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ABC
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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.

The Institute has representation in practically all the major research, educational, planning and industrial establishments covering all aspects of acoustics including aerodynamic noise, environmental acoustics, architectural acoustics, audiology, building acoustics, hearing, electroacoustics, infrasonics, ultrasonics, noise, physical acoustics, speech, transportation noise, underwater acoustics and vibration.

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Dear Fellow Member,

I have great pleasure in announcing the decisions taken by Council in respect of its 1990 honours. There were many very high quality nominations submitted and the Medals and Awards Committee was faced with a very difficult task in making its recommendations.

The Rayleigh Medal has been awarded to Professor Frank J Fahy of the ISVR at the University of Southampton, for his outstanding researches in acoustics and structural/acoustic interactions. In addition to his undoubted scholarship he is a dedicated and innovative teacher who has made invaluable contributions to the national and international advancement of the profession of acoustics. He is without doubt a worthy recipient of the Institute's premier honour.

Dr Ann P Dowling of the Department of Engineering at the University of Cambridge has been awarded the A B Wood Medal for her distinguished researches in the area of underwater flow-related problems. She has made the science of flow-acoustic-thermal interactions her own, and in a field of great practical significance has addressed the need to influence engineering practice as thoroughly as she penetrates the subject's most fundamental foundations.

The biennial award of the Tyndall Medal has been made to Dr Nicholas G Pace of the School of Physics at the University of Bath for his contributions to our fundamental understanding of the interaction of acoustic waves with materials including the seabed. His research is of international repute and ideally meets the medal criterion of achievement and services in the field of acoustics.

The seventh R W B Stephens Lecturer will be Dr J M Bowsher of the Department of Physics at the University of Surrey, in recognition of his prominence in the field of musical acoustics. His research has been concerned not only with the fundamental understanding of the many physical problems associated with musical instruments, but also with the all-embracing nature of musical acoustics as an example of man's heritage and culture. He is ideally placed to put his own work in the context of the influence which the doyen of acoustics has had on so many of us.

The Institute has good reason to feel proud in having such eminent members to honour. They will be presented with their awards at the Acoustics '90 Spring Conference which will be held at Southampton from 27-30 March 1990.

Sound Systems for High Definition Television

D J Meares BBC Research Department

Introduction

Within the foreseeable future High Definition Television (HDTV) will be available in the UK, either as an extended definition format such as High Definition Pal or as a fully fledged HDTV system with approximately double the definition in all three dimensions. That this has long been recognized is evidenced by the large number of research institutions around the world involved in related developments. What is not terribly surprising is that the vast majority of the effort has so far been expended on the vision side of the HDTV problem: very little effort, by comparison, has been applied to the question of what form of sound should accompany this new format of picture.

That is not to say that no effort has been applied to the sound studies. Indeed, it is the purpose of this article to draw together an outline of the work that has been carried out and to indicate those areas where most work is still needed.

The vision format

Though there are competing formats around the world, based on the local existing television systems and specifically the picture repetition or frame rate, the scene can be adequately set by referring to the HDTV system being developed in Europe by the Eureka 95 Consortium.

Remembering that the existing UK TV system is 625/50/2:1 (i.e. 625 lines/50 fields per second/2:1 interlaced line structure), the new HDTV proposal is for an ultimate studio standard of 1250/50/1:1. This means that there will be approximately twice the definition of picture both horizontally and vertically. Also the move from interlaced (2:1) to progressive (1:1) scanning will give twice the temporal definition, i.e. motion portrayal will be improved as well. This is shown schematically in Figure 1, where to be more precise, the figures for the active picture area are shown. (Thus the overall line rate of 1250 lines per picture is shown as 1152 lines per active picture.)

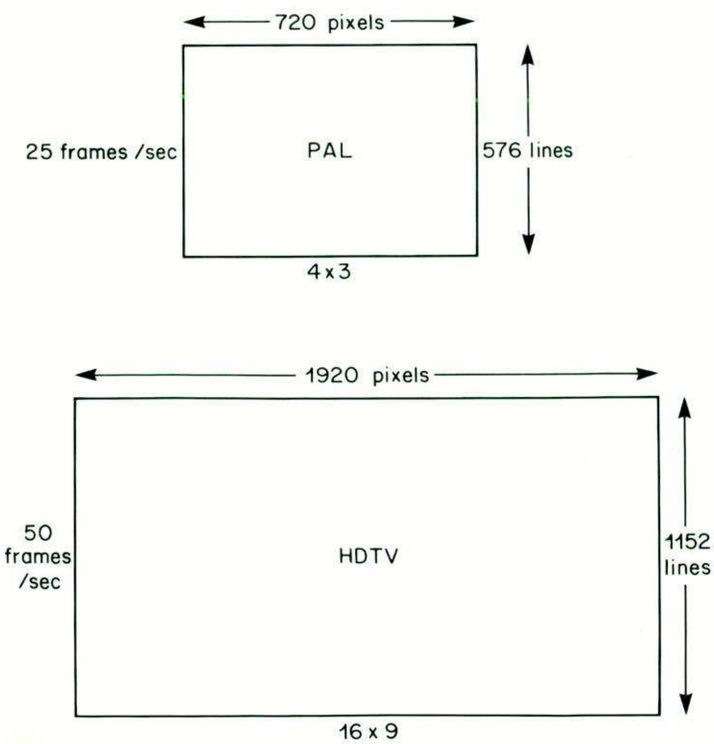


Fig. 1. The shape of things to come

Also shown is one of the most immediately noticeable features of HDTV, namely the change in aspect ratio from 4 × 3 to 16 × 9. Subjectively this new aspect ratio is much more pleasant to the viewer, perhaps reflecting the normally horizontal nature of nature, or the fact that our eyes are disposed that way and thus give a wider lateral perspective than vertical perspective. Obviously there is nothing fundamentally new about this; the film industry has always worked with wider aspect ratios, but it does make an impact in the context of home viewing of television.

One should also bear in mind that these developments are accompanied by the proposition that larger pictures will be the norm for HDTV. Again, this may be partially following the example of the film industry and/or real life, where the image presented to the eye covers a much greater part of the retina than would the image of a normal television picture at normal viewing distances. But how large a picture will be considered acceptable in the domestic environment as opposed to the cinema?

Tests recently carried out as part of the Eureka 95 study[1,2] looked specifically at this point, asking not only how large a picture could be fitted into people's existing home setups, but also asking how large it could be even taking into account a rearrangement of the TV room or lounge. Results of this study confirmed suspicions that there was indeed an upper limit to the size of picture that would be acceptable. For existing arrangements the preferred size was 1 m, whilst for rearranged conditions the preferred size was 1.2 m.

It would appear therefore that, with the advent of HDTV, viewers will be subjected to pictures of much greater clarity and size. Surely then the accompanying sound will have to be that much more impressive as well.

Sound systems: the fundamental requirements

One way in which the sound system for HDTV could be more impressive, would be to provide surround sound instead of mono or stereo. In this context some of the pioneering work of the seventies should be borne in mind, even though that work was for sound-only systems.

The particular study of relevance[3] examined the acuity of the ear to directional cues. (The term ear is used here to cover the ear/brain combination.) Figure 2 shows the accuracy with which a group of subjects were able to detect the direction of a sound, whose source they could not see, from all directions in an anechoic chamber. Though somewhat less accurate for those directions out of the frontal quadrant, nowhere could the results be said to be poor. Figure 3 shows the results for the co-positioning of two sound sources under otherwise similar test conditions. These results are even more accurate.

However, if one looks at the generation of phantom images between pairs of loudspeakers arranged around a listener in a square format (Fig. 4), very variable and uneven results are produced. Whilst front and back quadrant results are rather similar, the side quadrant images show a strong tendency to be drawn to the front of the listener and are very unstable with head movement. There is also a noticeably diffuse quality to the side images making it less certain just where

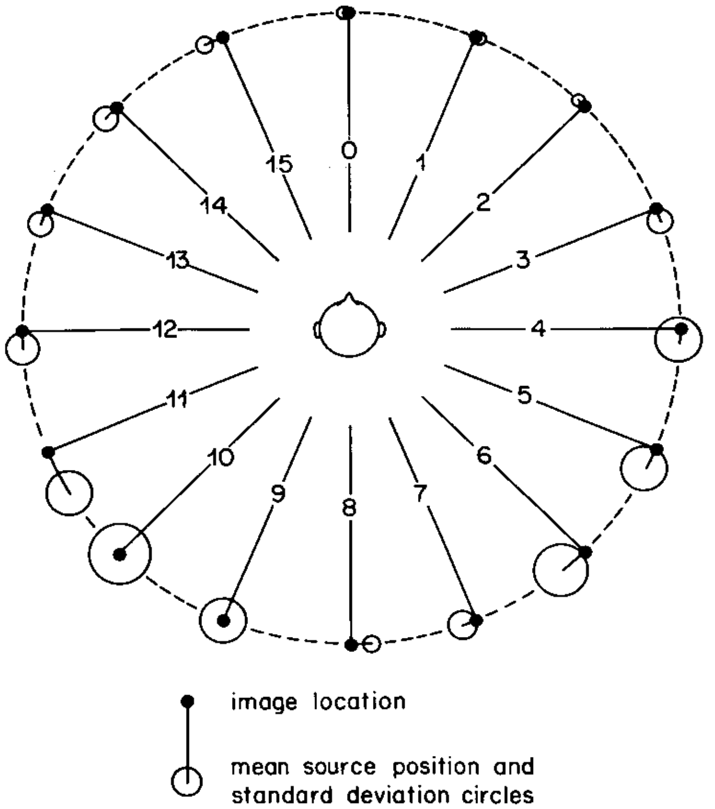


Fig. 2. Absolute sound localization in the free-field room

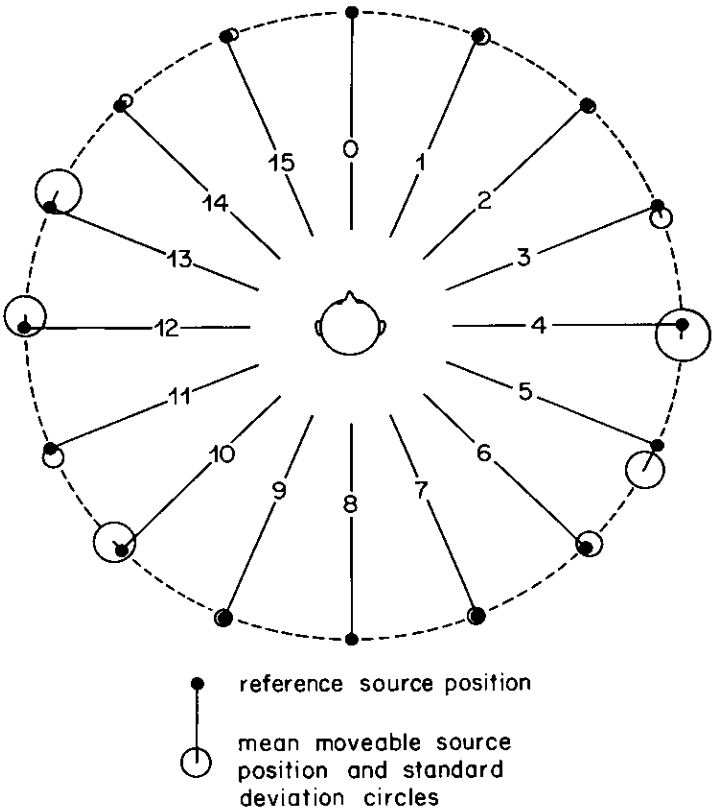


Fig. 3. Relative sound localization in the free-field room

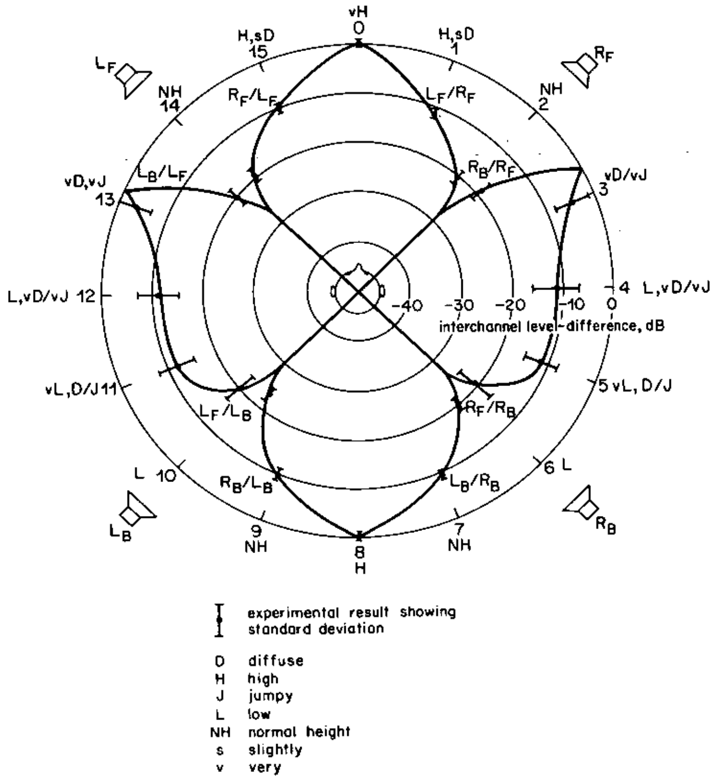


Fig. 4. Interchannel level-difference versus image location for adjacent pairs of loudspeakers, in a free-field room with a reflecting floor

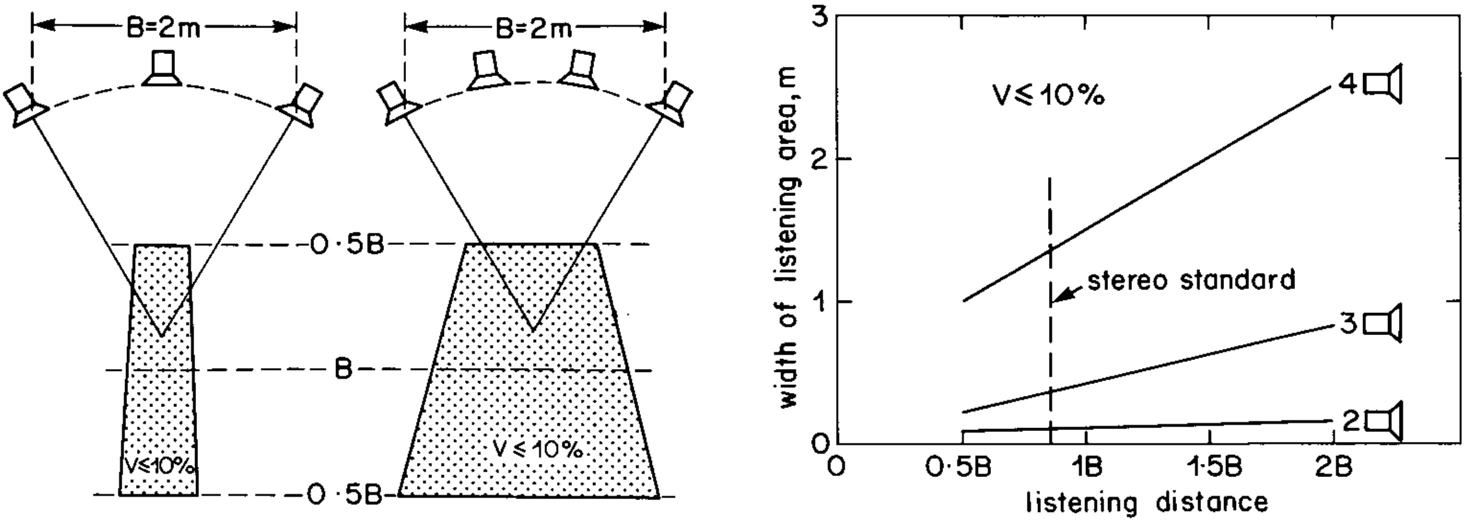
they are located. Thus the use of surround sound is not conclusively the right way forward.

In the domestic environment there is seldom a household where people listen/view only one at a time. It is much more common and probably the norm for families to wish to view collectively, at least some of the time. The BBC's experimental Television Stereo work, now amounting to the production of many hundreds of programmes, has shown that whilst aural and visual directional cues can be made to match for a single viewer/listener, it is much more difficult to achieve such a result even for just two people sitting side by side. If, therefore, those directional cues are to be considered a valid and usable part of the producer's armoury in creating an element of a programme, he has to be sure of where the sounds will be reproduced for his audience. It could be argued in the context of HDTV that if the picture is both larger and more detailed, then the importance of this factor is increased.

This point has been addressed in a recent CCIR (Comité Consultatif International des Radiocommunications) submission from the Federal Republic of Germany[4]. Figure 5 shows the relevant results demonstrating clearly that an increase in the number of loudspeakers (and channels) used to reproduce a frontal sound stage will increase the usable listening area for a given accuracy of sound reproduction. The move from two channel to three increases the width of the listening area by a factor of about three, whilst the use of four channels increases it by a further factor of four.

Another factor that should be borne in mind is that the eye is more powerful than the ear: if there is doubt as to where a sound is coming from the brain places more emphasis on visual cues than on aural cues. Recent work by NHK (Nippon Hoso Kyokai) in Japan[5] has examined this in some detail. Figure 6 shows both the experimental setup and the results for this work. Specifically they found that for a picture of a talking person, if the sound was mislocated by 10 deg listeners were easily able to detect it, even if they were not disturbed by the mislocation. However an error of 15 deg or more started to cause some annoyance to the audience. Such an error is easily created by off-centre listening.

What, then, is the optimum choice of sound system for HDTV? Specifically, how many channels are needed, and how should they be reproduced? Though the Japanese have again addressed this question,[6] it is one that is still being explored by many workers in the field. The Japanese results can be summarized by Figure 7. This shows seven different loudspeaker arrangements and the results of evaluations on



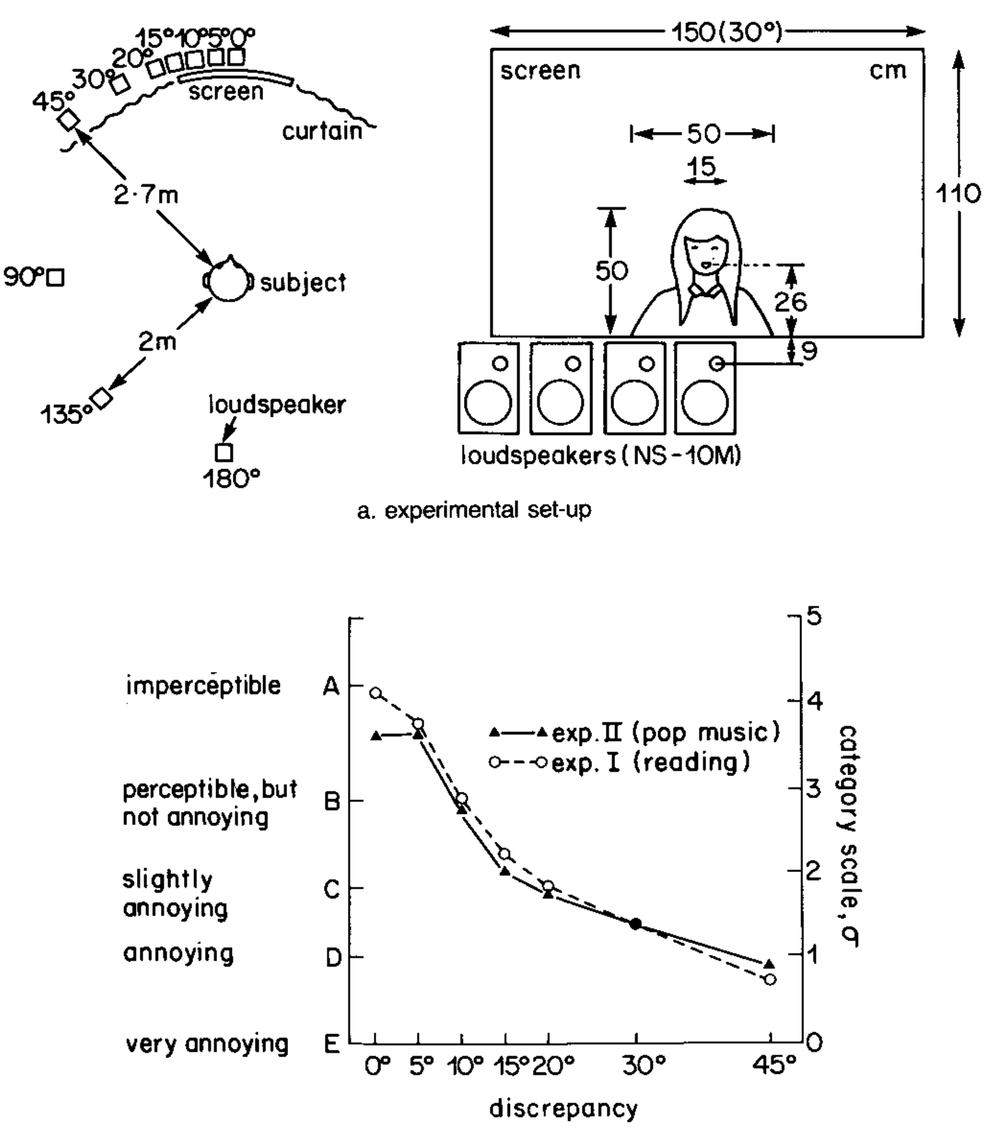
a. pictorial

b. graphical

Fig. 5. Listening areas for multichannel stereophony

them, both for realism and for stability and accuracy of sound location for an off-centre listener. Interestingly, it is the two surround systems with a central loudspeaker between the stereo pair that score well on both counts. As far as directional cues are concerned the three-channel system also scores highly. This work however only used one musical item for its test material and thus much more work is required before such results could be claimed to apply to the whole gamut of television programmes. It is, however, a useful pointer for other workers.

It is just this question of how many channels and how they should be disposed that the author is studying at the moment. With programme colleagues at the BBC, several recordings of multichannel sound with HDTV have been made and subsequent mix down sessions in a Sypher channel have now started. The first sessions covering both the 1989 Wimbledon and FA Cup Final have been completed and additional tests on a Promenade Concert recording and Top of the Pops recording are being planned. The Sypher sessions took the multichannel source tapes and attempted to produce mix downs that could be reproduced compatibly in 5-channel, 4-channel, 3-channel, stereo or mono. Similar work will take place for other types of material and then the success or otherwise of the different forms of sound presentation will be judged by way of subjective tests.



a. experimental set-up

b. results

Fig. 6. Response to errors in sound localization

Sound systems: additional factors

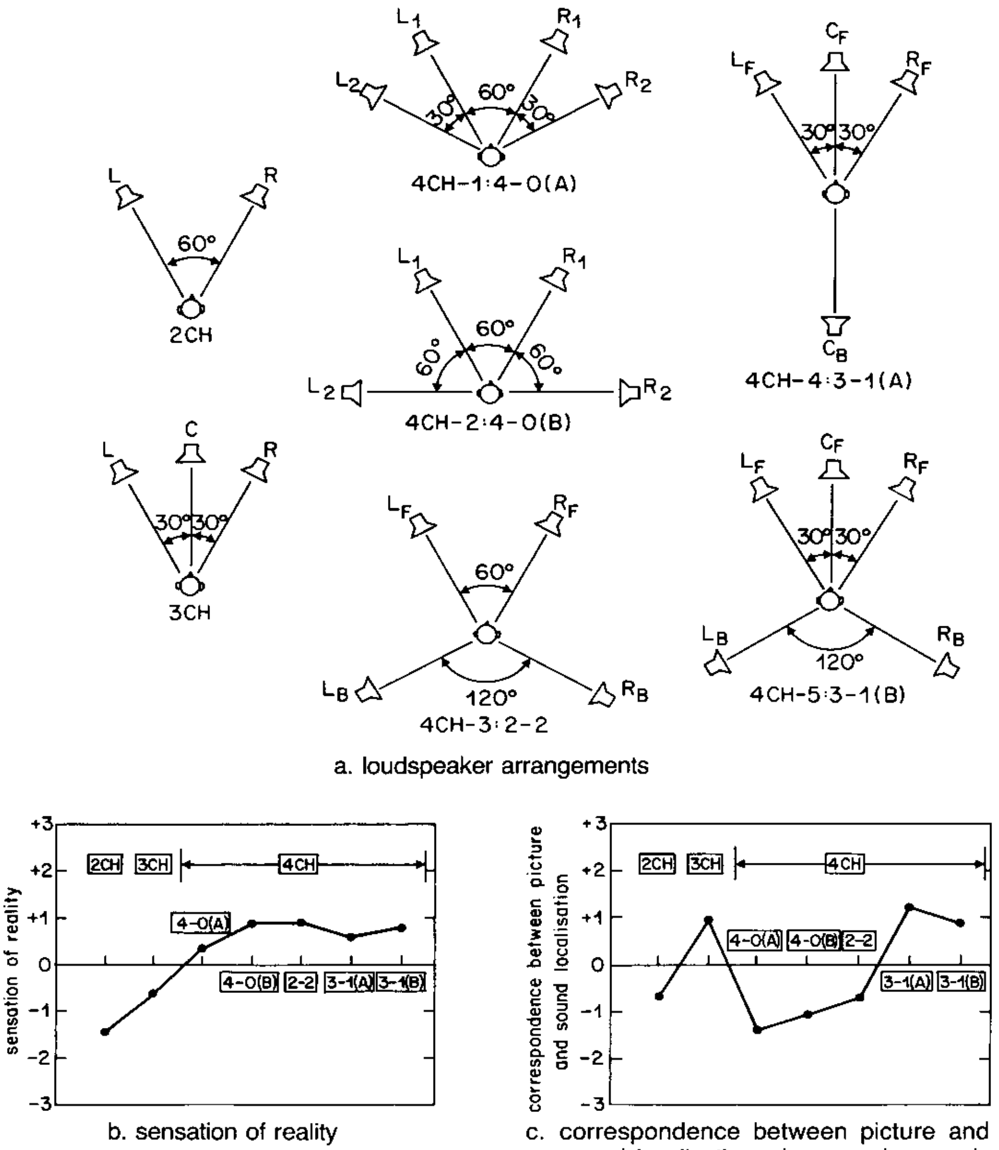
The significance of the question of compatibility should not be underestimated. Whilst a system may be developed that can provide, say, five-channel surround sound for HDTV, just how many of the audience will want surround sound? When that question was raised in the seventies for Radio, the answer was 'Not many'. Admittedly there were other factors involved, such as how could it be transmitted, but public resistance to the complexity of surround sound should be taken into account. In essence a specific room would have to be given over to the activity of HDTV viewing so that the correct loudspeaker arrangement could be set up. Even given an arrangement that allowed more than one listener at a time, would an optimum arrangement require centrally located seats or could the system be modified to accommodate the conventional domestic arrangement of seating, i.e. seats around the walls? In this context it is worth quoting the final paragraph of reference 1.

> The results help to confirm the view that the absolute size of domestic HDTV displays will be determined by practical limits such as room size and the willingness or otherwise of the householder to rearrange family viewing conditions to suit the HDTV display.

Though written specifically on the question of screen size, with a few choice word changes and the passage of a short period of time it may well be shown to apply equally to the sound side of HDTV.

And what of the non-surround listener? Would the transmitted sound signals be optimized with him sufficiently in mind? In the seventies it was clearly apparent that the reduction from surround sound to stereo in a multichannel system was not a simple matter. Some programmes, such as music from any concert hall, required less reverberation in the stereo than in the surround: thus rear channels should perhaps be attenuated in the compatible signals. For drama, does the same compatibility matrix provide the right answer? Insufficient work has as yet been carried out to answer this reliably.

There is also the thorny question of multilingual broadcasts. If the HDTV signal is to be provided by a satellite service then it is likely to cross international borders with inordinate ease. Indeed, the cost of HDTV programmes may mean they are viable only if made with an international audience in mind. How many channels are needed to provide a multilingual service? For programmes such as sport or music with commentary, then a clean feed of surround sound effects could be provided on, say, four or five channels (depending on the answer to the earlier question) and each language could be provided merely by adding one commentary channel per language. This cannot, however, be assumed to be true for other types of programme. As soon as the human voice becomes part of the programme, as in drama, and is intended to be in the environment being portrayed by the picture and the surround sound presentation, then each language requires a separate surround sound mix. One can only portray a person in a reverberant environment by ensuring that the reverberation is triggered by that person's voice.



a. loudspeaker arrangements

b. sensation of reality

c. correspondence between picture and sound localisation when an observer is seated 70cm off axis.

Fig. 7. Assessment of multichannel sound systems

Transmission factors

As already mentioned the European thrust into HDTV is being co-ordinated by the Eureka 95 Consortium. This covers all aspects from the studio through transmission to the receiver. The transmission of HDTV is being designed to be an evolutionary step from the Multiplexed Analogue Components (MAC) form of transmission. Thus as far as the sound signals are concerned, they will be conveyed via the digital 'packet system' already part of the MAC/packet specification.[7]

The data capacity available to the sound signals depends firstly on which form of satellite service is being considered. MAC signals destined for onwards conveyance to the ultimate customer via a cable distribution signal will be of the D2 format, whilst those intended for direct reception will, in the main, be of the D format. In rough terms the D MAC format provides for the equivalent of eight high quality audio channels, whilst the D2 format provides for only four high quality audio channels. Also, there is already pressure to consider the release of some of this capacity for other data services, such as teletext. Under such circumstances the use of all four channels of a D2 system just to provide surround sound to the few who want it could be considered a very extravagant use of the available capacity. Furthermore such an option leaves no capacity whatsoever for the provision of multilingual broadcasting. The hunt is on, therefore, to try to find ways of releasing data capacity by reducing the requirements of a surround sound service.

One such development, being studied by Philips in Eindhoven, uses a variation on the theme of subband encoding to reduce the data rate (see Figure 8). Essentially the incoming signals are divided into 'main' and 'hidden' channels and pairs (one of each type) are processed together. For each pair, both signals are processed via the subband codec to determine how many bits of each audio word are required to convey the necessary audio impression. The 'main' channel is then allocated the appropriate number of MSBs (Most Significant Bits) in the digital word whilst the remaining LSBs (Least Significant Bits) are used to convey the 'hidden' channel. If the subband rules have been correctly applied, then the combined signal will just sound like the main signal, the other one being 'hidden' by the rules of auditory masking. If this system can be shown to work on a wide range of material, and at the time of writing the real-time hardware is only just coming on-stream, then it will mean that two signals can be conveyed via the capacity of one channel. Additionally, the combined signal will have to be compatibly received by MAC receivers without the subband decoder.

Yet another strand of the Eureka study is accepting conventional digital encoding of the first two audio channels to provide the necessary MAC compatible reception of the signals, and is proposing to use the full strength of either subband or transform coding to reduce the data rate of the remaining audio signals by factors of 4:1 or more. Thus surround sound would require no more than two-and-a-half channels of the four-channel D2 capacity.

But why not use one of the 4-2-4 phase/amplitude matrix systems proposed in the seventies investigations? Specifically, why not use the Dolby Surround system now accepted as a *de facto* standard in the film industry. The main problem with these systems is the very limited interchannel separation that they provide unless one resorts to the use of non-linear circuit, or logic, enhancement. Such logic enhanced decoders subjectively overcome the limited separation, but impose severe limitations on the producer's freedom of placement of sound images. Figure 9 shows just how extensively the BBC producers use the stereo sound stage in TV stereo productions. Such complexity of sound stage leads to very interesting sound productions, as was clearly demonstrated at a previous Reproduced Sound Conference. The use of Dolby Surround would restrict a producer's work and eliminate such complex presentations.

Clearly, then, the way in which the sound signals of an HDTV service will be transmitted has not yet been determined. It is obvious, however, that whatever system is to be developed, it should not at this stage predetermine what sound signals are envisaged or could be conveyed. Obviously, an upper limit of channels may have to be set, but it should not override the necessary programming studies and conclusions of whether surround sound or multilingual broadcasting is appropriate.

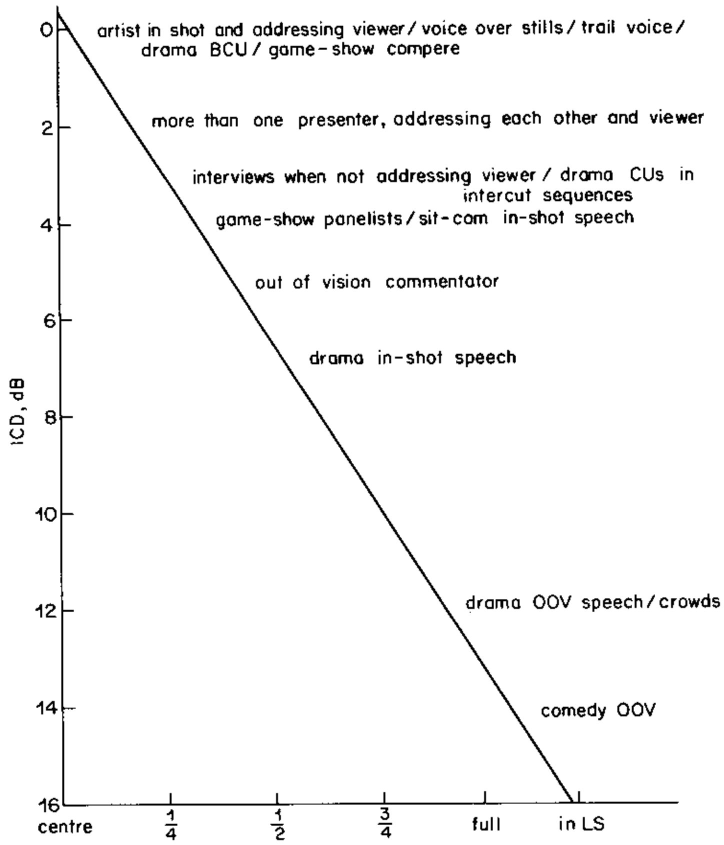


Fig. 9. Distribution of images: suggested limits of interchannel difference

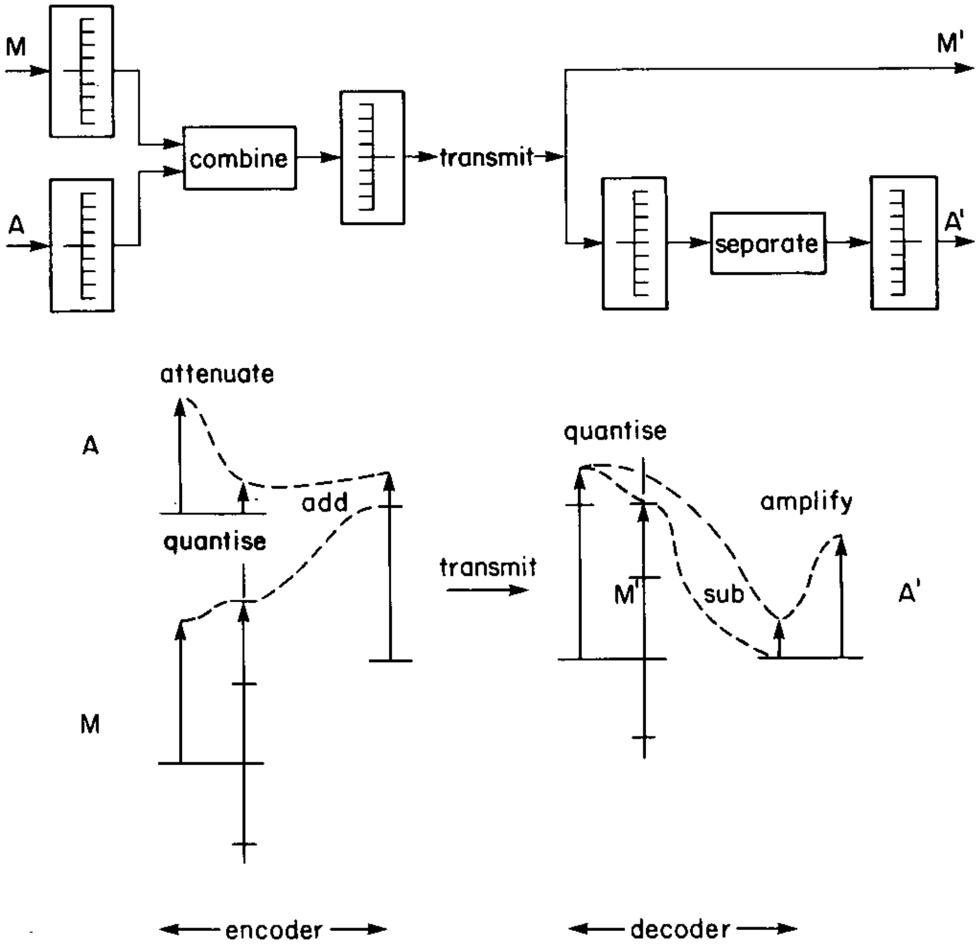


Fig. 8. Surround sound encoding using 'Hidden Channel' techniques

Conclusions

New HDTV video formats are being studied to bring to the home viewer greater definition and reality to their programmes. On a similar basis new forms of sound system are being examined.

Much work has already been carried out to study relevant properties of the human hearing system, but much more still needs to be done. Experimental programmes have been made by the BBC and others in order to decide whether surround sound or some lesser form of sound presentation is required to support the new pictures. Similarly, the possibility of multilingual programming is being studied, fully to exploit the possibly expensive HDTV productions.

On the transmission front, various groups are studying ways of combining the audio signals in a compatible way, such that the scarce resource of available capacity is not squandered.

Acknowledgements

The author would like to acknowledge the valuable discussions and programme-making assistance that have been afforded to him by his colleagues in BBC Television. The author would also like to thank the Director of Engineering of the BBC for permission to publish this paper.

The results shown in Figures 6 and 7 are reproduced by kind permission of NHK.

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1990 Spring Conference

ACOUSTICS '90

Institute of Sound and Vibration Research, University of Southampton, 27 – 30 March

Conference Organizer: Dr S J Elliott, MIOA
ISVR, University of Southampton

The Spring Conference is an opportunity for acousticians to present progress reports on their work in any field of the subject. It also offers members at all grades of the Institute the chance to participate in the major events in the Institute's year, including the 1990 AGM, the Annual Dinner and Presidential Address, the 1990 Rayleigh Medal and A B Wood Medal Lectures and the 1990 R W B Stephens Lecture.

The official opening of the A B Wood underwater tank at ISVR will also take place during the conference together with a programme of technical and social visits.

Acoustical Characteristics of Rectangular Pistons

G Bank and **J R Wright** Celestion International Ltd

Electrical circuit analogue modelling of the acoustical radiation from circular pistons is a widely-used technique. With the recent availability of radiation impedance data for various *rectangular* pistons, this technique has been applied to compare and contrast the behaviour of these two common types of radiator. It is observed that a simple change in geometry gives rise to an increase of up to 4 dB in acoustical output.

Introduction

The acoustical characteristics of circular piston transducers have been extensively modelled using established techniques, usually employing an electrical circuit as an analogue of the lumped (electrical, mechanical and acoustical) parameters of the device under investigation. Normally the acoustical elements (radiation impedance) of the system are neglected as insignificant quantities. This assumption can be acceptable under such conditions as high piston mass and at low frequencies.

In the case of rectangular pistons, the recent publication of radiation impedance data[1] now permits an investigation and comparison of the differing acoustical behaviour of these two types of radiator. Also, the majority of rectangular pistons are ribbon-type transducers, which are generally low-mass systems operating at higher audio frequencies. Therefore any such comparison requires consideration of the acoustical elements.

Past work on rectangular sources has usually involved the assumption of constant diaphragm acceleration: a particularly informative treatise in this vein was produced by Lipshitz and Vanderkooy,[2] where finite-length line sources having either monopole or dipole radiation characteristics were studied. The radiation impedance was neglected and constant acceleration was assumed. In reality the complex nature of the radiation impedance will preclude this, and other simple approximations.

The purpose of this paper is to analyse the effects of radiation impedance on circular and rectangular pistons operating in an infinite baffle environment. We will confine our study to loudspeakers, although by reciprocity the principle also applies to microphones.

Radiation impedance

The radiation resistance and radiation reactance functions for a flat circular piston in an infinite baffle are well documented.[3-5] They are derived using a classic analytical technique. (These functions are shown in Figure 2a.)

This same technique has been adapted to evaluate the radiation impedance functions of a rectangular diaphragm of any given aspect ratio.

Theory

Consider an infinitesimal area dS_1 on the surface of a flat rectangular piston. The piston is mounted flush within an infinite baffle and vibrating with simple harmonic motion with velocity u given by

$$u = u_0 e^{j\omega t}$$

where u_0 is the velocity amplitude
j is the complex operator $\sqrt{-1}$
$\omega = 2\pi f$ where f is the frequency of vibration
t is the time variable.

Let dp be the small change in air pressure that a movement of dS_1 causes at a point adjacent to another infinitesimal area dS_0.

If the elements dS_0 and dS_1 are separated by a distance r, then this change in pressure is given by

$$dp = \frac{j\rho c k u_0}{2\pi r} e^{j(\omega t - kr)} dS_1$$

where ρ is the density of air (= 1.18 kg/m^3 at 22 °C)
$k = 2\pi f/c$ where c is the velocity of sound in air (= 345 m/s at 22 °C)

Then the total acoustic pressure p adjacent to dS_0 is obtained by integrating dp over the entire piston surface:

$$p = \iint \frac{j\rho c k u_0}{2\pi r} e^{j(\omega t - kr)} dS_1$$

Thus the total reaction force acting on the piston is

$$fr = -\iint p \, dS_0$$

Therefore

$$fr = \frac{-j\rho c k u_0}{2\pi} e^{j\omega t} \iint dS_0 \iint \frac{e^{-jkr}}{r} dS_1$$

The radiation impedance Zar can now be obtained from its definition:

$$Zar = \frac{-fr}{u_0 e^{j\omega t}}$$

The geometry of the problem is described by Figure 1. The rectangular piston has length L and width W. In region I, θ is

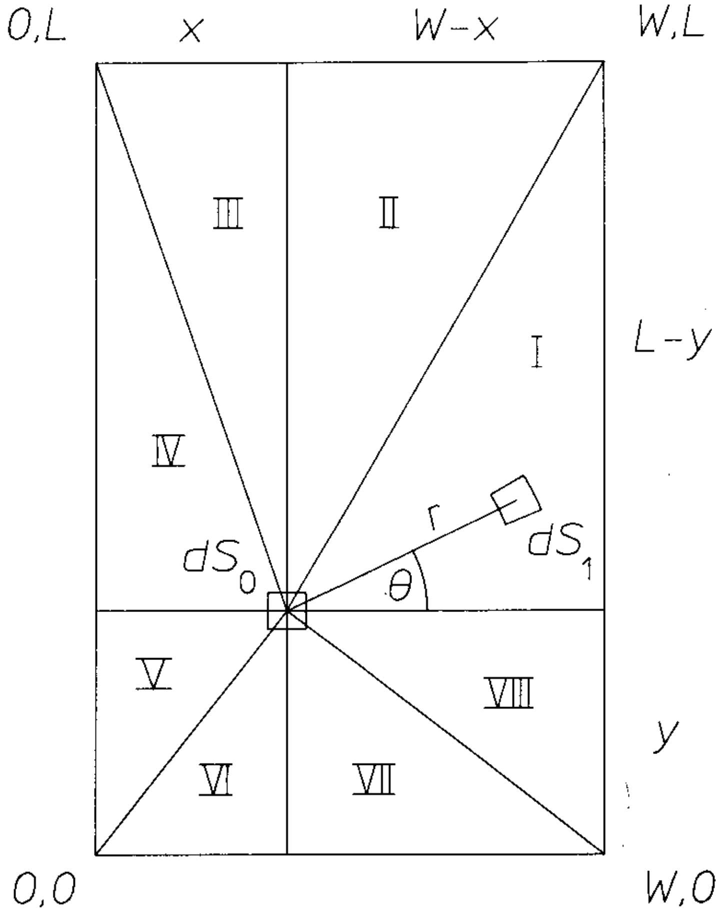


Figure 1. Geometry for the calculation of radiation impedance on one side of a rectangular piston in an infinite baffle

the angle between the horizontal and the line between dS_0 and dS_1. The area dS_1 is then represented by $r.dr.d\theta$ The area dS_0 is given simply by $dx.dy$.

The surface of the piston is originally divided into eight triangular sections, in order that the surface integration can be correctly constrained. In fact, we can make use of the horizontal and vertical axes of symmetry to simplify the calculation considerably. Because of the symmetrical nature of the problem, it is only necessary to perform the surface integration over sections I and II and multiply the result by a factor of four. This gives rise to the following expression for the radiation impedance:

$$Zar = \frac{4j\rho ck}{2\pi} \int_0^W \int_0^L \left\{ \int_0^{atan\left[\frac{L-y}{W-x}\right]} \int_0^{\frac{(W-x)}{\cos\theta}} e^{-jkr}\, dr\, d\theta + \int_0^{atan\left[\frac{W-x}{L-y}\right]} \int_0^{\frac{(L-y)}{\cos\theta}} e^{-jkr}\, dr\, d\theta \right\} dy\, dx$$

This expression can be divided by a normalizing term (ρcLW) to give rise to radiation impedance functions analogous to the traditional circular piston data.

The above quadruple integral can now be solved by numerical methods. This can be achieved with any suitable computer program. The data shown herein were obtained using Simpson's approximation with a variable step size, giving results which are convergent to within 0.1%. Detailed results are documented in ref. 1, but here we will consider one particular case.

The radiation impedance functions are found to be dependent on the aspect ratio of the rectangle, i.e. the ratio of length to width (L:W). Here we choose to investigate the behaviour of a rectangular piston having an aspect ratio of 50:1. Figure 2b shows the radiation impedance functions for this geometry. Notice that the ordinate uses a normalized frequency function, $k\sqrt{Sd/\pi}$, where Sd is the area of the piston. It has been established that this quantity is directly analogous to the traditional normalized frequency kR for a circular piston (where R is the radius of the circle) and, as such, permits a direct comparison of the radiation impedance functions for the two geometries.

Electrical circuit analogue modelling

Figure 3 shows an electrical circuit analogue for a loudspeaker. *Vg* is the electrical input voltage; *Re* is the d.c. resistance; *Cmes* is an electrical capacitance representing 'static' mechanical mass: *Lces* is an inductance representing mechanical compliance; *Res* represents mechanical damping. In the following analysis the frequency-dependent electrical components *Rem* and *Lem* will be neglected, as these are only significant in coil-type transducers.[6] Here we are interested in the effects of different acoustical elements (*Zerf* and *Zerb*). If we define the piston to be mounted in an infinite baffle in anechoic space, then the radiation impedance acting on the front of the diaphragm, *Zerf*, is identical to the rear radiation impedance, *Zerb*. So the circuit can be reduced to that of Figure 4.

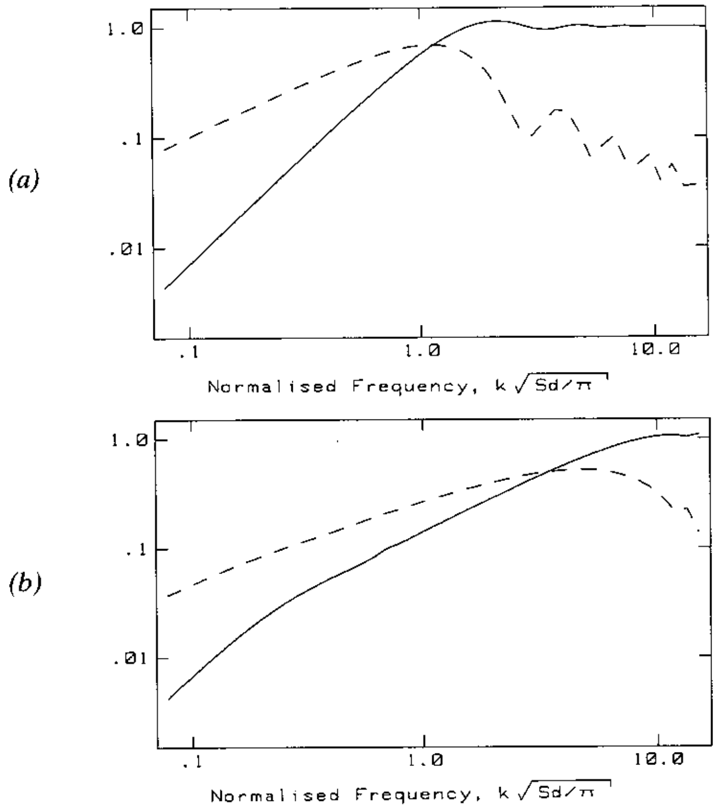


Figure 2. Normalized radiation impedance functions for (a) circular piston, and (b) 50:1 rectangular piston, mounted in an infinite baffle. Solid line – radiation resistance: broken line – radiation reactance.

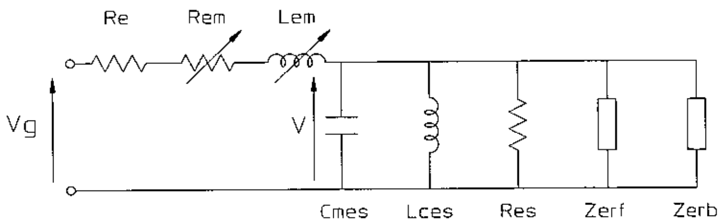
Sound pressure, sound power

Having calculated the surface velocity using the circuit analogue, it is now possible to predict Sound Pressure Level (SPL) or Sound Power Level (SWL).

At low frequencies or at large distances from the piston, the radiation pattern can be assumed to be hemispherical. In this case we can use an approximate formula for sound pressure, p:

$$p = \frac{j\rho cku_0S_d}{2\pi\, r_0} e^{-jkr}$$

where r_0 is the distance from the centre of the piston to the observation point.



$V = Bl.u$ where Bl is the force factor of the motor system and u is the (complex) velocity of the piston

Figure 3. Electrical circuit analogue for a loudspeaker

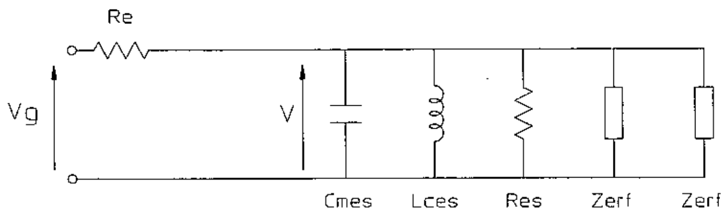
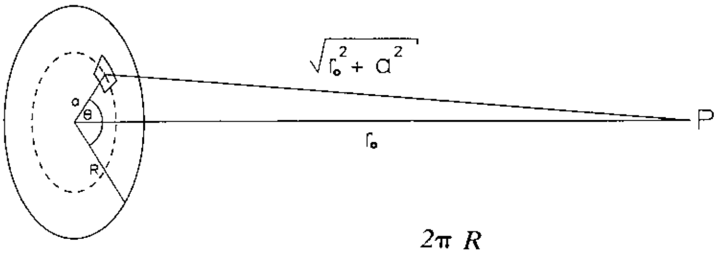


Figure 4. Simplified electrical circuit analogue for a loudspeaker mounted in an infinite baffle

Here we implicitly assume simple harmonic motion of the form $e^{j\omega t}$. However, for high frequencies or for distances close to the surface of the piston, a more rigorous approach is to divide the surface of the piston into infintesimal hemispherical sources (as with calculations of radiation impedance) all having the same (known) velocity, and to integrate over the surface to obtain p (Figs. 5 and 6).

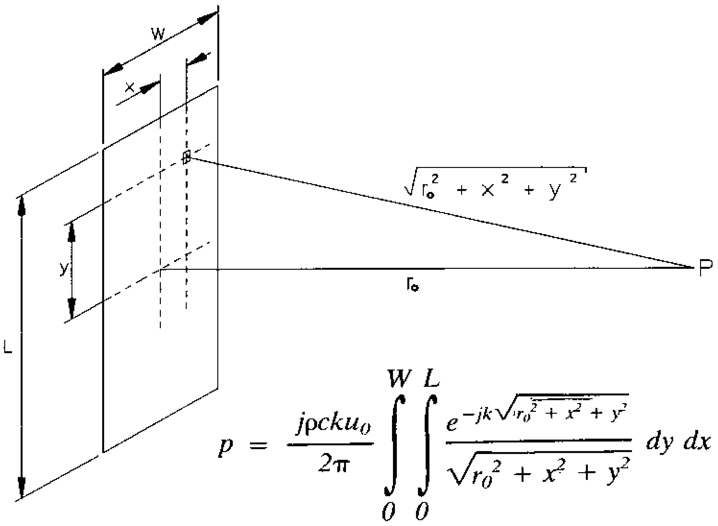
Circular piston



$$p = \frac{j\rho c k u_0}{2\pi} \int_0^{2\pi} \int_0^{R} \frac{e^{-jk\sqrt{r_0^2 + a^2}}}{\sqrt{r_0^2 + a^2}} \, a \, da \, d\theta$$

Figure 5. Calculation of sound pressure due to a circular piston, at any point along its axis

Rectangular piston



$$p = \frac{j\rho c k u_0}{2\pi} \int_0^{W} \int_0^{L} \frac{e^{-jk\sqrt{r_0^2 + x^2 + y^2}}}{\sqrt{r_0^2 + x^2 + y^2}} \, dy \, dx$$

Figure 6. Calculation of sound pressure due to a rectangular piston, at any point along its axis

In the case of Sound Power *(W)* we have the straightforward expression

$$W = \frac{u_0^2.Rerf}{2}$$

where $Zerf = Rerf + j.Xerf$. (Clearly knowledge of the radiation resistance is crucial to this calculation.)
Now Sound Pressure Level and Sound Power Level can be calculated from

$$SPL = 20.\log(|p|/p_0) \text{ and } SWL = 10.\log(|W|/W_0)$$

where $p_0 = 2.10^{-5}$ N/m^2 and $W_0 = 1.10^{-12}$ *Watt*

Results

A comparison is made between a circular piston and a rectangular piston having identical electro-mechanical parameters, the only difference being the radiation impedance data. The diaphragms are taken to have very low static mass (230 mg) because the radiation impedance is of greatest significance, and therefore of greatest interest, in such circumstances. The force factor *(Bl)* is 0.082 Tm, and the diaphragm area is 5.83×10^{-3} m^2. Compliance is taken to be very high, such that it is insignificant except at very low frequencies. The input electrical voltage is 0.26V. D.C. resistance *(Re)* is 0.138 ohm. Remember that it is most practical to assume an electrical input which is constant with frequency. It is less realistic to assume, for example, constant diaphragm acceleration, because of the complex nature of the radiation impedance.

As previously noted, if we wish to model loudspeaker behaviour at mid and high frequencies then we cannot ignore the effects of radiation impedance. Hence, all following data contain the functions shown in Figure 1 as representative of *Zerf*.

Figure 7 shows the difference in particle velocity magnitudes of the two diaphragms. Notice the discontinuity in the circular case.

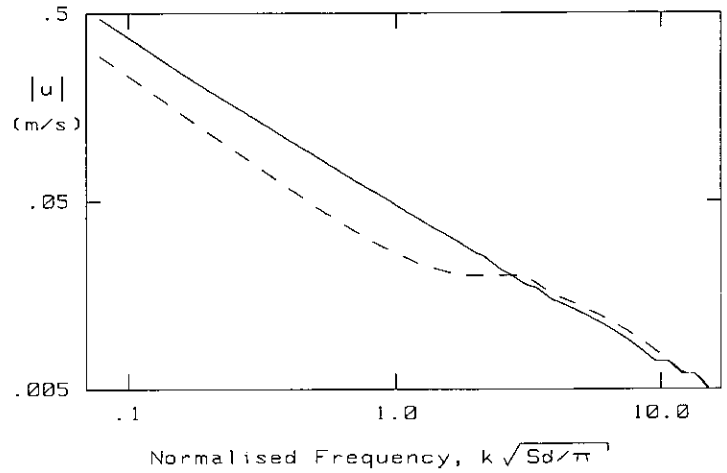


Figure 7. Modulus of particle velocity: broken line – circular diaphragm; solid line – rectangular diaphragm

Figures 8–10 compare the SPLs of the two cases at varying axial distances from the source. Note that the high-frequency response of the rectangular diaphragm becomes more extended with increasing distance. Another way of interpreting this phenomenon is that the soundfield becomes more hemispherical in the far-field. Because the equivalent circular piston has a maximum dimension (i.e. radius) of $R = 0.043$ m (cf. $L = 0.53$ m for the rectangle) radiation is already virtually hemispherical at $r_0 = 1$ m. Hence there is no significant change in SPL response shape for the circular radiator at $r_0 = 4$ m.

Figure 11 shows the Sound Power Level curves for the two cases. The particle velocity is dependent upon the radiation impedance (both resistance *and* reactance): hence there is a complex interaction between velocity and radiation resistance which determines the SWL. It is clearly inadequate to assume a velocity function (such as 'constant with frequency' or 'inversely proportional to frequency') when employing the radiation resistance to calculate Sound Power output. In the circular case the discontinuity in velocity is exaggerated by discontinuities in the radiation resistance. The rectangle exhibits a smooth roll-off in power response.

Perhaps the most significant observation is that the rectangular diaphragm exhibits up to 4 dB increase in efficiency in comparison with its circular counterpart. This is primarily due to the considerable reduction in radiation reactance (or 'mass loading' effect) at low frequencies. This is

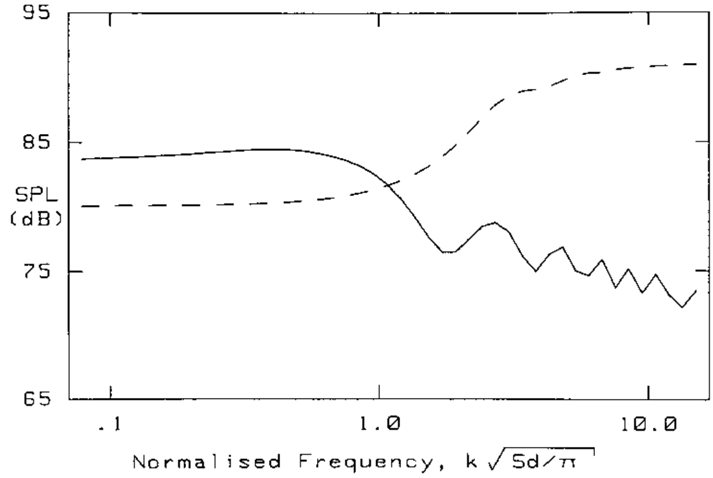


Figure 8. Comparison of the SPL models at a distance of 1 m along the piston axis: broken line – circular; solid line – rectangular

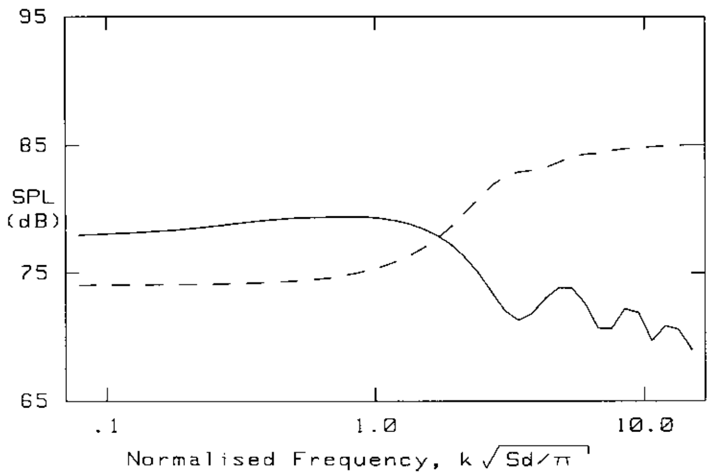


Figure 9. Comparison of the SPL models at a distance of 2 m along the piston axis: broken line – circular; solid line – rectangular

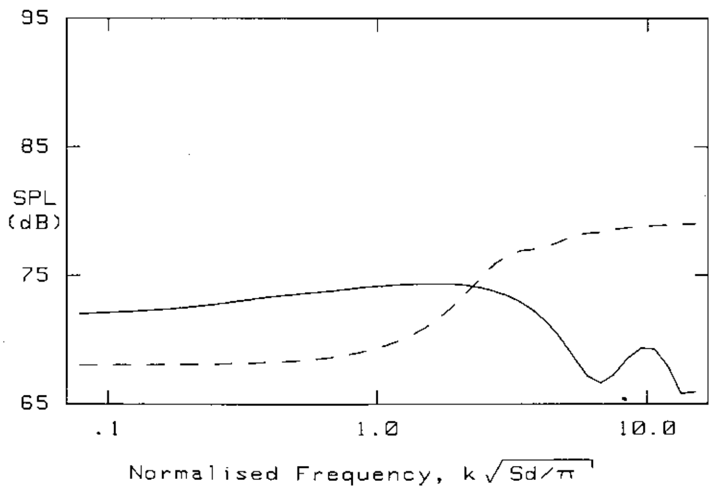


Figure 10. Comparison of the SPL models at a distance of 4 m along the piston axis: broken line – circular; solid line – rectangular

a consequence of the change in geometry, but remember that the radiating area is *identical* in both cases. The 'hemispherical approximation' formula is useful as a quick and simple indicator of this difference. At low frequencies, the predicted SPLs at 1 m are 84.1 dB and 80.1 dB respectively.

References

1 Bank, G and Wright, J R. *Radiation Impedance Calculations for a Rectangular Piston*, Audio Eng. Soc. Preprint 2777, March 1989.
2 Lipshitz, S P and Vanderkooy, J. *The Acoustic Radiation of Line

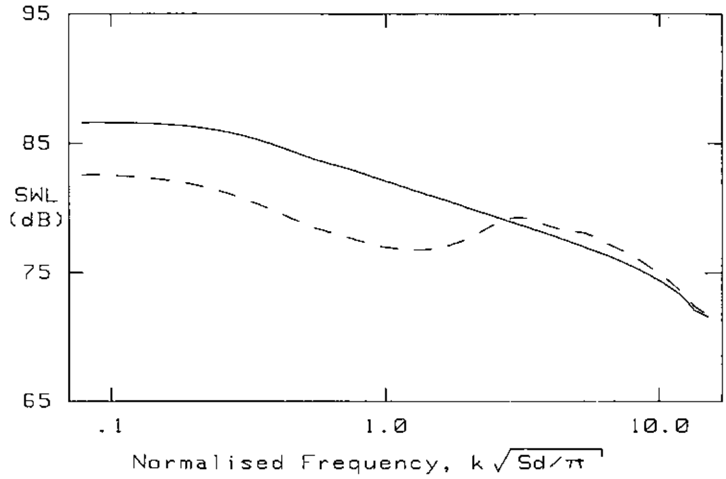


Figure 11. Sound Power Levels. Broken line – circular, solid – rectangular

Sources of Finite Length, Audio Eng. Soc. Preprint 2417, November 1986.
3 Rayleigh, J W S. *The Theory of Sound*, Dover, New York, 1945 (first edn 1896), Vol. 2 art. 302.
4 Beranek, L L. *Acoustics*, Amer. Inst. of Physics, New York, 1986 (first edn 1954).
5 Kinsler, L E and Frey, A R. *Fundamentals of Acoustics*, Wiley, New York, 1962, pp. 177–183.
6 Wright, J R. *An Empirical Model for Loudspeaker Motor Impedance*, Audio Eng. Soc. Preprint 2776, March 1989.

Technical Articles

The editorial board would welcome offers of technical articles on Acoustics and related subjects likely to be of general interest. Please contact the Editor, John Tyler, at 11 Colwyn Close, Yateley, Camberley, Surrey GU17 7QH.

NOMINATIONS FOR IOA HONOURS AND AWARDS

The Institute of Acoustics annually honours people whose contributions to acoustics have been particularly noteworthy. The awards under consideration during 1990 are the Rayleigh and A B Wood Medals, Honorary Fellowships and the Simon Alport Prize. The Rayleigh Medal will be awarded to a foreign acoustician and the A B Wood Medal to an acoustician from the USA/Canada. Nominations for these honours are now being sought.

Rayleigh Medal

John William Strutt, Third Baron Rayleigh (1842-1919) is remembered as a most versatile physicist, both as an experimentalist and as a theoretician. A graduate, fellow and finally Chancellor of Cambridge University, he was early elected to Fellowship of the Royal Society of which he was President from 1905 to 1908. He received the Nobel Prize for physics in 1904.

Rayleigh's work covered practically every branch of physics and he was the co-discoverer with William Ramsay of the rare gas argon. In acoustics, he published over 100 articles and his book *The Theory of Sound* remains a landmark in the development of the subject.

The Rayleigh Medal, of gold-plated silver and bearing the portrait of Lord Rayleigh, is awarded without regard to age to persons of undoubted renown for outstanding contributions to acoustics.

The award is normally made to a United Kingdom acoustician in even-numbered years and to a foreign acoustician in odd-numbered years. The Medal was instituted by the British Acoustical Society and has been awarded by the IOA since 1975.

The Institute is pleased to have honoured these acousticians with the Rayleigh Medal:

P H Parkin UK 1975
L M Brekhovskikh USSR 1977
E G S Paige UK 1978
E A G Shaw Canada 1979
P E Doak UK 1980
K U Ingard USA/Sweden 1981
G B Warburton UK 1982
E J Skudrzyk USA/Austria 1983
J E Ffowcs-Williams UK 1984
P J Westervelt USA 1985
E J Richards UK 1986
M R Schroeder Germany 1987
D G Crighton UK 1988
H E von Gierke USA 1989
F J Fahy UK 1990

A B Wood Medal

Albert Beaumont Wood was born in Yorkshire in 1890 and graduated from Manchester University in 1912. In 1915 he became one of the first two research scientists to work for the Admiralty on anti-submarine problems and he later designed the first directional hydrophone for use in submarine detection. He was well known for his many contributions to the science of underwater acoustics and for the help he gave to his younger colleagues.

The A B Wood Medal and Prize, instituted after his death as a result of the generosity of his friends on both sides of the Atlantic, is aimed at younger researchers whose work is associated with the sea. The silver-gilt medal, parchment scroll and cash prize were first awarded by the Institute of Physics in 1970 and are awarded alternately to acousticians domiciled in the UK or in the USA/Canada.

Recipients of the A B Wood Medal are as follows:

P A Crowther UK 1976
P R Stepanishen USA 1977
A D Hawkins UK 1978
P H Rogers USA 1979
I Roebuck UK 1980
R C Spindel USA 1981
M J Buckingham UK 1982
P N Mikhalevsky USA 1983
M J Earwicker UK 1984
T K Stanton USA 1985
P D Thorne UK 1986
D Chapman Canada 1987
V F Humphrey UK 1988
M G Brown USA 1989
A P Dowling UK 1990

Honorary Fellows

Honorary Fellowships are awarded to distinguished persons intimately connected with acoustics, or a science allied thereto, whom the Institute wishes to honour for exceptionally important services in connection therewith, and any distinguished person whom the Institute may desire to honour for service to the Institute or whose association therewith is of benefit to the Institute, shall be eligible to become Honorary Fellow of the Institute. The total number of Honorary Fellows shall not exceed 2 per cent of the number of persons elected as Corporate Members of the Institute. Honorary Fellows are:

W P Mason USA 1974
D G Tucker UK 1975
R W B Stephens UK 1977
L W Cremer W Germany 1977
J Lighthill UK 1978
W A Allen UK 1978
E J Richards UK 1978
J Lamb UK 1980
W Taylor UK 1980
F Interslev Denmark 1981
C A Taylor UK 1985
B Pippard UK 1985
P V Bruel UK 1986
C M McKinney USA 1986
M E Delany UK 1989

Simon Alport Prize

The prize is donated by Cirrus Research and awarded by the Institute in memory of Simon Alport, a young engineer whose career in acoustics was tragically cut short. It is presented to the person or persons who, in the opinion of the judges, have published during the year of the award the best paper describing work involving the use of computers in acoustics. Papers published in English in recognized journals or in the proceedings of conferences or meetings will be eligible for consideration. Recipients must be under the age of 30 years on the date of publication. The previous winners are:

J R Wright UK 1987
A M Raper UK 1988

NEW ELECTIONS

The following elections to membership of the IOA were recently approved by Council.

FIOA

D G Bull	M A Jack
J R Cowell	C L Morfey
B Haltoff	

MIOA

J R Brooks	S H James
G C Boutell	G T H Junefelt
J T Cowling	A K L Leung
G Dalgarno	H M Leung
R B Gillham	C K D Law
N L Gross	F R Mark
P M Guest	R L Simpson
H H R Gwatkin	S P S Tsoi
K Harpur	

AMIOA

D C Anderson	J Lloyd
J Britten	P Mallard
J Dalton	S Mesure
C E F Herbert	D R Moore
S J Holmes	N D Porter
C J Jackson	S D Stringer
R F Jones	J D Waring

Associate

C P Chin	W S Kwok
S Clark	J P North
J W Howie	C R Walsh

Student

A D Brierly	J R Landick

IOA Diploma Examination 1989

Report of the Chief Examiner

Once again, a perturbation has been induced in the Table of Results by a change of Specialist Examiner. This year, the examiner for the *Architectural and Building Acoustics* Module was new, and the Results Table reflects this fact. With an externally assessed examination, it is inevitable that a change in examiner will upset the established pattern and style of questions and that this could result in candidates behaving in a rather different way from before. This happened in recent years of the Diploma with the *Law and Administration* Module and with the *Noise Control Engineering* Module. The *Law and Administration* Module examiner also changed this year, but this time without too many disturbances. The Chief Examiner is of the opinion that these perturbations are not a cause for serious concern and hopes that the new Syllabus which comes into effect with the 1990 examinations will help to reduce them in future.

A great deal of effort has been devoted in the past year to the creation of a new Syllabus to cover the examination years 1990–1995, and to reflect the importance of the Diploma as a part of the educational qualifications for the grades of IEng and CEng which members are now

Continued on opposite page

IOA Diploma Examination 1989

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

Bristol Polytechnic
P A Austin
S P Brown
S K Candy
M R Cranfield
M C Dillon
T J Dixon
P J Dykes
H P Mackie
N J Norwood
M L Parenti
J Savage

Colchester Institute
P R Anderson
S R Barker
S J Daniels
M P Hollier
L Leadbetter
S Looser
H D McGregor
D J Osborne
C M Pink
B Rochester
I J Sams
A Smalls

Cornwall College
M Slater
S P Smith
P A Trew
K F Wakely
A Whitfield

Derbyshire College
L J Armstrong
G D Aveyard
N A Beardsley
T J Braund
M S Briggs
M C Checkley
I J Cook
P J Dawson
N R Duffin
L Fawthrop
L M Gartside
R Knox
J E Prosser
N J Proudfoot
S C Quick

Heriot-Watt University
P J Allish
M C C Duffy

Leeds Polytechnic
D J Cherry
C W Hill

Liverpool Polytechnic
E M Bichard
R J Chuter
C M Dawson
A B Dunn
G C Edwards
D M Foreman
L McLintock
P G Michel
P Slinger
H A Thomas
D R Tinker
M A Walker
L J Williamson

IOA Diploma Summary 1989

College	Architectural Acoustics			General Acoustics			Law and Administration			Noise Control Engineering			Transportation Noise			Vibration Control			Project			Totals				Pass %
	M	P	F	M	P	F	M	P	F	M	P	F	M	P	F	M	P	F	M	P	F	M +	P +	F →	T	
A	6	15	2	1	36	5	6	17	0	2	14	3	5	18	1	2	2	1	3	35	10	25	137	22 →	184	88.0
B	0	10	4	0	13	1	0	1	0	0	1	0	1	10	2	1	5	0	4	11	2	6	51	9 →	66	86.4
C	0	1	0	0	0	0	0	0	0	0	5	1	0	0	0	0	0	0	0	2	0	0	8	1 →	9	88.9
D	0	0	0	0	4	4	0	4	0	0	1	1	0	1	1	0	0	0	1	5	3	1	15	9 →	25	64.0
E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	2	1 →	3	66.7
F	0	0	0	2	10	0	2	10	0	0	11	1	0	0	0	0	0	0	3	9	0	7	40	1 →	48	97.9
G	6	8	2	2	20	0	1	11	1	3	4	1	2	13	0	1	0	0	2	9	12	17	65	16 →	98	83.7
H	0	0	1	6	7	2	2	11	2	2	2	0	4	8	3	0	0	0	2	13	4	16	41	12 →	69	82.6
J	0	0	0	4	8	0	1	5	0	4	8	1	0	0	0	3	4	2	3	9	0	15	34	3 →	52	94.2
K	0	0	0	0	1	0	0	1	0	0	0	0	0	2	0	0	0	0	0	2	0	0	6	0 →	6	100.0
L	0	0	0	0	9	0	1	5	3	0	7	2	0	0	0	0	0	0	0	2	7	1	23	12 →	36	66.7
P	0	8	2	5	10	0	0	1	1	0	2	0	2	8	2	1	5	2	2	12	0	10	46	7 →	63	88.9
Totals	12	42	11	20	118	12	13	66	7	11	55	10	14	60	9	8	16	5	20	111	39	98	468	93 →	659	
Pass %	83.1			92.0			91.9			86.8			89.2			82.8			77.1			85.9				85.9

M — Merit P — Pass F — Fail T — Total

Note: Candidates who did not submit their project report by the due date are shown to have failed in the Table of Results.

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
- F Bristol 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
- P Sheffield Polytechnic

NESCOT (North East Surrey College of Technology)

N Barrett	C P Jones	A J Pipe
M J Bates	P L Jones	T L Powell
S Byrne	S C Jones	S A Rundle
J Dalton	P J Kessel	P Saich
P A Dinn	A C Lewis	P J C Shortt
D F Dooley	G B C Madden	M A Stagg
K M Gentles	S D McQuade	P J Summersell
G St J Hawkes	N H Nawell	P T E Symonds
R G Heathcock	P Nicholas	J G Tierney
J M Hewish	A R Page	J M Tomalin
S Howells	C M Pennington	M S Wright
S J James		

Newcastle Polytechnic

G R Anderson	K W C Gong	M J Scott
J M Anderson	T A Mawdesley	M B Yeadon
D Cudmore		

Sheffield City Polytechnic

S R Butler	R B Griffiths	D W Mosley
H J Cipcer	P T Jackson	S Walker
J C Compton	R Kirk	P Whitaker
S Dawson	I J McKechnie	B J White

North Staffordshire Polytechnic

C A Britton	M S Rowley	J W Sweetland

Tottenham College

C M Alston	K Eleftheriou-Vaus	P Mallard
S M Beaghan	M G Esom	J Robinson
J Britten	J R Gerring	C N Savage
B P Creavin	N M Hargreaves	

Congratulations also go to the candidates listed below for obtaining passes in additional Specialist Modules in 1989

Colchester Institute

A Lockwood	M D Wheatley

Liverpool Polytechnic

R T F Dennison	S J Haigh	R Pemberton
J Gledhill		

NESCOT

D S Cunningham	D G Langdown	G E Scott
J J Farr	R K Parkinson	G J Steady
L T Glass		

Tottenham College

G F Bradford	S C Coxell	A L Watts
A Conrad		

Certificate of Competence in Work-place Noise Assessment Pass List

Colchester Institute

A D Coles	B G Hatch	G Seal
J C Galley	R A Pettitt	D S Wood
C P Gray	W E Scott	

NESCOT

M East	S Mills	S Rabson
M C Hinks		

Sheffield City Polytechnic

D J Cherry	P T Jackson	D W Mosley
R M Ford	J E Kaczmaryk	P Naylor
D Gresswell	A S King	I Twynholm-Mason
R B Griffiths	A G Lee	S Walker
J P Hunt	P Milner	

able to approach via the Institute of Acoustics. An additional aim is to make it clearer to both candidates and tutors that the Diploma is intended to train practical acousticians having both a reasonable grounding in the basic physics and also the ability to tackle problems in the field. An innovation in the Syllabus is the appearance of Commentaries expanding upon the underlying aims and coverage of each module. A new module on *Sound Reproduction* has been added to reflect the increasing importance of this aspect of acoustics.

An important change to the administration of examinations was instituted this year: the Chief Examiner and Deputy Chief Examiner moderated nearly every script submitted by candidates. In particular, the Chief Examiner scrutinized a significant number of the General Module scripts to test that the marking was uniform and fair between Colleges and also to investigate possible reasons for the unusually high average mark. He is glad to report that all was well; candidates had clearly been very well prepared for the examination by most Colleges and marking had been fair and careful.

As mentioned above, the *Architectural Acoustics* Module caused more than a little concern this year; to resolve any possible doubts, it was decided that the Chief Examiner should remark the entire paper. The result of this exercise was a marginal change in overall marks, but the distribution of Merits and Passes was slightly affected by adjustments made to the class boundaries by the Chief Examiner as a result of the greater knowledge he had gained about the paper.

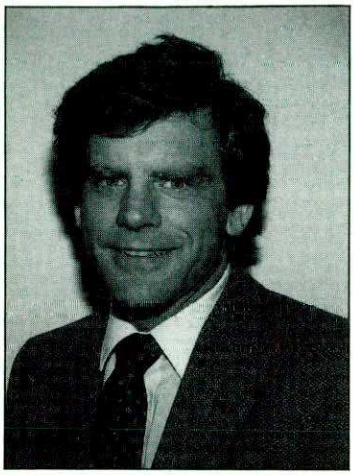
In the previous years, the Chief Examiner's report has expressed concern about the inability of some candidates to tackle problems which were not exactly along the lines of those in which they had been coached. The scripts of the *Architectural Acoustics* candidates reinforced this concern: many candidates presented answers containing largely irrelevant standard bookwork and exhibited a disturbing lack of ability to examine the problem which had been posed in a systematic and scientific way. The very low average mark on the paper this year seems entirely fair and appropriate. It is hoped that Colleges will address this problem in the future.

J M B

The 1989 A B Wood Medal and Prize

Michael G Brown

For his contributions to knowledge in theoretical underwater acoustics.



Michael Brown was born in 1954. He studied physics at the University of California at Irvine and was awarded a BA in 1977. Subsequently he carried out research at the Scripps Institution of Oceanography of the University of California at San Diego for his PhD, which was awarded in 1982. During this period he investigated the problem as to whether measured acoustic travel times between many different sources and receivers could be inverted to yield useful estimates of the three-dimensional sound speed field. His major contribution was the application of a Green Function to acoustic propagation in the oceans. This formed the bulk of his thesis and was subsequently published in 1982. Prior to his work the procedure had been awkward; namely to compute the multipath travel time pattern using the parabolic wave equation. This approach only permits calculation within a very narrow band. In order to consider the propagation of a pulse it is necessary to add the solutions from many adjoining narrow frequency bands. Professor Brown showed that the pulse response could be computed directly, subject to the same underlying assumptions. He demonstrated that the two procedures led to identical results. The work has been the backbone of tomographic interpretation ever since. The computer code he developed as part of his studies has been extensively used in interpreting a number of tomographic experiments and is now a standard code for rapidly computing the impulse response for range independent propagation along wholly refractive paths in the ocean's interior.

In 1982 Professor Brown joined the Rosentiel School of Marine and Atmospheric Science at the University of Miami as Assistant Professor and subsequently became Associate Professor in 1985. Here he began an investigation which led to a series of papers that extended our knowledge in several areas of ocean acoustics. Prior to this work there had been very few applications of catastrophe theory to the marine environment. His research has led to the new and exciting prediction of classical chaos due to a proliferation of caustics in ray theoretical acoustic propagation. As a consequence, even when the ocean environment is known exactly there exists a predictable horizon that limits the range to which acoustic fields can be predicted.

Professor Brown has recently turned his attention to a new set of ocean problems. These deal with tracer dispersal in a turbulent flow and also with new methods of using freely floating drifters for making underwater measurements. He has demonstrated an outstanding command of theoretical acoustics and the maturity and insight to identify and apply theories to new topics of study.

Professor Brown was presented with the A B Wood Medal during the IOA 'Sonar Signal Processing' Conference held at Loughborough 11-13 December.

A Note on Sponsors, Exhibitions and Advertisements

You may have read, in the July edition of the *Bulletin*, that the Institute is making some changes in its Sponsor Membership Scheme. These include different levels of Sponsorship and increased opportunities for commercial companies to promote their products and services at Institute events.

There are many benefits to be gained by closer links with commercial companies involved in Acoustics and the revised scheme offers ways to improve these relationships. Many companies benefit from the work the Institute does in creating a market for acoustic products and services, and the Institute gains from the information and knowledge available within different commercial concerns. Closer links with the commercial sector also provide financial and technical advantages for the Institute.

There are now three grades of sponsoring which closely follow the concept of corporate member grading. Initially four commercial companies have become 'Key Sponsors'; Brüel and Kjær, CEL, Cirrus Research and Hakuto, all of whom have been closely concerned with the Institute and all have staff members who are corporate members.

At present the main opportunity for direct communication between members and commercial companies is via the exhibitions which take place at Institute meetings and conferences. This is an important area of activity which could be improved to the benefit of both the exhibitors and the members of the Institute. Certainly, many new measurement techniques have first been shown to members at Institute conferences.

For some time it has been felt that improvements could be made to the exhibition format and to help produce these improvements, an Exhibition Manager has been appointed. This is, like all Institute activities, a purely voluntary post and Andy Watson has 'volunteered' for this task. His job will be to improve the quality of exhibitions and to increase the number of opportunities available for commercial companies to meet with Institute members. Andy will not be responsible for organizing Institute events, but will be liaising with organizers to ensure that exhibitions are given proper consideration.

During the recent Windermere conferences, we had the opportunity of discussing exhibitions with all of the companies represented at these events and we were very pleased to learn that there is a high degree of interest in our plans to improve this side of the Institute's activities. As a result of these discussions, we will be producing a new Exhibition Policy which should ensure that future events provide even greater opportunities for successful exhibitions.

One of the first jobs to be carried out is the creation of a database of companies interested in participating in our events and this is being put together by our secretary Cathy Mackenzie. This database will be used to distribute information about exhibiting at Institute events.

We feel sure that every commercial company, consultancy practice and educational establishment could benefit from a presence at Institute events and this is a good time to ensure that your organization is kept informed of these opportunities. Please contact Cathy Mackenzie or Andy Watson to include your organization in the exhibition database and I look forward to meeting many more new exhibitors at future Institute events.

At the same time, our longstanding arrangement with our Advertising Agent has ceased and the job is being taken on by Keith Rose from the BBC. Keith has been a Fellow of the Institute since 1977 and has been involved in Acoustics for about 30 years; his book on Studio Design is a classic.

The initial task will be to broaden the advertiser base, to try and make the *Bulletin* self-financing.

I have been given the task of coordinating these new initiatives and will be responsible to Council for ensuring that the new posts work together with the Secretariat; as advertiser, sponsors and exhibitors tend to have many common elements. Council is most concerned that these changes do not in any way dilute the academic and professional approach of the Institute, but only strengthen it financially.

Dudley Wallis

NON-INSTITUTE MEETINGS

1990	
February	*Fourth Conference on Hydro- and Geophysical Acoustics,* Rostock, E. Germany.
6–8 March	International Congress on *Recent Developments in Air and Structure Borne Sound and Vibration,* organized by the Dept. of Mechanical Engineering, 201 Ross Hall, Auburn University, AL 36849-3541, USA.
20–22 March	IMechE International Conference on *Engineering – A Quieter Europe,* at the Centennial Centre, Birmingham. Details from IMechE on 01-222 7899.
10–13 April	First French Conference on Acoustics. Details from: Congrès Français d'Acoustique, I.C.P.I. Lyon, 25 rue du Plat (or 31 Place Bellecour) 69288 Lyon Cedex 02, France.
21–25 May	Meeting of the Acoustical Society of America, State College, Pennsylvania.
6–8 June	16th World Congress of the International Association against Noise, AICB, hosted by The National Society for Clean Air, at the Brighton Conference Centre. Details from: National Society for Clean Air, 136 North Street, Brighton, BN1 1RG. Tel: 02273 26313.
19–23 June	Symposium on *Physical Acoustics, Fundamental and Applications,* at the Catholic University Leuven Campus Kortrijk in Belgium. Details from: Prof. O. Leroy, Katholieke Universiteit Leuven Campus Kortrijk, E. Sabbelaan, B-8500 Kortrijk, Belgium. Tel: (056) 21 79 31.
8–10 August	International Tire/Road Noise Conference, Gothenburg, Sweden. Details from: U Sandberg, Swedish Road and Traffic Research Institute, S-581 01 Lønkoeping, Sweden. Tel: +46-13-115200.
13–15 August	*Internoise '90,* International Conference of Noise Control Engineering, Gothenburg, Sweden. Contact: Internoise 90, Chalmers University of Technology, Gothenburg, Sweden. Tel: INT+ 4631 72 22 11
27–31 August	*12th International Symposium on Nonlinear Acoustics,* in Austin, Texas. Details from: Mark Hamilton, Department of Mechanical Engineering, The University of Texas at Austin, Austin TX 78712-1063, USA.
October	*29th Acoustical Conference on Room and Building Acoustics* – Czechoslovakia.
26–30 November	Meeting of the Acoustical Society of America – San Diego, California.

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.

BRANCH AND GROUP NEWS

North West Branch

September evening meeting

The Branch held its September evening meeting at Vibronoise Limited. Ken Irish gave a warm welcome and introduced Karl Pratt and his superb presentation on the 'Dynamic Analysis of Structures using Finite Element Methods'. With the aid of equipment from Brüel & Kjær and Protek, we were entertainingly guided step by step through the dynamic analysis of a fabricated mild steel bracket. Karl described the various types of element used in finite element analysis and then demonstrated how to generate the three-dimensional computer model of the test bracket. He explained how the latest computer software had simplified this process, and reduced the timescale significantly. For example, a few years ago this simple structure would have taken approximately two days to generate and now takes approximately two-and-a-half hours. Following discussion on boundary conditions he illustrated the predicted natural frequency and characteristic mode shapes. The modal stresses were displayed and discussed; these can sometimes be useful in checking if the model is correct as some of the simpler stresses can be calculated and checked against the values obtained from the model. The next stage was to add damping in order to analyse the forced response of the theoretical model. The loss factors can be defined for the various materials in the system based upon energy sharing. He then carried out modal analysis on the model structure and compared the results with measurements made on the real structure. The results showed that extremely close modal correlation can be achieved between a theoretical model and the real structure. Karl illustrated along the way many of the pitfalls that can occur when using these techniques. As a finale Karl presented a set of high resolution computer displays showing the modal stress plots of typical structures. This was followed by a lively discussion which continued over the delicious refreshments.

Meet the IOA evening at Salford

In October approximately 90 undergraduates and NW Branch members attended the 'Meet the IOA' evening at the University of Salford. The meeting provided an opportunity for anyone studying acoustics to meet and discuss the Institute and careers in acoustics. Mike Ankers gave a presentation on the aims and structure of the IOA and introduced our invited speakers for the evening, Duncan Templeton of BDP, Nicola Alexander of Vibronoise and Don Baines of ICL. Following the presentations there was plenty of opportunity to visit the display stands and talk to representatives from Accent Systems, Brüel & Kjær, CEL, Cirrus Research, Dunegan, PDA, SUBS and Vibronoise. I would like to thank all those who supported this successful meeting, in particular the guest speakers and the representatives of all the companies who attended.

Chris Waites

Eastern Region Branch

Visit to British Telecom Research Labs

A small group of 7 members were treated to a very interesting afternoon by BT Research Labs staff on 11 October last.

The first part of the visit was spent in the sound and vibration labs. Excellent practicals were given in the anechoic and reverberation chambers, the former being used for a vivid demonstration of ambisonic sound. Vibration testing facilities were also featured.

The hosts for the second part of the afternoon were the speech and natural language division. The initial demonstration featured a speech-activated home banking system, with a high level of security, which is in current public use. This was followed by details of the Skyphone system for use on aircraft which is being developed from the extensive speech processing techniques available.

Annual General Meeting and Laboratory Visit, Woods of Colchester Ltd

The first annual general meeting of the Eastern Branch was held at Woods of Colchester on the evening of 15 November 1989. Eighteen members of the branch attended. The meeting was formally opened by chairman David Bull. The secretary's report was then presented, and a brief résumé follows:

The Eastern Branch has now successfully completed its first year of operation. So far four events have taken place since the inaugural meeting held in Bury St Edmunds on 11 October 1988.

The Spring/Summer programme began on 1 March 1989 at Colchester Institute with a double headed meeting 'Noise Standards and Legislation', with speakers, Alan Dove (HSE) and Bill Uttley (BRE). An interesting presentation was followed by a lively debate. 'Getting Computers to Talk' in Bury St Edmunds on 26 April was presented by Marcel Tatham. Keith Rose co-hosted two visits to the BBC radio studios, at Chelmsford on 14 June and in Norwich on 21 June. In both cases the feedback was very positive.

A very informative visit to BT at Ipswich in the afternoon of 11 October was disappointingly attended by only seven members.

The eight-strong committee of the Eastern Branch under the guidance of Chairman David Bull have now had a

Letter from the Vice-President Groups and Branches

I have some good news for overseas members. At its recent meeting, Council adopted the idea, originally put forward by a member at a local branch meeting, that we should have an Overseas Liaison Officer. The main task of the appointee will be to improve the links between the Institute and members overseas so that their specific needs can be covered a little better than they have in the past. If there are any members, either at home or abroad, who have suggestions for consideration by the liaison officer, please let me know in the first instance.

Branch activities in the UK seem to be growing and I am particularly pleased that secretaries are taking the time and trouble to write reports for the *Bulletin*. I know from those meetings I have attended and from members I have spoken to that the quality of the speakers and visits is extremely high and of great interest and benefit to those who attend. On behalf of Council I wish to thank those who have organized these events and would point out that, thanks to the *Bulletin*, their efforts do not go unnoticed by the membership at large.

For obvious reasons there is a growing interest in 'noise in the workplace'. Branches might wish to give some thought to organizing a local meeting to cover the latest developments. I'm sure the HSE specialist inspectors will be willing to help. Why not ask other local societies such as the Institute of Occupational Safety and Hygiene if they would like to take part in a joint meeting?

Geoff Kerry

total of six meetings and the future programme covers a number of very attractive events, and will be publicized via the excellent newsletter which is mailed direct to the IOA members in the region, and produced by Terry Metcalfe. The Branch has also forged useful links with other professional bodies and future events could include some joint ventures.

The hidden sponsorship received by the Branch in the form of support by the committee's employing organizations is gratefully acknowledged; without it our future success would certainly be less secure.

The main thrust of future activity in the Branch needs to be centred on the expansion of membership and increased interest and awareness of the IOA in the region.

The treasurer gave a brief statement of the branch funds. All of the present committee members were re-elected en bloc.

David Bull thanked the committee and all those who had assisted in the organization of events in the first year.

Members felt that half-day meetings are worth having provided that the content is worthwhile: the low attendance at the BT visit was due to a combination of many factors and future events should be better supported. They are likely to include some joint ventures with other professional bodies such as RIBA and the IEE; this will ensure that the high quality of programmed events is maintained. Events for the coming year will include 'Computer based H&V Acoustic design' in March 1990, a visit to Lotus Cars in April and possibly a half-day meeting on Vibration with the Environmental Health officers in June. Further visits to BBC studios are another possibility.

Woods of Colchester R&D visit

The branch was treated to a guided tour of the Woods Laboratory; several dynamic systems were demonstrated to show the range of work undertaken at Colchester. For many people it was their first opportunity to view 'Industrial Fans' first hand.

The working model of a Low Vibration/High Efficiency variable pitch in motion axial fan, developed for the clean room industry, was the first demonstration. This was followed by a Jetfoil tunnel ventilation fan, a low noise heat transfer fan, Axcent 2 mixed flow fan in an Air handling unit and a demonstration of the problems associated with Inverter Drives used for fan speed control.

The work involved in the development of fans was outlined and the problems associated with special products such as fans to meet airstream temperatures of 600 °C for 1 h were discussed.

This tour was enthusiastically received and guide Peter Hunnaball and his staff were kept busy with the questions put to them by the visitors.

Peter Hunnaball

Copy for the *Bulletin*

Contributions and information for the April issue of *Acoustics Bulletin* should reach Marjorie Winterbottom at 14 Witney Road, Long Hanborough, Oxon OX7 2BJ, no later than Tuesday, 20 February.

Diploma in Acoustics & Noise Control

Prize Winner:
B Rochester – Colchester Institute

Highly Commended:
M S Briggs – Derbyshire College of Higher Education
M C Checkley – Derbyshire College of Higher Education
K M Gently – NESCOT
M P Hollier – Colchester Institute
P Mallard – Tottenham College

New Products

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

Noise event card
The CEL 5739 Noise Event Card for the CEL 238A Secondary Processor is designed to be used with the 100 dB span CEL 493/2 Precision Integrating Sound Level Meter. The combination monitors all sound levels in the range 40-140 dB(A) and records the date and time, duration and rating sound levels of any noise event which exceeds the user-set limit. In addition a graph of the sound level caused by the event can be produced. All results are stored in a battery backed up memory and can be subsequently printed on the CEL 238's buildin high resolution thermal printer, or transferred over the computer interface to a PC.

For further information please contact Lucas CEL Instruments Ltd., 35-37 Bury Mead Road, Hitchin, Herts. SG5 1RT. Tel: 0462 422411; Fax: 0462 422511; Telex: 826615 CEL G.

Environmental noise analyser
The Model 870 Environmental Noise Analyser from Larson Davis has a measurement range of 115 dB(A) and is to IEC 651 Type 0 accuracy. Its dual statistical processors provide both short term and long term reports of L_{Aeq}, L_N, SEL, Time History, and level exceedances.

The Model 870 has a full complement of detector modes with a choice of 'slow', 'fast' or 'impulse' and in parallel with these the weighted or unweighted peak may be measured and stored simultaneously. Additionally, there is the facility to store three channels of synchronous analogue data, such as temperature, wind speed, wind direction, humidity, etc. For data download, complete reports may be outputted directly to a printer or to a computer using the Larson Davis programs or the user's own program. The large memory capacity of the 870 provides the choice of data processing by the 870 or by the computer. If required it can store over three days worth of 1 second L_{eq}'s. For more complex applications, several Model 870s can be linked for simultaneous measurements which can be relayed by radio modem to a central computer.

For more information please contact Alan Boyer, Industrial & Marine Acoustics Ltd., 16 Scardale Crescent, Scarborough, North Yorkshire YO12 6LA. Tel: 0723 364495; Fax 0723 500094.

New low-density infill material
Glass Fibre Thermo-Acoustic Batt has been specially developed for insulation specialists EBIS Ltd. to provide the attenuation needed for industrial silencer infill – whilst offering greatly improved handling characteristics over non self-supporting mineral fibre slabs.

The inherent advantage of the long fibres in Thermo-Acoustic Batt allow acoustic performance to be maintained at relatively low densities. Normal binder content has been raised from 5 to 7% ensuring high rigidity and resistance to compression. The strength is equivalent to mineral fibre slabs at much higher densities.

Thermo-Acoustic Batts are rot-proof, odourless, non-hydroscopic and do not encourage the growth of fungi or moulds. They are dimensionally stable under varying conditions of temperature

NEW PRODUCTS *continued*

and humidity and exhibited no settlement when tested under vibration to BS 2975.

More information is available from K. Lancaster, EBIS Ltd, Fryers Close, Bloxwich, Walsall WS3 2XQ. Tel: 0922 710727.

Acoustic wall and ceiling panels

The Heraklith Acoustic range of ceiling and wall panels has been introduced onto the British market by Atellus Limited.

Manufactured from magnesite bound woodwool by a patented process proven over 80 years, they contain no noxious nor allergy-inducing elements and are ecologically and biologically positive.

Heraklith panels are tough, durable, impact resistant, dimensionally stable, have high humidity resistance and provide high sound absorption and attenuation performance. Ideally suited for the interiors of sports halls, schools, swimming pools, retail interiors and offices, the performance of Heraklith Acoustic panels makes them also suitable for workshops and factories.

A variety of surface finishes, panel thicknesses and sizes and edge details, for different methods of installation, are available as standard and panels can be supplied either natural colour or white as standard, with colours to special order.

For further information please contact James Muir, Atellus Limited, Park House, Marlow Road, Maidenhead, Berkshire SL6 6NR. Tel: 0628 34563.

Institute of Acoustics Meetings

1990			
February	M	Noise from Electric Motors	Bratby/Nottingham
March	M	PC Programmes in Acoustics & Speech	London
27-30 March	M	**Spring Conference – Acoustics 90**	University of Southampton
14-21 May	M	Noise and Vibration from the Channel Tunnel Project	Ashford, Kent
May	M or BAG	Measurement of Vibration in and around Buildings	London
June	M	Military Aircraft Noise	Lakenheath
September	M	In-situ Transmission Loss Measurement	London
September	M	High-intensity Sound	London
October	M	Low-frequency Noise and Vibration in Transportation	London
November	M	**Reproduced Sound 6**	Windermere
22-25 November	M/SG	**Autumn Conference 90 – Speech**	Windermere

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
LB = London Branch

EB = Eastern Branch
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
P.O. Box 320
St Albans
Herts. AL1 1PZ
Tel: 0727 48195

NEW ELECTIONS

Elections to membership of the IOA at the grades shown were approved by Council in October 1989:

FIOA

A P Dowling
P Howell
W Stubbs

MIOA

N J H Alexander
C F Au
K A Broughton
M Budd
S G Carden
K C Cheung
H G Cox
J Dye
R M Ford
N J Fowler
S L Goodman
C Grimwood
C D Harfield
N Hill
M Kleiner
W-T L Lau
T H Lewers
D J-F Luquet
D Markham
R C McLean
R T McMillan
P W Moore
D E Poley
A K Pratt
K Scannell
S A W Skrautvol
M R Smith
E E Snow
P Tarrant
J D Tattersall
D G B Thomas
K-K Tsang
K-Y Tsang
I Twynholm-Mason
E K Wong
M L Wright

AMIOA

P J Allish
C M Alston
G D Aveyard
C Barlow
J J L Beard
C Beckett
S P Boyle
T J Braund
C A Britton
I D Clarke
C M Dawson
P J Dawson
S Dawson
D M Foreman
A A Gibson
R B Griffiths
J L Horner
B R Q Hunter
R N Hunter
D King
D G Langdon
A Lockwood
D Maundrill
P A McLean
H D McGregor
J P Newton
N J Norwood
A J Pipe
N J Proudfoot
J Robinson
P Saish
M H D Santer
K J Thomas
H M Thornton
K F Wakely
S J Walsh
B A Wilkins
J W H Wong
M E Wainwright

Associates

S J Diston
M E Wong
K Cheung
Y A Hon
Y K Lai
T Leung
Y K Leung
W Lok
C H Ng
C Tam

Students

H A Akil
I A Mair
P J Moys
P Robinson