THE NON-ENVIRONMENT CONTROL ROOM

The concept of the sound-absorbing acoustic trap has become closely identified with specific styles of acoustic design. In this article Philip Newell looks at how and why they work. He then proceeds to the concept of the 'non-environment' control room and the experience with the rooms built so far

The concept of the recently emerging 'all-trap' or 'non-environment' room was discussed in 'Monitor systems — part 11' (*Studio Sound* March 1991). Suggestions that bass traps had no mathematically proven acoustic basis have been rife for years but recent research by Brazilian acoustician Luis Soares has begun to throw more light on the subject. The fact that they do work is patently obvious to all who have ears to listen but one problem with their academic acceptance has been their empirical origins and complex nature of operation. Within the recording industry, the term 'bass trap' can usually be traced back to Tom Hidley in the late '60s.

In the '50s, Hidley worked for JBL in Los Angeles, and on one particular occasion, a loudspeaker was taken into a listening/testing room known to have low frequency problems. Upon setting the system up, it was noticed that the LF response was smoother than usual and this was initially put down to the new loudspeaker design. When this loudspeaker was auditioned elsewhere, the benefits were no longer apparent, so other loudspeakers were taken into the test room, where once again, a smoother LF response was noticed. Something had clearly happened to the test room, but the only change to the room was that a group of blackboards and screens had been moved into the room for temporary storage. When these were removed, the bass problems returned, so Hidley asked colleague Bart Locanthi what was happening. Locanthi, whose knowledge of acoustics was at that time significantly greater than Hidley's, replied that the boards were acting as traps, the low frequencies effectively went in but did not appreciably re-appear.

Some years later, Hidley was working in New York, when the Record Plant asked him to look at some LF problems in a room. Remembering the earlier traps he decided to try a system of angled, free hanging baffles in a giant contrivance on wheels (which proved too heavy to be movable) that dramatically improved the acoustics of the room. Such traps and Tom Hidley became almost synonymous over the next 20 years. After a brief retirement from studio design in the early '80s, Hidley returned with a new all-trap approach around 1984. As discussed in 'Monitor Systems' the concept was intended to achieve the monitoring performance of a large anechoic chamber, effective down to very low frequencies, while retaining an acceptably live acoustic for speech and other activities within the room. The answer was the 'monitor dead' approach where the monitors could 'see' no reflective surfaces other than the hard floor, while the occupants of the room could perceive reflexions from their own voices and activities via a hard front wall, much of the equipment, and again, the floor. It was from the psychoacoustic viewpoint of the relatively low perceived imaging disturbance caused by vertical reflexions that the floor was chosen as the main reflective surface. It could provide some desirable reflexions with minimal, unwanted, side effects. The full development of the principle led to rooms with hard front walls and floors, with every other surface trapped to as low a frequency as possible given the size of the space available.

The trapping system has developed over the years to a high degree of effectiveness and predictability, but although the free-hanging, fluff-covered baffles look simple, the acoustic manipulations that enable them to be effective have proved hideously complex. When the traps form the bulk of a room, they act as absorbers, diffusers and waveguides, reducing very significantly the broadband energy, which can return to the listening area after the first pass from the monitors. The empirical evolution of trap design has passed through many phases on its way to current thinking. During this process, many designers have used the concepts 'parrot fashion' with varying degrees of success, frequently achieving a success rate greater than would be expected from mere fluke by virtue of the fact that the traps work in such multifunctional ways. On the other hand, the inappropriate use of such systems had also led some designers, whose applications have been unsuccessful, to suggest that the whole concept is flawed and inappropriate for the studio design application.

In their current forms, the all-trap, or non-environment rooms originating from Hidley's mid '80s ideas are highly effective in the control of low frequency reverberation times. While the fine detail of the construction concepts still require a degree of practical experience in their fine tuning, the basic concepts are now quite well understood. There is no deliberate vagueness here to protect trade secrets, it is just that the overall complex inter-reactions take some understanding, and where compromises are required experience has no substitute. In essence, however, heavily trapped rooms show modal characteristics that are firstly typical of physically larger rooms, and secondly, much broader than the modes of a similar, untrapped room.

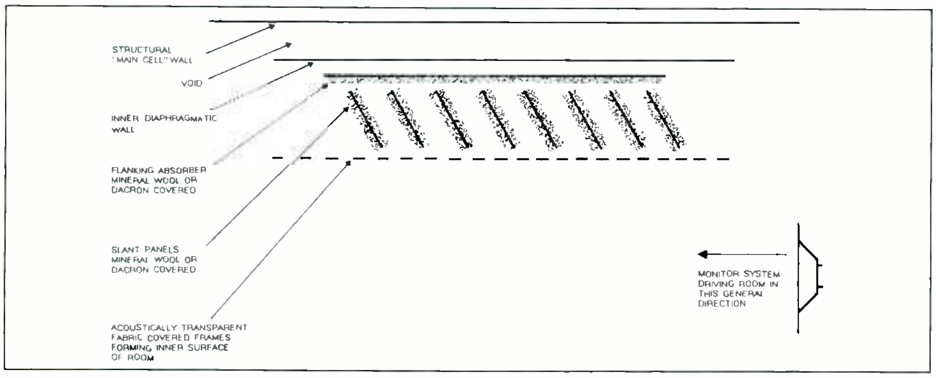

FIG 1: Plan view of full development of a Hidley style wall trap

Theory of operation

Fig 1 shows a section of a typical Hidley-trapped wall. The flanking panel, which hangs parallel to the wall, is extremely important in terms of the effectiveness of the overall system. The 'chip cutter' slant panels in front act partially as waveguides, bending the low frequency incident waves to cause them to strike the flanking panels at an angle of around 45°. The 45° angle renders the absorption more effective than would be the case for a too shallow or too direct strike. This is akin to the use of wedges in anechoic chambers where the wavefronts largely strike the absorbent materials in a gradual manner. Three feet of foam wedges, although containing less absorbent material than a 3 ft thick solid foam block, are more effective in terms of absorption. Again, the destructive power of an ocean wave striking a sheer cliff is greater than that same wave could achieve when rolling up a sloping beach. It is thus important that the slant panels are orientated such that they capture the wavefront at an optimum angle to steer that wave towards the flanking absorbers at an angle of maximum absorption.

The waveguide effect can clearly be shown by hanging baffles consisting only of dense *Rockwool* or similar absorbent in the position of the normal slant panels. When this is done, the absorption is greatly reduced at low frequencies. Inserting a thin solid panel within the absorbent baffle will begin to improve the low frequency absorption, which will continue to improve as the solid panel is thickened, thus becoming less transparent to the low frequencies. Once the panel thickness becomes sufficient for the waveguide effect to be significant, then no further increase in thickness will show any benefit in terms of LF control. Indeed, as far as the low frequencies are concerned, the solid panels alone will show a marked improvement in the performance of the trap than would be the case for the absorbent panel alone.

When the panels are formed from a combination of solid core and absorbent covering, the absorbent covering has entirely different modes of operation in terms of the low frequency, and the mid/high frequency absorption. At middle and high frequencies, the absorption is a function of density, porosity and thickness, and is entirely conventional in operation. At low frequencies, where the wave is directed between the panels, the wavefront entering the slant array will follow the waveguide panels. The sections of the wavefront passing immediately adjacent to the surface of the panels will have to 'drag' their way through possibly several feet of absorbent. **Fig 2** shows how the wavefront will be distorted in shape as the absorbent slows down and reduces the amplitude of the sections of the wave which are forced to pass through the absorbent material. Bearing in mind the complex path that the wavefront must follow in order to re-enter the listening room, especially in the light of the effect of the absorption of the flanking panels and a certain degree of absorption in the slant panels themselves, it is not too hard to see the potential for reflexion suppression.

The effective low frequency limit of the trapping is partially a function of the size of the flanking panels, where the largest dimension of the panel determines the half wavelength of the lowest frequency, which can be effectively absorbed. The room design itself also has a bearing upon the overall operation. Were the room to be considered a duct, then an absorber placed in that duct can be expected to achieve a certain degree of absorption. It is a well known acoustical principle that an absorber placed at the end of a side branch off that duct can achieve greater absorption than when placed directly in the duct itself. If one imagines the slant panels as producing a series of side

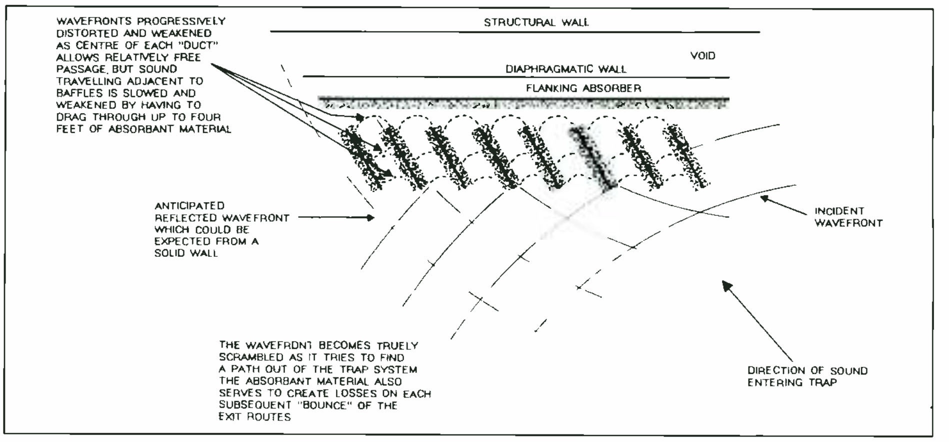

FIG 2a: Mid/high frequency absorption in a typical trap system

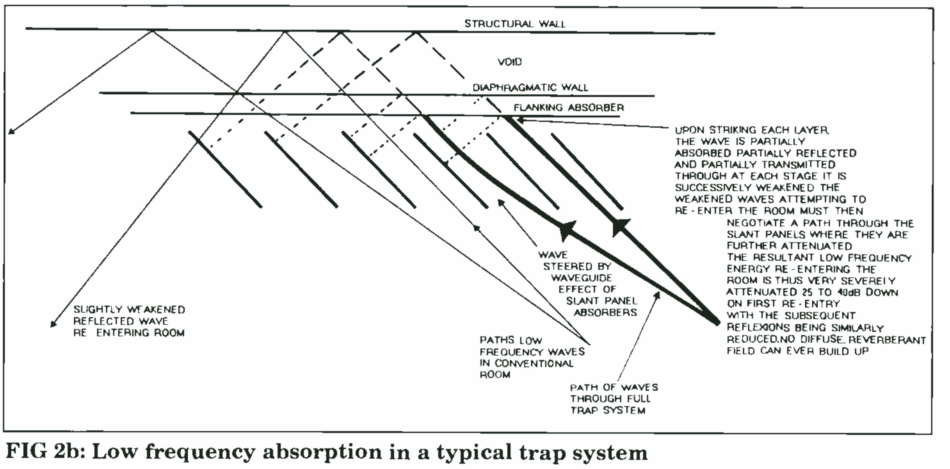

FIG 2b: Low frequency absorption in a typical trap system

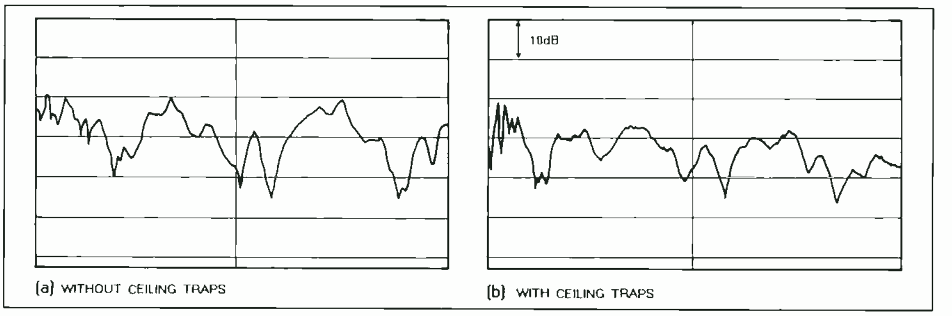

FIG 3: Effect of ceiling traps on modal pattern of room

branches off the main duct (the room) then the greater effectiveness of the flanking absorbers when placed behind the slant panels can be more readily understood. Some of the complexity of the systems can now be seen, as things are happening on several different scales simultaneously.

When these Hidley traps are enclosed within a diaphragmatic shell, the effect on low frequency reverberation time is even more noticeable. Reverberation is in fact a misnomer under such circumstances as no diffuse field ever develops. Individual reflexions decay before any truly diffuse field can be realised. Such a diaphragmatic shell would typically consist of a 4x2 inch timber frame, boarded on one side with a plasterboard/insulation board/plasterboard covering (somewhat similar to the old BBC 'Camden partitioning'). Where a significant gap can be left between this shell and an outer, sound containment wall, the low frequencies are even further controlled. The low frequencies will see the inner wall as being relatively transparent and hence will see the larger room of the sound containment shell. Even so, some attenuation will take place as the LF travels once each way through the wall, subsequently reducing yet again the LF energy returning into the room. As can be seen, the different mechanisms keep nibbling away at the potential reverberant energy, gradually taking it down to insignificant levels.

A further aspect of such systems is that sound passing over such a series of side branches can be slowed down by the highly dispersive nature of the multiple slant panels and the gaps in between. This is another means by which the room appears to be acoustically larger than its physical size. Typical modal patterns are shown in **Fig 3(a)** with **Fig 3(b)** showing the very even overall response after the addition of full ceiling traps; in this case the ceiling baffles were 24 ft long. Experience has shown that for the greatest sonic spaciousness, the slant panels should be in the order of 12 to 18 inches apart. Both extremes of spacing would yield flat walls, as one at each end would expose the flanking panel to only random incidence absorption, while too many panels, taken to the extreme, would yield a solid mass of panels, see **Fig 4**. Two to 4 ft appears to be the optimum range for overall trap depth; below 2 ft, audible effectiveness drops off rapidly whereas over 4 ft, further increases produce little significant effect and would generally be considered wasteful of both materials and available floor space.

Fig 5 shows a Schroeder plot of a typical decay curve for such a room. As can be seen, unlike a conventional room with a linear reverberation decay, the non-environment rooms lose their energy very rapidly in the initial stages of their decay. The rapid removal of energy, particularly when the room is excited from the direction of the monitor loudspeakers, allows much more 'space' for the perception of fine detail in the sound immediately following any transient excitation. Such a decay curve renders normal reverberation time measurement all but meaningless as we are no longer dealing with a room in any acoustically conventional sense of the word. **Fig 6** shows the decay tail of a 20 Hz highpass filtered step function for the first critical 20 ms after excitation from a well designed monitor system. The lack of resonant/reverberant overhang is clearly apparent, rendering insignificant the amount of masking energy available to muddy or smear the audible clarity of the monitor response. Strictly in terms of definition, imaging, a general clarity and the overall ability to show fine detail; when equipped with a suitable monitor system, such rooms are appearing to achieve results which have hitherto rarely been realised.

Aims, priorities and early reactions

Ever since the early days of Westlake Audio, Hidley had a goal of achieving a commonality of control room performance from room to room and country to country. Looking back on it, given the variability in shapes, sizes and installed equipment, the goal was probably unachievable given the technology of the day. In 1970 I built a super-dead control room for a client who agreed with the general idea. Again, because of the dead acoustic giving no help to the monitor loudness, I had to install four specially designed, electronically crossed over loudspeakers using 18 inch bass drivers of relatively high efficiency. Many people liked the monitoring but the room as a whole was not well received and was rebuilt within months on more conventional lines, though the studio recording areas remained the same for almost 20 years. The super-dead room was an early attempt to remove the room from the monitoring equation. Had I realised then what I know now, the addition of a hard front wall surface and a hard instead of carpeted floor would have rendered this room an early version of something remarkably similar to some of my current thinking.

There has always been a great deal of common philosophical ground between Hidley and myself, ever since I met him in 1974 and asked him to re-build the control room at The Manor, Oxford, UK. On the other hand, we have always had a differing order of priority for many of the aspects involved. The first great digging in of heels came with the proposals for the stone room in Townhouse 2, London, in 1978 where I opted for a far from controlled acoustic to break the grip of trends towards ever more 'neutral' studio areas as well as control rooms. One cannot however, deny Hidley's worldwide success with many, well satisfied clients, myself included. As technical director and a staff engineer/producer of the Virgin Recording Studio operation, I had already been designing studios for six years or more; why should I bring in another designer, Hidley, from 6,000 miles away? In a word, marketing. The fledgling Virgin organisation was trying to throw off its early image and needed something radical. It is hard now to visualise just how radical a development it was but I can still see the looks of stunned disbelief on the faces of so many people at the re-opening party in August '75.

I flooded daylight into the studio and we used glass doors between the studio and control room; there were so many departures from the norms of the day that I alone would have really been sticking my neck out in attempting to take such radical steps. Remember, I had nearly just lost my neck five years earlier with the super dead room at Majestic. David Hawkins, then owner of Scenic Sounds who were the Westlake agents in the UK, had done an excellent job of preparing the industry to expect something new from California. It took not only a viable new concept, but also a customer who was willing to take a risk and a well prepared marketing exercise in order to achieve a successful relaunch. But shouldn't the performance of the room have been able to sell itself in a 'technical' industry? Good question! The relevance of all of this will become apparent in later paragraphs.

Shortly after the completion of the Manor, Hidley sold his part of Westlake and came to Europe to form Eastlake. Around the time of the Townhouse construction in 1978/9, he then sold Eastlake to David Hawkins and retired to Hawaii. I effectively lost touch with Tom till he read some of my articles in 1989. Realising the commonality of some of our needs, we co-sponsored 1/10 scale modelling, carried out by Luis Soares at the UK Institute of Sound and Vibration Research (ISVR) on the full implications of the trapping systems.

Practical realisations

Eventually, I built a modified full scale model at the UK's Liverpool Music House (LMH), also incorporating a new monitor system using Keith

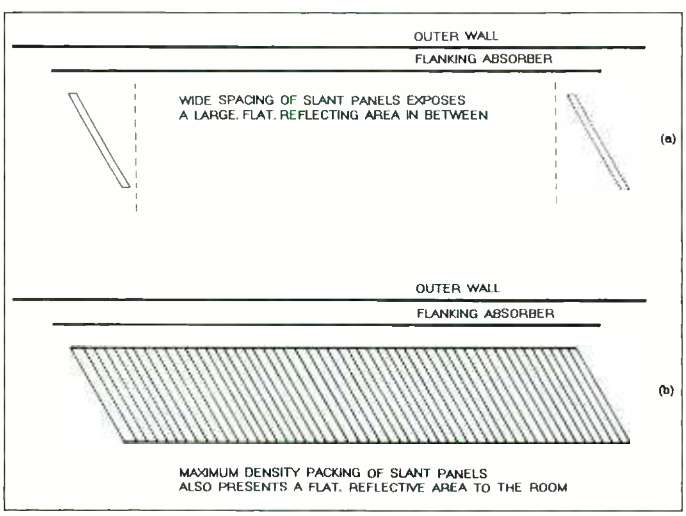

FIG 4: Effects of extremes of slant panel spacing

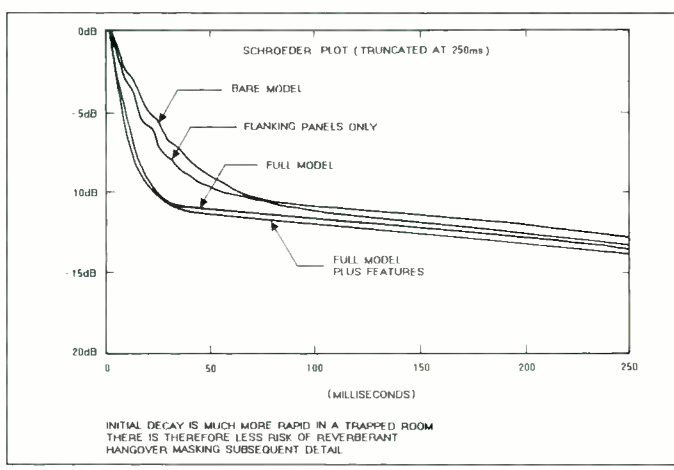

FIG 5: Schroeder plots of impulse decay curves of a modal room as trapping system is installed step-by-step (Courtesy Luis Soares)

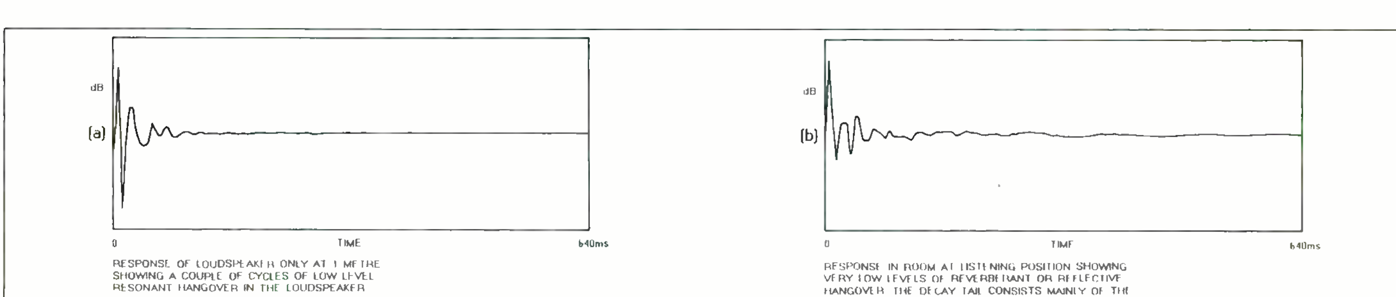

FIG 6: Impulse response of monitor system and room at Liverpool Music House 0 to 200 Hz

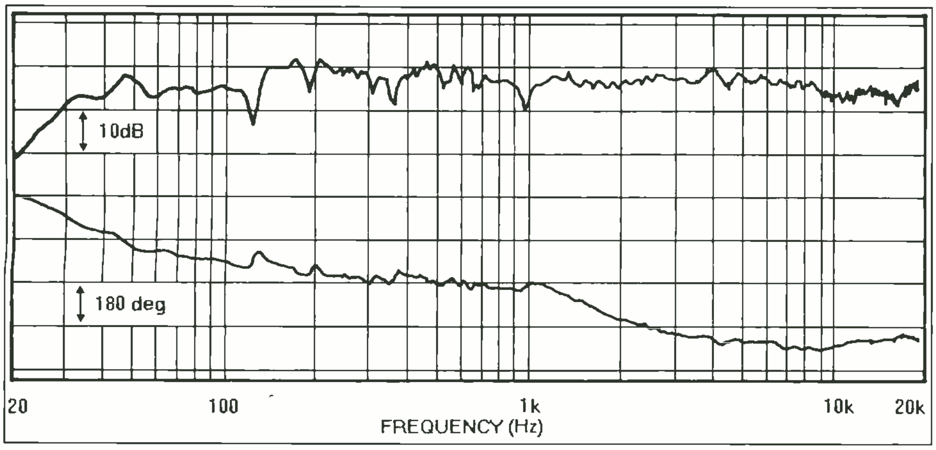

FIG 7a: 2-way monitor measured on-axis at 2 metres in situ in Liverpool Music House

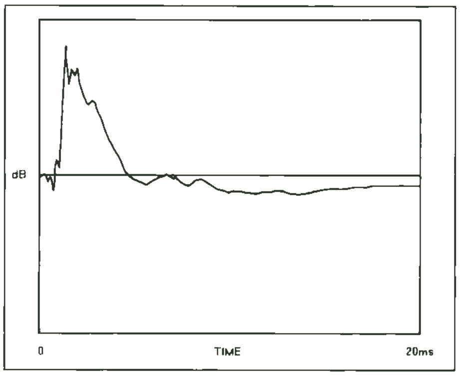

FIG 7b: Decay tail of step function — first 20 ms at Liverpool Music House (20 Hz and 20 kHz filtered)

Holland's (of the ISVR) newly developed axisymmetric horn, which was optimally matched to a TAD *2001* compression driver. The whole place was one giant test rig. Holland and I had in the past couple of years made presentations at the Institute of Acoustics (I of A) conferences, on developments in horn designs, and also on our feelings that transient accuracy, as defined by a plot of a step function response, was the key to sonic neutrality (*Studio Sound*, August 1989). Some comments at the time were to the effect that we were trying to re-invent the square wheel.

The new, large, highly absorbent rooms, however, would give no help in terms of loudness to the loudspeaker output. Indeed, they would be so similar to free-field conditions as far as the monitors were concerned that a 6 dB fall off per doubling of distance could quite reasonably be expected. We realised that high SPL monitors would be necessary, and a good step function response would require a minimum number of crossover points if amplitude and phase were to be maximally linearised. At the time, a superior horn and driver system appeared to be our only hope of achieving these goals on a reliable basis. In order to support such transient accuracy at the listening position, especially in terms of the reduction of the masking of further detail in the transient tail, a relatively dead room, even at low frequencies, was a further, seemingly mandatory requirement.

Once again, there was a strong link with Hidley's thinking, as he has been expounding the need for phase accuracy for 15 years or more. Without accuracy of both amplitude and phase responses, there is no hope of any system following a squarewave or a step function. Before the conclusion of the research projects of Soares and Holland, I cannot deny having to borrow a number of Hidley's techniques for the construction of the LMH. The results are shown in **Fig 7**. Plot (a) shows the amplitude and phase responses of the initially installed system with a temporary 20 Hz highpass filter, while (b) shows the step function response. Both these measurements were taken via multipoint Fast Fourier Transforms, in the room. There is no smoothing or ⅓-octave averaging they are raw plots. Everybody involved was delighted with the performance of the room and monitor system, both sonically and in terms of measurements: the two do not always coincide. The new horn was a revelation, maintaining its response with the TAD *2001* to around 22 kHz and yielding an exceptionally smooth directivity. The horn performance details had been first announced and published at the November 1990 I of A 'Reproduced Sound' conference.

When Hidley had launched his new room concept in the mid '80s, he was deemed by some, mostly in the UK, to be saying that his old rooms were a mistake. This was, of course, not so but merely the result of further experience and revised concepts. Anyhow, forewarned is forearmed so I decided to try to avoid falling into a similar trap by taking a stream of my former clients and colleagues to see and hear the new room in order to gain their comments and general opinions.

The acid test

The outcome, while most revealing, was not what I had anticipated. Some typical comments were "the biggest hi-fi I have ever heard", "I have heard for the first time what I always thought true stereo ought to sound like", "the best imaging I have ever heard" and so forth. A general consensus was that the bass was exceptionally clear and tight; the top was sweet, fat, clear and smooth, and most definitely not archetypal horn sounding. I could not have been more pleased with the visitors' reactions, in fact it was six weeks before LMH finally hooked up their *NS10*s; everybody had been happy with the main system and tapes taken away showed few surprises. Mixing was proving easy, as the overall clarity allowed clear cut decisions on positioning, equalisation and relative level.

The only significant questions from the auditioners were as to whether one would tend to mix with too much bass and too much reverberation in a room that was without a conventional reverb time, especially at low frequencies. The comments and questions coincided with the general reactions to the new style Hidley rooms upon their launch in the mid '80s. Once again, the answer seemed to be that one very rapidly accustoms oneself to the general characteristics, and as the reverb times of control rooms are generally of a much shorter nature than those added for musical effect, in practice there is no problem. In any case, the use of nearfield monitors on the mixing console would be generally similar to their use in a well designed studio of more conventional form. After all, one of the purposes of nearfield monitors such as *NS10*s is to eliminate as far as possible the room from the overall equation. The new non-environment rooms provided in effect a full range, 20 Hz to 20 kHz nearfield monitoring situation. Apart from the aspect of a more general reference to the frequency range of a typical, domestic system, the large monitors would seem to be generally restating their claim to be the main reference for a mix.

A few weeks later I began to receive some unexpected comments from a number of the people I had taken to the LMH, to the effect, "If you can give my studio some of the properties of LMH, then I would like to speak to you about it." Unfortunately, they were asking for some mutually exclusive characteristics such as a warm, wrapped around, low frequency character with the definition and clarity of the LMH system. Obviously, if the all-encompassing, warm, low frequency response were a function of the low frequency reverberation characteristics of their room, then it could not be achieved in conjunction with the clarity of the LMH system, as the clarity of that system had been achieved by the effective removal of any low frequency room reverberation. In 'Monitor systems — part 10', (*Studio Sound* February 1991) I discussed the concept that given the weaknesses in the electro-mechanical monitoring systems, it was not unreasonable to expect exponents of very differing types of music to opt for different systems. In Part 11, I expanded this further by suggesting that no single control room design could necessarily provide optimum conditions for music of either acoustic or electronic origins. The article concluded with a proposal for a room of a 'non-environment' type with dual monitoring and an artificial reverberation system distributed along the side walls, which could be switched in at will. I did not fully appreciate just how much of a necessity that may be until I received the delayed responses from the LMH auditioners.

What are our objectives?

Control rooms are no longer just control rooms. Often they are now the performing studios and it is the 'vibe value' of the conventional monitor system in a conventional control room that has now become such an established part of the performing side of a recording process. A neutral environment is by no means always desirable in a performing room. Possibly my concept of a multi-monitored, optionally artificially reverberated room may well be the only way out if one room is intended to cater for all tastes.

Returning to the purpose of a control room, if we restrict ourselves initially to the classical concept of a reference room, then among other things, one of the assessment aims will be to check the suitability of the mixes for domestic consumption. Concepts of control rooms having domestic-type reverberation times are waning as so many people now listen either on headphones or in cars, where conventional room reverberation times are not evident. Consequently, the non-environment rooms may well relate more appropriately to such listening conditions than would the conventional designs of control rooms. The question would seem to be, if no one type of room can be representative of all typical listening environments, then which design concept will produce the best end results on the types of listening systems for which those rooms were not optimised? The new non-environment rooms, with suitable monitor systems, are almost certainly capable of high definition of fine detail due to their greatly reduced masking of low level sounds by the reverberant hang-over from any immediately proceeding high level signals. Undoubtedly, there are many people who are excited by the detail and clarity of these rooms.

On the other hand, as a performing room, especially as so much of the music is now performed in the control rooms, there are other people who equally undoubtedly respond to the power and wash of a more reverberant room. Given these individual preferences, it is becoming apparent to me that each control room must be tailored to proposed usage to a degree never before apparent. Not only the acoustics but the overall feel of the environment must be optimised to the requirements of individual owners and users.

It is difficult to work to standards in such a subjective area. Taking things to an extreme, if a studio with poor monitoring were consistently producing big selling recordings, could it be considered a poor studio? It is not beyond the realms of reason that the success could be down to the effect of a couple of members of staff spurring on the bands to new heights of performance. Yes, it certainly can come down to such non-engineering criteria, but while we cannot define it, then nor can we deny it.

I have now built three rooms in Liverpool only a very short distance from each other. There is an old style room with an old style monitor system, a new style room with an old style monitor system, and a new style room with a new style monitor system. Each has developed partisan clientele who opt for whichever studio provides them with their specific needs. The three studios are not even in effective competition with each other, as there is little movement of work from one to another. While I can now achieve a great degree of predictability in the performance of any given room design, unfortunately I cannot box the sound and post it to people. When a client now asks me which approach to recommend, I still prefer sending the client, with his or her respective clients, to listen to the various approaches before final discussions take place.

The pro-conventional room lobby cite the warmth, the power, and the intimacy as pro's for their rooms. They complain about lack of intimacy in the non-environment rooms, as if the music were a separate happening in which they were only observers and not fully involved. The 'non-environment' followers claim superior imaging, definition, clarity, ease of decision making and general 'accuracy' for their rooms. They all seem to have satisfied and partisan clients who tell them that their room is the most representative that they have used. Even I must admit that with my old producer's hat on as opposed to my studio designer's hat, my choice would be dependent upon the type of music, the band and possibly which side of the bed I had just fallen out of.

And with my studio designer's hat on? If I think about it too hard I'll probably end up being arrested for taking my clothes off in the public library or something similar. Maybe the magazine should go and do some interviews on the subject, to find out what the industry wants, especially as I am now finding that many potential acoustic 'improvements' may well be retrograde steps in terms of the operational compromises for everyday use.

DESIGN PROJECTS

We asked a selection of studio design companies what they had been up to recently

Recording Architecture have recently completed this Portuguese studio complex in the centre of Lisbon, called Exit. There are three live areas, control room, machine room, programming suite and recreational areas. Special attention to glazing and careful planning allows vision from every space into every corner. Other recent contracts include Studio Three at CTS, Wembley, UK, and a new test chamber and listening/evaluation suite incorporating Black Box Acoustic Conditioning System elements for Canon Audio in Woking, UK

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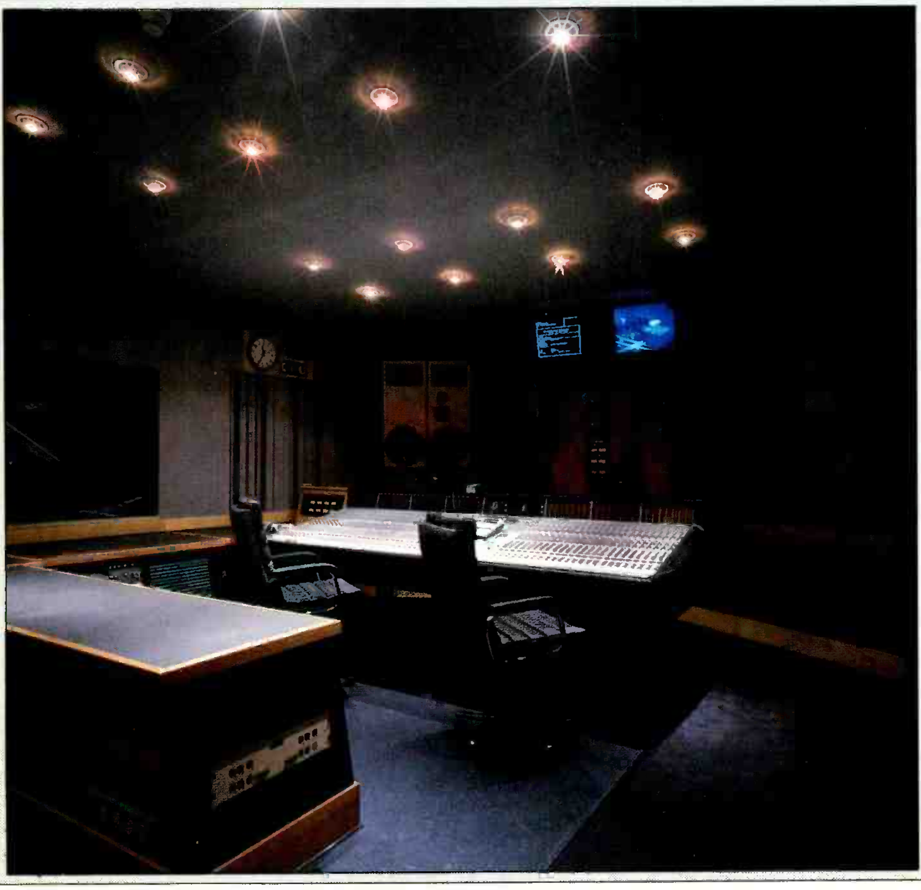

A recently completed project from Harris Grant Associates was Studio Four at the BBC Maida Vale Centre, London (left). Neil Grant commented that his company had never been busier, but most of the work was outside the UK. Other recent projects include the complete acoustic and technical design of Hit Factory New York. HGA finished Hit Factory London earlier this year

Harris Grant Associates
The Property Building
Pinewood Film Studios, Pinewood Road, Iver, Bucks SL0 0NH, UK.
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The Acoustics Design Group completed this audio-for-video suite recently for Eurosonic studios in Madrid, Spain. The facility includes a remotely and pneumatically operated variable reverberation time system in the recording area. The location within a roof space at the top of Eurosonic's complex gave rise to the ceiling profile and incorporation of skylights. Other current projects for ADG include Abbey Road's Studio Two; a major studio in California, the owner of which is remaining nameless at the moment; and a major recording studio in Port of Spain, Trinidad

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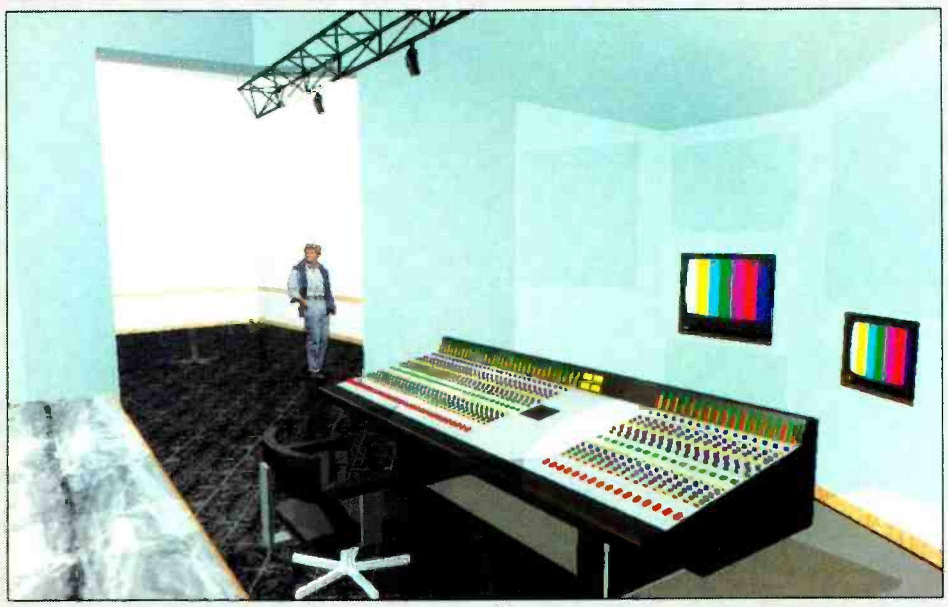

Russ Berger Design Group of Dallas, TX, recently completed the design of a 6800 ft² building addition for General Television Network (GTN), in Oak Park, MI. This 3D CAD drawing was developed in order to give GTN a conceptual idea of what the final facility would look like.

The finished surround sound audio post-production control room and studio

Russ Berger Design Group Inc,
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Eastlake Audio commissioned this model for a six-studio complex plus drama and broadcast studio facilities they are designing and building for the Government of Lagos state, Nigeria. The model is lying on part of the proposed building site. Other recent work includes the design and construction of a new 24-track Spanish facility in Barcelona; a personal recording studio for Italian superstar Antonello Venditti, at his house just outside Rome; and the completion of a state run 100-man orchestral studio in Tripoli, Libya

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A recent project from the Walters-Storyk Design Group was this five room post-production facility in Los Angeles, USA, Margarita Mix. Just for a change all the rooms are named after women, like Studio Barbara and Studio Anna. Other projects include a commission from The Sony Business and Professional Group to design a reference-quality corporate demo room for their professional products. WSDG has also developed a new AutoCAD-compatible acoustic design program called CART (Computerised Acoustic Ray Tracing). The process automatically calculates and graphically displays acoustic ray behaviour. Recent projects using the system includes Studio 9 at Howard Schwartz Recording and JSM Music, a new multi-studio complex, both in New York

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