAs. A McKie (University of Hull) described laser generation and detection of ultrasound and a system which is now being used for making ultrasonic measurements of solids at high temperatures. The potential of this system was demonstrated by detailed measurements of the temperature dependence of the velocity of sound in mild steel at temperatures in excess of 800°C.

The meeting was attended by about 30 participants and will be remembered both for the high quality of the contributions and the lively constructive discussions that followed. The AGM of the Physical Acoustics Group was also held during the meeting. □

Dr D P Almond

ROYAL COLLEGE OF MUSIC

The Britten Opera Theatre

This new specially designed students' opera theatre, opened by Her Majesty the Queen on 5 Nov, has been constructed within one of the internal courtyards of the Royal College of Music behind the main College building designed by Sir Arthur Blomfield in 1892.

In designing the acoustics **ARUP ACOUSTICS'** principle aim was to provide an intimate and powerful acoustic, which would not over-flatter student performances, and which would be sufficiently analytical for teaching purposes.

Following a study of the acoustics of the reverberation times within the world's leading opera houses, a mid-frequency reverberation time target of 1.25s (fully occupied) was chosen as most appropriate to train singers and musicians in the art of opera. The achieved reverberation time, 1.2s full, is satisfyingly close to the design target.

The compact size of the auditorium is helpful in achieving a powerful sound and intimate acoustic. Objective and subjective tests have also shown that the auditorium is suitable for occasional speech use.

Control of ventilation noise posed particular problems for the design team, given that the main plant was located immediately below the rear stalls. A criterion of NR20 was set up and levels between NR19 and NR22 have been achieved generally.

The theatre has been fully wired both to accommodate the foreseeable uses of sound equipment in future opera productions and to provide the most up to date studio recording facilities.

Further information may be obtained from Rob Harris, ARUP ACOUSTICS, Radley House, St Cross Road, Winchester SO23 9HX

(Editor's note: I attended one of the rehearsals for the opening performances and confirm that the acoustic was superb in a delightfully intimate theatre.)

A Celebration

ISTITUTO DI ACUSTICA "O.M. CORBINO", 50th ANNIVERSARY CELEBRATION, ROME, ITALY, 28-30 APRIL 1987.

The "Istituto di Acustica O.M. Corbino" of the Italian National Research Council will celebrate its Fiftieth Anniversary with a 3 day meeting (28-30 April 1987) in Rome, Italy.

Several invited speakers will review the state of the art and future trends of different topics in Acoustics. A tentative list of subjects includes Ultrasonics, Quantum Acoustics, Noise, Architectural Acoustics, Acoustic Signal Processing, Speech and Transduction.

A Symposium on the work of O.M. Corbino, founder of the Institute, will be organized on the first day jointly with the Department of Physics of the University of Roma.

For further information please contact Dr P.E. Giua, Director, Istituto di Acustica Via Cassia 1216, 00189 Roma, Italy; tel. +6-3765757-.□

The Pipe Organ

David Walters

". . . A Damned Kist o' Whistles"

Sir Christopher Wren's celebrated comment on the proposed size of the organ case to be erected in his new St. Paul's Cathedral is unhappily typical of some architects' dismissive attitude to the organ. But the organ has an ancestry stretching back much further than the 17th century, for, apart from the human voice, it is the most ancient of all musical instruments existing today. Ctesibios of Alexandra is credited with its introduction in the third century BC. His instrument, the Hydraulos, maintained a nominally constant wind pressure to its pipes by the displacement of water in a reservoir in the base of the instrument, hence the name. Although the existence of these instruments had been common knowledge for centuries from references in the literature, the precise details of their mechanism and layout was not understood until 1885 when a detailed terra cotta model of one was discovered in the ruins of Carthage. It looks surprisingly similar to a small chamber organ of today, having rows of pipes on the top, a keyboard for the player on one side and two bellows, or possibly pumps, for the wind supply on the other side.

The descendants of these instruments are with us today in vast profusion and they can concern acousticians at a number of levels: the acoustic designer of a concert hall has to deal with a sound source of large dimension, capable of emitting sound throughout the whole range of audible frequencies. Even when silent, its presence can affect the acoustic quality of the room since it contains many tuned resonators, which are liable to influence the reverberant behaviour of the room. At another level, the physics of organ pipes is a subject that has intrigued investigators since Mersenne and still holds some unresolved mysteries. The mysteries, it should be stated, are greater for those who are attempting to define the behaviour of organ pipes in rigorous scientific terms than they are for the craftsmen who make and voice them, using knowledge and skills handed down and developed over the centuries, and who know fairly precisely how to achieve the effects they desire.

After the somewhat crude instruments which came into use in the larger European churches and cathedrals in the middle ages, the organ probably reached its *artistic* plateau towards the end of the 17th century. By this time a typical instrument would contain two or three individual departments (really separate organs) each with its own keyboard or 'manual', with (at least on the European mainland) another department controlled by a pedal keyboard with a compass of a little over two octaves. Each department would consist of a wind-chest upon which there would be typically eight to twelve ranks of pipes, or 'stops'. Most stops would have one pipe for each note throughout the compass, and the pipes in the different ranks would differ from each other in material or shape to give differing qualities of tone. Some of these ranks will be at normal pitch: that is to say, if you press the middle C key, the pipe connected to the key will actually sound middle C. Others will sound at pitches an octave or two octaves higher or an octave lower. Yet others may sound at pitches other than these, but somewhere on the harmonic series, and some may consist of three or more pipes sounding higher harmonics simultaneously. It is this feature which gives the richness and sparkle to the full organ sound in a well conceived instrument. The pitch at which a rank sounds is customarily defined by the nominal length of the longest pipe in the rank. Thus an 8-foot stop sounds middle C when the middle C key is depressed, and higher-sounding ranks are defined as 4-foot, 2-foot and so on, and lower-sounding ones as 16-foot or 32-foot. Fig 1 shows a typical array of flue and reed pipes.

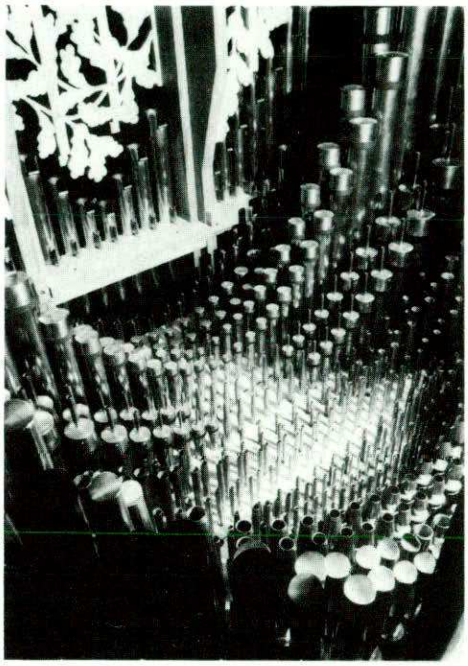


Figure 1 Impressive ranks

Each key on the keyboard would be connected to a valve in the wind-chest governing the admission of air to the pipes belonging to that note. This valve, or 'pallet', admits air to a groove below the pipes, running at right-angles to the ranks of pipes. Holes are bored upwards from these wind grooves to emerge from the upper boards of the wind-chest, and upon these holes the pipes stand. Thus the depressing of a key can cause the pipe for that note in every rank to sound. So that the organist may control which ranks are to sound and which remain silent, sliders are incorporated in the wind-chest between the wind-grooves and the upper boards, running underneath each rank. These are made to be moveable longitudinally by a small amount, so that the holes from the grooves to the pipes either run clear through, or are cut off by the slider. The movement of the sliders is controlled by simple mechanical linkages to the stop-knobs placed conveniently to the organist's hands (Fig 2). When one considers that

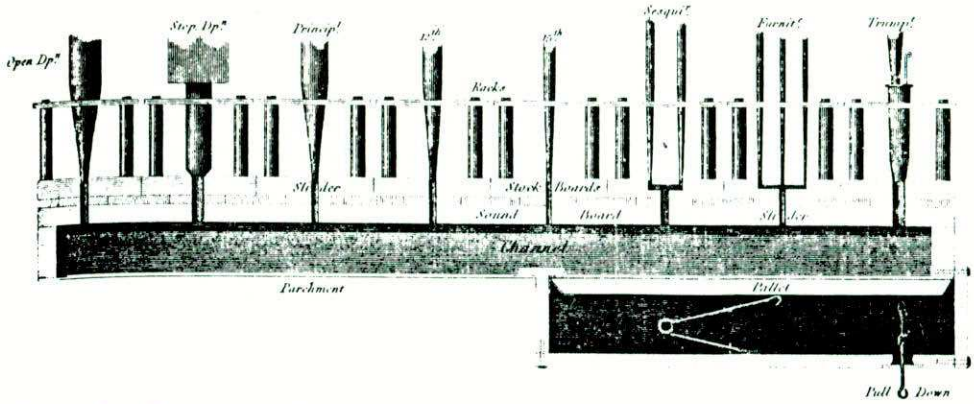


Figure 2 Control of air to pipes is by movement of sliders

this pneumatic machine was made almost entirely of wood, that it had to work sweetly and smoothly for an indefinite number of years and had to remain free from significant air leaks, it is obvious that these wind-chests are examples of precision timber engineering of a very high order indeed. This elegant but basically simple arrangement (Fig 3) represents the typical internal mechanism of an organ of the 18th century, though, of course, many variations in detail existed. The wind was supplied from bellows operated by human muscle-power, at a pressure characteristically in the range 50mm-80mm of water gauge. The whole instrument would be contained within a case, the best examples of which were fine specimens of architectural design and craftsmanship. The 18th century organ case also performed the acoustical function of modifying and projecting the sound.

The English organ of the late 18th century was characterised by sweetness, brightness and refinement of sound rather than by the massive tonalities of the 'mighty organ' of later times. Typically, the 18th century organ would have had one, two or three manual keyboards, but rarely a pedal keyboard, though this had been normal on the continent of Europe for at least two centuries. But all this was to change in the 19th century, with the shift towards Romanticism and in what might be called the sociology of music-making. Organs were required to have louder voices, and be capable of imitating the instruments of the orchestra. Cities did not yet have their city orchestras, but choral societies were coming into existence all over the country, whose staple diet was a repertoire of the great oratorios of the 18th century. With a chorus of several hundred voices, the performances were much more 'beefy' than anything envisaged by their composers. Without benefit of an accompanying orchestra, the organ was called upon to fulfill this role, and in many cities it was a matter of municipal pride to install in Town Hall or Assembly Room a fine, large organ to support the local choirs. Examples are William Hill's historic instrument in Birmingham Town Hall (1835), and Henry Willis' masterpiece in St. George's Hall, Liverpool (1855). The former instrument has very recently undergone a thorough overhaul and restoration, and the expenditure of a large sum of money on this much loved organ reflects great credit on the City Council. The present condition and future life expectancy of the Liverpool organ, however, must give cause for very serious misgivings.

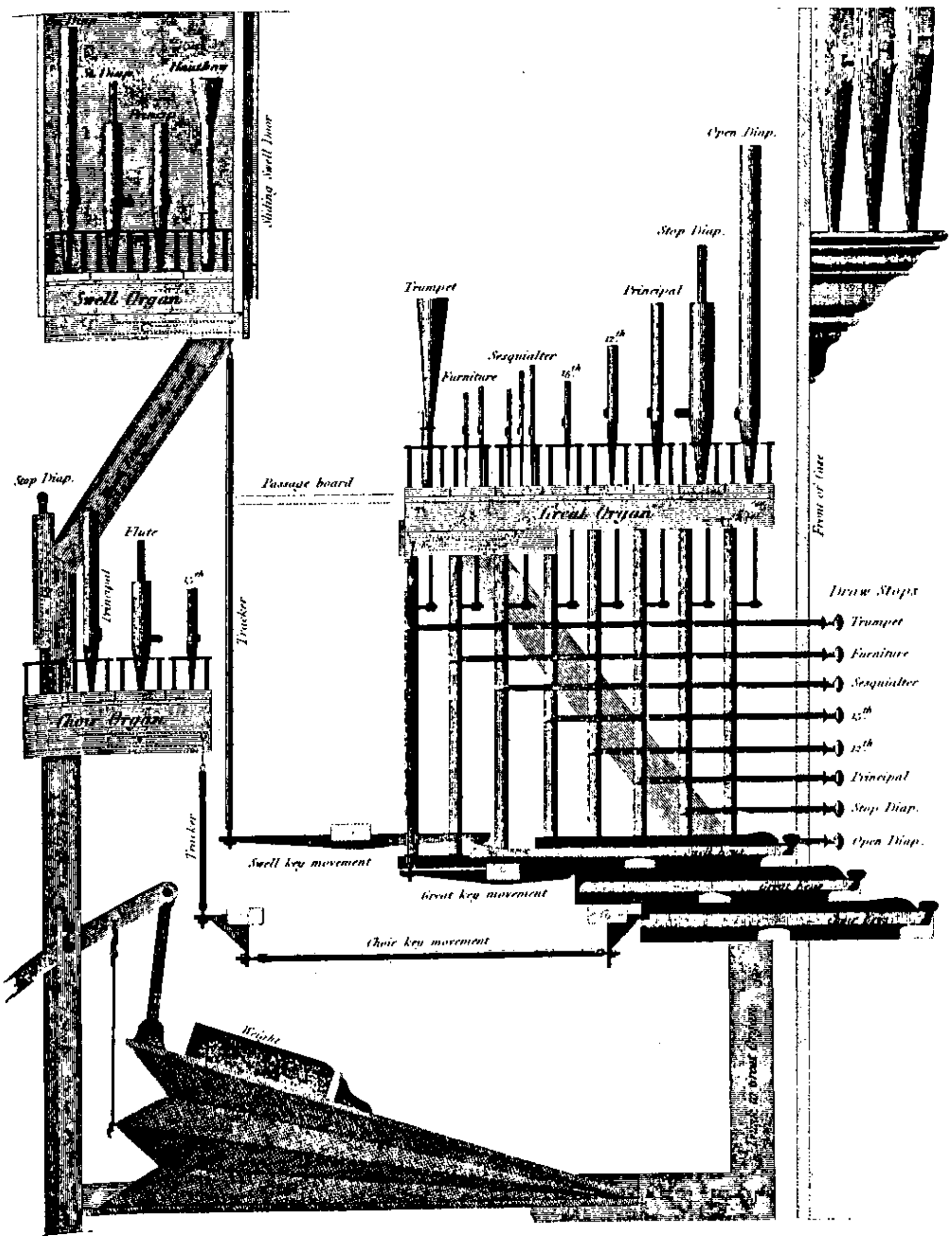


Figure 3 Internal mechanism of an organ of the 18th century

A new Local Government Officer made his appearance during this period — the City Organist, appointed to display his skills on the newly installed civic organ. Though admiring their prowess, it is hard to repress a patronising smile at their heroic transciptions of orchestral music, whilst leaving unexplored the vast repertoire of real organ music. But visits from symphony orchestras were rare occurrences in many places, and in this way the standard orchestral repertoire was introduced to audiences who would otherwise never have heard it.

All these changes had profound effects upon the internal mechanism of the organ. The increase in physical size meant that the mechanical connection between the keys and the pallets often had to be longer, more cumbersome and inertia-ridden; wind pressures were raised to enable pipe-voicers to produce the bigger sound that was called for, causing an increase in the force needed at the keys to open the pallets. The earliest successful means of reducing the load on the organist's fingers came about 1850, by the insertion of a pneumatic relay (called by its inventor 'the pneumatic lever'), somewhere in the mechanical action close to the keys.

Soon this was developed into 'tubular pneumatic action', in which a small pallet valve was actuated by the key lever itself, and was connected to a pneumatic mechanism at the wind-chest below the pallet by a length (sometimes a very long length) of lead tubing with a bore of about 5/16". Many of these pneumatic actions were examples of very fine craftsmanship, and quite a few survive in working order today. I imagine that an engineer working today in the field of pneumatics would be likely to raise a sceptical eyebrow if required to design a pneumatic transmission system, with a rapid response and capable of a high repetition rate, working on an air pressure of about 0.25 lbf/in^2. No doubt he would dismiss the whole notion as absurd if it were added that the system would be expected to have a reliable service life of about half a century!

With the developments in the use of electricity for such purposes as the electric telegraph in the latter half of the last century it was naturally not long before the principle was applied to organ actions. The key pallet was replaced by an electric contact which was connected to a magnetic valve at the wind-chest; the final movement of the pallet, however, continued at first to be effected pneumatically. Many organs built or rebuilt in the present century have actions which are developments and refinements of this system. In some instances, the availability of more powerful electro-magnets has enabled organbuilders to eliminate the final pneumatic stage, and operate the pallet itself electro-magnetically. Similar pneumatic, electro-pneumatic and direct electric actions have been developed to operate the sliders controlling the different ranks of pipes.

The methods used for producing an adequate supply of wind at a controlled pressure provide an interesting side light on the development of organ technology. In the early days of low wind pressures, the task was well within the capability of human muscle power, though for the larger instruments more than one man might be required to produce the necessary volume of air. Foot- or hand-operated 'feeder' bellows supplied wind to 'reservoir' bellows, weighted on their tops to give the desired pressure. In the nineteenth century, the requirements of the larger instruments with higher wind pressures demanded some form of mechanical power, to replace the flagging muscles of the human blower, and steam engines and gas engines were pressed into service, driving a crankshaft connected to the feeders by belts and pulleys. Control of the input of wind was crudely managed by a linkage from the reservoir which shifted the belt from a fast to a loose pulley as it became fully inflated. The reciprocating hydraulic engine was a rather more elegant solution where a reasonable water pressure was available in the public mains. This could be connected directly to the feeders, and the reservoir could control the output by being connected to the water supply valve. The earliest use of electric motors also involved the use of belt-driven crankshafts, though the rise and fall of the reservoir could now be made to control the motor's speed rheostatically.

Nowadays, the generally used method of raising the wind, in organs large and small, is by the centrifugal fan blower. The modern organ blower is a refined version of the industrial centrifugal fan, carefully designed and manufactured to give silent operation and a virtually constant pressure whatever the wind demand may be at any moment. The latter requirement has been met by refinements in rotor and blade tip design, which also ensure that no 'flutter' is superimposed on the wind stream by the blade passage frequency. Indeed, it is possible, in small organs where the blower can be sited close to the wind-chest, to eliminate the reservoir, with its pressure-controlling weights, by using one of the small constant-pressure blowers which provide a wind pressure which does not vary through the whole range of demand, from zero to the maximum rated output of the machine.

All the examples of mechanical ingenuity so far described have been developed for the sole purpose of enabling the player to cause the desired pipes to sound with as much promptness and facility as possible. Organ pipes, as is well known, belong to two main species, flue pipes and reed pipes, of which the former are usually the more numerous in any instrument. Fig 4 illustrates the form of a typical metal flue pipe, and also gives the standard names of the various parts. Organ pipe metal is usually an alloy of tin and lead, which can vary between about 10% and 98% of tin. The proportion of tin, besides affecting the mechanical strength of the finished pipe, has an effect on the tone produced, and is thus one of the variables which can be manipulated by the designer. The pipes are rolled up out of cast sheet, and soldered together (a job requiring considerable skill, since the melting point of the solder is very close to that of the metal being soldered). Wood is also used for certain classes of flue pipes, and so is copper, but more rarely.

In the tonal designing of an organ, the designer will have in his mind a clear idea of the sort of sound he wants each stop to produce, and so will decide upon some of the design variables before any pipes are made — the composition of the metal to be used, its thickness, the 'scale' of the pipes, the proportions of the mouths, and the wind pressure. From this information, the pipe-maker will make up all the pipes for each stop and pass them to the voicer. The voicer will cut each pipe down to its proper speaking length (the pipe-maker will have left them slightly over length) cut up the paper lip to give the correct proportions for the mouth opening, enlarge or make smaller the foot-hole to regulate the amount of wind admitted to the pipe and, by small adjustments to the upper lip and the width of the flue (the narrow slit between languid and lower lip), put each pipe on something like its proper speech. With all the pipes belonging to a particular stop thus treated and placed on his voicing machine (in effect, a small single-manual organ — see Fig 5), he will try them all through, for one of his objects is to make them all sound as though they were the different notes of a single

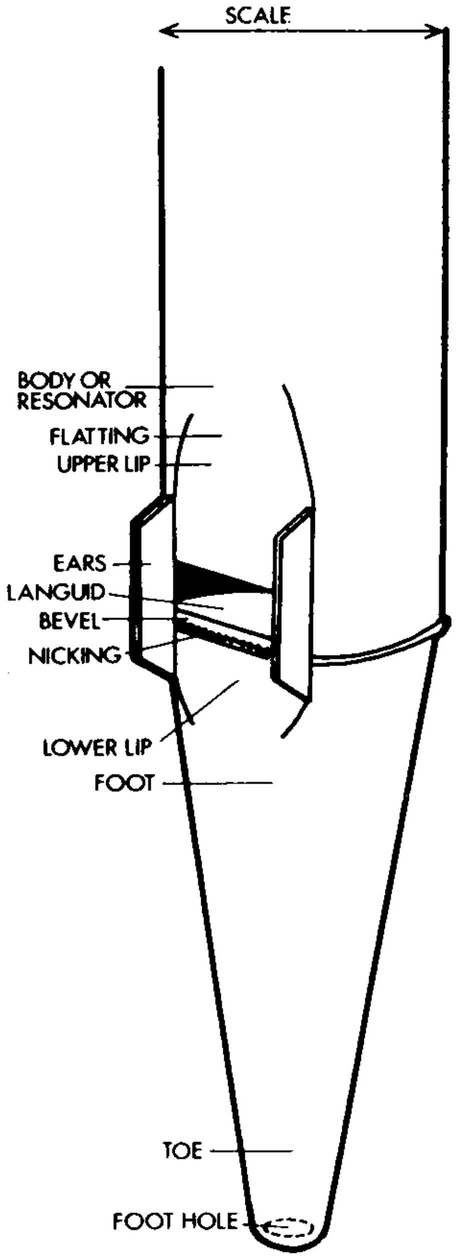


Figure 4 Typical metal flue pipe giving standard names of parts

instrument. The nicking applied to the edge of the languid of most flue pipes is another of the operations carried out during voicing; it has an effect on the initial transient behaviour of the pipe, making the wind stream more turbulent, and also cutting out any unmusical noisiness by producing a velocity gradient between the sheet of wind emerging from the flue, and the surrounding still air.

In general, pipes of narrow scale more readily produce a rich series of upper harmonics than wide scaled pipes, which more readily produce a more fundamental, 'flutey', tone. Directing the wind stream more into the pipe (by pulling out the upper lip or pressing down the languid) also tends to suppress upper harmonics, whilst the reverse process enhances them. Increasing the wind pressure develops the upper harmonics, increasing the cut-up of the upper lip reduces them. There are many other

Figure 5 Voicing machine — a small single manual organ

fine manipulations available to the pipe voicer, and it is clear that a great deal of the voicer's own experience, skill and personality is incorporated in the sound of the finished instrument at this stage. As well as making each separate stop into an integral musical instrument, in an organ of many stops, each must be voiced to make its own individual contribution, and to blend with its fellows into a musical whole. The voicer's task will not be completed until he makes these final fine adjustments to the whole of the pipework in the finished organ, where the acoustics will be far different from those in the voicing shop.

The transient behaviour of a pipe at the onset of the sound, and to a lesser extent at the end of the sound, has an important bearing on the perceived quality

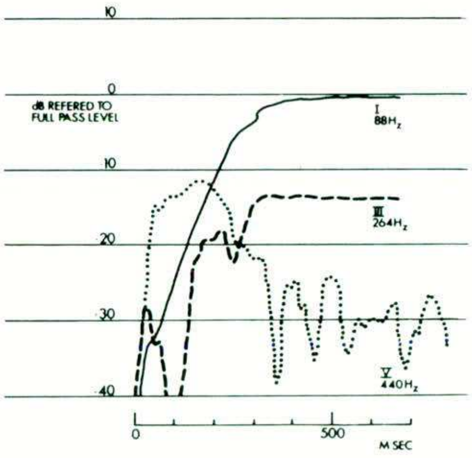


Figure 6 Illustration of starting transients of an organ pipe

of the sound, an assertion which can be readily verified by removing the starting transient from a recording of organ pipe sounds. The proper regulation of these transients is one of the matters which concern the pipe voicer. Fig 6 shows some aspects of the starting transient of an organ pipe. The measurement was made on a wooden pipe, stopped at the upper end, with a nominal note of FF (1½ octaves below middle C). Being a stopped pipe, its sound consists principally of the odd-numbered harmonics. It can be seen that, at the onset of the sound, and for the first 100 or so msec, it is the 5th harmonic which predominates, sounding the note A above middle C, and that it does not achieve its steady state condition until nearly half a second after the onset of speech. This is, of course, an example of a pipe which is in need of some attention to make it speak rather more promptly, but some such pattern of transient behaviour of organ pipes is quite typical, and, indeed, desirable, to give definition and character to the music.

The note sounded by a flue pipe is determined by the length of the air column within the resonator or pipe body. Exact tuning is effected by altering this length or modifying the end correction in one of a number of possible ways. The sound is maintained by the sheet of air issuing from the flue, which passes back and forth across the upper lip, being driven alternately into and outside the pipe by the frequency of the resonating air in the pipe body, rather in the manner of a reed. The 'air-reed' concept is adequate to describe the maintaining of the continuing sound of a flue pipe, but does not account for the initiation of the sound. It is likely that the air column is first excited into resonance by edge-tones developed at the upper lip of the pipe, and the initial transition from edge-tone mode to air-reed mode may account for the interesting transient behaviour of the pipe at the onset of speech.

In reed pipes it is the reed, rather than the resonator, which determines the note, the resonator playing the secondary role of re-inforcing the sound and modifying its quality. Fig 7 shows the general form of a typical reed pipe. The brass tongue vibrates against the open sided brass tube, or shallot. Tongue and shallot are fixed into the cast metal block and are encased in a socket into which the wind is introduced to set the tongue into vibration. The shallot is connected through the block to the resonator above. Tuning is effected by altering the vibrating length of the tongue with the tuning spring.

Resonators of reed pipes are usually made to the full speaking length of the note, though fractional lengths may also be used. A type of reed pipe in which the size of the resonator bears no obvious relationship to the note of the pipe, and which passed out of favour in the early 18th century, is now making its appearance in new instruments designed on classical lines. This is the 'regal' (a name which has no connections with royalty). The resonator of a regal pipe is small, and was sometimes of a bizarre shape. The sound, which varied from a strangulated buzzing to a loud snarl, is inclined to cause surprise at first hearing. They tended to be a little unstable in tuning, and for that reason they were often placed on their own wind-chest close to the organist, so that he could readily knock them back into tune when necessary.

The evolution of the organ over the centuries into its present form has been subject to many influences, such as changing fashions in music making, in liturgical usage and in the craft of organ

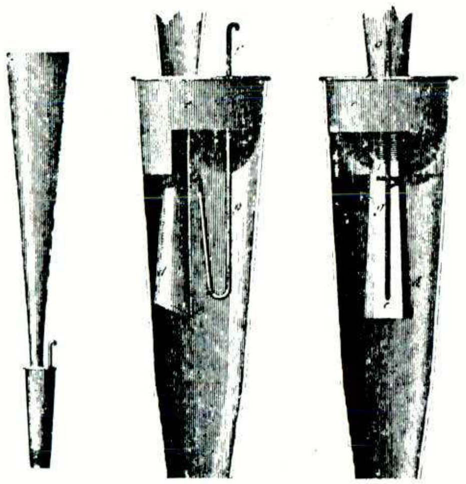


Figure 7 General form of a typical reed pipe

building itself. It also developed clearly differentiated regional characteristics. It is still a living craft and in 1985 British organ builders completed 62 new instruments of all sizes, ranging from the smallest, with but one manual keyboard and no pedals, with three stops, up to that with four manuals and 45 stops in the Albert Hall, Bolton.

What are the trends evident in organ building today? The great nineteenth century romantic organ, with its imitative orchestral effects is no longer to be found amongst the organs being built today. Instead we see a return to a simpler instrument, one that is content to be an organ rather than a 'one-man-band', one that is based on the classical principles of tonal design and can give (with larger instruments) a convincing account of the whole vast repertoire of organ music. Alongside this trend has come a significant return to mechanical key actions, instead of the former electric or electro-pneumatic actions. The direct mechanical connection between the player's fingers and the pallets which admit wind to the pipes enables the player to develop a more sensitive and 'musical' way of playing. For instance, he has control over the speed with which the pallets open, and can thus vary the starting transients of the pipes. In 1985, of the 62 new organs completed, 47 of them were built with mechanical actions, including the large 4-manual instrument in Bolton.

Over the past fifty years, 'electronic' organs have been developed as less expensive substitutes for the pipe organ. As a new kind of musical instrument they have proved useful and successful, though less so as exact imitators of the pipe organ. The type which most closely approaches the sound of the organ is that in which the wave-forms of actual organ pipe sounds are stored digitally, and also that in which spinning discs have the wave-form engraved on them, and from which the voltages to drive the amplifiers are produced electrostatically. There is also the question of relative longevity. After perhaps 20 years the factory-produced electronic organ will be an obsolete model, and replacement components will probably be no longer available. The pipe organ with mechanical action, if properly maintained and overhauled and cleaned every 30 or 40 years, will last for centuries, always retaining its value in cash, as well as aesthetic, terms. This is not a point of view unique to the present writer; to cull one final piece of information from the organ-building statistics for 1985 (for which I am indebted to the painstaking annual labours of Mr John Norman), in that year 22 new pipe organs were built as replacements of superannuated electronic instruments.□

Acknowledgements

The author gratefully acknowledges permission to use illustrations as follows:

Fig 1 from a photograph by Kenneth Ryder, organist of St Peter Mancroft. Figs 4 & 6 originally illustrated a paper by the author in the Journal of the Institute of Musical Instrument Technology, and are reproduced by permission of the Editor of that Journal. Fig 5 is reproduced with acknowledgement to Stephen Buckle, of F J Rogers Ltd, organ pipe makers, Leeds. Figs 2, 3 & 7 are reproduced from Rees' 'Cyclopaedia' (1818). The statistics of British organ building are compiled by John Norman and published annually in the journal 'The Organbuilder'.

BRANCH AND GROUP NEWS

Scottish Branch

Twenty members of the Scottish Branch visited the BBC Scotland studios at Queen Margaret Drive, Glasgow on 23 September 1986 and were given a most comprehensive tour of the radio and TV studios, as well as an insight into the range of BBC Scotland's work.

Members were interested to see the studios from which the highly popular 'Good morning, Scotland' radio programme emerged and were impressed by the computer-controlled routing of news from the various Scottish outstations and other UK studios. The facilities of the music recording studios and associated tape-editing equipment were also visited with short demonstrations on the mixer desk illustrating the power of the equipment.

The impressive new TV studios and beautifully renovated concert studio were also on the programme. An excerpt of digitally-recorded Mahler was played to the group as an example of the standards attained by the BBC. Several members had to be dragged away as they begged to hear more of the stunning recording!

The evening was completed with some excellent BBC coffee and appropriate words of thanks from our Branch Chairman Bill McTaggart to Trevor Sykes, BBC's engineering information officer in Glasgow, who had orchestrated the entire event most satisfactorily.

It is planned to hold the Branch AGM on Wednesday 21 January 1987 in Heriot-Watt University although the date is subject to confirmation. The AGM will be preceded by a technical meeting on various aspects of environmental noise and Branch members will be advised of the details in due course.

W Laurie

Physical Acoustics Group

The Physical Acoustics Group, of the Institutes of Physics and Acoustics, is to hold a meeting on Acoustic Microscopy and its Applications at Burlington House, Piccadilly, London W1 on 24th February 1987.

The meeting will follow the same pattern as developed at the Group's previous highly successful meeting on this topic providing an opportunity for the presentation of papers dealing with: new developments in the technique, applications, the performance of commercial instruments and new work in progress. Exhibition space is available for manufacturers of acoustic microscopes.

Registration forms and further details may be obtained from: The Meetings Officer, The Institute of Physics, 47 Belgrave Square, London SW1X 8QX.

Musical Acoustics Group

One day Seminar on The Modern Flute will be held at the Royal College of Music on 23 February 1987.

Organised by the Electroacoustic Music Association (EMAS) and the Musical Acoustics Group of the Institute of Acoustics (IOA) the programme will include the following sessions:

The flute: a historical perspective: Lewis Jones (Dept. of Musical Instrument Technology, London College of Furniture)

The structure of sound: Prof. Charles Taylor (IOA)

The Fairlight Computer Music Instrument: Javier Alvarez (EMAS)

Compositional techniques: Barry Anderson (EMAS)

Contemporary flute techniques: Pierre Yves Artaud (Director of Instrument Research, IRCAM, Paris); Katherine Lukas (Specialist in contemporary flute music)

with parallel sessions on:

Discussion on flute making led by Albert Cooper

Demonstration of Fairlight CMI

Open rehearsal for evening concert.

The day will finish with a concert including contemporary flute music.

Further details from Electroacoustic Music Association, 10 Stratford Place, London W1N 9AE and Institute of Acoustics Musical Acoustics Group, c/o Dr. J. Zarek, London College of Furniture, 41 Commercial Road, London E1 1LA.

Speech Group

Will members please note the new address of your Hon Secretary; this is

Dr. N M Brooke MOIA
School of Mathematical Sciences
University of Bath
Claverton Down
Bath BA2 7AY

North West Branch

Visit to the Leyland Technical Centre

On the last day in September branch members visited the Leyland Technical Centre near Preston. This is one of the most modern engineering laboratories in Europe and is dedicated to the

Letter from the Vice-President Groups and Branches

The Physical Acoustics Group, which is organised jointly with the Institute of Physics, has continued to develop since its conception 2 years ago and has a varied programme of meetings planned for the next year. Unfortunately, the Group appears joint in name only because despite considerable effort by myself and others the IOA has still no representative on the group committee although there is provision for a minimum of two in the draft constitution.

The Physicists running the group are naturally concerned about this and the bias that will naturally occur in meeting content. On their behalf I wish to appeal to the 40 plus members of the Institute who are members of that group to see if there is anybody who would like to play a more positive role in its organisation. A chance perhaps for a young person embarking on a career with a Physical acoustics bias, transducer design, materials development, crack detection etc., to meet others working in similar or complementary fields. If members would like more details please contact Cathy Mackenzie or myself or any member of the PAG committee.

I also wish to congratulate the Industrial Noise Group and the East Midlands Branch on organising the recent successful meeting on Noise and Vibration in the Aerospace Industry. I hope we can look forward to seeing more Branch and Group combined activities in the future.

Finally, I would like to thank Alison Hill for finding space in the Bulletin over the past seven years for items of news from Groups and Branches. Her delicate touch! i.e. written demand for copy to every Group and Branch secretary four times a year, has ensured that Institute members throughout the world know what's going on. Group and Branch Secretaries please don't wait for the new Editor to contact you, just continue to tell him what you have done, what you are doing and what you plan to do so that we will all know.□

Geoff Kerry

development of commercial vehicles of the highest quality. The purpose built facilities include a high speed circuit, braking straight, test hills, steering pad and noise strip. First hand experience was gained as we were driven around these facilities in a Leyland coach, this at times was more like flying than driving and provided good views of the site. Extensive noise and vibration testing is carried out and we were shown several vehicle pass-by tests to EEC requirements. We also watched vehicles under test on the durability tracks, driving alongside as they pounded over setts and concrete corrugations providing arduous conditions for accelerated life testing. In the laboratories, test track data is used on computer controlled rigs to provide 24 hour testing allowing the equivalent of many years normal service to be reduced to a few weeks. This was impressively illustrated in the test facility where a large truck was being driven hard by four computer controlled 250 kN electro-hydraulic actuators.

After touring the extensive laboratory facilities, including the huge semi-anechoic chamber there was time for coffee and questions. Mike Ankers rounded off this excellent visit by giving our thanks to the Leyland staff.

'Meet the IOA'

Over 40 undergraduates and NW branch members packed the Racecourse Hotel in Salford for this meeting. Geoff Kerry and Mike Ankers opened the proceedings illustrating the aims and structure of the IOA. Mike introduced the series of short presentations given by our invited speakers, Cliff Inman of Pilkington Glass, Mike Greenwood of Ferranti, Sue Ridler of AVT and Duncan Templeton of BDP. John Houldsworth of Brüel and Kjær and Geoff Coleman of CEL provided demonstration equipment for the evening. I would like to thank all those who supported this meeting in particular the guest speakers.

Thwaites Brewery

Branch members and their guests visited this Blackburn brewery to find out how fine beer is made. A short history of the brewery was given followed by an examination and tasting of the ingredients, malted barley, yeast and hops. The combined mixture is transformed into beer in large stainless steel vats. The tour ended in the small brewery museum where we each received a glass tankard and two cans of the final product. Following the tour we sampled the beer and food in the pub next door.

Chris Waites

IOA Diploma Examination 1986

The following candidates are to be congratulated on qualifying for the award of the Diploma in Acoustics and Noise Control.

North East Surrey College of Technology

P J Dennison	D R Stevens	K Harpur
J W Paterson	C A Wilson	J McGowan
S Blake	Miss G J Armstrong	R K Parkinson
P G Blake	Miss J C Bailey	M G Peters
I J Bollans	P T Bassett	M Pledger
B Bradley	D S Cunningham	J M Prince
A J Bride	M J Denwood	G A J Probert
R Halford	D W French	J R Pyke
Miss C A Harman	F C Goodall	P Rathbone
C R Hayes	B J Griffiths	L R Spearpoint
B R Johnson	D A Gunn	C R Stagg
A G Kemp	A Hargreaves	D I Torrance
Miss J E McCrae		

Liverpool Polytechnic

Mrs Y Shakur	D Markham	Miss E A Woloschin
A Gumbley		

Newcastle Upon Tyne Polytechnic

J P Lee	S Beamson	Mrs W Hardy
C Asadi	P A Coffin	A M Hurst
H B Thompson	L J Dodds	J P Jenkins
M R K Askew	M T Grant	J Shellam

Cornwall College of Further & Higher Education

D C Cook	G Charles	D J Spode
D M Worthington	J P Masters	

Leeds Polytechnic

D Bisson	P McDermott	A Rupkus

Tottenham College of Technology

G J Adams	N L Forster	M Sawyer
S P Owen	C J Grimwood	P R Sawyer
K Scannell	S B Hide	A Screeton
Miss M E Coleman	P H Lankester	J Sim
Mrs C A Dutton	A J Mitchell	J H Wilson
J G Fisher	J R Nolan	

Derbyshire College of Higher Education

R Pearce	N D Cooper	S Khajeh
R P Brailsford	E Davies	D Moore
K A Broughton	R M Ford	G Norman
J Chapman	S Hodgson	L Poultney
P Clayton	I C Keagle	A F Turton

Heriot-Watt University

G S Greenhill	A W M Somerville

IOA Diploma Examination 1986

The table of results shows some variation in the success pattern from previous years. This change is difficult to pinpoint but it may be due in part to a change in some of the examiners. The results are summarised as before.

The number of students sitting the examination was 433, higher than 1985 but still below the 1984 level of 503. The overall pass marks are very similar to previous years examinations although there is a considerable variation in the pass and merit ratio between colleges. The overall merits have increased by around 30% over last year. The project success rate is 75% of students submitted projects of acceptable standard.

Colchester Institute

S Bennett
G C Bouttell
K M Harvey
W G Kasprzok
M J Porter
S Rock
M J Smith
M G Stephenson
D G B Thomas
A G Tull

North Staffordshire Polytechnic

Mrs H A Hull
D Brassington
Miss L A Brookman
S G Houldroft
Miss P A McElhannan
A Montgomery
R Muirhead
J C Polden
E J Walker

University of Ulster

L Dargan
R W Lamont

Congratulations also go to the candidates listed below for obtaining passes in additional Specialist Modules in 1986.

North East Surrey College of Technology

R J Hossack
B Irving
N C Tappin
L Cronin
P G Gough
A J C Martin
M J Barrett
N J Barrett
I J Bollans
B R Johnson
D R Stevens

Liverpool Polytechnic

D A Logan
M I Redman
M A Carson
Mrs M C Merriot
C J Yates

Newcastle Upon Tyne Polytechnic

N C Rotheroe

Tottenham College of Technology

I D Chapman
S P Owen
F Robotham

Derbyshire College of Higher Education

L Smith

Heriot-Watt University

A W M Somerville

Material for the April issue of Acoustics Bulletin should reach J W Tyler at Pooh Corner, Chalkhouse Green, Reading, Berks RG4 9AG, no later than Tuesday 24 February.

INSTITUTE MEDALS 1988

Anyone wishing to put forward a name for consideration by the Medals and Awards Committee as a possible recipient of the Rayleigh, Tyndall or A B Wood Medal for 1988 should write in strict confidence to the President, enclosing a brief outline of achievements, etc, before the end of March. The 1988 Medals will all be awarded to UK citizens. □

THE SIMON ALPORT MEMORIAL PRIZE

The prize will be awarded by the Institute of Acoustics and has been donated by Cirrus Research Limited in memory of Simon Alport, a young engineer, whose career in acoustics was tragically cut short.

The prize of £250 will be awarded in early Spring of 1987 to the person who, in the opinion of the judges, has published the best recent paper describing work involving the use of computers in acoustics. Authors must be under the age of 28 years on the date of publication to be eligible. Papers with multiple authors will be considered. □

IOA Diploma Summary 1986

	General Module			Architectural Acoustics			Noise Control Engineering			Transportation Noise			Vibration Control			Law and Administration			Instrument. and Measurement M P F	TOTALS				Pass	Projects
	M	P	F	M	P	F	M	P	F	M	P	F	M	P	F	M	P	F		M +	P +	F	→ T	%	Complete
A	6	31	3	8	12	2	6	7	2	2	15	—	1	5	1	4	21	3		27	91	11	→ 129	91.5	
B	1	3	1	1	4	—	—	2	—	1	4	1	1	3	—	—	—	—		4	16	2	→ 22	90.9	
C	1	10	1	—	11	1	—	1	—	—	1	—	—	—	—	3	9	1		4	32	3	→ 39	92.3	
D	1	4	2	—	3	1	—	—	—	—	6	—	—	—	—	—	4	1		1	17	4	→ 22	81.8	
E	—	9	2	—	—	—	—	10	1	—	—	—	—	—	—	1	9	1	Information not yet available	1	28	4	→ 33	87.9	Information not yet available
F	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		—	—	—	→ —	—	
G	8	11	—	3	7	2	1	7	1	3	8	3	—	—	—	1	12	2		16	45	8	→ 69	88.4	
H	8	8	3	—	—	—	4	10	6	—	2	—	—	1	—	4	13	2		16	34	11	→ 61	81.9	
J	7	3	—	1	3	—	1	8	1	—	—	—	—	—	—	2	4	—		11	18	1	→ 30	96.6	
K	—	—	1	—	—	—	—	2	—	—	—	—	—	—	—	—	2	1		—	4	2	→ 6	66.6	
L	2	7	1	—	—	—	4	4	—	—	—	—	1	—	—	2	5	2		9	16	3	→ 28	89.2	
N	—	1	—	—	1	1	—	—	—	—	—	—	—	—	—	—	1	—		—	3	1	→ 4	75.0	
Totals	34	87	14	13	41	7	16	51	11	6	36	4	3	9	1	17	80	13		89	304	50	→ 443	88.7	
Module Pass %	89.6			88.5			85.9			91.3			92.3												

Key to Diploma Centres:

A: North East Surrey College of Technology
B: Liverpool Polytechnic
C: Newcastle Polytechnic
D: Cornwall College of Further and Higher Education
E: Leeds Polytechnic
G: Tottenham College of Technology
H: Derby Lonsdale College of Higher Education
J: Colchester Institute of Higher Education
K: Heriot Watt University
L: North Staffordshire Polytechnic
N: Ulster Polytechnic

New Products

Submissions for inclusion in this section should be sent direct to J W Sargent, Building Research Establishment, Garston, Watford WD2 7JR.

Vibration Measurement

Geo Space Corporation has just released a new brochure entitled "Velocity Detectors for a Variety of applications" to help engineers and scientists solve problems involving vibration measurement from 2 kHz down to 1/2 Hz. Geo Space has manufactured inertial sensors for nearly three decades and offers a family of geophones and hydrophones.

A new configuration for connecting acoustic emission sensors to security, intrusion detection and military systems has recently been introduced. The assembly provides complete environmental protection for sensitive geophone elements in harsh field environments. A model GS-20D geophone is installed in a high — impact, thermoplastic case with an integral spike or flat base. The waterproof sensor assembly is connected by a 2-conductor, polyurethane jacketed cable to a sealed jack that mates to a bulkhead connector. Either single or multiple geophones can be connected in series or parallel along the cable, which can be from 1 to 100 metres long.

For a free copy of the brochure or more information contact Addison & Baxter Limited 0908 641771, the exclusive representative for Geo Space Corporation in Europe.

Noise Control and Heat Shielding Materials

The Industrialite Division of British Uralite has issued a new leaflet on its Quelclad noise control materials and Nurashield heat control materials.

Quelclad materials are available in three grades — flexible, standard and heavy — for sound insulation, sound absorption and vibration damping. The materials are based on a unique bonded fibre laminate and designed for application to a variety of surfaces. The leaflet is available from Industrialite Division, British Uralite PLC, Higham, Rochester, Kent ME3 7JA. Tel: 047482 3451.

Leq Software

Cirrus Research announce a new software suite for their range of Leq and sound level meters, the 'S24' suite. The S24 suite can take input from up to 4 meters simultaneously, displaying the current levels and the global Leq on screen. The programme can store up to 48,000 separate sound level samples or Short Leqs on disc for later retrieval and analysis. The shortest Leq which can be taken is 1 second and about 24 hours can be stored on a disc with 1 second resolution.

The data retrieval programme can present the data in several different ways:- as a time history, as a normal or cumulative histogram, or as values of L1, L10, L50 & L90. Data can be

NON-INSTITUTE MEETINGS

1987

25-26 February. *First International Conference on Vibration Control in Optics and Metrology*. London. Contact: Conference Office, Sira Ltd, South Hill, Chislehurst, Kent BR7 5EH.

24-26 March. *DAGE '87*. Aachen. Contact: Prof H Kuttruff, Institut für Technische Akustik, Templergraben 55, Aachen.

1-3 April. *Condition Monitoring*. Swansea. Contact: Mervyn H Jones, University College of Swansea, The Abbey, Singleton Park, Swansea SA2 8PP.

9-10 April. *Physics in medical ultrasound*, Durham. Contact: Dr K Martin, Regional Medical Physics Department, Newcastle General Hospital, Newcastle upon Tyne, NE4 6BE.

28 May. *Developments in instrumentation and computation for acoustics*, London.

June. *Noise annoyance assessment — subjective or objective criteria?* Birmingham.

6-9 July. *Ultrasonics International 87*. London. Contact: Marija Vukovojac, Conference Organizer, Ultrasonics International 87, Butterworth Scientific Ltd, PO Box 63, Westbury House, Bury Street, Guildford, Surrey GU2 5BH.

8-10 July. *NOISE-CON 87*. Pennsylvania. Contact: Conference Secretariat, NOISE-CON 87, the Graduate Program in Acoustics, Applied Science Building, University Park, PA 16802, USA. (300-word Abstracts by 7 November 1986).

September. *Sound propagation through the open air*, OU.

September. *Applications of automatic speech recognition*, London.

13-18 September. *4th European Conference on Non-Destructive Testing*. London. Contact: Conference Associates NDT, 27A Medway Street, Westminster, London SW1P 2BD.

15-17 September. *INTER-NOISE 87*. Beijing, China. Contact. INTER-NOISE 87 Secretariat, 5 Zongguancun Street, PO Box 2712, Beijing, China.

1988

9/10 April. *Physics in medical ultrasound*. Durham. Contact: Dr K Martin, Regional Medical Physics Department, Newcastle General Hospital, Newcastle upon Tyne, NE4 6BE.

21-25 August. *Noise '88, The 5th International Congress on Noise as a Public Health Problem*. Stockholm. Contact: RESO Congress Service, 5-113 92 Stockholm, Sweden.

Information relating to meetings of possible interest to readers should be with the Editor at the address on page 1 no later than four months before the date of the meeting. □

Note from Acting Editor: I would like to take this opportunity to thank Alison Hill for a great deal of help and guidance in producing this issue.

Also thanks to the many contributors who got their copy to me on time.

John Tyler

analysed for the whole period or between any 2 times.

Cirrus have also produced a new Integrating Plug-in Unit for their CRL 2.35A System. This unit, the CRD 1.25B, meets BS 6698 Class 1 and DP15 interface specifications. The unit will give Leq over any period using a 'STOP' button, '8 hour Leq', 'Short Leq' and Sound Exposure Level. The computer interface fitted to the CRD 125B can be connected to IBM PC, BBC or APPLE 2E computers to record 'Short Leq' data.

Further details from Cirrus Research Limited, Acoustic House, Bridlington Road, Hunmanby, North Yorkshire, YO14 0PH. Tel: 0723 891655.

New CEL Noise Meter Catalogue

Recently published by CEL Instruments is Issue 6 of their Shortform Catalogue. Several new instruments are featured in the 28-page catalogue for the first time.

In the Microprocessor-based Precision Sound Level category are the CEL 393, CEL 493 and CEL 275 meters which are companion to the CEL 238 Secondary Processor. In the Frequency Analysis category new products are the CEL-8000 Real-time Analyzer, CEL-6000 Signal processor and three plug-in filters for the new sound level meters. In the Vibration Measurement category new products are the CEL-217 Charge Amplifier and CEL-221 Digital Vibration Meter.

Copies of the catalogue are available from Lucas CEL Instruments Ltd, 35-37 Bury Mead Road, Hitchin, Herts SG5 1RT Tel: 0462 52731.

New Instruments and Sensor from Hakuto

Piezo plastic accelerometer:-

This is the Worlds' first all plastic transducer and offers excellent frequency response down to 0.5 Hz.

Fast transient memory:-

The AD 5122 is an ultra high precision transient analyser offering 16 bit sampling at 1 Mhz. The instrument has zooming, programmable clocks and input types as standard.

Portable acoustic analyser:-

A new portable analyser, the AD 3523, has the capability of giving FFT analysis, 1/3 Octave, time and histogram information. This instrument can be mains or battery powered.

Multi channel transient memory system:-

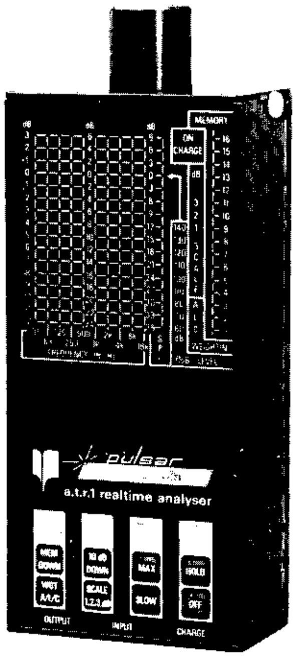
The ELK 7000 series can be expanded to provide up to 90 channels of transient capture. Sampling rates can be as high as 50 Mhz and 10 or 12 bit accuracy is available.

Further details are available from Hakuto (UK) Limited, Eleanor House, 33-35 Eleanor Cross Road, Waltham Cross, Herts EN8 7LF Tel: 0992 769090.

ATR 1 Real Time Analyser

The ATR 1 from Pulsar Instruments is a 10 octave Real Time Analyser in a small hand held package.

With a dynamic range of over 45 dB on scale the ATR 1 allows the simultaneous measurement of all 10 octave bands from 31.5 to 16 kHz plus an 11th channel reading sound level in either dBA, dBC or dBLin. All the spectra together with range data and weighting etc. can be stored in one of 16 memories and recalled for later evaluation.



Pulsar ATR 1 Real Time Analyser

Digital Leq Meter — Pulsar Model 228

The Model 228 Leq meter has a total integrating range from 40 to 140 dBA with six 40 dB display ranges and ten pre-set measuring times ranging from 2 seconds to 16 minutes. The meter automatically resets it's stores and restarts a new measurement at the end of each period, while the display holds the previous period's Leq.

Further details on these instruments is available from Pulsar Instruments, Bridlington Road Industrial Estate, Hunmanby, North Yorkshire YO14 0PH. Tel: 0723 891662.

Accelerometer — A/123/E

The A/123/E Accelerometer from D J Birchall Limited is one of a range with Integral Electronics. The Internal Voltage Output Amplifier will operate using any unregulated power supply from 8 volts to 40 volts. The Piezo-Ceramic Element is a Patented 'Konic' Shear Device reducing base strain sensitivity and pyro-electric effect.

The miniature size of the A/123/E makes it suitable for light structure vibration measurement, whilst its all welded case renders it relatively robust. It weighs only 5 grams, has a sensitivity of 7 mv/g and a resonant frequency of 50 kHz.

The flat face construction is suitable for bonding down, where tapping of holes in the specimen is prohibited.

Further details from D J Birchall Ltd, 102 Bath Road, Cheltenham, Glos GL53 7JX Tel: 0242 518588.□

NEW BOOK

Transportation Noise Reference Book

Due to be published in March by Butterworth, this new reference book is described by the publishers as *"the most comprehensive international reference book on all aspects of noise generated by road, rail and air transport. The handbook has been specially written by a team of experts from both sides of the Atlantic, selected for their specialist knowledge by editor, Paul Nelson of the Transport and Road Research Laboratory, Crowthorne, UK.*

All aspects of noise and vibration generation from transport sources are covered together with their effects on man and his environment. The methods of controlling and reducing the impact of transportation noise are given full coverage. The carefully researched and well-documented chapters will be of use to engineers in the automobile, aircraft and railway industries as well as those involved in the planning and the design of transport systems and associated land use. It will also be of value to social scientists and to the medical profession who have to deal with a wide range of community effects resulting from the impact of transportation noise. The role of Governments in introducing legislative controls and fiscal incentives to reduce noise is also covered in the book and these aspects will be of use to both the legislator and to the legal profession."

The IOA hope to review this book later in the year.□

Institute of Acoustics Meetings

1987			
18 February	SB	Environmental Impact Assessment (G M Jackson and T F Murphy)	Southampton
20 February	M	Noise in Mechanical Services	London
24 February	PAG	Acoustic Microscopes, the physics and their application	
March	M	Subjective Perception of Sound Quality by those with Sensitive Hearing. Joint with BSA	
March	NEB	Open Cast and Quarry Noise	Carlisle
4 March	SB	Investigation and Treatment of Hearing Disorders in Adults (A M Adams)	ISVR, Southampton
13-16 April	**M**	**Acoustics 87. IOA AGM**	**Portsmouth Polytechnic**
14-15 April	UAG	Sonar Transducers — Past, Present and Future	Birmingham
15 April	SB	Visit to Test Facilities of IAC (provisional)	Weybridge
13 May	SB	Subjective Effect of Mixed Noises (C G Rice)	Southampton
28 May	M	Developments in Instrumentation and Computation in Acoustics	London
September	PAG	Current Research Review Meeting, visit and AGM (venue to be arranged)	
June		Noise annoyance assessment — subjective or objective criteria?	Birmingham
September		Sound propagation through the open air	OU
September		Applications of automatic speech recognition	London
Autumn	PAG	Acoustic Microscopes and their Applications	
November		AUTUMN CONFERENCE	Windermere
Autumn		Noise control of factory buildings	
		Acoustic design of the integrated office	
1988			
February		The acoustics of doors, windows and facades	London
10-13 April		**SPRING CONFERENCE**	**Cambridge**
29 August — 1 September	**M**	**7th FASE Symposium: Speech**	**Edinburgh**

Key:

M = Meetings Committee Programme
BAG = Building Acoustics Group
ING = Industrial Noise Group
MAG = Musical Acoustics Group
PAG = Physical Acoustics Group
SG = Speech Group
UAG = Underwater Acoustics Group
LEM = London Evening Meeting

EMB = East Midlands Branch
NEB = North East Branch
NWB = North West Branch
SB = Southern Branch
ScB = Scottish Branch
SWB = South West Branch
YHB = Yorkshire and Humberside Branch

Further details from:
Institute of Acoustics
25 Chambers Street
Edinburgh EH1 1HU
Tel: 031-225 2143

Christchurch Printing Company Ltd., 19 Woodside Road, Bournemouth BH5 2BA