low level, and all musical notes die away or reverberate. Therefore substantial amounts of distortion do exist in all digital recording, affecting in particular the dying-away tail in reverberant surroundings. And it is just this effect on the ambient sound to which I and other observers have drawn attention.

Completing the digital chain

Now let us consider what will happen when the digital chain is extended all the way through to our home record player. I have shown this in the lower right-hand side of Fig. 1. The D/A converter is bypassed and signals, still in digital form, are impressed by laser (at least in the Philips/Sony system) on to a master disc. Then follow new plating and replicating processes to permit the mass-production of digital audio discs (DAD). The DAD home player will incorporate a D/A converter so that we connect the output to a normal hi-fi amplifier and loudspeaker set-up for listening purposes.

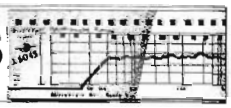
The advantages of digital audio should now be much more in evidence. After all, most of the restrictions in sound quality which we suffer at present are due to inadequacies in the LP record pressing cycle, the liability of vinyl LPs to attract dust and scratches, and the considerable distortions inherent in disc groove tracking and tracing. With these removed, DAD reproduction should be a revelation of clarity and freedom from distracting clicks and plops.

Even so, if there are indeed any audible problems with the digital process, surely we shall be exposed to their full glare since they will no longer be masked by the transfer to conventional LP which at present comes between us and the true digital sound.

There is still time for the backroom engineers to make quite sure that digital really does come up to all our expectations. The Philips/Sony Compact Disc (see our report on the Salzburg Presentation last month) appears to be the furthest advanced of the competing systems and yet is not due to appear until the end of next year. Let us hope that they get it right—or we shall get reaction like the following, which I quote from a letter recently received from reader K. W. Westcott in Australia: "If what I have heard of digital on the current 'digital' discs is any indication, digital could spell the end of musical sound on records. Frankly I have heard no digital disc that compares with a *good* analogue. Some give impressive, artificial sound. The usual effect is a cold, lifeless sort. I am even more worried about digital than SQ, and God knows I disliked that enough. All my friends share my opinion and have stopped buying digitals."

Sorry, Mr Westcott, I think you have overstated your case. Nevertheless the message is clear enough: digital records must bring us to a consistently higher plateau of quality than we now get from analogue, or they will fail.

Equipment Reviews



Quad ESL-63 electrostatic loudspeaker

Manufacturer: Acoustical Manufacturing Co. Ltd., Huntingdon, Cambs. PE18 7DB. Price: £1,000 per pair.

SO it's actually here at last. This oft rumoured, eagerly anticipated and much talked about loudspeaker has probably had the longest gestation period of any item of equipment which GRAMOPHONE has ever received for review; for, as many will have guessed, the 63 in its title refers to the year in which Mr Peter Walker, Quad's presiding genius, started working on it. Replacing every product each year in the Japanese manner has never been Quad style—"We try to get it right the first time"—but even so 18 years between models is a mite exceptional. Small wonder that at the recent Cunard High Fidelity Show everyone was talking about this loudspeaker (which was not there) and there was a deal of oneupmanship by those of us who had a pair over those who hadn't heard it yet.

Quad's first and still current full-range electrostatic loudspeaker, now nearing a quarter of a century in production, was so far ahead of its time, both in concept and in practice, that competitors reeled with shock. Laboratory teams were forced to spend time, effort and even money in trying to persuade their own company's products to render vaguely similar results to this new sound so obviously free from the quite outrageous resonances and colorations then accepted as the norm. The immediate effect on loudspeaker design was enormous and, even today, comments such as, "sounds a bit like an electrostatic" are seized on as high praise. Well, even at the end of 18 years, we must expect no such obvious a revelation for, in the interim, general standards have risen under the spur of fierce competition. However, it is already apparent that this new arrival has rippled the surface of any complacency we may have fostered about today's state of the art in sound reproduction.

A single membrane

Perhaps this revealing new loudspeaker has come at an opportune time. We are about to commit ourselves irrevocably to digital recording processes which may be deemed suspect in important parameters and which future progress will be unable to improve. As an example of what I mean, we can today retrieve Caruso or Beecham from archive groove or tape, with a result greatly superior to that achievable at the time of the original recording. Digital recordings in a format acceptable in their day would have set a limit for ever; no other information would have been stored for subsequent developments to reveal. Many intelligent people are suggesting that today's digital pill has too many side effects and that we should hold off for further consideration. Listening with this loudspeaker is certainly going to bolster their opinion; in a few short weeks it has often caused me to reconsider—both for and against—judgements which I had previously made on a fair number of records in my collection. So that perhaps is the true measure of the improvement it has to offer over all the competition, including its own worthy predecessor. How has this been achieved?

If I had to name the one major factor responsible for the superiority of this new design, I would say without hesitation it was that the complete sound originates from one single membrane which is electrically driven over its whole area. All previous designs with any claim to high fidelity, both electromagnetic and electrostatic, have used multiple units or sources with mechanical or electrical crossovers or both. Many have been highly ingenious in conception and excellently executed, but all have had to swallow compromise after inevitable compromise. Here we have something so close to the theoretical ideal that, for the first time, we can forget the loudspeaker as a barrier between us and a real source of live sound and look on it as a true and accurate recreator of the sound pressures which such a source would have produced.

Imagine a single thin plastics membrane weighing a little over one gram loosely stretched over a frame measuring about 800 x 600mm (30 x 24 inches). If you went out of doors to some quiet open spot and asked a friend to hold this frame between you and, say, a ticking clock, you would hear no change in the sound whatever. This is because the thin featherweight membrane would follow the air particle motions which constitute the radiating sound pressure waves very exactly. You could easily prove that this was so by substituting a solid board for the membrane, whereupon the sound would disappear, just as light does in a shadow. Now if it were possible to keep all parts of the membrane moving with each tick by some electrical means in exactly the same way as before, then the clock could be taken away and you would be listening to a reproduction—and that reproduction would by definition be completely indistinguishable from the original.

Quad have taken such a membrane, rendered it sufficiently electrically conductive to hold a standing charge of some 5,000 volts and stretched it as

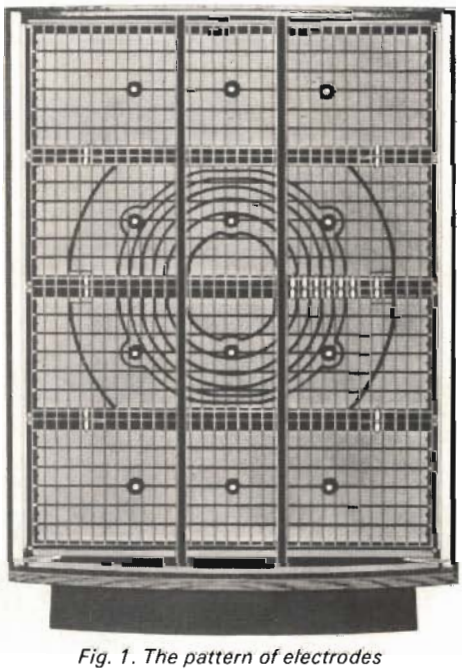


Fig. 1. The pattern of electrodes

a diaphragm between two sets of electrodes. These electrodes are made from copper-coated perforated plastics so that they are acoustically transparent. Each is mounted on a plastics grid, thus preventing it from moving in the plane parallel to the diaphragm, and each is cut to form circular concentric rings resembling an archery target. Figure 1 is a drawing of the construction in which you can see that the fixed electrodes are made up in four sections electrically bridged, the two outer ones continuous and the two inner ones ringed to form the 'target'. The audio signal is

raised in impedance by a pair of large transformers situated in the moulded plastics base which forms a plinth. It is then fed sequentially to each set of concentric rings via a series of inductors and capacitors which form a delay line. By selection of these constants, the designer can control the directivity of the loudspeaker, the mean spherical radiated energy and therefore the apparent source distance. The result will be a sound pressure wave of complete integrity in phase, frequency and directivity. All the response irregularities so familiar in multiple-unit loudspeakers are completely absent and smooth curves resembling amplifier treble tone control settings are measurable out to beyond 20kHz as one moves from the axis across the directivity pattern. After much experiment, the chosen directivity characteristic is one in which, both horizontally and vertically, there is a smooth tapering as the frequency increases (Fig. 2).

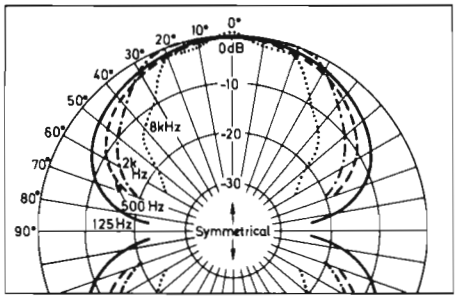


Fig. 2. Quad ESL-63 horizontal directivity pattern at four frequencies. (Vertical pattern is similar)

All GRAMOPHONE's audio team have visited the Quad factory over the last few weeks to see the initial production of this loudspeaker under way and, apart from marvelling at the skill of the lady winding the 6 x 40mm delay line inductors with 12,000 turns of wire little thicker than a hair, we were brought up short by one remarkable aspect of their final quality check procedure. Earlier in the laboratory we had been shown on an oscilloscope the loudspeaker responding most accurately to a pulsed square-wave, and been handed the tiny Bruel and Kjaer measuring microphone so that we could wave it about and examine for ourselves the complete regularity of the sound pattern produced. Now this in itself is a quite exceptional achievement, but we all kept our nerve and adopted a suitably blasé attitude indicating that we expected no less. However, in final test, we found on one side of the small partitioned area a 'standard' carefully measured loudspeaker and some two metres away a support on which each completed model was placed to be 'squeaked' for rattles and listened to on a taped selection of programme. Then both loudspeakers were fed with the same pulsed square-wave that we had seen before. This time, however, the microphone was clamped midway between the standard and the production model. The latter then had its audio connections reversed and lo and behold the square-wave was seen to be cancelled in air! An attenuator calibrated in 0.25dB steps could be adjusted for complete cancellation and, while I was there, no loudspeaker varied by as much as 0.5dB from the standard. Remember that this is a test, and a very critical one, of frequency response plus phase response plus directivity conducted in an open-sided booth on the factory floor.

The ESL-63 is a true dipole (its code name, FRED, was coined to stand for Full Range Electrostatic Doublet). Its sound dispersion pattern resembles two joined spheres, for it cannot move air in the plane of its diaphragm. Thus it directly excites room eigentones in only one dimension—although it is often preferable to angle it slightly and deliberately call up both horizontal modes, albeit some 2 or 3dB less than usual. This improvement in the ratio of direct-to-reflected sound, together with the smooth control of directivity, provides an unequalled statement of the stereo image when such is present in the programme, but an equally uncompromising declaration of disbelief in the false worship of too many microphones. Coupled with this is the utter smoothness of the very wide frequency response and the unnerving absence of self-generated colorations, which makes all the more obvious those which intruded at the source or are present in the listening room. Initial impressions have been unsettling for some listeners more familiar with the excesses emanating from too many of today's alleged high fidelity loudspeakers. Bland, dull, unexciting, cold, sterile are all words I have heard used to describe some of the sounds which can come from the ESL-63 and, fortunately for other loudspeaker manufacturers, they can all be true. Nobody is going to suggest that this is the loudspeaker for everyman and, in the present state of the art, many will prefer the warmth and the presence built into many good current moving-coil designs. I can go back 20-odd years and recall those same words being used about the first Quad ESL; I also remember Peter Walker saying, "If you don't like what comes out, pay more attention to what goes in". It is very significant that musicians and others who work in the field of live music are over the moon with this electrostatic design, when one chooses something appropriate and well accomplished for them to hear. They know that a brushed cymbal really has no predominant pitch nor does it hiss like steam; a bass drum has a decided snap to it and very little woody resonance; organ tone flows from open flues and snorts from boxy bourdons; violins can be sweet and seductive as well as sharp and glassy, and a good pianist at a good piano plays each and every note as a complete entity and not a slurred and smeary mish-mash. This loudspeaker can reveal all that and more, and I hope that it may regenerate realism in recording and reproduction in the same influential way that its predecessor did before it.

Even the loud world of pop may benefit, for the volume levels achievable (and the safety circuits incorporated) enable this loudspeaker to be used in circumstances where the early model would have had a very short life indeed. There are two protective arrangements in the ESL-63 which, in common with all electrostatic designs, needs guarding against excessive peak voltage swings. These, when transformed on to the fixed electrodes, could cause ionization of the air barrier, flashover, arcing and permanent damage. To avoid this, a soft limiting circuit comes into operation as a first line of defence as soon as the peak signal approaches 40 volts (100 watts into 8 ohms) and progressively bypasses any further amplifier output into some suitable power resistors. This arrangement works so well that one can deliberately push up the sound level well into limiting without making a nasty noise, until the amplifier itself current limits. However, if a fault occurs, there is a long-stop 'sniffer' which detects the onset of ionization and immediately triggers a triac (a type of fast-acting electronic switch) which in turn instantaneously short-circuits the signal being fed to the loudspeaker for about 200 milliseconds and repeats until the fault goes away. Because of this, amplifiers which are not short-circuit protected (most good designs are, but if in doubt consult the makers) should not be used with this loudspeaker. In practice this long-stop should never be called on to act but it needs to be there.

The normal load presented to the amplifier (Fig. 3) is an easy one to drive and any respectable amplifier design will cope. All the electronic bits and pieces of this loudspeaker are in the plinth and are best left undisturbed, as some quite lethal voltages are around when the thing is going. Here we find a small 5.3kV power supply using a rectifier/capacitor ladder fed from a mains transformer with IEC input socket, On/Off switch, red LED indicator and mains voltage

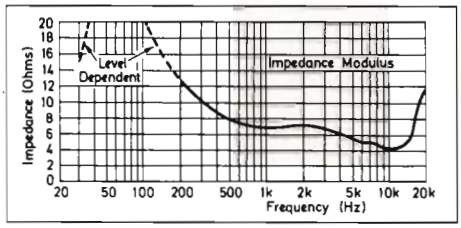


Fig. 3. Impedance modulus

selector. Power can be left on, as the consumption required to maintain the charge on the diaphragm is negligible. The two six-section delay lines and their terminating resistors are fitted on two printed boards immediately below the fixed electrodes. Spring-loaded terminals are used for audio signal connection and there are a few other components associated with frequency corrections to counteract floor reflections, etc. Incidentally, some users in some rooms who listen a lot to the spoken word, particularly the male voice, have preferred to raise this loudspeaker a little distance from the floor. Male speech originates both from the mouth and the chest wall; common microphone placing can favour the latter and recreating this sound at the normal loudspeaker height can result in lost naturalness. The loudspeaker is not wrong, as you can prove by getting someone to sit on the floor beside it and talk, it is just that we are not used to hearing the effect of floor reflections on a voice originating from that height.

Being amongst the first to use and to have the opportunity of reporting on the results of 18 years of Peter Walker's working life has given me a great and continuing pleasure. Although much of that time has been involved with the investigation of materials and methods rather than continuous development of the principle, which he had established a quarter of a century ago in a famous article in *Wireless World*, the real reward to him and all of us comes when you, the eventual user, are transported by the magic of the music which these loudspeakers can bring. On the first evening when I had a pair of the Quad ESL-63 loudspeakers to myself at home, record followed record on to the turntable interspersed with favourite tapes. As it grew dark, the curtains remained undrawn and, with the darkness, the walls of my room slowly melted away to reveal in turn a favourite concert hall, a church, an intimate studio for a solo voice, a rowdy jazz club, even an opera house, and finished with that patriotic indulgence from Philips "The Last Night of the Proms".

It was 2.30 in the morning; all marvellous, and an experience I would recommend you to follow if you can manage to get hold of a pair of these truly remarkable loudspeakers; but hurry up, the queue is growing and unfortunately at present the factory can make only a very limited quantity each week.

GEOFFREY HORN.

MAKER'S SPECIFICATION
QUAD ESL-63 LOUDSPEAKER

1. Type	Full range electrostatic
2. Nominal impedance (ohms)	8
3. Sensitivity	1·5μbars/volt referred to 1 metre (i.e. 86dB/2·83 volts rms)
4. Maximum input (volts)	10 continuous 40 programme, undistorted output 50 peak permissible
5. Maximum output (N/m²)	2 at 2m on axis
6. Directivity index	*Hz* *dB* 125 5 500 6·4 2,000 7·2 8,000 10·6
7. Frequency response (low level, on axis)	—6dB at 35Hz 3rd order and at greater than 20kHz
8. AC supply (volts)	240/200, 120/100 50–60Hz 5VA
9. Dimensions (cm)	Height 92·5 Width 66 Depth 27 including 15cm base
10. Weight (kg)	18·7 (23 gross)