HI-FI CHOICE

LOUDSPEAKERS

A UNIQUE CONSUMER GUIDE: 84 MODELS REVIEWED & COMPARED

BY ANGUS McKENZIE

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Hi-Fi Choice: Loudspeakers
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Of all possible subjects in the *Hi-Fi Choice* series, loudspeakers are almost certainly the hardest products to assess. Reasonable faith can be placed in objective testing of electronic equipment, such as receivers or cassette decks, but any findings for loudspeakers must be mainly subjective. So the results printed in this publication can only be as good as the ears of the people involved.

Fortunately, the qualifications and experience of all involved are such that considerable confidence can be placed in the findings that follow. Indeed, we feel we can claim that it is the most authoritative and best informed survey on the subject yet available.

No two pairs of ears are identical, and so opinions must differ. But if the publication is accepted as a guideline rather than a definitive statement, it should help the reader to make a more informed choice. But your ears must be the final arbiter. Try listening to loudspeakers in your own home before making up your mind.

I would like to thank all involved for their conscientious hard work in helping to ensure the success of this project, particularly Angus McKenzie for his unstinting dedication to the publication and his constant determination to be fair in his assessments.

In addition, my thanks must go to Nicky Paul-Barron and Tony Faulkner for their continuing hard work throughout. Nor must I forget both Fiona McKenzie and Lynn Burnetts who were invaluable in helping to maintain the equilibrium of all involved. Finally, my thanks to all the manufacturers and advertisers who have supported this project fully.

If you would like details of future issues, please write to me with a stamped addressed envelope and I will forward them to you as soon as they become available. Unfortunately, neither the publishers nor the author can guarantee to reply to any correspondence concerning the contents of this publication, although we would be delighted to receive any constructive suggestions.

The Editor

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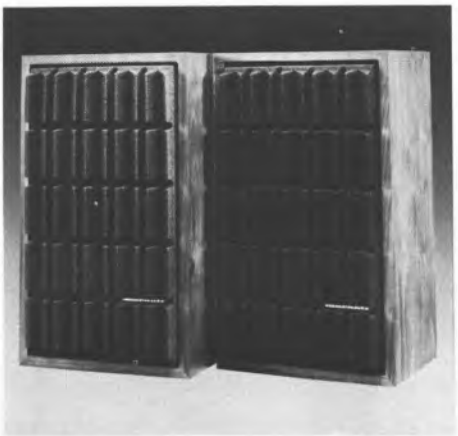

MODEL HD 55 THREE-WAY BOOKSHELF
SPEAKER SYSTEM
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Hi-Fi explained.

Hi-Fi has to be the most misunderstood and abused term in the English Language.

Everybody knows and uses it, but virtually no two people's understanding of it is the same.

A recent piece of research showed that most people thought that anything more sophisticated than an electrified horn-gramophone was hi-fi.

And seven watts per channel was seen as big time—where it was understood at all.

What was the sample used for this all revealing piece of erudition? Two hundred and fifty people interviewed emerging from hi-fi stores in Tottenham Court Road. Where else!

So we thought we'd put the record straight. And try and go for some sort of definition.

What It Is. And What It Isn't.

Properly the term is High Fidelity. 'Fidelity' means faithfulness or accuracy. So High Fidelity means ultra-faithfulness—to the original.

Hi-Fi however is not another way of saying 'stereo'. In fact hi-fi needn't be stereo, and most stereo isn't hi-fi.

More Of What It Is.

The technical requirements of equipment that are to be considered hi-fi are being raised all the time.

What was acceptable just three or four years ago won't do today.

The absolute minimum level of performance is said to be expressed in the German Din 45/500 standard.

Which doesn't really make anyone much wiser.

Basically it's this.

The equipment used to put the signal onto a record is constructed with a view to ensuring that only that signal is recorded, free from distortion or any additional noise.

The equipment you use to replay that record also shouldn't distort or add to that original signal.

Which seems simple enough.

But unfortunately sound reproduction equipment that promises this doesn't come cheap.

What Does Hi-Fi Look Like?

This is probably the biggest elephant trap of all.

Very, very few manufacturers of electronics make high-fidelity equipment.

Not because they can't, but because they won't.

Years ago marketing men realised that more and more people were becoming enthusiastic about good music. They also realised that most people don't have a very perceptive 'ear'. So they started to build sound reproduction equipment that looked like the expensive best. The trouble was that those big fat boxes were virtually empty. And sounded it to all but the millions of people who were satisfied—with equipment that just looked the part.

Today nothing has changed.

So How Do You Tell.

Good high fidelity stereo sound reproduction doesn't come cheap.

In this world we get what we pay for.

And if equipment costs a lot to manufacture no manufacturer is going to give it away.

So the best way to make the right decision is to get the specialist Hi-Fi Journals and read up the reviews.

If you're going to spend several hundred pounds check very carefully what you're going to spend it on first.

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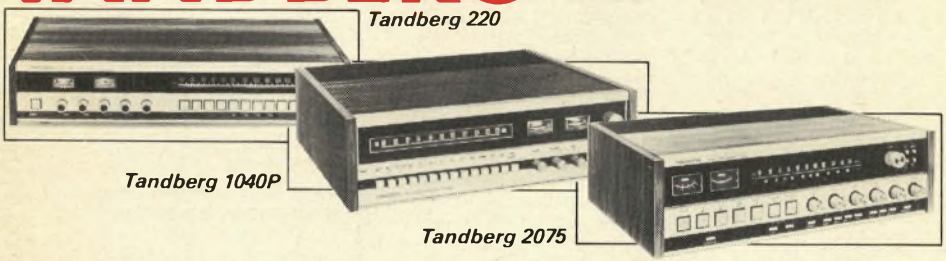

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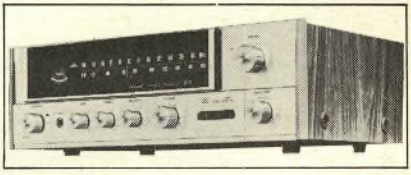
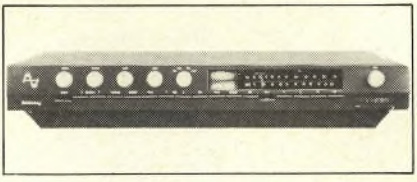


Sansui 331



Armstrong 625

Akai 1020	*POA*	Luxman 800	*POA*	Sansui	*POA*
Armstrong 625	*POA*	Marantz	*POA*	Tandberg	*POA*
Armstrong 626	*POA*	Pioneer	*POA*	Technics	*POA*
Goodmans	*POA*	Rotel RX402	*POA*	Yamaha	*POA*
Leak	*POA*	Rotel RX602	*POA*		
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Sounds that characterise a certain make i.e. "the so-and-so sound". Although these sounds are sometimes acceptable and desirable for certain types of music or listener, when it comes to real music, a good speaker should not add any character of its own. It must be completely neutral and transparent, giving an impression of listening to music rather than hi-fi equipment.

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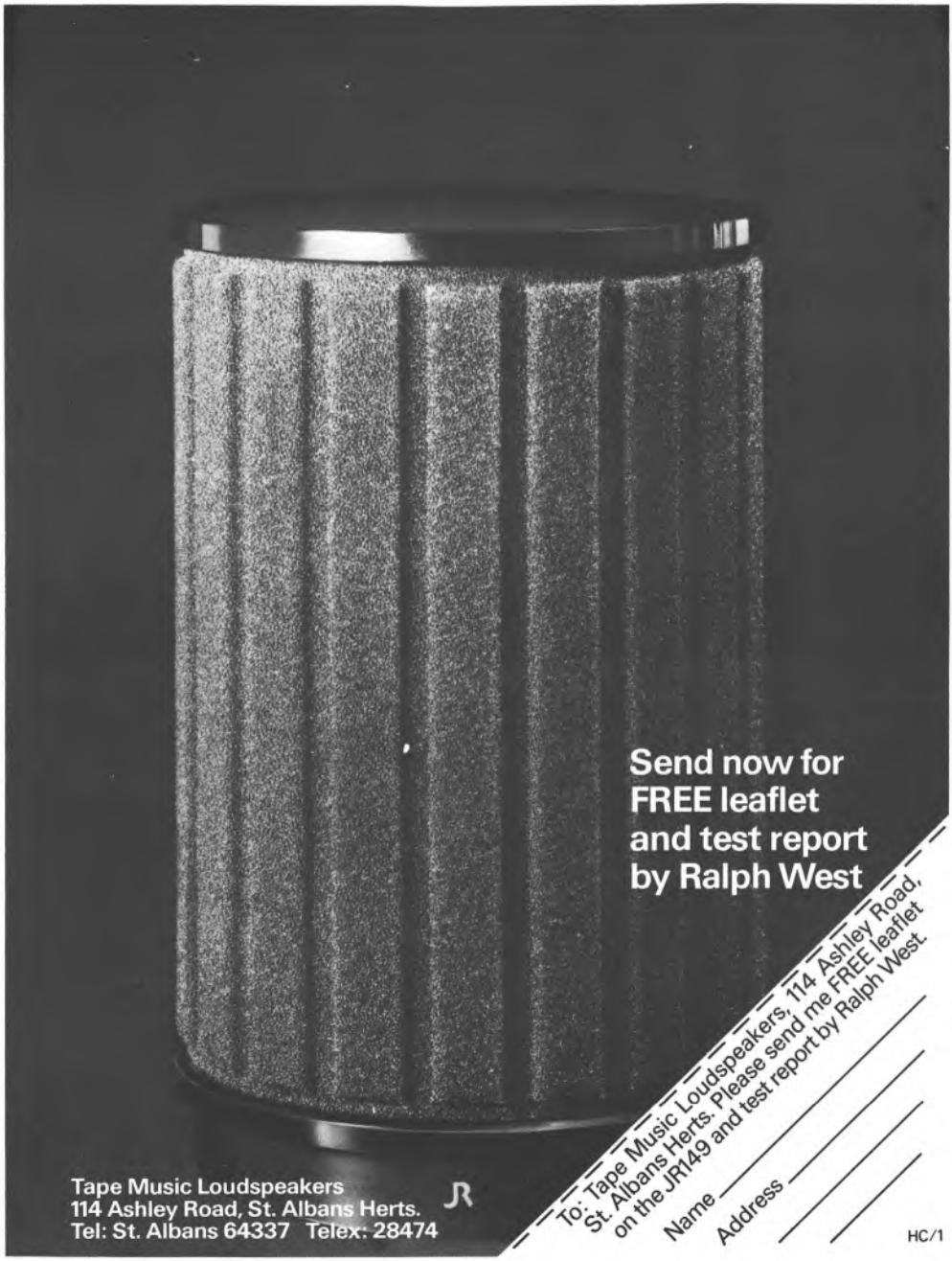
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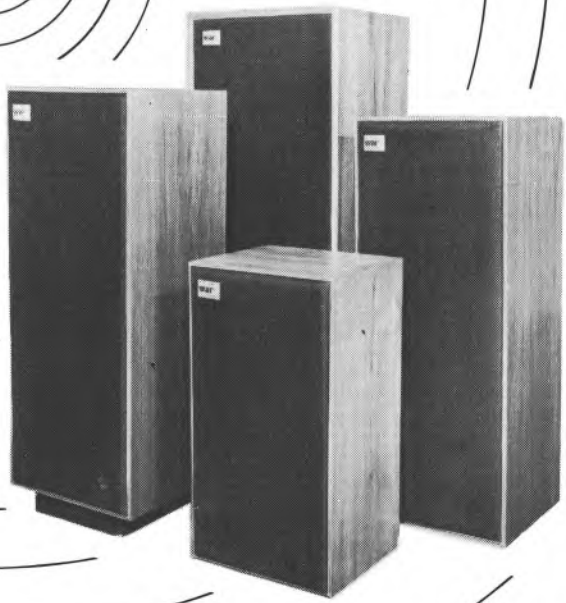

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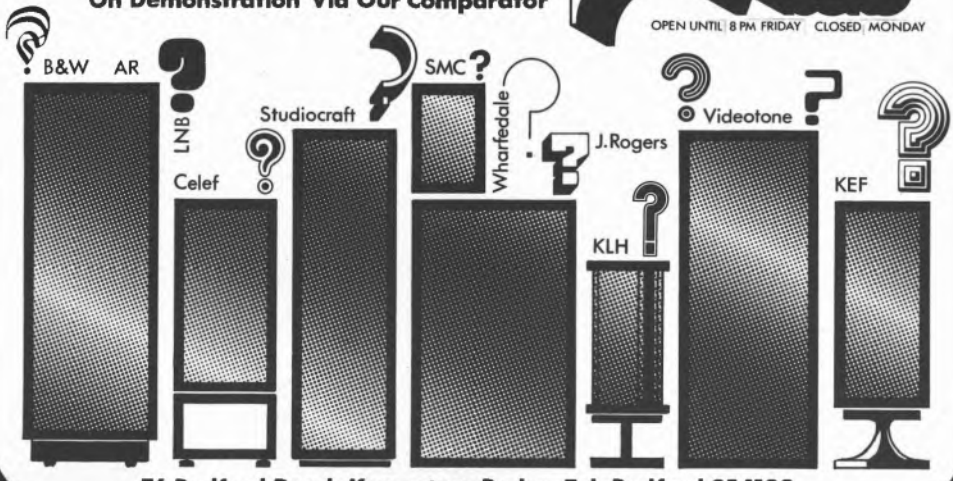

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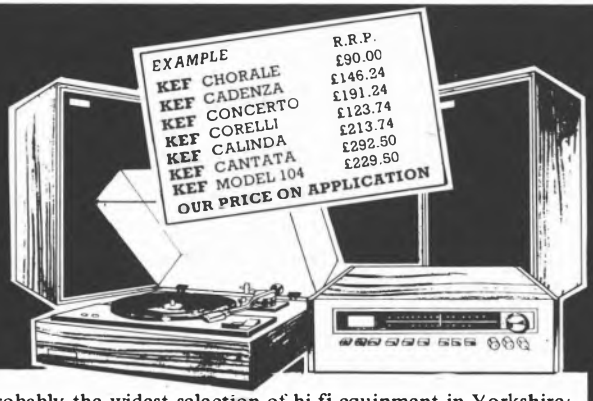

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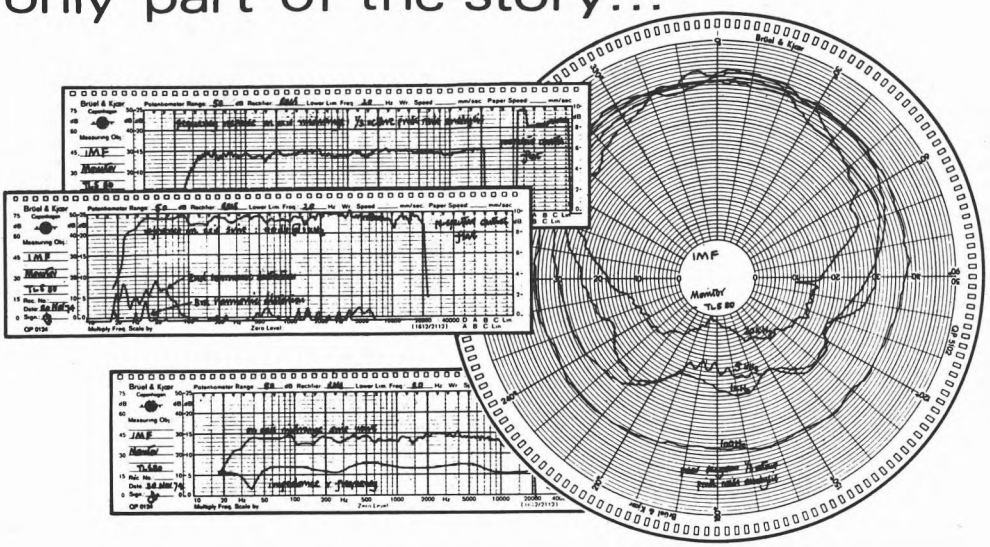

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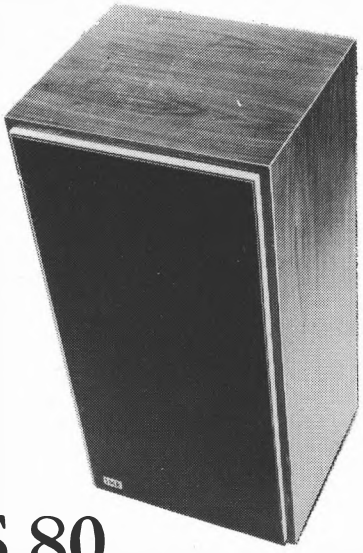

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Despite reviewing some 18 loudspeakers in a survey two years ago, the thought of coping with over 80 pairs seemed at first impossible. I have always regarded loudspeakers as the most difficult product to assess in the hi-fi chain. Obviously, it is not possible to judge them solely on subjective criteria, although such testing can give a reasonably accurate indication. Consequently, in conjunction with my colleagues, I began to think about which particular aspects of performance were the most important and the types of test that would be fair and relevant to all different models.

Parameters such as frequency response, distortion, sensitivity—as well as any difficulties an amplifier might have in driving a loudspeaker—had all to be examined objectively. This meant that virtually all measurements would have to be made in an anechoic environment. I therefore approached Roy Brooker of the Hirst Research Centre who, although slightly taken aback at the prospect of his anechoic chamber being booked for two and a half weeks or more, was fortunately most encouraging. I would like to thank him, both for his magnificent work as well as his enthusiastic help and assistance in making the project feasible.

Thanks must also go to my two colleagues, Nicky Paul-Barron and Tony Faulkner, who spent many weeks supervising and participating in all the tests. I am most grateful for their interest and patience throughout. Additionally, my wife, Fiona, and secretary, Lynn Burnetts, accepted weeks of my continuous dictation, made endless cups of coffee and refreshments for all the panel members, and it is fair to say that without their co-operation the whole project would not have been possible.

I must also thank the editor, Sally Peberdy, for the amazing amount of work she did, having been suddenly thrown in at the deep end immediately after being appointed in April. Her continual encouragement kept us all going—especially when we were dreaming and almost eating loudspeakers.

Thanks, too, to the hardworking listening panels, who gave up evening after evening to be submitted to the same test programme over and over again on so many loudspeakers. I wonder how many readers would be prepared to hear the same tape recording of ten items, perhaps 30 times in a day.

Finally, thanks must go to the publishers for commissioning the project and to all the manufacturers who loaned products for review, having been satisfied, sometimes after lengthy discussion, that we were going to be fair in the overall evaluation.

Naturally, subjective evaluation is always more difficult than objective. In many instances criticism is clearly a matter of opinion. However, when my opinion unanimously coincides with that of my colleagues and the listening panels, as well as the opinion of those I respect in the trade, then it seems reasonable to place a degree of faith in the reviews that follow. There will be many instances, though, where listeners loyal to one product or another will disagree—often for perfectly valid reasons. But loudspeakers doing particularly well in both the listening tests and the anechoic chamber, and which are reasonably priced in terms of value for money, must surely be better than those that fared worse. A few loudspeakers were thought to be totally unacceptable, a fact that was substantiated by visitors to the house being asked—without knowing our opinion—to listen to a speaker which we thought particularly poor and then also condemning it. Even so, almost all speakers, even the poorest, had some merit.

I can, with a twinkle in my eye and my tongue in cheek, liken loudspeakers to women. Some are attractive to all, others only to some. Just as beauty is in the eye of the beholder, some will enjoy one sound and some another. Some loudspeakers are fat, others thin. Some are tall. Some are short. Some even look pregnant. And some, both women and loudspeakers, are too expensive for some men. But, in this analogy, what is finally important is the faithful art of sound reproduction!

This book, therefore, has been written with that last point in mind. It should be stressed that very great care has been taken to ensure that all testing has been done fairly, and in such a way as

not to favour certain loudspeakers whilst unfairly condemning others. To illustrate to the reader exactly how the project commenced we include the text of the original letter sent to each supplier, detailing the entire project:

Until now, the prospective purchaser of hi-fi equipment has had to base his buying decision on fundamentally inadequate information. Apart from manufacturers' literature, diverse reviews written according to different criteria in various magazines, and not always reliable advice from shop salesmen, the potential customer has had little from which to make a choice.

Hence 'Hi-Fi Choice'.

Each volume in the series comprehensively reviews a large selection of equipment within a specific product category, occasionally excluding brands which, in the opinion of the publishers, are insufficiently available.

Two volumes have now been published—'Hi-Fi Choice: Cassette Decks' and 'Hi-Fi Choice: Receivers'. The third, 'Hi-Fi Choice: Loudspeakers', has a planned publication date of August 27, 1976.

Aquarius Books Limited have again appointed Angus McKenzie Facilities Limited to supervise and research the project. The compilation of written material will be under the personal supervision of Angus McKenzie with Sally Peberdy acting as Editor.

The success and acceptance by both public and trade of the two previous projects, allied to the reputation of Angus McKenzie Facilities Limited, is such that the publishers have every confidence that all manufacturers/importers will be able to support fully 'Hi-Fi Choice: Loudspeakers'.

In the interest of readers, the detailed notes that follow will be disclosed in full in the publication, and the publishers again have confidence that the reader will accept the entire methods and means by which the project has been accomplished.

Selected manufacturers and importers of loudspeakers with a recommended retail price in excess of £80.00 per pair (exclusive of VAT) and lower than £550.00 per pair (exclusive of VAT) will be invited to submit samples from their range. Because of the vast number of loudspeakers available on the market and the restricted number of pages economically available to the publishers, not all manufacturers/importers will be asked to participate. In the interest of readers the samples chosen for review will be decided according to market share and trade recommendation. Although any such means of selection must, by definition, be at best arbitrary and at the discretion of the publishers, a considerable amount of initial research has been undertaken to try and ensure both fairness and accuracy in the selection process.

Because time is of the essence, all loudspeakers chosen for review must be delivered to Angus McKenzie Facilities Limited by 1 May, 1976. It is regretted that no late entries can be submitted.

Upon delivery, each pair of loudspeakers will be given an extensive listening test, using a high calibre master tape including anechoic speech, sound effects, and classical and pop music. The performance of each loudspeaker will be compared against two other models—the standard selected for this survey and a model that is widely accepted as representing good value in the specific price category involved. Any loudspeakers which obviously fail to approach a reasonable standard will at this stage be aborted from further tests, and will be the subject of a short report in the publication. However, it is fully anticipated that any such aborts will only represent a minority of all loudspeakers submitted, and the majority will continue to the anechoic room.

The anechoic room tests will be extensive, and include frequency response on axis, at 45^{o} off axis, and at 45^{o} sideways to axis, and impedance curve measurements.

The loudspeakers will then be subjected to panel listening tests prior to the final tests which will include power rating measurements. Although every care will be taken during this test, it is possible that tweeters may blow, and all manufacturers will be required to be responsible for their replacement.

The publishers request the suppliers to be responsible for the insurance of all equipment loaned for review during the time that equipment is away from the suppliers' premises. They also ask the suppliers' indulgence in a request that equipment be retained if possible for at least four weeks after publication, so that any readers queries resulting can be resolved.

Neither the publishers nor Angus McKenzie Facilities Limited can be held responsible in any way whatsoever for any errors or omissions contained in the publication. Naturally, the Laboratory will take all reasonable steps to ensure the impartiality and accuracy of conclusions made.

It is intended also that the publication will be made available in a similar format in other countries, and the publishers reserve the right to publish relevant data overseas with, however, the full knowledge of suppliers at the time.

It is understood that price will, of course, be a contributory factor in determining the value for money of any particular unit, and naturally less expensive models will not be expected to perform to as high a standard as more expensive models. In this context the publishers will also bear in mind typical retail prices in addition to those claimed as recommended retail prices.

Submission of equipment for review will be taken to mean that suppliers agree to comply with all conditions and requests contained both above and on the form entitled 'Test Procedures'.

Types of Loudspeaker System

The moving coil is by far the most common type of loudspeaker transducer. An alternating current developed from the amplifier passes through a coil of wire fixed to a short cylinder of material. One end of the cylinder is joined either to the centre of the main cone or, in the case of a tweeter, to a diaphragm. The entire cylinder section is encased, both inside and out, by a powerful permanent magnet, so that as the current passes through the coil in one direction the entire assembly moves in relation, according to the laws of Physics (Fleming's rule). The cone is stabilised in position by a surround which attaches its circumference to the loudspeaker framework. The coil assembly is centred by what is known as a spider, which stops the assembly from moving sideways.

The moving coil loudspeaker is virtually identical in operation to the moving coil microphone. However, whereas in the case of the loudspeaker the current from the amplifier causes the coil to move, sound pressure on the microphone moves a diaphragm, with a coil fastened to its centre, in and out of the magnetic field which generates the alternating current which can then be amplified.

The first moving coil loudspeakers did not use permanent magnets, since 45 years ago these were both insufficiently powerful and could only be manufactured with difficulty. Consequently, the first loudspeakers used electro magnets, through which a DC current is passed in order to generate the magnetic field.

Other early transducer variations included moving iron loudspeakers and crystal speakers, which gave a very low output and were very small. Subsequent developments over the years have included the Corona Wind Loudspeaker, the Ionophone, the Isodynamic and the Ribbon. But the only development of any considerable consequence at the moment would seem to be the Push Pull Electrostatic, which was originally developed at about the same time by David Tombs of Imperial College and Peter Walker of the Acoustical Manufacturing Company.

It could be said that Tombs' push pull device, which was developed during the time that I was myself at Imperial, and his Corona Wind Loudspeaker initiated me in 1954/5 into the mysteries of transduction. I can remember demonstrating the latter at the Physical Society Exhibition. But I also recall with sadness my severe illness resulting from the ozone poisoning of the tissues at the back of my nose. Should some other enthusiastic engineer wish to explore the possibilities of the Corona, I would strongly recommend his wearing a nose bag!

The push pull electrostatic relies on the following principle—namely that a 6kV potential from a very high impedance DC source fed into a diaphragm will cause that diaphragm to take up a position in space in linear proportion to an alternating push pull voltage fed to two plates either side of the original diaphragm. These outside plates, which are fed from a high step up ratio transformer via a crossover network driven from the loudspeaker's input terminals, have holes cut in them to permit the sound pressure to pass through from the inner moving diaphragm. The push pull action very significantly reduces distortion, as the electrostatic field becomes linear rather than of the square law type. And, because almost the entire diaphragm is within the electrostatic field, its movement as an entity is much more linear than the diaphragm of a moving coil loudspeaker. Consequently, not only is subjective response much smoother, but coloration is also minimal—certainly much better than any moving coil loudspeaker can as yet hope to be. However, despite the horizontal polar diagram of an electrostatic loudspeaker being quite acceptable, the vertical is rather poor.

The dimensions of a full size electrostatic are totally dissimilar to those of a moving coil speaker. Whereas the proportions of the latter resemble those of a coffin, the former has a considerable frontal area whilst the thickness from back to front is no more than a few inches.

Some manufacturers attempt to marry a push pull electrostatic for the treble end with a moving coil type for bass, but up to now the combination does not appear to me to have been a success, although I feel strongly that a model incorporating an electronic crossover and two separate amplifiers should provide a good overall sound which is relatively uncolored. I have never been happy with attempts that I have heard over the years to combine the two basically different

types and normally the let down has been coloration at lower frequencies rather than any other deficiency. Perhaps the lack of coloration in the electrostatic makes any coloration present in the woofer far too obvious.

Large loudspeaker cones are capable of moving more air than the smaller variety, and are thus necessary for the reproduction of low notes. However, they are almost completely unsuitable for reproducing the treble end—the result being bad coloration and a noticeable lack of top frequencies. For this reason medium sized diaphragm units, called 'squawkers', are designed for middle range notes and 'tweeters' or even 'super tweeters' for high ones. Therefore speaker systems contain at least two or three units for reproducing the entire audio spectrum. Since each speaker unit is only designed to reproduce a specific band of frequencies an electrical network known as a crossover splits and directs the audio currents to the appropriate units.

Unfortunately, a large bass cone on its own will not reproduce low frequencies effectively. Because, as the cone moves towards the listener, the air pressure escapes around the back of the unit, thus cancelling itself. Consequently a forward wave front does not develop, as the air rushes around to take up the rarefaction behind the cone. The loudspeaker designer has to stop this happening. He does so by placing the speaker in a box, but this is in no way the final solution. The cubic capacity of the inside of the box is very important, controlling the lowest frequency that can be reproduced by the entire system. The designer can also reinforce the bass by incorporating portholes, either with or without tunnels. Although these can dramatically affect the reproduction, the size and nature of such ports are too complicated to discuss in this volume. A few other tricks can be used to achieve bass end reinforcement and smoothness. Acoustic resistance is often employed. Defined rather crudely this virtually means putting the equivalent of a cardigan in the porthole. Various forms of resistance are used with the effect of allowing air to pass through only with reluctance. One loudspeaker, produced in the United Kingdom, went so far as to have hinged doors, which could be opened or closed to any degree. Accordingly, the manufacturers claimed that the loudspeaker could suit any listening environment. To an extent this worked, but for other reasons it was not altogether practical.

Unfortunately a loudspeaker is very inefficient, and the average person requires an amplifier with a power output capability of 20W to reproduce sound levels which are equivalent to as little as 50 thousandths of a watt. When it is realised that the ear can hear sounds one ten-millionth as powerful as this, perhaps the incredible sensitivity of the human ear will be understood. And this combination, allied to the extraordinary powers of the human brain as a computer-analyser, makes it very difficult indeed for a loudspeaker to even appear to approach the quality of an original sound.

The Subjective Listening Tests, the Panels and the Programme

When the entire loudspeaker review project was planned, well in advance of the beginning of the testing, it was decided to divide the tests into three well separated sections.

The first part consisted of listening tests, involving my colleagues, myself and, whenever possible, a very experienced engineer employed by a non-commercial organisation engaged in quality monitoring and audio research. Well over 80 pairs of loudspeakers were delivered and, in addition to writing a lengthy subjective listening report on each model, it was necessary to make the unfortunate decision to reject over 20 pairs from the remainder of the tests. This decision was taken where we considered a speaker to represent poor value for money or to reproduce an unacceptable sound quality. The rejected models all receive short reviews later in the publication.

Almost all the initial 'in-house' tests were made solely in mono, except in the case of the linear phase designs and one or two others fairly close to the rejection borderline, which were given very careful and extensive listening. Each loudspeaker was compared in performance on a pre-determined programme against a standard whose faults, although few, were well known to us. In addition, we used as 'anchors' two pairs of stacked Quad electrostatic speakers throughout the tests, which gave both a predictable and generally excellent quality.

At no time was I told by my colleagues the identity of any loudspeaker auditioned until the end of several days' comparisons. Furthermore, to avoid any possibility of bias, I always marked each loudspeaker's performance on every band separately and before my colleagues contributed their marks. However, despite this caution, it was exceptionally rare for our marks to show more than half a point difference. And, as the tests proceeded, we always took the greatest care whenever marks were close to certain borderlines.

Whatever its good or bad points the standard was always marked '7'. The speaker under test was marked against this. A mark of '5' indicated that the speaker was only just acceptable to us whilst possessing very noticeable failings. A mark of '6' showed that the speaker was pretty good, acceptable to us, and possessing only minor failings as compared with the standard. A mark above '7' showed a clear preference for the test speaker over the standard. Needless to say, loudspeakers given marks varying from '1' to '4' were not only unacceptable but considered diabolical, agonising or, at the best, rather poor. All marks were given to quarter points. At the end of each test, involving 20 comparisons, the loudspeaker was summed up in general and then an overall mark agreed as an average. In doing so, certain test tracks were regarded as being more important than others, and were weighted accordingly. In general, speakers marked below '5' receive short reviews, as do a few receiving '5¼' which were rejected if they were extremely expensive.

The mono tests were made using 38cm/sec Dolby A tape recordings, dubbed directly from master tapes, and played back on a Revox A700 equipped with a comprehensive remote control box. The signal was passed through a Technics 9600 professional pre-amplifier and into a Crown DC 300A amplifier connected via a switch box to the appropriate loudspeakers. The specially prepared tape repeated tracks on first the left channel, then the right, then left again followed finally by right. The balance control of the pre-amplifier was used to adjust for differing loudspeaker sensitivities.

Every care was taken to place the loudspeaker being tested accurately and in accordance with the manufacturer's recommendation. At times this involved considerable trouble. Most tests were carried out in my normal listening room. However, where appropriate, further tests were made in my lounge which is rather more reverberant and which also has somewhat more convenient corners and walls.

Throughout each test, pre-printed forms were filled out either by my hard-working secretary, Lynn Burnetts or, occasionally, by my wife, Fiona. Sometimes, I was dictating so much that Lynn almost got writer's cramp. Frequently, the test had to be stopped to permit discussion of particular points before comments were committed to paper. Although the test was gruelling for both the loudspeakers and listeners, it was nonetheless fascinating and, at times, I regret to say that certain sounds produced a rather hilarious atmosphere, which was difficult to tone down!

For the interest of readers, the following were the mono listening tests:

1. Pink noise switching rapidly, then slowly, between reference and test speakers.
2. Male and female anechoic speech.
3. Swept oscillator test to check for obvious anomalies and rattles.
4. Anechoic drum kit and solo anechoic tambourine.
5. Anechoic pop.
6. Copy from Elton John master tape.
7. Anechoic recording of Victorian football rattle.
8. Anechoic aerosol spray.
9. Anechoic harmonica.
10. Anechoic Stradivarius violin.
11. Borodin Polovtsian Dances (choir of 800 plus full orchestra in Royal Albert Hall).
12. Tchaikovsky Piano Concerto (Royal Albert Hall).
13. Brahms Double Concerto (Festival Hall).
14. Beethoven Hammerklavier Piano Sonata (Queen Elizabeth Hall).
15. Westminster Cathedral Organ.
16. Madrigals recorded in All Saints Church, Petersham.
17. William Alwyn String Quartet.
18. Philip Jones Brass Ensemble.
19. Stravinsky Petrushka (Fairfield Hall, Croydon).

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WILLENHALL	Walsall Road, Willenhall, Staffordshire	Tel: 0902 604111
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LONDON, Dagenham	Rainham Road South, Dagenham, RM10 8ST	Tel: 01-595 5111
LONDON, Potters Bar	Station Close, Darkes Lane, Potters Bar	Tel: 0707 43491
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20. Pop music track, copied from master kindly supplied by Pye Records Limited.

On occasion, we also carried out additional comparisons with anechoic recordings of a klaxon horn, jingling keys, an electric shaver and live recordings of music including Dvořák's Te Deum and many other items. Virtually all types of music and sound effects were represented. But no doubt some readers will think of some types of music that might be insufficiently represented in the mono programme.

The average duration of each initial mono test was 45 minutes, although in several instances this was extended to as much as one and a half hours. Analysis of all the results culled from these tests took many days, and the compilation of all the necessary data for every loudspeaker almost literally took weeks. Unfortunately, matters were not made easier by certain manufacturers, who not only delivered speakers for review at the last possible moment, but were equally elusive during the test programme on those occasions when we had to make special enquiries about their product. It is fair to add, however, that this period coincided with important exhibitions, both at home and overseas. Suffice to say that my colleague Nicky Paul-Barron alone was reduced to spending some three or more weeks continuously on the telephone, organising deliveries and obtaining information.

After the mono tests were completed, almost all the loudspeakers had to be moved to storage premises in Alperton, from where the van driver, John Thodey, made almost daily journeys to Hirst Laboratories to deliver and collect speakers before and after testing. I would here like to thank Mr. Geoffrey Faulkner, of Hudsons Brick and Supply, for making available a large storeroom, without which we would have faced insurmountable difficulties in trying to store 170 loudspeakers within a few miles of the Laboratory.

When analysing the results, my colleagues and I had to decide how fairly to reject some of the loudspeakers. Based on our experiences during evaluation, we decided to adopt the criteria of 'Was the loudspeaker even plausible at its price?'. We are all satisfied that those speakers receiving short reviews show either obvious design faults or coloration problems, such that it was impossible for any of us to listen to music reproduced by them with any enjoyment. Of these models, one or two could give high sound pressure levels on pop music, but were still regarded as poor value for money. It is sadly inevitable that when there are so many well-designed loudspeakers at reasonable prices, a proportion must fall by the wayside.

Following the mono tests, the second part of the test procedure involved somewhat gruelling tests in Hirst Laboratories' anechoic chamber at G.E.C., Wembley. For details of these, please see the chapter on the Anechoic Chamber. Sixty loudspeakers went through the anechoic tests, before being split into three groups for the extended panel listening tests.

The first group were those loudspeakers considered suitable primarily for listening to classical music. Usually these were loudspeakers which were either small or had a somewhat poor power rating. Other loudspeakers, producing high output power levels but more colored than average, were put into the pop music panel tests whilst being excluded from the classical tests, because of the detrimental effect of coloration on classical music. However the majority of speakers fell into the third category, being included in both the classical and pop music categories.

My colleagues and I made up two entirely separate test programmes for the classical and pop music panels.

The classical programme included pink noise, applause, speech, madrigals, Polovtsian Dances, Dvořák Wind Serenade, a Steinway piano, Westminster Cathedral Organ, Hindemith Mathis der Maler, Alwyn String Quartet, Petrushka (Royal Festival Hall), Beethoven 4th Symphony (Royal Albert Hall), the pop track supplied by Pye records, and finally the live versus recorded sound of harmonica.

The pop programme commenced with pink noise, followed by anechoic drums, anechoic folk music, anechoic pop group, the Hendon Brass Band, Pye Records' 'This is It' (Melba Moore), Elton John, Tony Hatch light orchestral, The Hollies, heavy rock, modern jazz, and solo guitar and drum recorded specially in a studio. The pop programme ended with a recording of Dvořák's New World symphony recorded in Liverpool

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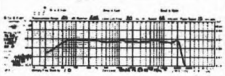

IMPEDANCE: 6-8 OHMS.
MAX. PEAK POWER INPUT: 120 WATTS. DIN
MAX. CONTINUOUS POWER INPUT: 65 WATTS. DIN
FREQUENCY RANGE: 30-20,000 Hz.
INPUT FOR 96dB AT 1 METRE: 6 WATTS.
MID. RANGE DRIVER IN TRANSMISSION LINE ENCLOSURE: 100mm.
TWEETER. 20mm DOME UNIT.

TK45 per pair

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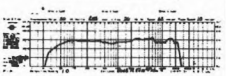
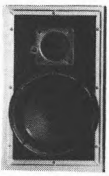
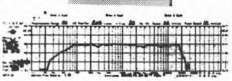


IMPEDANCE: 6-8 OHMS.
MAX. PEAK POWER INPUT: 80 WATTS. DIN
MAX. CONTINUOUS POWER INPUT: 50 WATTS. DIN
FREQUENCY RANGE: 35-20,000 Hz.
INPUT FOR 96dB AT 1 METRE: 6 WATTS.
BASS DRIVER: 250mm.
MID. RANGE DRIVER IN TRANSMISSION LINE ENCLOSURE: 100mm.
TWEETER: 25mm.

TK30 per pair

COMET PRICE £44.90
REC. RET. PRICE £59.04

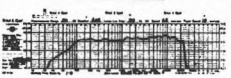




IMPEDANCE: 6-8 OHMS.
MAX. PEAK POWER INPUT: 40 WATTS. DIN
MAX. CONTINUOUS POWER INPUT: 30 WATTS. DIN
FREQUENCY RANGE: 50-20,000 Hz.
INPUT FOR 96dB AT 1 METRE: 4.7 WATTS.
BASS DRIVER: 200mm.
TWEETER: 50mm.

TK20 per pair

COMET PRICE £33.50
REC. RET. PRICE £43.27



IMPEDANCE: 6-8 OHMS.
MAX. PEAK POWER INPUT: 30 WATTS. DIN
MAX. CONTINUOUS POWER INPUT: 20 WATTS. DIN
FREQUENCY RANGE: 60-20,000 Hz.
INPUT FOR 96dB at 1 METRE. 24 WATTS.
BASS DRIVER: 160mm.
TWEETER: 60mm.

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Philharmonic Hall. I would here like to acknowledge with grateful thanks the assistance received from Polydor Records, Pye Records, Unicorn Records, the BBC, Tamas Vasary, Oxford University Press, Bob Auger Associates and The National Youth Orchestra, all of whom contributed recordings or allowed their recordings to be used for the listening tests.

Members of the classical music panel included John Fletcher (a principal of the LSO), John Fraser (classical music recording engineer), Anthony Howell (classical music producer and publisher), David Hudson (recording engineer and music producer), Tom Kramer (classical music enthusiast), Stephanie and Max Lehmann (classical music and hi-fi enthusiasts), Robin Marshall (audio and electronic engineer), Andrew Massey (classical music conductor and director of music at the Middlesex Polytechnic), John Parry (professional singer), Andrew Quick (Tonmeister student from Surrey University), Ian Wemyss (quality control and audio engineer in broadcasting), Graham White (professional musician). I also filled in forms during tests as a correlation between stereo and mono listening tests.

The pop music panel were also very experienced, and included, as well as some of the classical panel members, Malcolm Davies (Pye Records disc cutting engineer), John Gardiner (electronics engineer), David Harris (manager of Air Studios), Mike Hastings (pop music and hi-fi enthusiast), Dave Martin (sound recording and public address engineer), Mike Perry (hi-fi enthusiast), Tony Shields (professional audio equipment executive) and Carlos Ulms (chief recording engineer and studio manager, Polydor Records, London).

Some 36 hours of stereo listening tests were heard by the panels, in which all the members filled in forms whilst listening. Each test included a live-versus-recorded comparison, in which I played a harmonica in between the relevant pair of speakers, filling in gaps left in the tape for the purpose.

Before each group of tests, my colleagues and I explained to the panel the types of problem that might be expected, and we found that every single member contributed considerably to the overall consensus of opinion. I should like to thank the panel members not only for the amazing amount of time that they gave up freely, but also for the accuracy and consistency that they showed. In general, their marks correlated amazingly well as a group, but they also correlated surprisingly well with our opinions based on the internal tests. At no time during the stereo panel tests did any panel member know which speaker they were hearing; they were only told the names of the different speakers, including the comparison standards, at the end of the tests.

We frequently changed the standard, and sometimes varied the position of the test speaker, this usually being done after a coffee or food break when the panel would have tended to forget the sound of the main standard. Comparison tests included, for example, an old pair of Spendor BC1s with a new pair, the Chartwell LS3/5A against the Audiomaster version, and comparisons of speakers generally rated highly. We also put into the tests a few speakers which had been excluded from the objective tests, as a double check, and these were generally rated as very poor. In one case, after the panel had heard a few seconds of pink noise on a test speaker, they all broke down with uncontrollable laughter, but it would not be fair to name this speaker. Panel members did not compare notes during tests, although after their test report sheets had been handed in we all discussed the relevant speaker without its identity being disclosed, unless it was one which had already been rejected in our own tests.

I would here like to pay tribute to my wife who looked after lunches, teas and dinners, and never-ending cold drinks during the very hot weather in June. I would also like to thank David Goren, a student from Southampton University who assisted us in the preparation and running of the tests. Throughout each programme, Sally Peberdy, the Editor, correlated results from the forms, so that at each break I could see how different speakers were faring. This allowed us occasionally to do a retest if necessary with an alternate standard, which proved useful at times.

Each loudspeaker was heard in the position recommended by the manufacturer, and whilst this was often quite difficult for us, I think that we were always very fair. In general, the differences between speakers were surprisingly marked, both

in coloration and response, and every now and again one or another panel asked to have a comparison with a pair of Acoustical Manufacturing 'Quad' Electrostatics, a speaker well known to almost all members of the panels. These electrostatics were classed as 'anchor references', since not only are they generally regarded as very good loudspeakers, but also very smooth and uncolored. Additionally, their weaker points are well known, eg. power handling and bass-end performance.

Two IC150 Amcron pre-amplifiers drove DC300A amplifiers connected to the relevant pairs of speakers. A remote control box, made by us for the purpose, muted either or both pre-amps and also passed current through a red or green light to show the panel which loudspeaker system was working. Special black voile curtain material supplied by Ken Russell of Rank in Yorkshire was used to obscure all the systems from the panels, and this curtaining was tested for sound absorption in an anechoic chamber, where it was found that not more than 1dB at 15kHz was absorbed through four layers. The use of two complete systems fed in parallel at their inputs allowed gain, balance and any tone controls to be varied in the two set ups. It was essential for the volumes of the two pairs of speakers to be identical throughout the tests. A probe microphone in the listening room fed a peak programme meter in our laboratory, and my colleagues informed me over a talkback system if the volume settings were even slightly inaccurate. This also allowed us to control the maximum sound pressure level heard by the panel.

Every care was taken to allow each system to perform at its best, and because of the various sensitivities of the speakers we chose the extremely powerful DC300A amplifiers, so that at no time could any amplifier clipping be heard which would be disadvantageous to a speaker system. Bear in mind that some of the master tapes such as the anechoic drum recordings had amazingly sharp transients which required sudden high peak to peak outputs from the amplifier. I would like to thank MacInnes Laboratories for the loan of the extra amplifier and pre-amplifier required for the listening tests. I must also thank Russ Andrews, a dealer in Edinburgh, for his kindness in loaning us a Naim Amplifier which was also occasionally used during listening tests.

The standards for comparison purposes included the following speakers:— Celef, Studio Professional; Chartwell LS3/5A; KEF 103; KEF 104AB; Monitor Audio MA4; Quad Electrostatics; Spendor BC1 (old and new models); Tannoy Devon; Yamaha 645; Yamaha 1000M.

The Anechoic Chamber

Different domestic listening rooms add very different sounds to the output of a loudspeaker. Heavily furnished rooms add comparatively little, whilst others, with only thin carpets, curtains and rather bare walls, can add an appreciable amount of coloration to the reproduced sound. Consequently, to take away the variable factor introduced by the listening environment, loudspeakers have to be tested in a room with virtually no reverberation across the entire audio range.

The Anechoic Chamber

A room specially constructed to have no reverberation is known as an anechoic chamber. Varying considerably in size, the walls, floor and ceiling are literally covered by hundreds of wedges. Each sticks out several feet into the air, and is filled with an absorbent material such as fibreglass. Even the door to the room is similarly treated. Across the floor is a metal grid which is normally taken away when measurements are in progress, but which has to be replaced when someone is in the room positioning loudspeakers or microphones.

The loudspeaker to be tested is placed on a small platform a few feet above floor level. The platform can be rotated so that the horizontal polar diagram of the unit can be checked without moving the microphone. However, to measure the vertical polar diagram pattern, it is necessary to readjust the microphone height. A probe microphone is almost always set up at a distance of one metre from the front of the loudspeaker, pointing towards it along a line at right angles to the speaker.

Most good anechoic chambers have an internal cubic capacity of approximately 50 cubic metres. A photograph of the Hirst Laboratory chamber illustrates the rather eery appearance of the interior. My colleagues and I all found the atmosphere in the room very odd indeed, especially when the door was closed. After a while, as the ears became more and more sensitive, it was possible to hear the blood running through the veins near the ear drum. One hand clap, though, completely changes the sound until the ear recovers from the transient. This phenomenon alone indicates that the ear/brain combination has a logarithmic rather than a linear response with a compression characteristic. Obviously the sound will not be heard below a certain level, but the threshold of audibility in the average human ear is at a remarkably low level.

The measuring microphone used in our tests was of the Bruel & Kjaer half inch free field type, mounted at the end of an extremely narrow gooseneck so that only a minor disturbance to the sound field was produced. The room was calibrated using a wide range loudspeaker, previously measured in another much larger anechoic chamber known to be excellent and very consistent, and minor modifications were made to the chamber in order to remove some small ripples at high frequencies.

The output from the test microphone was connected through to a Bruel & Kjaer Spectrometer/Microphone Amplifier. The response of the measuring equipment was virtually flat from well below 20Hz to above 20kHz, although the chamber itself had a slight bass roll off below 100Hz. This was corrected in the measuring equipment by a compensation circuit. The output from this equipment fed a Bruel & Kjaer Pen Chart Recorder.

For the distortion tests our own laboratory Bruel & Kjaer 2010 Analyser with a 1902 Intermodulation and Distortion Test Set were used, making it simple to pen chart what would otherwise have been very lengthy and laborious measurements.

In an anechoic chamber, it becomes possible to measure the performance of a loudspeaker very accurately, without the cancellation and addition effects which have to be taken into account when measurements are attempted in any normal room. The human ear is virtually omni-directional at low frequencies, but at middle and high frequencies the brain is able to resolve the position and amplitude of a sound very accurately—even in the slightly reverberant acoustic of an average living room. Consequently, the ear discriminates between the direct sound reproduced by the loudspeaker and the reverberation of that sound from the walls, etc, of the room. The anechoic chamber allows the direct radiation of the loudspeaker to be monitored, thereby giving a useful measurement of the basic output of the speaker—provided that all the main energy of the loudspeaker is radiated towards the test microphone. But, for this reason, it is almost impossible to attempt measurements of omni-directional speakers in the anechoic chamber. However, please see the chapter on omni-directional loudspeakers.

For each main frequency response measurement, a test microphone was placed in the position which gave the most favourable overall response. This was usually near the axis of the tweeter or squawker. If the loudspeaker was a three unit system it was usually found on or near the squawker axis. Both sine wave (slow sweep) and third octave pink noise response measure-

ments were taken on axis, whilst 30° horizontally off axis and 22½° vertically off axis readings were taken with a swept frequency sine wave. Many loudspeakers produced a very marked fall off at the treble end when off axis, although some showed almost the same response as on axis.

The angles for the off axis measurements were decided by a series of experiments involving both loudspeakers and listeners moving around a typical room to determine the reasonable height and width variations over which a loudspeaker should give a reasonable performance. If a single loudspeaker was used, a few speakers produced severe interference patterns when the head was moved slightly from side to side, others presented a similar problem when the head was moved vertically. Somewhat surprisingly, we found that certain loudspeakers only gave of their best performance if the listener literally lay on the floor or stood up, whereas others were designed to work optimally when the listener was sitting in an average chair, positioned two to three metres away from the speakers. Although we checked for polar diagram anomalies in the subjective tests, we also measured them in the chamber as explained—provided the speaker was of at least acceptable quality.

Distortion tests were carried out at a sound pressure level of 90dB, measured one metre away from the front of each loudspeaker. This level was pre-determined as an average level produced at middle frequencies. We then swept a fundamental frequency from low to high, pen charting separately the second and third harmonic distortion over the audio range, the equipment automatically locking on to the appropriate harmonic throughout the sweep.

A third test involved a swept intermodulation measurement in which two frequencies were driven through the loudspeaker approximately 300Hz apart. We analysed the output from the loudspeaker 300Hz above the higher frequency, which represents what is known as $2f_2-f_1$ distortion. This product can be termed the third order distortion of the loudspeaker, and was usually worse than the normal third harmonic distortion.

We also measured the impedance of each loudspeaker in the anechoic chamber. This was taken over the entire audio frequency range by measuring the voltage across the speaker terminals when driven from a very high source impedance. In addition, we measured the phase between the voltage supplied and the current drawn by each loudspeaker over the entire audio range, so that by examining both it became possible to predict any problems that might be encountered by certain amplifiers in driving that particular speaker.

Whereas measurements of the frequency response of loudspeakers at middle and high frequencies are very valid as measured in an anechoic chamber, it should be emphasised that although measurements of bass response are helpful, an entirely different response would be met with in the average room. Thus the bass performance as shown by the response charts made in the chamber should be accepted with a very large pinch of salt, since fortunately we do not have to listen to loudspeakers in our daily life in an anechoic environment, which would be most oppressive!

Despite anechoic chambers being extremely useful, the results obtained should only be analysed very carefully by an experienced engineer, as it is very easy to misinterpret anechoic response curves. Only experience enables someone to know whether a fairly visible but very narrow dip will be audible as opposed to a minute but very wide shelf. Such a dip or shelf may well be audible in one part of the frequency range but not in another. Consequently, I give an explanation of the curves in the general reviews.

Before loudspeaker evaluation began, we booked the Hirst Laboratory's chamber for a day, during which we made many anechoic recordings, both in mono and stereo, of differing sound effects, speech and music. The greatest care was taken to ensure that all the recording equipment was lined up extremely accurately, and professional recording tape of the highest possible performance was chosen. All recordings were made simultaneously with and without Dolby A processing. In general, the Dolby processed tapes were used for playback because of their superior signal-to-noise ratio. But, purely as a precaution rather than as any criticism of the processing, a few extremely critical sounds were replayed from the non-Dolbyed tapes. Sounds involving sharp

transients were well under-recorded in order to preserve relatively undistorted reproduction at all frequencies. This resulted in some very remarkable sounds being reproduced through the loudspeakers tested. Naturally, we recorded far more material than we needed, which allowed us to select the best and most appropriate sounds to demonstrate the differences between one speaker and another.

Sound effects included water and ice being poured from a jug into a plastic bucket, blowing air into water through a rubber tube, an aerosol spray, jingling keys, a Victorian football rattle, tearing paper, lighting matches, telephone bells, clocks ticking and alarms ringing, fourteen people hand clapping, four people eating crisps, typing, a klaxon horn, an electric razor, etc.

Specially prepared semi-nonsense sentences were read by my wife and my colleague, Nicky Paul-Barron, whilst, sometimes joined by my wife, I recorded some long speech tracks. Musical sounds included a performance by Eli Goren, leader of the BBC Symphony Orchestra, of a Telemann violin sonata on both a Stradivarius and another excellent violin, which nevertheless sounded very different. Additionally, we recorded a complete pop group, comprising Hammond organ, bass guitar, rhythm guitar, and Nicky Paul-Barron on drums. The reader can no doubt imagine the difficulties we had in getting all the instruments and instrumentalists into the chamber! We also recorded some solo drum tracks, which were quite astonishing when reproduced. Other instruments included a harmonica —played by myself—oboe (Antony Askew) euphonium, and bass trombone (Steve Saunders) with various mutes. Finally we managed to record a complete country and western style group (The Cobblers) after which, at midnight, my colleagues and I were virtually exhausted but very satisfied.

I would like to thank all the musicians very much for allowing us to record them in the anechoic chamber in what were possibly the most dreadful working conditions that they had ever experienced. They all told me that it was exceptionally difficult to play in an anechoic environment, but all nevertheless produced remarkable recordings which were very helpful.

In general, the anechoic recordings were not only exceptionally clean but extraordinarily clear, which greatly assisted us in reaching rapid conclusions about speaker performance. Naturally, we had to be certain that faults shown up by these recordings were significant. However, in all cases, the problem areas were also evident on normal live recorded material. Basically, the anechoic recordings allowed us to ascertain more accurately the nature of the fault. Therefore, I must recommend that manufacturers use such a technique during the design of a loudspeaker.

During the 'in-house' listening tests we found the anechoic recordings most helpful, and we repeatedly carried out live versus recorded testing—usually with speech, harmonica and the aerosol. We also went to many live concerts during the period of the listening tests, so that we had the true sound of music constantly in mind.

Some readers may understandably query the use of anechoic music recordings, since they are not typical of any sounds that would normally be heard. Although this criticism could be valid for some, the experienced listener is able to isolate a sound from its ambience. To verify this theory, I listened to the acoustic sounds of a symphony orchestra at the Festival Hall for a whole concert. I found that it became possible mentally to analyse mid and high frequency components with surprising accuracy. Lower frequencies were more difficult because of the normal characteristics of hearing at lower frequencies.

I can best explain the difference between a live sound heard in a concert hall and the reproduced sound—whether in mono, stereo or four channel —by saying that the most audible difference was in the total absence of normal background noise. Also, one can hear transients with far greater clarity in real life. At low frequencies, the complete lack of any boominess or resonance produced a depth and openness of sound which I have only heard approached by listening to dummy head binaural recordings, reproduced over the best quality stereo headphones. The latter combination was far more realistic than any quadraphonically reproduced sound that I have ever heard. This is probably due more to the loudspeakers employed rather than any constraints introduced by quadraphonic recording techniques.

Finally, on analysing the frequency response

plots made in the anechoic chamber, I must mention that I have a slight doubt about the accuracy of the measurements below 70Hz. With normal moving coil systems, there is not likely to be more than an error of a dB or two at 50Hz, but in my opinion, the pen charts are slightly optimistic here. It is exceptionally difficult to work out an appropriate compensation that might be added, and such compensation will be different depending on the size of the speaker. In all probability, the response will be between 1dB and 3dB down on that shown on the charts. In the case of the Acoustical Manufacturing 'Quad' Electrostatic, since the system is bi-directional at low frequencies, the error may be greater. I suggest that as the listening environment largely controls the bass end, variations will consequently be greater in practice, more so than any minor corrections that might be necessary on the response as indicated. Unfortunately, a very much larger chamber would be necessary to check a loudspeaker's performance accurately, and probably the only sufficiently accurate one would be the enormous chamber at the Building Research Station in Garston, Herts. Even tests in the open air would be unreliable, unless each loudspeaker was raised at least 12 metres above ground level, which would require an extremely expensive beanstalk, as well as a day without wind.

Coloration

A loudspeaker's job is to provide a sound pressure level in the environment in which it is placed, which is at all times directly proportional to the audio voltage fed to it. But, in virtually every loudspeaker, the cone or diaphragm does not achieve perfect linearity with the driving voltage. Sometimes the frequency response of the system is relatively poor, yet some loudspeakers can measure extremely well but sound quite hopelessly wrong.

Every loudspeaker so far made adds an additional sound to the theoretically correct one, and the degree to which this happens can be termed the severity of the 'coloration' of the sound. A typical example of coloration can be obtained if you ask a friend to speak to you quite normally, and then through cupped hands or through a paper tube. The colored sound will contain components which were not originally in the voice. These may be produced by cabinet resonances, internal sound reflections inside the loudspeaker cabinet, or even in the loudspeaker cone or diaphragm.

Sometimes coloration is produced over the major proportion of the speaker's response, but, as often as not, it is produced over a relatively small band—usually at middle frequencies. The subjective panel noticed that a recording of a harmonica sometimes sounded realistic, but quite frequently sounded more like an accordion or, in extreme cases, like a squeeze box being playing in a wasps' nest! Violin tone occasionally sounded so colored that the listener gained the impression that the instrument was being played inside a wardrobe or large plastic dustbin, with or without a metal lid as appropriate. Occasionally, the violin tone which was reproduced, sounded as if it was being played with emery paper. If you listen to a violin at a distance of about 2 metres you should hear a firm and sweet high frequency sound, matched by a firm and solid resonance from the body of the instrument. A violin is quite a bright instrument, but its tone should never be spiky or pinched—let alone honky or seriously lacking in body.

A large Victorian football rattle, kindly loaned by a friend, was also recorded in the anechoic chamber and reproduced over each loudspeaker. The transients introduced by the ratchet mechanism were indeed a hard test for each tweeter, and in some cases clear signs of chirping were introduced, which were attributed to some form of ringing.

The crossover units of some speakers allowed too much high frequency sound to be fed into the woofer, and since in general woofers have their frequency range extended rather too high up at middle frequencies, high frequencies produced by the rattle tended to be reproduced also by the woofer with occasional drastic results. In such cases, a dark and muffled plopping sound was heard in addition to the main sound which exaggerated the effects that would be produced by many percussive instruments.

Some loudspeakers reproduced white or pink noise with a steam locomotive chimney sound, which is usually caused by coloration, but sometimes by serious response anomalies at upper mid

frequencies. In the reviews, I sometimes liken the coloration produced by a speaker to an added vowel sound such as 'aw', 'ee' or 'ong', since it is felt that vowel sounds in the same frequency range would indicate more clearly to a reader the effect of coloration which can otherwise be rather difficult to describe.

At bass frequencies, coloration, if introduced, causes a loudspeaker to become perhaps boxy or honky. Bass notes can sometimes sound flabby, whereas a good loudspeaker will reproduce them clearly and fairly well damped. A few loudspeakers appear to have an overdamped bass, and low frequencies only became realistic when the volume was increased to a fairly high level. Although this effect is partly due to deficiencies in the human ear, undoubtedly the use of too large and powerful a magnet on the bass unit can result in a lack of body in the bass notes reproduced. All these effects could also be termed coloration.

Some cabinet designs allow the cabinet walls or structure to go on vibrating after a note is finished, or alternatively, once the air inside the cabinet has been excited, it may go on resonating at some frequencies for several thousandths of a second after the original note or transient has ceased. This effect obviously clouds over some of the music following immediately after a transient, and the worst examples of this were found in the omni-directional loudspeakers, as well as some other models, which receive severe criticism for this in the brief review section.

Perhaps the most uncolored loudspeaker known to the writer is the Quad Electrostatic and I suggest that you take an opportunity to listen to it, comparing the reproduction with an average moving coil loudspeaker, after which I feel you will see what I mean when I say that the coloration introduced by a loudspeaker is probably one of the most important factors in evaluation. Some moving coil loudspeakers have surprisingly low coloration and amongst the best of them in this respect at middle and high frequencies are the BBC designed LS3/5A, Spendor BC1 and KEF 103 models.

The thickness of the cabinet walls can affect coloration, and the computation of the correct thickness is not at all easy. To avoid internal reflections inside the cabinet, almost all well designed loudspeaker systems have the interior cabinet walls lined with a thick felt-like substance in order to dampen any reflections, in much the same way as the fibreglass wedges deaden the sound in an anechoic chamber. Thus, the inside of the cabinet should be acoustically very dead. The rigidity of the cabinet is also important, and some low frequency coloration can be removed by adding strengthening struts from one side wall to the other. If designed unskillfully, however, these struts may well cause the cabinet walls to vibrate in a harmonic mode, the frequency of which may happen to coincide with some resonance or other of the entire system, thus worsening the overall subjective coloration.

In many designs, the crossover frequency between the woofer and the squawker or tweeter is set too high, so that at the higher end of the woofer's frequency range, cone break-up becomes evident, and harmonic and intermodulation distortion produce the effect of coloration. As previously explained, any breakthrough of frequencies from any unit into such a woofer can emphasise mid-frequency coloration.

The mechanical design of tweeter units is exceptionally difficult, and we found in the listening tests that soft domed models seem to give a more silky and purer sound than hard ones. On the other hand, soft domed tweeters are much more difficult to quality control, since any slight variation in the doping or thickness of the dome has a more significant effect on performance. Tweeters having a horn loaded throat seem to produce a typical type of focused sound which sometimes gives a 'cupped hands' effect on speech. The sound from such tweeters was frequently found to be significantly detached from the other sounds produced by the speaker. In a few models of tweeter, prisms or other deflecting surfaces are introduced in an attempt to widen the polar diagram at high frequencies. In listening tests, however, we found that in many cases there were gaps in the sound field in which odd cancellations or suck-outs were clearly audible, thus showing that the design of such additional mechanisms is very critical indeed. Some tweeters have defraction plates to sprinkle out, as it were, high frequencies in all directions. Once again we subjectively detected areas of high frequency peaks, which at times became

quite objectionable. A few manufacturers have removed or modified the defraction plate or its associated mouth in order to improve the sound, but only rarely was the quality better rather than worse.

The effect of poorly or incorrectly designed crossover networks can also be detrimental to the coloration performance, and one recent change of crossover components caused a very substantial improvement in the apparent high frequency coloration performance of a tweeter unit.

I reviewed, in a survey of 18 loudspeakers about 18 months ago, a KEF 104/AB, and whilst I considered it then a good loudspeaker, I claimed that something was wrong with the design of the T27 tweeter unit. Many other reviewers had made similar comments, and I was most interested to receive a demonstration recently by Laurie Fincham, KEF's chief engineer, which showed quite clearly that the tweeter had never been at fault. He admitted that a relatively minor change in the crossover gave the clearly improved performance, though the general circuit analysis was so complex that he had to use a fairly sophisticated computer to redesign the circuit. Whereas the old circuit produced a slight chimney-like sound at the lower end of the high frequency range, this virtually disappeared when he switched the tweeter over to the new crossover circuit which is incorporated in the KEF 104AB's reviewed in this book. This improvement was put into production in the early summer of this year. I mention this particular point here because of its relevance to high frequency coloration generally, since it clearly shows that whilst a trained ear can detect a problem in a particular frequency band, it is not at all easy to find the direct cause of the problem. I am told by KEF that the anechoic chamber response tests of the old and new designs are virtually identical, and so this is obviously a typical example of the importance of subjective listening tests in the design of a loudspeaker, which must then be followed by lengthy investigations of the cause of any anomalous sounds.

If noticeable coloration is present in a loudspeaker over a particular frequency band, the frequency response as measured will not necessarily be affected if measured normally. Subjectively, however, the ears' attention will be drawn to that specific band, and the impression given is of an excessive output being present in the same band compared with other frequency bands. The reason for this is that the additional output given during programme by the coloration effectively adds to the power output in that band at the time that the voltage input to the speaker is directly controlling the unit's diaphragm. Generally, the total energy produced by a given sound is thus greater, although the transient energy should not be affected. Sine wave response tests will not show this up. Similarly, pink noise measurements are also fairly ineffective. However, the ear will note coloration on such a signal. Several types of pulse can show up coloration, which thus allows a form of objective measurement.

Sometimes loudspeaker manufacturers attempt to offset the apparent boost given by a colored band of frequencies by employing an acoustical or electrical 'suck-out' circuit which reduces the output energy in the appropriate band. Whilst this can be partially successful in giving less audible coloration on quite a lot of material, continuous sounds such as classical or pop organ appear to recede in the frequency range covered by the suck-out, and many instances of this receive comment in the reviews (nb: mid suck-outs are sometimes introduced for other reasons; see the chapter on frequency response).

Coloration can also be introduced by placing a loudspeaker inappropriately. Quite often a unit when mounted on its plinth will appear to be very good, but lower frequency coloration becomes evident if, for example, the speaker is mounted in a corner. In such a case it is true to say that the coloration is produced not by the speaker itself but by its acoustic environment, since low frequencies are always emphasised when a loudspeaker is placed close to a wall, floor or corner. Please see section on loudspeaker placement for further reference to this.

Distortion

Before attempting distortion measurements on loudspeakers, we felt it important to check the basic performance of all equipment in the chain,

including the test microphone. Many readers may well ask how on earth we can measure microphone distortion when all transducers are likely to be far worse than a good microphone. We eventually decided to use an intermodulation distortion method, in which one frequency was passed through one good loudspeaker, whilst the second one was reproduced by another unit of equal performance. Each individual loudspeaker, of course, could not generate intermodulation distortion within it, since it was itself only generating a single frequency plus a few harmonics. The microphone, however, would be picking up both tones simultaneously, and so we were able to carry out swept intermodulation measurements of $f_2 - f_1$, $2f_2 - 2f_1$ and $2f_2 - f_1$.

We were delighted and slightly surprised to find that the distortion of the B & K microphone and of the studio microphones used for some of the anechoic chamber recordings had virtually insignificant distortion contents. Thus we have confidence in all the distortion pen charts taken within the known bounds of the test equipment.

Because of breakthrough problems at very low frequencies in the tracking wave analyser, a 2nd harmonic distortion performance of the equipment was limited below 70Hz or so, and although this could have been eliminated, the actual curves would have taken perhaps ten times as long and it was not felt practical to do this. In any case, almost all loudspeakers had significantly more low frequency 2nd harmonic distortions than was produced by the equipment limitations referred to. The 2nd and 3rd harmonic distortion charts are shown as the distortion component present of the fundamental frequency marked on the chart and obviously fundamental frequencies above 10kHz on the 2nd harmonic chart and above 6.5kHz on the 3rd harmonic chart are fairly irrelevant. The half inch microphone used, however, being flat to about 35kHz, nevertheless showed some interesting distortion peaks well above the top of the audio spectrum on some loudspeakers. We also decided to measure $2f_2 - f_1$ intermodulation distortion with a frequency spacing between the two tones of 300Hz. This means that frequencies significantly below 400Hz are totally irrelevant, since the 2nd tone would be 100Hz and the equipment would be automatically analysing 700Hz (2x400Hz—100Hz—700Hz). If one frequency is very low the distortion produced will not be representative of two tones, since the basic response of the speaker will be going down dramatically on very low frequencies anyway. Intermodulation distortion is generated by tweeters; for example when two musical notes are produced from different instruments in the same frequency region simultaneously.

Incidentally, such notes would almost always be harmonics rather than fundamental tones in tweeters, although squawkers might well give intermodulation products on high frequency fundamentals. We were horrified to find that some speakers exceeded 1% distortion at middle and high frequencies when only two tones were present, so the reader can imagine the distortion content when more tones are present at the same time. To put these figures in perspective, I feel sure that almost any reviewer would severely condemn an amplifier producing distortion which was half as much as that produced by most of the loudspeakers and so this proves clearly that the loudspeaker is basically one of the weakest items in the hi-fi chain.

At low frequencies, most loudspeakers gave predominantly 2nd harmonic distortion, whereas at mid and high frequencies the 3rd harmonic tended to be worse (some tweeters had noticeable 2nd harmonic peaks though). We did not have time to investigate the causes of specific distortions, but as a rule 2nd harmonic distortion is caused by frequency doubling in the cabinet/speaker combination and 3rd harmonic distortion can be introduced by saturation of iron cored components in crossovers. Distortion can also be introduced by cone break-up in which a diaphragm or cone will tend to adopt a harmonic mode of movement when excited by a particular fundamental. This can be seen at the design stage by examining the movement of cones when lit by a stroboscopic lamp. The effect is similar to the stroboscope markings of a turntable, which will slowly move one way or the other unless the speed is correct. The movement of the loudspeaker cone will be seen to go in and out very slowly indeed although it is in reality going in and out at perhaps 100Hz or so. Any movement in the harmonic mode can be seen as variations in the slow in and out movement. Tweeters, however, are extremely difficult to test

in this way, and high speed photography is required, but this has nevertheless been achieved by a few manufacturers and research institutes.

When examining the distortion curves, allow for the response of the fundamental shown on the sine wave response chart. A 40dB difference between the response of the fundamental on this chart and the level of the distortion would represent 1% distortion, 50dB approximately 0.3% and 60dB 0.1%. All the distortion measurements were taken when the input to the loudspeaker represented the level required to give an average output at middle frequencies of around 90dB sound pressure level. In general, large bass woofers generated substantially less distortion than small ones but remember that small speakers would be, comparatively speaking, driven harder still in practice at this level than would larger units. Nevertheless, it shows fairly clearly that for any given amount of volume, the larger unit will usually reproduce a cleaner bass. The ear, however, is not so sensitive to low frequency distortion as it is to that introduced at higher frequencies, so obviously there are swings and roundabouts.

Impedance and Phase

The DC resistance of a circuit is normally quoted in ohms and the well-known Ohm's Law defines resistance as the voltage applied divided by the current drawn. In AC circuits, the equivalent resistance at a particular frequency is termed the impedance, and by convention and convenience is also quoted in ohms. A loudspeaker's impedance is usually quoted nominally at 8 ohms for example, but when the same speaker is measured in the laboratory over the audio range its actual impedance can be seen to vary from as low as 6 ohms to well above 25 ohms. The higher values of impedance usually occur at low frequencies and, since transistorised amplifiers are not worried about very high impedance points in a loudspeaker's impedance curve, we did not bother to note measurements above 27.5 ohms. By doing this it allowed us to see very clear impedance changes at the lower end and, in particular, note if it went below 6 ohms at any frequency. Unfortunately, some speakers, rated nominally at 8 ohms, had impedances as low as 4.5 ohms and thus would present difficulties to many amplifiers. Modern transistorised amplifiers are theoretically voltage generators and the lower the impedance of the loudspeaker at any particular frequency, the greater will be the current drawn at that frequency and therefore the higher will be the power dissipated in the voice coil and crossover network.

We measured the impedance by generating a constant current source and measuring the voltage across the loudspeaker terminals. This enabled us to pen chart the impedance over the audio spectrum, our measurement actually representing what is termed 'the modulus of impedance' rather than the pure resistive impedance component.

The phase relationship between the voltage and the current was also measured using a Hewlett Packard gain/phase meter and we measured the phase lead or lag in degrees, again over the complete audio spectrum. The amount of phase variation from zero degrees gave us an indication of the 'imaginary' component in parallel with the equivalent resistance. The impedance and phase measurements were taken at a fairly low level. We checked in the laboratory a few speakers at different levels and found that the voltage/current relationship always seemed to remain similar except for the electrostatics. It would have been virtually impossible to make the measurements at a substantially higher level, since the source voltage to the constant current series resistor would have had to be hundreds of volts and this would have been extremely difficult and impracticable to obtain.

Very considerable differences in impedance characteristics were noted in different loudspeakers and some of the impedance pen charts published literally look like the Alps. These curves must not in any way be confused with the response ones and it is because of possible confusions that some reviewers, including myself, quite reasonably do not like publishing them. In almost all cases peaks and troughs are irrelevant if they are substantially above 8 ohms, but I have commented in the reviews on any points in the charts where the impedance drops below 8 ohms.

Whilst on the subject of phasing, I should refer to some loudspeaker designs in which the loudspeaker's acoustic output is claimed to be linear in phase with respect to the input. These 'linear

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phase' designs include models made by B & W (DM6), Technics, B & O and Leak, and in all cases a listening panel found quite severe problems in both vertical and horizontal polar diagrams. If a loudspeaker is designed to beam a linear phase sound at a point away from the loudspeaker, and at a stated height above ground level, any other vertical listening position will clearly be other than phase linear, since the ratio of path differences between the different units of the speaker and the listener's ears will be changed. As the frequency is raised, phase becomes evermore critical, and unfortunately I must admit that not only am I bitterly disappointed by the linear phase designs but I feel that other parameters than phase have been sacrificed in an effort to achieve good square wave reproduction into an appropriate microphone in a specific position in an anechoic chamber. I would here like to draw the attention of the interested reader to some letters on linear phase that have been published in the early months of 1976 in *Wireless World*. My colleagues and I all place ourselves in the Dudley Harwood camp, and like Hans Evers we too would be prepared to 'eat our hats' if phase relationships are that important in single loudspeaker reproduction. I am making arrangements, however, to order some hats made of rice paper just in case! But when it comes to phasing the different loudspeaker system in a hi-fi chain, this of course is vital since one is dealing with the correlation of phase between two loudspeakers reproducing the same frequency range.

Efficiency and Power Output

When each loudspeaker was tested in the anechoic chamber the output level was measured for an RMS input level of 2.83V. For this test both unweighted and dBA weighted outputs were measured for pink noise input to the speaker. We were most interested to find a very considerable spread in the efficiency of the loudspeakers, a few models giving below 80dB sound pressure level out, whereas the most efficient loudspeakers produced levels of nearly 90dBA for the same input. To put this into perspective, a loudspeaker which gave a 90dBA and fed with 1W of power would give the same acoustic output as another speaker when driven with 10W, if the second speaker was 10dB less efficient. This tremendous variation of efficiency will emphasise perhaps the necessity of choosing an appropriate amplifier to drive your chosen loudspeaker system. Many hi-fi enthusiasts have commented to me that they cannot understand why some people seem to need a 60W-capability amplifier, whereas they themselves achieve full room volume with only 10W or so. The answer, of course, is in the varying sensitivities of different loudspeakers.

It is extremely difficult to tie up some measured sensitivities with the effective aural sensitivity of some units. Some loudspeakers, having very pronounced peaks in the response, sound louder than others having a similar overall sensitivity but a generally smoother response. A system that has a lift in the 2kHz presence region will almost always sound louder than one not possessing this lift, despite the fact that the main energy in the average programme reproduced is between 1 and 2 octaves below 2kHz. Many readers, after reading this book, may well be choosing a loudspeaker with relatively low coloration, a fairly wide response, and one that lacks general peakiness in the treble. In general such loudspeakers are audibly less efficient and will thus require a more powerful amplifier to drive them. For general purposes most of the better loudspeakers will require an amplifier having a peak output capability of 40W RMS if the listening room is not on the small side. If you already have an amplifier of substantially less power rating, perhaps of 15W maximum output power or so, then you may well have to choose a loudspeaker which is more efficient, but unfortunately, in most cases a high efficiency ties in with worse than average coloration. One of the most efficient loudspeakers in the survey was the Lowther, which can reach full room volume when driven with just a few watts, but the coloration at middle frequencies was so severe that the listening panel found the quality completely unacceptable.

If a loudspeaker has to be driven hard to give a required output level, because the system is relatively inefficient, problems may well be experienced in the overheating of the speech coils. In general, classical music contains much less continuous energy than pop music and so you are unlikely to get overheating problems if

you are primarily interested in reproducing classical music. A word of warning here, though, is most appropriate. Electronic classical music is well known for its tendency to blow up tweeters, since some long sustained tones at high frequency can cause severe damage by the heating effect. In the anechoic chamber only one loudspeaker failed under test. The Leak 3020 managed all its response tests and even the 2nd and 3rd harmonic distortion ones, but when in the swept intermodulation tests the two frequencies reached around 5kHz, a loud fizzing was heard followed by complete breakdown of the tweeter. The level at this point was only just over 90dB, the latter level having been set at a lower frequency, the slightly higher level being given out because of the speaker's increased efficiency at 5kHz. The second sample was then tested at a 3dB lower level and managed the entire test sequence without mishap. I must mention here that the initial samples of the Leak 3020 tested were factory protoypes sent to us at an early stage, in order to allow them to be included in this book. The problem was explained to the manufacturers and they will naturally be attending to it and I trust that production samples will have better heat dissipation in the tweeter. 90dB is not too loud and is a level that you would have at home if you were playing electronic music feeding somewhere between 1W and 5W into the average speaker system.

Pop music and especially heavy rock is very demanding indeed on a loudspeaker system, since most listeners frequently reproduce it fairly loud or even extremely loud! Very few of the smallest systems reviewed in this book are suitable for reproducing loud pop music, for it usually contains considerable peak energies at very low frequencies produced by bass guitars and percussion. Smaller sizes of woofer are not normally designed to take a lot of punishment, and if such units are interconnected with an amplifier capable of producing a high output power, the cone literally shoots out of the gap, hits the end stop and the coil former then can become so damaged and physically distorted that it will not return to its original centre position. Damaged woofers, if they are indeed still actually working, will normally make a flapping noise and do not reproduce bass frequencies without considerable scraping and grinding noises becoming fairly obvious. You can always check for this if you suspect your woofer, by lightly and carefully pushing it in evenly and noting if the movement is free, or alternatively, if you can hear a slight scratching sound as the coil former scrapes against the magnet assembly.

The output capability of a loudspeaker is dependent on its efficiency, and the lower the efficiency the more drive the loudspeaker will need, and so the greater will be the heating effect in the unit driving coils. It is better therefore to note the output power capability rather than the input rating to gain an idea of how loud a loudspeaker will go. The most inefficient loudspeaker that I have yet come across was the KLH 9 electrostatic, which required approximately 8dB more drive than a 'Quad' electrostatic for the same output level. We did try a pair of KLH 9's as a possible reference standard, but found that the requirement for a 200W amplifier to drive them was a bit ridiculous, especially when the acoustic output at that level was not particularly loud. The speaker was also rejected because of its extremely poor polar diagram at high frequencies. Notwithstanding these criticisms, though, the KLH 9's certainly do sound very nice indeed if the listener is precisely in the 'hot seat' position.

In the case of electrostatic loudspeakers their power handling restriction is dependent largely on the distance between the plates. The closer these plates are in any particular design, the lower is the peak voltage that can be applied across them to move the main diaphragm, which then gives the acoustic output. It is dangerous to use a hi-fi amplifier which is capable of giving a higher output voltage than that specified as a maximum by the manufacturers, and in the case of the 'Quad' electrostatic speaker the maximum allowable voltage that can be sent to the speaker is 20V RMS. The Quad 303 amplifier is designed to give this maximum voltage and their later model, the 405, can have a modification wired in to limit the output voltage to 20V. Incidentally, the Acoustical Manufacturing Company suggest that if you wish to use stacked 'Quad' electrostatics, it is better to connect the speakers in series rather than in parallel, as otherwise the amplifier will be loaded too heavily. This then allows amplifiers, capable of giving up to 40V RMS, to be used safely

with stacked electrostatics and we used this combination through the mono tests as an anchor reference standard of known high quality.

Apart from the basic efficiency of the individual units used in a loudspeaker system, efficiency is also highly dependent on the type of crossover unit employed and quite frequently a manufacturer has to attenuate the output of a tweeter or squawker because of the relative inefficiency of most woofers. Many loudspeakers employ controls which vary the output to some of the units and if you turn these controls up the overall efficiency will increase, but you will dramatically affect the balance of the entire sound output. A unit's efficiency is also dependent on the type of magnet that is used and the distance between the outside diameter and the coil and the magnet assembly. The type of suspension used will also govern efficiency. The general impedance of the system controls apparent efficiency, but this is only because transistor amplifiers are ideally constant voltage generators. Provided that your amplifier is capable of delivering its output without any problems into a 4 ohm load, a 4 ohm loudspeaker will give an apparent increased volume when compared with an 8 ohm one of equal power efficiency. This is because the 4 ohm loudspeaker will be taking twice the current of the 8 ohm one and so of course the wattage dissipated is doubled and hence the speaker is apparently 3dB louder.

In making all the output level tests it is emphasised that each loudspeaker, whatever its impedance, was driven at the same input voltage level of 2.83V, which is equivalent to precisely 1W if dissipated in a pure 8 ohm load. Since the impedance of loudspeakers is very variable, the calculation of overall efficiency is almost impossible and in any case irrelevant for modern amplifier/loudspeaker combinations. For this reason the reviews only contain figures for output level when driven by pink noise having a RMS value of 2.83V. Please see chapters on 'Impedance and Phase' and 'Amplifier Requirements and Interconnection with Loudspeakers' when considering the effect that loudspeakers have on various types of amplifier.

The average loudspeaker gives around 4mW output for an input of 1W, although one would naturally find variations in efficiency. Most loudspeakers, though, for the same input, would give between 1mW and 10mW, thus representing a power transfer efficiency somewhere between 0.1% and 1%. In terms of output level, then, the output would be somewhere between 20dB and 3dB below the theoretical output that might be obtained from an infinitely efficient system. Horn-loaded loudspeakers are of course much more efficient and it is for this reason that many public address systems incorporate large metal-mouthed monstrosities, in order to give a better coverage for a given input power. The most efficient loudspeaker in the survey was the Lowther and this was somewhere between 10 and 15 times more efficient than the average of the speakers in the survey. Horn-loaded units thus can achieve somewhere between 5% and 10% power transfer efficiency. Finally, the output figures given in each loudspeaker's tables represent the energy received by the probe microphone when it was one metre in front of the speaker. In a normal living room the measurement would probably give a 3dB higher reading, since a considerable amount of sound would be reflected on to the microphone from the walls of the room. A loudspeaker will sound louder in a reverberant room, as compared with a rather dead one, for any given input power.

Frequency Response

The average ear responds to frequencies from as low as 20Hz to around 16kHz or so, although younger people may well hear up to at least 20kHz. However, very low frequencies can only be heard properly in a hall or other very large room. Thus it becomes virtually impossible to reproduce frequencies below 40Hz or so in the average living room, since the wavelength of their low notes is so long that the sound is literally not projected to the listener. Strange as it may seem, there is not much point in choosing a loudspeaker with a low frequency response, extending well below the effective cut-off frequency of your particular room. Many of the larger speakers in this survey do not give any significant benefit over medium sized ones in the average room. But in studio control rooms, especially where the walls and ceiling have been acoustically treated, low frequencies can be reproduced more clearly, sometimes well below

the predicted cut-off frequency. The point I am making is that a medium sized speaker will almost certainly give at least as much satisfaction as a large one in the average room and, quite possibly, a fairly modest speaker may well give you a lot of pleasure in a small room. (Please see the section dealing with room placement).

Consequently, I attach maximum importance to the measurement of frequency response from about 50Hz at the bass end to around 15kHz at the high frequency end, and you will notice some most unusual anomalies in the response curves for each speaker. The forward-facing energy output should be maintained at a flat response over the full frequency range mentioned, no matter how many units are mounted in the enclosure. Unfortunately, many speaker designs have an incorrect balance between the general output level from the tweeter and the lower frequency units, which resulted in some speakers sounding clearly up in response in some region or another.

A retailer told me recently that if he is demonstrating several small loudspeakers with a comparator, as often as not the uninformed purchaser goes for the unit which is the toppiest. It is perhaps for this reason that some designs are ridiculously toppy, and thus unacceptable to musicians and others possessing a reasonable idea of sound balance.

On the other hand, some tweeters had a generally correct balance against other units, but produced unpleasant resonances and valleys over their response range, which caused the loudspeaker to give a scratchy, brittle, hard or screechy sound. One well-known European make of tweeter appears to have a clear, unpleasant resonance at a very high frequency, producing a steely sound which became very tiring.

The sound of pink noise reproduced by each loudspeaker was very different, and whilst some were remarkably smooth and continuous—although perhaps with response anomalies—others sounded excessively peaky at high frequencies. You can try the effect yourself at home by listening to FM tuner hiss when the tuner is set well away from any station.

Each individual unit in a complete system is designed by its original maker to encompass a specific frequency band, and crossover networks have to be employed by the designer to split up the audio signal appropriately to the different units. The crossover not only has to accomplish this whilst allowing the system to present an overall flat response, but it must also attenuate frequencies outside the unit's range from getting into that unit, as otherwise, additional coloration might be produced. The crossovers have to be designed extremely carefully, since not only is the turnover point of considerable importance, but the reactance over the audio band is vital if the different units are to present a reasonable load to the amplifier driving them via the crossover.

Sometimes mid-frequency suck-outs are introduced to offset coloration, but occasionally they can be inserted to provide a specific effect, which some engineers have felt appropriate particularly for professional monitoring applications. My colleagues and I are not at all convinced that this practice of introducing, for example, a 2 or 3dB valley at around 2kHz is wise, for although it may allow a sound to be audibly better in fairly reverberant rooms, in some rooms which are better acoustically, the suck-out becomes clearly audible, causing the presence region to recede somewhat. Some broadcasting organisations frequently employ monitor loudspeakers with this presence dip, as it is claimed that the average control room used for mobile recordings is fairly reverberant. I feel, however, that under some circumstances this might cause an engineer to add more presence to a sound than might be advisable, but this will largely depend on the experience of the engineer.

Some loudspeakers show an upper bass boost, and this became particularly noticeable when the speaker was placed near a wall. This boost is often introduced to offset a fall-off of response at a lower frequency, but unfortunately many sounds are audibly affected by such a boost. Male speech should not be boomy, but sometimes can be rather chesty in the case of bass voices.

At the high-frequency end, some tweeters had very pronounced dynamic resonances, and with one make one member of the panel asked to be excluded from the test as he said that the resonance heard by him was so objectionable that he could not be rational about the performance of the speaker at lower frequencies. A quick test

proved the resonance to be around 20kHz!

Many loudspeaker systems incorporate sensitivity controls, allowing independent variation of the output levels of one or more units. Some systems incorporating such controls did not give a smooth overall response, and quite frequently we had to cut mid or top to achieve an acceptable sound quality. Where tweeters had noticeable peaks, we found that the best position for the control often lowered the overall high frequency energy fairly appreciably, although such a position gave a total high frequency energy that was less than would be required for a flat average response. It was felt in general that marginally too little top was preferred to an equivalent boost, and that small valleys in the response virtually anywhere were preferable to the equivalent hills. Often, a slight shelf treble boost was not disliked unless it was accompanied by peaks, provided mid and lower frequencies did not have an equivalent trough.

It appears that it is important for a loudspeaker system's direct energy to be equal when comparing the octaves above and below 1kHz. For example, the average response around 500Hz should be as close as possible to that around 2kHz, and the 100Hz region should be equal to that at 10kHz etc. Loudspeakers not having this type of balance will almost always produce sounds which are clearly deficient in one way or another.

Some loudspeakers have specifications in which the response is said to extend to 20kHz and beyond, whereas others only specify the response to 15kHz. I feel it is dangerous to be too concerned about such differences, since so many of the sound sources cut off very steeply above 15kHz anyway. However, I did find that much is lost for the average person if the response falls rapidly above 12kHz, and a few loudspeakers counteracted such a fall by introducing a hill around 8kHz. This often produces a very hard or brittle quality, which at first gives the impression that extreme top is up rather than down. Surprisingly, I find that massed strings show up the problem quite clearly for they become strident and tend to lose some of their silkiness. Brass and percussion instruments can come forward in a balance, whilst transients seem to be ripped off.

If the response shows a boost in the upper mid-frequency region, the sound can appear to be similar to that given by mid-frequency coloration, but the effect is sometimes rather different. A hollowness can be produced, and the loudspeaker will sound much less realistic. In the reviews, I have used many descriptive words in an effort to describe the peaks and valleys in the middle frequency band. Since vowel sounds are at middle frequencies, boost regions can be likened to such sounds.

Errors at lower middle frequencies and upper bass ones tend to produce boxiness or a cardboardy enclosed sound, which unfortunately betrays so many speakers. I emphasise again that anomalies in frequency response are fairly difficult to differentiate from coloration in the same region, and it is here that reference to the frequency response pen charts will be found useful. If a loudspeaker does not show any clear signs of humps in a region where comments of boxiness are made, it can almost certainly be assumed that the comment refers to coloration. Note here that the height of a loudspeaker above floor level can be quite critical, since even the floor can appreciably alter the apparent bass end performance. Some speakers, such as the Tangent model RS6, are specifically designed for floor mounting, whereas others require different heights of plinth. Anomalies at the bass end will be noted on many pen charts, and in such cases I feel it most important for the reader to note the subjective comments of the panel, since anechoic chamber tests at lower frequencies are purely an indication of a loudspeaker's capability.

Some manufacturers stipulate that their loudspeaker should be tested hard up against a solid reflective wall rather than the absorbent wall normally found in a chamber. It was totally impracticable to do this. In any case, it is felt that loudspeakers are not normally screwed to a living room wall. Measurements, however, made in this way would give a definite lift to lower frequencies, and quite clearly many small loudspeakers would give an improved overall performance—but possibly these upper bass regions may become rather excessive. We feel that it is better to interpret the pen charts in the way previously suggested.

I have also been recommended to do measure-

ments in a reverberant room so that a total energy response and output could be measured. Once again, I do not really agree with this procedure, since our ears hear the direct sound of a loudspeaker, followed by any indirect sounds, in the same way that the ear picks out any required conversation at a party whilst tending to ignore anything other than the direct information. Measurements in reverberant chambers would not show anomalies of direct radiated response if these were 'filled-in' by backward facing radiation clearly separated from the main sound source. Further comments will be found in the chapter dealing with omni-directional loudspeakers.

In *Hi-Fi Choice: Receivers*, I explained that an amplifier should have a reasonably good damping factor, this being the ratio of the load impedance presented to the amplifier to the source impedance of the amplifier itself. If the amplifier's source impedance is below 1/10th of the lowest impedance presented by the complete speaker system, no response problems are likely to be encountered due to the amplifier/speaker combination, although some bass notes might be heard to be slightly soggy when driven from a barely adequate amplifier.

It is important, therefore, for the wire used to connect the amplifier to the speaker to be of several amps rating. Consequently, the total resistance in the leads should be kept as low as possible. Bell wire is hopelessly inadequate, and even some makes of twisted flex have too high a resistance. For most installations, 5amp twin mains cable is recommended, although if the loudspeakers are located even 15ft away from the amplifier it may be necessary to increase the rating to 10amps, particularly if the full output potential of the amplifier is required by the loudspeaker. Always use wires with two colours so that you can be sure of connecting the speakers in phase. If they are not in phase an unusual, and typical, sound is produced, in which central images become excessively blurred and bass frequencies are curtailed. To check phasing, place the two speakers face to face with only a very small gap for the sound to come out, and play a mono signal to both. Change the leads around to one loudspeaker only, and you will notice that one way there is much less bass. This position is out of phase and incorrect.

In practice, some loudspeakers subjectively sound down in bass at domestic volume, and yet seem to become more bassy when driven fairly hard. This effect is not likely to be produced by the speaker itself having a different response at different dynamic levels. The ear, however, has an odd characteristic, such that as the volume of a programme is progressively reduced the apparent amount of bass, and to a lesser degree extreme top, reduces more than mid frequencies. Some charts, known as Fletcher Munson curves, show this quite clearly, and it is for this reason that some amplifiers and receivers incorporate a loudness control to boost bass and top at lower listening levels. I do not personally like such controls for I prefer to adjust the volume so that I can hear the sound at a realistic level and thus theoretically the correct balance between bass, middle and top frequencies. If a programme is reproduced at well above the level intended by the producer of the source, then the listener will hear too much bass and treble, and this is the main reason why powerful loudspeakers can often sound more impressive at bass frequencies.

In some cases, small loudspeakers have a fairly severe power limitation in terms of output power, rather than the power necessary to produce the output. However, if small loudspeakers do not allow a realistic volume to be achieved they will naturally sound light in bass. You might try to prove this sometime by carefully altering the volume to a fairly high power rating speaker system driven by a known programme source.

It is important that you should look through the chapter on the anechoic chamber with reference to response, particularly noting the calibration of response curves at 50Hz.

Polar Response and Omni-Directional Speakers

An ideal loudspeaker would sound equally good when listened to from any angle in front of it. Most loudspeakers are intended to give their optimum sound quality when the listener is directly ahead of them, although a few units are designed to beam the audio signal into a central position if they are listened to as stereo pairs. Unfortunately, many such models presented a noticeable wavering of high frequencies as the

listener's head moved from side to side or up and down or both. The severity of this wavering was noted by the listening panel. In the worst cases, where the listening position was very severely limited, the loudspeaker cannot be recommended for other than special applications, unless the system had important merits. The vertical polar diagram of the Quad Electrostatic loudspeaker is pretty poor, but the main axis is designed to beam pretty accurately towards the listener sitting at a reasonable distance back from the loudspeakers. Some cases of vertical polar diagram inadequacies were so marked that the reproduction was virtually intolerable in normal listening positions, and a considerable improvement was only noted if the listener either sat on the floor—or in extreme cases, lay down on the floor or even stood up! If two or three people are relaxing on a sofa about two and a half metres back from a pair of loudspeakers, it is only reasonable to expect that a loudspeaker system should present them all with more or less an equal sound quality, although they would naturally hear the left/right balance slightly differently.

We all found that some tweeters seemed to spray beams of exaggerated treble in specific directions which were not necessarily directly in front. Fortunately, most tweeters gave a very even distribution of treble over a fairly wide angle in front and thus stereo images were reproduced much more clearly over a wider area.

Sometimes, in three speaker systems, the tweeter and the squawker were placed side by side with the woofer below them. However, having had the experience of listening to all the loudspeakers in this survey, I should say that a vertical line for all the units seems far preferable in preserving stereo images. Loudspeakers that do nevertheless have some of the units in a horizontal line are usually supplied as stereo pairs with, in the main, the tweeters on the outside and squawkers on the inside. This tended to give a slight widening effect at very high frequencies, which exaggerated a common similar fault of many stereophonic recordings. To take an extreme case; one loudspeaker pair reproduced the main body of a voice at half left, whilst the sibilants and consonants were heard clearly at extreme left, giving the listener the impression that the singer was virtually lying down!

The best designs located the squawker and the tweeter immediately above the woofer, thus producing less marked differences in sound quality when the head was raised or lowered. Some loudspeakers, though, presented severe vertical polar diagram problems if the tweeter was too far above the woofer, the treble tending to sound somewhat detached. Many very expensive loudspeakers had quite serious anomalies in the polar diagram at middle and high frequencies and it is clear that manufacturers should pay more attention to the problem in general.

A few loudspeakers had the tweeters and squawkers mounted diagonally, which seem to us to offer the worst of both worlds in that both vertical and horizontal polar diagrams were affected. In extreme cases of poor polar performance a loudspeaker gave a very colored reproduction off axis, and comments are made where appropriate. We also found that the frequency response seemed totally different for some speakers when the listener moved his head slightly.

One loudspeaker incorporated an extraordinary contraption, which rebounded the treble from an upward facing tweeter to a horizontal beam. When a listener was on this beam, the sound appeared slightly toppy, but pretty good, but if the listener was too high or too low, the sound once again deteriorated dramatically. A knob allowed a reflected angle to be varied at will and perhaps this is better than some of the other tweeter arrangements.

Some omni-directional loudspeakers were submitted by their manufacturers, but unfortunately, we all took an instant dislike to them, even if we did not actually know that they were omni-directional. Throughout the initial in-house tests, I was not told by my colleagues the identity of any of the loudspeakers being heard. To prevent any possibility of deducing any makes by knowing what had arrived and what had not, I was only told the subjective test results at fairly long intervals, so that I tended to forget any memories of specific loudspeakers over a period of days, and this avoided any bias in back correlation of memories with the written forms. There were some loudspeakers, however, which were so poor in subjective performance that I could not

forget them and, unfortunately, the omni-directional types were intensely disliked. One of them received comments that "the sound was as if a 12" woofer was submerged at the bottom of an enormous plastic dustbin with a cardboard inner lining, but with a 1" tweeter hanging over the edge of the top". Not only was the coloration most oppressive to the panel, but some bands of frequencies receded most noticeably. One loudspeaker reproduced Eli Goren's Stradivarius violin as if it was being played inside a large wardrobe with the door almost closed.

To make quite sure, however, that our criticisms of omni-directional loudspeakers, as submitted, were valid, we also heard them again without knowing what they were in my lounge, which is somewhat more reverberant than my acoustically treated listening room. Results were not significantly better even when the loudspeakers were placed in a corner. In particular, any muddiness in the bass that was audible in my normal listening room became much worse in the more reverberant surrounding of my lounge. We tried every conceivable type of positioning, and in some places noted treble frequencies reflected from various walls and furniture several feet away from the loudspeaker. Since I am totally blind, which is surprisingly useful in relation to these tests, I feel that I am unbiased by appearance, and at the time I gained an impression that some of the omni-directional speakers were 4' wide and 1' tall. I realise that I am being most provocative on the subject of such speakers, and I wish to make it clear that the opinions of my colleagues and I, although in total agreement, may not necessarily agree with those of some other people. Suffice it to say, though, that after considerable discussion with many other loudspeaker experts and professional listeners, there would seem to be an almost unanimous dislike of this type of loudspeaker. Being perhaps somewhat cruel I should add that most of the omni-directional loudspeakers gave a similar sound quality in all directions, which as an alternative was equally poor in all directions.

Whereas in a forward facing loudspeaker the ear can discriminate clearly between direct sound and the reflected sound, the output of an omni-directional loudspeaker is sprayed out in all directions. Consequently, a very much higher proportion of the total sound energy is reproduced at random from all reflecting surfaces, rather than direct. Any slight difference of reflective co-efficience of horizontal or vertical surfaces behind, above, and on either side of an omni-directional loudspeaker will therefore lead to subjective response anomalies. I am not entirely against omni-directional loudspeakers, though, since I will never forget an experience that I had over 20 years ago when I heard a remarkable loudspeaker, which was omni-directional, made by the late Cecil J. Watts—known as "Watts Folly"! Its size was enormous but the sound quality it reproduced monaurally was very good indeed provided it was placed fairly close to a bare wall. Memories can be distorted though, and I wonder how this loudspeaker would sound today, particularly in stereo.

As I have explained, because omni-directional loudspeakers are highly likely to spray out frequencies in such a fashion that they become separated in different directions, it can be appreciated that a stereo pair will usually give very blurred central images. This may not be a disadvantage with some close and multimiked recordings but these are usually rather unrealistic anyway. Stereo radio programmes, though, lack clarity of positioning, and vocal sibilants seem to come from all over the place and usually detached from the rest of the speaker's body.

For this reason I am afraid that all the omni-directional loudspeakers of one form or another have only been given short reviews, for in any case, it is extremely difficult and irrelevant to measure them in a normal anechoic chamber. Their protagonists do measure them in a totally reverberant room, but for me this would be far more ridiculous a compromise than a measurement made in an anechoic room or even an average listening room.

I am not interested in the total acoustic output in all directions of a loudspeaker, since most of this is either absorbed by its surroundings, or is reflected to such a degree that most ears can discriminate it from the direct sound. Nevertheless, I hope that the manufacturers of omni-directional loudspeakers will understand my point of view.

Crossover Networks

The audio input signal to the loudspeaker system has to pass through a crossover network of some type, which allows the appropriate frequency bands to be passed on to the individual units that make up the system. Fortunately the laws of physics are such that, whereas a resistor attenuates all frequencies equally, capacitors conveniently cut bass at 6dB per octave, and inductances cut high frequencies at the same slope. Combinations of these three types of components can thus be used to split up the audio range into two, three or even four outputs. The crudest systems allow all the audio frequencies to go through into the low frequency unit, whilst a capacitor feed is employed to pass only high frequencies through to the tweeter. This extremely simple type of crossover is rather ineffective, since the rate of cut off of low frequencies to the tweeter is only at 6dB per octave and thus some middle frequencies will be reproduced by the tweeter, which may well add some coloration to them in a frequency band for which it was not designed. Furthermore, by applying the entire frequency range to the lower frequency unit, high frequencies will be colored, although most units would have a somewhat poor response above 6kHz or so. One of the simplest crossovers is employed in the Jordan Watts loudspeaker and its failings were attributed partly to the unsatisfactory crossover.

Most well-designed crossovers cut at 12 or even 18dB per octave, although some super tweeters are connected across the lower frequency tweeter by just a capacitor, the super tweeter being added to reinforce the extreme top octave. In addition to resistors, capacitors and inductors, some manufacturers also use small auto transformers to attenuate or even boost the level to a unit by inserting an impedance change in the circuit. An auto transformer is very nearly a perfect power transfer device, but it changes an effective impedance of a unit from 4 ohms to, say, 8 ohms. In such a case a transformer will lower the level to the tweeter by 3dB, although this effective impedance is doubled because the voltage gain of a transformer is proportional to the square of the impedance change. A transformer is therefore more efficient than a resistor pad and will preserve damping factor. Many manufacturers have several different taps on the primary and on the secondary, allowing the sensitivity of the tweeter or other unit to be varied at will. A few manufacturers actually set up the appropriate tap in quality control departments to select the flattest overall response. A cheaper method of achieving a similar result is to insert a potentiometer in the feed to a unit. However the different positions of this, when loaded by the unit in question, will reflect a varying impedance on the crossover, and thus tend to change its characteristics. Whilst some manufacturers get away with this technique, I am afraid others do not and we found that in the worst cases holes in the response curve near the crossover frequency seemed to develop when the potentiometer was moved away from its nominally correct position.

Some crossover networks have to employ very large values of capacity and inductance to achieve a low or middle frequency crossover point. High quality capacitors of a very high value are extremely expensive, and so most manufacturers use reversible electrolytics, which, whilst having a very high capacity in a very small size, have a degree of equivalent internal resistance and so can be what is termed 'lossy', i.e. rather inefficient. Some manufacturers go to the trouble of measuring the 'Q factor' of these components and reject any that are below an acceptable standard. Similarly, high quality inductors of a few millihenries are also extremely expensive, since they have to be wound with fairly thick copper wire in an annular ring-type construction. Very many turns of expensive copper wire are required to give a sufficient inductance for use at low frequencies if the device is air cored. If, however, inside the turns of wire a core of magnetic material is placed, the inductance increases dramatically, but at high levels some cores can saturate and thus induce distortion. This is almost always third harmonic and it can contribute to a degraded sound quality of low frequencies at high levels. The best types of core material are extremely expensive and so in some designs less expensive materials have been used.

One loudspeaker crossover of particular interest is employed in the Spendor BC3 pro-

fessional monitor, the circuit of which is shown in Fig. 1. The five 6-watt resistors are used to attenuate or damp parts of the circuit, and 14 polyester or paper capacitors are used in combinations giving eight capacitive lumps. Note that none of these are electrolytic types. One air cored inductance and six radio metal cored inductors are used, the latter having very good saturation levels. One auto transformer is also to be found in the circuit. The crossover components in the BC3 thus contribute to an appreciable percentage of the loudspeaker's cost, since radio metal is extremely expensive.

The choice of component values, if made from a theoretical computation, requires a fairly sophisticated computer and so many manufacturers design an approximate circuit, using pocket calculators, and then trim them by experimentation, perhaps when the unit is being tested in an anechoic chamber. I am told that some manufacturers arrive at an anechoic chamber with armfuls of different values of components and take them on and off a circuit board with all the outputs going to the relevant units in the complete system being tested in the chamber. Crossovers designed in this way may well work quite satisfactorily, but as often as not the impedance characteristic will suffer and furthermore a form of ringing or resonance near a crossover point can be introduced. If a computer is programmed correctly, with all the relevant performance parameters of the individual units, and the required crossover frequencies, the network is more likely to be an optimum one and this point would seem to be proved in the new computer-designed crossover now installed in the KEF model 104AB. In older textbooks the reader may see circuits termed 'half section' or 'quarter section'. Theoretical values are given for specified crossover frequencies, or alternatively a formula is presented for the reader to work out, which will make most of us dive for a cold wet towel, which might be placed around the head! Unfortunately most of these published crossovers assume perfect loudspeaker units which have no resonances and are of constant impedance at all frequencies. Alas, in real life, the crossover has sometimes to compensate for resonances and varying sensitivities and impedances and so a computer or experimentation has to be introduced.

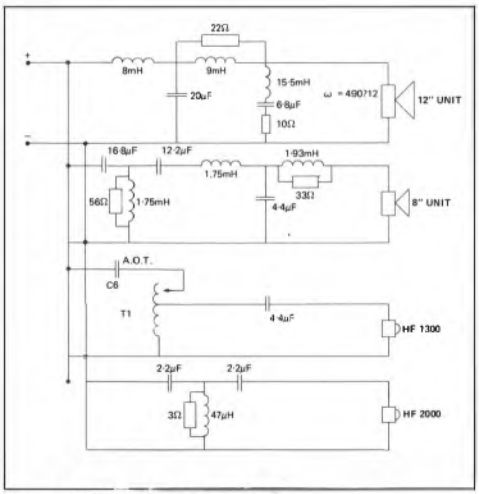

Fig. 1: BC3 Filter Network

Two other crossover networks are shown in Figs. 2 and 3, the new and the old KEF 104 circuits. Laurie Fincham of KEF has explained to me that whilst the main elements of the crossover were designed fairly conventionally, the matching circuitry to the tweeter includes the part that had to be computer designed. He said that his team wanted to compensate the characteristics of the tweeter so that it would match into a perfect theoretical basic crossover and thus some of the components act to cancel out the inductive parts of the tweeter's equivalent electrical circuit. Even he was surprised at the improvement in sound quality introduced by his technique and interested readers are referred to a paper given by him to the Audio Engineering Society.

In order to achieve a better linear phase characteristic, speakers claiming to be such are usually designed with crossovers having a slower fall-off rate, which allows the phase relationships on the correct axis to be made. Unfortunately the employment of such circuits tends to introduce more coloration and cancellation effects introduced by more than one unit reproducing a given frequency. This would seem to be a further

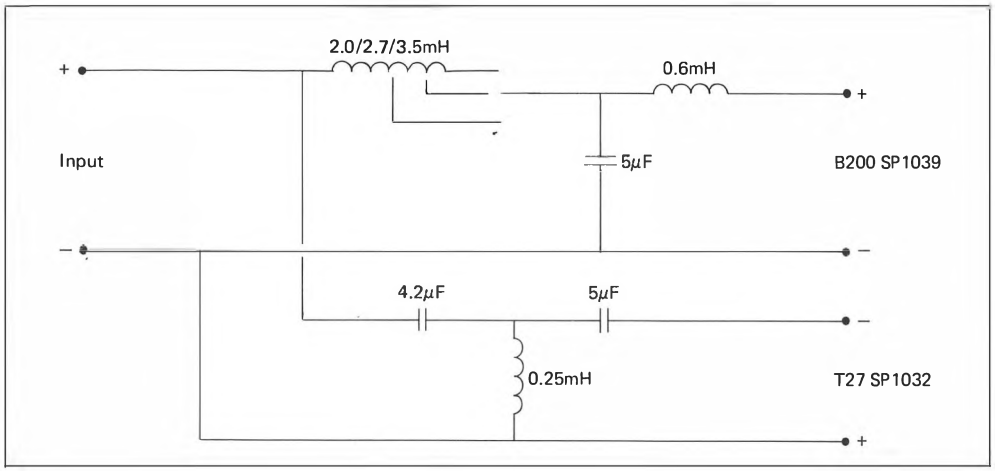

Fig. 2: Model 104 Crossover Network Standard

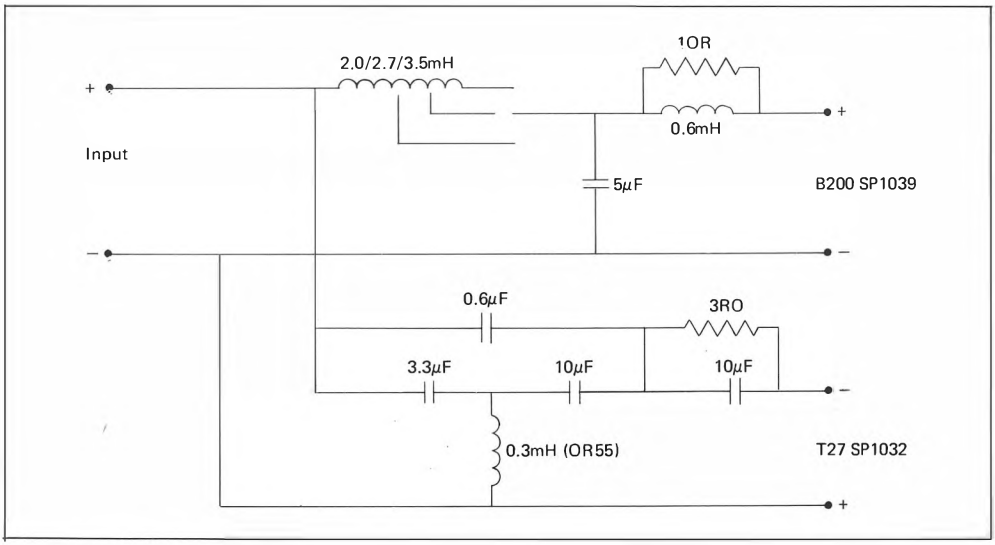

Fig. 3: Model 104 'Acoustic Butterworth' Network

explanation of why we found linear phase loudspeakers very unsatisfactory in their vertical polar diagram performance.

We found in practice that most loudspeakers employing complicated crossovers tended to be less efficient, and thus required higher power capability amplifiers. Please look at the chapter dealing with efficiency.

Loudspeaker Placement and Positioning

Throughout the book I refer to different types of placement for the loudspeaker systems in an average room. Manufacturers usually stipulate whether their units should be mounted on a stand (plinth), on a shelf at the front edge, against a wall, in a corner of a room, on the floor, or perhaps on a plinth hard back against a wall. In general, manufacturers' recommendations are satisfactory, but you may well find that alternate placement gives improved results. Stands, if recommended, can usually be obtained with the speakers; they are sometimes included in the price, but more often cost extra.

When a speaker is placed on the floor away from a wall, bass frequencies are enhanced, the amount of this enhancement being highly dependent on the type of bass loading employed in the system. Speakers such as the IMF Monitor and Tangent RS 6 require floor loading (i.e. not on a plinth), for bass enhancement, and the Tangent is designed so that the floor reflects even lower mid frequencies as well, the system being designed to be flat under these circumstances. Unfortunately our subjective panel found otherwise. If a loudspeaker is raised above the floor, there is much less help at low frequencies, but if this is the stipulated position, then floor enhancement is not necessary and can be undesirable. There will also be enhancement against a wall, and this is of course increased if the speaker is mounted on the floor and against the wall, since there are then two surfaces against the cabinet. If the speaker is placed in a corner, there will be three surfaces reinforcing the lower frequencies, but then the sound quality usually becomes unacceptably boomy. Such a position, however, may be indicated in a small room to reinforce the bass of a speaker which has a poor bass end. When a speaker is mounted on the front edge of a shelf, there is slight bass reinforcement which will be more pronounced as the speaker is pushed further back towards the wall. Once again, the bass reinforcement will be dependent on bass loading inside the cabinet, and some speakers will show much more of a bass boost than others. The Spendor BC1 for example appears to become quite boomy in such a situation, and is virtually impossible in a corner, but sounds appreciably better on a high stand. The KEF 104AB, however, sounds only marginally more bassy on the front of a shelf. The Yamaha 1000M's bass end is, in my opinion, slightly improved by front edge shelf mounting, although the manufacturers stipulate a plinth.

The vertical height of a speaker system is vital, particularly when the high frequency polar diagram is very directional. After much experimentation we found that it is better if the speaker's squawker and tweeter are a few cm above a listener's ears rather than below them, although there will be a few exceptions to this. This will allow people standing up well back from the speakers to get a well balanced sound, and will also decrease absorption of high frequencies by furniture etc. This brings up the point that in a number of installations that I have come across, the owner has located his system inside an enormous and very expensive long cabinet, constructed to contain the entire hi-fi system, as well as cocktail cabinet, record storage etc. Sliding or hinged doors conceal the speakers, as if the owner is ashamed of them. I have often been appalled at the coloration and boom produced by placing speakers inside cupboards, and whilst such cabinets are undoubtedly impressive, a knowledgeable person will be most unimpressed with the ghastly sound produced. Similarly, some people hide their speakers behind a sofa or curtains, and spend their lives listening to a soggy, mellow sound, similar to their grandmother's pre-war radiogram! Loudspeakers should be seen as well as heard, although undoubtedly some systems quite definitely should be seen and not heard!

If you want to cover a fairly wide listening area in the room, it is an advantage to have the loudspeakers well above floor level, unless they are floor mounting types. Sometimes I have known speakers mounted near the ceiling, in which case bass is reinforced in the same way as if they were near the floor. However, it may be necessary to mount the loudspeakers upside down in order for high frequencies to be reasonably audible. It is usually better in such cases to tilt the speaker downwards a bit, so that the treble is beamed at the listener. Listening height can be very critical, and it is well worthwhile spending a considerable amount of time experi-

menting with speaker positioning. If you have to cover a wide listening area, the speaker should only be slightly tilted inwards, and sometimes it will be better if their fronts are parallel to one another. Speakers with a poor polar diagram, though, should be tilted inwards so that once again they beam at a central position. It is better, incidentally, to beam slightly behind the listener rather than in front, as otherwise treble images will be very confused at the back of the room.

Room furnishings can make an enormous difference to the sound quality produced, and in particular, if fitted carpets are installed the general sound quality will be less colored, since there will be less reflection generally. A heavily furnished room will thus improve the ratio of direct to reverberant sound, and so stereo positioning will be noticeably more precise. You should avoid large areas of naked glass, since reflected high frequencies will alter image positions often quite dramatically. A solo violin, for example, may well sound as if the high harmonics are coming from a direction totally different from the main body of the instrument, and this will give the impression of the sound balance being rather poor, which may not be the case. It is better to cover highly reflective surfaces such as glass with curtaining to avoid this problem. If your loudspeaker has a particularly good bass response, it may well cause various items in the room to vibrate in sympathy with some notes. I have frequently heard bits of electric fires, or poorly hung windows, vibrate like mad when low organ notes are reproduced. One interesting phenomenon which took me a long time to resolve was a wavering of high frequencies from one loudspeaker in a pair, always on the right hand side of the room. The effect was similar to that of a tape recording played with bad head-to-tape contact. I was even more puzzled when it dawned upon me that I only experienced the trouble during winter months. I spent hours investigating it, to discover eventually that heat from an electric fire under the speaker shelf was causing an irregular air flow upwards in front of the speaker, and causing variable defraction and refraction. When the fire was moved the problem vanished. I now have central heating!

By far the most difficult loudspeaker to position is the full range electrostatic type, and I can only suggest that you try different positions until you are satisfied. As a general rule, keep the speaker at least 60cm away from a wall, and 1 metre away from a corner. It will be useful sometimes to place a small block under the back leg if you normally sit on a fairly low chair or settee. This may help the main high frequency energy to be beamed at the listener's ears rather than above them.

Bass frequencies are also very dependent on room shape, and there are no hard-and-fast rules as to where speakers should be placed in different rooms, because every room is different. There is always personal preference to consider when deciding how wide apart the speakers should be, but as a general rule the angle between the two speakers and the listener should not be greater than 60^{O}. The type of programme usually listened to will also influence placement.

Some loudspeakers, such as the KEF 103, can be mounted vertically or horizontally, a square frame with the speakers on it being rotatable through 90^{O} to allow the tweeter to be above the woofer for either type of mounting. Loudspeakers should always be used as recommended. Placing them horizontally if they are vertical types will cause bad errors in stereo positioning, and you will also find serious degradation in the general horizontal polar response pattern. Speakers will almost invariably perform better with the tweeter above the woofer rather than beside it, and this is confirmed by all the polar diagram measurements made in this survey.

My final recommendation is to experiment with long connecting leads until the best position is found, when a more permanent installation can be made.

The Programme Source

When choosing a loudspeaker, you should bear in mind the type of music or programme source most likely to be reproduced on your system. As the ideal loudspeaker is virtually unobtainable, you will have to make many compromises. This chapter explains the compromises, and discusses the different priorities required for different types of programme source.

Almost every owner of a hi-fi system uses records as an important programme source. But,

whereas pop music is generally played fairly loudly, classical music is usually reproduced at a lower level. Additionally, the energy spectrum of pop music is very wide indeed, with very high levels being presented to the loudspeaker at almost all audio frequencies. For example, at the deep bass end, a bass guitar can cause a power amplifier to be very near to peak output capability before you might realise it. At the other extreme, many percussion sounds can similarly drive an amplifier to its limit.

The heating effect of loud pop music on a powerful loudspeaker system can be measured in the laboratory. In particular, it has been found that the coils of tweeters get considerably warmer on pop music than on the equivalent peak playback level of classical music. Consequently, should you want really clear reproduction of pop music from records at a reasonably loud volume, you will not be satisfied by any of the relatively small loudspeakers in this survey.

Some types of classical music, in particular church organ, loud operatic and choral music, can be very demanding on a loudspeaker. Of course, orchestral music does have climaxes, and if these are to be clearly reproduced and give a sense of realism, you will once again need a fairly powerful amplifier/speaker combination. However, as most people replay classical records at an average level appreciably lower than they might play pop, a medium sized loudspeaker of between forty and sixty litres in capacity should prove satisfactory. But, if your interest is in reproducing very low frequencies clearly, you might well have to consider the purchase of a somewhat bigger enclosure. Remember here, though, the comments made in the frequency response and speaker positioning chapters.

Today, the quality of most records is largely dependent on the quality of the basic sound balance produced by studio engineers. This quality tends to vary considerably from record company to record company. Some records of classical music contain, in my opinion, a very colored sound. Sometimes this is caused by the studio in which the recording is made. But, as often as not, it is the result of the engineer, in his effort to produce a total, balanced sound required by his producer, using rather too many microphones.

The philosophy behind classical sound balance is sometimes difficult to understand. Where some producers attempt to reproduce on record a realistic account of what might be heard in the concert hall, the majority strive for a more abstract type of sound, which brings the orchestra and music into the home, but with an artificial form of ambience, stereo positioning and response. Both philosophies have their good and bad points, but assuming that a classical gramophone record is produced with a basically good, well-balanced sound, a loudspeaker should be chosen which has a smooth response and, at most, fairly low coloration.

Stereo broadcasts of classical music are almost always much more natural, as the broadcast engineer usually attempts to put over to the listener the atmosphere of the concert hall itself, together with the presence of an audience. If your prime interest is in listening to stereo radio the coloration performance of a speaker is even more important, for the sound as broadcast is normally only colored by the ambience of the concert hall or studio employed. Again, coloration is important for listeners to stereo plays and documentary programmes. Even a relatively small amount of coloration in a loudspeaker can cause a voice to become unnatural.

Because broadcasts of pre-recorded programmes are usually more hissy than the average gramophone record, any 'peakiness' in the tweeter can become objectionable. However, for light music and popular music programmes, the sound balance of the speaker is not so important. Such broadcasts are almost always balanced to give a reproduction of how they actually sound in the studio and are not normally broadcast with such a wide dynamic range. Gramophone records of both classical and popular music, on the other hand, are not so naturally balanced, and so do not make so great a demand on the coloration performance of a speaker. Consequently, for a record programme source, your choice might be a loudspeaker with many excellent virtues, but with rather more coloration than some other unit which may not have such a wide response.

One further important point about the sound reproduced from gramophone records is the build up of a general high frequency energy in the

complete system. Many records have a degree of brilliance added to them either by frequency response modifications or by the use of multi-mic techniques. Most pick-up cartridges, although measuring flat when played back with a sine wave response record, show resonances around 10kHz or so, caused by ringing of the inductance of the cartridge combined with the capacity of the pick-up lead and the input circuits of the pre-amplifier. Thus the dynamic response of a pick-up may show a boost between 2 and 6dB at 10kHz with respect to its sine wave response. A bright record played in such conditions through a system connected to bright loudspeakers will thus become very toppy indeed, and it is for this reason that the panel, myself, and my colleagues have been rather critical of over-bright loudspeakers. Furthermore, the effect of the pick-up's dynamic resonances on HF and over-brightness of a speaker system will emphasise popples and crackles. The appropriate choice of loudspeaker system can make an amazing difference to background noise, the smoother the speaker the less objectionable the noise.

Stereo records contain sounds from as low as 30Hz to a maximum of around 20kHz, although the energy at both extremes is usually somewhat curtailed owing to difficulties in cutting. However, stereo broadcasts have their response curtailed very sharply indeed above 15kHz. So, if you are primarily interested in stereo radio you should not need to worry too much about a loudspeaker's performance above this point. As opposed to this, the bass response of some broadcasts extends to well below 50Hz—although for other reasons this is usually slightly curtailed.

The distortion performance of stereo radio broadcasts is usually very much better than that from records. This means any loudspeaker distortion problems will be more noticeable on stereo broadcasts than they might be on gramophone records, except for bass distortion, as there is usually more bass energy on record.

In general, high quality home recorded cassettes and reel to reel recordings require almost the same capability of a loudspeaker as the programme that has been recorded. But, because of difficulties in manufacture, prerecorded cassettes and cartridges are rather less demanding on a loudspeaker, since both very high and very low frequency energies are considerably lower. By far the most demanding source for the loudspeaker is the master or high quality copy tape or, alternatively, the actual monitor output of a control desk before it goes onto the tape itself. In each instance, high frequency transients are likely to be much more faithful, and therefore show up the deficiencies of tweeters more easily. And, because bass cut has to be introduced during cutting to avoid undue groove excursions, the original sound of a pop session will contain even more bass than the average pop record. For this reason, professional studios and broadcasting organisations usually use very powerful loudspeakers capable of accepting bass transients of considerable intensity without distress.

Surprisingly, the average professional monitor loudspeaker is not as realistic as the better quality, but usually smaller, domestic speaker. Professional engineers normally monitor at least 10dB louder than the average domestic listening level, and in some pop studios, I have heard peak levels approaching 20dB louder than my natural average listening level! The reader can well imagine the type of loudspeaker that has to be employed by the professional to reproduce sound levels of such intensity. Powerful speakers, such as these professional monitors, are often driven by amplifiers with at least 100W per channel rating and a capability of up to several hundred watts. This is not always entirely due to the value of the average sound level to be reproduced. To cope with the monitoring outputs from a control desk of some musical instruments with very sharp transients, having a peak to peak level far in excess of that which is reproduced from even the master tape, an amplifier with a reserve power handling capacity of two or three times is necessary.

Readers might be surprised to know that on some recording sessions I frequently use a Crown DC300, with an output capability of 200W per channel, to drive Spendor BC1 monitors, despite the fact that the actual volume reproduced is not very much louder than the normal volume I use at home. If I replay the master tape over the same chain I find I need approximately 4dB less peak power to achieve the same audible playback volume.

Amplifier Requirements and Interconnection with the Loudspeakers

There are many different types of connection used on various models of loudspeaker, and most common are 4mm banana type terminal sockets and loudspeaker DIN sockets. Some loudspeakers had ordinary screw terminals or, alternatively push lock types which allow a user to push in a bared wire end, which is then clamped when the lock is released.

There did not seem to be any particular standard on loudspeaker DIN sockets, for some of them were female chassis mounting whilst others were male. The Mirsch loudspeaker employed a short length of twin lead (a few inches) with a male cable plug, a DIN extension plug to socket lead being supplied with each loudspeaker. Unfortunately speaker DIN sockets are not recommended for use on high voltage or high current systems and so the more powerful loudspeakers are never supplied with DIN sockets etc if their manufacturers adhere to the DIN specification. Some British manufacturers use a small input connector frame on which both banana sockets and a loudspeaker DIN socket between them are mounted. This makes it easier for interconnection with various types of lead. The Spendor BC3 professional monitor loudspeaker was supplied with a 3 pin cannon socket, as used in most recording and broadcasting studios, but you may have difficulty acquiring the mating plug, although usually these are supplied with the loudspeaker but require soldering. In a few cases we found that the input terminal board rattled. Although this was usually due to internal screws not being tightened adequately, sometimes the basic design was not altogether suitable. In other cases, however, a rattle at low frequencies was noted due to the fabric on the front of the speaker vibrating against the cabinet framework at certain specific frequencies. This occasionally was audible on programmes including, in particular, our organ recording made at Westminster Cathedral.

You should always use a high current carrying cable for interconnecting the loudspeaker with the amplifier. Some longer DIN interconnection leads, as supplied pre-packed and made up, have a resistance which is rather on the high side and if you use two or more of them in series you might well notice a power loss in the system. Some years ago I had to use some loudspeaker connecting wire to interconnect two loudspeakers some 35' away from the power amplifier and, despite the wire being fairly substantial, the total wire resistance in each loudspeaker circuit amounted to 4 ohms. This not only affected the available power output from the speaker, but would most definitely affect the damping factor, particularly at frequencies where the loudspeaker's impedance was low. To minimise resistive losses, always make sure that you tighten up any wires around screw terminals very thoroughly, and that all the wires at the end of the cable are twisted round each other before placing the end around each terminal, which should then grip the wire very securely. If you are using banana plugs, I recommend the type that has a slight spring action built in so that it will grip the inner diameter of the socket securely. Some banana plugs are rather loose when inserted into the socket and these are likely to give a lot of trouble.

As explained in the chapter dealing with Impedance and Phase, some loudspeaker systems require a pretty good amplifier to drive them and perhaps the most difficult type of speaker to drive is the electrostatic. Some amplifiers can go into oscillation when interconnected with an ESL and an improvement or even a complete cure can be effected by placing a 2 ohm resistor or so in series with the live lead at the amplifier end.

As is explained in the chapter dealing with impedance and phase, an amplifier is asked to deliver a voltage which is not necessarily absolutely in phase with the current. If a single unit is measured on its own, having been directly connected to the amplifier, the current will be almost in phase across the audio spectrum although the inductance of the speaker will cause a slight phase shift at higher frequencies. Unfortunately the complex crossover components needed to split the audio signal to the different parts of a complete system introduce considerable phase shifts, and at some frequencies a current may be as much as a $\pm 60^{o}$ out of phase with respect to the voltage. At each frequency the load on the amplifier has a real

part in ohms and what is termed an 'imaginary part' equivalent to a capacitance or an inductance in parallel. Ideally, my colleagues and I should have measured the real and imaginary parts of the impedance over the entire audio spectrum, but it would have been virtually impossible to pen-chart. By taking the measurements as we did, though, we established that the average amplifer has a very hard job indeed when driving a typical loudspeaker. Amplifiers may well give a very satisfactory performance into a pure 8 ohm load, but strange effects can be noted when the same amplifier is connected to a loudspeaker having a very low impedance over part of the audio spectrum. This becomes particularly difficult if the area of low impedance is at middle frequencies, since any amplifier problems become more audible. If the impedance curve shows considerable areas below 6 ohms, some amplifiers will have quite a problem delivering power to them. If the phase angle in degrees of current lag or lead is considerable, it means that the capacitive or inductive component at the appropriate frequency is also considerable and once again there are more likely to be problems with a few types of amplifier. It is often for this reason that loudspeakers sound rather different when driven from a choice of two or three different amplifiers.

Professional and Domestic Listening Ergonomics and Presentation

The professional listener, especially when he is monitoring sound in the control room, must have loudspeakers that are absolutely reliable and that have very low distortion overall. This will allow him to hear more easily the onset of distortion introduced by any component of his recording equipment chain. The professional monitor speaker must also be capable of reproducing very high sound pressure levels, and most people who have never been in a control room, particularly when pop music is being recorded, would hardly believe the incredibly high volumes that for some reason many pop engineers favour. It has become a habit, it seems, amongst such engineers, that they should monitor at levels up to 20dB louder than domestic listening levels and I have always thought this quite ridiculous. Apart from any slight hearing damage that might be introduced over a period of a few years, sound balances made at a high level can often become deficient in bass when reproduced at domestic levels, because of the ears' dynamic response characteristics. For the record, I have measured peaks of 115dB in pop control rooms, and this level approaches that of aircraft heard more or less near the flightpath on take off. Some researchers have asked for engineers voluntarily to have their ears tested at intervals and indeed several engineers have come forward. If you, however, were a pop engineer and you had the slightest suspicion that your ears were not as good as they might be, I feel pretty sure that you would go to your own doctor rather than risk a derogatory comment from the researcher to perhaps one of your associates in the research institute where measurements were made. I would think that this philosophy would invalidate any research done, unless the researchers took a random cross-sample of engineers, all of whom were tested without any vetoes. Coloration is not quite so important in pop recording, since an engineer and his producer are creating a sound rather than reproducing a realistic reproduction of the original. Many well-known professional monitors, therefore, are somewhat highly colored, although there is no doubt that they can sound extremely impressive on the right music. The problem for professionals is that it is extremely difficult to design a loudspeaker with a very high power output capability, a wide frequency response and also low coloration, and so the priorities are somewhat different. A professional will usually use an amplifier which can deliver at least 200W into the loudspeaker, whereas such an amplifier, if driven fully in a domestic environment, would cause the average domestic speaker either to blow up or almost blow the listener's ears out in an average room! Many people, though, want this sort of volume at home and like to have a model of professional monitor speaker that is capable of very high output levels. Many speakers in this survey will do this, but relatively few are reasonably uncolored.

In the domestic environment, most listeners rarely exceed a sound pressure level of 93dB in their rooms, although the occasional climax might peak somewhat higher, particularly on a

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sharp transient. The priorities for domestic listening are probably coloration and a smooth frequency response, and to a lesser degree power handling. The polar diagram response (the capability of a loudspeaker to reproduce a full frequency range across a fairly wide horizontal and vertical arc) is of course important provided that more than one person wants to listen to the programme. Also it is naturally important for optimum quality to be produced from the loudspeaker in a direction which is acceptable to the listener, and thus a system which throws most of the sound well below or above the listener's ears is clearly not practical. The appearance of the cabinet is important and most are well made these days, although some are more presentable than others. The type of mesh covering the front of the loudspeaker is important both acoustically and visually, and it is sad that so many cloths selected because they do not attentuate high frequencies, may look rather unattractive. I was told recently that some British loudspeakers were not acceptable in Japan, and that British manufacturers were puzzled because the external appearance was excellent. However, for some extraordinary reason, many Japanese hi-fi enthusiasts listen to their systems with the front panel permanently withdrawn and expect the loudspeaker system to be well presented inside. For this reason you may be paying an awful lot of money for the internal appearance of a Japanese speaker, which really does not matter to the average European. Many loudspeakers have sensitivity controls for their tweeters and squawkers, and on Japanese models these are normally on the interior front panel behind the front cover. The covers on such models can usually be withdrawn very readily and so this is not too much of a snag. Some other models, though, have the controls on the rear.

The appearance of some loudspeakers is very odd indeed and perhaps man and wife together should look at them before a decision is made! One particular loudspeaker was likened quite coincidentally by two separate people to a pregnant kangaroo. Its bulging stomach unfortunately inspired laughter from several people, but some readers will obviously be prepared to accept the most extraordinary looking appliances provided that their wives do not protest. Acoustical 'Quad' electrostatic loudspeakers unfortunately take up a lot of room, and perhaps resemble an old-type electric fire, but on the other hand produce a sound quality which is virtually unequalled in several aspects within its limitations, provided that the listener is sitting in the right position. Appearance does not matter so much, even if it is unusual, provided that the manufacturers take the trouble, as Peter Walker did, when the design is well thought out.

If you want to move your speakers around a bit, you may find useful some loudspeakers that are mounted on casters. Many manufacturers supply metal framework plinths often on casters and these will not only allow the speaker position to be moved but should optimise the height of the loudspeaker above floor level. In general, if a loudspeaker is available with a plinth, it is advisable to purchase the plinth, so that you can be sure that you are operating the loudspeaker optimally.

Acoustic Research AR12

Acoustic Research International Ltd, High Street,
Houghton Regis, Bedfordshire LU5 2BR. 0582 603151

In the past Acoustic Research have been extremely well known in the US, but rather less so in the UK. However, now that their loudspeakers are being made in this country, their entire range is obviously receiving more publicity. The AR12 is a very recent model incorporating a three-unit system. The bass woofer is 254mm diameter, the mid range unit is 56mm and the tweeter is 19mm.

Switches on the rear panel can be used to adjust mid frequency and high frequency outputs. Each switch has two cut positions as well as a nominally flat one. Input connection is with screw terminals, and the cabinet measures 635 × 354 × 273mm. Teak or walnut finishes are available. Weight is 17kg.

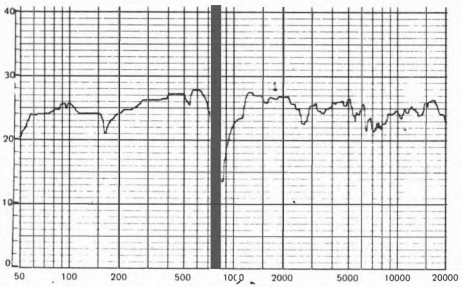
The anechoic chamber on axis response showed the most extraordinary dip at 800Hz, amounting to some 16dB. Apart from this dip the response was pretty good from 55Hz to 20kHz. It is therefore so unfortunate that this dip seemed to destroy an otherwise excellent curve. Incidentally, even the manufacturers' own pen chart showed this dip. Off the horizontal axis the 800Hz dip became less serious and the high frequency end was slightly curtailed—but not seriously. Vertically off axis, the dip disappears and the general response curve becomes appreciably better. The MF switch cuts the 1.5kHz response by approximately 4dB and 7.5dB, whereas the HF cut switch brings in a shelf cut of 3dB and 6dB respectively. Third octave pink noise tests on axis showed the 800Hz pink noise to be about 8dB down in energy. The harmonic distortion performance of the loudspeaker was creditable, and measured very well, the worst figure being noted at 160Hz (1.6% 2nd harmonic). Similar figures were also noticed for IM distortion at 1.5kHz and 10kHz. The minimum impedance was noted at 8kHz, the modulus measuring only 4 ohms. We also measured 5 ohms at 1kHz. On other frequencies the impedance was quite acceptable. The voltage/current phase response was remarkably flat across the entire audio band width. The weighted sensitivity was 82dBA, unweighted being 84.5dB for 2.83V RMS. An output of 103dBA was obtained in our power test, thus making the loudspeaker marginally below average in efficiency, but with good power output capability. It would seem reasonable to use an amplifier of 100W rating with the speaker, and the manufacturers claim that a 150W would cause no problems.

The mid-frequency trough was clearly audible to the entire panel and quite clearly this emphasised the effect of brightness, producing a somewhat thin and hollow sound quality. The body and chest voice of vocalists seemed to be fairly severely lacking and this was particularly noticed on a pop track. Some mid-frequency coloration was noted, but this was not too severe, resembling 'AR' and 'ONG' sounds being added. Three panel members used the word 'nasal' to describe the vocal quality. Not only do many instruments such as piano become very thin, but reverberation is subjectively reduced in the reproduced sound. Deep bass was rather lacking, but unfortunately mid and upper bass were none too clear either, being rated by some as boxy. Although the panel generally disliked the sound quality, they did agree that high frequencies were clear and were certainly not peaky. My colleagues and I cannot understand how such a mid frequency suck-out can be allowed to occur and this obviously controlled the entire subjective balance of the speaker.

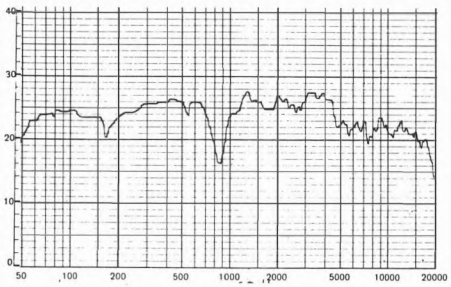
Its good points, though, are its pretty low distortion and relatively high output capability for its size. Unfortunately, its subjective performance and rather high price do not allow it to be recommended, making it a rather poor value for money. Nevertheless you may possibly like its sound quality if you have a rather reverberant room, which might help fill in the MF hole. I suggest a careful study of its competition, for in such a competitive market, other speakers are significantly better value for money.

Height	635mm
Width	354mm
Depth	273mm
Weight	17kg
Finishes	Teak/walnut
Input connections	Screw terminals
User adjustments	MF & HF
Lowest Impedance (Modulus)	4Ω8kHz/5Ω1kHz
Maximum SPL	103dBA
Sensitivity dBA pink noise 2.83V RMS 1m	82dBA
Recommended maximum amp power	100 watts
External volume	61 litres
Optimum listening height above base of speaker	480mm
R.R.P. (ex. VAT)	£238.00

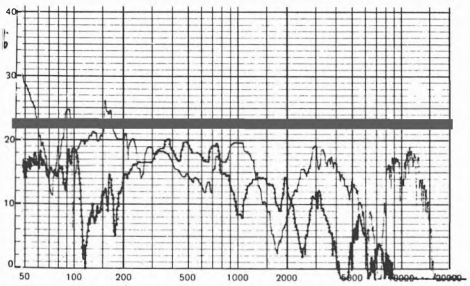
Not normally discounted



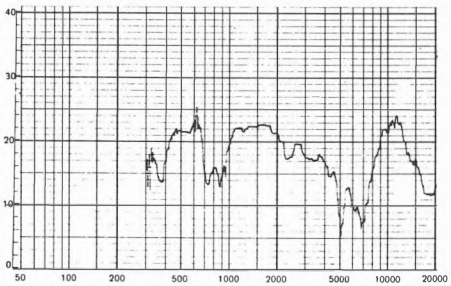
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2 - f_1$)

The size is 635 × 354 × 273mm. Input connections are on screw terminals, and the system incorporates a treble cut switch which lowers the 14kHz response by approximately 4dB. The loudspeaker is designed for shelf mounting and weighs 15.9kg. Teak and walnut finishes are available. The manufacturers claim that ideally the loudspeaker should be surrounded by books, so that the speaker front is in line with the front of the books on the shelf.

When measured in the anechoic chamber in a free field environment we noted that the bass response became established by 60Hz and did not rise significantly until about 200Hz in a rather wide hump. A 5.5dB peak was noticed at 650Hz, above which the response fell, gradually, showing a dip of around 3dB from nominally flat at both 4.3kHz and 6kHz. The HF response was rather up and down but reached a peak of +5dB at 14kHz. The horizontal off axis response was very consistent, but vertically off axis a 19dB suck-out appeared at 1.2kHz, which is very unfortunate and due to acoustic phase cancellation between the units acoustically. Apart from this the response was marginally flatter than on axis. Pink noise third octave response showed very much the same trends. The output SPL for 2.8V in pink noise measured 84.5dBA and 86.5dB unweighted, proving the loudspeaker to be of average sensitivity and certainly adequate for normal purposes. Distortion was very low at the bass end and second harmonic rose to a peak of just 1% at 1.5kHz. The third harmonic distortion was maximum at 800Hz, but this measured only 0.5%. The IM distortion peaked at 0.65% between 800Hz and 2.5kHz. Distortion performance, then, must be regarded as very good and certainly better than average. The lowest modulus of impedance was measured at 1.5kHz (6.5 ohms) and thus presents virtually no problem to any reasonable amplifier. The voltage/current phase response was also excellent showing maximum divergence at 70Hz, and generally over the HF band of not more than ± 30°. The maximum power output on our special test was at 104dBA, surprisingly loud for a medium sized speaker. This level would be achieved at peaks from a 100W amplifier and is surely more than enough for any normal domestic user.

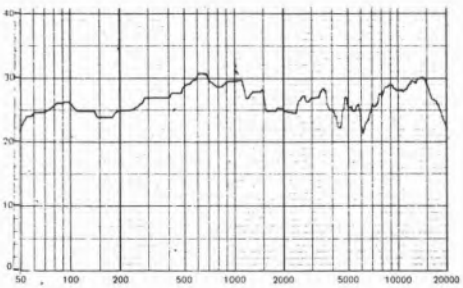
AR's response measurement technique, using a reverberation room, in addition to virtually mounting the loudspeaker in a brick wall, built into one wall on one side of an anechoic chamber, does not in our opinion reflect the subjective audible performance of the speaker in good domestic surroundings. However, since the loudspeaker should be shelf mounted, we naturally have reservations about low frequencies on our own chamber charts, and quite clearly in the listening tests the bass end was helped by the shelf mounting. Thus the low end performance was subjectively fairly flat, but possibly contributed to the many panel remarks of the mid-frequency performance appearing to be down. Many panel members remarked on the sound being somewhat boxy and almost everyone found the top end clear but over bright—due presumably to the measured dips in the response in the lower and mid HF, and the noticeable rise at EHF. The speaker unfortunately was disliked considerably by virtually the entire classical panel and several commented that the MF balance was clearly wrong, being rather forward. Frequencies either side of this upper hump appeared to recede. I must add that I was not too impressed with the sound of the speaker and surprisingly found that it gave a slightly better performance mounted on a plinth rather than a shelf, although the bass end was rather curtailed but at least not so boxy.

In general the pop panel thought slightly more highly of the loudspeaker, but again the marks were on the low side. The member who liked the speaker more than the others still stated nevertheless that the top end was rather thin and felt that the extreme bass end was clearly lacking. In stereo I felt that the middle sounded hollow and the bass seemed artificial, the speaker clearly lacking body. This speaker was clearly a disappointment to the panel and our own opinions in the laboratory confirm the subjective comments that the upper mid hump caused noticeable recession of mid and presence regions.

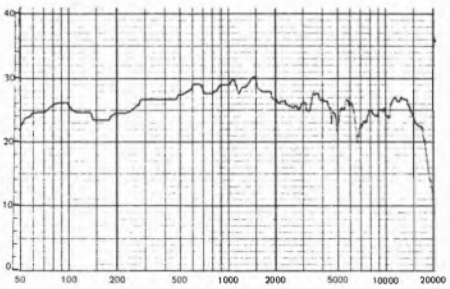
Unfortunately this speaker cannot really be recommended, although some readers may well like its sound if the speaker is to be used in rooms that are themselves rather highly colored at middle frequencies. This is because the speaker itself was in general reasonably uncolored, and its apparent response variations would tend to be corrected in more reverberant rooms.

Height	635mm
Width	354mm
Depth	273mm
Weight	16kg
Finishes	Teak/walnut
Input connections	Screw terminals
User adjustments	HF
Lowest Impedance (Modulus)	6.5Ω1.5kHz/8Ω100Hz
Maximum SPL	104dBA
Sensitivity dBA pink noise 2.83V RMS 1m	84.5dBA
Recommended maximum amp power	100 watts
External volume	61 litres
Optimum listening height above base of speaker	470mm
R.R.P. (ex. VAT)	£117.00

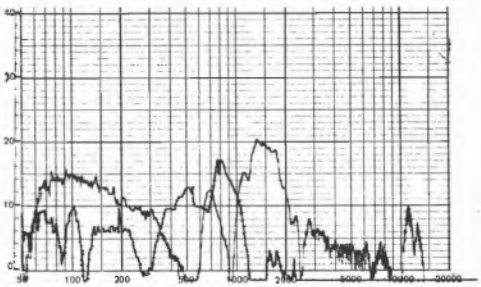
Not normally discounted



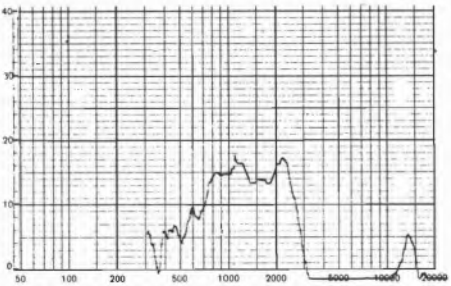
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2 - f_1$)

Audiomaster Image 2

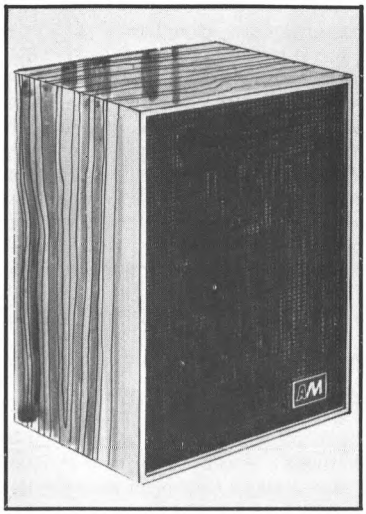
K J Leisuresound Ltd, 101 St Albans Road, Watford WD1 1RD. Watford 33011

A two-unit system incorporating a KEF B200 and a Peerless HF type K010 unit, the latter being a 25mm soft dome type. The cabinet, available in teak or walnut, measures 463 × 287 × 231mm and weighs 8.1kg. Banana sockets are provided for input connection, and the system is designed for front edge shelf mounting.

Although the lower bass is reasonably well maintained for a small cabinet, the anechoic chamber on axis response showed a dip of 6dB at 450Hz. Although there is a lower presence valley, upper presence shoots up some 5dB at 3.3kHz. The response continues to go up and down rather like a yoyo, but mainly up as far as 10kHz (+5dB). Above 13kHz the response returns to flat up to 20kHz. Horizontally off axis the curve is somewhat flatter at the HF end with the exception of a +8dB hump at 7kHz. Vertically off axis the curve looks reasonably good and we noted that the acoustic cancellation only measured 7dB at the crossover point, replacing a 4dB peak on axis. Second harmonic distortion reached 2% at 200Hz, but generally the harmonic distortion components are below 1%, excepting an excursion to 3% second harmonic at 7kHz. IM distortion was below 0.7% throughout. The impedance curve was very satisfactory. The electrical phase response, however, showed a peak of +50° at 2kHz. The loudspeaker was well below average sensitivity, our standard noise signal producing 80.5dBA SPL (83dB unweighted). Somewhat surprisingly our power test did not show very serious degradation until 102dBA was reached, at which point the tweeter was complaining bitterly. We recommend amplifiers of up to 50W rating for this system, although the Peerless tweeter might not like prolonged HF high energy levels. A 50W amplifier would allow the loudspeaker to peak approximately 97dBA at one metre.

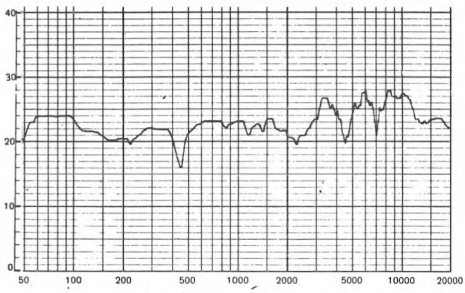
The entire classical music panel found the high frequency end grossly excessive and comments included 'thin, hard, screaming top, brittle, metallic, metal strings and metal hammers, etc'. A few members found a subjective lack of bass and body. Middle frequencies were obviously masked by the excessive treble. The top sometimes hurt the listeners' ears and unfortunately this speaker received rather low marks. I am sorry that I have to concur completely with the panel's opinion and I cannot understand why the manufacturers allow such an uneven response to be produced by their loudspeaker. Much of the trouble is clearly due to the matching of the Peerless tweeter, but if the energy applied to it could be lowered somewhat, the system would sound far better balanced, and might even become recommendable at its reasonably modest price. It was interesting that no derogatory comments were made about coloration. It therefore seems such a shame that I have to condemn this system. Not recommended then unless the manufacturers change its balance somewhat dramatically.

Finally, I should comment that it would appear that the manufacturers have attempted to aim the balance of this loudspeaker at what would initially attract an unknowledgeable potential purchaser, who may be listening to a comparative demonstration. It is so easy to be impressed solely by a loudspeaker's apparently amazing top, but one soon tires of it in a domestic environment, particularly when one is trying to relax and listen to well balanced classical or light music.

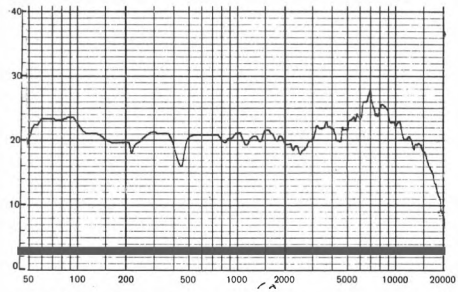


Height	463mm
Width	287mm
Depth	231mm
Weight	8.1kg
Finishes	Teak/walnut
Input connections	4mm banana sockets
User adjustments	none
Lowest Impedance (Modulus)	6Ω8kHz/8.5Ω100Hz
Maximum SPL	102dBA
Sensitivity dBA pink noise 2.83V RMS 1m	80.5dBA
Recommended maximum amp power	50 watts
External volume	30.7 litres
Optimum listening height above base of speaker	330mm
R.R.P. (ex. VAT)	£96.17

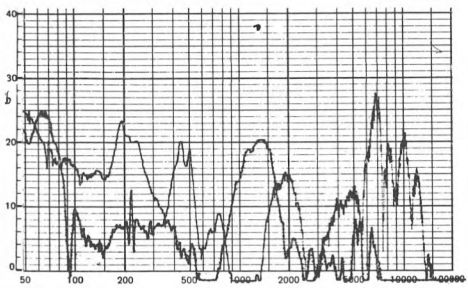
Not normally discounted



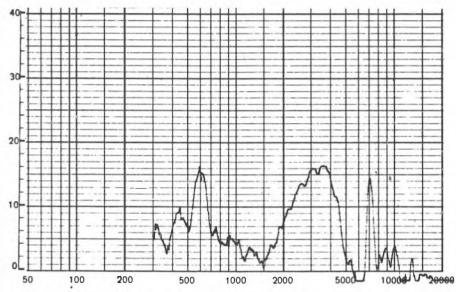
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2-f_1$)

Audiomaster LS3/5A

K J Leisuresound Ltd, 101 St Albans Road, Watford WD1 1RD. Watford 33011

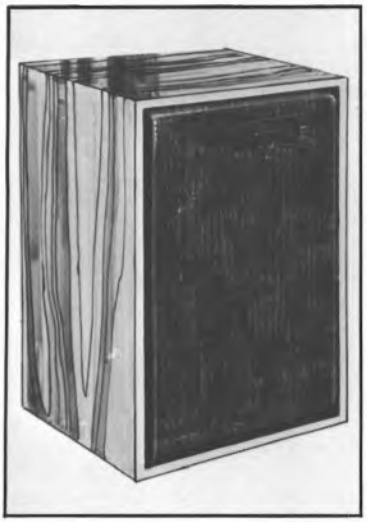
Manufactured by an associate company of KJ Leisuresound Ltd, this model loudspeaker is a version of the relatively new BBC design and includes a very complex crossover feeding two units. The manufacturers claim that they have adhered precisely to the BBC design and that the performance measures approximately along the centre line of the BBC specification (note that Chartwell also make a version of the LS3/5A). The cabinet measures 305 × 190 × 160mm and weighs approximately 5.3kg. The cabinet is available in teak or walnut and the input connections are with normal banana sockets (nb: not terminals). The system incorporates a KEF B110 100mm plastic cone bass driver and a KEF T27 18mm dome tweeter unit. The cabinet is very heavily lagged and is designed for book shelf mounting with its back not too close to a wall, thus allowing the bass to be enhanced by its surroundings. The small size makes it eminently suitable for rooms with very limited space.

The anechoic chamber on axis pen charts, taken in a free field, show the anticipated bass roll off, commencing from 90Hz and falling fairly rapidly below this. A dip of 3dB will be noticed at 1.5kHz, and a further dip of some 8dB was found at 6.5kHz.. Unfortunately this is followed by a +5dB peak at around 13kHz. The curve off axis horizontally shows a clear improvement—the 6.5kHz dip being less marked and almost disappearing. Regrettably, the 1.5kHz dip degrades to −5dB, however, the top end becomes much flatter. Vertically off axis a new dip appears at 3.8kHz, which unfortunately reaches −20dB. In this instance the two original dips both show a slight improvement, and the EHF end does not rise so much. Both second harmonic and third harmonic distortion at low frequencies reached approximately 3% at our test level. Harmonic distortion at middle and higher frequencies averages around 1%. IM distortion peaks at around 0.5%, but is generally lower than this.

The lowest impedance points are at 150Hz and 10kHz—the modulus being around 9 ohms at both frequencies. We feel that the entire impedance curve could, with advantage, be somewhat lower, so that the loudspeaker would give slightly higher efficiency. The general V/I phase shows a maximum excursion of ± 55° at the bass end, but elsewhere no more than ± 30°. The dBA weighted sensitivity is extremely low, an output of only 78dBA being achieved for an input of 2.83V. The broad band unweighted output was 80.5dBA, again very low. The maximum power output in our special test was rather too low at 96dBA at which level the bass unit was hitting the end stop. The manufacturers recommend an amplifier of not more than 25/30W rating for these loudspeakers, as prolonged use at higher peaks may well damage the units. This unfortunately will limit the maximum normal monitoring level to about 92dBA and is thus only suitable for smaller rooms, and most certainly not recommended for replaying loud pop music.

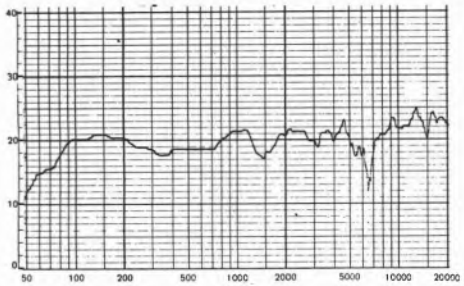
This loudspeaker was compared at great length with the Chartwell version and was found, both by my colleagues, myself, and by the classical listening panel, to have a slight lack of presence and a clear subjective EHF boost. This gave a slightly thinner sound to all music, but notwithstanding this, the speaker was basically liked, within reason, although the significant deficiency at the bass end was noticed by everyone. Please see Chartwell LS3/5A review for more subjective comments.

This speaker had noticeably less coloration than average and can be recommended for installations in very small rooms and for use with material not containing a high proportion of energy at low frequencies. It is particularly useful where space on a shelf is fairly restricted, but its reproduction cannot really be termed hi-fi, since much detail at the lower end is lost on orchestral and organ music. It sounded better, however, on chamber music and unaccompanied choral music and, in particular, speech reproduced pretty well, but with rather more than average sibilance. My colleagues and I cannot deny that we prefer the sound of the Chartwell version of this BBC design, but no doubt some readers will prefer the Audiomaster, particularly in rooms that have an inherent presence boost introduced by bare walls, etc. Recommended then with extreme caution, but bear in mind the limitations of bass response, power rating, poor efficiency and also the price which is by no means cheap, all things being considered.

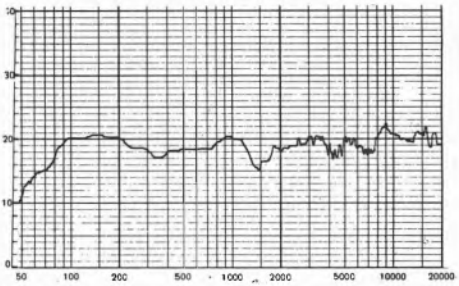


Height	298mm
Width	190mm
Depth	165mm
Weight	5.3kg
Finishes	Teak/walnut
Input connections	4mm banana sockets
User adjustments	none
Lowest Impedance (Modulus)	9Ω150Hz/9.5Ω10kHz
Maximum SPL	96dBA
Sensitivity dBA pink noise 2.83V RMS 1m	78dBA
Recommended maximum amp power	30 watts
External volume	9.3 litres
Optimum listening height above base of speaker	210mm
R.R.P. (ex. VAT)	£124.37

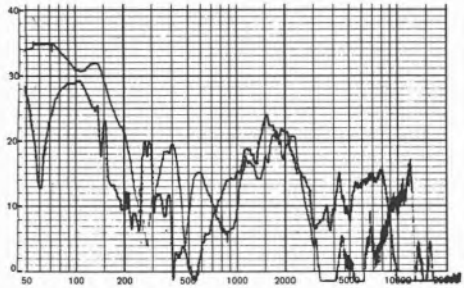
Not normally discounted



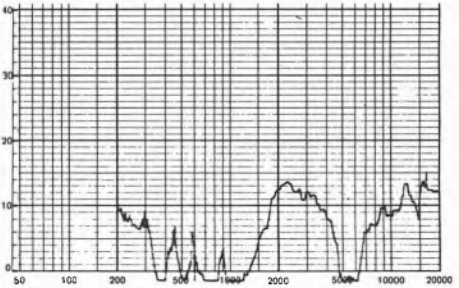
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2 - f_1$)

Beovox M70

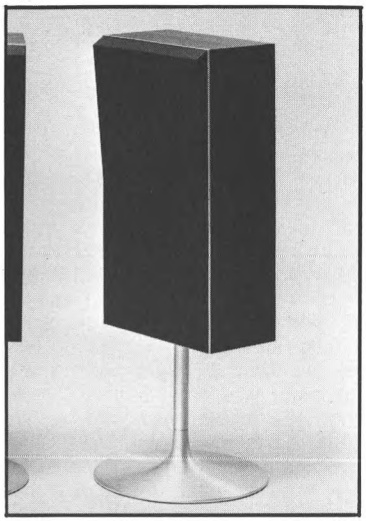
Bang & Olufsen (UK) Ltd, Eastbrook Road, Gloucester GL4 7DE. 0452 21591

Although B & O have been making speakers for a long time now, they have only recently introduced their linear phase models, and the M70 is one of these. It includes a 245mm woofer, a 60mm mid range unit and a 25mm tweeter, with a 125mm phase link unit which can be termed a filler. The cabinet, in teak or rosewood, measures 650mm × 350mm × 290mm, and weighs 26kg. Input connection is with a recessed DIN mounted plug. The loudspeaker is available with or without a plinth.

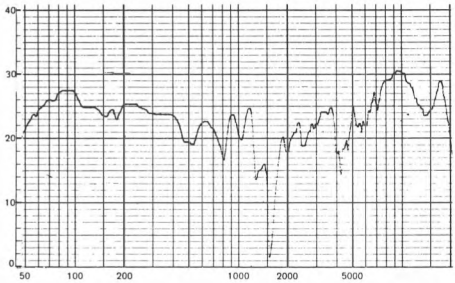
The sine wave on axis response showed some considerable irregularities (see pen chart), the main one being a 23dB suck-out at 1.5kHz. Off axis horizontally, more suck-outs became evident (eg. 19dB down at 500Hz) and vertically the irregularities were so great that the pen went off the bottom of the paper at 500Hz and 1.3kHz; thus the response is clearly unacceptable. 100Hz produced a total of approximately 10% harmonic distortion, but at higher frequencies the distortion was significantly better, although we noted 3% second harmonic distortion at 8kHz. The worst IM distortion occurred at 2kHz (2%) and this is not altogether satisfactory. The loudspeaker measured close to 4 ohms throughout its range, and thus is not suitable for many types of amplifier, more usually rated at 8 ohms. The V/I phase measured pretty well, and was very flat indeed at mid and lower high frequencies, but tended to deviate as usual at both ends of the audio spectrum. An output of 81dBA weighted and 84.5dB unweighted was reached for an input voltage of 2.83V RMS pink noise. The unit is thus slightly less sensitive than average, but still reasonable. A fairly high power output was reached before the quality became intolerable (103dBA), at which level bass frequencies became mixed up with mid in the mid-frequency unit's output.

Considerable mid-frequency coloration was noted by the panel, and several commented on the highly uneven response. Applause was very unnatural, and the treble end appeared bright and rather harsh. The panel noticed the mid frequency suck-out, which disturbed them considerably, and furthermore, the polar diagram problems were clearly evident. A few panel members off axis found the reproduced quality plummy, but the bass in general was considered reasonable. Unfortunately the panel clearly did not like this speaker, and indeed in its present form, the linear phase concept appears to be something of a mistake, since so far, it obviously can only be nominally correct for one listener. I feel that B & O must correct their problems of coloration and poor frequency response before continuing with linear phase reproduction. Since the price is very high, the speaker cannot possibly be recommended, especially with its lack of sensitivity. I consider it very poor value for money.

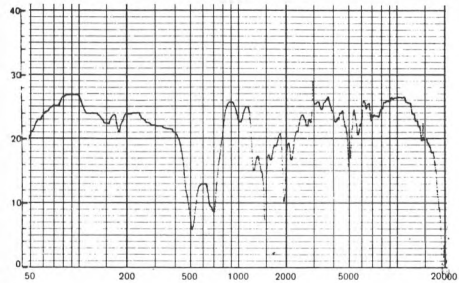
This speaker is a typical example of a linear phase type, and thus it would seem that I must condemn them as a species. I cannot understand how frequency response, such as that shown in the accompanying pen charts, can possibly validate a speaker system, and since my criticisms are backed by the panel members, as well as the anechoic chamber pen charts, B & O will have to consider very carefully their future loudspeaker designs.



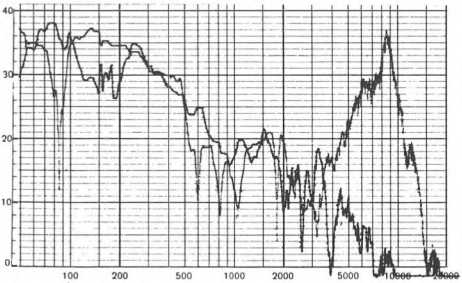
Height	650mm
Width	350mm
Depth	290mm
Weight	25kg
Finishes	Teak/rosewood
Input connections	Recessed L/S DIN plug
User adjustments	none
Lowest Impedance (Modulus)	3.5Ω100Hz/3.75Ω5kHz
Maximum SPL	103dBA
Sensitivity dBA pink noise 2.83V RMS 1m	81dBA
Recommended maximum amp power	60 watts
External volume	66 litres
Optimum listening height above base of speaker	350mm
Typical retail price (ex. VAT)	£293.00



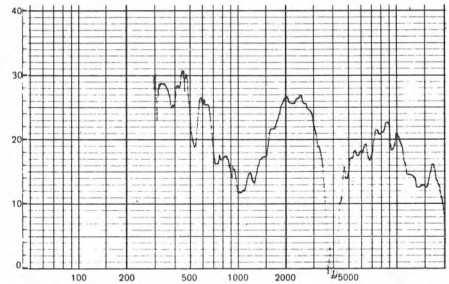
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2 - f_1$)

B & N Radford M180

B & N Audio Developments Ltd, Southlands Road,
Torquay, Devon. 0803 211747

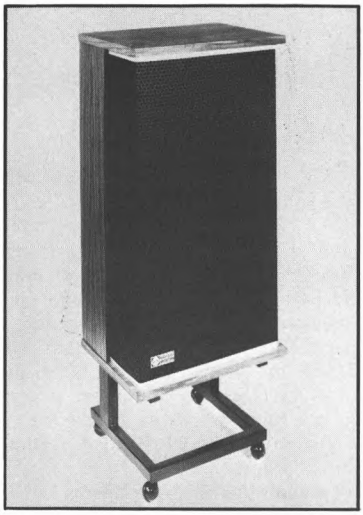
This loudspeaker includes a rather unconventional system incorporating a single woofer, two squawkers and two tweeters. Each of the two squawker/tweeter combinations are mounted vertically to either side of the apex of a very obtuse angle triangle across the front, so that the main radiation beams are either side of a line normal to the front of the cabinet. The front grille conceals this triangular front mounting panel. The cabinet is fairly large, measuring 595 × 340 × 265mm deep, and is available in teak or walnut, or rosewood to special order. Input connection is with banana sockets. The weight is 30kg, and the appearance is most attractive. The speaker was originally designed by Arthur Radford, and is now being made under licence.

On axis the sine wave pen chart showed a clear rise at mid frequencies of some 5dB. The presence region showed some hills and valleys, but the response extended reasonably flat up to 15kHz. The bass response measured quite well. At 30° off axis horizontally the response became very jagged at high frequencies—several large dips becoming evident, as well as a general fall off over the entire band. Vertically off axis a very large suck-out of 20dB at 2kHz becomes evident. Both in the chamber and in the listening tests the speaker obviously had quite a severe polar diagram problem, and audibly the response was different with comparatively small head movements. Harmonic and IM distortion performances were exceptionally good, certainly among the best, and even at low frequencies distortion did not become worse than 0.5%. In general the impedance plot was good, although at EHF the measurements fell to a modulus of 4 ohms at 20kHz. The electrical phase was remarkably flat, within ± 20% over the audio range. The speaker was below average sensitivity, an output of 80.5dBA being given with an input of 2.83V RMS pink noise (unweighted = 82.5dB). The loudspeaker became very unpleasant indeed at 103dBA, but this level was very loud of course. We feel that the manufacturer's rating of 60W is somewhat conservative, and probably the loudspeaker would be satisfactory with a 100W amplifier on normal programmes.

Unfortunately our listening panel did not like this speaker at all, finding mid frequencies very colored. The effect of the mid-frequency hump caused some of the panel to suggest dips in the response to either side of this peak and, in any case, several commented that the response seemed to have clear anomalies. Off axis the panel heard the suck-outs quite clearly. The sound was generally muddy and confused. Our recording of a Steinway grand piano was said to sound more like an upright. The treble was said to be 'twinkly', and the mid range rather boxy. Other panel comments were unfortunately somewhat more derogatory. It seems most unfortunate that subjectively this speaker fared so badly, but when the entire panel condemns it, it seems very difficult to convey any enthusiasm for the product.

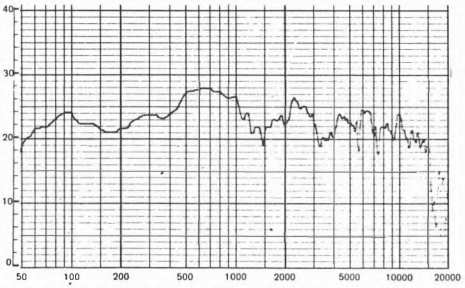
In our own internal listening tests, carried out in mono, we also heard severe polar diagram problems, and I personally found the speaker to be very highly colored. Note that in all the 'in-house' tests I did not know which speaker we were listening to, and so these comments are completely unbiased. From looking at the manufacturer's literature it seems that the very points which they regard as being particularly good, and which they have attempted to improve, are the very ones in which the main subjective criticisms lie—namely coloration and horizontal polar diagram.

At its rather high price I feel it is poor value for money and cannot be recommended. Perhaps the manufacturers should spend some time listening to very high quality tape recordings reproduced by their speaker, for only thus can problem areas be solved satisfactorily. Just before finishing this review I heard that a minor change is being made to the crossover, and whilst this might improve the mid-frequency peak I cannot see how it can affect either coloration or the polar diagram problems significantly. Incidentally, the manufacturers claim the speaker to have direct radiation giving an omni-directional characteristic over a 180° front angle.

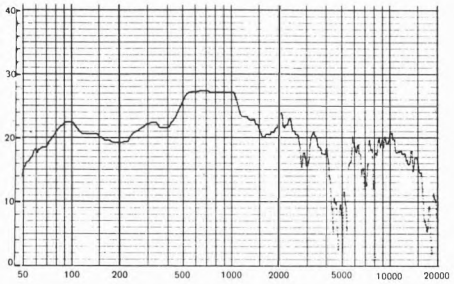


Height	805mm
Width	375mm
Depth	290mm
Weight	30kg
Finishes	Teak/walnut
Input connections	4mm banana
User adjustments	none
Lowest Impedance (Modulus)	4Ω20kHz/6Ω5kHz
Maximum SPL	103dBA
Sensitivity dBA pink noise 2.83V RMS 1m	80.5dBA
Recommended maximum amp power	100 watts
External volume	87.5 litres
Optimum listening height above base of speaker	620mm
R.R.P. (ex. VAT)	£336.00

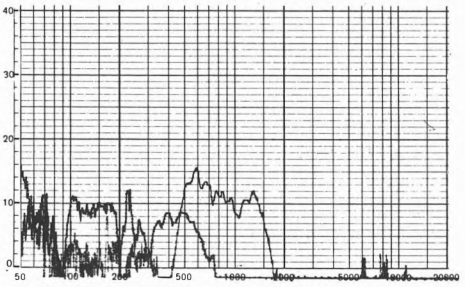
Not normally discounted



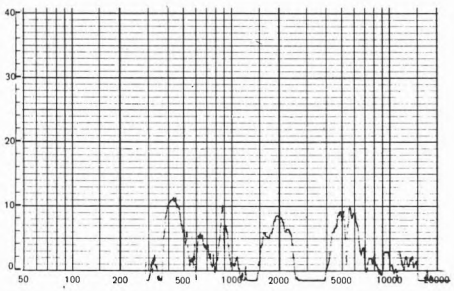
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2 - f_1$)

Bose 301

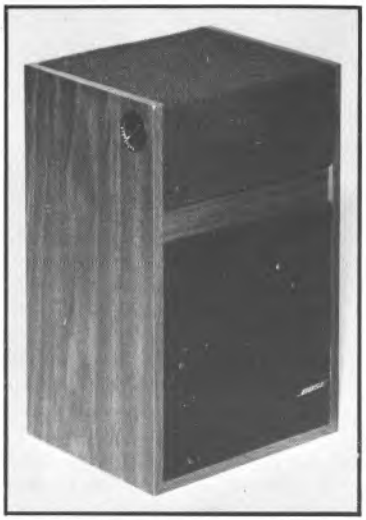
Bose (UK) Ltd, Milton Regis, Sittingbourne, Kent.
0795 75341

Bose loudspeakers have a reputation for giving comparatively high output SPL's from quite small cabinets, and this model achieved a maximum of 106dBA from a cabinet only 432 x 267 x 241mm. The cabinet is only available in walnut, and contains just a two-unit system, the tweeter of which beams on to a rotatable planar reflector so that its main energy can be beamed in any required direction. The loudspeaker was tested upright, ie. with the tweeter above the woofer and facing upwards but appreciably backwards. The reflector beamed the treble end towards the panel's average listening height. Input connections were with screw terminals, and the construction of the speaker allows for vertical or horizontal mounting, the systems being supplied in pairs which are mirror images of one another. They are designed for low or high mounting against a wall and at least 30cm above floor level and away from a corner.

In the anechoic chamber the on axis sine wave response was reasonably flat from 85Hz to 1kHz. At 2kHz a 15dB valley became evident, but the response established itself to flat again at 3kHz. Above 7kHz quite severe peaks and valleys became apparent. Off axis horizontally the presence and HF region generally dipped more, reducing the HF energy somewhat. Vertically off axis the peaks and valleys are in different places, but are about the same proportion as on axis. It is only fair to add that in the chamber the response was not measured under ideal conditions, since there would normally be some back reflection from a wall which would add energy, particularly in the presence region where the speaker would thus be made rather more omni-directional. However, the reflector was optimised for the best available response in the chamber, and it dramatically affected the response above 1.3kHz. The harmonic and IM distortion performances were pretty good—the highest distortions being measured at around 1.4%, but at most frequencies distortion was significantly lower. This is creditable on such a small speaker system. The impedance curve showed no particular problems at all. The electrical phase also was comparatively good. The speaker had average sensitivity, our standard pink noise level giving a weighted output of 83dBA (86dB unweighted). The manufacturers rate the loudspeaker at 60W and we feel that it is well able to withstand a peak output from such a rated amplifier, at which level it should give just in excess of 100dBA without trouble on a normal programme.

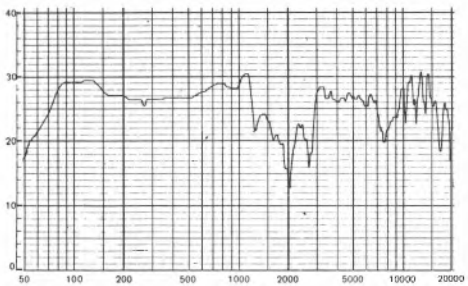
The listening panel found the loudspeaker to lack deep bass, but what was more serious was the clearly audible lack of output in the lower presence region. The treble end was said by most members to be very peaky and metallic sounding. Many instruments tended to recede somewhat because of the lack of presence, whereas percussion sounds became too brittle and forward. The overall balance of the loudspeaker was said to be wrong, and some mid coloration was also noticed.

In our internal tests we found that the loudspeaker did have a polar diagram problem, and whilst one or two types of programme material sounded reasonable, many other types seemed to sound rather odd. I did not find the speaker quite so colored as the panel evidently did, but I did agree that the HF end was excessively peaky. The treble dispersion mechanism was found to be fairly difficult to adjust correctly, and in any case clearly suits only one pre-adjusted listening height, thus making the speakers only suitable for one listener in an ideal position. Since the speaker was in general not liked, it seems that it cannot be recommended, although for specialist applications its reasonable price might attract some purchasers. Unfortunately, competition is too great, and the only real merit of the speakers is their reasonably high output capability for the size of cabinet.

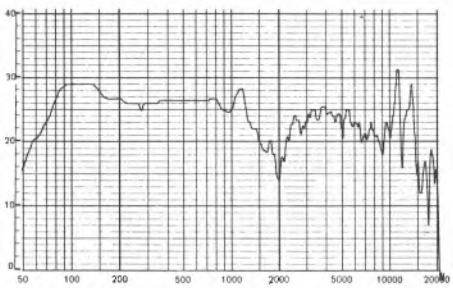


Height	432mm
Width	267mm
Depth	241mm
Weight	7.5kg
Finishes	Walnut
Input connections	Screw terminals
User adjustments	HF
Lowest Impedance (Modulus)	6.5Ω45Hz/7Ω175Hz
Maximum SPL	106dBA
Sensitivity dBA pink noise 2.83V RMS 1m	83dBA
Recommended maximum amp power	60 watts
External volume	27.8 litres
Optimum listening height above base of speaker	390mm
R.R.P. (ex. VAT)	£135.00

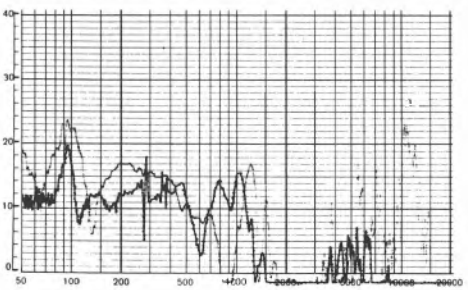
Occasionally discounted



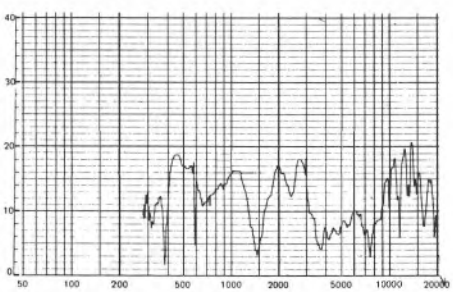
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2 - f_1$)

Bowers & Wilkins DM4

Bowers & Wilkins Loudspeakers Ltd, Meadow Road
Worthing, Sussex BN13 1QA. 0903 205611

Bowers & Wilkins enjoy an excellent reputation for their loudspeakers and in the past have been given the Queen's Award to Industry. Their DM4 is a fairly small three-unit system in a cabinet measuring 533mm high, 254mm wide and 254mm deep. The bass unit, a DW200/4, has an effective cone diameter of 164mm and the mid unit is a Celestion HF1300/2. The tweeter is a 4001G 19mm unit and has a Mylar dome. The cabinet is available in teak, walnut, rosewood and white satin finishes. Input connection is with either banana sockets or a DIN socket connected in parallel. The weight is 11.1kg. The loudspeaker is recommended for stand mounting with its back against a wall. Each model is supplied with an individual pen chart and we were all very impressed with the instruction manual, which quoted extensive performance data on the loudspeaker as measured in an anechoic chamber, etc.

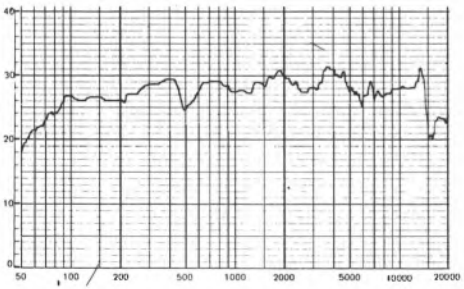
The axial response in the anechoic chamber showed a fairly steep bass cut below 85Hz. The response from the upper bass right up to 14kHz was surprisingly flat, but a pronounced dip occurred at 16kHz (−8dB). When mounted against a wall the upper bass came up appreciably and thus some boom and chestiness was produced which tended to mask the low bass performance. The horizontal polar diagram was relatively good, a degree of HF loss becoming apparent. The vertical off axis response, though, showed a heavy dip at 3.5kHz of some 15dB and also a 6dB dip at 10kHz. Bass distortion was primarily second harmonic, but measured only 3% at 100Hz. Elsewhere harmonic distortion reached a maximum of about 1%, but was generally substantially lower. 1% IM distortion was noted at 3.2kHz, although other frequencies were better. The impedance reached a minimum of 4.5 ohms at 200Hz, but was also only 5½ ohms at 8kHz. The minimum impedance then was rather on the low side, but might not be too troublesome. The maximum phase variation was from −45° to +35°. The weighted sensitivity for 2.83V input was 86dBA, unweighted being 87.5dB. Thus the speaker was very sensitive. The maximum power output was 102dBA. The manufacturers recommend a maximum input of 30W, which would thus give a peak output of around 101dB.

Both my colleagues, myself, and members of the listening panels commented that the bass was in general very light, but middle frequencies appeared somewhat colored. Unfortunately the treble end sounded peaky, particularly on pink noise. Several panel members commented on boxiness, and the loudspeaker seemed to produce a nasal quality, which was rather disliked. High frequencies received comments such as 'scratchy', 'harsh' or 'rather shrill'. The speaker continually lacked body and sounded a little shallow. Several panel members noticed the EHF loss, but attributed this, slightly incorrectly, to a mid HF peak, which was not really there. Strongest criticisms were of the middle frequency coloration and the peaky sound produced by the tweeter. My colleagues and I, though, did not dislike the speaker quite as much as the panel did and we all consider that the DM4 should be heard since it does at least offer good sensitivity and will give reasonable results from a relatively lower powered amplifier. In our opinion the manufacturers will have to improve on coloration, though, as the competition is so considerable.

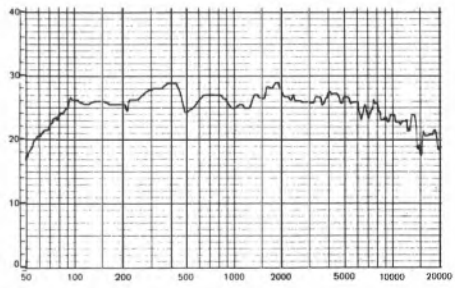
On looking over all the listening panel comments, it is rather difficult actually to recommend the loudspeaker, although it could be considered reasonable value for money. If you can accept mid-frequency coloration, you may very well like the sound, but it would appear that too much attention has been taken in attempting a fairly flat anechoic chamber response, as opposed to a subjective smooth one without coloration.

Height	533mm
Width	254mm
Depth	254mm
Weight	11.1kg
Finishes	Teak/walnut/rosewood/white satin
Input connections	4mm sockets + L/S DIN socket
User adjustments	none
Lowest Impedance (Modulus)	4.5Ω150Hz/5.5Ω8kHz
Maximum SPL	102dBA
Sensitivity dBA pink noise 2.83V RMS 1m	86dBA
Recommended maximum amp power	30 watts
External volume	34.4 litres
Optimum listening height above base of speaker	340mm
R.R.P. (ex. VAT)	£125.28

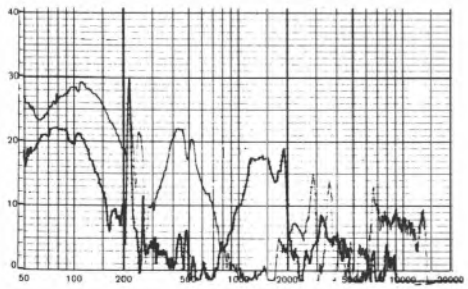
Not normally discounted



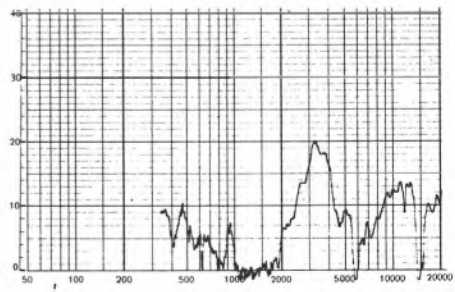
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2-f_1$)

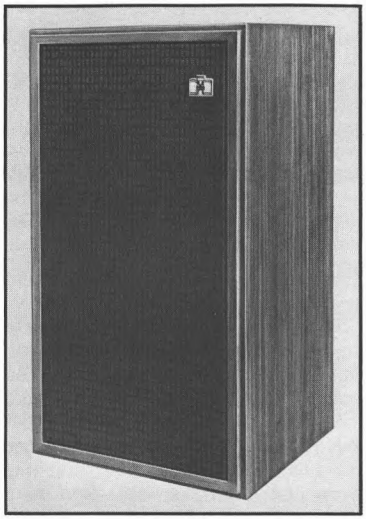
Castle Acoustics Kendal

Castle Acoustics Ltd, Shortbank Road, Skipton, West Yorkshire. 0756 5333

The designer of this system was John Collinson, who used to head the H.J. Leak/Wharfedale loudspeaker design team, but who now runs Castle as a totally independent company. The two-unit Kendal is modestly priced. It measures 525 x 290 x 280mm deep and weighs 11kg. The cabinet is available in teak, walnut; oak, mahogany or rosewood at extra cost. The bass/mid range unit covers the range from 50Hz to 3.5kHz, being 20cm diameter and reflex loaded. The tweeter, a 30mm unit, has a low mass plastic diaphragm. The braced cabinet is constructed of veneered chipboard, covered with a protective coat of polyurethane lacquer. This explains why these particular loudspeakers retained their smart appearance without being scratched throughout the tests. Banana sockets paralleled with a loudspeaker DIN socket provide input connection.

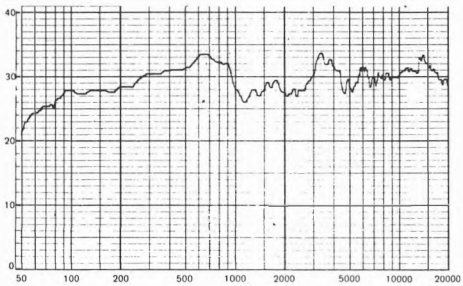
The on-axis sine wave plot showed a lack of extreme bass and a valley in the lower presence region with a hill immediately above and below it. The treble end appeared to rise at EHF. Off axis the HF band retarded somewhat, with the usual dips here and there. The horizontal polar diagram was better than average but, as expected vertically, cancellations took place in the presence region. Harmonic distortion averaged around 1% generally, and the intermodulation distortion measured fairly well, but peaked at 1.2% at 3.5kHz—the crossover point. The impedance plot was generally reasonable but showed a dip to 5 ohms at very high frequencies. The electrical phase measured very well above 200Hz, but presented the usual swings at LF. The speaker was very sensitive, our pink noise test signal developing 87dBA at 1 metre (unweighted 89.5dB). Somewhat astonishingly, the speaker was able to give 107dBA, at which level the sound had deteriorated markedly—sounding rather dirty, which is hardly surprising. The manufacturers recommend that an amplifier of up to 50W rating is satisfactory, and if this is driven hard the loudspeaker will almost blow your brains out in a domestic situation and so a modest amplifier will provide adequate volume in a normal room.

Both the pop and classical listening panels found deep bass lacking from this loudspeaker. Middle frequencies were slightly colored. Lower presence frequencies seemed somewhat down, but the higher presence region was clearly rather forward and bright giving the subjective effect of EHF being down, although it was not found to be so in the anechoic chamber. Coloration had a slight 'AW' sound and the sound quality was very slightly nasal and tubey. Some detail at high frequencies appeared to be slightly missing and the speaker generally lacked a little body. Notwithstanding the above criticisms, the loudspeaker was not disliked by either panel, and at its price can clearly be recommended as good value for money. The great difference, though, between speakers costing below £120 excluding VAT and those costing somewhat higher seems to be fairly marked, but if you can only afford speakers in the Kendal price category I do not think that you will be too disappointed. Although the manufacturers recommended that the loudspeaker should be tested on a plinth, they would clearly give a better bass end performance subjectively if placed on the front of a shelf, and so the panels' reservations concerning the lack of body might well be withdrawn by shelf mounting. Quite clearly, the Kendal should be heard and should provide relatively trouble free performance. Our own tests, incidentally, agree with the panels' comments and we all felt that the reproduction was acceptable, although not outstanding.

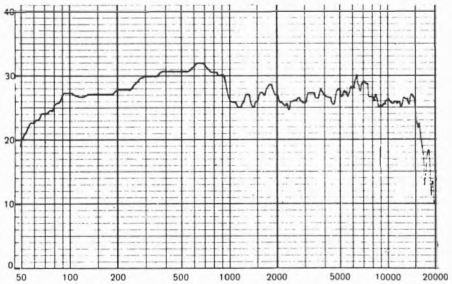


Height	525mm
Width	290mm
Depth	280mm
Weight	11kg
Finishes	Teak/walnut/oak/mahogany/rosewood
Input connections	4mm banana sockets + L/S DIN socket
User adjustments	none
Lowest Impedance (Modulus)	5Ω12kHz/7.5Ω250Hz
Maximum SPL	107dBA
Sensitivity dBA pink noise 2.83V RMS 1m	87dBA
Recommended maximum amp power	50 watts
External volume	42.6 litres
Optimum listening height above base of speaker	380mm
R.R.P. (ex. VAT)	£106.00

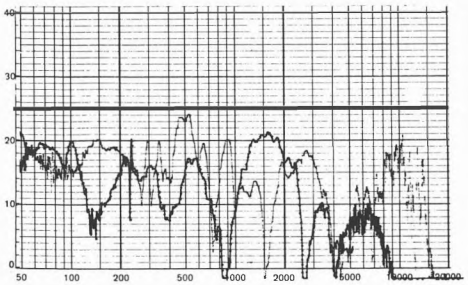
Not normally discounted



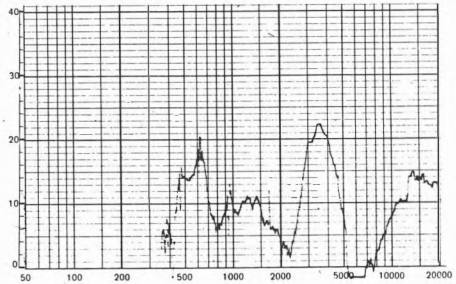
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2-f_1$)

Celef Mini Professional

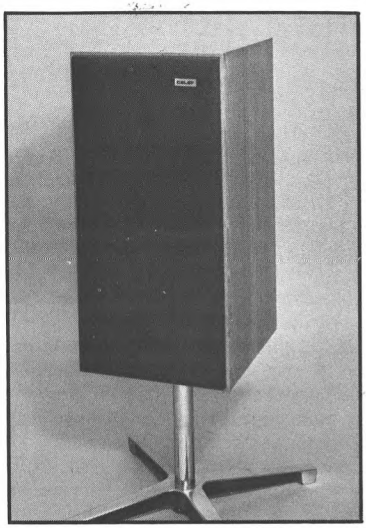
Celef Audio Ltd, 130 Thirsk Road, Borehamwood, Herts.
01-207 1150

Celef is a relative newcomer amongst loudspeaker manufacturers and I am pleased to say that both their speakers reviewed in this book have done comparatively well, which is a credit to them. The Mini Pro is a two-unit system incorporating a 200mm bass/mid unit with a Bextrene cone (KEF B200) and the tweeter is a 20mm (Audax) doped fabric dome. The cabinet, normally available in teak, can also be supplied at extra cost in walnut, white or rosewood finishes. Dimensions are 584 × 305 × 279mm, and it weighs 15kg. Input connections are on banana type terminal sockets, which are particularly convenient. The bass loading uses twin resistive ports, which are hand constructed and welded. These ports are filled with specially prepared polypropylene drinking straws, so that they offer the required acoustic resistance. (what a useful way to use drinking straws!)

The anechoic chamber response showed a very reasonable overall shape on axis, within bounds of 6dB from 60Hz to 20kHz, with the usual dips and hills. (See pen chart.) Off axis horizontally EHF rolls off above 9kHz but, as anticipated, vertically off axis a very large dip appears at 2.6kHz, due to acoustic cancellation in the outputs from the units. However, apart from this dip, the output is reasonably flat up to 12kHz. Although in general the harmonic distortion is below 1% three second harmonic bumps occur between 2 and 3% at 80Hz, 200Hz and 450Hz respectively. IM distortion always measured below 0.8% maximum. The impedance generally measured satisfactorily, although we did notice a modulus dip at approximately 3.5kHz to 6 ohms. Just below this there was a sharp positive electrical phase peak reaching 50° and this signifies that the resistive component might be rather low here. But I do not feel that problems would be likely to arise other than with pretty poor amplifiers. Our standard pink noise signal produced a weighted output of 82dBA and thus the speaker is slightly less sensitive than average. Our power test showed severe deterioration at the bass end when a level of 102dBA was reached, but this represents peak output from a 100W amplifier. The manufacturers recommend amplifiers from 25 to 80W rating, which seems a little loose, and from our tests we feel we can recommend use with an amplifier of at least a 50W capability. The manufacturer recommends a plinth between 250mm and 450mm height with the back of the loudspeaker at least 15cm away from a wall.

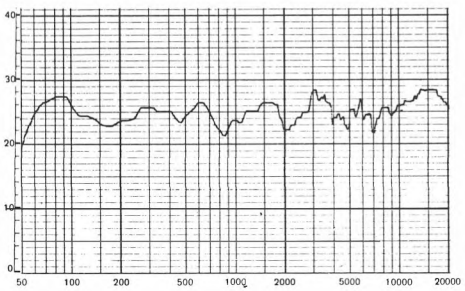
Although the classical panel heard slight coloration at middle frequencies, the pop one found the coloration to be fairly minimal. High frequencies were heard to be slightly up, but certainly not peaky, which is a most important point. Slight bass boom was noticed, particularly on voice and timpani and some panel members commented that EHF was audibly down a little, but these members were rather off axis. Most commented that high frequencies were just a little strident and hard. The pop panel found the response generally very smooth, although they agreed that high frequencies were just a little bright. All who heard this loudspeaker clearly liked its qualities very much and unhesitatingly I can recommend it quite strongly for all types of music. In the main it gave an excellent account of itself and perhaps the only criticism might be a slight lack of stereo positioning accuracy off axis, but it is certainly appreciably better in this respect than many other systems. It will probably be better to tilt the loudspeakers inwards very slightly towards the listening position. This loudspeaker scored very high marks in all the listening tests and can thus be strongly recommended as its price seems to make it excellent value for money. You will almost certainly like this speaker very much, but as with all loudspeakers, you are advised to listen to it first on known material.

The manufacturers are frankly, as yet, rather a small company, and it is a credit to them that they have made one of the best speakers in this survey. You may have difficulty in obtaining this speaker, but if your heart is set on it, I consider that it is well worth taking a deal of trouble to find a pair. Although a year ago almost all Celef's main dealers were around London, they now have fairly good national representation.

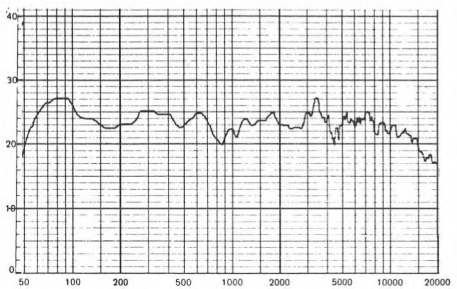


Height	584mm
Width	305mm
Depth	279mm
Weight	15kg
Finishes	Teak/walnut/white/rosewood
Input connections	4mm banana terminals
User adjustments	none
Lowest Impedance (Modulus)	6Ω3.5kHz/6.5Ω500Hz
Maximum SPL	102dBA
Sensitivity dBA pink noise 2.83V RMS 1m	82dBA
Recommended maximum amp power	50 watts
External volume	49.1 litres
Optimum listening height above base of speaker	400mm
R.R.P. (ex. VAT)	£165.00

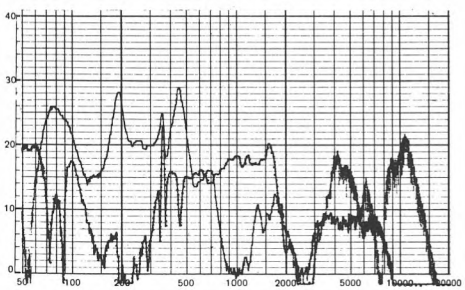
Not normally discounted



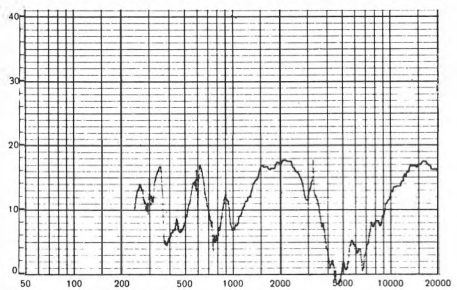
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2-f_1$)

Celef Studio Professional

Celef Audio Ltd, 130 Thirsk Road, Borehamwood, Herts.
01-207 1150

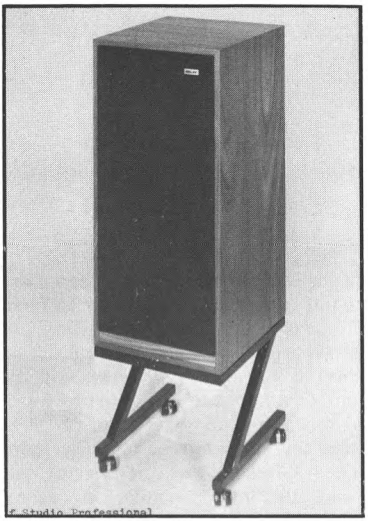
At the time we began this survey, the Studio Professional had only just been designed. So they were literally red hot off the prototype production line. The cabinet is pretty large measuring 762 × 343 × 381mm, and contains a KEF B139 low bass unit, an Audax 203mm Bextrene unit covering upper bass and mid range, with high frequencies being taken care of by an Audax 25mm soft doped fabric dome tweeter. The B139 unit is loaded into a non-symmetrical damped chamber with rear resistive reflex loading and, as with the Mini Pro, the port uses polypropylene drinking straws for acoustic resistance. The system weighs 30kg and employs banana terminal sockets for interconnection. The cabinet is normally available in teak or walnut, but rosewood, grey formica or white finishes are available to special order.

The sine wave on axis response measured reasonably flat from 50Hz to 20kHz, the main deviations noted being dips at 6kHz and 8kHz, with peaks at 4kHz and 15kHz. Horizontally off axis the peaks tend to flatten, but high frequencies become slightly curtailed above 9kHz, although the curve looks flatter. Vertically off axis the dip comes in at 600Hz and a larger dip occurs at 3kHz. Once again high frequencies are curtailed, but above 10kHz. Above 100Hz all distortion components are generally well below 0.8%. Even below 100Hz the distortion does not exceed 1%. IM distortion, giving 0.7% at 450Hz, is in general substantially below 0.5% throughout and I consider this creditable. The impedance curve is reasonably satisfactory, except at 1kHz where the modulus drops to 5 ohms. It is unfortunate that this is right in the middle of the audio spectrum. Electrical phase measured between ±40° throughout which is perfectly acceptable. 82.5dBA weighted was reached from our standard pink noise source (85dB unweighted) and the loudspeaker reached 105dBA before we suspected that the bass electrical crossover/inductor possibly became saturated. I reckon that the speaker can be used safely on normal programmes with an amplifier capable of delivering a maximum of 100W, providing it is not clipped. This will allow peak levels of 102dBA to be reached without audible deterioration.

The classical panel found the loudspeaker to have a solid firm bass, but suspected a very slight hole at upper mid frequencies—barely confirmed by pen chart. High frequencies were regarded as slightly too bright, but generally pretty smooth. Some mid coloration was noted and a few members commented that the polar diagram presented a slight problem, although we could not confirm this with our measurements. Applause sounded slightly cupped. Despite the criticisms the entire classical panel liked the loudspeaker very much and clearly recommended it.

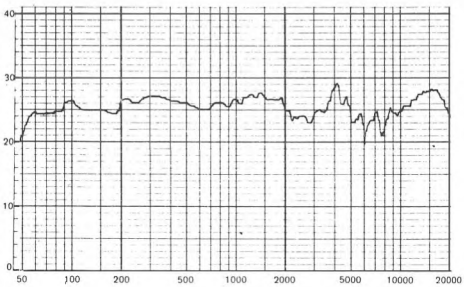
Some 'AW' and 'AR' coloration was noticed by the pop panel, who found the speaker just a little hollow and boxy. It was also felt to be slightly nasal and tunnelly. The reproduced quality sometimes tended to edginess and hardness. Low bass was said to be well extended and upper bass less boxy than average. Bass frequencies clearly had better definition than usual. Although high frequencies were a little hard, most of the panel liked it that way. The pop panel rated this speaker highly and recommended it, and considering that most higher powered speakers fared relatively badly in this survey, this is praise indeed.

It is possible that a modification to the crossover feeding the B139 could allow even higher output levels without distortion and this will almost certainly be looked into by the manufacturers. Since the Celef Studio Professional was liked by both panels I can unhesitatingly recommend it, since it gives quite a high power output at good quality. Unfortunately, though, despite the fact that its price includes stands, it is pretty expensive. This will obviously rule it out for many potential purchasers. Nevertheless, I still regard it as reasonable value for money. It would seem to be particularly useful for quality monitoring, but I cannot really recommend it for pop studio control rooms, where exceptionally high output power levels are required, and in which speakers of very high efficiency are vital.

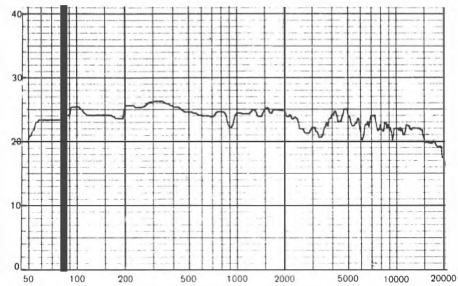


Height	762mm
Width	343mm
Depth	381mm
Weight	30kg
Finishes	Teak/walnut/rosewood/white/grey
Input connections	4mm banana terminals
User adjustments	none
Lowest Impedance (Modulus)	5Ω1kHz/5.75Ω125Hz
Maximum SPL	105dBA
Sensitivity dBA pink noise 2.83V RMS 1m	82.5dBA
Recommended maximum amp power	100 watts
External volume	99.5 litres
Optimum listening height above base of speaker	460mm
R.R.P. (ex. VAT) including price of stands	£360.00

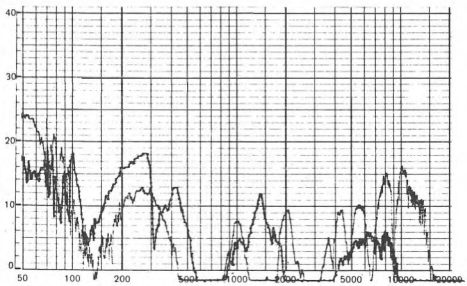
Not normally discounted



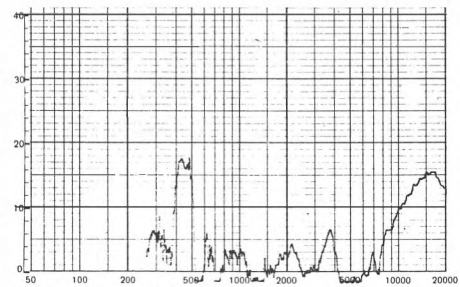
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2-f_1$)

Celestion Ditton 33

Rola Celestion Ltd, Ditton Works, Foxhall Road, Ipswich, Suffolk IP3 8JP. 0473 73131

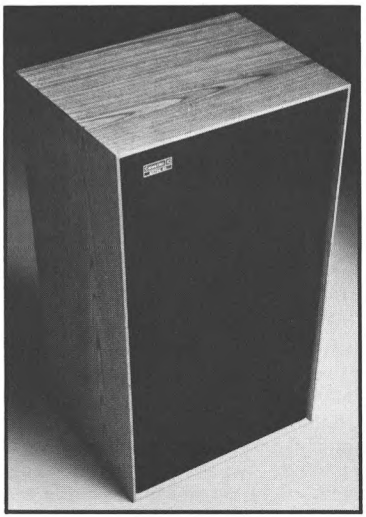
Although a fairly recent addition to the Celestion range, the Ditton 33 has rapidly become established as a popular model. One of the larger systems in the Celestion family, the cabinet measures $610 \times 355 \times 267$mm, and weighs 15.3kg. Cabinet finishes in teak or walnut are available, and connection is made with banana sockets, conveniently in parallel with a loudspeaker DIN socket. The three-unit system incorporates a 250mm bass woofer, having a treated paper cone and PVC surround. The squawker also has a paper cone and has a circumference of 127mm. The tweeter has a 25mm soft dome, type HD1000. The Ditton 33 is recommended for plinth mounting 50cm or so in front of a wall.

The anechoic chamber sine wave on axis response proved to be reasonably flat, although slight humps and valleys were clearly contributory factors to the subjective comments made. Off axis horizontally we noted a lower presence bump of just 3dB at 1.3kHz, and an apparent suck-out at 4.5kHz of some 9dB. Generally, presence and HF were down compared with the on axis response. Vertically off axis, the suck-out became fairly marked at 2.8kHz, which caused the general presence region to recede. The harmonic distortion performance was in general very good indeed, with just minor excursions to around 1% or so at one or two spot frequencies. The IM distortion was substantially better than 0.5%, except at 2kHz where it reached 0.7%. At 100Hz, and between 10 and 15kHz, the impedance dropped to around 4 ohms modulus. This will probably match fairly satisfactorily with most amplifiers. The electrical phase response was held within quite fine limits throughout the audio spectrum. The weighted sensitivity from our pink noise signal was about average, an output of 84dBA being achieved (86.5dB unweighted). At 103dBA our power output test showed appreciable bass output coming from the squawker, and the quality by this level had deteriorated markedly. Celestion recommend a 40W amplifier for driving the Ditton 33, and we consider this quite reasonable, the peak output with such an amplifier being around 100dBA, which is loud, allowing the speaker to be recommended for quite large rooms.

The classical listening panel found deep bass rather lacking, and noted some tendency to boxiness. Slight mid coloration was heard, but this was by no means excessive. The general sound quality was found a little hard and toppy, and the presence region was noticeably slightly forward. Most remarked that the sound was relatively clear and clean, but a few found it occasionally congested. The classical panel thought well of this loudspeaker, and felt that it could be recommended for classical music, provided you like a slightly brighter than average sound quality.

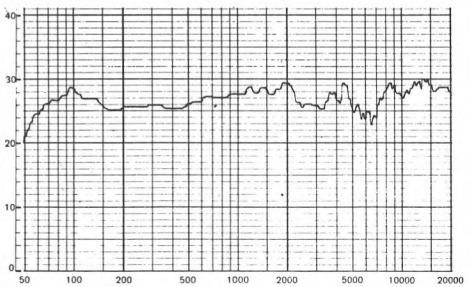
The pop music panel also found the speaker on the toppy side, and commented that voices and strings sounded a little tinny and metallic, but not excessively so. Again, slight mid coloration was noted. The pop panel rated the speaker from average to very good, the general concensus of opinion being quite favourable.

Both panels then made comments which allow the speaker to be recommended as an overall good basic for all material and, since the general coloration was lower than average, I can recommend it as a relatively good buy for normal average applications. Around its price bracket, though, there are a few other loudspeakers which should also be considered, and quite clearly it will be a matter of personal taste whether you prefer a slightly bright overall sound, or one not possessing quite such a clear quality, but which is marginally better balanced. Whereas the lack of deep bass should not be considered too seriously for the reproduction of classical music, some will find it a disadvantage in the reproduction of a wide range of pop music, but unfortunately systems having excellent deep bass performance usually have shortcomings elsewhere. Clearly, one of the better speakers in this survey.

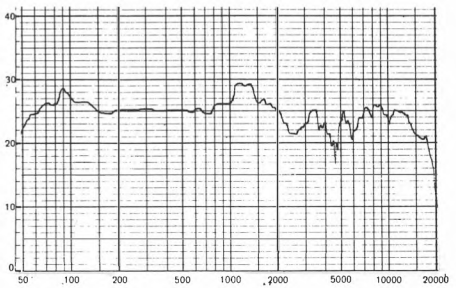


Height	610mm
Width	355mm
Depth	267mm
Weight	15.3kg
Finishes	Teak/walnut
Input connections	4mm banana sockets + L/S DIN socket
User adjustments	none
Lowest Impedance (Modulus)	4Ω12kHz/4.5Ω100Hz
Maximum SPL	103dBA
Sensitivity dBA pink noise 2.83V RMS 1m	84dBA
Recommended maximum amp power	40 watts
External volume	57.8 litres
Optimum listening height above base of speaker	400mm
R.R.P. (ex. VAT)	£166.75

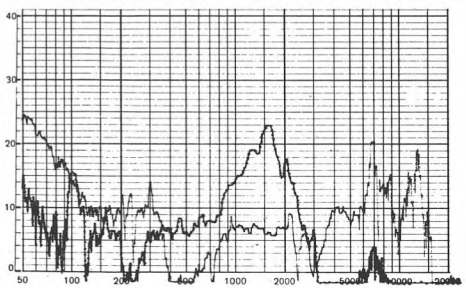
Normally substantially discounted



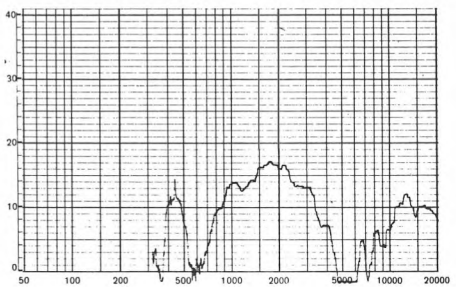
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2-f_1$)

Celestion UL 6

Rola Celestion Ltd, Ditton Works, Foxhall Road, Ipswich, Suffolk IP3 8JP. 0473 73131

This relatively small speaker incorporates a 152mm mid/bass unit and an HD 1000 pressure dome tweeter. An auxiliary bass radiator is provided, and the system is housed in a cabinet measuring 292 × 412 × 222mm deep, weighing 8kg. The cabinet is available in teak or walnut. Input connection is with banana sockets, paralleled conveniently with a loudspeaker DIN socket. This inexpensive system is designed for shelf mounting as close to a back wall as possible, and it was tested in this position, although in the anechoic chamber measurements were made in a free field, as was normal. As this loudspeaker won the 5th Japanese stereo component Grand Prix contest, we were all most interested to see how it would perform, especially since the Japanese do not appear to seek the same sound in a loudspeaker as we do.

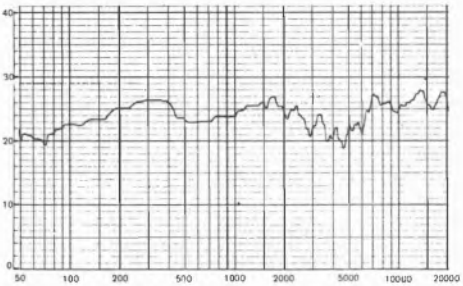
The sine wave response on axis showed a fairly poor bass end, but a reasonably flat response at middle and high frequencies, with an unfortunate but decided dip of 5dB around 4.5kHz. Off axis however, a 700Hz dip appeared of just 4dB, but otherwise the response was again reasonable. Vertically off axis, acoustic cancellation of 17dB was noticeable at 2.1kHz. Considerable second harmonic distortion of around 3% occurred up to as high as 400Hz, but third harmonic was significantly lower. At higher frequencies the distortion hovered around 1% on average. The IM performance was reasonably good. The modulus of impedance drops to around 5 ohms at 200Hz, and between 10kHz and 15kHz, but this is considered fairly satisfactory. The electrical phase response had the usual variations at bass frequencies, but was flatter than average at mid and high frequencies. 82dB output was achieved from 2.83V RMS pink noise, and the unweighted output measured 84.5dB SPL. The loudspeaker showed audible deterioration at 103dBA, at which point bass frequencies became excessively muddy. The manufacturers rate the loudspeaker at 9V continuous sine wave, but we reckon that it can be used safely with amplifiers of up to 40W rating, with the reservations mentioned in the power output introductory chapter. A 40W amplifier should reproduce sound levels around 98dBA peak, which is pretty loud.

The deep bass was substantially missing from this speaker's reproduction, and unfortunately the entire panel found that the subjective effect of the presence dip caused nearly all music to become tinny and metallic. Mid frequencies were just slightly colored. Several panel members found that speech was rather sibilant, and that the reproduction lacked body. Unfortunately the panel did not particularly like this speaker since the entire HF end was obviously excessive, although generally clear. I gained the impression that a piano sounded as if it had been modified to have metal hammers. The left hand appeared to recede somewhat, and the presence suck-out also removed gut and attack from cellos in particular. Although the anechoic chamber responses were clearly reasonable on axis, I must assume that the suck-outs appearing slightly off axis must have exaggerated the subjective brightness of the system, since many panel members downgraded it for its apparent considerable top boost. I feel that if the 4kHz response could be lifted about 4dB or so, the speaker would sound much more balanced. Many listeners may well like it though, and once again it would perform significantly better in more reverberant rooms than the average domestic room. Rooms with bare walls, for example, would probably help the speaker a lot, and perhaps if the units were mounted very near corners, the bass end would be enhanced.

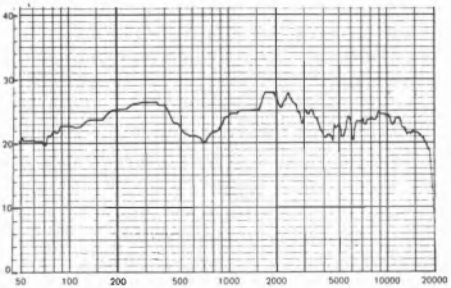
Despite this loudspeaker's reputation, I do not feel that it can be recommended, although one must remember that it is pretty inexpensive. It is still nevertheless reasonable value for money, whilst not being considered a best buy.

Height	292mm
Width	412mm
Depth	222mm
Weight	8kg
Finishes	Teak/walnut
Input connections	4mm banana sockets + L/S DIN
User adjustments	none
Lowest Impedance (Modulus)	5Ω12kHz/5.5Ω200Hz
Maximum SPL	103dBA
Sensitivity dBA pink noise 2.83V RMS 1m	82dBA
Recommended maximum amp power	40 watts
External volume	26.7 litres
Optimum listening height above base of speaker	170mm
R.R.P. (ex. VAT)	£102.44

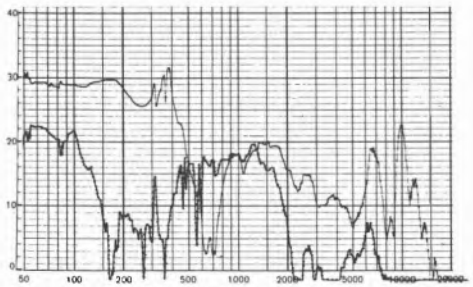
Occasionally discounted



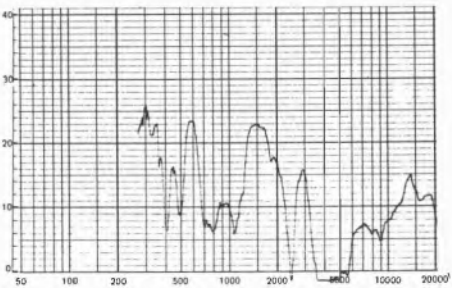
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2 - f_1$)

An auxiliary bass radiator is included in this two-unit system incorporated in a cabinet measuring 584 x 280 x 235mm. Thus the cabinet is rather shallow from back to front, but is fairly tall in proportion. The system weighs 11kg and is available in teak or walnut finishes. Input connections are with banana sockets, conveniently in parallel with a DIN loudspeaker type. The mid/bass unit is 205mm diameter, and the HF unit is an HD1000 pressure dome tweeter. The ABR is also 205mm.

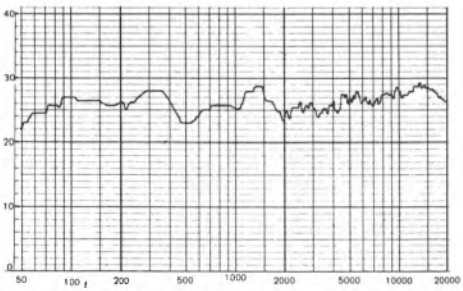
The on-axis sine wave response was surprisingly flat from 50Hz to 20kHz within bounds of about 6dB; but the pink noise third octave response showed a general tendency of slight brightness and an EHF shelf boost, so that the general balance of the loudspeaker was marginally down in the mid and up at HF. Horizontally off axis high frequencies tend to recede just a little, but the presence region goes somewhat forward. Vertically off axis a dip appears at 1.8kHz and a slight rise at 3kHz, above which the response is pretty flat. The harmonic distortion performance is generally rather high, averaging around 2% at low frequencies, and 1% in the mid region. Approximately 2% distortion is reached again at 3kHz and 10.5kHz (all primarily second harmonic). The third harmonic distortion was in general lower than second. IM distortion was generally below 1%, but reached a peak of 1.4% at 1.5kHz. The impedance curve showed a modulus that was rather low between 3kHz and 15kHz, in which region it averaged 4.5 ohms, and thus a compatible amplifier will be necessary to avoid matching problems. Fortunately, however, the electrical phase was held within fairly tight limits of $\pm 30^{o}$ throughout the audio spectrum, and thus the speaker is primarily resistive. The loudspeaker had about average sensitivity, our pink noise test signal developing an 83.5dBA weighted SPL (86dB unweighted). The power test caused significant audible deterioration at 103dBA, at which point the bass end became unacceptably muddy. The manufacturers recommend an amplifier capable of delivering 25W, but we feel that a slightly more powerful amplifier would not cause trouble on normal classical music. A programme peaking 25W would incidentally give an output level at around 96dBA, which is fairly loud.

Whilst the pop listening panel quite liked this loudspeaker, the classical panel found the quality to be rather too bright and toppy. On all types of programme material the speaker subjectively lacked body, and the presence of the general HF shelf clearly contributed to this finding. Classical string tone became slightly strident giving the impression of over-developed bows. The pop panel, however, quite liked the brightness, finding the reproduction clear and analytical, but nevertheless still on the toppy side. The coloration seemed fairly low and only occasionally received comment. One or two panel members commented that the stereo images were not as clear as usual. The loudspeaker was shelf mounted and this tended to produce a lift in the upper bass, but with a noticeable low bass fall off which continually received comment.

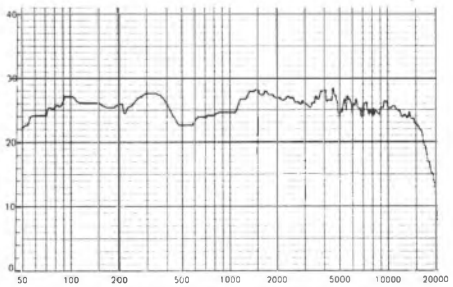
Therefore, while the classical panel found the speaker's balance to be unrealistic, the pop panel appreciated the loudspeaker, and thus I can recommend it with slight reservations within its price bracket for the reproduction of light and pop music. It is particularly satisfactory if you like a bright sound quality and the system will give more than enough room volume for normal purposes from a comparatively low powered amplifier (e.g. 20W). The speaker is clearly very reasonable value for money, but since it is not necessarily a good all rounder, I feel that you should take my mild recommendation with a degree of caution and I should encourage you to hear some alternatives before a final decision. The manufacturers have clearly taken some trouble in designing this speaker, but I feel that they would benefit from listening critically themselves to high quality master tapes on their own loudspeakers, and this might well result in their improving the HF balance slightly. From looking at the response curve I should add that very minor general shelves or troughs seem to have a surprising effect on subjective balance, and I trust that I have not been too unfair in my criticisms of this system.

Height	584mm
Width	280mm
Depth	235mm
Weight	11kg
Finishes	Teak/walnut
Input connections	4mm banana sockets + L/S DIN socket
User adjustments	none
Lowest Impedance (Modulus)	4Ω3kHz/5.5Ω150Hz
Maximum SPL	103dBA
Sensitivity dBA pink noise 2.83V RMS 1m	83.5dBA
Recommended maximum amp power	30 watts
External volume	38.4 litres
Optimum listening height above base of speaker	450mm
R.R.P. (ex. VAT)	£126.29

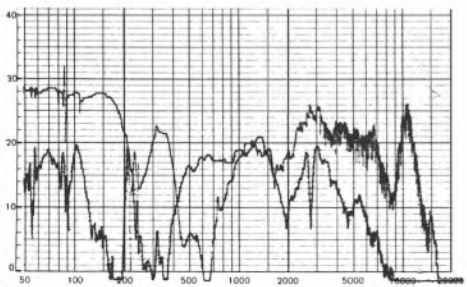
Occasionally discounted



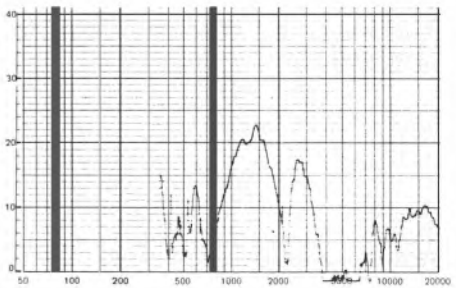
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2-f_1$)

Chartwell LS3/5A

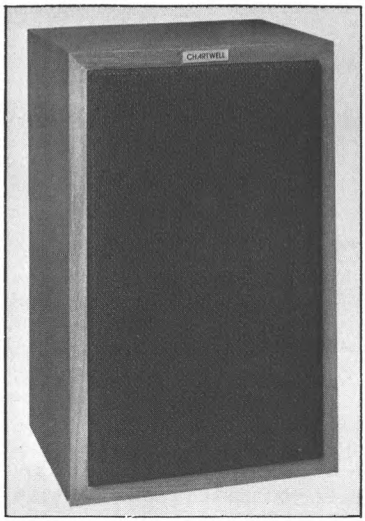
Chartwell Electro Acoustics Ltd, Alric Avenue, Harlesden, London NW10 8RA. 01-451 1442

The basic details of this loudspeaker are identical to those of the Audiomaster LS3/5A (viz). The speaker is available in teak, rosewood or walnut finishes and the input connections are with screw terminals (nb. rosewood finish considerably more expensive).

The bass end performance on axis is virtually identical to the Audiomaster's and whilst the 1.5kHz dip is about the same, the Audiomaster's 6.3kHz dip of 8dB is replaced by two far less marked ones slightly lower in frequency. The EHF end also rises only half as much as the Audiomaster's and thus the speaker sounds rather more balanced between the mid and high-frequency response. Off axis horizontally the dips became very slightly worse, but the slight EHF rise became a slight fall off at 14kHz and this is quite satisfactory. Off axis vertically, the 1.5kHz dip disappears but at 3.8kHz and 4.5kHz dips of approximately 12dB occur. The EHF end improves over the on axis response. The harmonic distortion curves are almost identical to those of the Audiomaster's version, but the swept inter-modulation plot shows marginally higher distortion, particularly at 3kHz, but this is probably because the speaker's response is flatter here. Impedance and phase measurements are again almost identical to the Audiomaster's measurements. The available power output is again identical on our test programme at 96dBA, and thus very low, but the sensitivity is marginally inferior at 77dBA weighted, thus very insensitive. The manufacturers recommend not more than a 30W capability amplifier for interconnection and thus the available power output is very restricted.

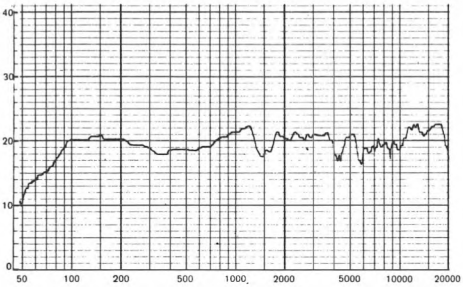
In general the listening panel found the response to be surprisingly smooth at middle and high frequencies, but bass frequencies seemed rather curtailed, with low bass frequencies almost completely absent. The sound was quoted at times as being slightly thin. Many of the panel liked this loudspeaker and it scored some surprisingly high marks, although it also scored two very low ones. The loudspeaker sounded somewhat better if some low bass boost was applied but under these conditions great care must be taken not to overdrive the bass unit. Coloration was found to be pretty low and the unit is recommended for shelf mounting, in which position it was auditioned. This loudspeaker can be recommended for classical and light orchestral music only and it will not give sufficient volume for normal use in other than pretty small rooms. Provided the power output limitation and lack of bass are understood, the speaker should perform very satisfactorily and will give clean uncolored reproduction of most programme material. It gave particularly good reproduction from speech and chamber music.

Some panel members stated that the speaker was slightly boxy and yet found applause very revealing, for it was reproduced surprisingly accurately. This again shows the coloration to be low. Although the speaker is recommended with caution, its price seems slightly on the high side for its size, and unfortunately the very complicated BBC crossover design largely contributes to this. It can only be rated then as rather average value for money and if you have a little more room and want a rather higher output potential, there are a few other speakers in this survey which are more recommendable and could be regarded as significantly better value for money. The Chartwell LS3/5A is a speaker which I consider must be heard in one's domestic environment before purchase, but has been chosen as a very small reference standard by quite a number of BBC employees, who have been fairly impressed with it.

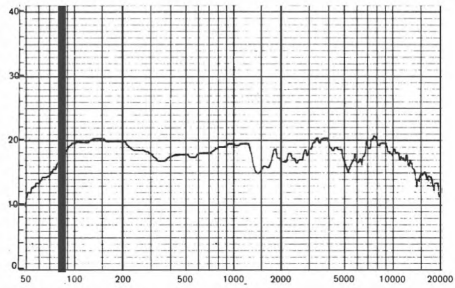


Height	305mm
Width	190mm
Depth	160mm
Weight	5.3kg
Finishes	Teak/rosewood/walnut
Input connections	Screw terminals
User adjustments	none
Lowest Impedance (Modulus)	9Ω12kHz/9.5Ω175Hz
Maximum SPL	96dBA
Sensitivity dBA pink noise 2.83V RMS 1m	77dBA
Recommended maximum amp power	30 watts
External volume	9.27 litres
Optimum listening height above base of speaker	210mm
R.R.P. (ex. VAT)	£125.00

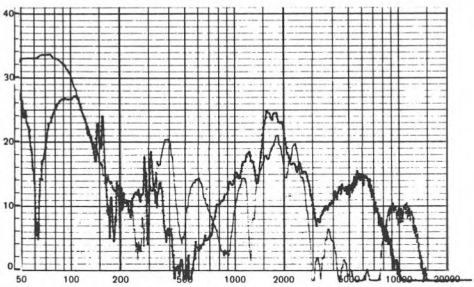
Not normally discounted



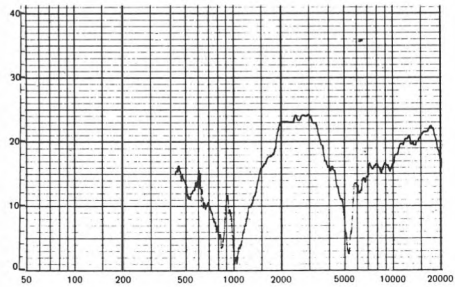
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2-f_1$)

Chartwell PM 200

Chartwell Electro Acoustics Ltd, Alric Avenue, Harlesden, London NW10 8RA. 01-451 1442

This system incorporates just two units, high frequencies being fed to an extensively modified Isophon KK10/8 tweeter, and low frequencies coming from a Chartwell 203mm Bextrene cone bass/mid unit. Each unit is protected by a separate fuse. The bass reflex cabinet, available in teak as standard or rosewood at extra cost, measures 660 × 343 × 286mm deep, and weighs 15kg. Input connections are banana sockets in parallel with a loudspeaker DIN one. The system is designed for plinth mounting away from a wall or corner, the plinth being available from the manufacturer.

The on-axis sine wave response showed a significant dip at 3.8kHz, and also a plateau rise between 5 and 8kHz, with an additional peak at 12kHz, although the overall response is nevertheless reasonably flat. Horizontally off axis the 3.8kHz dip improves, but frequencies above 10kHz become noticeably curtailed. As would be expected, the vertical off axis shows an acoustic cancellation between 2 and 2.5kHz of some 10dB, but this is somewhat less of a cancellation than average. Very high frequencies can become slightly curtailed above 11kHz. Both 2nd and 3rd harmonic distortion is generally below 0.5% between 70Hz and 9kHz, but the Isophon tweeter, as with the model 400, showed bad 2nd harmonic distortion at 10kHz (some 5%). 3rd order IM distortion was very low throughout. The impedance dropped to 5 ohms at 5kHz, and the electrical phase varied from +50° to −20°. Unfortunately the maximum positive error was at 2kHz, which is unusual, since it is as often as not at lower frequencies. A weighted output of 81dBA was reached from our standard pink noise source (83dB unweighted), and on the power output tests the loudspeaker reached 102dBA, at which point the bass unit was virtually hitting the end stop.

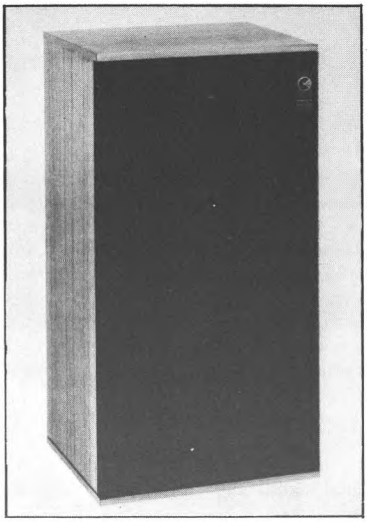
Despite the manufacturer's optimistic rating of 125W, I feel it safer to recommend amplifiers of not more than 60W rating for this system.

The classical panel heard the slight suck-outs around the presence region, and said that this system provided slightly too much high-frequency energy. Vocal quality was just a little nasal. The panel members slightly off axis did notice the EHF roll off.

The pop panel had much the same criticisms, and particularly noticed the high-frequency brilliance which they considered a little excessive. Some instruments' fundamentals or lower harmonics tended to recede. The HF brightness was regarded as a good point by one panel member. Some slight mid-frequency coloration was noted, and one or two pop engineers considered the deep bass end somewhat lacking. One well-known engineer found the treble end peaky and was obviously disturbed by the Isophon tweeter distortion. The bass end was found to be quite good by most listeners, and considering the modest size of the cabinet, obviously did well. Quite clearly the panel's comments confirm the variation found in the pen chart recordings.

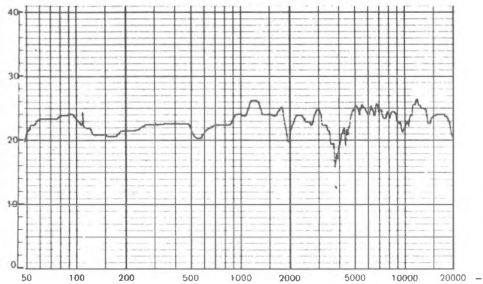
It is a pity that this loudspeaker only scored average marks, and it will be very much a matter of personal taste whether you like it or not. Its price is quite modest, but I advise you to look at some of its competition at around the same cost. It can be rated as reasonably good value for money, but both panels, and my colleagues and I felt it came within an intermediate group which some people would regard as below average. I certainly do not consider, though, that the speaker should be rated as poor in any way.

At the last moment, just before sending copy to the printers, the manufacturers informed us that they will be particularly attending to improving the crossover unit, which has caused equalisation problems.

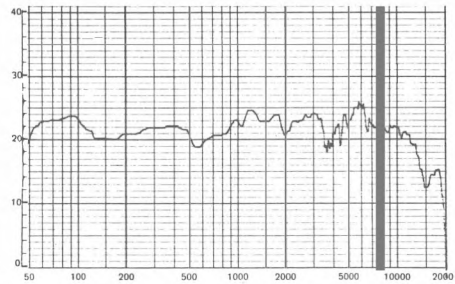


Height	660mm
Width	343mm
Depth	286mm
Weight	15kg
Finishes	Teak/rosewood
Input connections	4mm banana sockets + L/S DIN socket
User adjustments	none
Lowest Impedance (Modulus)	5Ω5kHz/11.5Ω130Hz
Maximum SPL	102dBA
Sensitivity dBA pink noise 2.83V RMS 1m	81dBA
Recommended maximum amp power	60 watts
External volume	64.7 litres
Optimum listening height above base of speaker	400mm
R.R.P. (ex. VAT)	£149.00

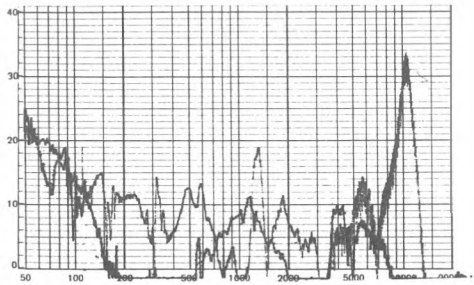
Not normally discounted



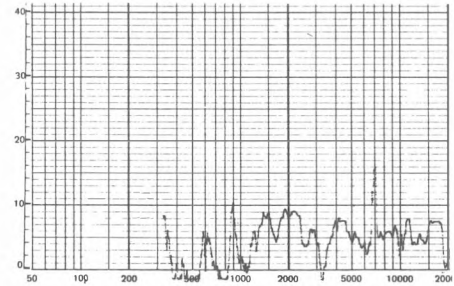
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2-f_1$)

Chartwell PM 400

Chartwell Electro Acoustics Ltd, Alric Avenue, Harlesden, London NW10 8RA. 01-451 1442

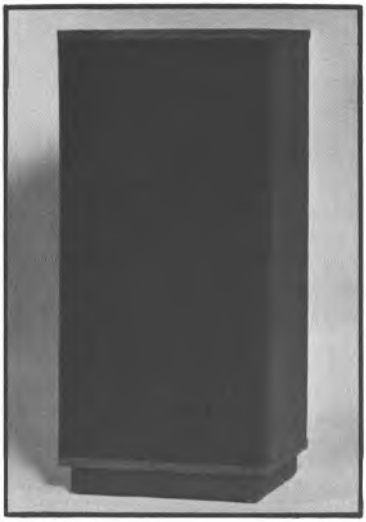
The PM 400 is the largest in the Chartwell range, and has been designed to meet monitoring applications in other than very high output sound pressure level requirement areas. The large bass reflex type cabinet measures 864 × 381 × 330mm deep and weighs 29.5kg. It is available in teak, walnut or rosewood, the last two being more expensive. Input connection is with banana socket in parallel with a loudspeaker DIN alternate socket. The bass is taken care of with a 305mm Chartwell unit, whilst mid frequencies are reproduced with a Chartwell 127mm Bextrene cone unit. A considerably modified Isophon KK10/8 tweeter becomes the source for high frequencies. Each unit is protected by a separate fuse.

The on-axis sine wave chart reveals a pretty flat response from 55Hz to 20kHz, being within 6dB borderlines all the way. A tendency for dips around 1.5kHz and 6kHz is counteracted by a hill in the presence region. Horizontally off axis, frequencies above 11kHz become curtailed a bit, but the general curve is significantly better than average. An acoustic cancellation of 17dB occurred vertically off axis at 3.1kHz, and once again frequencies are curtailed above 11kHz. Harmonic distortion is generally predominantly 3rd harmonic, and at worst measured only 1.4% (60Hz), but higher up was substantially lower. Unfortunately the Isophon tweeter produced horrific distortion (2nd harmonic) at 10kHz amounting to some 12%, which seems most unfortunate, but is only likely to be heard by very young listeners. The 3rd order distortion was generally very low, the worst being only 0.6%. At 1kHz the modulus of impedance dropped to only 5 ohms, and this impedance is repeated unfortunately from 3kHz upwards, and thus the loudspeaker might present quite a difficult load to below average amplifiers. The electrical phase errors, however, are minimal, but if you want full power from this loudspeaker you must make sure that your amplifier will deliver adequate power in to 4 ohms, in which case it would be satisfactory. At 105dBA, bass frequencies commenced coming out of the squawker, and thus sounded very dirty, but this level is of course extremely loud. An output of 83.5dBA weighted was achieved from our standard pink noise source (86dB unweighted). Although the manufacturers state that the loudspeaker can be used with 250W capable amplifiers, I cannot see any point in using one of more than 100W rating because of the audible deterioration above this level.

The classical panel heard slight mid-frequency coloration, and thought that high frequencies were up slightly as a plateau (pen chart confirms). The entire panel liked this speaker very much, finding its sound quality open, solid and with a good overall response. Bass frequencies appeared more extended towards the low end, and the system lacked the upper bass boom so audible in many other larger systems. Three panel members noted high frequency distortion, which I attribute to the 10kHz problem previously referred to. The panel considered the loudspeaker an excellent buy, and it seemed to perform well at relatively high listening levels.

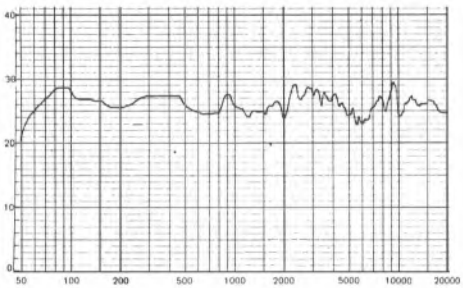
Some members of the pop panel found the high frequencies rather edgy and raspy. The speaker was particularly liked, though, by pop recording engineers. The entire pop panel noted the HF shelf up, and also slight middle-frequency coloration, but appreciated the speaker's good qualities very much indeed.

Since both panels confirmed our own high opinion of this system, it can be warmly recommended, and seems good value for money. It will certainly be loud enough for the average high quality amplifier, and should establish itself as one of the better loudspeakers on the market. I wish, however, that the manufacturers could do something about the Isophon tweeter distortion, even if this seems as if I am asking for the lily to be gilded. Once, again, a fine loudspeaker, made by a comparatively small company, whose distribution is rapidly expanding.

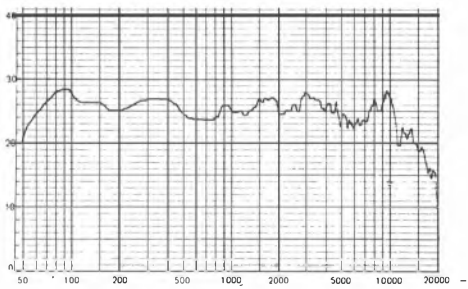


Height	864mm
Width	381mm
Depth	330mm
Weight	29.5kg
Finishes	Teak/walnut/rosewood
Input connections	4mm banana socket + L/S DIN socket
User adjustments	none
Lowest Impedance (Modulus)	4.5Ω10kHz/5Ω1kHz
Maximum SPL	105dBA
Sensitivity dBA pink noise 2.83V RMS 1m	83.5dBA
Recommended maximum amp power	100 watts
External volume	108.6 litres
Optimum listening height above base of speaker	630mm
R.R.P. (ex. VAT)	£257.00

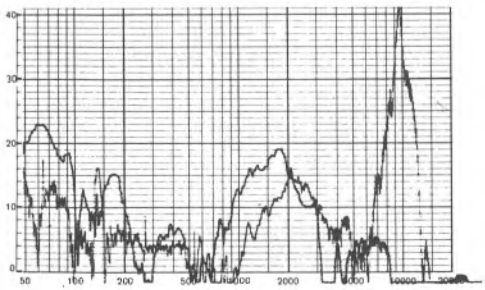
Not normally discounted



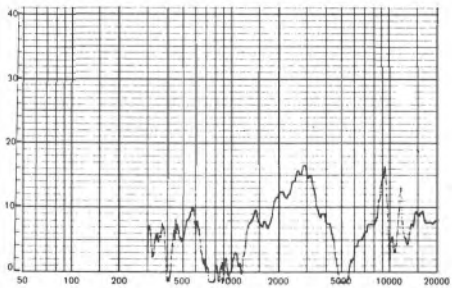
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2-f_1$)

Dansk A25

Plustronics Ltd, Hempstalls Lane, Newcastle, Staffs ST5 0SW. 0782 615131

This two-unit system is incorporated in a cabinet 500 × 250 × 250mm deep, weighing 8.75kg. No user adjustments are provided, and connections are via a captive lead terminating in a L/S DIN plug. The system is designed to be mounted on the front edge of a shelf, and teak or black finishes are available.

In the anechoic chamber, the pen chart recording of the axial sine wave response showed it to be within borderlines of 8dB from 60Hz to 20kHz, but some significant trends were noted. A 3dB shelf up was noted between 600Hz and 1.5kHz, in addition to a 3dB hump at 100Hz. We also noted a 3dB hump between 8 and 10kHz, which then fell off to −3dB at 15kHz. Horizontally off axis, a 9dB dip occurred at 2kHz with an additional dip of 10dB at 4kHz. Above 6kHz, the response rolled off fairly rapidly to −7dB at 10kHz, and −14dB at 15kHz. Vertically off axis, a 5dB dip at 3kHz was noted, but in general, the response was rather better, the EHF still falling off noticeably. We noticed predominantly third harmonic distortion in the bass, but it was always at a pretty low level. Second harmonic peaked 1.4% at 500Hz. IM distortion was always better than 0.6%, and this is very good for a budget loudspeaker. The impedance drops to 4.5 ohms modulus at 100Hz, which is fairly reasonable. The electrical phase measured within reasonably fine tolerances. This system was slightly above average sensitivity, our test noise signal producing an output of 85dBA weighted at one metre (87dB unweighted). A remarkable 107dBA was reached in our power test, at which level the sound became what can only be described as extremely harsh and unpleasant. Considering that we were peaking around 100W at this point, this is really pretty good for an inexpensive system.

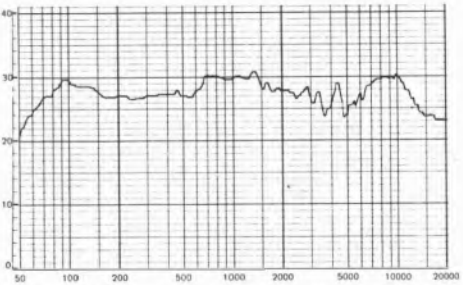
The panel stated that this speaker produced rather a tube tunnel-like effect in the mid-frequency region. Mid-frequency coloration was also noted, together with a general upper mid boost. Piano music reproduced with considerable coloration and was not liked at all. EHF was stated by several to be well down, and this is confirmed by the off axis pen charts.

Our mono 'in house' tests also showed extreme top to be rather muffled, although high frequencies were reasonably bright. Strangely, this speaker sounded better with a little treble boost on the pre-amplifier, but too much over emphasised the HF region. Low-bass frequencies seemed down, but on axis coloration seemed to improve somewhat. This speaker was quite clearly not rejected by the listening panels, but on the other hand, no-one really enthused about it. Considering its modest price however, it has done fairly well, but I feel that it is a typical example of a product missing the mark because others more expensive sound considerably better.

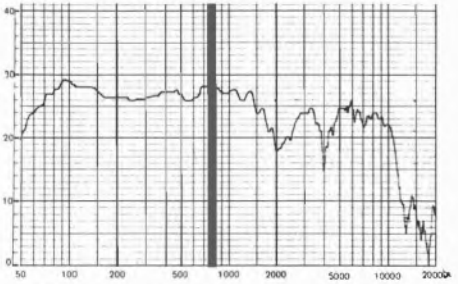
If your budget is severely limited then you may not be disappointed with this loudspeaker, but I suggest that you bear in mind that you will have to live with the sound for possibly several years, and so perhaps you should try to re-budget so that you can spend rather more on your speakers.

Height	500mm
Width	250mm
Depth	250mm
Weight	8.75kg
Finishes	Teak/black
Input connections	Captive lead to L/S DIN plug
User adjustments	none
Lowest Impedance (Modulus)	4.5Ω150Hz/6Ω12kHz
Maximum SPL	107dBA
Sensitivity dBA pink noise 2.83V RMS 1m	85dBA
Recommended maximum amp power	50 watts
External volume	45.6 litres
Optimum listening height above base of speaker	370mm
R.R.P. (ex. VAT)	£88.06

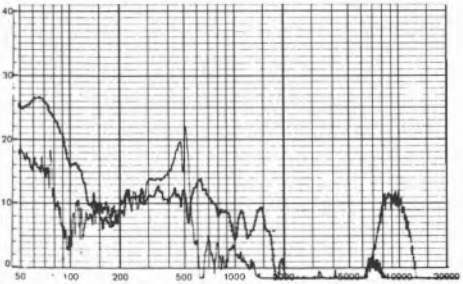
Not normally discounted



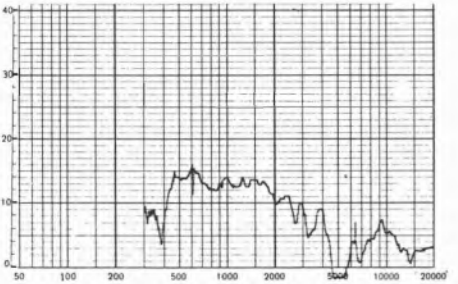
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2 - f_1$)

Electrovoice Interface A

AEL Electronics Ltd, 91 Ewell Road, Surbiton, Surrey KT6 6AH. 01-399 0966

A three-unit system, which is delivered complete with a special electronic equaliser designed to tailor the frequency response when inserted into the break points immediately prior to the main amplifier in a receiver or hi-fi set up. The cabinet, measuring 560 × 360 × 200mm deep and weighing 12.5kg is available in teak finish. The equaliser control unit has three positions, and whilst position 1 appeared to produce too bright a sound, position 2 was rather lacking in top, and the third position sounded very muffled. The equaliser also cuts rumble below 50Hz to avoid undue cone excursions. The loudspeaker incorporates both backward and forward facing HF units, thus giving the top end a more omni-directional characteristic than average. We tested the system on a shelf, which we found necessary to enhance the bass a little. Input connection is with screw terminals. Two extra terminals are provided, which are normally short circuited, but are intended to allow a sensing adaptor (available at extra cost) to cut the output to the tweeter if the input level to the system is advanced too much.

The anechoic chamber on axis sine wave pen chart measured only the direct output from the system, the back radiator's power being literally absorbed by the walls of the chamber. Notwithstanding this, the response measured within 5dB from 70Hz to 18kHz. Below 70 and above 18 the response fell sharply. The equaliser's HF cut switch introduces either a 4dB or 8dB cut at 15kHz. Horizontally off axis, a large dip occurred of 20dB at 2.5kHz. Another dip occurred of 10dB at 3.4kHz. HF fell a bit, but in normal surroundings of course this would be enhanced by the back radiation. Vertically off axis, the cancellation was at 3kHz (18dB) and the response then shelved down about 3dB across the entire HF region (nb. back radiation would reinforce this). Harmonic distortion generally measured better than 1% above 100Hz. The impedance dropped to 5 ohms modulus at 200Hz, but was otherwise satisfactory. Electrical phase varied from +30° to −45°. The sensitivity was slightly higher than average, a weighted output of 85dBA (87dB unweighted) being reached from our standard source.

In the power output test, bass frequencies deteriorated very noticeably when the output reached 103dBA, and so I can see little advantage in using more than a 50W amplifier for this speaker for wide range material.

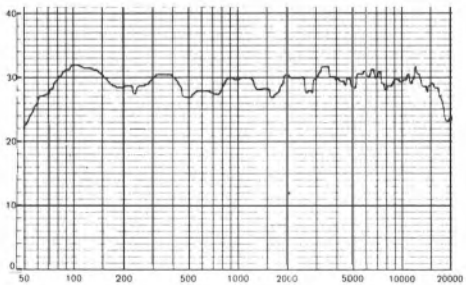
The classical music panel found that too much top was being added by the backward facing tweeter, and for most listeners the treble end improved with a small degree of HF cut (position 2). An MF suck-out was suspected, and some coloration noted, although this was not really serious. The loudspeaker lacked deep bass. The sound quality was said to be clear, relatively clean but toppy in position 1. The entire panel would have liked the ability to control the output energy from the backward facing tweeters. The stereo positioning was sometimes said to be fuzzy, which was obviously due to the backward facing radiator. The classical music panel found the sound rather exciting on pop music.

The pop music panel varied considerably in their findings. Some liked the HF openness and clarity, whilst others found it excessively toppy. Position 2 unfortunately took the treble down too much for them. The bass end seemed to be slightly lacking, and the speaker in general had fairly low coloration.

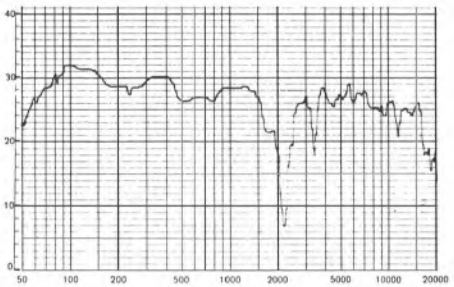
This was not an easy system to assess, and its performance varied dramatically with position. Since at times panel members liked its sound very much it would only be fair to recommend that you listen to it if you think you may like its properties. As it is pretty expensive, and has much competition, I cannot really say that it is other than moderate value for money. Some panel members clearly did not like its HF properties, and you may be irritated too. Definitely listen in your own home before purchase.

Height	560mm
Width	360mm
Depth	200mm
Weight	12.5kg
Finishes	Teak
Input connections	Screw terminals
User adjustments	HF
Lowest Impedance (Modulus)	5Ω200Hz/7.5Ω60Hz
Maximum SPL	103dBA
Sensitivity dBA pink noise 2.83V RMS 1m	85dBA
Recommended maximum amp power	50 watts
External volume	40.3 litres
Optimum listening height above base of speaker	310mm
R.R.P. (ex. VAT)	£287.50

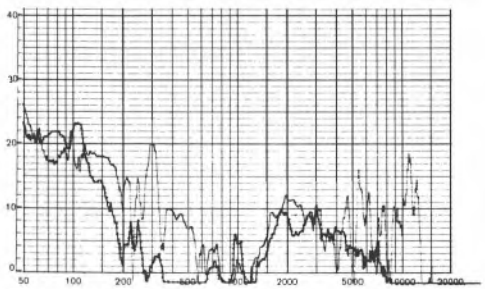
Occasionally discounted



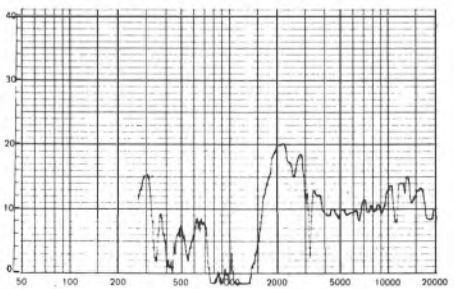
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2-f_1$)

Exact Acoustics RH4

Exact Acoustics Ltd, Factory 3, 164 High Street, Barnet, Herts. 01-449 8286

Designed by Boothroyd-Stuart and Partners, this consists of a four-unit system in a cabinet measuring 622 x 254 x 254mm. It weighs 10kg, and is available at the moment in only one special finish: brown Nextel—a paint made by 3M consisting of Neoprene balls in suspension. The surface can be cleaned with a wet cloth and is not susceptible to burnishing. The makers claim that the paint will actually wear away sooner than develop a shine, and unfortunately, during our tests, it did begin to wear and peel off slightly. Banana sockets in parallel with an LS DIN are provided for interconnection. A 200mm Bextrene cone unit with a 38mm pole is provided for bass, and mid range is catered for by a 76mm sealed unit, whilst a 25mm hard domed pressure tweeter looks after the general high frequency end. An extra 19mm plastic domed super tweeter is provided for EHF. The speaker is designed for plinth mounting (plinth provided at no extra cost) which raises the speaker approximately 150mm above the floor level.

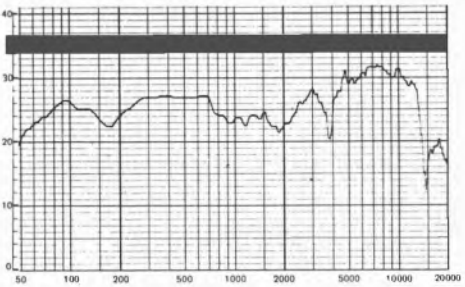
From 55Hz to around 1kHz the response remained within 5dB borderlines, but unfortunately, in the presence region and general high frequency end, the sine wave on axis measured response showed appreciable peaks and valleys (see pen chart). The general tendency was to an appreciable HF shelf rising to a peak of 7dB at 7kHz. Therefore, the response must be regarded as rather unsatisfactory. Off axis horizontally, low and mid HF were approximately flat, but 10kHz still remained about 5dB up. Vertically off axis, a 10dB suck-out occurred at 3.5kHz and the curve was again somewhat irregular, particularly at the high end. Some second harmonic distortion was noticed in the bass region peaking at 7% between 70Hz and 100Hz. Several second harmonic spikes occurred at HF at around 1%. Third harmonic distortion always measured significantly below the second harmonic. IM distortion usually measured around 1%. Above 2kHz, the impedance modulus drops to 5 ohms or lower, reaching a null at 3kHz of only 4 ohms. This might well present a slight strain on amplifiers whose power rating is lowered into 4 ohms. Above 100Hz the electrical phase was held within fairly close limits but the usual phase variations occurred at LF. The speaker had average sensitivity, our standard pink noise signal giving an output of 84dBA weighted, 86dB unweighted. At 103dBA in our power test, mid frequencies began to crack noticeably. I recommend that amplifiers of up to 60W rating should be satisfactory with this system and such amplifiers would enable peak levels of 102dBA to be achieved. This of course is loud. The system is fused with a 2.5 amp quick blow type, in the hope that sustained high frequency peaks would blow the fuse rather than the tweeters.

The classical listening panel found the reproduction bright, clear and smooth despite the pen chart indications. It was classed as musical, but did possess slight bass boominess and some 'ONG' coloration. Two panel members queried the accuracy of the stereo image. Some comments of a nasal sound being heard on vocal were made. The bass end sounded slightly muddy on some programme material. Whilst the classical panel liked this loudspeaker, our pop music panel quite clearly did not, finding the bass end boomy and yet lacking somehow. They clearly heard the lower HF and upper HF response anomalies. The presence region seemed down and yet the sound quality was hard and brittle. Several panel members commented that the EHF region seemed down and this was clearly caused by the mid HF being up in proportion.

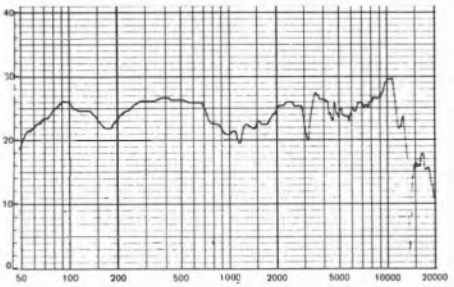
Considering the comments of both the panels, it is clear that this loudspeaker can only be recommended with caution. However, you may well like it if you appreciate a very bright HF and you are prepared to accept the response anomalies. It seems that it cannot be recommended for pop music reproduction, but lovers of classical music are advised to hear it before purchase. Considering it is a four-unit system, the price seems reasonable. If you like it, this could be regarded as rather average value for money.

Height	622mm
Width	254mm
Depth	254mm
Weight	10kg
Finishes	Brown Nextel
Input connections	4mm banana socket + L/S DIN socket
User adjustments	none
Lowest Impedance (Modulus)	4Ω3kHz/6Ω400Hz
Maximum SPL	103dBA
Sensitivity dBA pink noise 2.83V RMS 1m	84dBA
Recommended maximum amp power	60 watts
External volume	40.1 litres
Optimum listening height above base of speaker	490mm
R.R.P. (ex. VAT) including price of stands	£235.00

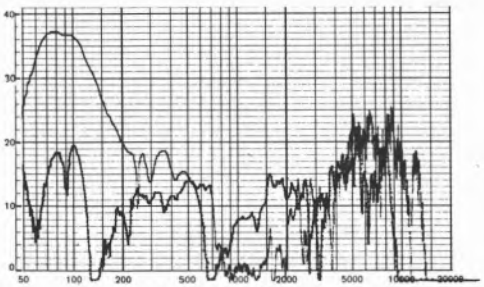
Not normally discounted



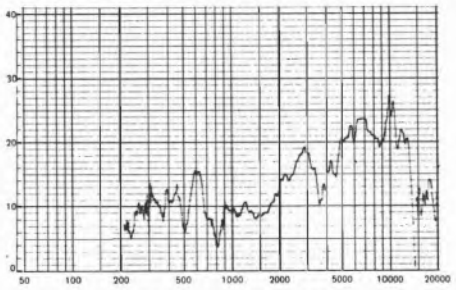
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2 - f_1$)

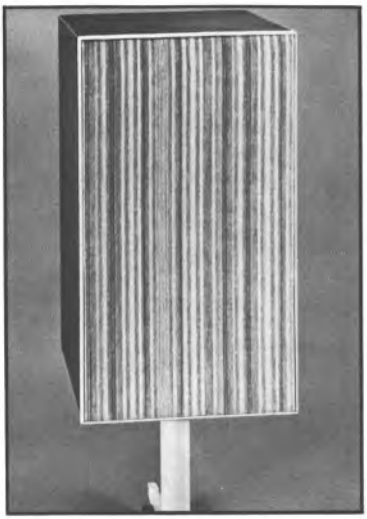
Ferrograph Monitor S1

Wilmot Breeden Electronics Ltd, Durban Road, South Bersted, Bognor Regis PO22 9RL. 02433 25811

This three-unit system is housed in a bass reflex cabinet constructed of polyester-faced high-density chipboard. Its dimensions are 603 × 350 × 440mm and input connection is with push lock terminals. Weight is 25kg. The only finish available is American walnut. The front grille is gender-style folkweave fabric. The bass unit is a 330 x 241mm elliptical, the mid range is 102mm and the high frequency unit is 25mm. A stand can be supplied and the speaker is intended for plinth mounting.

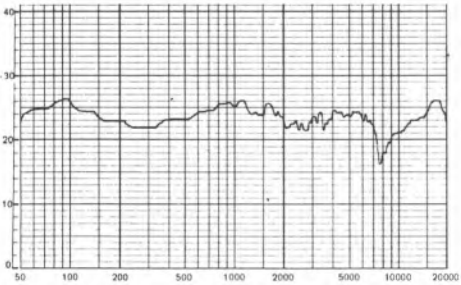
The sine wave on-axis response measured within borderlines of 6dB from 45Hz to 20kHz with the exception of a clear suck-out of some 6dB at 7.8kHz. Off axis horizontally, high frequencies become noticeably curtailed, e.g. 15kHz becomes −10dB at only 30° away from the normal line. Vertically off axis, the main suck-out worsens and goes down in frequency slightly and also EHF falls off noticeably. Harmonic distortion was better than 1% at all frequencies above 70Hz. IM distortion measured particularly well—usually around 0.3%. The impedance throughout measured below 7.5 ohms, falling to 5 ohms at 100Hz and 500Hz. The electrical phase response was within very close tolerances and whilst this is generally a fairly low impedance speaker, it should match most amplifiers pretty well. The sensitivity was slightly below average, our pink noise test signal developing 80.5dBA weighted SPL (83dB unweighted). On the power output test the quality deteriorated dramatically at 103dBA. The manufacturers' peak power rating of 100W would appear to be reasonable and at this input level the system would be pretty loud.

The classical panel did not like this loudspeaker very much, finding the quality rather cotton-woolly and colored, and also spiky at high frequencies. Speech and singers became lispy and nasal. The speaker appeared to lack presence. The entire panel regarded the sound as muffled and also lacking in clarity. In our own in-house tests my colleagues and I also found that the coloration was rather high and the treble end again seemed spiky. Wide range material seemed to come over with rather a hard yet muffled quality, appearing pinched at times. A professional classical musician rated the loudspeaker particularly poor and thought it to be a fairly small one. He found the sound rather boring and did not rate the speaker well on any track. I am afraid that this loudspeaker was a very great disappointment to both the classical panel members and myself and once again I suggest that the manufacturers should study its performance on well engineered master tapes. Unfortunately at its high price I must regard it as relatively poor value for money and therefore I cannot recommend it for normal purposes at all. It seems so unfortunate that a company, so long established in making domestic and professional tape recorders, have designed a loudspeaker which does not seem to be musical. I hope that later products from this company will turn out appreciably better than this one has.

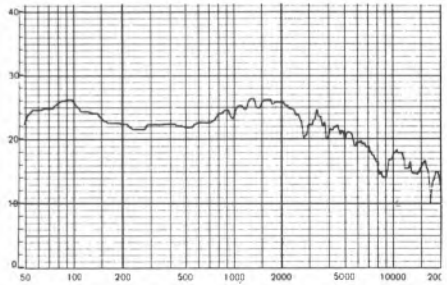


Height	603mm
Width	350mm
Depth	440mm
Weight	25kg
Finishes	American walnut
Input connections	Push lock terminals
User adjustments	none
Lowest Impedance (Modulus)	5Ω90Hz/5Ω500Hz
Maximum SPL	103dBA
Sensitivity dBA pink noise 2.83V RMS 1m	80.5dBA
Recommended maximum amp power	100 watts
External volume	92.8 litres
Optimum listening height above base of speaker	370mm
R.R.P. (ex. VAT)	£228.00

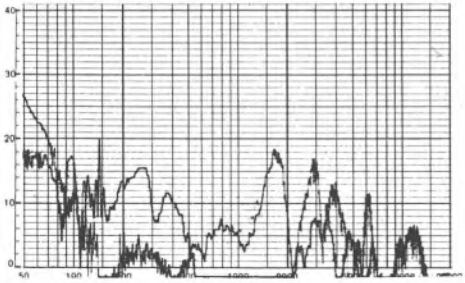
Normally substantially discounted



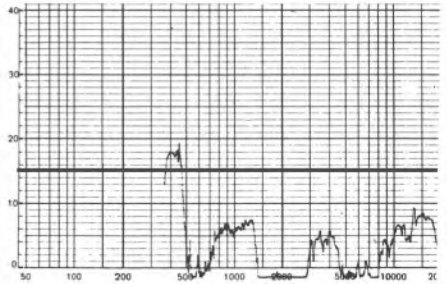
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2 - f_1$)

Goodmans Achromat 100

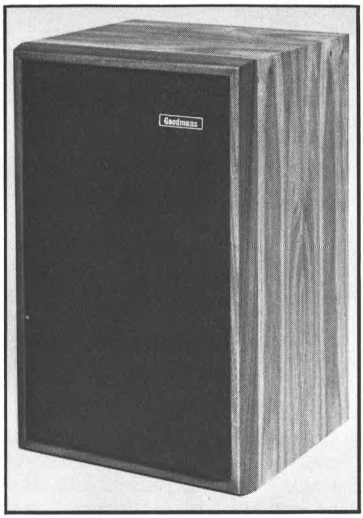
Goodmans Loudspeakers Ltd, Downley Road, Havant, Hants. 07012 6344

Goodmans are one of the longest established loudspeaker manufacturers in Europe, and their latest Achromat range is aimed at a mass market. The Achromat 100 is the smallest Goodmans model in this survey, the cabinet measuring 350 × 212 × 233mm deep and weighing 6kg. Teak and walnut finishes are available and input connection is with banana sockets in parallel with a loudspeaker DIN type. The two unit system has a 175mm long throw drive unit for bass, a 38mm dome type tweeter is provided for treble, having an aluminium voice coil and viscous damping. The system is designed essentially for shelf mounting so that bass frequencies are enhanced a little, and it is recommended that the loudspeakers should be placed against a wall.

The on axis sine wave response showed it to be within bounds of 7dB from 80Hz to 20kHz, but unfortunately, the general balance of the system favoured the high frequency end with a noticeable dip in the lower presence region. Shelf mounting would of course help lower mid and upper bass, but this could tend to cause an apparent mid frequency loss. Off axis horizontally, the response was essentially similar up to 8kHz, but above this, EHF was curtailed somewhat, falling particularly steeply above 12kHz. Off axis vertically, an acoustic cancellation of 10dB occurred at 4kHz, high frequencies also being curtailed above 10kHz. Distortion was primarily second harmonic and reached some 8% at 100Hz. Even at 700Hz, a distortion peak of 8% was noticed, and in general second harmonic distortion was none too good throughout the audio range. IM distortion peaked rather high at 3% around 620Hz and 1kHz, but was generally around 0.7%, again higher than average. The impedance curve showed the loudspeaker to be generally rather higher than optimum, since the minimum was 8 ohms, and greater sensitivity could have been achieved if this had been designed to be 6 ohms for example. Electrical phase response was excellent. The sensitivity was significantly below average, only 90dBA weighted being reached from our standard input pink noise source (82dB unweighted). At 99dBA on our power output test, the bass unit became fairly uncontrolled and began to hit the end stop and sounded uncomfortable. I recommend amplifiers of maximum rating 50W for classical programme and 30W for pop programme for use with this speaker, and even the former will give an output level from the speaker of only around 96dBA, which will be sufficiently loud for a normal programme, but will not accommodate loud transients satisfactorily on wide range material.

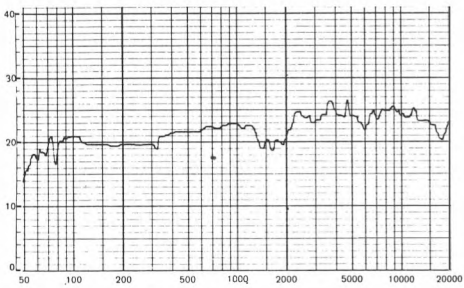
The classical panel found low frequencies to be generally lacking both in response and body, which is hardly surprising for such a small unit. The anticipated subjective hole in the middle was evident, and high frequencies became hard and metallic. Upper strings sounded thin and fizzy, and some panel members noted that bass and high frequencies seemed detached somewhat. The treble end in fact was regarded as rather fierce and became tiring to some panel members. Applause sounded cardboardy. Some EHF loss was distinctly heard off axis. The sound quality deteriorated noticeably when the speaker was driven fairly loud but within its power rating. The panel did not particularly enthuse over this loudspeaker and stated that the frequency balance was obviously wrong. However, considering its modest price, the loudspeaker was certainly not condemned. Coloration seemed to be reasonably low, since no specific comments were made about it and I personally thought it was reasonable in this respect. In our in-house tests we found that the loudspeaker sounded better in a more reverberant room, which clearly helped middle frequencies.

At its price, then, the loudspeaker should be considered, but I regard it as vital to have a demonstration on good quality material before you purchase it. Its hard metallic top may even attract you to it, but I suggest you look at some of the competition and compare it. It is obviously pretty good value for money, but cannot be regarded as a best buy.

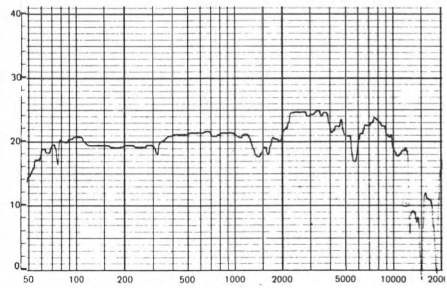


Height	350mm
Width	212mm
Depth	233mm
Weight	6kg
Finishes	Teak/walnut
Input connections	4mm banana socket + L/S DIN socket
User adjustments	none
Lowest Impedance (Modulus)	8Ω200Hz/8Ω20kHz
Maximum SPL	99dBA
Sensitivity dBA pink noise 2.83V RMS 1m	80dBA
Recommended maximum amp power	*30 watts
External volume	17.3 litres
Optimum listening height above base of speaker	260mm
R.R.P. (ex. VAT)	£98.52

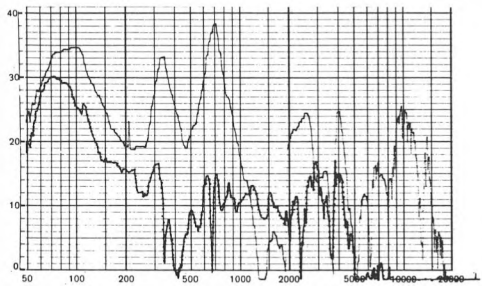
Normally substantially discounted



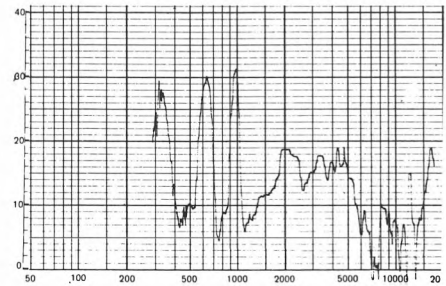
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2-f_1$)

Goodmans Achromat 250

Goodmans Loudspeakers Ltd, Downley Road, Havant, Hants. 07012 6344

The Achromat 250 is a two unit system in a cabinet measuring 540 × 272 × 278mm deep, and weighing 11.6kg. It is available in teak or walnut finishes and inter connection is made with banana sockets in parallel with a loudspeaker DIN type. The bass unit is a 203mm long throw type whilst the HF tweeter is a 25mm viscous damped dome radiator. The system is designed for stand mounting away from a wall or corner.

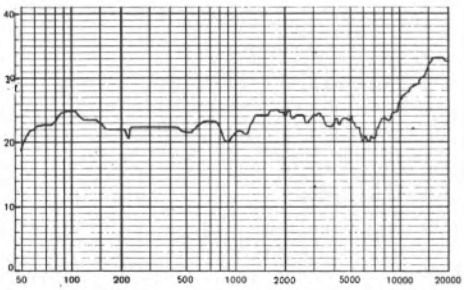
The on axis sine wave anechoic chamber pen charts showed a reasonably flat response from 50Hz to 10kHz but there was an alarming rise at EHF, peaking some 11dB at 16kHz! Although the response at MF and HF was held within reasonable limits, the frequency balance again was wrong; presence frequencies being at the top end of the limit, whilst middle frequencies tended to be at the bottom end, this tendency always introducing an apparent presence forwardness. Off axis horizontally, the response looks rather better, although still up comparatively at EHF. Vertically off axis, an acoustic cancellation of 12dB occurred at 3.8kHz and the top rise was still marked, but reduced to about 7dB. Very bad second harmonic distortion was noted around 75Hz amounting to 12%. This did not reduce to 1% until 250Hz was reached. Third harmonic distortion reached a peak of 1.4% at 1kHz. Between 2kHz and 3kHz the IM distortion peaked at nearly 2% which was clearly noticeable. In general, the impedance measured well, but at EHF it reduced to below 5 ohms and surely the manufacturers should bring in some attenuation here to increase the impedance and reduce the absurdly high output. The electrical phase response was quite reasonable. The system had below average sensitivity, 81.5dBA being reached from our standard noise signal (85dB unweighted). At 101dBA, bass frequencies deteriorated dramatically and very high frequencies literally became painful. The manufacturers rated the loudspeaker for use with between 25W and 60W amplifiers and this would seem to be reasonable, providing you are not wanting to reproduce very high frequency sounds continually.

The classical panel found the high frequency end really piercing, and most instruments having appreciably high frequency harmonics sounded very thin. Some 'AR' coloration was noted and through the programme the treble end was found to be hard and fizzy. The treble end problem gave rise to continued remarks concerning an apparent mid frequency suck-out, which did not really exist. Several comments were made that tape hiss became considerably exaggerated, and so if these loudspeakers are used to reproduce gramophone records that have an above average surface noise, they could sound rather objectionable. Bass frequencies reproduced quite clearly, and the sound of a bass drum was liked, despite very bad harmonic distortion measurements. The entire panel gave this speaker rather low marks because of its grossly exaggerated EHF, which greatly affected the entire overall sound balance, obviously giving the subjective lack of mid band frequencies.

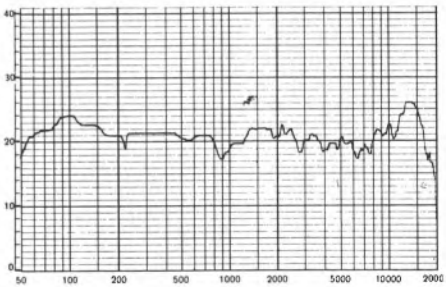
The serious EHF problem and the rather high second harmonic distortion, unfortunately forces me to withhold any recommendation for purchase of this system. Sometimes inexperienced listeners can be attracted to an extremely toppy loudspeaker when it is demonstrated, imagining that the more top that it reproduced, the better is the loudspeaker. I am afraid that this model is a clear example of a system with excessive top and I suggest that its only purpose is to bring some life into extremely dull recordings or alternatively, to bring back some life in reproduction to people who are losing their hearing at EHF. I found that at times very high harmonics literally hurt my ears and in the internal tests cries of 'ouch' were all too frequent. Surely this ridiculous response anomaly should be corrected by the manufacturers.

Height	540mm
Width	272mm
Depth	278mm
Weight	11.6kg
Finishes	Teak/walnut
Input connections	4mm banana sockets + L/S DIN socket
User adjustments	none
Lowest Impedance (Modulus)	4.5Ω15kHz/5.5Ω100Hz
Maximum SPL	101dBA
Sensitivity dBA pink noise 2.83V RMS 1m	81.5dBA
Recommended maximum amp power	60 watts
External volume	40.8 litres
Optimum listening height above base of speaker	370mm
R.R.P. (ex. VAT)	£144.70

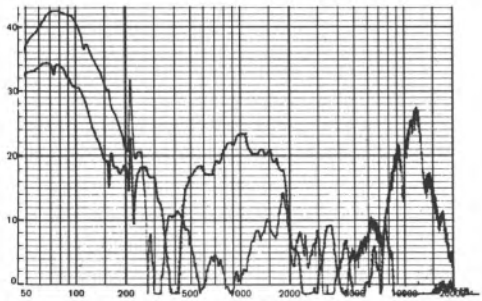
Normally substantially discounted



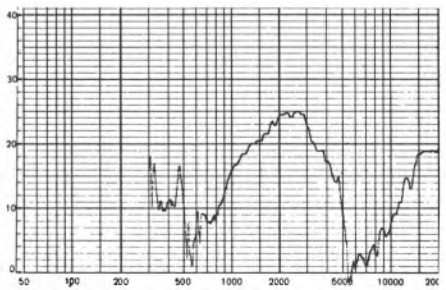
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2 - f_1$)

Goodmans Achromat 400

Goodmans Loudspeakers Ltd, Downley Road, Havant, Hants. 07012 6344

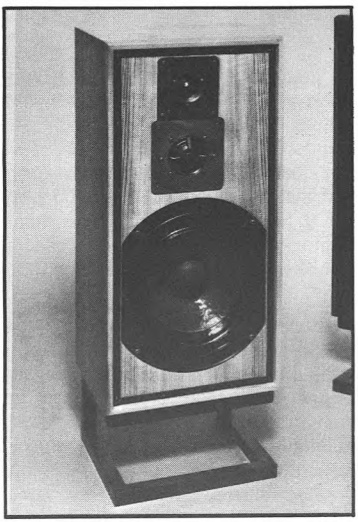
This is the largest Goodmans loudspeaker in this survey, with a cabinet measuring 657 × 327 × 292mm deep. It weighs 16.5kg, and is available in teak, walnut or white finishes. Input connections are on banana sockets in parallel with a loudspeaker DIN type. This system has three units and is designed for stand mounting away from a wall. It employs a 260mm long throw bass drive unit and viscous damped domed radiators for mid and top. CS3 stands allow either vertical or 5 degree back tilting positions, and are available at extra cost.

In the anechoic chamber, the sine wave on axis response appeared to reveal a slight bass rise around 100Hz, and a clear upper mid and presence suck-out reaching a maximum cut of 5dB. High frequencies were fairly flat, but unfortunately, EHF rose to an unwelcome +5dB shelf from 12 to 20kHz. Horizontally off axis, the response looked rather better, the EHF rise on axis becoming more or less flat. Vertically off axis, an additional acoustic cancellation occurred at 5kHz with a null around 12dB, but EHF still appeared to be up quite considerably. 10% second harmonic distortion was noted at 50Hz, but this reduced to 1% distortion by 200Hz. At middle and presence frequencies second harmonic was pretty low, but third harmonic reaches nearly 2% at 700Hz. At other frequencies, the distortion was below 1% generally. IM distortion peaked 1% at 500Hz ($f_1 = 200$Hz), but at other frequencies was generally around 0.5% or so. The impedance curve looked quite reasonable, the lowest point being 5.5 ohm modulus at 100Hz. The electrical phase response was satisfactory. An output of 80.5dBA SPL was reached (84dB unweighted) from our standard pink noise input source, and thus this speaker was rather below average sensitivity. Our power output test produced a maximum level of 103dBA, at which point mid frequencies became extremely dirty, and some cracking was noticed. The manufacturers state that the loudspeaker is suitable for use with amplifiers of up to 75W rating, and this would allow peak levels of 99dBA to be achieved, loud, but not extremely loud.

The classical panel said that the loudspeakers lacked mid, tenors, for example, receding quite noticeably. A tendency towards boom and tizz was apparent. Speech was sibilant and toppy, and the treble tinny and metallic. The panel rated this a rather average loudspeaker.

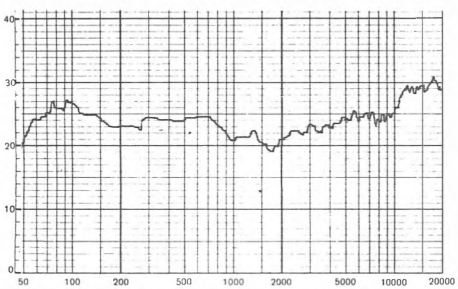
The pop music panel regarded it as below average, the entire panel finding the total HF region excessive. Strings and many other instruments sounded thin, and the loudspeaker subjectively lacked mid. The bass end was generally liked, and seemed fairly extended. Coloration was significantly better than average. They said that the system had reasonable potential if the response errors were corrected. Tape hiss became rather predominant, and the top end sounded spiky.

Unfortunately, our internal listening test and both panel tests came very much to the same conclusion, in that they condemned the loudspeaker's incorrect balance between mid and top. It seems incomprehensible that Goodmans should introduce a clear EHF boost when surely any frequency correction away from the norm should be done by tone controls on a pre-amplifier rather than in the loudspeaker system itself. Matters would not be so bad if the manufacturers incorporated an EHF roll off switch so that those who want to break wine glasses could do so at will, whereas other users could create a better balanced sound. Although the speaker scored average to low marks, its lack of coloration and potential might well make it recommendable if the EHF problem is attended to, for its price is very reasonable for a three unit system in an average sized cabinet. In its present state I am afraid that I cannot recommend it, but perhaps one day I will be able to regard it as reasonable value for money.

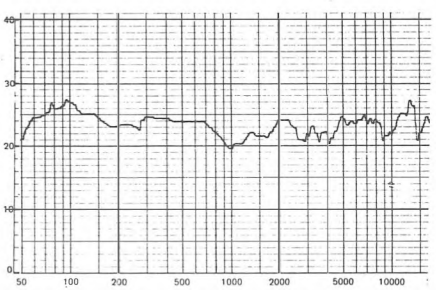


Height	657mm
Width	327mm
Depth	292mm
Weight	16.5kg
Finishes	Teak/walnut/white
Input connections	4mm banana sockets + L/S DIN socket
User adjustments	none
Lowest Impedance (Modulus)	5.5Ω100Hz/6.5Ω2.5kHz
Maximum SPL	103dBA
Sensitivity dBA pink noise 2.83V RMS 1m	80.5dBA
Recommended maximum amp power	75 watts
External volume	62.7 litres
Optimum listening height above base of speaker	480mm
R.R.P. (ex. VAT)	£190.50

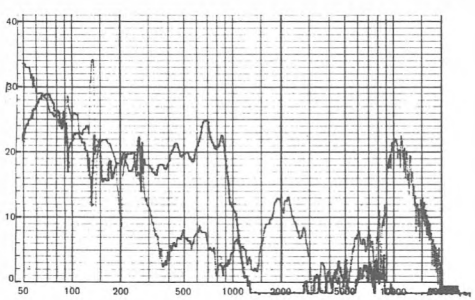
Normally substantially discounted



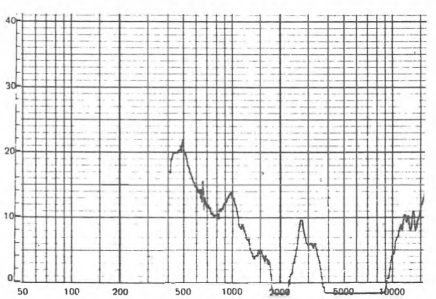
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2-f_1$)

IMF Monitor TLS 80

IMF Ltd, Westbourne Street, High Wycombe, Bucks.
0494 35166

A fairly expensive system designed to give high quality monitoring for professional and domestic applications. It is incorporated in a large cabinet measuring 978 × 457 × 406mm deep. It is one of the heaviest speakers in the survey, weighing 34kg, and includes four units, the woofer being enclosed in a transmission line. The woofer is a 300 × 210mm elliptical flat polystyrene diaphragm KEF B139, and the mid-frequency unit is a modified KEF B110 152mm Bextrene cone contained in a separate transmission line, full of damping material. The presence region is transduced by a Rola Celestion HF1300 44mm diaphragm unit, whilst EHF comes from a Coles 19mm chemical dome super tweeter. A three position perspective controls mid frequencies, as a shelf from 400Hz to 4kHz, adjustments being in 2dB steps up and down from nominally flat. Only walnut finish is available, and the loudspeakers are supplied in mirror matched pairs with input connections using 4mm banana sockets. The system is, of course, floor mounting, and it is recommended that the speakers are placed away from a wall, and particularly away from a corner.

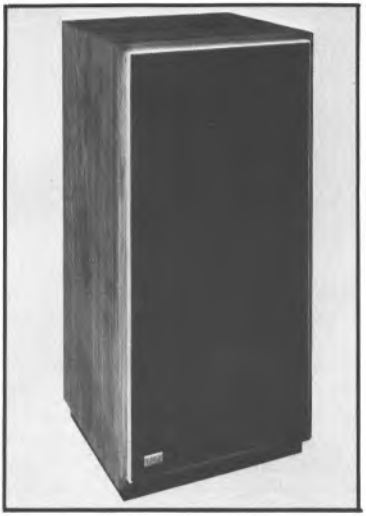
In the anechoic chamber, the lower bass region actually measured up by some 6dB compared with the upper bass region, although the response was generally ±3dB from 40Hz to 13kHz. A sharp +5dB peak occurred at 14kHz. Off axis horizontally, a slight HF loss and a noticeable EHF loss occurred, whereas vertically, two acoustic suck-outs became apparent of some 25dB at 3.5kHz and 15dB at 12kHz. Some acoustic cancellation is to be expected vertically in a four unit system, but surely these dips are excessive. Between 100Hz and 20kHz the distortion was generally better than 1%, but at 50Hz the second harmonic rose to 3.3%, which would, however, not really be audible at such a low frequency. IM distortion was usually around 1%.

Generally, the impedance of the speaker was rather lower than average, being around 7.5 ohms, but three dips of 5 ohms or lower were detected at 650Hz, 3.5kHz and between 18 and 20kHz. Between 80Hz and 20kHz the electrical phase characteristic was held within very tight limits, which is creditable. The system had about average sensitivity, our standard noise source giving an output of 83dBA weighted SPL (85.5dB unweighted). At 105dBA on our power output test, the quality became rather nasty, and so I recommend that amplifiers of up to 100 watts are best suited to drive the system. The manufacturers recommend a marginally lower powered amplifier, and perhaps a 60W one might be safer.

Both panels listened to the speaker in the normal flat position of the perspective control, and found it generally to be lacking at mid frequencies, and also in the upper-bass region. Low bass frequencies literally shook the floor, and at first impressed listeners, but later the panels queried whether it was a little excessive there. Bass frequencies seemed to the panels to be underdamped, and several comments of boom and tizz were made. The system appeared to lack life and sounded a little unreal. Solo piano was reproduced with some 'awing' coloration. The classical panel gave it rather an average mark.

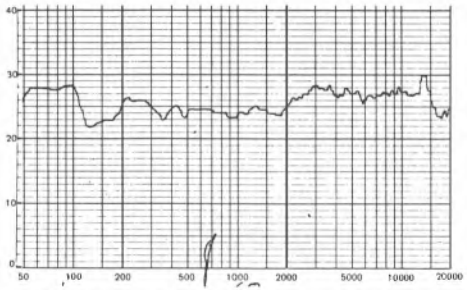
The pop panel downed the speaker more, finding very low frequencies to be subjectively boosted, and suggested that there might be a resonance somewhere. Again, several commented that the upper bass region was lacking. High frequencies sounded thin and a little hard.

Notwithstanding the criticisms of the pop panel, I personally liked the quality on pop music quite a lot, and if the manufacturers had labelled the perspective control more suitably (the boost position should have been regarded as nominally flat), the loudspeaker might well have done a little better, although perhaps the upper bass loss would have been more apparent. At its rather high price, and in many situations cumbersome dimensions, I feel that I cannot recommend the system with much enthusiasm, although undoubtedly, many pop music enthusiasts will appreciate its fascinating characteristics, particularly at the bass end. I should add that although it generally had rather lower than expected marks, one or two panel members marked it slightly above average, and so it is certainly worth hearing.

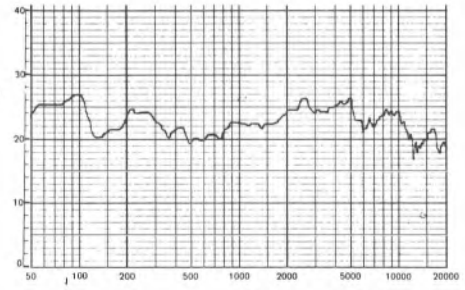


Height	978mm
Width	457mm
Depth	406mm
Weight	34kg
Finishes	Walnut
Input connections	4mm banana terminals
User adjustments	MF
Lowest Impedance (Modulus)	4Ω18kHz/4.75Ω3.5kHz
Maximum SPL	105dBA
Sensitivity dBA pink noise 2.83V RMS 1m	83dBA
Recommended maximum amp power	100 watts
External volume	181.46 litres
Optimum listening height above base of speaker	630mm
R.R.P. (ex. VAT)	£399.38

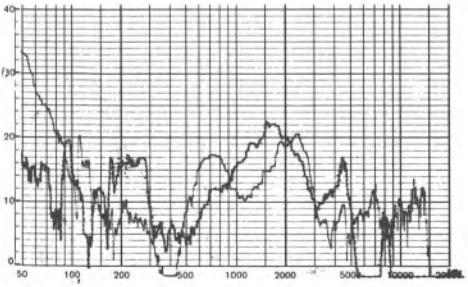
Not normally discounted



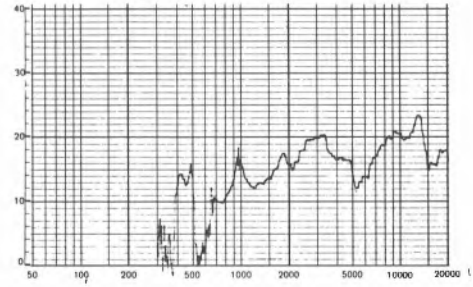
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2-f_1$)

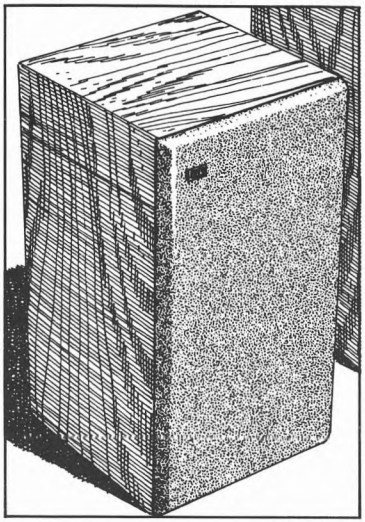
JBL Decade L26

C E Hammond & Co Ltd, 111 Chertsey Road, Byfleet, Surrey KT14 7LA. Byfleet 41131

The L26 is the cheapest of the three JBL loudspeakers in this survey. It is capable of giving an exceptionally high output, and is designed to be very efficient and powerful. The cabinet measures 610 × 320 × 340mm deep, and is available in oak with brown, blue or orange fronts. It is a two unit system, the bass and mid end being reproduced from a 250mm driver having a 50mm copper voice coil. High frequencies come from a 36mm direct drive unit, consisting of a small cone with a dome in its centre, and damped by a ring of dense foam. A potentiometer adjusts the relative output from the tweeter by ±3dB ref nominal. Input connection is with push lock terminals, and each speaker weighs 19kg. It is designed for shelf mounting, and is recommended for a front edge position.

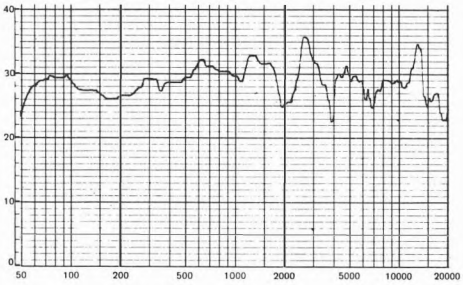
The sine wave on axis pen chart showed a slight lack of upper bass, and peaks in the mid at 600Hz and 1.3kHz (averaging +3.5dB). In the lower presence region, the response is very variable, finally ending up with an EHF peak of +5.5dB at 13.5kHz. The response was thus extremely peaky and contributed to some of the unpleasant sound quality heard. Off axis horizontally, the curve was generally flatter, but vertically the acoustic cancellation reached a somewhat alarming null of 16dB at around 2kHz, which is hardly acceptable. However, the curve was otherwise rather smoother than that taken on axis. Second harmonic distortion above 70Hz always measured better than 1% third harmonic, actually being commendably below 0.3% generally, with the exception of a rise to 0.7% at 70Hz. IM distortion measured better than 0.5% throughout. The impedance was satisfactory, except between 4kHz and 7kHz, where it fell to approximately 5 ohms modulus, and this was a trifle on the low side. From 100Hz upwards the electrical phase response was very good. The system was well above average sensitivity, our test noise signal producing a weighted output of 87.5dBA SPL (89.5dB unweighted). At the staggeringly high output level of 112dBA, mid frequencies became very confused, but so did my colleagues who were covering their ears at the time! Even a 35W domestic amplifier will give a 103dBA peak from the loudspeaker, but it seems that higher power amplifiers will probably be satisfactory, provided the energy is not too continuous at peak level.

The pop panel found upper mid frequencies very badly colored, and lower HF was heard to be very peaky and over bright. The reproduced sound was shrieky, shrill and hard. Bass frequencies seemed severely lacking at normal levels, but improved when the speaker was driven harder. The top end became very edgy and unpleasant when loud, and I personally found it most oppressive, particularly when approaching high levels. The pop panel disliked this speaker considerably, but surprisingly found its quality preferable to the more expensive JBL Horizon. It scored low marks, and can only be recommended for reproducing very loud levels where quantity is a higher priority than quality. It will obviously be popular for use in discos and for pop music PA systems, but we note that its price has increased by nearly 50% over the last year, and this seems to be a ridiculous exaggeration of the dollar/pound situation. I must admit that I was somewhat surprised that the pop panel disliked this speaker so much, but it was heard on a wide range of material by a very experienced group of people. I cannot recommend it under any circumstances for normal domestic listening, and certainly not for the reproduction of classical music.

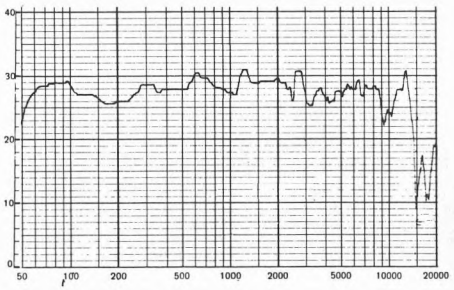


Height	610mm
Width	320mm
Depth	340mm
Weight	19kg
Finishes	Oak with brown/blue or orange grilles
Input connections	Push lock terminals
User adjustments	HF
Lowest Impedance (Modulus)	5Ω5kHz/6.5Ω150Hz
Maximum SPL	112dBA
Sensitivity dBA pink noise 2.83V RMS 1m	87.5dBA
Recommended maximum amp power	35 watts
External volume	66.3 litres
Optimum listening height above base of speaker	480mm
R.R.P. (ex. VAT)	£354.00

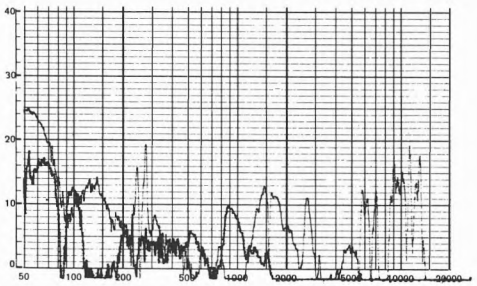
Occasionally discounted



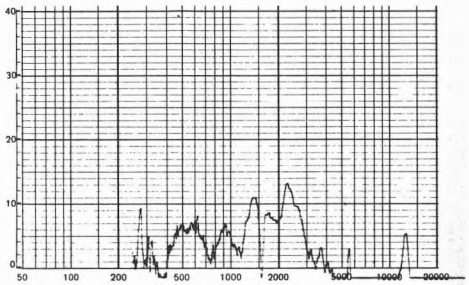
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2-f_1$)

JBL Horizon L166

C E Hammond & Co Ltd, 111 Chertsey Road, Byfleet, Surrey KT14 7LA. Byfleet 41131

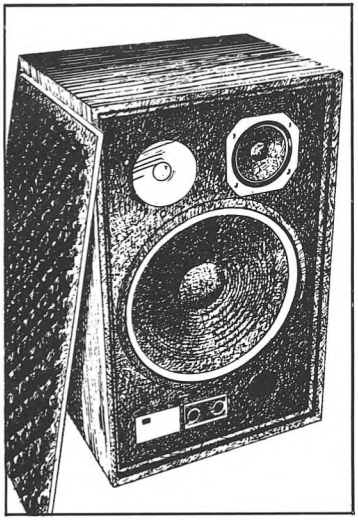
This very expensive JBL loudspeaker, again designed specifically for the reproduction of music at very high sound pressure levels, has a cabinet measuring 597 × 362 × 330mm deep, which weighs approximately 25kg. The 3 unit system incorporates a 300mm LF unit, having a 76mm edge wound copper ribbon voice coil, a 130mm mid unit with a 22mm copper voice coil, and a 25mm high frequency hemispherical radiator. The tweeter, model JBL 066 is a hard dome impregnated fabric/aluminium type, vapour deposition being used for impregnating the aluminium. The walnut cabinet is provided with controls on mid and treble units, allowing variations up and down from nominally flat. Push lock terminals are provided for input connections. We did not like the appearance of the front grille, but this is claimed to be very acoustically transparent. The loudspeaker is designed for front edge shelf mounting.

In the anechoic chamber, the on axis sine wave response showed the bass to be somewhat humpy, but in general, it was down on the average response elsewhere. The bass end, however, would be helped by shelf mounting, but please refer to the listening panel comments later in this review where we noted that bass response improved at higher listening levels. The remainder of the response showed continuous variations up and down, ending in a final peak of 6dB at 20kHz. Off axis horizontally, the treble end is lowered by a few dB, but the 20kHz peak disappears. A 15dB acoustic cancellation occurred vertically off axis at 1.5kHz, but elsewhere the HF is also lowered generally. Both mid and HF adjustments alter the response from +3dB to −3dB from their relevant units. Apart from a 1.6% second harmonic peak at 800Hz, elsewhere this distortion was below 1%. At 200Hz there was a third harmonic peak of 2.5%, but again elsewhere it was satisfactory. The IM distortion was substantially below 0.5% throughout. The impedance was very satisfactory with the sole exception of a dip to approximately 5 ohms modulus at 8kHz, and the electrical phase response was ± 30° from 100Hz upwards. The system was very sensitive, an output of 88dBA being reached from our standard pink noise source (90dB unweighted). At 109dBA middle frequencies became very dirty, but this is a pretty deafening level in domestic surroundings, which would be reached, incidentally, when a 100W amplifier was feeding the system at near its peak level. The system is designed to withstand very high average energy levels and is thus suitable for smaller disco and pop PA purposes (but do not forget you will need a very deep pocket).

The classical listening panel found middle frequencies to be very colored and up subjectively. The presence region appeared hard and excessive. The sound was said to be boxy and honky with brittle lower top. Cellos sounded cardboardy. Some panel members stated that the HF end was clear and some indeed quite liked it, although others disliked it fairly strongly.

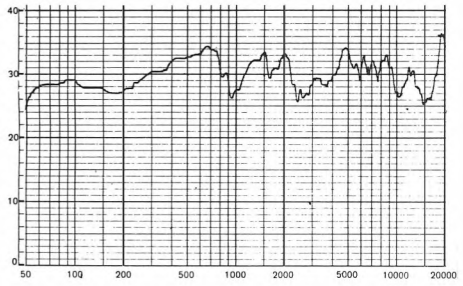
The pop panel marked the speaker very low indeed and clearly disliked it intensely. Continued comments referring to upper mid and lower top coloration were made, and the sound had rather too much presence. (nb. Controls used in flat positions.) Strings were strident, and the bass lacked body and did not seem to crawl out of the cabinet at normal levels, sounding over damped. At higher levels, however, the bass end did come to life more. Further comments of 'thin and boxy', 'scratchy and hard', and 'thump missing from bass drum' are typical of the panel's findings. One professional London studio engineer well used to monitoring pop music actually marked the loudspeaker as low as he could.

These findings are all most unfortunate for a loudspeaker designed to reproduce pop material pretty well, but it is only fair to add that I myself felt that although the sound was very different from that which one might expect to hear, it was nevertheless plausible. At times it was exciting when loud, but I feel that balancing with such a loudspeaker could be highly dangerous, since it might lead to incorrect proportions of sound being taped. Unless you want a very loud colored speaker, I cannot recommend it at its exceptionally high cost, which makes it extremely poor value for money. Please see additional comments on high level output loudspeakers in the conclusions section.

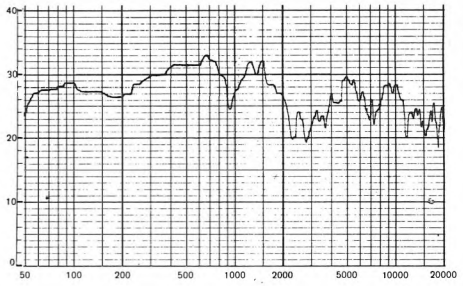


Height	597mm
Width	362mm
Depth	330mm
Weight	25kg
Finishes	Walnut
Input connections	Push lock terminals
User adjustments	HF & MF
Lowest Impedance (Modulus)	5Ω8kHz/6.5Ω150Hz
Maximum SPL	109dBA
Sensitivity dBA pink noise 2.83V RMS 1m	88dBA
Recommended maximum amp power	100 watts
External volume	71.3 litres
Optimum listening height above base of speaker	485mm
R.R.P. (ex. VAT)	£660.00

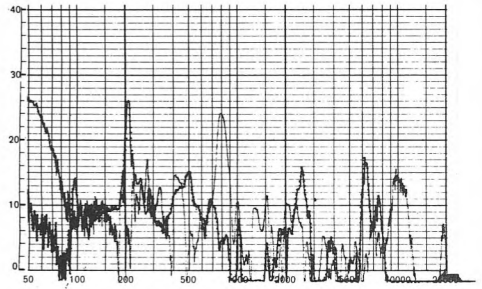
Occasionally discounted



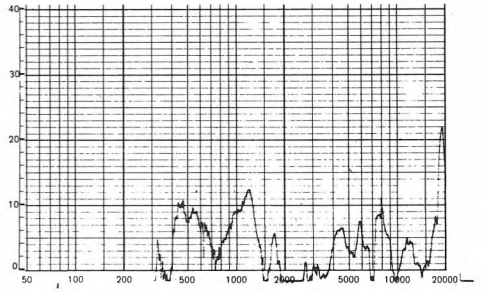
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2 - f_1$)

JR 149

Tape Music Distributors Ltd, 114 Ashley Road, St Albans, Herts AL1 5JR. St Albans 64337

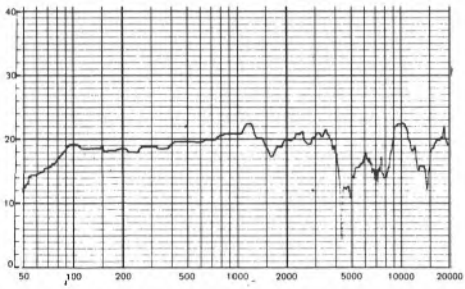
It is a pleasure to see Jim Rogers back in the loudspeaker business. His new company's speakers are being marketed by Tape Music Distributors. The JR 149 is highly unconventional in that it is round vertically and has an aluminium main outer cabinet with a metal strut to stabilise the structure. The system incorporates a KEF 130mm B110 bass unit and a KEF 20mm T27 dome tweeter. The crossover is very carefully designed to suck-out a peak in the B110 and the rigidity of the cabinet is claimed to reduce considerably cabinet vibration and radiation. Both units radiate directly from the front of the cylinder (see photo). The bottom and top of the cylinder are covered by round sections of wood and the overall finish is available in aluminium, teak or walnut veneers. Special finishes are also available in rosewood, yew, black or white acrylic, red or green leather inlay or gold plate at extra cost. A captive lead is supplied having a DIN plug at its end. The crossover is external and is covered by a metal plate with a centre fixing screw, the plate also revealing the wire input connections, and the cable can also be stored underneath this plate. The diameter is 230mm and the height 370mm. The total weight is 5.5kg.

The anechoic chamber sine wave on-axis response is none too smooth, showing a slight dip at 1.6kHz, and marked dips at 4.2kHz and 14.5kHz. The bass end is reasonably flat down to 90Hz, below which the response falls fairly rapidly. The horizontal off-axis response shows similar dips, but vertically off axis the general HF performance is very slightly curtailed, and the dips change around a little. 3% 2nd harmonic distortion was measured at 100Hz. Above this frequency, only two peaks at around 1% were noted at 420Hz and 2.2kHz. The 3rd harmonic distortion was lower generally, but peaked about 1% at 1.5kHz. The swept IM distortion reached a peak of 0.7% at 2.5kHz and 1% at 16kHz. This distortion performance can be considered quite satisfactory. The impedance curve shows a minimum of 6.25 ohms at 10kHz, but generally elsewhere the impedance is well above 8 ohms, and no problems should be experienced feeding the speaker from any reasonable amplifier. At very low bass frequencies the V/I phase swung from −55° to +55° but elsewhere the phase kept between bounds of −30° and +45°. This electrical phase variation was rather wider than average but reasonably acceptable. The loudspeaker was extremely insensitive, only 76dBA output being achieved for a 2.83V input of pink noise. The unweighted output here measured 78dB, again rather poor. The power output available, however, was quite astonishing, considering the poor sensitivity and relatively small size, since 99dBA was reached, but at this level an input equivalent to 200W into 8 ohms was necessary at peaks! The power test is only about a minute and a half long and surprisingly no damage resulted, and with the manufacturer's permission I can safely recommend the use of a 60W-capable amplifier with the speakers for classical music, but not more than a 35W-capable amplifier for pop music, since the latter's duty cycle is such as to produce higher average output power levels, which could harm the speaker after a while. At 99dBA, incidentally, bass frequencies began to come out of the T27 tweeter causing significant audible deterioration. With a 60W amplifier you should be able to achieve approximately 94dBA from this system, which thus becomes suitable for fairly small rooms, but inadequate for reproducing loud music in medium sized rooms.

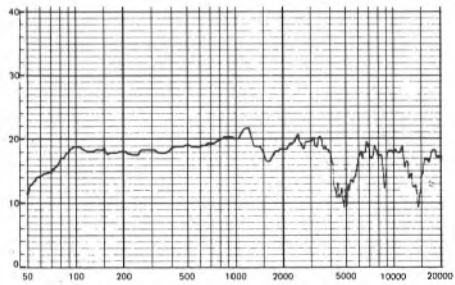
Some slight presence suck-out was heard subjectively, and the speaker seemed to produce bass somewhat artificially and with some boxiness. Bass frequencies sounded a little muddy and slight MF coloration was audible. Low bass frequencies seemed to be missing, but the general overall response received several praiseworthy comments from the panel. The panel was very impressed with this speaker and marked it pretty high. The speaker can be recommended as a good buy for the reproduction of classical music, but its bass limitation and inefficiency unfortunately do not recommend it for the reproduction of pop music. The most unusual design will clearly please some and put others off, but nevertheless I feel the system can be recommended with the reservations mentioned, particularly bearing in mind the small size and fairly modest price.

Height	370mm
Dia	230mm
Weight	5.5kg
Finishes	Teak/walnut/aluminium/rosewood/yew
	black leather inlay, gold plated
Input connections	Captive lead with L/S DIN plug
User adjustments	none
Lowest Impedance (Modulus)	6Ω10kHz/9.5Ω175Hz
Maximum SPL	99dBA
Sensitivity dBA pink noise 2.83V RMS 1m	76dBA
Recommended maximum amp power	*35 watts
External volume	15.37 litres
Optimum listening height above base of speaker	300mm
R.R.P. (ex. VAT)	£110.00

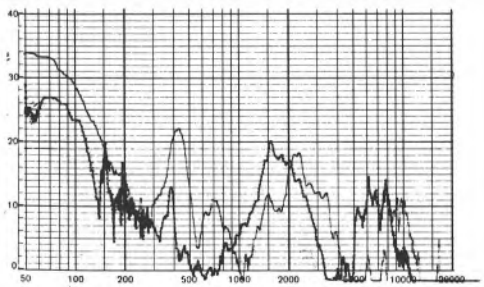
Occasionally discounted



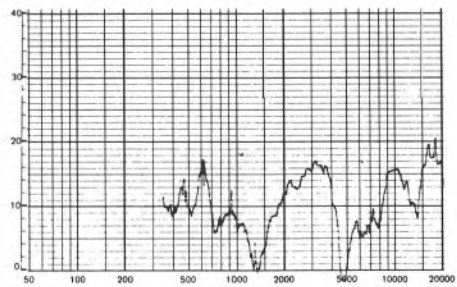
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2 - f_1$)

KEF 103

KEF Electronics Ltd, Tovil, Maidstone, Kent ME15 6QP.
0622 57258

The KEF 103 is basically an infinite baffle loaded two-speaker system incorporated in a cabinet measuring 500 × 330 × 226mm deep. It weighs 19.5kg and teak or walnut finishes are available. There is no treble adjustment. Banana sockets in parallel with loudspeaker DINs are provided for external connection. The system is designed for plinth mounting, but can also be used on the front edge of a shelf. The units comprise a KEF B200 bass unit and a T52 tweeter matched with a very carefully designed crossover.

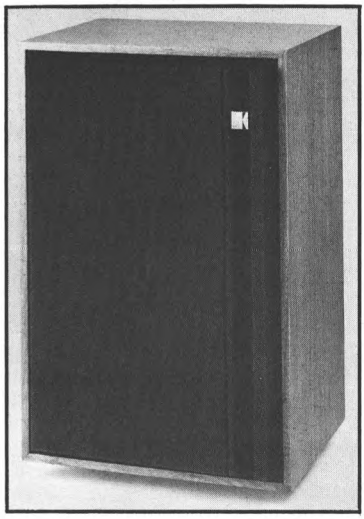
The B200 has a coated Bextrene diaphragm and plasticised PVC cone edge suspension. The front panel speaker mounting can be turned through 90°, allowing the system to be vertically or horizontally mounted.

In the anechoic chamber, our sine wave on-axis pen chart revealed a hump of 4dB at 100Hz, below which the response fell so that it was −3dB from nominal at 55Hz. From 120Hz to 20kHz the response remained within borderlines of 6dB, but we also noticed its general smoothness throughout. Off axis horizontally the response was held close to the on-axis one up to 7kHz, above which it rolled off gently to around 13kHz and then fell sharply, reaching its maximum dip at 16kHz. Vertically off axis, the only dip that occurred was 9dB at 3.8kHz. EHF rolled off, but did not show a dip anywhere near so pronounced as horizontally off axis. At 70Hz, a second harmonic distortion of 4.5% was noted, but this was only slightly noticeable subjectively. Between 150Hz and 5kHz harmonic distortion measured below 0.6%. At 7.5kHz third harmonic distortion of 1.2% was noted, but this of little consequence. IM distortion rose slowly from 2kHz (0.3%) up to 20kHz, where it reached 2%. This is regarded as acceptable. The impedance was generally very satisfactory, but possibly a little on the high side, and more sensitivity could have been gained if it had been lowered slightly. Electrical phase showed variations from 55° to −40°. Unfortunately, the loudspeaker was rather less sensitive than average, an output of only 78.5dBA weighted (82dB unweighted) being reached from our standard pink noise source. The maximum power output measured 102dBA at which point the B200 was cracking up badly. On a typical programme, KEF recommend an amplifier of up to 100W rating, which will be capable of providing an output SPL at 1 metre of approximately 99dBA. This is adequate for normal domestic listening levels even in fairly large rooms, but is inadequate for loud pop, the speaker sensitivity clearly being insufficient for such purposes.

Both panels rated this speaker highly, finding that its general smooth quality was most commendable, but commenting on the slight tendency to boom in the mid bass. The presence region seemed just a little forward, and the treble end appeared just about right. The loudspeaker continually received praise for its smoothness, clarity and cleanness with a good stereo positioning. The pop panel did comment that the lower bass appeared to be lacking, but this is only to be expected from a relatively small speaker. The classical panel found the sound quality extremely good, and it was rated as one of the best in the survey. Occasionally slight mid coloration was noted, and a tendency to boxiness was sometimes remarked upon. There were also one or two comments on bass being a little muddy.

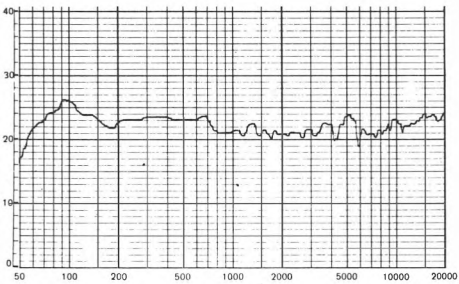
It seems amazing that such a moderately priced loudspeaker has received comparatively little adverse comment from the panels, and my colleagues and I agree with their high opinion of this speaker. I can unhesitatingly recommend it for the reproduction of classical music, and light music in domestic conditions, and I feel that it will give considerable pleasure to its purchasers. For heavy pop, though, the KEF 104 shows its superiority at the bass end.

Highly recommended, then, and exceptionally good value for money, but note the relative inefficiency which requires a higher than average powered amplifier to drive it.

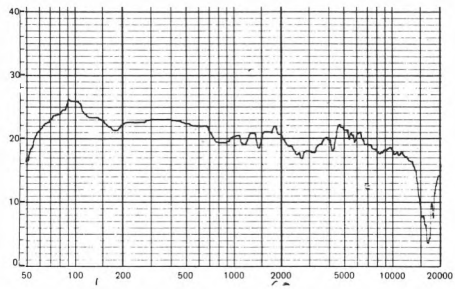


Height	500mm
Width	330mm
Depth	226mm
Weight	19.5kg
Finishes	Walnut/teak
Input connections	4mm banana sockets + L/S DIN socket
User adjustments	none
Lowest Impedance (Modulus)	8.5Ω20kHz/8.7Ω150Hz
Maximum SPL	102dBA
Sensitivity dBA pink noise 2.83V RMS 1m	78.5dBA
Recommended maximum amp power	100 watts
External volume	37.3 litres
Optimum listening height above base of speaker	405mm
R.R.P. (ex. VAT)	£145.00

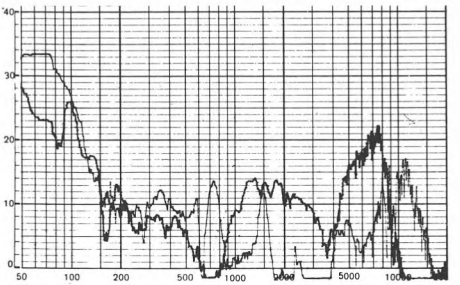
Occasionally discounted



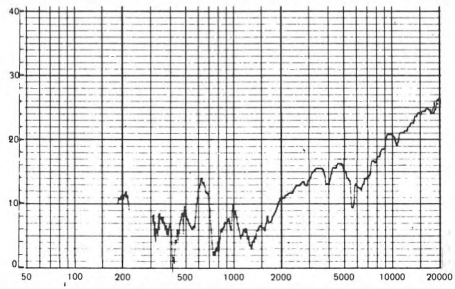
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2-f_1$)

KEF 104 AB

KEF Electronics Ltd, Tovil, Maidstone, Kent ME15 6QP.
0622 57258

The 104 AB is at present the top model in KEF's reference series and is basically a 2-unit system in a cabinet measuring 630 × 330 × 260mm deep and weighing 15.8kg. Cabinet finishes in walnut, teak or white are available and input connection is on banana sockets in parallel with an L/S DIN. An ABR in the form of a BD139 cone reinforces the output of the bass/mid unit below 45Hz, the latter unit being a B200. The tweeter is a KEF T27 (fused) pressure-formed unit and with a Melinex dome having an integrally damped roll surround. A mid control switch allows mid frequencies to be adjusted to ±2dB of nominal. The system is designed for plinth mounting and should not be used too close to a back wall or corner.

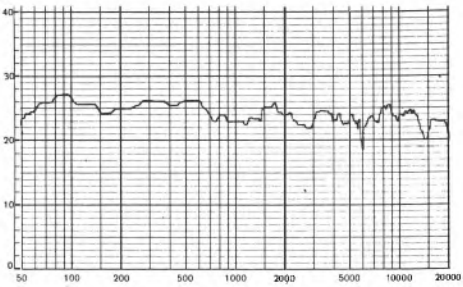
In the anechoic chamber, the bass response was very flat within its own band, measuring with a 4dB borderline from 50Hz to 600Hz. Above this frequency the general trend is to be within a 6dB borderline, generally at a slightly lower level than that at low frequencies, but up to 20kHz. Two troughs were apparent at 6kHz and 15kHz. Off-axis horizontally, two minor dips occurred at 800Hz and 3kHz, and EHF came down a little. A 10dB acoustic cancellation occurred off axis vertically at 3kHz and again the EHF rolled off slightly. 3.4% 2nd harmonic distortion was noted at 70Hz, but this is not regarded as too serious. Above 100Hz, harmonic distortion in general was significantly below 1%. IM distortion always measured below 0.8%. The impedance curve was excellent and gave a minimum modulus of 6 ohms at 10kHz, which should not present problems to amplifiers. However we noticed a 70° electrical phase shift between V and I at 3kHz, which shows that at this frequency there is considerable reactance in the crossover but the modulus at this point was fairly high, so that no significant problems should be caused. The loudspeaker's sensitivity was pretty low, only 78dBA weighted SPL being achieved from our standard input noise source (81.5dB unweighted). In our power test the quality remained good until we were peaking the equivalent of 250W, at which level 102dBA was reached and the sound became very muddy and dirty. I recommend that for normal programmes, amplifiers of up to a 100W rating can be used at whose peak level an output of approximately 98dBA maximum will be given 1 metre away from a single speaker. Whilst this level is pretty loud, spiky transients from brass instruments or opera might well cause an amplifier to clip and it is possible that a higher powered amplifier might be satisfactory on wider dynamic range programmes not having a high average energy content.

The classical music panel liked this loudspeaker very much indeed and found its quality surprisingly close to that from the KEF 103. Two members found the low bass was better but there were a few comments that the coloration was marginally inferior to the 103. Quite clearly, the KEF 104 AB was regarded as one of the best loudspeakers in the entire survey, but it was difficult to choose between the 104 AB and 103. The choice was dependent upon the type of programme heard. The pop panel also commented on slight mid coloration but heard more clearly the extended bass response, which was praised. There was substantially less bass boom than on the 103, and slightly less presence but with good clean and clear HF. Generally, the pop panel preferred this speaker to the 103 and recommended it very strongly indeed. Our in-house listening tests confirm all the above remarks and we found it extremely difficult to choose between the two KEF models.

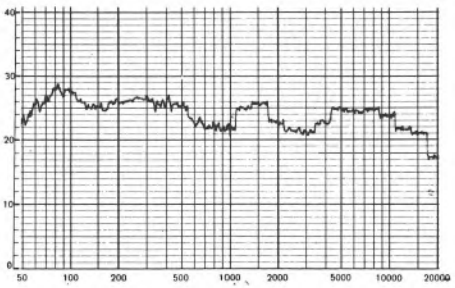
The extended bass response and the general clarity of this loudspeaker makes it one of the top recommendations in this survey, although I must point out that its input sensitivity was just a little disappointing. I can recommend it very strongly indeed for general purpose audio reproduction under domestic conditions and it is a musician's speaker rather than one suitable for high level monitoring, where its sensitivity limitation obviously makes it unsuitable. Notwithstanding its good points, I recommend that you compare it with the somewhat cheaper KEF 103 (see review) but nevertheless, at its price I consider it very good value for money. Please see comments on crossover in Introductory chapter.

Height	630mm
Width	330mm
Depth	260mm
Weight	15.8kg
Finishes	Walnut/teak/white
Input connections	4mm banana terminals + L/S DIN
User adjustments	MF
Lowest Impedance (Modulus)	6Ω10kHz/8.5Ω150Hz
Maximum SPL	102dBA
Sensitivity dBA pink noise 2.83V RMS 1m	78dBA
Recommended maximum amp power	100 watts
External volume	54 litres
Optimum listening height above base of speaker	485mm
R.R.P. (ex. VAT)	£185.00

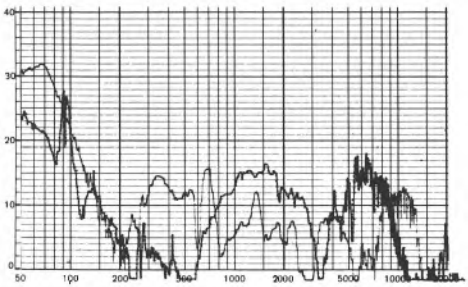
Occasionally discounted



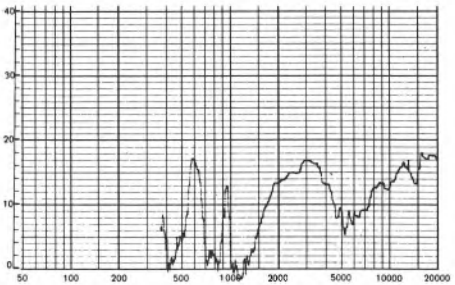
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2-f_1$)

KLH 317

Webland International Ltd, Mirabel House, 117/121
Wandsworth Bridge Road, London SW6. 01-736 0987

This American two-unit system is incorporated in a cabinet weighing 13.5kg and measuring 584 × 305 × 248mm deep. Only walnut finish is available, and screw terminals are provided for input connection. An HF switch having a nominally flat centre position allows for boost or cut by 2.5dB. The tweeter unit is a Peerless 38mm hard dome (Peerless is an associated company of KLH), and the woofer is a 255mm fabric cone, made by KLH. The system is designed for plinth mounting.

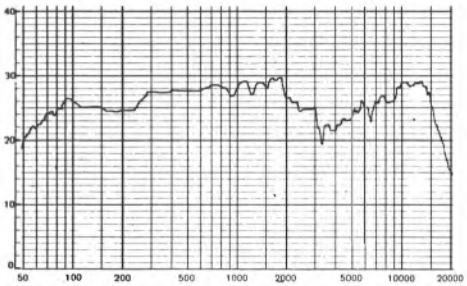
The anechoic chamber sine wave on axis response shows a marked valley in the presence region, reaching a minimum of −7dB (see pen chart). The bass end shelves down throughout by about 2dB, but begins to fall fast below 70Hz. Two hills occur around 1.5kHz, and between 10 and 13kHz,. the latter clearly exaggerating the effect of the presence dip. Horizontally off axis the general shape of the HF region is marginally improved, but the main presence dip is unchanged, and immediately below it a new peak appears at 1.7kHz of some 3.5dB, below which the original hill becomes slightly flattened. Vertically off axis, the presence dip disappears, but is replaced by an acoustic cancellation of 15dB at 2kHz. The high frequency end seems to be marginally flatter. Bass distortion is very low, measuring less than 1% generally. Second harmonic distortion peaks unfortunately at 2.2% at 900Hz, but apart from this above 2kHz the distortion is very low indeed, being below 0.3%. The IM distortion peaks to 1% at 600Hz, but is generally lower. The impedance never drops below 8 ohms, which although satisfactory shows that the speaker's sensitivity could be increased marginally without any detrimental effect on most amplifiers. The electrical phase varies from +30° to −40° over the audio spectrum, which is reasonable. The loudspeaker has average sensitivity, an output of 84dBA weighted (86dB unweighted) being reached from our noise signal. An output of 106dB was reached in the power test, at which level the bass unit was hitting its end stop. It would seem reasonable to use a 50W amplifier, thus allowing weighted peaks of about 101dBA to be given, which is loud.

The pop music panel found this speaker rather boxy and they continually queried the presence region suck-out. Some instruments appeared to recede since they were losing presence, and the general sound quality was rather harsh and hollow. The treble end was bright, exaggerated by the presence suck-out, but notwithstanding the criticisms, this relatively inexpensive loudspeaker scored slightly higher marks than expected. The upper bass was found to be reasonably uncolored, but generally the speaker was heard to be very slightly lacking bass. Bass drums reproduced pretty well.

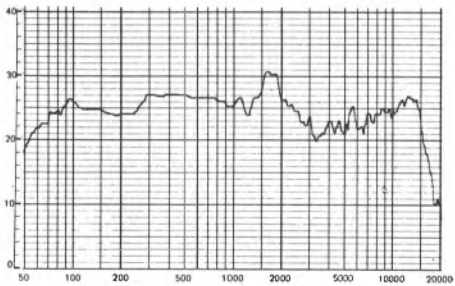
Our in-house listening tests showed string tone to be quite pleasant, although we felt that the presence suck-out was most unfortunate. Both in our internal tests and in the panel tests the speaker generally scored rather average marks. I consider it a borderline case for recommendation, particularly for the reproduction of pop music. The presence dip will of course tend to change the balance of sound, but this may well be an advantage if your room is rather reverberant. I consider the loudspeaker to be pretty good value for money, and since you may well not dislike it, this model should at least be considered if within your price bracket, for it will enable you to obtain a reasonable listening level in even quite large rooms from a fairly moderate amplifier. It seems amazing that this loudspeaker has done rather better than other American loudspeakers costing perhaps three times as much. Despite its response irregularities, no significant comments were made about coloration, and this is creditable.

Height	584mm
Width	305mm
Depth	248mm
Weight	13.5kg
Finishes	Walnut
Input connections	Screw terminals
User adjustments	HF
Lowest Impedance (Modulus)	8Ω150Hz/12.5Ω10kHz
Maximum SPL	106dBA
Sensitivity dBA pink noise 2.83V RMS 1m	84dBA
Recommended maximum amp power	50 watts
External volume	44.1 litres
Optimum listening height above base of speaker	370mm
R.R.P. (ex. VAT)	£130.67

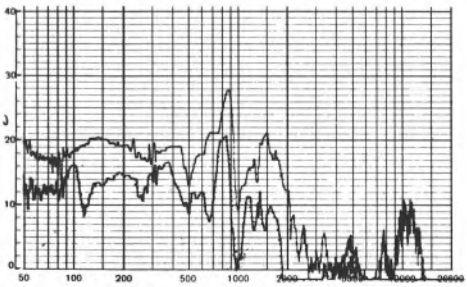
Occasionally discounted



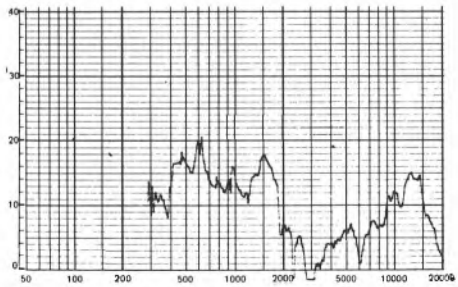
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2-f_1$)

KLH CL4

Webland International Ltd, Mirabel House, 117/121 Wandsworth Bridge Road, London SW6. 01-736 0987

A three-unit system housed in a cabinet measuring 686 × 362 × 330mm deep and weighing 27kg. MF and HF adjustments are provided for increasing or lowering the appropriate energy by ±2dB. The cabinet is available in walnut finish only and input connection is on screw terminals. The system is designed for plinth mounting away from a wall. The bass unit is a 254mm cone type known as Megaflux, in which the manufacturers claim better than average linearity and concentration. The mid-range unit is a 114mm cone type and high frequencies are taken care of by a 25mm low mass dome tweeter.

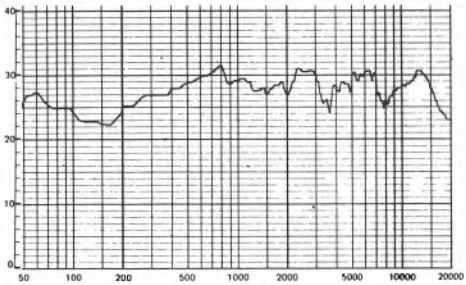
The sine wave on-axis anechoic chamber chart showed a noticeable lack of upper and mid bass, the former being around 5dB down from the average response. At middle and high frequencies the response fell between 7dB borderlines but was in general up rather than down as far as 15kHz, above which frequency the response rolled off. Off axis horizontally, the response was slightly smoother up to 13kHz. At 3.8kHz, the vertical off-axis response showed a large acoustic cancellation of 15dB and two other smaller dips also appeared. From 70Hz to 20kHz the harmonic distortion components were all below 0.4% which is excellent. IM distortion was again below 0.4% with the exception of a small peak to 0.7% at 5kHz. The impedance overall was fairly high, the minimum modulus measuring 7 ohms between 5kHz and 10kHz. The electrical phase angle variation was held within exceptionally tight limits from 80Hz to 20kHz. Perhaps the manufacturers could consider a slight lowering of impedance to increase the sensitivity marginally, for this should not be detrimental to amplifier performance. Notwithstanding this, though, the sensitivity was above average, our pink noise test level producing a weighted output of 86dBA (87dB unweighted). On our power test some apparent squaring off of vocal peaks occurred when the level reached 105dBA (very loud). It would seem that a 60W amplifier will be more than adequate to drive this loudspeaker very loud and even a modest amplifier will produce more than adequate volume in a domestic environment.

The classical music panel rated this speaker rather low and one member stated that a recording of a Steinway piano sounded rather like an understrung upright. Some mid coloration and boxiness were evident. The treble end was pinched and fizzy and the bass end clearly weak. String instruments were thin and strident, and voices were nasal and tubey. Another member commented that the piano gave an aluminium hammer sound. Organ music reproduced with very poor pedal notes. Upper mid was also hard and some body was lacking. The hollow and yet rusty and edgy sound unfortunately rather condemns this loudspeaker for classical music. Surprisingly two panel members actually heard the loudspeaker's fall-off above 15kHz. The pop panel more strongly disliked the speaker, finding the high frequency end very brittle and harsh. Middle frequencies sounded boxy and chest voices generally sounded rather retarded. Bass notes were considered over-damped, thin and hollow. Brass instruments were very screechy and vocals were sibilant to an excessive degree. A few members, though, suggested that the treble end was fairly clean. Bass frequencies seemed to become strident when the speaker was driven harder.

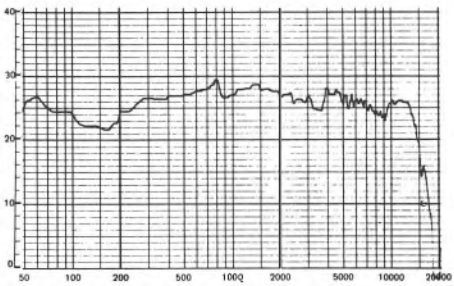
Since both panels and our internal listening tests all found the loudspeaker to be lacking in bass, and with a very hard and peaky treble, I cannot recommend the system for domestic use. In any case it is on the expensive side for a relatively small system and quite obviously the dollar/pound situation is against this speaker. Its only merit is its high efficiency and the high output level obtainable from even a modest amplifier.

Height	686mm
Width	362mm
Depth	330mm
Weight	27kg
Finishes	Walnut
Input connections	Screw
User adjustments	HF & MF
Lowest Impedance (Modulus)	7Ω9kHz/9Ω100Hz
Maximum SPL	105dBA
Sensitivity dBA pink noise 2.83V RMS 1m	86dBA
Recommended maximum amp power	60 watts
External volume	82 litres
Optimum listening height above base of speaker	420mm
R.R.P. (ex. VAT)	£320.00

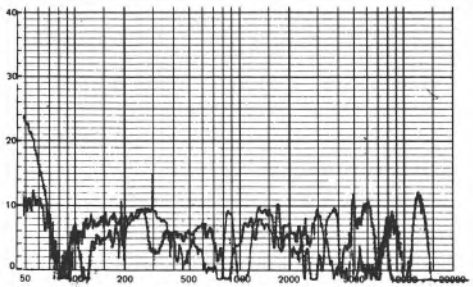
Occasionally discounted



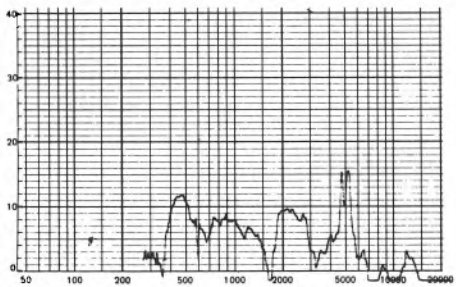
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2 - f_1$)

LNB Para-Lab Super

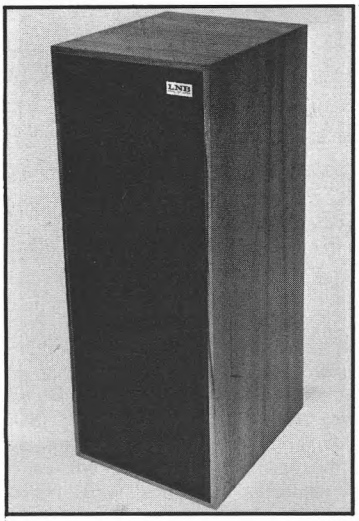
LNB Ltd, Duke Street, Loughborough, Leics. 0509 61229

This modest-sized two-speaker system is designed to be mounted on a shelf, either horizontally or vertically. The cabinet measures 597 × 228 × 260mm deep, and weighs 8kg. Teak or walnut finish is available as standard, with Jacobean oak available to special order. Screw terminals are provided for connections. A T27 KEF tweeter (25mm dome) is complemented by an Elac 165mm long-throw bass unit mounted in a labyrinth.

Despite the manufacturer's claim of a response within borderlines of 6dB from 40Hz to 25kHz, the anechoic chamber sine wave on axis pen chart revealed clearly greater deviations. It is virtually impossible to describe the pen chart to the uninitiated reader, but suffice it to say that humps, dips, peaks and valleys are within borderlines of some 17dB from 80Hz to 20kHz. We cannot help wondering whether the manufacturers used an incredibly slow pen chart speed to check their own response charts, although they claim to have used a reasonable speed. Off axis horizontally, the response looks fairly similar, but one further significant dip appears. A 22dB dip occurred at 4.2kHz when the response was measured vertically off axis, but otherwise the curve again is similar. Some 5% 2nd harmonic distortion is reached at 320Hz, and generally at lower mid and bass frequencies it is anything but good, averaging around 2.5%. The 2nd harmonic distortion remains somewhat poor in the Elac woofer, and also some 3rd harmonic distortion becomes noticeable at 1.8kHz. The T27 tweeter fares much better, causing no particular distortion problems. Intermodulation distortion is present in the woofer, averaging between 1 and 2%. The impedance curve is pretty good, and electrical phase falls between ±40°. The sensitivity from our standard source was well below average, an output of 80dBA weighted being reached (82.5dB unweighted). The power test produced significant and serious bass distortion at 102dBA, but this level is pretty good for such a small speaker system. I feel that a 50W amplifier can be used fairly safely with this system, and would give potential peaks of around 97dBA.

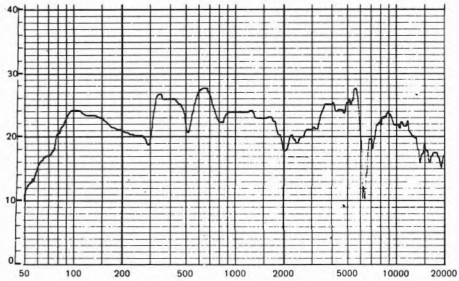
The classical music panel rated this speaker very low on average, but one or two marked it above average. The sound was said to be very boring, with relatively little bass, and very colored mid, and the HF end seemed to vary considerably, dependent on seating position. Comments varied from describing the quality as muffled to strident, and whilst some considered the speaker rather over bright, others followed the valleys and found it dull. Something is quite clearly wrong in the way that the manufacturers have mounted the T27 tweeter in the cabinet. Furthermore, the crossover network appears to be rather poorly matched with the units, and this may be giving rise to some of the response anomalies.

In our own internal listening tests, without knowing what the speaker was, I myself said that the sound was very boring, though surprisingly I did not comment on the exceptionally peaky response, other than to say that it was thin and subjectively had no bass. It would seem that the reproduced quality in any case varied appreciably from one type of programme material to another, and so I cannot really recommend this speaker at all, despite its very modest price. I must suggest that potential purchasers consider spending another £10 or £20 and they will find a few significantly better buys.

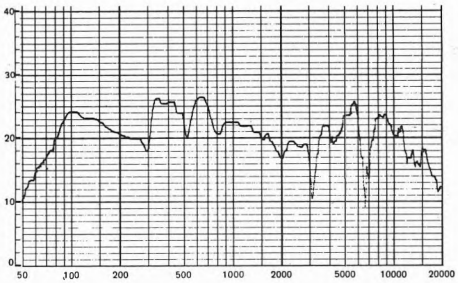


Height	597mm
Width	228mm
Depth	260mm
Weight	8kg
Finishes	Teak/walnut/oak
Input connections	Screw terminals
User adjustments	none
Lowest Impedance (Modulus)	6Ω8kHz/9Ω200Hz
Maximum SPL	102dBA
Sensitivity dBA pink noise 2.83V RMS 1m	80dBA
Recommended maximum amp power	50 watts
External volume	35.4 litres
Optimum listening height above base of speaker	500mm
R.R.P. (ex. VAT)	£80.00

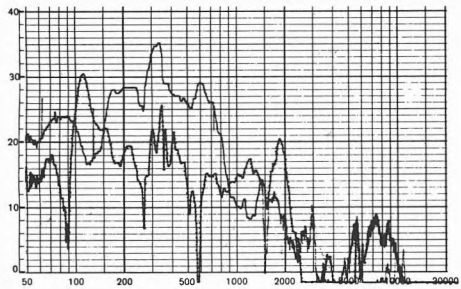
Occasionally discounted



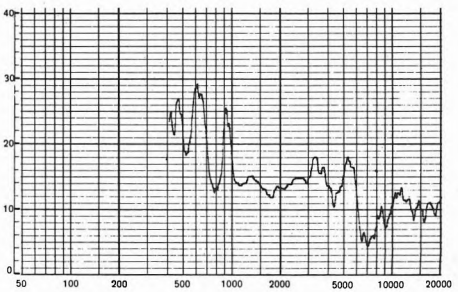
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2-f_1$)

Marantz Imperial 5G

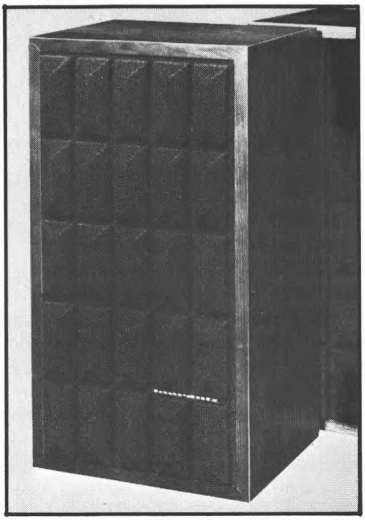
Marantz Audio (UK) Ltd, 203 London Road, Staines, Middlesex

In the past this system has been quite moderately priced, but with a recent change of importer and the dollar/pound adjustments it has gone up significantly. The two-unit system is mounted in a cabinet measuring 584 × 305 × 241mm deep, and weighs 18kg. Walnut or teak finishes are available, and input connection is with screw terminals on the rear panel. The speaker should be used on the front edge of a shelf for optimum results. The three-position high frequency output switch puts in a 2.5dB shelf up and down from nominally flat.

In the anechoic chamber the sine wave on-axis response shows a 2dB rise in the mid bass, but upper bass dips down some 4dB. A high frequency presence dip became very marked (−6dB). The response then expands reasonably through to 15kHz but a slight rise becomes apparent at 16kHz. Horizontally off axis the presence dip broadens but it is not quite so bad, and in general the high frequencies are attenuated by around 2dB, but the fall off becomes more rapid above 13kHz. Vertically off axis a dip (acoustic cancellation) occurs at 2.5kHz of 17dB, but the response is reasonably close to the on axis curve, but with very high frequencies very slightly curtailed. Harmonic distortion (both 2nd and 3rd) measured better than 1% from 80Hz to 20kHz, and IM distortion was generally better than 0.4%, but showed a slight peak to 0.8% at 2kHz. The impedance curve looked very satisfactory. The sensitivity was slightly below average, our pink noise signal developing 81.5dBA weighted (84dB unweighted) at one metre. The power test revealed roughness developing at 102dBA, and I recommend amplifiers of not more than 40W rating for general use with this system. A 40W amplifier would allow peaks of around 98dBA to be achieved, which should be adequate for average rooms.

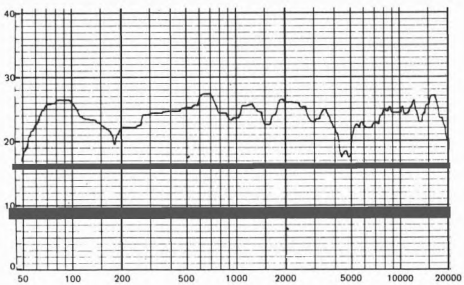
Our classical music panel suggested that lower bass was down, and furthermore an upper bass dip must have contributed to some general comments of the bass register being backward. Mid-frequency response variations were heard, and middle top appeared hard and up in places, this being the subjective effect presumably of the measured valley here, either side of which would be audibly up. The polar diagram was none too good, introducing marked coloration off axis. Many panel members commented on phasiness and poor stereo positioning. Our internal mono listening tests sounded quite promising, and clearly in stereo they disappointed both the panel and us. Nevertheless, the speaker was regarded as average, and so some may well like its sound quality. The pop music panel rated the speaker significantly lower, finding the phasiness even more annoying. There seemed to be too much middle presence and the speaker lacked deep bass, but upper bass appeared boomy. They said that the speaker was boxy and colored off axis. Quality and forwardness of the presence region was highly dependent on seating position. The panel severely criticised mid coloration, and since it has so many problems it cannot be recommended for pop music reproduction.

It is a shame that what at first appeared to be a good loudspeaker in mono was let down so badly in stereo, and for this reason I just cannot really recommend it. At its new price it would seem to be relatively poorer value for money, and too many other systems sounded significantly better while costing at most only marginally more.

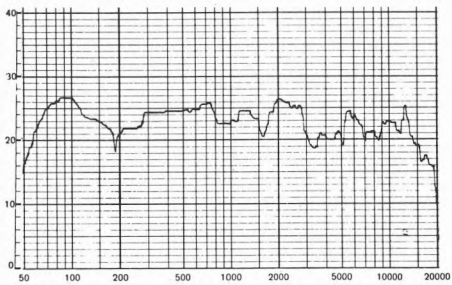


Height	584mm
Width	305mm
Depth	241mm
Weight	18kg
Finishes	Walnut/teak
Input connections	Screw terminals
User adjustments	HF
Lowest Impedance (Modulus)	6.5Ω12kHz/6.5Ω150Hz
Maximum SPL	102dBA
Sensitivity dBA pink noise 2.83V RMS 1m	81.5dBA
Recommended maximum amp power	40 watts
External volume	42.9 litres
Optimum listening height above base of speaker	460mm
R.R.P. (ex. VAT)	£110.00

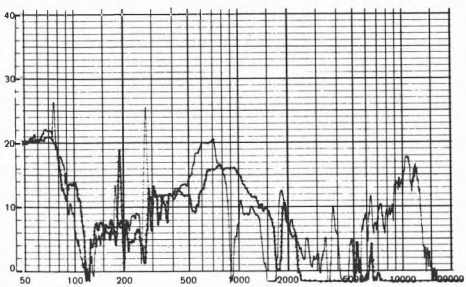
Occasionally discounted



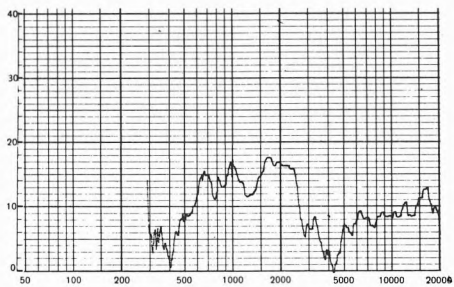
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2-f_1$)

Marantz Imperial 6G

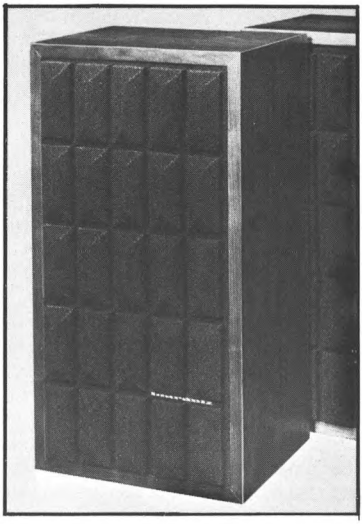
Marantz Audio (UK) Ltd, 203 London Road, Staines, Middlesex

A two-unit system incorporated into a cabinet measuring 648 × 362 × 285mm deep and weighing approximately 18kg. Walnut or teak finishes are available. Screw terminals provide input connection. A three-position high-frequency level selector (centre nominally flat) allows balance to be changed. The 6G is designed for front edge shelf mounting, in which position it was auditioned. The bass/mid range unit is 250mm, whilst the tweeter is 44mm.

The anechoic chamber on-axis sine wave chart showed a response falling between 6dB borderlines between 55Hz and 15kHz with a general tendency for the HF end to be slightly down. The response tends to lump up at 100Hz. An acoustic cancellation at 3.2kHz of 13dB was present horizontally off axis and HF generally rolls off. Vertically off axis, a fairly broad cancellation occurs around 2.4kHz of about 6dB, but minimising to −15dB in the centre. Again EHF rolls off. The HF switch affects the response by approximately ±2dB. Above 200Hz both 2nd and 3rd harmonic distortion measured below 1%. However, at 150Hz 2% 2nd harmonic occurred. The IM distortion hovers around 1% from the bass unit, but the treble IM distortion was rather better, being generally around 0.4%. In general, IM distortion was somewhat higher than average. The impedance drops to 5 ohms modulus between 5kHz and 10kHz and this is on the low side, unfortunately. The electrical phase varied from +40° to −30°, (about average). Sensitivity was average, an output of 84.5dBA weighted (88dB unweighted) being reached from our test noise source. Rough cracking noises appeared in our power test when the output reached a higher than expected 104dBA, the entire system noticeably protesting. I recommend that a 50W amplifier is best suited for these speakers, but a much lower powered one will surely give adequate volume for an average room.

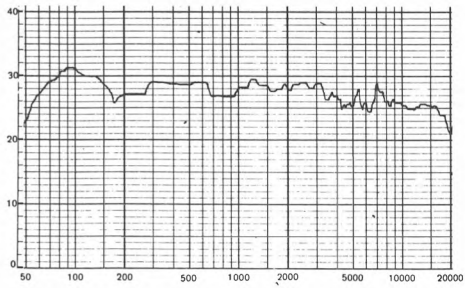
The classical music panel did not much like the sound from this speaker, finding it to have a significant polar diagram problem. Stereo positioning and acoustic phase appeared to almost everyone to be very vague at times, sounding almost out of phase. Mid HF was rather bright on axis but became very colored off axis. Upper bass appeared boomy but lower bass seemed subjectively down. Several members heard some very high frequency loss and the speakers did not appear well matched. It would seem from the comments that plinth mounting might be more suitable for some applications, although very low bass frequencies would then almost disappear subjectively. The entire panel found this speaker rather disappointing, but it did sound appreciably better when a listener was precisely on axis, which was confirmed in our own in-house tests.

This loudspeaker did significantly better in mono than it did in stereo, since for the former my colleagues and I listened to it precisely on axis. In this case it sounded quite reasonable, but the moment our heads were moved to the side, mid-frequency coloration became very marked, obviously being contributed from the bass unit. It seems that the crossover frequency was rather too high for it. Since there are other units offering much better performance than this one at about the same price, I cannot really recommend it and it cannot be said to be even reasonable value for money. Marantz must look into the properties of their bass and mid range units with respect to coloration off axis, since this was clearly the main problem. The measured presence hole in the response off axis also seems to be highly significant.

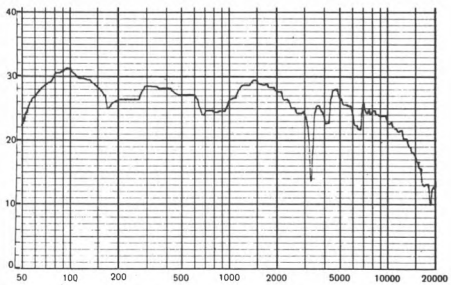


Height	648mm
Width	362mm
Depth	285mm
Weight	18kg
Finishes	Walnut/teak
Input connections	Screw terminals
User adjustments	HF
Lowest Impedance (Modulus)	5Ω8kHz/7.5Ω125Hz
Maximum SPL	104dBA
Sensitivity dBA pink noise 2.83V RMS 1m	84.5dBA
Recommended maximum amp power	50 watts
External volume	66.8 litres
Optimum listening height above base of speaker	490mm
R.R.P. (ex. VAT)	£150.00

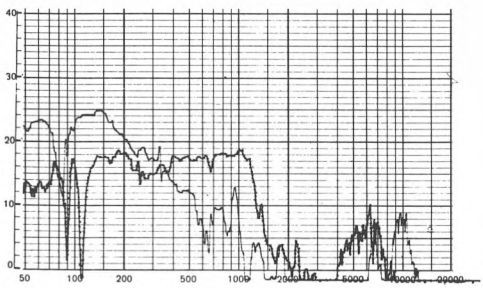
Occasionally discounted



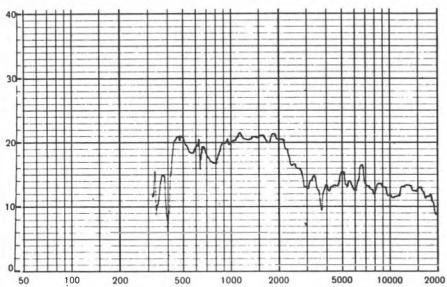
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2-f_1$)

Monitor Audio MA 3

Monitor Audio Ltd, 347F Cherry Hinton Road, Cambridge CB1 4DJ. 0223 42898

This is the largest system in the manufacturers' range, incorporating three separate fused units in a cabinet 702 × 337 × 317mm deep, and weighing 27kg. Teak and walnut finishes are standard, and white or rosewood to special order. Terminal type banana sockets are provided for interconnection. The system is designed for low plinth mounting away from a wall. The bass unit is a 350mm × 228mm (EMI) eliptical, with a fibre plastic laminated cone with alloy centre stiffner, also having a 50mm high temperature rating voice coil. The B & W MW150 squawker is a 160mm doped matrixed Bextrene cone, exponentially flared (25mm voice coil), and the tweeter is a 25mm synthetic dome special Isophon unit.

The anechoic chamber on axis sine wave response chart was pretty good, but showed a double humped dip giving minima of 13dB at 4.2kHz. and 10dB at 3.8kHz. Elsewhere the response fell between 5.5dB borderlines from 45Hz to 20kHz. Horizontal off axis EHF is rather curtailed. Vertically off axis the curve measured very well, being within 7dB borderlines from 50Hz to 20kHz, the presence on axis suck-outs disappearing. It would seem that the units are rather too far apart, and that the squawker is mounted in such a position as to cause on-axis acoustic cancellations.

Above 55Hz right across the audio band, harmonic distortion measured significantly below 0.7%, and this is most creditable. IM distortion reached a maximum peak of only 0.45% at 3kHz, and we were not able to find any reason for slight scratchiness heard from the Isophon tweeter, but perhaps this develops at a somewhat higher level than our distortion measurements were made at. The impedance curve showed a rather nasty dip of around 4 ohms modulus at 1kHz, which is rather an awkward place for it. The electrical phase was held within reasonable limits. The loudspeaker was just below average sensitivity, our standard noise source giving an output of 82.5dBA weighted at 1 metre (85.5dB unweighted). Our power test revealed mid-frequency cracking when the output reached 105dBA, which of course is very loud. I would feel it safe to use amplifiers of up to 125W rating, especially since the units are fuse protected, and this will allow peak dBA weighted outputs of around 103dBA to be achieved.

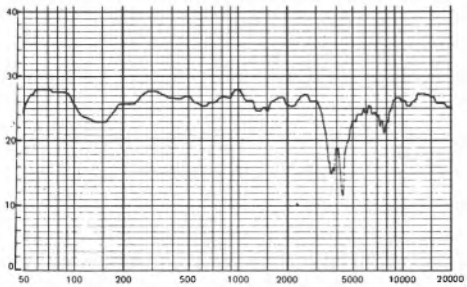
The classical music panel heard the on-axis presence suck-out quite clearly, and made repeated comments concerning it, and this virtually overrode all other criticisms. Mid coloration was noticed, and the general sound quality was said to be rather unreal. A lack of presence caused the top end to become subjectively rather thin and overbright. The bass end was generally praised. The single pop track played to this panel was claimed to have its balance changed somewhat. This panel marked the speaker at below average.

The pop music panel praised the well extended firm bass. The sound was found a little adenoidal and nasal on vocal. 'AR' sounding coloration was heard, and the top end sounded substantially peaky and down off axis. The overall sound was hollow and lacked upper mid (probably presence suck-out). Brass was rather harsh. The sound was said to be cold, and some ringing was suspected on the percussion 'high hat'. The speaker was said to be tiring to listen to by a few, and there was a tendency to vocal sibilance and spitting. In general this panel marked the speaker as being rather average, the main comment being that high frequencies seemed to be hard and sometimes brittle.

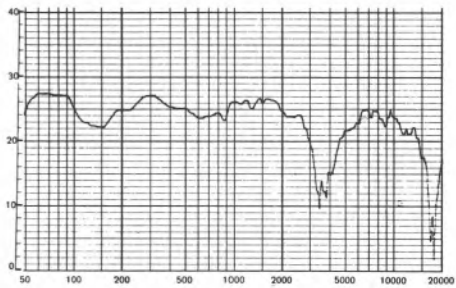
After writing this review, another pair of MA3s were brought round, straight off the production line. Subjectively they did not possess the presence suck-out, possibly caused in the earlier pair by the squawker being out of phase. The hollow quality improved somewhat, but the sound seemed even harder and more brittle, and was marginally more colored in the presence region. Nevertheless, the new pair sounded somewhat better, and whilst my colleagues and I found HF bordering on oppressive, undoubtedly some readers would find it exciting.

Height	702mm
Width	337mm
Depth	317mm
Weight	27kg
Finishes	Teak/walnut/white/rosewood
Input connections	4mm banana terminals
User adjustments	none
Lowest Impedance (Modulus)	4.5Ω1kHz/6Ω80Hz
Maximum SPL	105dBA
Sensitivity dBA pink noise 2.83V RMS 1m	82.5dBA
Recommended maximum amp power	125 watts
External volume	75 litres
Optimum listening height above base of speaker	480mm
R.R.P. (ex. VAT)	£324.00

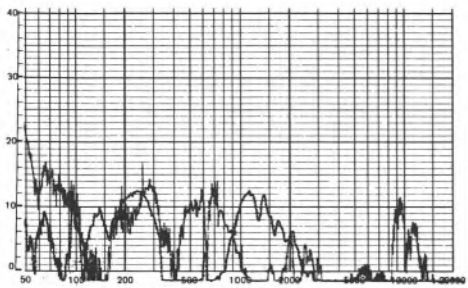
Occasionally discounted



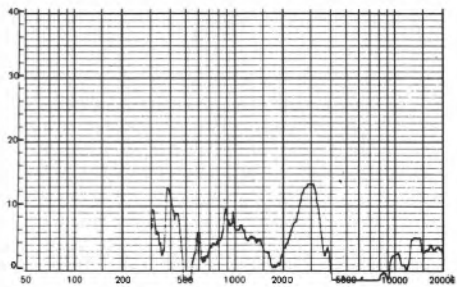
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2-f_1$)

Monitor Audio MA 4

Monitor Audio Ltd, 347F Cherry Hinton Road, Cambridge CB1 4DJ. 0223 42898

A two-unit system in a medium sized cabinet, measuring 694 × 316 × 280mm deep, and weighing 16kg. Teak or walnut finishes are available, and white or rosewood to special order. The bass end and mid range come from a 220mm Bextrene cone unit, KEF B1039, with a 33mm high power voice coil, whilst the tweeter is a special modified Isophon unit, having a yellow dome with applied surround damping and a centre absorption plug. It has a ducted port bass reflex system having banana terminal sockets for input connection. The system is designed for low plinth mounting away from a wall or corner.

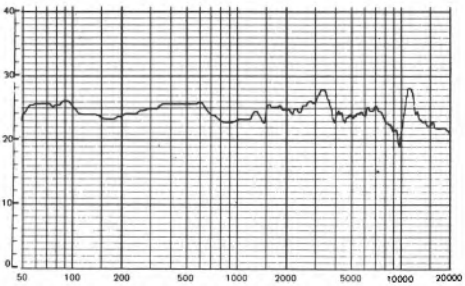
Our sine wave on-axis pen chart showed a relatively flat response within 6dB borderlines from 50Hz to 20kHz, with the sole exception of a 6dB sharp dip at 9.8kHz. The pink noise response also seemed to show a pretty flat curve, and whilst it integrated the 9.8kHz null, it did show a rise in the presence region. Off axis horizontally, the 3kHz hill became a dip. High frequencies were generally slightly down, and the 9.8kHz sharp dip disappeared. Vertically off axis a dip of 18dB occurred (acoustic cancellation) at 3.3kHz. The remainder of the curve was very satisfactory. Between 100Hz and 20kHz, 2nd and 3rd harmonic distortion was below 0.8%. The maximum IM distortion peak was at 3kHz, but even here the measurement was only 0.9%. The impedance curve was very satisfactory, although on the high side, showing that the sensitivity could have been marginally increased without any detrimental effect on amplifier loading. Electrical phase was also held within fairly fine margins. Our test pink noise signal developed an output of 82dBA weighted (84.5dB unweighted), and the loudspeaker managed to reach 104dBA on our power output test, at which point low frequencies were clearly breaking through into the tweeter. I recommend that amplifiers of up to 75W output rating should work satisfactorily with this model, although care will have to be taken to avoid prolonged high energy high-frequency outputs.

The classical music panel heard some mid-frequency coloration, and felt that there was a subjective upper mid or lower top boost somewhere. In general, the panel liked it quite a lot. Slight criticisms were made of a tendency to boxiness, and strings sounding slightly nasal. One member thought he could detect some distortion at very high frequencies. The bass end was generally liked, and seemed to be pretty firm, although one member remarked that the system produced a slight honk. In general the classical panel recommended this speaker, though. The pop panel, unfortunately, did not like the speaker so much, commenting that the mid range seemed subjectively peaky but with a valley somewhere, and they heard some 'AW' coloration. HF was found to be edgy and harsh. The bass end was pretty good. EHF was noticeably down off axis, and this received several comments from members. Mid frequencies sounded rather tunnelly and hollow, and presence seemed rather forward (perhaps the 3.3kHz rise). Some 'spittiness' was noticed on sibilants, and a few remarked that high frequencies were not always clear. Perhaps this ties in with the classical panel's comment concerning slight HF distortion.

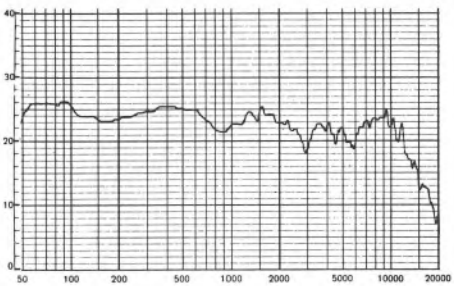
Quite frankly, the MA 4 did not come up to expectations on pop, but did well on classical music. It seems fair to recommend it more specifically for classical music, but you may well like it on light and pop music, and you should listen to a demonstration. It would seem to be a pretty good buy at its price, which is most reasonable, but you may find in the end that you dislike the Isophon tweeter, as did one or two panel members, though this will be very personal. Our own in-house listening tests were favourable, and we found the response smooth in general, although at times I detected a slight harshness at HF.

Height	694mm
Width	316mm
Depth	280mm
Weight	16kg
Finishes	Teak/walnut/rosewood/white
Input connections	4mm banana terminals
User adjustments	none
Lowest Impedance (Modulus)	8Ω150Hz/9.5Ω12kHz
Maximum SPL	104dBA
Sensitivity dBA pink noise 2.83V RMS 1m	82dBA
Recommended maximum amp power	75 watts
External volume	61.4 litres
Optimum listening height above base of speaker	370mm
R.R.P. (ex. VAT)	£158.00

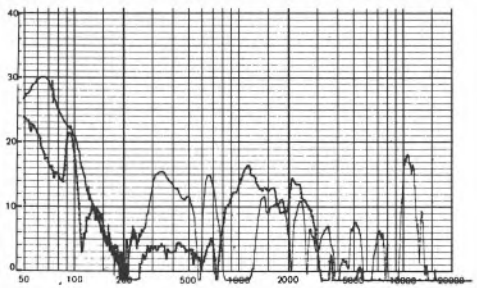
Occasionally discounted



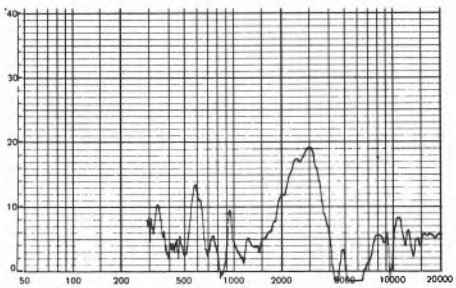
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2 - f_1$)

Mordaunt Short Pageant Series 2

Mordaunt Short Ltd, Durford Mill, Petersfield, Hants GU31 5BB. 073080 721

The Pageant was found to be a most interesting loudspeaker and incorporates a two-unit system in a cabinet measuring 533 × 330 × 230mm deep, weighing 9.6kg. Teak or walnut finishes are available and others are apparently also available to special order. The bass/mid unit has a cone of 140mm in a 208mm chassis. The viscous damped cone is made from heavy duty impregnated paper. The tweeter has a 25mm synthetic dome (Isophon unmodified KK 10/8). Two switches provide mid or top cut of approximately 2.5dB respectively. Push lock terminals are provided for interconnection and the system is designed for either plinth or front of shelf mounting, the latter being used for our listening tests.

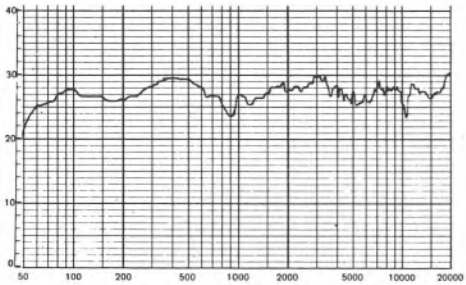
Our sine wave on-axis pen chart recording shows that the response was maintained between 7dB borderlines from 55Hz to 20kHz, quite an achievement in an inexpensive speaker. The general shape just showed mild hills and valleys across the audio band. Frequencies above 7kHz are slightly curtailed progressively on our horizontal off-axis measurement. Vertically off axis, a suck-out of 16dB occurred at 3kHz, the remainder of the curve showing a slight roll off of EHF, compared with on axis. The 2nd harmonic distortion plot revealed a somewhat inexplicable rise to 2.2% at 310Hz and the anticipated peak at 10kHz, amounting to some 7%, was attributed to the Isophon tweeter. At bass frequencies distortion was surprisingly low, being generally lower than 1.4% whereas at mid and top the general tendency was to show two harmonic distortion humps of 1.4% around 1.5kHz and 2.2kHz (see chart). IM distortion was pretty low except at 2.8kHz where it measured 1.4%. The impedance was reasonably satisfactory throughout and the electrical phase response measured excellently. The loudspeaker had average sensitivity, our test signal developing a weighted output of 84dBA at 1 metre (86.5dB unweighted). The relatively small system gave a remarkable 105dBA in our power test at which point the sound quality deteriorated somewhat dramatically. I recommend amplifiers of not more than 50W rating in general for they will in any case allow generally loud reproduction of music in even a fairly large room.

The classical music panel rated this loudspeaker rather above average, which for its price is most creditable. The bass end seemed slightly lacking. Mid frequencies were slightly colored off axis and the treble end was found slightly coarse and peaky. One or two members found the stereo positioning accuracy to be marginally below average. In general the panel found the sound pretty smooth and pleasant to listen to and my colleagues and I certainly agreed with this finding in our own listening tests. The pop music panel also gave this system slightly above average marks. They found the sound surprisingly uncolored, but found middle frequencies slightly down and high frequencies a little up. Deep bass was found lacking on heavy pop material, but upper bass was regarded as good. Several commented that the reproduction was clear and clean. A few comments were made, though, of hollowness. The pop panel liked this speaker quite a lot, but found mid HF slightly too forward and I concur with this. Both panels, when eventually told the price of the loudspeaker, stated that it must be recommended very highly indeed.

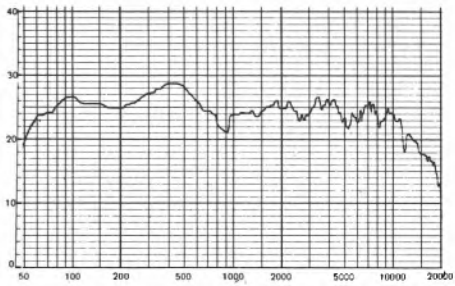
One must bear in mind the relation between performance and cost when assessing a system. I not only recommend this speaker very highly, but rate it excellent value for money. What a pleasure it has been for us to find no very serious faults in such an inexpensive design, and it would be unrealistic to try and pick unfair holes in this system. Classical music enthusiasts might well try plinth mounting, although the low bass end will definitely be enhanced if the speakers are shelf mounted, but this might in some circumstances add a little boom. Very strongly recommended indeed at its cost.

Height	533mm
Width	330mm
Depth	230mm
Weight	9.6kg
Finishes	Teak/walnut
Input connections	Push lock terminals
User adjustments	HF & MF
Lowest Impedance (Modulus)	6Ω200Hz/6.5Ω35Hz
Maximum SPL	105dBA
Sensitivity dBA pink noise 2.83V RMS 1m	84dBA
Recommended maximum amp power	50 watts
External volume	40.5 litres
Optimum listening height above base of speaker	400mm
R.R.P. (ex. VAT)	£124.00

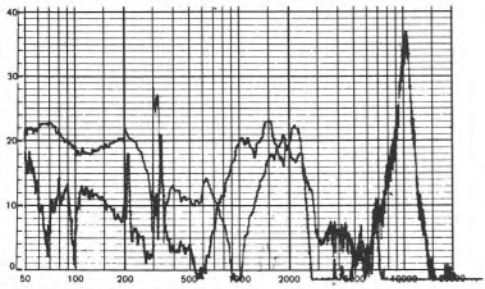
Occasionally discounted



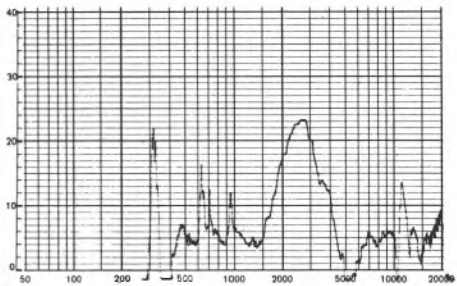
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2-f_1$)

Philips Motional Feedback RH541

Philips Electrical Ltd, Century House, Shaftesbury Avenue, London WC2. 01-689 2166

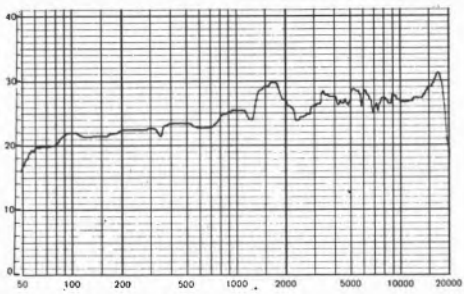
This 3-unit system is fairly similar to the model RH544, containing a built-in amplifier and 5-pin DIN audio input and output sockets, complemented by a captive AC mains lead. Three switched input sensitivities are available, 1V, 7.5V and 19V being required for maximum output level. No HF roll-off pot or switch is provided, unfortunately. The cabinet is finished in black/ash and measures 294 × 229 × 184mm deep and weighs 6.8kg. The amplifier is not energised until an audio input signal is present, a low current drain detector being provided. The system is designed for shelf mounting with its back against a wall.

In the anechoic chamber we found that the sine wave on-axis response rose slowly from 100Hz to 1kHz (about 3dB). Above 1.5kHz the response rose to a shelf of approximately +4dB within borderlines of 6dB up to 15kHz, but at 1.5kHz itself a curve peaked up an additional 2dB. As with the model 544 we regard the response balance as highly unsatisfactory. Horizontally off axis the lump at 1.5kHz remains, but the general shape is slightly flatter. Vertically off axis the general response shape is very similar to that on axis, but EHF is actually marginally flatter. Apart from a 2nd and 3rd harmonic distortion peak of 1.2% at 320Hz, the distortion was generally below 1% as was the IM distortion. An ouput of 101dBA was achieved in our power test before distortion became quite intolerable (the bass unit also hit the end stop here).

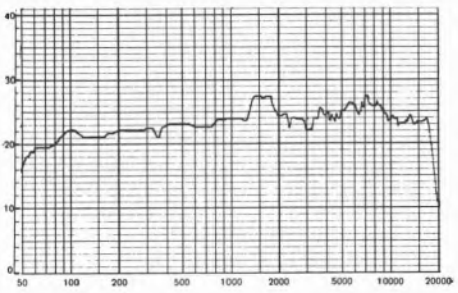
The listening panel marked this loudspeaker rather low and the entire panel found the speaker excessively toppy. All music was significantly over bright and lacking in bass, warmth and body. The balance of this loudspeaker was so clearly wrong that perhaps it might be more suitable for reproducing appropriate music to small animals and birds rather than human beings! I am sorry to be so rude, but surely a designer should attempt to make the response of a loudspeaker system to be flat rather than with a built-in total imbalance of sound. As with the model RH544, I would imagine that it would be possible to correct the problem with a few passive components, if your heart is set on purchasing one of these units, but when there are so many other speakers that are better balanced it seems hardly worth while even to bother with this one. Perhaps in the rest of Europe listeners like their music excessively toppy, but for the British market I feel the manufacturers must put the anomaly right. In any case, I must comment that surely tone controls are for altering sound balance and so if you like a bright sound why not use them. Incidentally you will only need a pre-amplifier to drive these speakers, the same point also applying, of course, to the model RH544.

Height	294mm
Width	229mm
Depth	184mm
Weight	6.8kg
Finishes	Black/ash
Input connections	5 pin DIN
User adjustments	none—see review
Lowest Impedance (Modulus)	see review
Maximum SPL	101dBA
Sensitivity dBA pink noise 2.83V RMS 1m	see review
Recommended maximum amp power	see review
External volume	12.4 litres
Optimum listening height above base of speaker	230mm
R.R.P. (ex. VAT)	£165.40

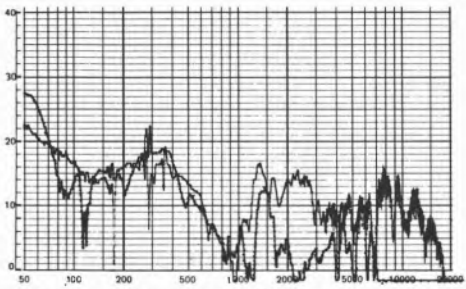
Occasionally discounted



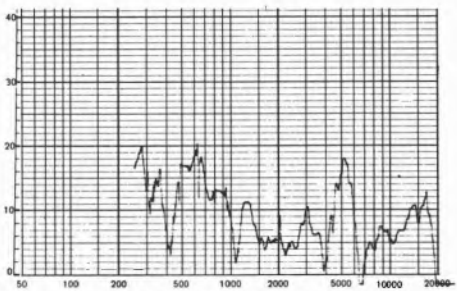
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2-f_1$)

Philips Motional Feedback RH544

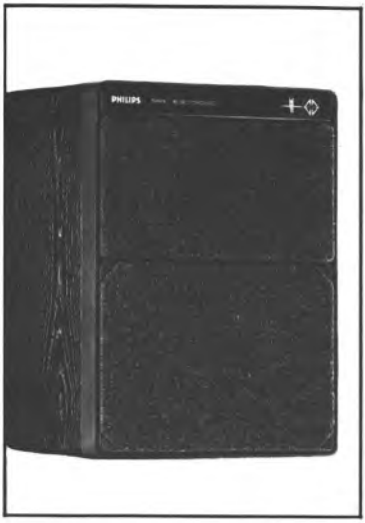
Philips Electrical Ltd, Century House, Shaftesbury Avenue, London WC2. 01-689 2166

The 544 is an integrated 3-way loudspeaker system incorporating a built-in amplifier having feed-back from the bass unit back to the amplifier, which it is claimed reduces low frequency distortion. A stereo signal can either be fed separately to a pair of speakers, or can be plugged into one of them with the second speaker taking its drive from a socket on the first (the latter being normally recommended). An input level anywhere between 1V and 20V is required for full output, a preset gain control being provided. Each system also incorporates a treble control varying the response fairly considerably from a so-called flat one. The cabinet is only available in ash veneer. It is designed for shelf mounting, as close to a wall as possible to provide bass reinforcement. Input connection is on a 5-pin DIN socket and of course mains connection is also required, the speaker taking a maximum of 150W at 240V AC. The back panel includes a mains on/off switch (red indicator on front panel), a voltage selector, an L/R reversal switch and audio and mains interconnection sockets. An auto mains switch is also provided, which turns the DC supply to the amplifier off when no input signal is present for several minutes, HT returning immediately on the application of even a fairly weak audio signal. The cabinet measures 391 × 288 × 216mm deep and weighs 12.3kg.

In the anechoic chamber the sine wave on-axis response measured within the amazingly narrow borderlines of 3dB from 50Hz to 900Hz, but above this the entire response shelved up approximately 5dB establishing within the upper band borderlines of 5.5dB. The treble control was able to bring down the 10kHz response by a maximum of 11dB but in no way could it correct the general tendency of an HF/LF shelf, since when lower HF was improved, EHF was torn right off. Off axis horizontally a 3.5dB dip becomes evident centring on 4kHz, and EHF becomes slightly curtailed. Vertically off axis a very large acoustic cancellation of about 26dB occurs at 3.8kHz and a dip of 5dB is also produced at 700Hz. Above 70Hz the harmonic distortion is always below 0.3% but 2nd harmonic does reach 1% at 50Hz (academic!). Again IM distortion is also incredibly low, being always below 0.3%. Our power test showed that at 102dBA the quality was very poor, bass frequencies being confused with mid generally. We consider, however, the output to be more than adequate for normal domestic listening levels.

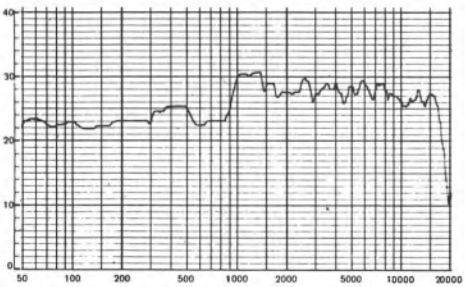
The classical music panel found the bass to be deficient and high frequencies became extremely hard and brittle due to the overall response imbalance. The sound quality was strident and generally rather toppy. Many commented that the mid was colored and tunnelly. The panel unfortunately rejected the speaker because of its response imbalance, which seems inexplicable. The pop music panel found low bass to be subjectively missing, whilst upper bass was boomy. To them the speaker had fairly low coloration, but the presence region was very hard and HF seemed peaky and excessive. The speaker sounded thin and lacked body and also sounded hollow and occasionally nasal. The top end received comments that it was very clear but absurdly over bright. It emphasised tape hiss and sibilants and sounded metallic. 'High hat' coloration was noted and the most usual continued comment referred to the frequency imbalance.

It is most unfortunate that Philips have designed such an odd response for this system, since everyone criticised it. Notwithstanding this, the speaker shows considerable promise, possessing a clarity and lack of distortion that is almost outstanding. In its present form I just cannot recommend it, but an enthusiastic dealer might well be able to insert passive electronic components in the input circuit which could at least correct the response anomaly. Considering that the price includes the built-in amplifier, it is moderately good value for money if only the reproduced quality could have been better balanced. Could the manufacturers please attend to the balance problem as a matter of urgency?

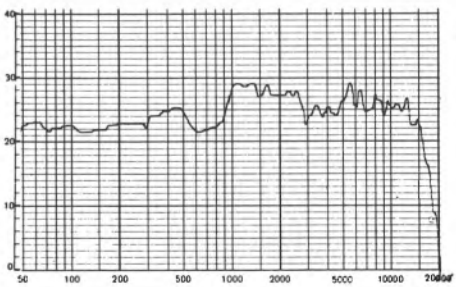


Height	391mm
Width	288mm
Depth	216mm
Weight	12.3kg
Finishes	Ash
Input connections	5 pin DIN
User adjustments	HF—see review
Lowest Impedance (Modulus)	see review
Maximum SPL	102dBA
Sensitivity dBA pink noise 2.83V RMS 1m	see review
Recommended maximum amp power	see review
External volume	24.3 litres
Optimum listening height above base of speaker	240mm
R.R.P. (ex. VAT)	£259.88

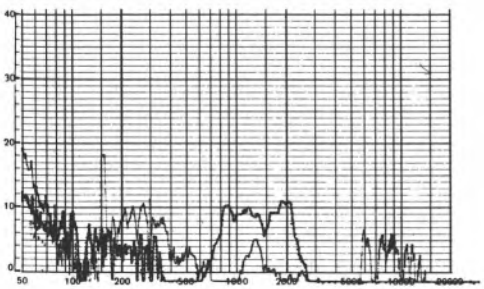
Occasionally discounted



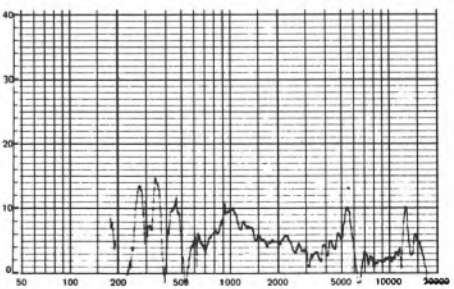
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2-f_1$)

AN IMPORTANT ANNOUNCEMENT TO THE READERS OF THIS MAGAZINE

The United Kingdom is fortunate in having several companies who have deservedly won world-wide recognition for the consistently high quality of their loudspeakers. This is the result of thousands of hours of study, design, measurement, and scientifically objective listening tests.

The capital investment in laboratory facilities and equipment by the leading loudspeaker manufacturers in the United Kingdom is enormous, backed up by a staff of Graduate Engineers who are dedicated to producing advancement in the science of sound reproduction in the home.

No expert or group, no matter how well intentioned or serious of purpose, can evaluate the products of these companies without having equivalent knowledge, time and facilities. Anything less than this must be viewed as an opinion, nothing more, a personal opinion that may have no relevance to your requirements and listening environment. Both the listening environment and all components of the ancillary equipment feeding the loudspeaker will radically influence the sound reproduction in your home.

What, you may ask, should the prospective purchaser do to be sure of making a wise investment. First, carefully read the published literature of many reputable manufacturers. Second, locate a serious dealer of high fidelity equipment in your local area and discuss your requirements with him. Finally, arrange for a home trial of the two or three alternatives that seem most interesting to you. There in your own listening room, with your own associated equipment, and with the recordings you know, there is every likelihood that your final decision will give you satisfaction for years to come.

Both companies who are signatories to this announcement are convinced that the final choice must be the customer's. The perfect loudspeaker for your use is the loudspeaker which in your opinion provides you with the most life-like recreation of the original sound in your home.

Martin L. Borish

MARTIN L. BORISH
PRESIDENT

TELEDYNE ACOUSTIC RESEARCH

JOHN BOWERS
MANAGING DIRECTOR

B&W Loudspeakers

This loudspeaker is the only electrostatic in the survey and despite have been designed over 20 years ago is virtually in its original form, although the crossover has been changed slightly. Input connection is by means of banana sockets. An AC/DC power supply is required, for which a Bulgin mains socket is provided at the rear. On the back panel, a light is fitted to indicate that mains are switched on. It is intended that the two speakers should be switched on at the same time as the main amplifier or receiver and thus they should be driven from switched mains outlet sockets. The loudspeaker does not reach full efficiency for a few minutes after switch on, but gives a useful output within about 30 secs. Unfortunately, different units require various times for the basic charging up of the plates, and we have known some samples to take at least 5 mins before sensitivity equality is reached. The speaker is available in bronze or black finish and has wooden side panels. Two bass units are complemented by a central treble one and the speaker incorporates a fairly complex crossover. (Please see section on Types of Loudspeaker System, which describes the operational mode of an electrostatic.)

The on axis response had to be measured at 3 metres at the manufacturer's request, and this presented some problems. The bass response, as expected, shows a severe free-field cut of 5dB at 150Hz and shelved down to −10dB below this. With normal floor loading, though, I should expect the bass to be reasonably flat down to about 80Hz, with a rapid fall-off below this. Two significant valleys in the response were noted at 6.8Hz (−5dB) and at 15.5kHz (−8dB). These valleys could be partly due to difficulties in measuring this particular type of transducer in the chamber, but the optimum microphone position was chosen after prolonged experimentation. Apart from these two dips and the bass roll-off, the response seemed very flat (making allowance for free-field testing). Off horizontal axis, the response showed some irregularities, notably a hole around 3.5kHz, but was subjectively reasonable. Vertically off axis, comparatively large suck-outs became noticeable, particularly at HF, and since the speaker has basically a velocity type transducing characteristic, the output falls vertically off axis anyway. At very low frequencies, harmonic distortion measured rather badly, possibly due in part to saturation of the input transformer. At middle and high frequencies the distortion was exceptionally low, the IM measurement averaging a maximum of 0.5%, despite the measurement being taken approximately 5dB higher than any other loudspeaker tested. At lower input levels, the speaker's distortion markedly fell below this. The impedance varies greatly with level, and at low levels it is appreciably lower at bass frequencies than it is at medium levels. Above 10kHz, it falls well below 4 ohms. This varying impedance makes the Quad ELS a difficult loudspeaker to drive, and it requires a very good amplifier indeed to avoid matching problems. The sensitivity (measured at 3 metres) computed for 1 metre is surprisingly higher than expected, an output of approximately 82dBA being achieved (84dB) unweighted). The speaker arced at 100dBA and below this point the sound quality was unusually clean at mid and high frequencies. I consider that it is most unwise to use amplifiers of higher than 45W rating with the speaker, and in any case if any arcing is heard (spitty, cracky noises) the volume must be brought down immediately, as otherwise permanent damage may result.

Both in the panel and in-house listening tests, listeners found the vertical polar diagram performance extremely poor, the optimum quality being achieved precisely on axis. If heard too high or too low in vertical angle, the quality was distinctly muffled and listeners in such positions down-rated the speaker considerably. Precisely on axis, though, some listeners (including myself) found the quality more analytical and open and less colored than any other speaker in the survey. Others, however, disliked this quality, finding it too brittle and revealing. It seemed that most panel members would only accept the quality when they knew what the speaker was, for it was so different. The bass end performance was better than expected, but was still lacking at VLF.

We also tried listening to stacked pairs, and here not only was the bass considerably superior but the overall volume was more than adequate for all my normal listening in a domestic environment. Stacking must be done very accurately, though, as otherwise interference patterns will be set up causing cancellations of various fre-

● *Because of the intricacies of the design and the differences between single and stacked pairs, the*

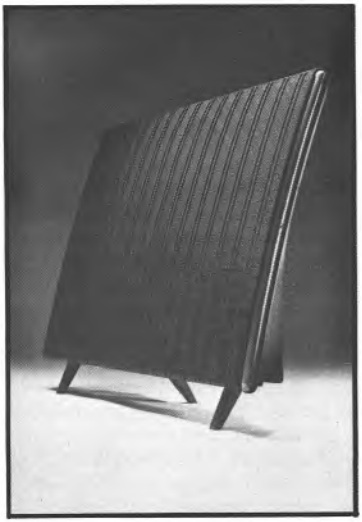
quencies in the optimum listening position. Stacking kits only appear to be available for the time being from Audio T as far as we can establish.

Some listeners remarked that the electrostatics seemed slightly colored in the upper mid and lower top, and on investigation it is clear that the sound reproduced can adopt the coloration produced from the effective air space behind the loudspeaker. Because the back of the speaker is completely open, low and mid frequencies come equally from back and front, and so any air or cavity resonances around the back will tend to produce more of an omni-directional radiation. So it is important for the speakers to be well away from a wall, with plenty of air space to either side as well. Sharp transients on programmes can cause arcing, and to avoid this the general volume level on very high quality programme material has to be held down. The lower the general quality of the programme, and the less the amount of high frequency peak energy, the louder will be the maximum general level that can be reproduced.

When stacked, we all noticed that organ music reproduced extremely well, with a surprising amount of bass. Although at first the bass end seemed down, I realised that it was not. Bass frequencies were being reproduced without added coloration, boom or boxiness, all of which normally add to the general amount of subjective bass in a system. Right across the audio range sounds were unusually open, and with virtually no overhang. Orchestral climaxes were handled very well from the stacked pair, but even in this configuration the volume would not be sufficient for some pop music enthusiasts. I feel a little suspicious about the quality of the input transformer, judging by its low frequency performance at low levels. I am also surprised that EHF seemed slightly down, but I do not regard this as too serious (younger ears might object, though).

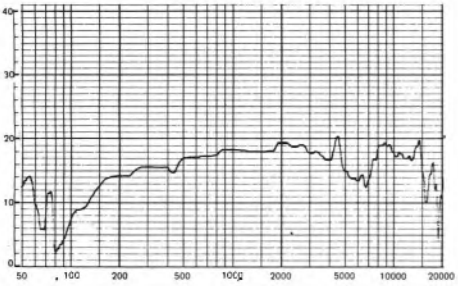
The sound quality of the Quad ELS itself is clearly almost completely without the coloration one sadly becomes accustomed to with box-speakers, although bass frequencies can become a little muddy and boomy if the units are not positioned very accurately and correctly. It would be an advantage for the manufacturers to put a height adjustment screw on the back centre leg, for this would allow the speakers to beam high frequencies at the required seating position. The loudspeakers are not suitable for small rooms, although their maximum output level limitation will not allow a single pair to give enough volume for very large rooms, particularly on pop music. They are obviously classical musicians' speakers, reproducing speech, chamber music and unaccompanied choral music outstandingly well. Whilst a single pair does not handle heavy orchestral climaxes at a loud volume without arcing, they also lack bass body even when positioned correctly. The frequency response measured in the anechoic chamber must be regarded with a degree of qualification, although several panel members did suspect the valley at 6kHz, and also the slight lack of EHF. The bass end was stated to be audibly down, but not seriously so. The bass response shown in the pen chart does not represent the response that will be gained under normal circumstances, and this will be highly dependent on speaker positioning. Coloration will obviously be introduced from back reflections, and so heavy curtains hung on the wall behind the units will probably be an advantage.

Since these loudspeakers are so different from any moving coil types, I strongly advise that you listen to them on various types of source material before you consider purchase. Also, try to get a dealer to demonstrate them to you in your home. If you do not want to reproduce music too loudly I can recommend them, particularly if you like a very clear, clean and analytical quality. If you want a noticeably better bass performance, and you want approximately 4.5dB more subjective volume capability, you will have to consider stacked pairs but these are enormous and very expensive. For general purposes I cannot really recommend the loudspeakers, because of the severe polar diagram restrictions in particuar, but if you are prepared to sit always in the 'hot seat' you may very much appreciate their quality, as the stereo positioning accuracy was superb. You will also need an outstandingly good amplifier to drive them at their best, and note that some amplifiers are totally unsuitable without modification. At the price for a single pair they can only be considered average value for money. In stacked form they are, of course, poor value.

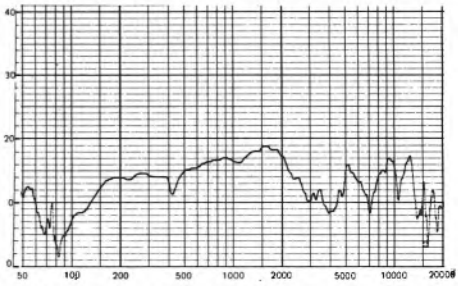


Height	787mm
Width	876mm
Depth	*266mm
Weight	18kg
Finishes	Bronze/black
Input connections	4mm banana sockets
User adjustments	none
Lowest Impedance (Modulus)	2Ω18kHz–see review
Maximum SPL	100dBA
Sensitivity dBA pink noise 2.83V RMS 1m	82dBA
Recommended maximum amp power	45 watts
External volume	not applicable
Optimum listening height above base of speaker	see review
R.R.P. (ex. VAT)	£276.00

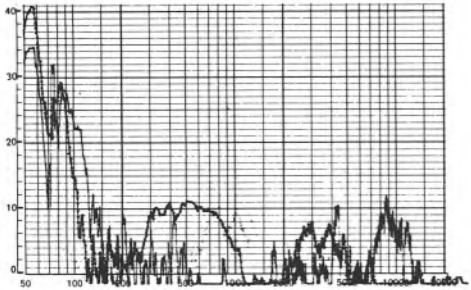
Not normally discounted



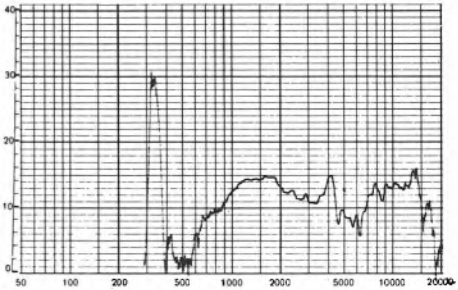
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2-f_1$)

Richard Allan 828 LP

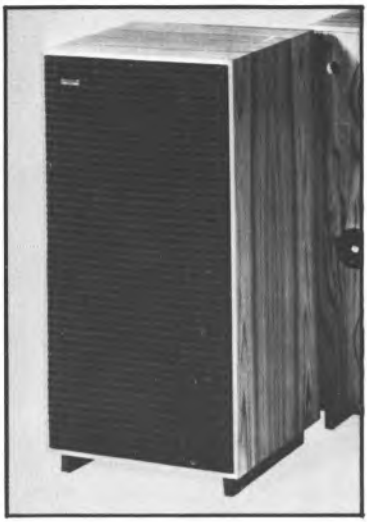
Richard Allan Radio Ltd, Bradford Road, Gomersal, Cleckheaton BD19 4AZ. 0274 872442

A 3-unit system incorporated in a cabinet having a dissipated transmission line (ported labyrinth) for low frequencies. The cabinet, weighing 31.8kg, measures 787 × 381 × 305mm deep. Input connection is with banana terminal sockets and finishes in teak or walnut are available. Mid and HF five-position switches allow the response to be varied, but unfortunately no nominally flat position is indicated on them, which is most annoying. The speaker should be floor mounted. Two HP8B bass/mid units are provided, each of 200mm diameter, Bextrene coned and having 38mm extra long voice coils. Treble comes from a DT20 wide dispersion dome unit. Crossover frequencies occur at 250Hz and 3.5kHz, the network incorporating many components to give a claimed reasonable matching and electrical phase compatibility.

As seems usual with transmission line speakers, our sine wave on axis response chart revealed a lack of upper bass. Mid frequencies were reasonably smooth. At 5.5kHz a 5dB peak was noted but apart from this the high end was within borderlines of about 6dB showing a few significant hills and valleys. Off axis horizontally the shape was fairly similar, but frequencies above 12kHz were curtailed slightly. Vertically off axis a big dip occurred at 3.5kHz of some 25dB, and the response generally humped between 7kHz and 10kHz, above which the response rolled off fairly gently. The response controls vary HF within 5dB limits and MF 4dB. 2.7% 2nd harmonic distortion was noted at 150Hz and also 1.4% at 11kHz. Apart from this, harmonic distortion was generally below 0.7%. IM distortion reached a peak of 1.2% at 2.8kHz, but was significantly lower over the rest of its range. The most significant impedance dips are at 3kHz and between 8 and 10kHz (5.5 ohms modulus), but these are not really of much consequence. Electrical phase measured reasonably well. The loudspeaker had about average sensitivity, an output of 83dBA weighted being reached from our test signal (85dB unweighted). Somewhat surprisingly in our power test, bass cracked when the output reached 101dBA and we feel that this is rather poorer than expected. Amplifiers capable of a delivery of 50W RMS into 8 ohms would thus seem to be pretty compatible.

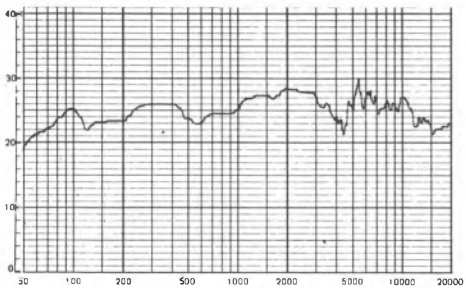
The classical music panel marked the loudspeaker as rather average and heard noticeable bass boominess, the low bass shaking the wooden floor somewhat excessively. Some members found the top end muffled whilst others regarded it as very peaky. Several people suggested the presence of a mid valley, which seemed very noticeable. Lower mid coloration was heard by most of the panel. The subjective effect of mounting the speaker on the floor quite clearly was to boost low and mid-bass whilst not reinforcing so much upper bass and mid. The humps in lower and higher HF quite clearly produced the subjective slight lack of mid. The pop music panel found voices to be somewhat adenoidal and there appeared to be a presence blanket and the panel also commented on the apparent hole at MF. They regarded the bass end as very good. They noted a lack of HF energy off axis. One member commented that bass rumble was present, which appeared to be on one note. The treble end was sometimes thin, edgy and bright. MF coloration was heard by most of the panel. Strings were rather unclear and yet forward. Continual comments about nasal quality were penned. The panel suspected a polar diagram problem and found that many instruments and also reverberation tended to recede.

This loudspeaker cannot really be recommended for either pop or classical music, although it initially gave a moderately good impression when we heard it at first in mono on axis. Nevertheless the price does seem reasonable and if you are interested then you should not purchase it without a demonstration on known material.

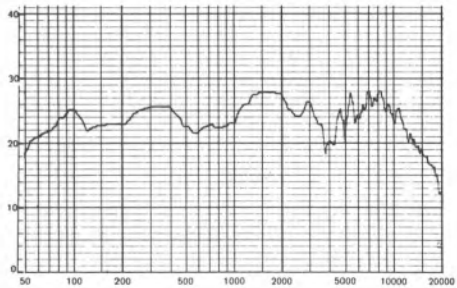


Height	787mm
Width	381mm
Depth	305mm
Weight	31.8kg
Finishes	Teak/walnut
Input connections	4mm banana sockets + L/S DIN socket
User adjustments	MF & HF
Lowest Impedance (Modulus)	5.5Ω9kHz/6Ω3kHz
Maximum SPL	101dBA
Sensitivity dBA pink noise 2.83V RMS 1m	83dBA
Recommended maximum amp power	50 watts
External volume	91.5 litres
Optimum listening height above base of speaker	600mm
R.R.P. (ex. VAT)	£189.00

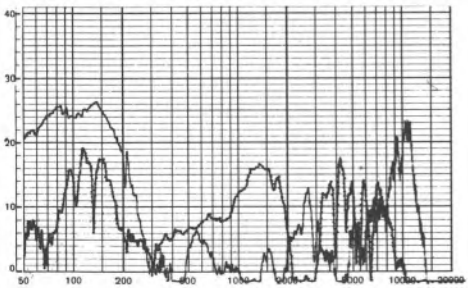
Occasionally discounted



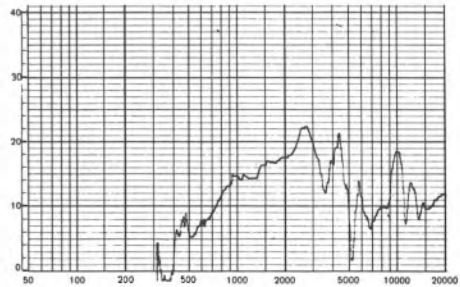
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2 - f_1$)

Sansui ES 200 (Improved)

Vernitron Ltd, Thornhill, Southampton SO9 5QF.
0703 444811

A three-unit system incorporated in a cabinet measuring 596 × 314 × 293mm deep, and weighing 15kg. Although Japanese designed, it is made in Belgium. The cabinet is finished in walnut, and has screw terminals for interconnections. It is designed for high plinth mounting, away from a wall or corner. The woofer is 255mm, the domed squawker is 35mm and the tweeter, also domed, is 19mm.

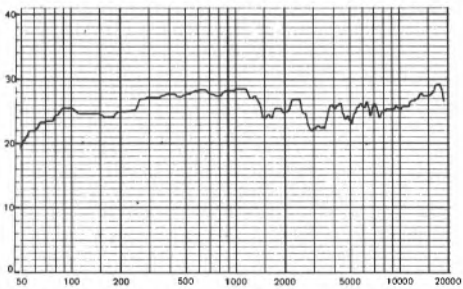
The sine wave on axis response was within 7dB borderlines from 60Hz to 20kHz, but the general trend showed a rise between 300Hz and 1kHz, a dip at 3kHz and rising EHF above 10kHz. A 10dB fairly broad dip occurred around 5kHz horizontally off axis, and frequencies above 10kHz were also slightly curtailed. Vertically off axis a broad dip, caused by acoustic cancellation, occurred with a maximum null of some 23dB being noted at 4.5kHz. I presume that the off-axis dips and nulls are caused by the diagonal placement relatively of the squawker and tweeter above the woofer. Harmonic distortion was below 1% throughout the range of 50Hz to 20kHz. Remarkably, the distortion above 1.2kHz is below 0.22%. IM distortion was generally below 0.5%, but one or two peaks above this were noted. Quite significant was the exceptionally low IM distortion below 0.1% between 2kHz and 8kHz. The impedance curve was most satisfactory, and the electrical phase measured well. The loudspeaker had about average sensitivity giving an output of 83dBA from our standard pink noise source (86dB unweighted). Our power test allowed an output of 105dB to be reached, at which point the speaker clearly became pretty confused and unpleasant.

The classical music panel unfortunately marked this speaker slightly below average, claiming it to lack presence. It seemed to reproduce vocalists as if mouths had platinum tipped teeth. Low frequencies seemed lacking, and some mid coloration was noticed. The sound was clearly strident and a little peaky. Some boxiness and plumminess were noted. It was rather difficult to nail the panel down to give a clear indication of their feelings, but in general no-one seemed to like it very much. On the other hand, only one member clearly disliked it. The panel suspected a polar diagram problem.

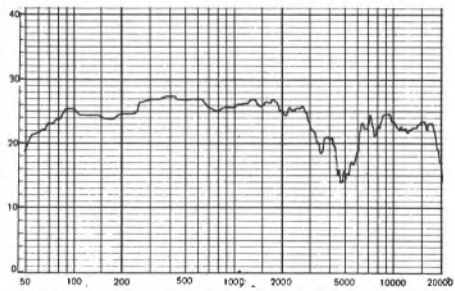
The pop music panel also rated it below average, stating it to lack bass punch, low bass frequencies not appearing to be reproduced at all. Again the sound was boxy and mid frequencies appeared colored and prominent. A hole was detected in the lower presence region, and upper presence was found a little peaky. Several remarked on poor separation of instruments and said the sound appeared slightly muddy and lacked real clarity. Again some of the remarks are difficult to reconcile with the pen charts and also with the extremely low general distortion produced, and I feel it advisable that you should listen to this loudspeaker yourself, for you may like its particular qualities. It can probably be purchased at a reasonable discount, in which case it could represent good value for money, though it is not clearly recommendable unless you can hear it for yourself. If appropriate, you should also bear in mind its relatively high output power potential.

Height	596mm
Width	314mm
Depth	293mm
Weight	15kg
Finishes	Walnut
Input connections	Screw terminals
User adjustments	none
Lowest Impedance (Modulus)	7Ω18kHz/7Ω2kHz
Maximum SPL	105dBA
Sensitivity dBA pink noise 2.83V RMS 1m	83dBA
Recommended maximum amp power	60 watts
External volume	54.8 litres
Optimum listening height above base of speaker	460mm
R.R.P. (ex. VAT)	£164.10

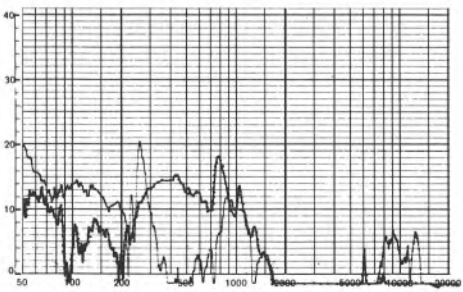
Normally substantially discounted



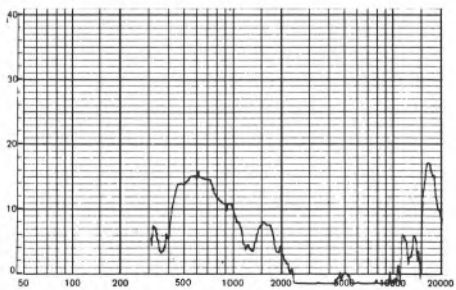
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2-f_1$)

SMC AL 12

Bedford Audio Supplies Ltd, 76 Bedford Road, Kempston, Bedfordshire. 0234 854133

A two-unit system in which, surprisingly, the bass unit is mounted above the tweeter. The acoustic labyrinth bass-loaded cabinet measures 597 × 292 × 295mm deep and weighs 14kg. It is available in teak as standard, with other finishes available to special order. The speakers are supplied in mirror image pairs, and banana sockets in parallel with a L/S DIN socket are provided for input connections. The speakers are designed for plinth mounting against a wall. The bass unit is a 210mm doped Bextrene cone with Neoprene surround, whilst the treble is a 19mm Melinex dome pressure unit. We note that ferrite cored inductors are used in the crossover, and these would have to be very good to avoid saturation.

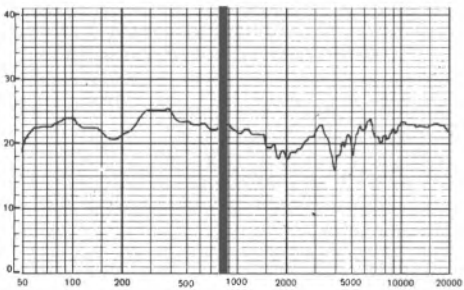
In the anechoic chamber, the on-axis sine wave response showed a slight 100Hz hump and a more significant hill around 350Hz. At 4kHz a 6dB dip occurred, but above this the response was reasonably flat, though marginally up as far as 20kHz. Horizontally off axis, a general presence dip occurred, and also EHF rolled off fairly noticeably. Vertically off axis, an acoustic cancellation occurred at 3.5kHz (−23dB) and above 9kHz the response fell off noticeably. Three second harmonic distortion peaks were noticed, at 200Hz (4%), at 550Hz (3%) and at 8kHz (1.8%). Third harmonic distortion was generally below 1.2%. IM distortion reached a peak of 1.6% at 600Hz, but otherwise was generally below 1%. The impedance curve was very satisfactory. Electrical phase showed excursions of +55° at 3.5kHz and −40° at 1kHz, and this is somewhat unusual at middle frequencies. The loudspeaker was very insensitive, giving an output of 78.5dBA weighted (82dB unweighted) from our test noise source. However in the power test, the bass unit hit the end stop at a level of only 95dBA, and this is most unfortunate since it obviously limits the available power output on bass transients. The speaker is rated at 30W music power, and 30W peak input on programme would only give an output level of 92dBA, which is barely adequate, unless you have a small room.

The classical music panel rated this speaker quite highly, although the entire panel commented on the mid boost. Almost everyone found the HF slightly up subjectively, and the sound quality was a little strident. A lack of presence was heard by some, and many found the bass to be missing. Although the sound quality was reasonably well liked, the severe power output limitation rather restricts our recommendation to those who will never want to play music even moderately loud. It is definitely precluded from being recommended for pop music addicts, and I suggest that the manufacturers should look into the bass loading problem carefully so that they can avoid undue excursions of the bass cone.

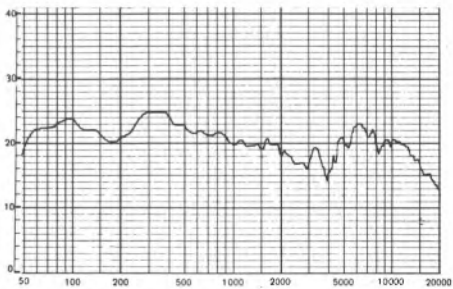
The price is reasonable, and the speaker's quality will obviously attract some purchasers. However, you are advised to try the loudest type of programme that you are likely to want in your home before deciding on their purchase. Recommended then, with considerable caution, and then only for music not containing too much power at lower bass frequencies.

Height	597mm
Width	292mm
Depth	295mm
Weight	14kg
Finishes	Teak
Input connections	4mm banana sockets + L/S DIN socket
User adjustments	none
Lowest Impedance (Modulus)	6Ω8kHz/7Ω400Hz
Maximum SPL	95dBA
Sensitivity dBA pink noise 2.83V RMS 1m	78.5dBA
Recommended maximum amp power	30 watts
External volume	51.4 litres
Optimum listening height above base of speaker	350mm
R.R.P. (ex. VAT)	£132.00

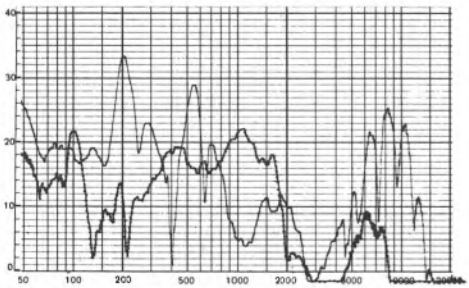
Not normally discounted



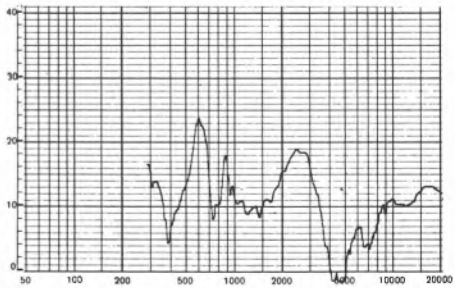
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2 - f_1$)

SMC AS 40

Bedford Audio Supplies Ltd, 76 Bedford Road, Kempston, Bedfordshire. 0234 854133

A three-unit system incorporated in a cabinet 635 × 324 × 356mm deep and weighing 18kg. It is apparently available only in teak. The system incorporates infinite baffle bass loading, with a 250mm bass woofer, a 120mm mid range and a 25mm tweeter. Screw terminals are provided for interconnection, and it is intended that the system should be on a plinth.

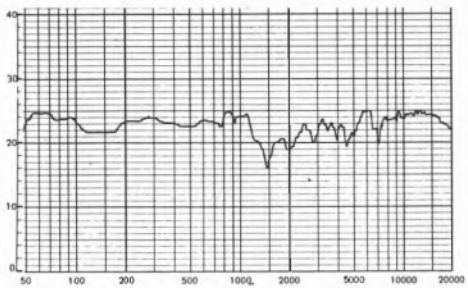
The on-axis sine wave anechoic response measured within borderlines of 5dB from 45Hz to 20kHz, with the exception of a dip of 6dB at 1.5kHz. Horizontally off axis the dip largely disappeared, but two dips became more marked at 3 and 5kHz (−5dB). High frequencies roll off such that 15kHz becomes −7dB. Vertically off axis the 1.5kHz dip degrades by 1dB and an additional acoustic cancellation appears of 10dB at 4kHz. High frequencies are well maintained. Above 200Hz all distortion components are below 0.7%. Some second harmonic distortion is developed in the bass region, peaking 5% at 70Hz. IM distortion was below 0.4% throughout. The impedance curve is very satisfactory, as is the electrical phase measurement. The loudspeaker is very insensitive, an output of only 79dBA being reached from our standard noise source (82.5dB unw). In our power test the squawker began to distort quite badly at 99dBA, but this is pretty loud anyway. The AS 40 is recommended for use with amplifiers of up to 50W RMS power rating, which should provide adequate level for small and medium sized rooms only.

The classical music panel found this loudspeaker to be generally rather bright, but two members off axis heard EHF loss. The speaker seemed deficient in low bass. It was generally quite well liked, and gave of its best on strings and vocal. It tended to be rather strident on pop music, and just a few members commented on slight mid coloration.

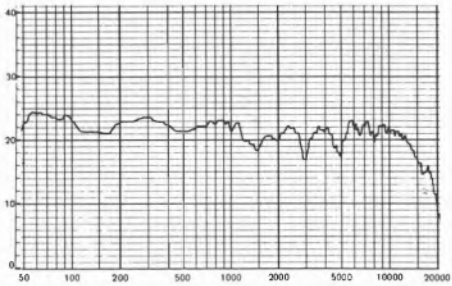
Our own in-house tests also showed the loudspeaker to give a pretty good sound quality, and at its price it should at least be considered against other comparatively priced units. The price is fairly reasonable, but there are nevertheless a few which did better generally and cost quite a deal less. It would only be fair to recommend it, though, provided that you can accept the comparatively poor sensitivity, have a not too large room, and can accept that it cannot give loud levels.

Height	635mm
Width	324mm
Depth	356mm
Weight	18kg
Finishes	Teak
Input connections	4mm banana sockets + L/S DIN socket
User adjustments	none
Lowest Impedance (Modulus)	7Ω10kHz/7Ω120Hz
Maximum SPL	99dBA
Sensitivity dBA pink noise 2.83V RMS 1m	79dBA
Recommended maximum amp power	50 watts
External volume	73.2 litres
Optimum listening height above base of speaker	570mm
R.R.P. (ex. VAT)	£177.78

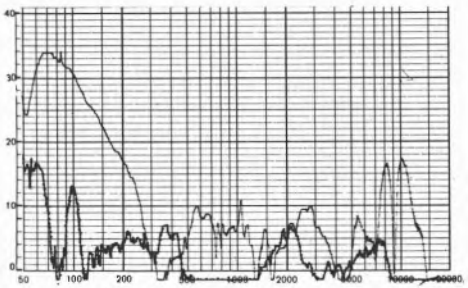
Not normally discounted



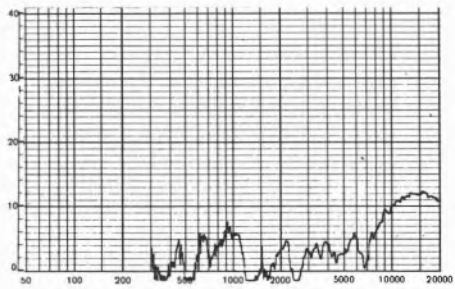
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2-f_1$)

Sony SS 5050

Sony (UK) Ltd, 134 Regent Street, London W1R 6DJ.
01-439 3874

The 5050 includes a three-unit system in a cabinet 630 × 365 × 318mm deep, and weighing 20kg. Mid and high-frequency potentiometers are provided for adjusting squawker and tweeter levels within a range of 6 and 4dB respectively. The bass unit is a 300mm cone made from a carbon fibre type material. The mid range unit is a 35mm dome type, and is complemented by a domed tweeter (25mm), which again is made from carbon fibre material. Terminals are provided for input connection, and the cabinet is available in walnut only. The system is designed for low plinth mounting.

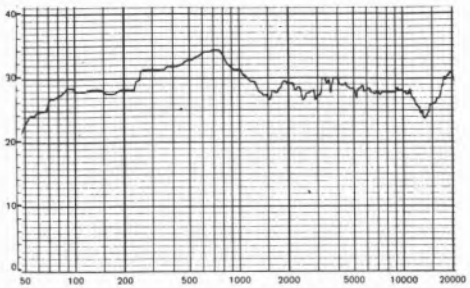
The sine wave on axis response showed a rapid fall-off of bass below 80Hz, and a marked MF hill peaking to +5dB at 700Hz. Above 1kHz the response is surprisingly flat to 10kHz, but shows a rapid fall off at 14kHz (−5dB), but is up again by 20kHz. Off axis horizontally the polar diagram is clearly poor since high frequencies above 3kHz are significantly curtailed (eg 10kHz is −7dB). Vertically off axis an acoustic cancellation occurs of 15dB at 5.5kHz, but above this the response is reasonably similar to the on axis curve. The pen charts give a clear indication of a poor polar diagram generally. Harmonic distortion measured below 0.5% from 80Hz to 20kHz, and this should be regarded as excellent. IM distortion is similarly good. The impedance never fell below 6.5 ohms modulus, and since the electrical phase does not vary by more than +10° to −20° from 100Hz to 20kHz this is clearly a very easy loudspeaker to drive. It has well above-average sensitivity, our pink noise test signal developing 87dB weighted (89.5dB unweighted) at a distance of 1 metre. The power test revealed severe mid-frequency distortion at 104dBA and thus I see no point in driving the loudspeaker from an amplifier rated higher than 50W, even a 10W amplifier giving adequate room volume.

The panel unfortunately rated the sound quality pretty low, finding the bass end very poor, and mid frequencies colored. High frequencies appeared to have a sock in front of them. Various comments were made about the speaker lacking about every frequency you can imagine, and I cannot help wondering what they thought it did have! Vocals appeared to come from a long plastic pipe, reproducing with a hollow quality. The speaker lacked definition, and mid frequencies were honky. The MF hill clearly contributed to this, and the sound was generally boxy anyway. The entire panel condemned this speaker, and I must assume that the very poor polar diagram horizontally was largely responsible.

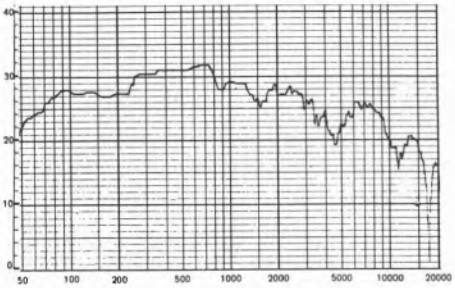
In our internal mono tests the speaker sounded acceptable when we were exactly on axis, but even so, still scored rather mediocre marks for quality. It is a pity that the sound quality was so poor, for the sensitivity was excellent. It would seem that carbon fibre is not the ideal material to use for loudspeakers, if the SS 5050 is a typical example, and in the circumstances I just cannot recommend this model. The price is rather high, and so the system is below-average value for money. My colleagues and I were so disappointed with this product, which could have been so much better if its designers had listened to it carefully on high-quality European music. I cannot understand how a loudspeaker with such a poor bass response can be so expensive, and an attempt must be made to iron out the response irregularities.

Height	630mm
Width	365mm
Depth	318mm
Weight	20kg
Finishes	Walnut
Input connections	Push lock terminals
User adjustments	MF & HF
Lowest Impedance (Modulus)	6.5Ω12kHz/6.5Ω2.5kHz
Maximum SPL	104dBA
Sensitivity dBA pink noise 2.83V RMS 1m	87dBA
Recommended maximum amp power	50 watts
External volume	73.1 litres
Optimum listening height above base of speaker	430mm
R.R.P. (ex. VAT)	£231.02

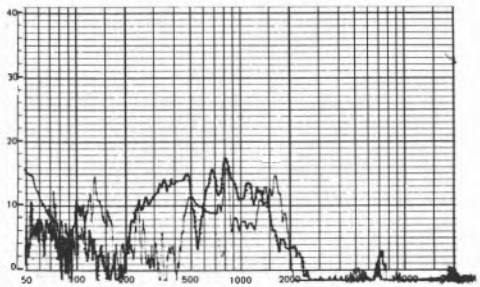
Occasionally discounted



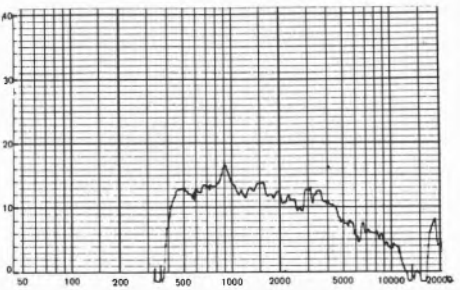
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2 - f_1$)

Spendor BC1

Spendor Audio Systems Ltd, Unit 12, Station Road
Industrial Estate, Hailsham, Sussex. 0323 843474

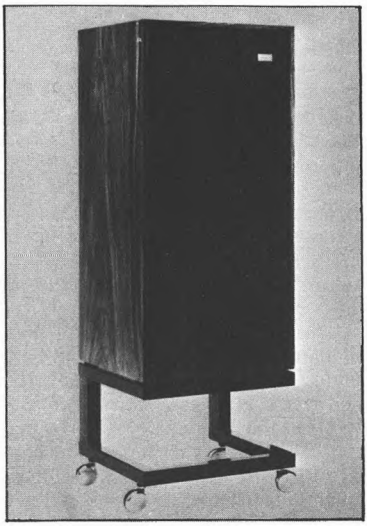
Originally a two-speaker system, but some years ago the manufacturers added an STC 4001G tweeter to the existing Celestion HF1300 squawker and 8" Bextrene cone bass unit, which has a 1" voice coil. The cabinet size is 635 × 298 × 305mm deep. The speaker is available in teak finish or at slightly extra cost in walnut or rosewood. Input connection is by means of 4mm banana terminal sockets. The weight of each speaker is 15kg approximately.

In the anechoic chamber the on-axis response showed a slight rise around 80Hz and a clear dip around 4kHz reaching a maximum cut of 5dB. An EHF fall off above 13kHz was fairly marked but the response came up again to flat by 17kHz. The pink noise on axis obviously smoothed out the dips, but still showed the general shape of the sine-wave curve. The horizontal off axis plot was very similar but showed a tendency to a 2½dB shelf down between 6kHz and 10kHz. The vertical off axis response exaggerated the dips found on axis, the 4kHz dip increasing to 14dB, whilst the 14kHz dip increased to 10dB. Generally, the IM distortion was around 1% at middle and high frequencies. Quite severe harmonic distortion, mainly second, was noted at low frequencies rising to a peak of 8% at 90Hz at our standard measurements level. At middle and high frequencies the distortion was in general pretty low but showed peaks at 3kHz , 11kHz (second harmonic) of 0.5%, and 3kHz and 7.5kHz (third harmonic) at also around 0.5%. The loudspeaker was rather less sensitive than average, an output of 80.5dBA being achieved at 2.83V input of pink noise (83dB unweighted). On our power test programme the loudspeaker gave severe audible deterioration at 101dBA, approximately the equivalent of full output without clipping from a 100W amplifier. Thus if the loudspeaker is driven on normal classical and pop programmes from a 50W capable amplifier, audible distortion should not be serious (except at VLF).

The impedance curve shows that at extremely high frequencies the impedance falls rapidly to a minimum of 5.5 ohms (modulus) at 19kHz. This impedance curve should be regarded as very satisfactory and no problems should be experienced when driving the speaker from a good amplifier. Electrical phase response showed variations from +55° at 12.5kHz and −35° between 500 and 900Hz.

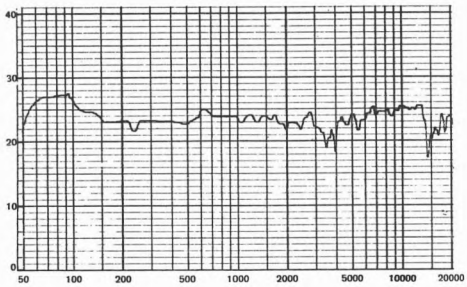
Unfortunately, the latest production samples of the BC1 as reviewed proved rather a disappointment to us, since subjectively they were rather muffled in the presence region, and most of the panel remarked on a lack of extreme top brilliance as compared with a pair of three-year-old samples used regularly in my company. The loudspeaker has a reputation of having extremely low coloration, although possessing a slightly bass boom and almost a honk at around 100Hz or so, which seemed to be slightly worse on the recent samples. When the loudspeaker was auditioned on a shelf rather than on its normal plinth, the bass boom became considerably exaggerated and was disliked by the listeners. Clearly the subjective effect of the bass rise and the lack of presence and extreme top gave the recent sample an unbalanced sound quality and the manufacturers said they would shortly attend to this problem in production. Due to this imbalance, increased coloration became audible at upper middle frequencies, and despite the good reputation and fame of this unit I feel it can only be recommended with caution at the time of writing. The stereo positioning was extremely accurate of both the old and new samples and over the years in many listening tests the BC1 has proved superior to most other loudspeakers here, in this respect. Notwithstanding the criticisms, my colleagues and I consider the BC1 still to be smooth in response subjectively, but possibly the bass unit is under damped.

Two other versions are available, one with high power output capability (the BC2) the other being a version including a monitor amplifier of either 25W or 50W rating. These latter models are known as the BC1AB 25 and BC1AB 50 respectively. Despite my criticisms, I can still honestly say that in many respects I like the sound of even the new samples, but unfortunately competition is stiff and Spendor will have to sort out their production problems. Their reference standard BC1 undoubtedly is one of the finest loudspeaker designs in the world and up to six months ago or so I have unhesitatingly recommended the BC1 very strongly. I hope that by the time you are reading this the quality of the speakers will be back to that of old and I strongly recommend that you hear the speakers for yourself in comparison with some of the competition, for you may like them very much. Even so they are very much a classical musician's speaker rather than a pop one.

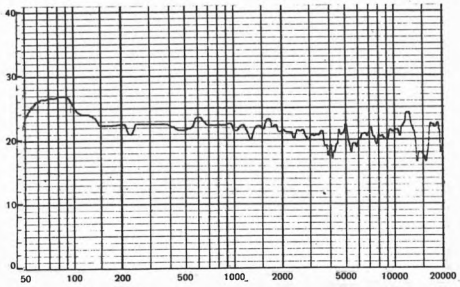


Height	635mm
Width	298mm
Depth	305mm
Weight	15kg
Finishes	Teak/walnut/rosewood
Input connections	4mm banana terminals
User adjustments	none
Lowest Impedance (Modulus)	5.5Ω19kHz/9Ω150Hz
Maximum SPL	101dBA
Sensitivity dBA pink noise 2.83V RMS 1m	80.5dBA
Recommended maximum amp power	50 watts
External volume	57.7 litres
Optimum listening height above base of speaker	440mm
R.R.P. (ex. VAT)	£205.80

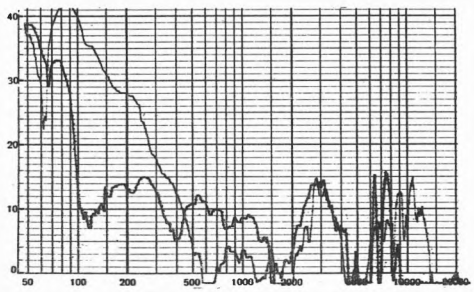
Occasionally discounted



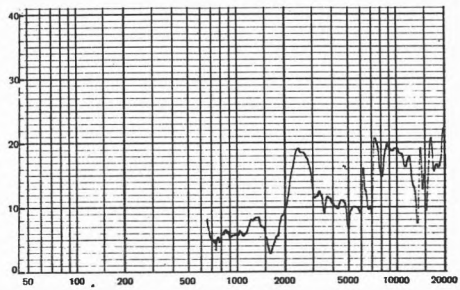
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2-f_1$)

Spendor BC3

Spendor Audio Systems Ltd, Unit 12, Station Road
Industrial Estate, Hailsham, Sussex. 0323 843474

Although some readers may class this as the big brother of the BC1, it is very different, employing a four unit system in a considerably larger cabinet, measuring 800 × 395 × 395mm deep, and weighing 34kg. The standard finish is teak, but walnut or rosewood are available at extra cost. Input connection is with a professional three-pin XLR socket, a type frequently used in studios. The system is designed for high plinth mounting away from a wall or corner, and suitable plinths are available. The bass unit is a Spendor Bextrene cone 300mm unit whilst the mid range unit is a Spendor 205mm Bextrene cone with a 38mm voice coil. The squawker is a Celestion HF 1300, and the super tweeter is a Celestion HC 2000. The system, a bass reflex type having two small ports, incorporates an extremely complicated crossover (see introduction) and is designed for high quality domestic and professional monitoring.

The sine wave on axis pen chart reveals a slight boost around 90Hz, followed by a little valley in the upper bass, returning to flat across the middle, but rising slightly at 1kHz. A dip at 4.5kHz to 6kHz is followed by a general HF tendency of shelving up, reaching a peak of +5dB at 10kHz, above which the response nulls in rather an odd way around 16kHz (−16dB), above which the response comes up again to +4dB at 18kHz. Off axis horizontally the response up to 4kHz is reasonably similar, but the 4.5kHz dip degrades by 2dB, above which the response shows a general loss of HF compared with the on-axis measurement. Vertically off axis, although the 4.5kHz suck-out is removed, one or two others appear, and again the tendency is for slightly less HF output. Both 2nd and 3rd harmonic distortion are below 0.7% from 70Hz to 20kHz, and bass distortion was dramatically superior to that of the BC 1, not rising above 1.4%, even at 50Hz. IM distortion is generally around or below 0.6%, but two peaks occur at 2 and 10kHz of 1.2% and 1% respectively. The impedance curve shows a fall to 5 ohms modulus at 1.5kHz and a further fall to 3 ohms at 20kHz. The electrical phase varied from +40 to −10°, but the combination of phase and impedance confirmed that this loudspeaker is slightly harder than average to drive adequately, and a reasonably good amplifier will be found essential to get the best out of it. The sensitivity was very slightly below average, our test signal developing a weighted output of 82.5dBa (85dB unweighted). At 105dBA, our power test showed bass frequencies to be coming out of the mid unit, with obviously deleterious effects. I recommend up to a 100W amplifier, but care should be taken to avoid continuous high frequency energy at high levels.

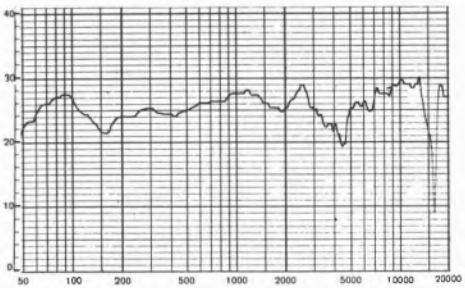
Our classical music panel heard slight mid-frequency coloration, but in general high and bass frequencies were less colored than average. The subjective effect of the HF peaks combined with the rise at 90Hz gave the impression of some mid suck-out resulting in comments of 'tunnelly'. Slight boominess was noticed on speech. Some listeners found the general response smooth, but there was a tendency to harshness and over brightness in the HF region. The stereo-image positioning produced some praiseworthy comments. The speaker fared well on orchestral music. The bass end seemed fairly extended and tight. The hole in the response at 4.5kHz was audible to the panel, two members also noting the EHF fall off.

The pop panel suggested that voices were slightly nasal and hollow. EHF frequencies were audibly down, but HF was too bright. Again the panel heard the 4.5kHz hole. Mid frequencies were slightly colored. Generally the bass end and HF were regarded as fairly clean, with the bass being quite well extended. The upper bass seemed less boomy and honky than average, which is an important point. Slight grittiness at HF was heard, with a suspicion of HF distortion, although this was difficult to confirm. Bass was said to be well defined.

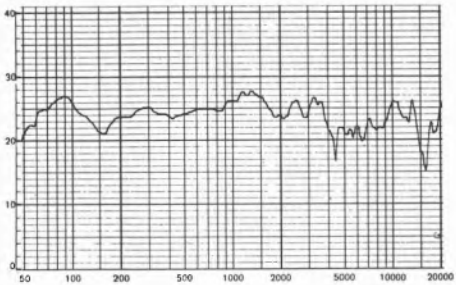
At its price this speaker can only be recommended with a degree of caution, and whilst the classical panel quite liked it, the pop panel were far more aware of its faults. Unfortunately the system employs an extremely expensive crossover, and this clearly affects the value for money aspect—which can only be considered as fair. Notwithstanding this, its apparent smoothness on pink noise shows the quality of the speaker, and this may encourage some purchasers.

Height	800mm
Width	395mm
Depth	395mm
Weight	34kg
Finishes	Teak/walnut/rosewood
Input connections	3 pin XLR socket
User adjustments	none
Lowest Impedance (Modulus)	3Ω20kHz/5Ω1.2kHz
Maximum SPL	105dBA
Sensitivity dBA pink noise 2.83V RMS 1m	82.5dBA
Recommended maximum amp power	100 watts
External volume	124.3 litres
Optimum listening height above base of speaker	640mm
R.R.P. (ex. VAT)	£396.80

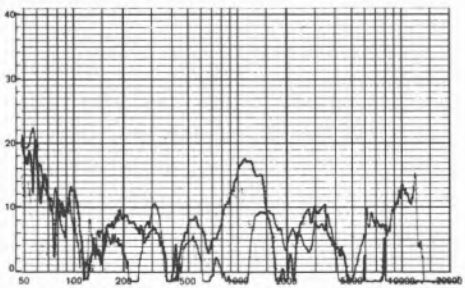
Occasionally discounted



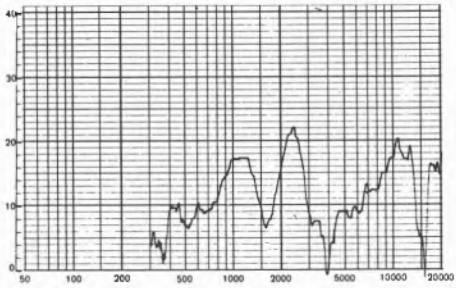
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2 - f_1$)

Tandberg TL 3520

Tandberg (UK) Ltd, Farnell House, 81 Kirkstall Road, Leeds LS3 1HR. 0532 35111

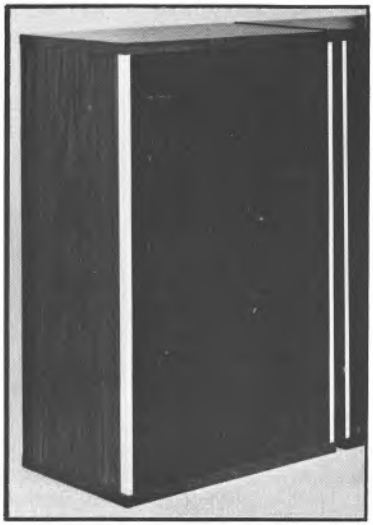
Although Tandberg give strong publicity to their receivers and recorders, their loudspeakers have received milder promotion. This model incorporates a three-unit system in an average-sized cabinet, 590 × 355 × 260mm deep, weighing 13kg. It is available in teak, rosewood, walnut or white, and connection is by screw terminals. Low plinth or shelf mounting is recommended, and we auditioned it on a plinth. The 254mm bass unit is complemented by a 70mm mid range and a 20mm domed tweeter.

The sine wave on-axis anechoic chamber chart showed a response within borderlines of only 2.5dB from 60Hz to 3kHz, but above the latter the frequency response shelves up 2dB and stays within 3dB borderlines to 10kHz, above which it rises again an additional 3.5dB at 15kHz. Although the response then seems good, the general trend of energy is very much in favour of high frequencies, and this clearly caused many of the panel comments. Off axis horizontally the response dips 6dB at 800Hz, and above 8kHz the response is curtailed somewhat as compared with the on axis measurements. Vertically off axis an 800Hz dip of 4dB is complemented by an unfortunate acoustic cancellation of some 15dB at 4kHz, and again the HF is curtailed, though only slightly, and still up rather than down. Third-harmonic distortion peaks 2.5% at 200Hz, but elsewhere is below 0.5%. Second-harmonic distortion peaks around 0.8% at 5kHz, 9.5kHz and 10.5kHz, but is generally significantly lower. IM distortion is always better than 0.5%. The impedance curve is very satisfactory, the only dip being a 6 ohm modulus at 150Hz which is insignificant. Electrical phase is also held within reasonable limits. The speaker had marginally above-average sensitivity, an output of 84.5dBA weighted (87dB unweighted) being reached from our standard pink noise source. 105dBA was reached in our power output test, at which level the bass unit was literally hitting its end stop. A 50W amplifier would seem to be perfectly suitable for this speaker, and at maximum output, a rather loud level of about 102dBA would be achieved.

Both panels found the low bass to be rather lacking, and the treble was generally considered hard and too bright, particularly at the very high end when the listeners were off axis. Nevertheless the sound quality was thought clean and clear at high frequencies, although some muddiness was noted in the lower mid region. The high frequency peak was clearly evident.

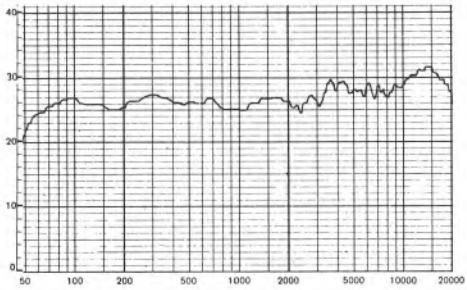
The panel said that the bass was very solid and clean, although very low bass was clearly lacking. They considered the presence response too forward, and obviously heard the shelf boost. The most praiseworthy continual comments referred to clarity and cleanness, but unfortunately it was considered that the HF boost might eventually cause listener fatigue. Cymbals were brittle and the general sound unrealistic. The loudspeaker was praised by two panel members, but the remainder scored it about average, giving the over-bright top as their reason for downgrading it.

I consider that in general this loudspeaker performed remarkably well, bearing in mind its response anomaly. It was certainly not rejected outright by anyone, but it seems clear that if the response were flattened somewhat it would have done appreciably better, and might have been fairly strongly recommended. No significant comments concerning coloration were made, but this may well have been due to the masking effect of the over-bright treble. I can recommend this speaker if you are prepared to accept its brightness, and perhaps it would sound better if the treble control was brought back a little. Once again, it has been designed for Continental markets, and would seem reasonable value for money. Its slightly above-average sensitivity is an advantage, allowing it to be used with low power amplifiers which will still provide quite adequate normal domestic listening levels without trouble. Recommended then, though with some reservations.

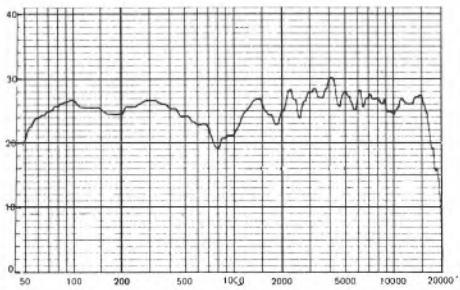


Height	590mm
Width	355mm
Depth	260mm
Weight	13kg
Finishes	Teak/rosewood/walnut/white
Input connections	Screw terminals
User adjustments	none
Lowest Impedance (Modulus)	6Ω150Hz/7Ω1.2kHz
Maximum SPL	105dBA
Sensitivity dBA pink noise 2.83V RMS 1m	84.5dBA
Recommended maximum amp power	50 watts
External volume	54.5 litres
Optimum listening height above base of speaker	420mm
R.R.P. (ex. VAT)	£173.78

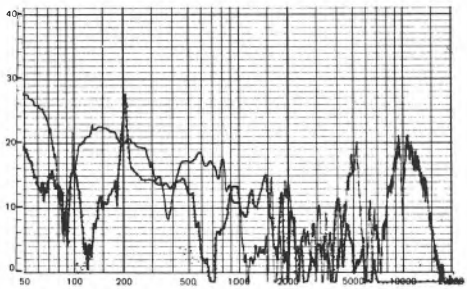
Occasionally discounted



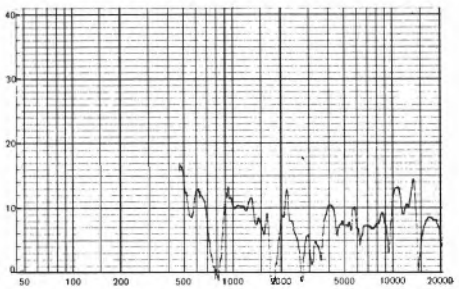
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2-f_1$)

Tangent RS 6

Tangent Acoustics Ltd, 3 Kesters Close, Hardwick, Cambs CB3 7QY. 0954 2658

This system is designed specifically for floor mounting, and incorporates three units in a cabinet 810 × 315 × 305mm deep, weighing 15kg. The bass unit, a KEF B200, is connected out of phase with the mid-frequency unit, a KEF B110, with a claim that the acoustic cancellation removes some of the boom and resonances of the two units. The tweeter, a KEF T27, has a wide dispersion dome. Input connection is with banana sockets, plus an L/S DIN one, and the cabinet is available in teak with other unspecified finishes to special order. The design is claimed to achieve better response linearity, and less susceptibility than average to room positioning by its use of acoustic negative feedback.

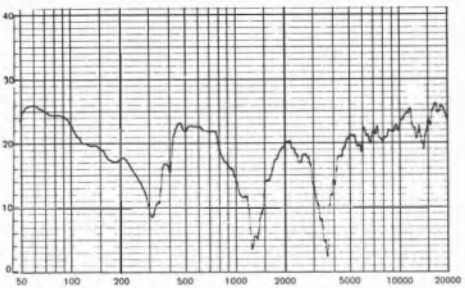
In the anechoic chamber the on axis sine wave response showed an expected acoustic cancellation of some 13dB at 250Hz, but additional cancellations were noted at 1.3kHz (−18dB) and 3.8kHz (−19dB), and hills of +3dB at 10kHz and +4dB at 15kHz were noted. At 50Hz a surprising rise of +4dB was penned. The same three dips also occurred off axis horizontally, but vertically the dips seemed to change frequency somewhat. Harmonic distortion was reasonable, but the chart irregularities in response make it exceptionally difficult to analyse. IM distortion fared about the same. The impedance dropped to only 4.5 ohms at 400Hz, and this is rather undesirable. The electrical phase also varied. The system was most insensitive, an output of only 76dBA weighted (80.5dB unweighted) being reached from our standard source. The power test produced an output of 99dBA at which point one of the units was heard to be hitting the end stop. The manufacturers recommend an amplifier of up to 100W rating, but even a 100W amplifier would only give maximum levels of around 98dBA in normal mounting conditions, which is hardly satisfactory for such a large speaker system.

In our mono tests, when we were sitting precisely on axis and at the best possible position, the loudspeaker sounded reasonably good, although we were well aware of the low mid suck-out.

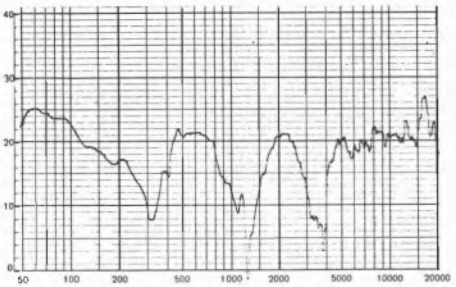
In stereo, however, our classical music panel rated the speaker very poor. The entire panel commented that the sound was all heavy boom and tizz, with clear evidence of mid and upper presence suck-outs. A serious bass boom problem with the continually audible suck-outs made the sound strongly disliked. The reproduction was also at times said to be plummy. The balance was said to be completely wrong, and such comments as 'where has the mid gone?' were typical. It seems pretty clear that the idea of using acoustic negative feedback by changing the phase of one unit is highly dangerous; although the loudspeaker might measure flatter in a reverberant surrounding, listeners always note the direct sound first, and if this is anomalous severe criticism results. Unless you are a bass frequency freak, I cannot possibly recommend this loudspeaker, especially considering its comments in stereo. Its price is also on the high side. Perhaps I should finish by at least praising the general lack of coloration of the system, and on some types of programme material I must admit that the sound was quite exciting (eg cathedral organ), although when the volume was increased signs of clipping became evident. Not recommended though, until the design problems are corrected.

Height	810mm
Width	315mm
Depth	305mm
Weight	15kg
Finishes	Teak
Input connections	4mm banana sockets + L/S DIN sockets
User adjustments	none
Lowest Impedance (Modulus)	4.5Ω450Hz/6.5Ω15kHz
Maximum SPL	99dBA
Sensitivity dBA pink noise 2.83V RMS 1m	76.5dBA
Recommended maximum amp power	100 watts
External volume	77.8 litres
Optimum listening height above base of speaker	560mm
R.R.P. (ex. VAT)	£230.96

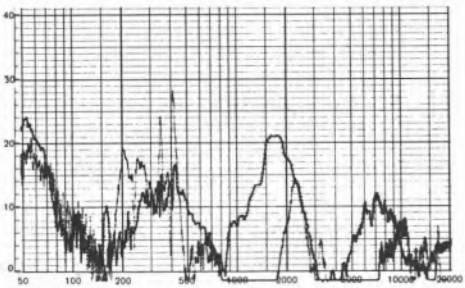
Not normally discounted



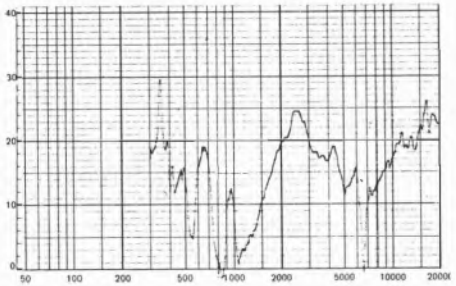
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2-f_1$)

Tannoy Cheviot

Tannoy Products Ltd, Canterbury Grove West, Norwood, London SE27 0PW. 01-670 1131

The Cheviot uses the same basic Tannoy 315mm dual concentric unit as the Devon, but the ported cabinet is larger, measuring 850 × 450 × 260mm deep, and weighing 34.5kg. The same roll off and energy controls are provided (see Devon review) and ash, teak or walnut finishes are available. The system incorporates push lock terminals, but unlike the Devon, is designed for floor mounting away from a corner, though it can be against a wall.

The anechoic chamber on axis chart revealed more peaks and valleys than the Devon, and we must assume that these variations are caused by cabinet resonances and damping effects. The same tendencies can also be noted in the off-axis response. One typical example of response differences between the two is the presence of a 7dB peak at 9.5kHz on axis, and this became audibly rather unpleasant. The pre-set adjustments gave similar variations to those of the Devon. The distortion in general was also similar, but marginally higher, and we must assume that perhaps any differences might be typical differences between units. The impedance and electrical phase response were also very similar and highly satisfactory. The system however is still more sensitive, a remarkable 89dBA weighted output being achieved from our standard pink noise source (91dB unweighted). An astonishing 113dBA was reached in our power test, at which point mid again suffered severely. The same power rating would apply, and we recommend amplifiers of not more than 60W rating for normal purposes, but perhaps slightly more powerful amplifiers might be used on material without high energy levels at low bass frequencies. This remarkable sensitivity thus allows very loud output levels to be achieved even from modest amplifiers. A 25W one, for example, would give a peak output around 103dBA! The loudspeaker could even reach normal room volume when driven from a transistor portable.

One member of our classical music panel wrote a marvellous pun when he said 'a rather nasal loud peaker'! High frequencies were strident, peaky and coarse, and mid frequencies were found too forward. The bass end was a bit tubey, but extended well down (obviously the effect of floor loading). Subjectively the EHF seemed down, but this was probably due to the 10kHz peak.

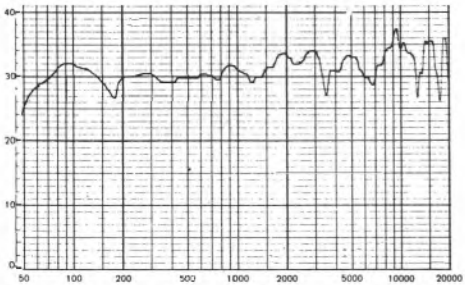
The pop panel said that bass frequencies shook the floor, but they were upset by an apparent hard upper mid-peak in the lower presence region. Top was said to be piercing with peaks. Again the quality was hard, hollow and tubey, or hard, thin and stringy. Some bass was soggy and mid-range coloration was frequently noted. Many other such derogatory adjectives were used to describe the HF end.

I myself noted that pink noise sounded rather like a steam locomotive blowing a gasket, and top appeared fierce. Brass was edgy, and vocal sibilant. Quite clearly, then, the 10kHz boost was generally objectionable, but could not be corrected without severe loss occurring at 15kHz.

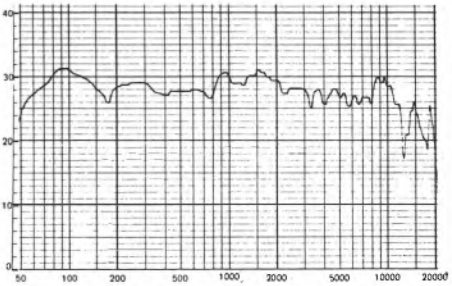
Notwithstanding all these comments, the speaker was at times liked in our mono tests, but the sound quality must be regarded as highly suspect, although some readers may find it attractive. The main virtue of this speaker is its incredible sensitivity and power output capability, and its reproduced quality may well be adequate for specialised purposes. I can definitely not recommend it though for normal-level domestic listening on either classical or pop material. Its price is reasonable for its size and efficiency, and perhaps some recording engineers might find its quality acceptable, though I advise considerable caution if it is used for sound balance. Perhaps third-octave equalisation might improve its sound quality considerably for such applications.

Height	850mm
Width	450mm
Depth	260mm
Weight	34.5kg
Finishes	Ash/teak/walnut with sand/blue/brown grilles
Input connections	Push lock terminals
User adjustments	HF
Lowest Impedance (Modulus)	7Ω125Hz/9Ω10kHz
Maximum SPL	113dBA
Sensitivity dBA pink noise 2.83V RMS 1m	89dBA
Recommended maximum amp power	60 watts
External volume	99.4 litres
Optimum listening height above base of speaker	580mm
R.R.P. (ex. VAT)	£254.00

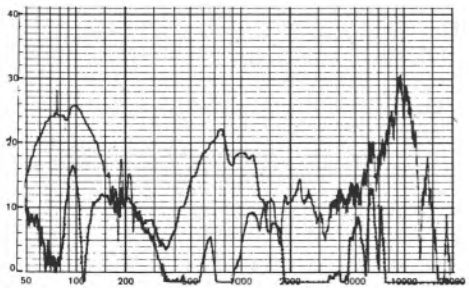
Occasionally discounted



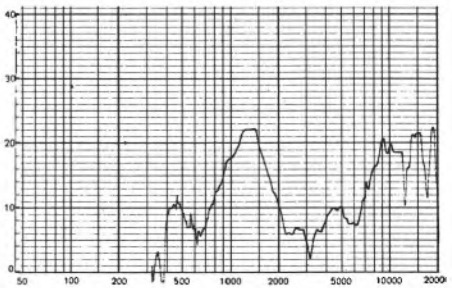
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2-f_1$)

Tannoy Devon

Tannoy Products Ltd, Canterbury Grove West, Norwood, London SE27 0PW. 01-670 1131

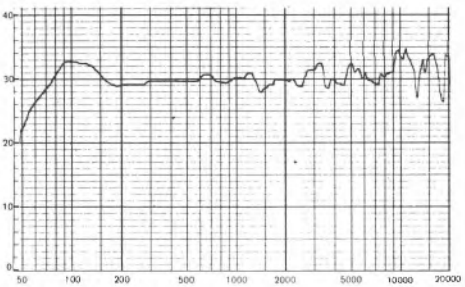
This system incorporates a 315mm dual concentric unit in which both sections are fed independently from an external crossover. The port-loaded cabinet measures 580 × 400 × 260mm deep, weighing 21kg, and is available in teak, ash and walnut with sand, blue or brown fronts. Two pre-set switches vary the general position of the presence and high frequency shelf, and also change the high frequency roll-off characteristic, being named energy and roll-off respectively. Push lock terminals are used for input connections. The system is designed for shelf mounting, as close to a back wall as possible. The HPD 315A dual concentric speaker incorporates a direct radiator for bass unit, including at its centre an independent high frequency compression driver. The bass voice coil (51mm) has a long throw action, and incorporates a high temperature dissipation mechanism, allowing it to reproduce very high sound pressure levels. The tweeter section, horn loaded, also has a 51mm voice coil with similar properties.

In the anechoic chamber, the bass end dropped below 60Hz, but showed a rise of 3dB at 100Hz. The response extended within borderlines of only 4dB to 9kHz. Unfortunately, the response then rose to +4dB at 10kHz, but −3dB at 13kHz and +4dB again at 15kHz, above which it continued to waver markedly. Off axis horizontally, high frequencies drooped about 5dB, no acoustic cancellations occurring. Similarly vertically off axis, the response also became shelved down at HF. The HF roll off switch adjusted the 10kHz response by 3dB, 6dB and 7dB, the last position affecting 15kHz substantially. The energy switch affected total presence and HF output by shelves of +1.5 and +3dB at 10kHz. In general, the harmonic distortion was better than 1%, although it peaked just above this at 100Hz and 10kHz respectively (2nd harmonic). IM distortion reached a peak of 1.2% at 1.5kHz, but also measured 1% at 10kHz and 15kHz, which probably emphasised the audible peakiness heard by the panel. The impedance was very satisfactory, and the electrical phase was held within reasonable limits. The system was well above normal sensitivity, 87.5dBA weighted being reached from our standard pink noise source (90dB unweighted). Our power test revealed an astonishing 110dBA output before mid frequencies cracked, but at this level the volume was literally agonizing. The manufacturers rate the system at 60W at which a weighted output of around 105dBA maximum would be achieved, and this is very loud indeed. With care, somewhat more powerful amplifiers might be used, but sustained low frequency peaks from instruments such as bass guitars will undoubtedly cause cone and coil former damage.

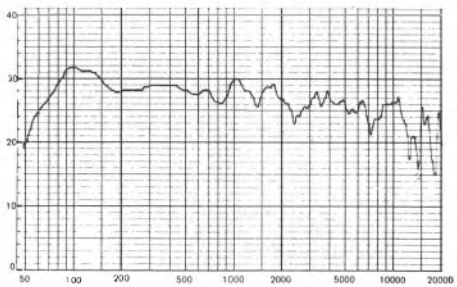
The panel found the sound very peaky at the HF end, and bass seemed surprisingly lacking on heavy pop material. Some mid-frequency coloration was evident, and several commented that high frequencies were also concerned—a comment only rarely made in this survey. One member noted the EHF valleys. Vocal definition was pretty good. One experienced pop engineer quite liked the sound generally, and found it very dry. At times the quality seemed raspy and spitty, particularly on brass. The Devon was clearly preferred to the Cheviot, but speech appeared to boom slightly and sometimes became nasal. Both panels varied in their opinions from pretty poor to slightly above average, and thus the sound quality appears to be very much a personal taste. It did not do quite as well as expected, but was clearly preferred to the more expensive JBLs. I cannot recommend it for normal domestic listening, though I can recommend it for some monitoring applications requiring high levels, the problem being the rarity of anything significantly better with lower coloration and a better sound quality which also gives a very high output level. Reasonable value for money.

Height	580mm
Width	400mm
Depth	260mm
Weight	21kg
Finishes	Teak/ash/walnut with sand/blue/brown grilles
Input connections	Push lock terminals
User adjustments	HF
Lowest Impedance (Modulus)	7.25Ω140Hz/8Ω12kHz
Maximum SPL	110dBA
Sensitivity dBA pink noise 2.83V RMS 1m	87.5dBA
Recommended maximum amp power	60 watts
External volume	60.3 litres
Optimum listening height above base of speaker	330mm
R.R.P. (ex. VAT)	£240.00

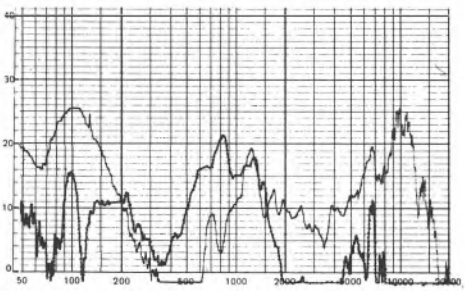
Occasionally discounted



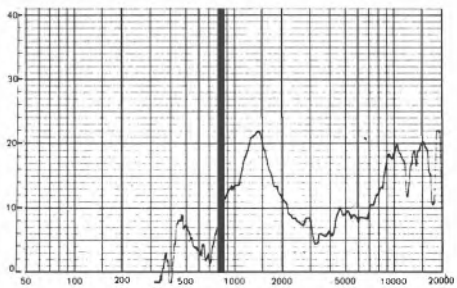
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2-f_1$)

Western Audio Research HD 7575

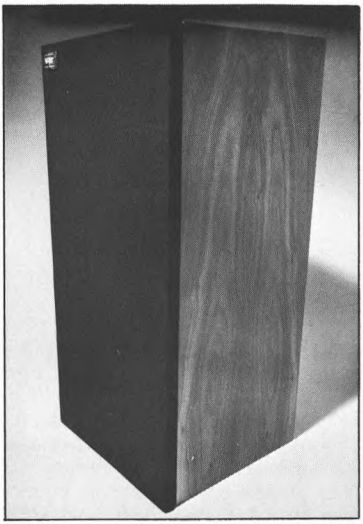
Western Audio Research, Chosen View Road, Cheltenham, Glos. 0242 34749

A three unit system mounted in a fairly large cabinet measuring 763 × 355 × 320mm deep, and weighing 19.5kg. Burmese teak or American walnut finishes are available, and banana terminals are supplied for interconnection. No adjustments are supplied. The system is designed for plinth mounting, and employs a 315mm Bextrene cone for bass, having a 51mm voice coil, a 116mm Bextrene cone for mid range enclosed in an isolated pressure chamber, and an integrated plastic dome tweeter. The system is termed an acoustic suspension with infinite baffle loading.

On axis the anechoic chamber sine wave pen chart showed a pretty flat bass response extending down to 55Hz, although a 2dB dip occurred at 150Hz. Mid was slightly up, but a 7dB hole appeared at 1.5kHz, which was approximately ½ octave wide. The presence region was slightly backward with an additional dip at 2.4kHz, and above this the response was fairly flat to 10kHz, but showed a rise of 3.5dB at 15kHz. Off axis horizontally, a 6dB hole appears at 5kHz, and the only other significant change is a slight loss of EHF so that 15kHz becomes −4dB. Vertically off axis a large cancellation occurs at 5.8kHz, of some 19dB, but the EHF response is maintained. Third harmonic distortion is very low throughout, always measuring below 0.4%. Three peaks in the second harmonic distortion occur at 1.4kHz and 4kHz and very markedly at 10.5kHz, amounting to some 3%, this being typical, it seems, of Isophon tweeters. IM distortion was better than 0.5% throughout. At 5kHz the impedance modulus drops to only 3.75 ohms and 5.5 ohms at 2kHz. This impedance drop is frankly too marked, and some trouble may be experienced with amplifiers giving reduced power in to less than 8 ohms. Electrical phase measured between ±40° throughout the audio range. The loudspeaker was below-average sensitivity, but still acceptable, giving an output of 81dBA weighted (84dB unweighted) from our pink noise source. The power output test produced 105dBA, at which point mid and top frequencies became extremely dirty. I recommend that amplifiers up to 100W RMS rating can be used, provided that prolonged high energy peaks are avoided, and the amplifier is not driven near its maximum all the time. A 25W amplifier should provide adequate room volume.

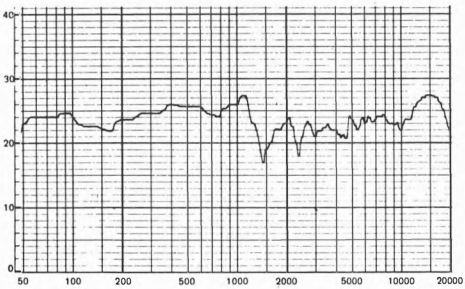
Both the classical and pop music panels heard mid-frequency coloration. The bass end was tighter than average, and extended reasonably well down. High frequencies were said to be rather bright, this being caused by the EHF rise with the presence frequencies suck-outs noted in the chamber. High frequencies tended to be somewhat piercing, particularly on string tone. Tape hiss was audibly emphasised. Cymbals sounded rather nasty, and comments of suspected HF distortion were made, which seemed to be consistent with the problems that we have found continually with the type of tweeter used. Whilst some panel members regarded the sound quality as being very open and crisp, others found it tiring and tending to be confused at times, so it is rather difficult to generalise. Both panels found the speaker to be over-bright, particularly at EHF, but in general they quite liked the sound and it could obviously be improved by turning down the treble control of the amplifier driving it. HF distortion was also noticed on vocal sibilants, some raspiness also being noted. The speaker scored two high marks, with the remaining ones fairly average, and this shows that the system is certainly worth hearing.

My colleagues and I in our mono listening tests found the speaker to be quite acceptable generally, but felt that the tweeter had a problem which should be dealt with by the manufacturers. This system is another which I consider a borderline for recommendation. Although it is fairly expensive. I consider it moderate value for money. Don't forget that loudspeakers having an EHF rise may well subjectively emphasise pick-up cartridge ringing, and noisy surfaces on discs, and this problem might well be exaggerated by the 10.5kHz distortion area.

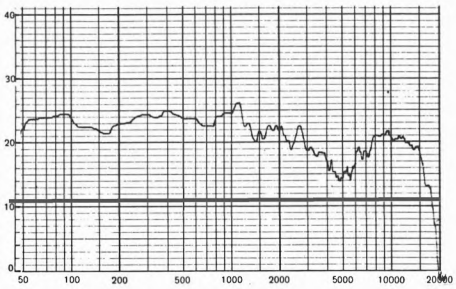


Height	763mm
Width	355mm
Depth	320mm
Weight	19.5kg
Finishes	Burmese teak/American walnut
Input connections	4mm banana terminals
User adjustments	none
Lowest Impedance (Modulus)	3.7Ω5kHz/5.5Ω1.5kHz
Maximum SPL	105dBA
Sensitivity dBA pink noise 2.83V RMS 1m	81dBA
Recommended maximum amp power	100 watts
External volume	86.7 litres
Optimum listening height above base of speaker	540mm
R.R.P. (ex. VAT)	£270.00

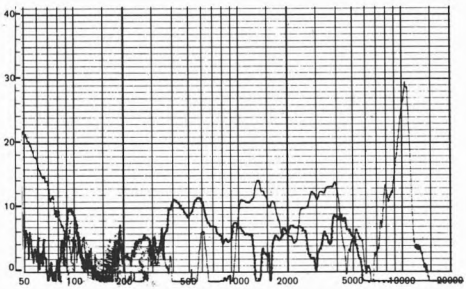
Not normally discounted



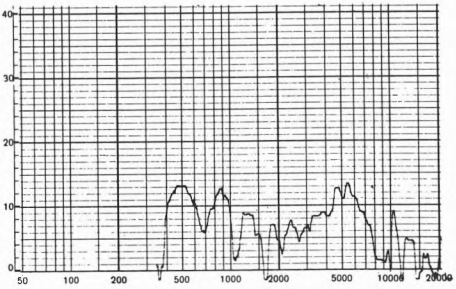
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2-f_1$)

Wharfedale Dovedale SP

Rank Audio Products Ltd, P O Box 70, Great West Road, Brentford, Middlesex. 01-568 9222

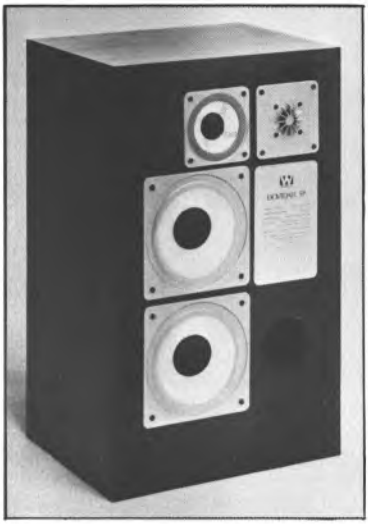
Wharfedale are one of the oldest established loudspeaker manufacturers in the world, and are now controlled by Rank. The Dovedale is a four unit system in a cabinet 635 × 392 × 317mm deep, weighing 23kg. Loudspeaker DIN sockets, in parallel with screw terminals, are provided for interconnection, and teak or walnut finishes are available. The system is designed for low plinth or floor mounting. Two bass woofers driven in parallel are both 170mm Bextrene cone types, and the mid range unit is a 100mm Bextrene cone with a doped suspension. The tweeter is a 30mm dome type.

The axial sine wave response showed a cancellation of 15dB at 720Hz, which was clearly audible. Rises either side of it are peaked up 3.5dB at 600Hz and 2dB at 1.8kHz, which naturally tended to exaggerate the effect of the hole. The response hovers within 3dB up to 10kHz, but above this a peak of some 4dB was penned at 13.5kHz, above which was a sharp dip of 8dB. 50Hz measured approximately 3dB down. Off axis horizontally the 720Hz dip deteriorated dramatically to −24dB and another cancellation occurred at 3kHz of 25dB. EHF rolls off noticeably. The dip at 720Hz reduces somewhat off axis vertically, but apart from this the response follows the on axis one, but showing an additional 5dB dip at 10kHz. At the 700Hz dip a second harmonic distortion output of 2.2% is noticed, referred to the nominal flat response. The fundamental, however, was clearly down at this frequency, which would emphasise the effect of the distortion. Apart from this, harmonic distortion was below 1%. At 1.5kHz the intermodulation distortion reached 1.8%. At 13kHz and 16kHz, we also noticed approximately 2.2% again, which is none too good. The impedance modulus drops to 5 ohms at 1.5kHz, but otherwise the curve looks satisfactory. The electrical phase held within limits of ±40°. The loudspeaker had average sensitivity, 83.5dBA weighted being reached in the test (86.5dB unweighted). In the power output test, when the volume reached 105dBA bass frequencies became very dirty indeed, this point being equivalent to the full output from a 100W amplifier. A 50W amplifier should be more than satisfactory for this system, and even a 20W one would give adequate room volume.

The pop music panel downed this speaker somewhat dramatically, hearing the mid suck-out very clearly. The sound was said to be muddy, tunnelly and very colored, and high frequencies were audibly peaky. Clarity was missing at high frequencies, and the upper presence region sounded very brittle. One panel member commented that vocalists' mouths seemed to be lined with metal. The panel suggested serious response anomalies (confirmed by pen charts). One member heard the polar diagram problem, also detecting the upper mid hump, and suggested that the speaker honked. Voices lisped, and several actually heard the 15kHz dip. The entire panel disliked the speaker, the main problems being mid and HF peakiness and bad coloration.

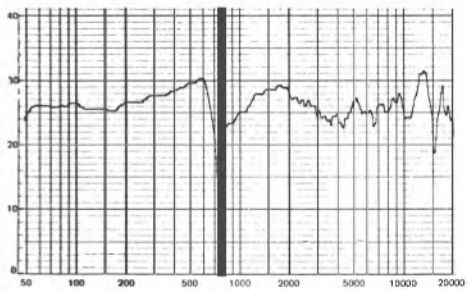
The classical panel made very similar remarks, also noting that high frequencies were scratchy.

My colleagues and I unfortunately must confirm the panel opinions, and because of this the Dovedale cannot be recommended in this book. The serious response anomalies must be looked into by the manufacturers for they are inexcusable in what is after all a fairly costly system. There are many other speakers in this survey which sound appreciably better and cost less.

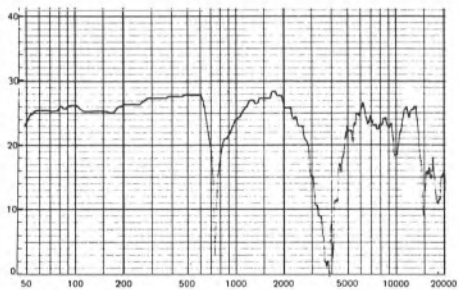


Height	635mm
Width	392mm
Depth	317mm
Weight	23kg
Finishes	Teak/walnut
Input connections	Screw terminals + L/S DIN socket
User adjustments	none
Lowest Impedance (Modulus)	5Ω1.7kHz/7Ω150Hz
Maximum SPL	105dBA
Sensitivity dBA pink noise 2.83V RMS 1m	83.5dBA
Recommended maximum amp power	50 watts
External volume	78.9 litres
Optimum listening height above base of speaker	480mm
R.R.P. (ex. VAT)	£175.32

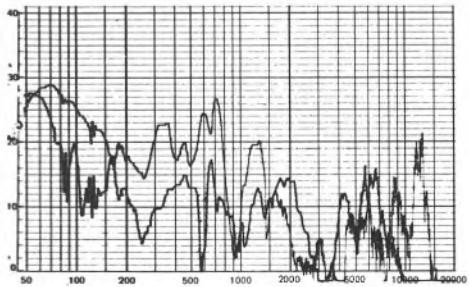
Normally substantially discounted



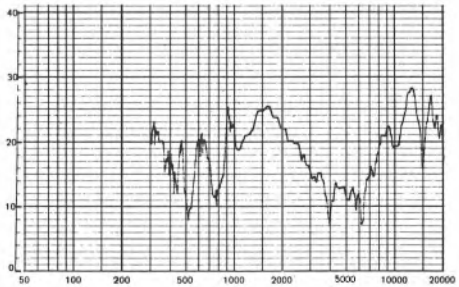
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2 - f_1$)

Yamaha NS 645

Natural Sounds Systems Ltd, Strathcona Road, North Wembley, Middlesex HA9 8QL. 01-904 0141

This two-speaker system is equipped with a treble control which can boost or completely cut off the output from the tweeter. The cabinet measures 540 × 300 × 259mm deep and weighs 11.6kg. It is only available in teak. Push lock terminals are provided for interconnection. A 250mm cone woofer is complemented by a 45mm soft dome tweeter, and the system is an infinite baffle type. The NS 645 is designed for front edge mounting on a shelf.

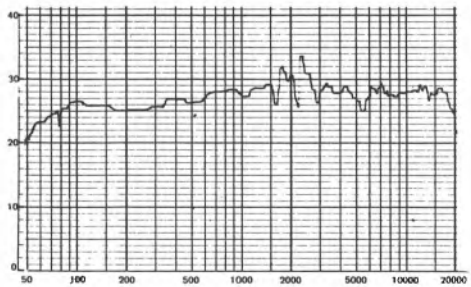
The anechoic on-axis sine wave response shows a shelf dip in the upper bass of around 2dB, and below 70Hz the bass falls fairly sharply. Between 1.5kHz and 2.8kHz the response wavers appreciably, the main peak being at +6.5dB at 2.3kHz. Apart from this, the loudspeaker's response is generally held within 4dB borderlines from 80Hz to 20kHz, the high frequencies being remarkably flat. In general the HF energy is towards the top limit whereas MF energy is a few dB down, with the aforementioned borderlines. The treble control was able to lift the 10kHz response up by a maximum of 1dB and could take it down any required amount, or indeed turn the tweeter off completely. This control is mounted on the front panel behind the removable grille. Horizontally off axis, HF becomes slightly curtailed, and the two mid peaks degrade slightly. Vertically off axis, a very sharp acoustic cancellation occurs of 10dB at 2.3kHz, which is not as serious as some cancellations have been in this survey. The HF remains satisfactory, but at 1kHz a hill becomes noticeable. Above 80Hz harmonic distortion is better than 1%. IM peaks 1.3% at 1.2kHz, but is otherwise lower. The speaker is nominally 4 ohms impedance and reaches a minimum modulus of 3.5 ohms between 5 and 7kHz. Amplifiers specified to work into 4 ohms would be satisfactory, but many 8 ohm rated models may well be incompatible. Electrical phase variations were rather wide, varying from +50° to −50°. The speaker was marginally above average sensitivity, which is to be expected from its low impedance, an output of 85dBA weighted (88dB unweighted) being reached from our 2.83V RMS pink noise source. The power output test showed that at 104dBA mid frequencies became very confused and muddy, but this level was pretty loud, of course. A 4 ohm specified amplifier of 25W rating should be more than adequate to drive this speaker, but probably a 50W one would not cause harm if used carefully.

Both the classical and pop music panels heard some phasing problems in this system, and noted that stereo images were decidedly wider and more diffuse than they should have been. The sound quality was very clear and clean at HF, but was said to be rather bright—though not extremely so. The upper mid range was found slightly forward. Low bass did not reproduce too well, but mid frequencies were only slightly colored. High frequencies did improve slightly when the treble control on the speaker was turned down a little, tending to reduce the hardness. Throughout the panel tests many remarked that the sound was clean. The upper bass and lower mid received favourable comments.

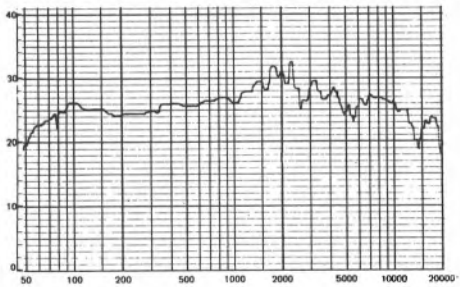
It seems a pity that this system produced a phasiness which upset a number of the stereo-listening panel members. My colleagues and I also confirm this problem, but I should emphasise that the loudspeaker was liked, and would have been reasonably recommendable judging purely from the mono listening tests. It seems possible that the stereo positioning problem arose because the tweeter is quite a distance away from the woofer vertically, and also slightly to one side of it, or else from the 250mm unit being crossed over rather too high. We found it very difficult to obtain a stable central image on white and pink noise—much more so than with most of the other loudspeakers surveyed. At its price the loudspeaker is quite reasonable value for money, and if you are not too worried about phasiness and if your room is reverberant you might well consider this model for its good sensitivity and pretty good output potential. I cannot recommend it, though, for critical listening.

Height	540mm
Width	300mm
Depth	259mm
Weight	11.6kg
Finishes	Teak
Input connections	Push lock terminals
User adjustments	HF
Lowest Impedance (Modulus)	3.5Ω6kHz/4.5Ω140Hz
Maximum SPL	104dBA
Sensitivity dBA pink noise 2.83V RMS 1m	85dBA
Recommended maximum amp power	*25 watts
External volume	41.9 litres
Optimum listening height above base of speaker	350mm
R.R.P. (ex. VAT)	£141.60

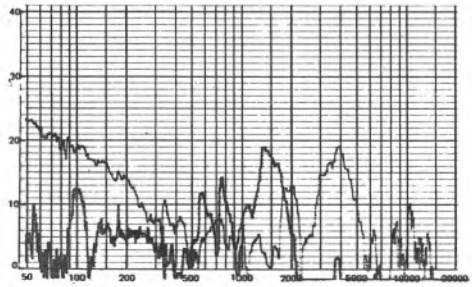
Not normally discounted



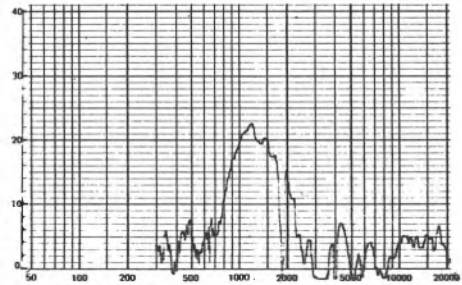
Sine wave on axis response



30° off axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2-f_1$)

Yamaha NS 1000M

Natural Sound Systems Ltd, Strathcona Road, North Wembley, Middlesex HA9 8QL. 01-904 0141

The 1000M is the top speaker in the Yamaha range marketed in the UK. It has already established itself as a professional monitor in several countries, but has only recently come to the UK. The three unit system is built into a cabinet measuring 675 × 375 × 326mm deep and weighs 31kg. Despite its reasonable size, though, it is very heavy. Adjustments, located on the front panel behind a detachable grille, allow variation of mid and HF outputs, with boost and complete cut available at extremes. The cabinet is finished in black ash, and is designed for high plinth mounting. Push lock terminals are provided for input connections. The bass unit has a 300mm cone, whereas the squawker has an 88mm Beryllium dome. The tweeter has a 30mm Beryllium dome. All units have a mesh cover over them, making the system very presentable even when the overall grille is removed.

In the anechoic chamber the sine wave on axis chart showed a bass roll-off of below 70Hz which was a little disappointing. The response falls within borderlines of 6dB from 70Hz to 20kHz, but when the controls are in their nominally flat positions there is a tendency to a slight lump at 1kHz. Moving off axis horizontally, the response was remarkably similar to that on axis, a slight loss of EHF being noticed. Vertically off axis an acoustic cancellation of 9dB occurs at 3kHz which is considerably better than the average vertical cancellation. Up to 3dB, lift is available on the pre-set controls at both mid and HF, and the controls can also turn the relevant units off.

Above 100Hz, right up to the extreme top, both harmonic and IM distortion were generally substantially better than 0.3% and quite clearly this produced a very clean sound quality throughout. Even at 70Hz the distortion was only 0.5%, and thus overall this speaker has the lowest distortion of any in the survey. The impedance drops to 5 ohms at 100Hz, which is not too serious, but elsewhere it is highly satisfactory. The electrical phase varied from ± 40° throughout the audio spectrum, which is reasonable, though bettered by quite a few. The loudspeaker had a good sensitivity giving an output 84.5dBA weighted (86.5dB unweighted) from our standard noise source. In the output power test, the sound did not deteriorate noticeably until a level of 109dBA was achieved, which was almost deafening, though just bettered (if you can say that) by one or two others, which sounded dramatically worse in quality anyway. This is another parameter where again the 1000M scores very heavily, since it provided a very loud monitoring level with a substantially better quality than other speakers give on average even at a somewhat lower level.

The manufacturers recommend amplifiers of up to 100W rating, but it seems that even higher powered amplifiers might be used, naturally with extreme care.

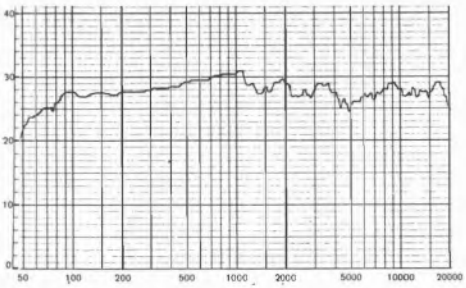
This system was quite clearly rated by both the classical and pop music panels as the overall best in the survey, although certain qualities were sometimes preferred in one or two other models. Both panels in general showed a preference for slightly reduced mid and HF, although one or two preferred it nominally flat. The reproduced sound has a smooth and very open sound quality, and was fairly uncolored. Strings became a little steely, but this improved with control adjustment. High frequencies were a little hard at times. Drum sounds were very tight and solid.

Whilst having this pair of loudspeakers on review, my colleagues and I have used them for professional monitoring, and we have been very pleased with the results. We would have liked slightly more deep bass, but were always attracted by its remarkable clarity. This is most definitely a loudspeaker to be heard, and I can recommend it strongly both for professional monitoring and domestic applications. Considering its excellent quality, the price is reasonable, and I have not been able to say this often of expensive speakers. Its only failing is the disappointing low bass performance, and also the tendency to hardness when working at very high levels.

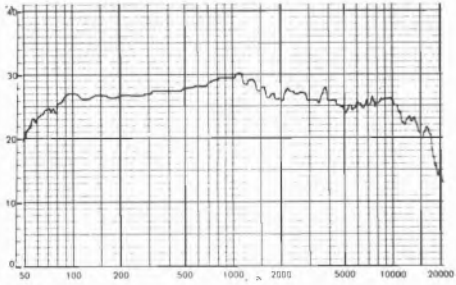
However, the low bass can be improved subjectively if the loudspeakers are mounted on the front edge of a wide shelf, with their backs about 150mm from the wall. We tried this whilst I was writing this review, and the results were certainly enthralling. With bass boost and considerable volume I listened to some stereo pop, and not only was the quality astounding but so very much better than other high power systems that I consider it will have a good future in recording studios.

Height	675mm
Width	375mm
Depth	326mm
Weight	31kg
Finishes	Black ash
Input connections	Push lock terminals
User adjustments	HF & MF
Lowest Impedance (Modulus)	5Ω100Hz/6.5Ω3kHz
Maximum SPL	109dBA
Sensitivity dBA pink noise 2.83V RMS 1m	84.5dBA
Recommended maximum amp power	100 watts
External volume	82.5 litres
Optimum listening height above base of speaker	550mm
R.R.P. (ex. VAT)	£444.00

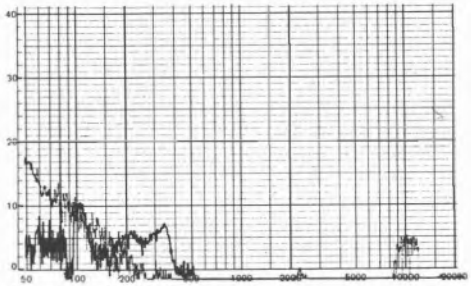
Not normally discounted



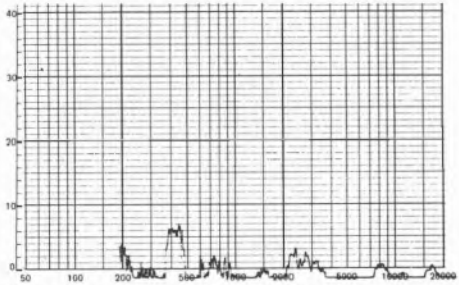
Sine wave on axis response



30° of axis horizontal response



Second and third harmonic distortion



Swept intermodulation distortion ($2f_2-f_1$)

Acoustic Research AR 16 This system is fairly inexpensive. Unfortunately in our listening tests it fared very badly, appearing almost totally lacking in real bass and with a very fierce HF end. Instruments were frequently said to be thin and lacking in body, and it would seem that the balance of the speaker is wrong. Coloration, although sometimes noted, was moderately low, but many sound effects were most unrealistic and toppy. Cello tone was at times seriously lacking in body. After considerable discussion I feel that this loudspeaker cannot be recommended, although its price is basically reasonable.

Beovox S45 A fairly small loudspeaker which was found to be rather lacking in body at lower mid frequencies and produced a rather hollow sound quality, often emphasising a boxiness when lower mid frequencies were present in the programme. In general, the high frequency end was found brittle and tended to spikiness. At times some coloration at mid frequencies was noted, although more usually the coloration was less noticeable, since the frequencies that would normally produce coloration seemed to be partly sucked-out, giving a subjective 'U' shaped response. When mounted on a plinth, the bass response seemed to be very poor and this unfortunately only confirmed the disappointing quality reproduced from this loudspeaker. Since there are so many alternatives which sounded much better at the same price this speaker cannot be recommended despite its pleasant styling.

BOSE 901 Being omni-directional, this loudspeaker is supplied with an independent equaliser unit which has to be inserted in the break points immediately before the main amplifier which drives them, so that compensation can be provided to give the preferred overall frequency response. This unit, which has the benefit of a very high power rating, is very efficient and fairly small. At the laboratory, we tried listening to the speaker when it was placed in several different positions including the corner of a room, against a wall and away from a wall with a reflecting panel placed behind it. Speech gave a very poor and unrealistic sound quality and in two separate tests comments were made that the voice seemed to be reproduced from inside a dustbin-like apparatus. Throughout all the tests, music reproduced with considerable coloration particularly at middle frequencies and when the speaker was placed in a corner a loud bass boominess became intolerable. Away from a corner, the bass end became more controlled and at times was fairly impressive. However, solo musical instruments such as the harmonica and violin, recorded in the anechoic chamber, reproduced with considerable boxy coloration. Notwithstanding the laboratory's general strong dislike for the sound quality, it is admitted that the sound was fairly consistent in all directions. If you must have an omni-directional speaker, then you should listen to a demonstration before contemplating purchase. At its price (£357 pp plus VAT) it surely cannot be considered as other than rather poor value for money. Please see reference to omni-directional speakers in the chapter entitled 'Polar Response and Omni-directional Speakers'.

Bowers & Wilkins DM 6 A linear phase design incorporating three units, which unfortunately seemed to direct its linear phase images to about chest height when listeners were seated in average height chairs. As I am marginally above average height, I needed to sit on the floor to hear the high frequencies correctly. When my colleagues and I sat normally, about 2 to 3 metres back from the speaker, high frequencies audibly receded, leaving a rather colored mid predominant. In the chamber, one tweeter blew its fuse at normal intermodulation test level. So in all the circumstances, I am afraid that this speaker must be regarded as unsatisfactory. Its price is high, and its mid-frequency performance rather too colored. In any case, our on axis pen chart revealed a 12dB dip at 1.3kHz, which was noticeable subjectively.

Cambridge Audio R50 A well-known design, it produced some excellent sounds at low frequencies but mid frequencies reproduced with considerable added coloration. Continual comments were made of 'AH' sounds, and this was noticed particularly on violin tone. The anechoic recording of the harmonica sounded more like an accordion, but what was more serious in the listening tests was the presence of a serious vertical polar diagram problem, producing a totally different sound from the speaker, dependent on the height of the listener's ears above the

ground. Pop music sounded well in the optimum listening position but classical music was generally unsatisfactory. Since the loudspeaker is rather expensive (£284 pp plus VAT), it cannot be recommended. However, two pop engineers found the quality fairly acceptable, and were not too troubled by the excessive coloration. Our power test, incidentally, showed severe audible deterioration at 104dBA.

Celestion UL10 My colleagues and I were so disappointed with this loudspeaker that we could not understand the extraordinary lack of lower and middle top frequencies in the general sound reproduced from it. Many instruments reproduced with a noticeable lack of lower harmonics, and the violin, for example, seemed to recede and return depending on the frequency of the note played. Some breakthrough of very high frequencies into the bass unit was clearly audible. This speaker cannot be recommended, then, because of the blanketing effect that is produced on frequencies in the 'presence' region. I cannot help feeling that some error might have been made in the design of the crossover.

Dalesford DS4 Although this speaker just passed the bottom limit of acceptability in the mono test, the classical panel all criticised the speaker's overall balance so heavily that we cannot recommend purchase of this system. Middle frequencies were clearly boosted on the pen chart on axis response and high frequencies appeared generally down above 1kHz, giving an overall effect of blanketing. Two panel members stated that the piano recording sounded as if the lid had been closed and that a mattress had been placed over the top. Second harmonic distortion from the Isophon tweeter was noted around 10.5kHz (3%). Unfortunately, too many other speakers at the same price are more satisfactory. Off axis, incidentally, HF reduced still further subjectively and some coloration was noticed at middle frequencies.

Eagle S2005 At middle frequencies, coloration was clearly audible. Furthermore, a bad vertical polar diagram problem was noted. Some upper mid-frequency resonances were noted which could have been introduced by a crossover problem. Voices sounded as if they were being reproduced by a cardboard box. The sound quality produced was very tiring and rather disliked and under these circumstances the speaker cannot be recommended.

JBL L 100 For some years this loudspeaker has been purchased for its capability of reproducing pop music at pretty high sound pressure levels and whilst it can produce a very thrilling bass performance when loud, the mid-frequency coloration and high-frequency edginess was so poor that it is felt that it cannot now be recommended in this book, because of its very high price. The sound quality of classical music was thought poor by all members of the 'in house' team, and no position of the squawker and tweeter controls could be found which could give a tolerable sound from such music. But, if you must have superb power handling for pop material, this speaker must be considered.

Unfortunately, there are too many speakers available which produce a much better sound, and therefore the Century cannot be recommended. The subjective test forms frequently showed comments such as 'colored mid', 'hollow', 'very fatiguing' and 'too brittle'. Despite the severe criticisms, though, some pop music enthusiasts may well still like the reproduced sound, although by no stretch of the imagination could this ever be said to be realistic. Note, though, that pop music is itself frequently artificial. Rejected then for the poor reproduced quality at a very high price. (£558 plus VAT per pair).

Jordan Watts Jodrell It is a pity that this speaker has to be criticised rather heavily for producing a very colored sound with an extremely hard and spiky top. Lower bass frequencies just did not seem to get out of the cabinet and although a tweeter gain control is provided, no position of this was found to be satisfactory. Reducing the tweeter volume merely caused a dip at lower HF frequencies which was all too obvious. Possibly a more comprehensive crossover might redeem this unit, but for the time being it must be considered poor value for money, since its sound quality was strongly disliked in the listening tests. Remember that I did not know what I was listening to during these tests and, unfortunately, I marked this speaker almost as low as any other one heard in the survey. There

are too many other loudspeakers available, which sound appreciably better at a similar cost, although I must commend the excellent appearance of the product, which is very solidly built.

Leak 3020 This very recent linear phase design proved rather a disappointment to us, since it not only had a vertical polar diagram problem, but on axis treble frequencies seemed to be subjectively rather up and down, which was confirmed by our pen chart. It was one of the only two loudspeakers in which the tweeter blew up during the intermodulation test, but the second sample worked satisfactorily 3dB lower. This proved it to have a clear power output problem, and so, unfortunately, it was decided to give this speaker only a short review. As with the 3050, the models received were pre-production prototypes, and I hope that in production their quality will be somewhat better.

Leak 3050 Some slight chimney-like coloration was produced, and the treble and mid regions seemed a little detached—a cupped hands sound on speech being clearly audible. A vertical polar diagram problem was noted but this was not very serious. Very low bass frequencies did not seem to get out of the cabinet and an upper mid or lower top suck-out caused recession of some instruments whilst making others overbright. Some coloration was noted on the lower violin strings, whereas higher ones tended to be slightly wiry. Unfortunately, this speaker could not cope with music when driven moderately loudly but the overall quality was quite definitely not too bad. This speaker only received a short review because there are too many others which did substantially better at the same price. I should add that the speakers submitted were pre-production types, and as a result of these comments the manufacturers have agreed to pull down the high frequency energy by about 3dB on the main production run. Unfortunately, production samples were not available early enough for this survey. I trust that Leak will be attending to the power output problem as well.

Lowther Super Acoustu Although this speaker is extremely efficient in giving a very high sound pressure level output for a relatively small input, its quality was sufficiently poor for the sound to be disliked intensely by all who listened to it on the test programme. Middle frequency coloration was extremely severe and the human voice was reproduced as if the sound was emanating from a long cardboard tunnel. In general, virtually all music had an added 'AW' sound, which was so marked that any other faults which might have been present in the speaker were more or less obscured. One panel member commented that the sound was rather like that reproduced by a pre-war cinema installation on an old optical sound track, but without low bass frequencies being noted. The sound of the violin had an added blowing and sucking noise, as if the player was breathing loudly through a cardboard tube. It is difficult to understand how some people obviously like the sound reproduced from this speaker and it must be assumed that they have not heard direct comparisons with other models or with live sounds. It is with extreme embarrassment that the writer has had to be so critical of the sound quality and it is hoped that readers will realise that, as with all other speakers, he made all the comments on the report form without knowing the loudspeaker type being auditioned at the time. Not recommended at all unless you must have extremely high efficiency to the considerable detriment of sound quality. A few days before going to press, the manufacturers informed us that this particular speaker has had minor cabinet redesign, which may alter its acoustic properties.

Marsden Hall Symphony 3522 Not only was this speaker rather colored at mid frequencies but an odd hollowness and general lack of mid frequencies on both samples unfortunately placed the model in the 'definitely not recommended' class. The bass response seemed reasonable but the general 'U' shaped frequency response is unacceptable. We cannot understand why this design should have sounded so odd and once again there are too many better alternatives.

Mirsh OM328 The panel heard this both in a normal environment and in the corner of a room and finally against a wall. In all positions the coloration problem was very noticeable. Very high frequencies seemed to be down, but several peaks were noticed between 1kHz and 10kHz, emphasising and coloring any tape hiss present. Very low bass frequencies seemed well down but upper bass

frequencies were very boomy. This loudspeaker is expensive and cannot be recommended because of its high coloration and rather odd response. Please see further references in the chapter on omni-directional loudspeakers.

Monitor Audio MA5 The first sample of this loudspeaker was found to be rather lacking in bass. Also it had a very brittle top with a particularly unpleasant EHF peak at around 12kHz produced by the Isophon tweeter employed. The manufacturers were informed about these comments, and then explained that we must have received by mistake the French export version, which they claimed to be toppier than the British one. After substituting another pair, the treble end was found to be better controlled, but an upper middle resonance became very objectionably audible on most material, and the impression was gained that there was a considerable boost present in the octave 500Hz to 1kHz. Because of this, the speaker cannot be recommended with confidence, but it is worth noting that the bass response improves considerably when the speaker is shelf mounted with the back close to a wall. Unfortunately, there are too many alternatives which sound better at a similar price.

Ortofon P75 This speaker gave generally a rather disappointing balance and considering its very high price cannot be recommended. The large cabinet did not produce a really good low bass end. On pop music, the bass guitar sounded as if it was being played with a woollen sock when the speaker was placed in an ordinary living room. In our acoustically treated listening room, the bass end was just generally lacking. Some coloration was noticed at mid frequencies and a slight smoky chimney effect was produced. Another disappointing speaker. Just before going to press, we learnt that this speaker is shortly to be discontinued.

Pioneer HPM 60 This time, the main problem was found in the poor polar diagram, since interference cancellations were produced as the listener's head moved sideways and up and down. Some coloration was noted at mid frequencies, and treble frequencies seemed to be rather spiky, even tape hiss becoming colored and peaky. It is suggested that the bass unit is taken up too high in frequency and the positions and individual polar diagrams of the speaker units would seem to be unfortunate. The treble end sounded detached. In some off axis positions, pop music reproduced very well with a good solid bass when driven hard, but the general problems unfortunately mean that no recommendation can be given.

Quasar QS2 Many loudspeakers could be said to be toppy but are certainly not unpleasant, but in the listening tests this speaker was found to be excessively brittle and peaky, for example, making a harmonica sound as if it was being played in a wasps' nest. The coloration was in general pretty low but it was felt that middle frequencies were sucked-out slightly. This probably contributed to the impression of too much top. Although the loudspeaker could be driven fairly hard, the treble end became so piercing as to produce a violent reaction from the listening panel. It is felt that if the tweeter energy were to be taken down somewhat, the reproduced sound quality could, in fact, be quite good. But, in the meantime, it is felt safer to withhold a recommendation of any kind.

Richard Allan 82L This speaker cannot be recommended because of very marked coloration at middle frequencies and a hole in the response somewhere in the lower top, which caused certain instruments to recede and reproduced male speech with a holding nose sound. Many musical sounds were rather hollow. The sound produced was often boxy as well as colored, and the speaker cannot therefore be rated even reasonable value for money.

Sonab OA14R This typical omni-directional loudspeaker was just not liked, since it was felt that with images sprayed out in all directions and reflected from walls a general blurring of sound occurred. Once again, the speaker reproduced sound with a tunnel-like quality and with considerable middle frequency coloration. A general cardboard box sound was produced with an effect on many musical instruments of severe recession away from the listener. The bass end performance seemed poor and lacking even when placed in the corner of a room, in which once again images were

found to be very blurred and strangely toppy but without clarity. Not recommended.

Tandberg Studio Monitor A speaker ruined by unfortunate polar diagram problems, since it sounded rather better if the listener was well below it at floor level. It was very colored when heard in a normal seating position. The power handling was very good. This could be a lot better if the manufacturers listened to it very carefully and re-located the positions of the individual units. Since the loudspeaker is so expensive it cannot be recommended, mainly due to the polar diagram problem.

Tannoy Arden Unfortunately, this large loud-speaker system was not particularly liked by the listening panel. The degree of discomfort, however, was largely dependent on the age of the listener, the younger listeners tending to find top so spiky, particularly at very high frequencies, that the sound was totally unacceptable to them. Perhaps the writer is getting a bit old (42) but the quality was not too unpleasant, although string instruments tended to be reproduced with rather a barbed wire effect. Some lower mid coloration was present and upper mid frequencies tended to recede somewhat, thus slightly altering musical balance. An harmonica reproduced as if it were a squeeze-box accordion and male human voices had an exaggerated chestiness and boom, which was a little tiring. Cellos, too, seemed to boom and zoom with an exaggerated mid bass. Whilst the power handling was very good indeed, the speaker became oppressive when loud, since the treble end was heard to shriek and became almost pain-ful. At best, then, the speaker was only just acceptable, but rated poor value for money. At worst, people with an extended EHF frequency response in their ears (most younger people) would find the speaker unacceptable. At £368 pp plus VAT it cannot be recommended.

Technics SB402 Severe polar diagram problems were the cause of the unfortunate downfall, in our estimation, of this speaker. The constant changing of sound quality with listening position just cannot be tolerated, and the manufacturers must study this aspect of loudspeaker design very closely. Good power handling though, and also capable of producing quite a good quality if the listener lies down on the floor well below the level of the front of the speaker. Surely another example of a loudspeaker design in an anechoic chamber with the microphone in a fixed position rather than one which has been carefully listened to and compared with other good units, let alone live sounds.

Technics 7000 A linear phase loudspeaker designed primarily for high quality monitoring, but my colleagues and I are of the opinion that it fails because of its serious vertical polar diagram problem. It is very expensive, and one would hardly be prepared to accept a total change of sound quality if under listening conditions it alters so dramatically with vertical head movement (listener standing up). Some 'AW' coloration was noted by the panels, which unfortunately helped my decision to withhold recommendation. Linear phase characteristics are surely one of the least important parameters in design, and other elements should be put right before even consider-ing linear phase. Precisely on axis, a few com-mented that the sound quality was nevertheless reasonable.

Venturi BIC Formula 6 A loudspeaker priced at £420 a pair plus VAT should give a well above average performance, but in the listening tests it unfortunately did not. Some 'AW' and slight 'EE' coloration was noted and, both in our special listening room and in a more reverberant lounge, a lack of deep bass was evident. The middle top was good but the impression was gained that very high frequencies were lacking. This lack of EHF was almost certainly due to the poor horizontal polar diagram at high frequencies, interference patterns being generated when the listener's head moved from side to side. The high frequency gain control was adjusted for optimum, but this was not really satisfactory subjectively. The speaker did, however, sound slightly better in an ordinary lounge, but still nowhere near as good as com-petition costing appreciably less. Therefore, this speaker cannot be recommended and is not, in the opinion of the writer, reasonable value for money. At higher levels, the speaker could be turned up fairly loud without too much distress, but a lack of bass punch became all the more evident on heavy pop material.

Videotone Supermax D402E It is a pity that the manufacturers seem to have chosen too high a crossover frequency, since coloration at mid frequencies was rather evident. Furthermore, some HF frequencies tended to get into the bass unit, causing an additional coloration. Lower top frequencies receded quite clearly. The top end was found rather spiky subjectively, particularly at around 10kHz or so. The bass was rather cardboardy and the top generally breathy, emphasising tape hiss and voice sibilants. Once again, it is felt that the competition is so strong that this speaker cannot be recommended.

Wharfedale Airedale A popular speaker for some years, but in the subjective panel test some coloration was noted at middle frequencies and also a chimney effect in the lower top region. The treble end was thought spiky and disliked although at the bass end the speaker performed very well. There is no doubt that this speaker has got some good points, but unfortunately, its high price of £284.80 a pair plus VAT precludes a recommendation, since the competition is so strong. You may find, however, that you are attracted to the bass end performance and the speaker would undoubtedly perform better in a more reverberant room than in a properly designed listening room—the latter showing up all too easily the coloration and spikiness previously mentioned. Not a good buy, then.

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During the early days of this survey, when we were assessing all the speakers in mono, I made a point of going to some concerts to hear a reasonable amount of live musical sound. With the memory of this, I can say quite categorically that no loudspeaker, as yet, can provide a sound which could really be said to be realistic. So, if you want to hear real music regularly, your first choice must be to visit live concerts. The selection of a loudspeaker will be a choice of one that does not have glaring faults in its reproduction. Some of them, quite frankly, are oppressive and objectionable, and I am afraid these must be set aside.

Having assembled such a mass of information about all the speakers reviewed in this book, it was necessary to spend about two weeks searching for significant trends in design, ergonomics and subjective listening test analyses, and coming to many conclusions. Most of these will be general, but a few are specific, and it will be easier to explain if I deal with general subjects separately.

Although there was a considerable range of personal taste, to my surprise this was nowhere near as variable as I had anticipated before starting the subjective listening tests. Bad coloration, for example, received condemnation frequently from an entire panel, and always from 75 per cent of the panel. Response anomalies also received similar comments, but with this parameter there was a clear division of priority between classical music and pop music listeners. I do not propose to comment on the actual finishes of the units, since it is obviously a matter of preference, and in any case virtually all manufacturers have learnt to present their products well—however they may sound!

Coloration. Throughout our internal mono listening and subjective stereo tests, my colleagues and I came to our own conclusions about coloration. We were gratified to find that in all cases our criticisms relating to this concurred with general listening panel comments. Looking over a broad sample of test forms it would seem that coloration characteristics were by far the most frequently criticised, and it is fair to comment that coloration was by far the most important factor in the judgement of reproduced quality. However, major faults in any other parameter naturally were of greater significance than slight coloration. The most oppressive coloration was generally found in loudspeakers showing it at middle frequencies, particularly between 500Hz and 2kHz. I suggest that this was caused by poor damping in the cabinet, or perhaps more often the use of woofers at too high a frequency. Some mid-range units appeared to be very poor, and also virtually all the omni-directional loudspeakers were highly unsatisfactory, since their output presented the coloration of the environment in addition to their inherent coloration. Any form of horn loading appeared to give more coloration than direct radiation. Such comments as 'horniness' or 'shriekiness' were frequently made. This often occurred with horn-loaded tweeters. We found that bass coloration was produced by many large systems, and we suspect that it was caused by air resonance inside the cabinet. Quite a few systems sounded boxy or boomy, whereas others, less colored produced a surprisingly tight, crisp bass sound. Sometimes a manufacturer introduced a dip in the response in the coloration region, and this introduced clear response anomalies, which sometimes caused me to come to the conclusion that sucking-away the problem created a more serious one.

High frequency coloration seemed to be independent from response anomalies, and often subjective comments were made which were clearly referring to coloration heard, though the panel member might have assumed that the response was the cause. High hat cymbals appeared to ring on some units, whereas an anechoic recording of a harmonica sounded more like an accordion on others, despite the response being reasonable. Some comments referred to wasps' nests, muted locomotive exhausts, shrieking, and perhaps the worst of all, 'ouch!'. Such high frequency coloration is exceptionally difficult to observe objectively,

since it requires the most esoteric test techniques, which unfortunately were outside the scope of this survey on economic grounds. I have naturally leaned fairly heavily on listening panel comments, including my own, in the final analysis, but since there was so much unanimity I feel that it is up to the relevant manufacturers to look into the matter further. Coloration also seemed to be introduced incidentally by inappropriate electrical crossover design, and further comments are made in the relevant introductory chapter.

Frequency Response. Both the classical and pop music panels obviously considered that a smooth response was very important from medium bass frequencies up to at least 15kHz. It was very clear, however, that the pop panel considered it necessary for the bass to be extended rather further than would be necessary for reproducing the average classical music programme. Both panels tended to note 3dB hills in response more easily than 3dB valleys of equal amplitude, but the most serious problems were encountered when a hill was surrounded by two valleys, or two hills had a dip below the average response in the middle. The most sensitive region appeared to be between 1 and 6kHz, over which frequency band the human ear is generally more sensitive anyway. Any form of discontinuity, such as sharp or deep nulls, always received severe criticism, usually resulting in the condemnation of the loudspeaker. Similarly, spikes were also rather oppressive. One general tendency on many units was the presence of a gentle but continuous rise above 5kHz extending to 14kHz, above which the response fell back. Speakers showing this tendency received quite severe criticism, which could go as far as, 'for goodness sake switch the Dolby B processing back in again'. I can see no reason whatever for introducing lifts at EHF, which in one or two cases reached as much as +10dB, for surely if a user wants it this way he should use the tone controls on his amplifier. There seems to be a tendency for some shops to recommend a speaker which sounds brighter than another, and they adopt the attitude of 'the brighter the better'. Our listening tests proved that under ideal conditions musicians, recording engineers and serious hi-fi enthusiasts criticised a toppy sound.

Sometimes comments referring to a ridiculously boosted top were not confirmed by pen charts, but on investigation we found that their overall balance between bass, middle and top was incorrect. The Philips motional feedback speaker for example had some 5dB more energy per octave on average above 1kHz than below it, and so quite obviously high frequencies tended to mask lower ones. Similar remarks apply to many other Continental designs. It would seem that Continentals on average prefer an unbalanced loudspeaker, though I cannot understand why. National preference is most interesting, however, and I will cover this later. Occasionally a speaker has been said to be 'shrieky' or just plain bright when it possesses equal energy per octave at HF and at MF. From the pen charts it would seem that an equal number of peaks and valleys of similar amplitude cause the peaks to be more audible. Comments of brightness also correlated sometimes with a lack of bass energy, particularly if there was a lack of upper bass. Sometimes a speaker's response showed a hump between 5 and 10kHz, above which the response fell so that at 15kHz it was nominally flat. This quite clearly resulted in comments of hardness, brittleness, and lack of clarity. A few panel members were able to put their finger on the fact that EHF was well down comparatively. It does not seem to be a cure-all to correct a poor response at 15kHz by a rise below it.

Both classical and pop panels found that a boost around 100Hz tended to introduce boominess, or in more severe cases, bass honking. Boosts between 40Hz and 75Hz introduced by some systems employing transmission lines were found at first to be impressive, but later were criticised and sometimes fairly heavily. These criticisms were most marked when the response fell off in the upper bass. It is only fair to add here that the location of a loudspeaker in the listening room is vital, and whereas some loudspeakers may give an apparent boost in even fairly large rooms, they may well sound better in recording studios or small halls. Larger cabinets did tend to give a more extended bass response, as would be expected, but in almost every case mid-

frequency coloration became more marked. Bass from large cabinets also seemed often to be less well damped, receiving comments of 'flabby' or 'loose'. One tendency that has crept into loudspeaker design in the last few years is the introduction of a small valley in the response between 2 and 3kHz or so. This was originally introduced internally as a basic design point by the BBC, and at the time they felt that it was an advantage in an attempt to counteract some mid-frequency coloration present both in the loudspeaker and in the average room environment. Our panels, however, almost always mildly criticised such dips, and this is particularly interesting in that the panels never knew what loudspeaker they were listening to. This was confirmed in many instances where we changed round the standard and test speaker pairs. We also did a considerable amount of experimentation in varying the comparison standards. The general consensus must be that if anything a 1dB boost in this frequency range was felt to be preferable to a more marked dip, although in other frequency regions it did not seem to make so much difference. Dips of more than 3dB in this region resulted in critical comments, one typical one regarding the marked difference in sound between the Chartwell and Audiomaster version of the BBC designed LS3/5A. The subjective comments were confirmed here by measured dips in the anechoic chamber.

Some loudspeakers had a series of sharp spikes in their HF and EHF output. These were usually disliked considerably, and only occasionally were they not severely criticised. One further region where humps in the response became rather objectionable was the mid-frequency range, usually between 300Hz and 1kHz. Some speakers showed up to 6dB hills here, and these rated as having a tunnelly sound quality. When mid-frequency hills were followed by valleys in the lower presence region, an adenoidal sound quality was remarked upon. Finally, on this topic, I should point out that loudspeakers' response curves are in general appalling, and if pen charts of other parts of the hi-fi chain were as bad on any piece of equipment reviewers would throw it out as being very poor. As yet, loudspeakers are surely the weakest link in the chain, but one must add to this the bad effects that some listening environments have on speakers, since even a comparatively good loudspeaker can sound dreadful in a highly reverberant or acoustically poor room.

Harmonic and Intermodulation Distortion. Many systems showed quite appreciable harmonic distortion at bass frequencies at our test level of 90dBA output measured at 1 metre away from the unit (and set at MF). Derogatory comments were only made if this distortion was of several per cent. More distortion could be present at lower bass frequencies than at mid-bass ones for equivalent comments. Between 200Hz and 7kHz, harmonic distortion was far more noticeable, although sometimes even 2 per cent distortion present at mid-frequencies was more or less unnoticed if the speaker had other problems masking it. Second harmonic distortion at bass frequencies was usually more marked than third harmonic, but at mid frequencies they tended to be around the same order of magnitude. Above 2.5kHz, third harmonic distortion was usually lower, and frequently below 0.3 per cent. Don't forget that unless you have superb ears you are unlikely to hear the second harmonic distortion of frequencies above 8.5kHz and third harmonic distortion of frequencies above 5.5kHz, since the harmonics fall outside the usual audible range. One particular tweeter had very bad harmonic distortion of a fundamental around 10.3kHz (up to 12 per cent was noted), and this seemed to be audible to quite a degree on occasions, although it seems difficult to understand how the harmonics could be heard by the panel. Perhaps prolonged IM tests with two frequencies very close together would reveal second order intermodulation products of considerable magnitude which would explain the subjective comments of grittiness. Some samples of this tweeter were noticeably better than others, but it is interesting that we could not find any definite correlation between listening quality and modifications carried out by some manufacturers to the tweeter itself. It is probable that considerable variations would be found between different tweeters of the same type, and so I must emphasise that the distortion measurements apply specifically to one loudspeaker of a pair tested, which may indeed not be typical. (The listening tests indicated the

audibility of sharp discontinuities in the harmonic distortion charts.) In the case of distortion found in bass and mid-range units I anticipated that units would be more uniform in their measured characteristics.

Intermodulation Distortion. The swept IM tests were made with the higher frequency varying from 400Hz to 20kHz, the lower one always tracking 300Hz below. IM distortion above 1 per cent would be most audible in the frequency range commented on in the reviews between 700Hz and 12kHz. Particularly creditable were loudspeakers having a general distortion level below 0.5 per cent. On reflection, I realise that this test should have been performed with a much smaller frequency difference, of say 20Hz rather than 300Hz, but this would have resulted in much more time being spent on the measurements since each chart would have taken 15 times longer to make. I would recommend that manufacturers look into this measurement technique for it is very revealing. The equipment used was a B&K 1902 intermodulation tracking generator in combination with a B&K 2010 superheterodyne analyser, plotting the upper third order IM product.

Impedance and Electrical Phase. Approximately half the loudspeakers showed the modulus of impedance dropping below 6 ohms, and those that do will clearly present a more difficult load to the average amplifier particularly those with inappropriate VI limiting. If the electrical phase is either considerably positive or negative near its minimum impedance point, matters will be found more awkward. Impedance variations significantly above 12 ohms or so are not of any importance with transistorised amplifiers, other than the fact that the damping factor improves as the impedance increases. In one case we found that the impedance of the speaker varied dramatically with level—this being the Acoustical Manufacturing 'Quad' Electrostatic. At very low levels the impedance is extremely low, but as the energy is increased into its input transformer the impedance increases noticeably, particularly at low frequencies. It is possible that some amplifiers will go unstable when interconnected with an Electrostatic because of its exceptionally low impedance at low levels, but this is more a sign of a poorer amplifier than a design problem in the Electrostatic. Electrical phase variations at low frequencies are quite clearly not as serious as at middle ones, and I have taken this into account when making comments. Similarly if an impedance minimum is between 300Hz and 10kHz I also regard it as more serious since most programme energy is generated in this frequency band, although of course there are exceptions, particularly in pop music. Note that by electrical phase I refer specifically to the phase relationship between the voltage presented to the loudspeaker terminals and the current drawn by the loudspeaker at any particular frequency. This relationship usually does not bear directly on acoustic phase, but it will have an indirect bearing. I cannot comment on this, though, as I have not been able to measure acoustic phase for this survey—it is exceptionally difficult to measure, takes a lot of time, and can give misleading results.

Sensitivity. The ratio of sensitivities between the most insensitive and the most sensitive speaker system actually measured somewhat horrifyingly at around 12.5dB. The Lowther, unfortunately rejected because of its coloration, was appreciably more sensitive still, but even a ratio of 12.5dB represents a power difference of nearly 18 times. Expressing this in other terms, the most sensitive loudspeaker would require 5W to establish a loud listening level, but the least sensitive would require 90W for the same acoustic output! Whereas the sensitive loudspeakers were almost invariably capable of giving very high output sound levels, the least sensitive ones rarely exceeded medium loud levels without significant distortion. Unfortunately though, almost invariably coloration was inversely proportional to sensitivity, many manufacturers reducing the sensitivity of the speaker in the process of removing coloration. This is quite obviously the reason why only rarely was a speaker capable of giving an exceptionally loud output level liked by the panels, and it is a most unfortunate condemnation of many famous makes of professional monitor. This is one field in which many speaker manufacturers are now concentrating, and I await some interesting develop-

ments in the next year or two. In the meantime, it would seem that I can only recommend the Yamaha 1000M in this context for its relative lack of coloration and high output potential. Sensitivity is always allied to impedance, for as the latter is lowered the output for a given voltage is increased, but if this is lowered too much other problems occur. Many loudspeakers could have their general average impedance lowered somewhat, which could allow them to have a sensitivity improvement of 2dB or so. The most insensitive speakers in the survey were the LS 3/5A models, the JDR Rodgers, the KEFs and the Tangent RS6. The most sensitive ones measured included the JBLs, Tannoys, Sony 5050 and Castle Acoustics Kendal.

Power Output Capability. The only speakers capable of giving the monitoring levels required by pop musicians and engineers were the JBLs, the Tannoys, the Yamaha 1000M and Technics 7000. I personally pity those people who require loudspeakers capable of delivering even higher levels in any normal environment since they will probably in time become partially deaf, with what is termed medically 'occupational hearing loss'. Our classical panel tests gave peak dBA sound pressure levels of about 96dB, but the RMS meter would have indicated these levels to be somewhat lower. The pop music panel listened to a level which peaked about 2dB louder, but the average power level was always considerably higher because of the programme material having in general a small dynamic range. On certain speakers the volume level was raised by request, but at no time did I inflict more than 100dBA on the panel as I did not want to produce even the slightest temporary deafness. The power output test itself proved that many loudspeakers were capable of producing significantly higher levels than the manufacturers realised, and most surprisingly not one single unit was damaged in this test, which never lasted more than around four minutes. It seems quite clear that in normal circumstances a loudspeaker will produce audible deterioration before damage results. Of course, either prolonged peaks at deep bass frequencies, or continuous high frequency energy (for example, in some electronic music, and running tapes past the replay head at speed) will damage a unit, and care must be taken to avoid this.

I remember once in an emergency that a pop musician's bass guitar speaker had blown, and I used a Tannoy monitor 'Red' in a very large lockwood cabinet, having been assured by the player that his amplifier did not give more than 60W. His very first bass note blew the bass cone, and on investigating his amplifier it was found to be capable of producing 200W! I had thus, inadvertently, been totally unfair to the speaker. The only other occasion on which I have perhaps been negligent in this respect was when I made a mistake of 10dB in SPL when performing a test on a tweeter some years ago, and after ten minutes of continuous high frequency energy an STC model blew, the input level having been 10W instead of the intended 1W.

On programme, though, it is surprising that you can use a much more powerful amplifier than the manufacturers recommend in general, provided you are sensible. I once used a pair of BC1 Spendors with an Amcron DC300A on an orchestral recording session for a Havergal Brian Symphony. A musician knocked a mic stand, and about 200W of power was dissipated in each Spendor for a second, but no damage resulted. Insensitive speakers will dissipate much of the input power into crossover components, whereas more sensitive ones dissipate most of the power into the coils. Usually large diameter coils in the speaker's drive system provide better heat dissipation, and it is significant that all the high output power speakers have specially constructed coil assemblies. Some speakers had bass loading problems which resulted in the bass cone waving around too much. A typical example of this was found in the SMC AL12 whose bass cone hit the end stop at only 95dBA, the lowest output of any speaker tested. The other extreme was an incredible 115dBA output achieved by the JBL Century, this representing 100 times available acoustic power output as compared with the SMC. In general I have recommended amplifier powers several dBs below the power required to give significant audible deterioration. It is probable that in many cases higher powered amplifiers could be used to accommodate the odd mid- and high-frequency transient without too much audible deterioration, but be extremely

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careful never to exceed my recommendations when using the loudspeaker on music having a much narrower dynamic range (eg. heavy rock etc). Note that in most cases amplifiers of significantly lower power may well provide more than adequate room volume, but I suggest that you should always go for the amplifier with the maximum recommended power.

National Tastes. Whilst writing this book I visited Japan on business, and listened to many Japanese loudspeakers in different environments. I discussed the problems of choice and personal preference with the foremost Japanese audio critic, Mr Asano, and whilst we respected each other's opinions we disagreed on our preferences. We felt it important to resolve these differences, and eventually I realised that the Japanese sometimes prefer their loudspeakers to be more colored than we do. Since their rooms are very much smaller on average, they are not so worried about polar diagram problems, and as the rooms are in general rather dead and uncolored they find that some coloration in a speaker actually improves the subjective sound quality for them. I personally disagree with their opinion, whilst nevertheless respecting it. It is significant, though, that some relatively uncolored British loudspeakers sell well in Japan, and conversely the Yamaha 1000M was relatively uncolored and became recommendable in this survey. The Japanese also do not seem to worry so much about deep bass performance, and on several recording and broadcasting sessions which I attended I noted the relatively poor bass response of the speaker systems used. Even with Japanese sound balances they do not seem to worry much about frequencies below 80Hz or so, but on the other hand they pay particular attention to clarity in the top octave or two. This national trend even dictates in many cases their methods of biasing tape recorders, as well as loudspeaker design and sound balancing techniques. Even their own music has a different frequency power distribution, and I also suspect that since the average Japanese person is some 150mm shorter, their ears might be rather more sensitive then ours at high frequencies. I heard much less low frequency noise pollution in Japan, and they are to be congratulated for going to great lengths to keep general noise down. This too may contribute to their clearly sensitive hearing.

Some years ago I was the guest of a major European tape manufacturer, and they organised a demonstration with high quality equipment of various master tapes etc. I was most unhappy with the sound quality, which seemed all boom and tizz, and found that I was hearing continual phasiness. They suggested that I should check the system through, and I found that left and right channels were reversed and also out of phase. It was also necessary to cut bass and treble slightly to get an acceptable sound. It was interesting that they then found the sound a little dull. It is clear, from analysing the results of our tests on speakers made by Tandberg, Philips and B & O, that Continentals do like more top than we do, though my answer to this is that they should alter the response from flat by altering the controls on the pre-amplifier to suit their tastes.

In general, Americans seem to like higher listening levels than we do, but I understand that many of their rooms are somewhat larger. Their rooms are probably on average more heavily carpeted than ours, and this of course will affect their preferences. American recordings are almost invariably more multi miked than many of ours, and they tend to prefer a stereo width which sometimes seems exaggerated. Phase correlation in central images is clearly more important with coincident mic recordings, and in general British loudspeakers were better in this respect.

Finally in this conclusions chapter, I would like to remind you again that although my colleagues and I are satisfied with the general subjective findings, there can only be one person who makes the final choice, and that must be you, the reader. In your own room at home you may well find that a pair of speakers with a gap in the response somewhere may well sound better in that particular environment. Notwithstanding this, then, I feel that the conclusions drawn from testing so many models should prove a good guide for purchasers. Try to spend as much as you need to, since the loudspeakers actually produce the sound that you hear and will have to live with, perhaps for many years.

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This survey has certainly proved to me that it is not necessary to spend a fortune on loudspeakers that will be very satisfactory in a domestic environment. Indeed, only rarely did expensive speakers sound better than medium priced units even at quite loud domestic listening levels—as often as not they actually sounded inferior. It would seem, though, that there is a clear point below which it is just not possible to market a speaker which would give reasonably acceptable results to the majority of critical listeners. The limit would appear to be around £110 per pair plus VAT.

Since the abolition of resale price maintenance, some manufacturers are naturally rather loath to publish even recommended retail prices. Throughout this book we have nevertheless published such prices, but with each one published in the reviews we state what we believe to be the speaker's availability at a discount. You will find in general that in the larger cities it will be easier to obtain a large discount than in smaller towns. If you live out in the country you may find it better to buy from a mail order establishment, but of course you risk disappointment if you do not obtain a competent demonstration. Exhibitions are not the best place to buy hi-fi, since the demonstration rooms have just about every kind of honk that you can imagine.

Remember that 10% more discount to you may represent a loss of half the remaining profit to the retailer, and so you cannot expect the best demonstrations laid on if you insist on the largest discount. Loudspeakers, however, are in general pretty reliable, so if you have made a definite choice I can see no reason why you should not deal with a discount organisation, provided that they stock the model you want, and do not try to switch your interest to some other model which may disappoint you. Very frequently a published recommended retail price is completely artificial, and you may only find some makes of speaker at their full price in very small shops. As much as 33⅓% discount is available from good discount organisations on certain products, but sometimes such organisations will have two outlets, one having demonstration facilities and a lower discount, whilst the sister outlet has no such facilities but gives a larger discount. I am tempted to suggest that they are encouraging customers to hear speakers in one shop and purchase them in another, which is in a way rather unfair. Don't forget your rights under the Sales of Goods Act, which are explained in full in *Hi-Fi Choice: Receivers*.

As with receivers, the improvement in quality from, say, £40 a pair up to £100 a pair is proportional to the square of the price, but between £100 and £200 a pair + VAT the improvement is more linear. Above about £250 a pair relatively few loudspeakers showed significant overall advantages, although many were better in one or two parameters and inferior in others.

If you have a small room and want a pair of particularly small loudspeakers that will be unobtrusive, perhaps mounted on a bookshelf, I can recommend the **Chartwell LS3/5A**, although its price (£125 pp + VAT) is a little high. They nevertheless represent very reasonable value for money, although their performance at the bass end is clearly poor, and reproduction of heavy pop music will be disappointing, due to the limited output capability. Their smoothness and clarity and lack of coloration are highly commendable though. Significantly cheaper are the **Castle Acoustics Kendals** (£107 pp + VAT) which represent good value for money. You should also consider the **Goodmans 100** (£98.58 pp + VAT) provided you can accept its very bright top (with quite a respectable output capability for its size) and furthermore, as with the LS3/5A, its requirement for back shelf mounting and a little bass boost in the pre-amplifier. Cheaper still is the **Dansk A25** (£89.46 pp + VAT), but we did have rather a lot of reservations. The **JR149** (£110 pp + VAT) cylindrical loudspeaker was very much liked, and was clearly better than any of the speakers mentioned up to now, but its shape may worry you. Its performance, though, was good, and it seemed to be surprisingly realistic at times. More conventional is the **Mordaunt Short Pageant** (£124 pp + VAT) which provided a surprisingly good sound quality—although, as with all the other less expensive units, it rather

lacked bass. If you want loud pop music reproduced at a loud listening level at as cheap a price as possible, I advise you at least to listen to the **KLH 317** (£130.67 pp + VAT).

In the medium cost bracket a moderately priced unit is the **Celestion Ditton 33**, a little toppy but reasonably well liked by most of the panel. Its price of £169.40 pp + VAT makes it fairly good value for money. You may prefer the sound quality of the **Monitor Audio MA4** (£158 pp + VAT) although the panel did have some reservations as to coloration. Subjectively, by far the best loudspeaker in this category, in my opinion, was the **KEF 103**, which represents excellent value for money (£150 pp + VAT). Its general smoothness and lack of coloration was continually praised by the panels, but its main snag is poor sensitivity which restricts its use to listeners who do not want to reproduce music very loudly. It will require a 50W amplifier to work at its best, and for this reason other loudspeakers in its price bracket have been mentioned. The **Celef Mini Pro** (£165 pp + VAT) was well liked by both panels and its slight tendency to brightness will almost certainly attract many purchasers. It is well designed and did not receive any severe criticism. The **KEF 104AB** is at the top end of the medium price bracket (£185 pp + VAT), and showed a significantly more extended bass end than the 103. It was very well liked by both panels, giving a smooth sound quality that was most commendable. Once again, sensitivity was rather poor, and so you will need a fairly powerful amplifier to get the most out of it. Finally in this category, it is only fair to mention the **Spendor BC1** (£205.80 pp + VAT) for this has been so well received and highly recommended in the past. At the time of writing, though, the manufacturers have begun to look into its temporary problems (see review), and matters may be back to normal by the time this book is printed. In the circumstances you should at least hear this model.

The **Tannoy Devon** has a remarkably high output potential for its relatively reasonable cost (£240 pp + VAT). Although the quality was not particularly liked, some panel members found it acceptable for some types of programme, and it will be found useful where high levels are essential. At £256 pp + VAT the **Chartwell 400** provides very good reproduction, and was well liked by both panels. It seems good value for money, and provides adequate volume for even large rooms under normal circumstances. The **Celef Studio Professional** (£360 pp + VAT including stands) was also very well liked, but was found to be just a little too bright on some programme material. Its price is reasonable, but it cannot really be said to be very good value for money, whilst nevertheless filling a marked gap in its price range. In a rather special class was the **Yamaha 1000M** (£499 pp + VAT). Both panels liked its quality very much, and although it was generally bright with its controls set normally, balance could be adjusted at will. Both panels found it relatively uncolored and extremely clean and clear throughout, facts which were borne out by its good distortion measurements. Not only did it give excellent reproduction of both classical and pop music at normal levels, but also it continued to give such reproduction at very high levels, which makes it virtually unique among speakers in this survey. It is very expensive, but I feel that its cost is completely justified. Clearly a loudspeaker which will delight its owner.

In a class completely on its own was the **Acoustical Manufacturing 'Quad' Electrostatic** (£276 pp + VAT). Opinions varied wildly, although when the panels were finally told what it was and sat precisely in the correct position it received praise from most listeners. Its reproduced sound quality is, in my opinion, extremely smooth and very clear indeed, and although this is high praise some listeners found it too revealing! It has a power output limitation, which is unfortunate, and its low bass response is somewhat curtailed. I also tried stacking two pairs in a special experimental frame, and found the available volume adequate for all my normal requirements. The bass response improved quite dramatically, and the sound quality was undoubtedly one of the most realistic that I have ever heard. However, the combination is unwieldy, takes up a lot of room, and also costs £552 + VAT, plus the cost of the framework, which is no small hole in any bank account! I can still recommend stacked pairs, though, for wealthy enthusiasts who appreciate superb quality and clarity. A single pair can also be

recommended, but I regard it as essential to hear them in your own home first. You will love them or hate them!

The above recommendations have been made on the results of analysing my own internal tests, anechoic chamber measurements, and finally and possibly most important of all, the panel listening tests in stereo. I feel pretty safe in confirming these recommendations, but there is no doubt that some readers will disagree with some of the criticisms in this book. Undoubtedly some readers will also hear problems in the recommended speakers which I might not have emphasised sufficiently. Loudspeakers are by far the most difficult product in the hi-fi chain to assess, but I trust that in this survey we have been fair and have made recommendations to satisfy all domestic requirements.

SPEAKERS

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Most people will tell you that it's really only the speakers that make a difference to the sound of your hi-fi system. So, you are advised to spend as much as you can on your speakers, buy an amp which gives you the most watts per £, and get a turntable that goes round in the right direction with what's left over. **This is a recipe for disaster.**

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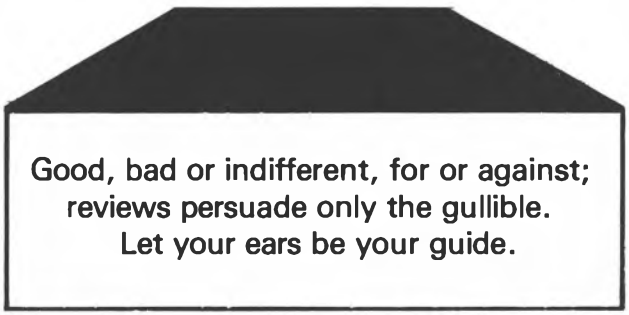

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In suggesting the most important parameters that should receive priority in the design of an ideal loudspeaker, I must restrict myself to the terms of reference used by the experienced musician and Hi-fi enthusiast, since professional requirements are not necessarily the same.

A loudspeaker must have a very low coloration over its entire acoustic output response range. This requirement is one of the most difficult to achieve with success. The response in an anechoic environment should measure flat from around 40Hz to at least 15kHz. By flat, I refer to the exceptionally difficult tolerance of ± 2.5dB with respect to the average response at middle frequencies. Whilst appreciating that it is a requirement which is almost impossible, it should at least be feasible to achieve it over the main part of the audio range. Not only should the response be within the borderlines mentioned, but the total energy per octave should be within even tighter borderlines, so that bass, mid, presence, HF and EHF regions should have equal energy outputs. Only in this way can the overall sound of the loudspeaker generally be balanced.

The harmonic distortion performance from 50Hz to harmonics generated up to 20kHz from appropriate fundamentals should not exceed 1% at low frequencies and 0.2% above 250Hz or so, this performance being maintained at all levels up to 90dB SPL, above which it would be realistic for the distortion to be allowed to rise somewhat. The frequency response should not vary by more than ± 5dB over an angle of $\pm 30^{o}$ horizontally, and $+22\frac{1}{2}^{o}$ and -10^{o} vertically. Once again, I appreciate that this is a very stringent specification, but there is no doubt that one day someone will achieve it.

In my opinion, the loudspeaker should be a direct radiator, having virtually no significant output from the sides or back, with the exception of a small amount of deep bass, created by the loudspeaker cabinet itself vibrating. The sensitivity of the loudspeaker should be as high as possible and ideally, should give an 86dB sound pressure level one metre away from the front when driven from 2.83V RMS. Once again, this sensitivity is not impossible, but not many good loudspeakers even get near this. The impedance of the loudspeaker should not drop below 6 ohms at any audio frequency and in the main should be 8 ohms or higher throughout. The phase angle between the voltage presented and the current drawn should not exceed $\pm 30^{o}$, and thus the loudspeaker system should present primarily a resistive impedance. The entire system should be capable of giving a sound pressure level output of up to 102dB at 1 metre for all classical and popular types of programme without distress, and should withstand sharp transients which themselves should give an output some 6dB higher.

No sensitivity controls should be provided, since in my opinion, these should be adjusted internally at the factory for optimum results in a good listening room. A domestic user should be encouraged either to make minor improvements to his room acoustics, or at worst use appropriately the tone controls on his preamplifier if he really feels that he wants to alter the response. The programme sources at your finger-tips are so variable in sound balance that you may well want to adjust tone controls anyway, so I can see no harm in using these to make a slight compensation for general personal taste. Finally, a team of listeners should listen to the design to see if any unforeseen snags crop up in subjective listening tests with all types of programme material auditioned. The price of the ideal loudspeaker would obviously be very high, a sensible upper limit being £400 pp plus VAT. A scaled down version of the speaker should be available, in which the bass is limited to 70Hz or so and in which the power output capability might be a few dB's inferior, and this system should not cost more than £250 pp plus VAT.

Maybe my suggestion for an ideal loudspeaker is a ridiculous pipe-dream, but at some time in the future we may look back to this book and realise that a product is available to these specifications. An entirely new philosophy and even design of transducer might be the answer, and I watch with much interest the development of systems incorporating electronic crossovers and separate amplifiers driving the different units. Such a system would of course cost more but you would not have to purchase an expensive amplifier to drive them, just a high quality pre-amp.

With tongue in cheek, I feel I must add that one day I should propose a specification for the ideal listener with a standard pair of ears!

Overall Comparison Chart

KEY
A Excellent/No problems encountered
B Good/Very slight reservations
C Fairly good/Slight reservations
D Slightly below average/A few marked problems
E Poor/Serious problems encountered
F Very poor/Very serious problems encountered

* Please see review

	Acoustic Research AR12	Acoustic Research AR14	Audiomaster Image 2	Audiomaster LS3/5A	Bayonix M/D	B & N Radford M/180	Bose 301	Bowers & Wilkins DM4	Castle Acoustics Kendal	Celef Mini Professional	Celef Studio Professional	Celestion Ditton 33	Celestion UL6	Celestion UL8	Chartwell LS3/5A	Chartwell PM200	Chartwell PM400	Danik A25	Electrovoice Interface A	Exact Acoustics RH4	Ferrograph SI Monitor	Goodmans Achromat 100	Goodmans Achromat 250	Goodmans Achromat 400
Width (metres)	354	354	287	190	350	375	267	254	290	305	343	355	412	280	190	343	381	250	360	254	350	212	272	327
Depth (metres)	273	273	231	165	290	290	241	254	280	279	381	267	222	235	160	286	330	250	200	254	440	233	278	292
Height (metres)	635	635	463	298	650	805	432	533	525	584	762	610	292	584	305	660	864	430	560	622	603	350	540	657
Weight (kgs.)	17	16	8.1	5.3	25	30	7.5	11.1	11	15	30	15.3	8	11	5.3	15	29.5	9	12.5	10	25	6	11.6	16.5
No. of Response Controls	2	1					1												1					
Recommended max. input (watts)	100	100	50	30	60	100	60	30	50	50	100	40	40	30	30	60	100	50	50	60	100	30*	60	75
Max. Music Output SPL (at 1m)	103	104	102	96	103	103	106	102	107	102	105	103	103	103	96	102	105	107	103	103	103	99	101	103
Output SPL for 2.83V (dBA)	82	84.5	80.5	78	81	80.5	83	86	87	82	82.5	84	82	83.5	77	81	83.5	85	85	84	80.5	80	81.5	80.5
Output SPL for 2.83V (dB unweighted)	84.5	86.5	83	80.5	84.5	82.5	86	87.5	89.5	84.5	85	86.5	84.5	86	79	83	86	87	87	86	83	82	85	84
Bass response on axis	C	C	C	E	C	C	C	D	D	B/C	A	C	D/E	C/D	E	C	A/B	D	C	D	C	D	C	B/C
Mid response on axis	F	E	D	C	F	E	C	C	C	A	B	B	C	D	B	C/D	B	C/D	C	C/D	C/D	C	C/D	D
Treble response on axis	B	C	E	D	F	C	E*	C/D	C	B	B/C	C	D	B/C	B	C/D	C	D	B*	D	D	C/D	D	C
EHF response on axis	B	E	E	C	E	C	D	D	B	B	B	B/C	C	C	B	C/D	B	D	C*	D	D	C	F	E
Coloration	C	B	B	B	E	E	C	D	D	B	C	C	C	B	A/B	B/C	C	C	B	C/D	E	B	C	B
Impedance	D	A	A	A	E*	D	A	D	C	A	C	D	C	D	A	C	D	D*	D	D	C	A	D	C
V/I Phase	A	A	D	D	C	A	C	D	C	D	C	A	D	A	D	D	A	A	D	D	A	B	C	C
Harmonic Distortion	C	C	E	E	F	A	B	E	C	E	C	C	E	E	E	C	F*	C	C	F	C	F	F	D
IM Distortion	D	B	B	A	F	A	C	C	C	C	B	B	D	C	D	A	B	B	C	C	B	F	E	C
Polar Diagram	B	C	D	D*	E	E	D*	C/D	C/D	C	C	C	C	B	C	C	B/C	D/E	D	C	D	C/D	C	C
Subjective Quality – Classical Music	D	D	E	C/D	E	E	D/E	D	C	B	B	B	D	D	C	C	B	C/D	C*	C	E	C/D	E	C/D
Subjective Quality – Pop Music	D	C	E	E	E	E	D/E	D	D	B	A/B	C	D	B/C	E	D	A/B	D/C	C*	D	E	E	D	D
Overall Subjective Quality	D	C/D	E	D	E	E	D	C/D	C/D	B	B	B/C	C/D	C	C/D	C/D	B	C/D	C	C/D	E	C/D	D/E	C/D
Value for money	D	C	D	C	E	E	D	C	B	A/B	C	A	B/C	D/C	D/C	C	D/C	C	C/D	C/D	C	D	D	D

IMF TLS 80	JBL L26 Decade	JBL L166 Horizon	JR149	KEF 103	KEF 104AB	KLH 317	KLH CL4	LNB Parabb Super	Marantz 5G	Marantz 6G	Monitor Audio MA3	Monitor Audio MA4	Mordaunt Short Pageant Series 2	Philips MFB 541	Philips MFB 544	Quad ELS	Richard Allan 828LP	Sansui ES 200 (improved)	SMC AL12	SMC AS40	Sony 5050	Spendor BC1	Spendor BC3	Tandberg TL3520	Tangent RS6	Tannoy Cheviot	Tannoy Devon	WAR HD7575	Wharfedale Dovedale SP	Yamaha NS 645	Yamaha NS 1000M
457	320	362		330	330	305	362	228	305	362	337	316	330	229	288	876	381	314	292	324	365	298	395	355	315	450	400	355	392	300	375
406	340	330	230 dia	226	260	248	330	260	241	285	317	280	230	184	216	266*	305	293	295	356	318	305	395	260	305	260	260	320	317	259	326
978	610	597	370	500	630	584	686	597	584	648	702	694	533	294	391	787	787	596	597	635	630	635	800	590	810	850	580	763	635	540	675
34	19	25	5.5	19.5	15.8	13.5	27	8	18	18	27	16	9.6	6.8	12.3	18	31.8	15	14	18	20	15	34	13	15	34.5	21	19.5	23	11.6	31
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100	35	100	35*	100	60	50	60	50	40	50	125	75	50	*	*	45	50	60	30	50	50	50	100	50	100	60	60	100	50	25*	100
105	112	109	99	102	102	106	105	102	102	104	105	104	105	101	102	100	101	105	95	99	104	101	105	105	99	113	110	105	105	104	109
83	87.5	88	76	78.5	78	84	86	80	81.5	84.5	82.5	82	84	*	*	82	83	83	78.5	79	87	80.5	82.5	84.5	76.5	88	87.5	81	83.5	85	84.5
85.5	89.5	90	78	82	81.5	86	87	82.5	84	88	85.5	84.5	86.5			84	85	86	82	82.5	89.5	83.5	85	87	80.5	91	90	84	86.5	86.5	86.5
D*	C*	B/C	D	C	B	C	D	E	D	C/D	A/B	B	C	E	C	D	C	D	D	C	D/E	D	C	C/D	B/C	B/C	C	B	B	D	B/C
A/B	D	D/E	C	B	B	B/C	D	E	C/D	B	B	C	C	E	D*	A	C/D	C/D	D	D*	E	A	C	B	E	C	B/C	D/E	F	C	B
C	D/E	D	D	A/B	A/B	D	D	F	D	C	D*	D	C	D	C	B	D	C/D	D	C	B/C	C	D	D*	C/D	E	D	C/D	C/D	C	A/B
C/D	D	D	D	A	B	D	C/D	D	B/C	C	B	D	C/D	D	B/C	B/C	C/D	C/D	A	B	C	C/D	E	D	C/D	E	E	D	E	C	A/B
C	F	F	B	A/B	B	C	D	E	D	D	D	C	B	B	C	A	D/E	C/D	B	C	E	B*	B/C	B	B	D	D	C	F	B/C	B
D	C	C	A	A	A	A	A	C	A	C	D	A	A			F*	A	A	A	A	A	B	E	A	D	A	A	E	C	E*	C
C	B	C	D	E	E	C	A	C	A	C	C	A	A			F*	B	B	E	A	C	E	C	B	F	B	B	D	C	C	B
C	C	E	C	C	C	D	A	F	C	C	A	B	F	D	A	F/D*	C	C	E	D	A	F	B	C	C	D	C	B	E	C	A
C	A	A	B	D	B	C	A	E	B	C	A	C	D	C	A	B	C	A	D	A	B	C	B	B	D	C	C	A	C	D	A
B	C	B	B/C	C	B/C	B	C	C	E*	E*	C*	B/C	C	A	B/C	F*	D	E	C	C	F	A	C	C/D	C	B/C	B/C	D	F	E*	B/C
C/D*	E	E	B	A	A	D	D	D	C/D	C/D	D*	C	C	E	D	A/D*	C/D	C/D	C	C	E	C*	B	C/D	D/E*	D	C/D	C	E	C*	A
C/D*	E	F	D	B	A/B	C/D	D	E	E	D	C/D*	C/D	C	E	D	B/E*	C/D	D	E*	D	E	D*	C/D	C	E	D	C/D	C/D	E	C	A*
C/D	C/E*	E	C	B	B	C/D	D	D/E	D	D	C/D*	C	C	E	D	*	C/D	C/D	C/D	C/D	E	C*	C	C/D	E	D	C/D	C/D	E	C*	A
D	E	F	A	A	A/B	B/C*	E	C/D	C	D	D	B	A/B	D	E	C/D	C	C	C/D	C/D	E	C	E	C/D	E	D	C	C/D	E	C	C

Many terms used in this book are described in the various chapters of the introduction. A few more important words or abbreviations are explained below.

ABR: Auxiliary Bass Radiator, usually in the form of a passive loudspeaker cone mounted over a form of port.
ACOUSTIC RESISTANCE: frequently applied in a port to add resistance to the air flow. Various types of this are used, including thin felt, drinking straws, or plastic type sponge materials.
ANECHOIC: an environment or sound in which no reverberation is present.
'AR': a term used to describe a form of coloration. Please see the chapter on coloration in the introduction.
'AW': a term used to describe a form of coloration. Please see the chapter on coloration in the introduction.
COLORATION: sounds added by the loudspeaker during and after the sound that is being reproduced directly. Frequently described in terms of vowel sounds.
dBA: sound pressure level measured in dB, but with a weighting curve applied to simulate subjective variations in volume.
DECIBEL: the logarithmic ratio between two levels which represents either a difference of level from a nominal one, or the gain or loss in volume of a particular circuit, sometimes at a specific frequency. A 1dB change of volume is approximately the lowest change on a programme or tone that can be heard by a fairly expert musician or engineer. 3dB represents double the power and 6dB a doubling of apparent volume, which is also equal to doubling the voltage. 10dB represents 10 times the power and $\sqrt{10}$ times the voltage, and 20dB represents 10 times the voltage and 100 times the power. dBs can be used to represent increased or decreased level changes or differences.
DIN COMPATIBILITY: the ability of a 5 pole DIN socket to be interconnected with external equipment designed approximately or precisely to DIN specifications, without problems arising in mismatching of hiss, response or distortion.
DISTORTION: any introduction of spurious or unnatural tones generated in electronic circuits which are not present in the original signal.
ELECTRICAL PHASE: the relationship between voltage and current, variations of which are caused by non-resistive elements at various frequencies.
'EE': a term used to describe a form of coloration. Please see the chapter on coloration in the introduction.
HORN LOADING: a mouth in front of or connected with a system or unit which usually has an exponential (curved) shape to increase efficiency. Horn loading has much the same effect as cupped hands when placed around a mouth to enhance the volume when you shout.
IMPEDANCE: the equivalent resistance of a loudspeaker at any specified frequency.
MODULUS: the total impedance at a frequency without regard to capacitive or inductive elements.
OHMS (Ω): a unit of resistance or impedance.
'ONG': a term used to describe a form of coloration. Please see the chapter on coloration in the introduction.
PINK NOISE: completely random generated noise that is effectively continuous power of equal energy per octave. Similar to white noise, but attenuated by 3dB per octave with increase of frequency.
POLAR DIAGRAM: refers to the frequency response of the loudspeaker away from the on-axis measurement.
PORT: a hole in the cabinet with or without a tunnel or its equivalent, which assists in the radiation of bass frequencies.
POTENTIOMETER: a manual device which alters the volume to units, allowing balance to be changed by the user.
RESONANCE: when a tone is applied at some frequencies to a loudspeaker, output is still heard for a very short while after the tone has stopped. Alternatively, the intensity of the tone is artificially enhanced by a cone, panel or other element in the room resonating.
SPL: sound presence level. This is stated in decibels with an identical scale as used in current government legislation concerning traffic noise and other noise pollution. Speech is normally around 65-70dB, a Mozart symphony can peak 95dB, and a Mahler symphony 105dB.
SQUAWKER: a unit radiating mid and/or lower high frequencies.
SUCK-OUT: an effect produced by anomalies in response giving the impression of a small part of the frequency range receding seriously.
SUPER TWEETER: the tweeter used to reinforce the top octave or so of the audio range.
TRANSDUCER: a device which changes energy from one type to another, e.g. electrical energy into sound energy or vice versa.
TRANSIENTS: sudden loud peaks in a programme which are of very short duration.

TWEETER: a unit radiating high frequencies.
UNWEIGHTED: implying a measurement with a flat microphone and meter from 20Hz to 20kHz.
V/I PHASE: please see the chapter on impedance and phase.
WATT (W): a unit of power, in particular referring to the input power of a loudspeaker. Approximately equivalent to the voltage times the current in AC outputs.
WHITE NOISE: as pink noise, but equal energy per Hz band width.
WOOFER: a unit radiating low frequencies.

Test Equipment used by Angus McKenzie Facilities Ltd for this Survey

2 B&K 2010 Heterodyne Analysers
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B&K 2426 Autorange Voltmeter
B&K 2203 Sound Pressure Level Meter
B&K 1902 Intermodulation Analyser
B&K 1022 Beat Frequency Oscillator
B&K 2606 Measuring Amplifier
B&K 1402 Random Noise Generator
B&K 1405 Pink/White Noise Generator
B&K 3921 Turntable
B&K 2305 Chart Recorder
B&K ½" and 1" Free Field Microphones
B&K 2113 Spectrometer
B&K Frequency Response Tracer 4709
Hewlett Packard 3310B Function Generator
Hewlett Packard 3575A Gain/Phase Meter
Hewlett Packard 3580 Audio Spectrum Analyser
Hewlett Packard 970A Digital Meter
Hewlett Packard 8012B Pulse Generator
Hewlett Packard 400FL Millivolt Meter
Bryans Instruments XY Plotter
Telequipment DM64 Storage Oscilloscope
Revox A700 Tape Recorder
Nagra 4S Stereo Portable Recorder
Philips Pro 36 Recorder
Telefunken M15 ½" Quadraphonic Recorder
Bias Electronics ½" Four Channel Recorder
Dolby A301 Noise Reduction System
Technics SU9600 Pre-Amplifier
Technics SE9600 Amplifier
Technics 110 Turntable (with carbon fibre arm and special cartridge)
Amber 4550 Realtime Spectrum Analyser
Levell DC Millivolt Meter
Levell AC Millivolt Meter
Levell Laboratory Pre-amplifier type TA 605
Marconi Attenuators
Quad 405 Current Dumping Amplifier
B&O Loudpeaker Comparator Unit
AMF Remote Control Switch Unit
AMF PPM to BBC standard
Muirhead 0.1% Decade Resistance Box
2 Amcron Laboratory DC300A Amplifiers and Pre-amplifiers
Additional Loudspeaker Amplifiers by BGW, Naim and Sansui
Wayne Autobalance Universal Bridge B642
Graphic Equalisers by JVC and Astronic
Microphones by Calrec, AKG, Schoeps, Shure
Levell Decade Resistance Box R601
Yamaha CT7000 FM Tuner
Mixing Equipment by Calrec and Midas
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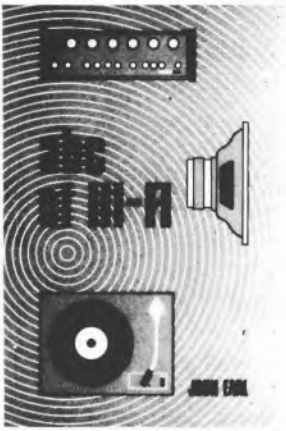

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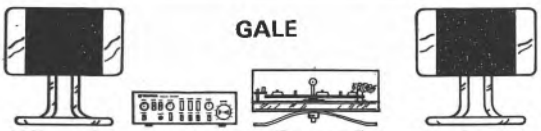

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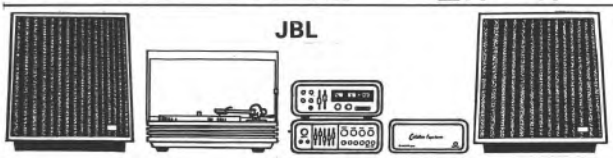

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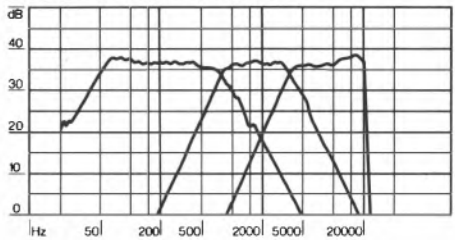
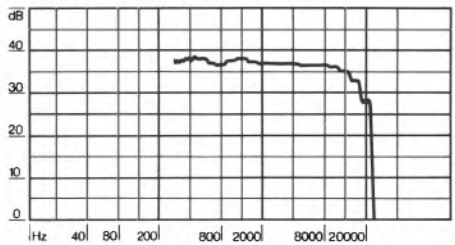
AR-12 Anechoic response



AR-12 Energy response



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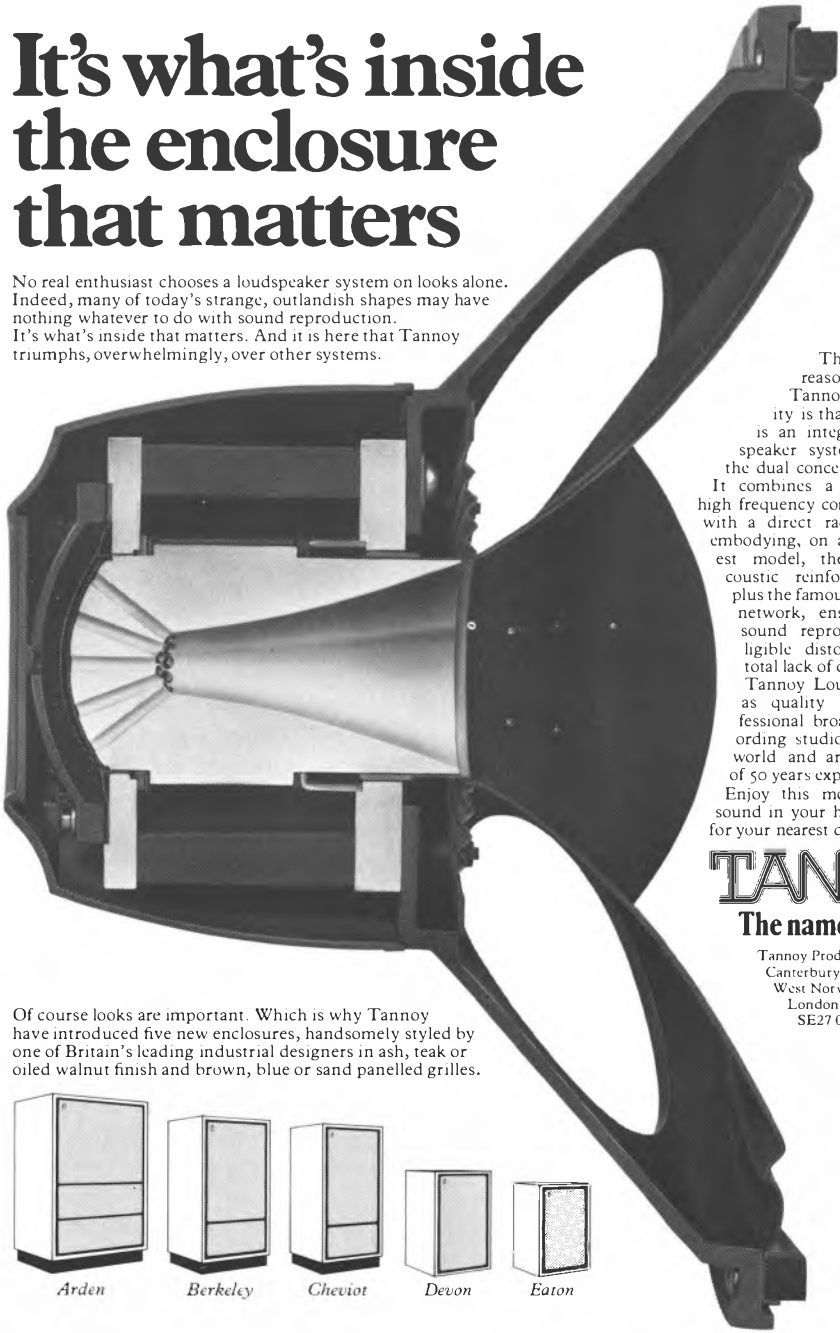

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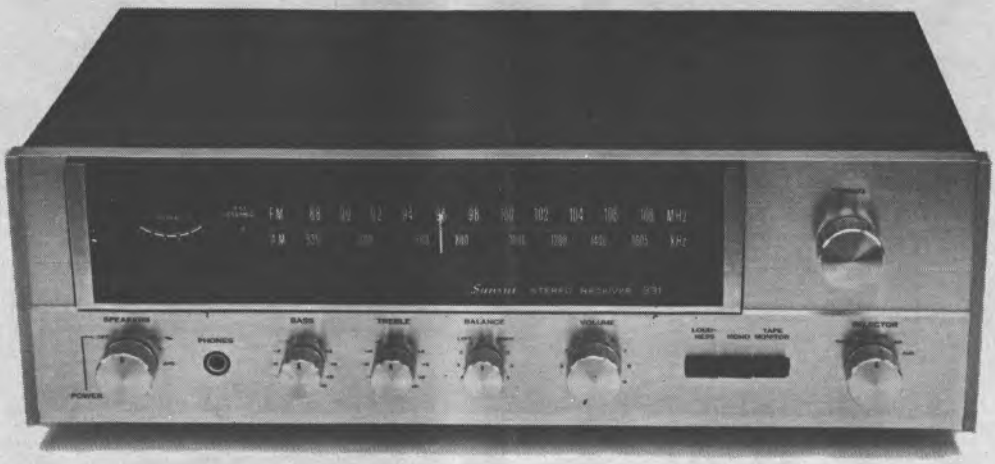

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Designed by the BBC and built under license from them, the LS3/5A is intended primarily for monitoring purposes where space is at a premium. An exceptional standard of performance is achieved and we believe that the loudspeaker will satisfy the most demanding user.
The LS3/5A is hand-built in small quantities. An unusual amount of care is taken in its construction and the attention to detail is possibly unique. Only in this way can a consistent high standard of performance and reliability be assured.
The enclosure is of the 'closed box' type and is constructed from expensive and rigidly specified materials. It employs a 4" plastics coned bass driver and a ¾" dome tweeter which are pre-selected to meet a rigid pass specification, together with a complex 18 component crossover network which is adjusted on test to equalise the relative sensitivities of the drive units. Each LS3/5A is compared with a reference model during listening tests using pink noise and master tape. Every one is guaranteed to meet its specification.
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audiomaster LS3/5A MONITOR

Reflection on an image

Image 2 has been designed and built to fulfil the steadily growing demand for a high performance loudspeaker of compact dimensions and modest cost. The critical listener will appreciate in particular the low order of colouration, the smooth response and the stable stereo image.
As with LS3/5A the enclosure is of the 'closed box' type with the cabinet damped internally by means of bitumastic pads and acoustic foam blocks. The smooth and well integrated response of Image 2 has been achieved by using an unusually complex filter network which equalises the individual drive units and provides optimum crossover slope rates. Close tolerance polyester film capacitors are employed to ensure reliability and long life.
Built to 'no compromise' standards, Image 2 has the backing of the Audiomaster 5 year guarantee.

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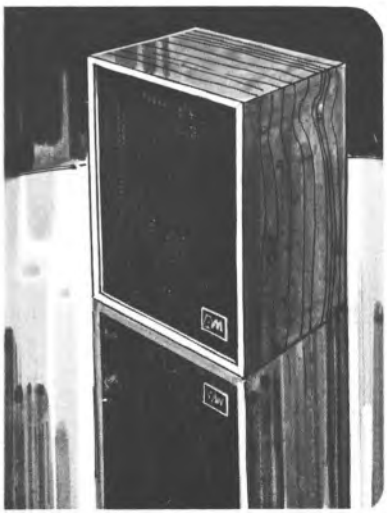

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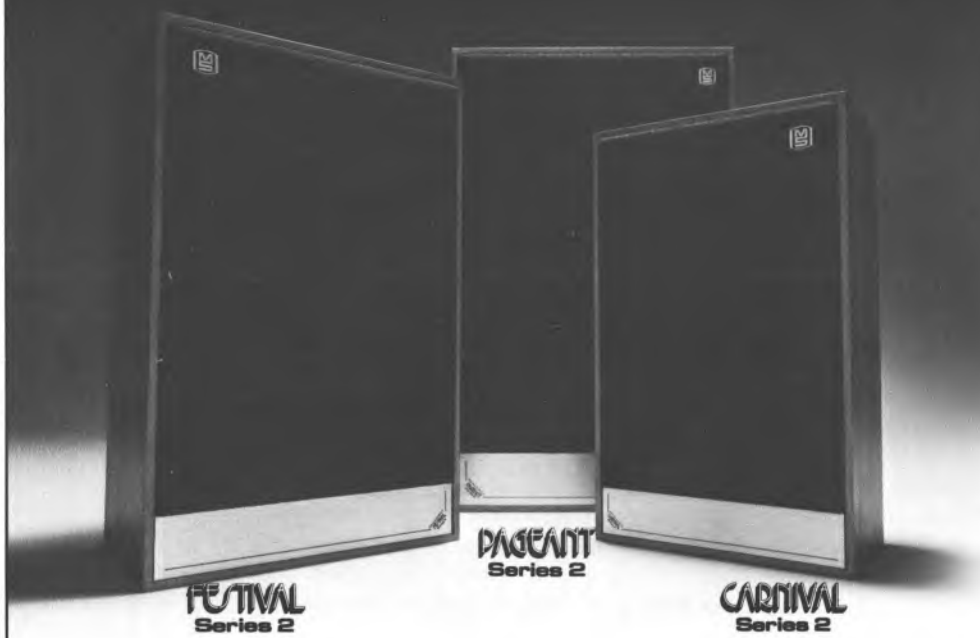

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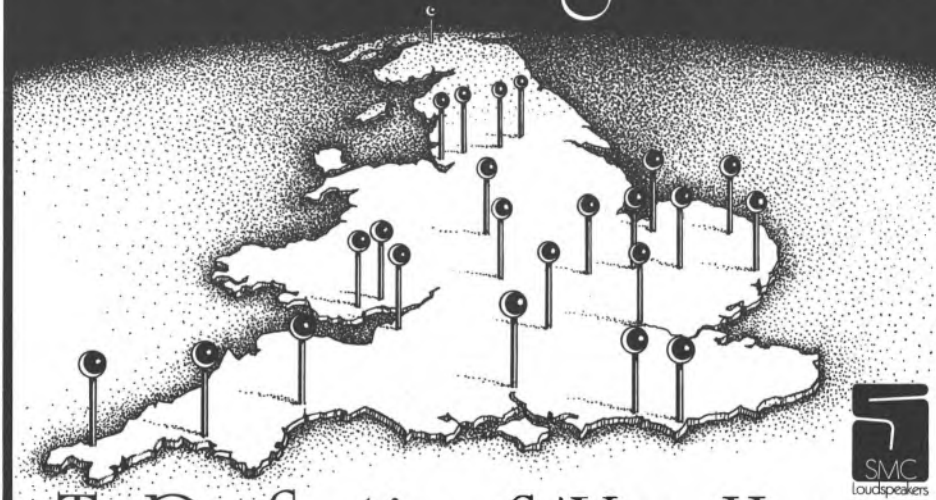

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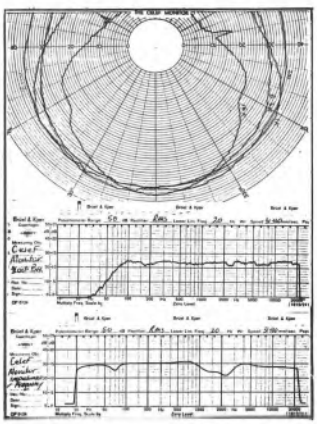

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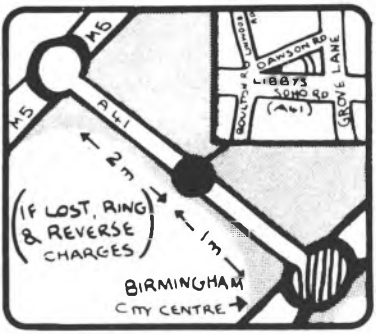

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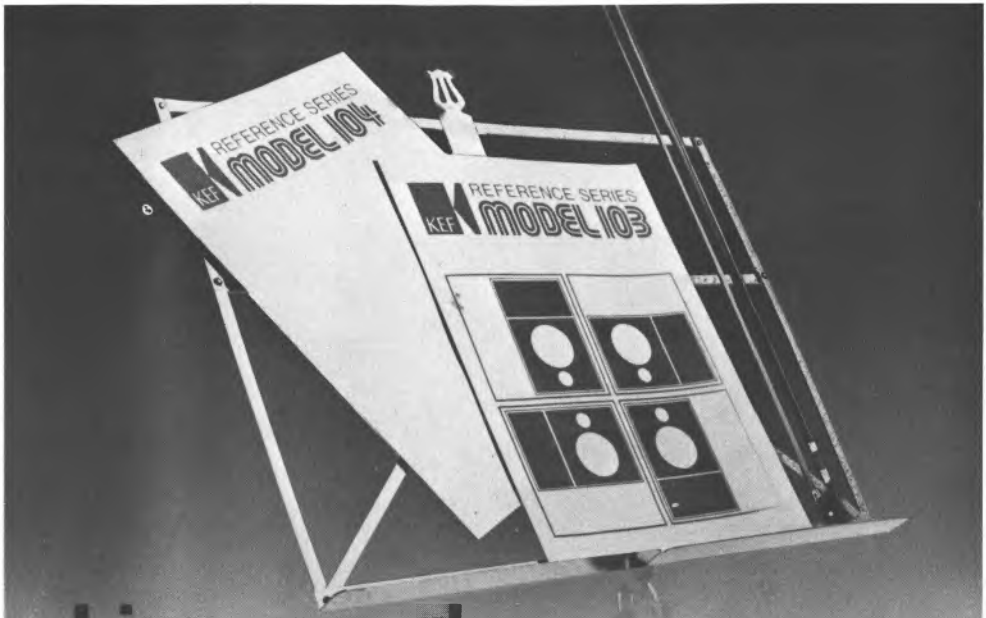

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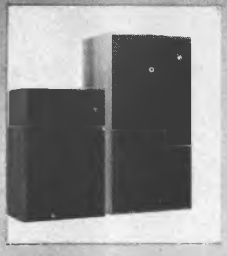

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All our latest thinking goes into Reference Series. Sophisticated KEF laminated drive unit diaphragms and anti-resonant cabinet linings work together to defeat colouration. New drive unit motor constructions handle higher power levels without distortion. New dividing networks use close-tolerance components to give smoother, distortion-free cross-over. Unusual design features too, like the acoustically coupled 13 by 9 inch bass radiator that extends Model 104 bass performance. Or the rotating steel baffle that keeps the Model 103 drivers in ideal stereo alignment, in whichever position you mount the cabinet. Even in their superbly detailed finish, Reference Series speakers show their breeding. The choice . . . shelf-mounting two-way Model 103 and free-standing three-way Model 104. The reference . . . live sound.

KEF the speaker engineers

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Ordinary speakers will unprepared for the

"The back is where the front should be...

...the front is the back...

...and the sound comes out the 'wrong' side.

Till I hear it, I don't believe it."

Because the technology is revolutionary, the Bose 901 speaker looks like nothing you've ever seen before.

It's not at all the box shape you've been led to expect of a speaker.

This is because the 901 works on the reflected sound principle. And not the usual direct sound principle.

Our angle is this.

The majority of sound you hear in a concert hall is reflected sound. (It can be as much as 89% reflected sound and only 11% direct sound.)

That's just the opposite of what conventional speakers offer and exactly what the 901 offers you.

Love it or hate it, it's like nothing you've ever heard before.

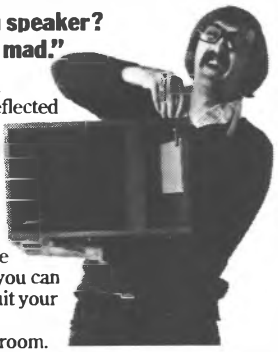
have left you quite Bose range.

"Computer matched drivers? In this? Pull the other one."

The 501, like all Bose speakers, feature computer-matched drivers.

They're matched by the custom-built Bose Syncom II computer to within ± 0.¾dB.

So far as we know, only Bose renounce human error matching methods in favour of computer reliability.



"Paddle my own speaker? You must be mad."

The Bose 301 also works on the reflected sound principle.

Except that it reflects the sound off a paddle within the speaker rather than off your wall.

By varying the angle of the paddle you can alter the sound to suit your own tastes and the dimensions of your room.

Adjustment is easy: you simply turn a knob on the outside of the cabinet.

"Twelve pairs of those tiny things can fill a 20,000 seat arena? No way."

The Bose 800 is a professional speaker, used by James Last, Bruce Springsteen etc.

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But

just as Sviatoslav can choose his piano so you too can choose your instruments. This being bicentennial year we can do no better than quote the wisdom of Abraham Lincoln:
"You can fool all of the people some of the time and some of the people all of the time but you cannot fool all of the people all of the time."

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