

A PASSIVE ROLE?

Capacitors & Resistors come under Martin Colloms' scrutiny

THOSE READERS WHO HAVE BEEN following my writings over the last eight years or so will be aware that I have changed my position regarding audio theory over that period from that of a rigid 'establishment' engineer to a more flexible view of technology and its interaction with reproduced sound quality. Too many ears, including my own and those of a number of respected colleagues, are reporting sound quality differences which, at present, are not adequately anticipated by established audio engineering principles.

In the May issue of *HFN/RR*, I summarised my empirical findings on amplifiers, these based on my experience of a wide variety of different designs and technologies, with the conclusion that 'Technology' in the accepted sense did not adequately describe sound quality. Indeed, it is even possible to construct two amplifiers of very similar performance, both meeting an exhaustive specification far in excess of that traditionally required for flawless reproduction, yet find significant subjective quality differences between them.

Experiments with cables have shown that a piece of wire is not the simple distortionless link we have assumed it to be. Likewise, the non-amplifying, non 'electronic' electrical components—resistors, capacitors and inductors—the so-called 'passive' components, can also have an influence on sound quality not immediately connected with their use as circuit elements. If these passive parts are not so passive after all, then where does the effect of the cables, the resistors and the capacitors leave off and where does that of the amplifier proper begin?

In fact, the effects are inseparable; logically, a good amplifier must use a combination of good technology, intelligent circuit design, optimum passive components and the right wire. The problem is thus rather one of where to start?

With this background preamble over, our passive component project may get underway. The first thing was to set up an audio system of as high a standard as was practicable, with the choice of optimum cable going without question; secondly, we used that system as a reference chain within which to observe differences, hopefully even improvements (these defined as changes in the recognised 'right' direction); thirdly, whenever possible we incorporated the change responsible for an improvement within the reference system, and thus moved the overall sound quality still further forward. By this means, a system could be refined to a point where even small component changes might exhibit a clear effect on the overall sound. The music program used was chosen to demonstrate soundstage width, depth, ambience, and focus, tonal and musical neutrality, good transient reproduction as well as lifelike dynamics.

The final system chosen consisted of Magneplanar MGIII loudspeakers, Audio Research SP-8 preamp and D-115 power

amplifier, Linn Sondek, Rega RB300 tonearm, van den Hul MC1000 m-c cartridge, Sony '552/702 CD player, with interconnects consisting of LC single-strand cable. Such a system, however, is not mandatory to detect subtle differences and does not need to be overly expensive. Cable differences can be audible and significant in a £500 vinyl disc system or a £750 CD-based system.

For the purposes of this article, the majority of the results are anecdotal, reporting what happened—or, as some may prefer to see it, what we *thought* happened—when a passive component was inserted or substituted. These assessments were carried out in the same manner as for other hi-fi products, with much the same attitudes present in the listeners' minds, the main differences being due to the large number of 'products' available. While readers must decide themselves whether or not to take these subjective findings on trust, a small number of controlled double-blind tests were also undertaken, and the results from these tests are presented separately.

CAPACITORS: TEST ONE

The capacitor was the primary target in this survey. Visually dominant, available in many different shapes, sizes, configurations and colours, they have been the subject of much written speculation on whether their audio performance conforms to that of the 'perfect' capacitor used by circuit designers. For this first series of tests, the capacitor under test was inserted between the pre and power amplifier, used as a simple AC coupling link. Although this will give a high-pass filter action, the impedances involved—600ohms source, 200k-ohms load—meant that capacitor values down to 0.47µF could be used without significant LF rolloff above 20Hz. The upper size limit is effectively unbounded, and we went as high as 10000µF (10millifarads) in order to get some idea of the audio quality of power supply components. (The Editor particularly wanted to include some Tantalum electrolytics in this test, but they were not available for the listening tests, so the results for these will be included in a later issue.)

Our reference for sound quality was, of course, the direct connection, which scored 95% on our scale of subjective judgment. By contrast, the insertion of the component under test—I must stress that this was a single series capacitor—resulted in a score ranging between 50% to 91% on the same scale. The insertion of capacitors scoring towards 91% was hard to detect, but at the 50% level, the insertion resulted in a clear modification of the sound of the reference system, almost as if a poorer amplifier had been substituted.

Here, then, are the results for this test, with the score corresponding to their approximate performance in the listening tests. (Note that the results for any particular capacitor may not always be applicable for other values of the same type, unless the

constructional details are very similar.)

C1 Make: Sidereal Score: 91%

Value: 5µF 200V

Dielectric: Metallised polypropylene

Comments: This US-made capacitor with multistrand copper leads is available from RATA in the UK. Compared with other types it showed noticeably better definition at both treble and bass extremes. The mid was in the top class for tonality, clarity and depth.

C2 Make: Ultracap Score: 88%

Type: CE323 series

Value: 4µF 210V

Dielectric: Metallised polypropylene

Comments: This white cylindrical US-made device is the latest version of the familiar capacitor made popular by J Peter Moncrieff's *JAR* magazine and appears in many high-end amplifiers. With the Sidereal, it leads the field.

C3 Make: Ultracap Score: 85%

Type: CE323 605220

Value: 6µF 210V

Dielectric: Metallised polypropylene

Comments: Sound similar to C2

C4 Make: Ultracap Score: 83%

Type: CE323

Value: 2µF 210V

Dielectric: Metallised polypropylene

Comments: This white cylindrical capacitor had a good HF performance, but some loss of ambience and space were noted in the lower frequency range.

C5 Make: High Lambda Score: 83%

Type: Taitso 2A205K

Value: 2.2µF

Dielectric: Polypropylene?

Comments: A large, very costly plastic film type, much in favour for very high quality crossovers, it showed some slight mid sharpness and hardening, a touch of treble fizz and mild loss of bass control.

C6 Make: Wondercap (Rel-Cap) Score: 75%

Type: PP3MF 106K2.5A, AR C-8446

Value: 10µF 250V

Dielectric: Polypropylene

Comments: A large yellow flat film capacitor, US made, used extensively by Audio Research and Counterpoint. Sound had good midrange character, fine depth and ambience, but there was some loss of definition and a slight tizz in the high treble.

C7 Make: Soshin Score: 75%

Type: WT-WT2A 335K

Value: 3.3µF

Dielectric: Not known

Comments: This is a Japanese high quality plastic film capacitor selected for audio quality. It had a pleasant sound, with good stereo focus but some loss of depth, as well as a slight nasal coloration, a slight 'boom', and some upper mid-to-treble grain.

C8 Make: WIMA Score: 70%

Type: MK P10



Value: 1.5µF 400V

Dielectric: Metallised polypropylene
Comments: This West German capacitor 'darkened' the tonal quality, with some loss of clarity and depth. The bass was good, while the treble was a touch 'zitty' and forward.

C9 Make: Prosec Filmcap Score: 70%
Type: 85E

Value: 10000µF 100V

Dielectric: Aluminium electrolytic
Comments: This large power supply electrolytic, made to a Denis Morecroft specification, has a special multi-fingered foil. The bass was slightly lumpy, the treble showing a slight soft 'fuzz', with a mild loss of treble localisation. Stereo was slightly muddled with some depth loss.

C10 Make: ROE Score: 70%

Type: Elkorah II A

Value: 10000µF 40V

Type: Aluminium electrolytic
Comments: This power supply reservoir cap with tag terminations sounded a bit loud and bright with a touch of treble fizz, yet with a crisp, well-defined quality. Bass was quite good, depth fair and stereo focus good.

C11 Make: AWD Score: 72%

Type: 35Y8

Value: 450µF 100V

Dielectric: Aluminium dielectric
Comments: This is a small power supply electrolytic, selected for sound quality. Sound was well-balanced and focused, with low coloration, firm dynamics, yet remained musical.

C12 Make: STC Score: 69%

Type: ALS20A-1030DF040

Value: 10000µF 40V

Dielectric: Aluminium electrolytic
Comments: A UK-made, high ripple rating reservoir cap with screw terminals, this gave a sonically pleasing depth, with treble a bit rough but quite well controlled. A firm bass, pleasant tonal balance, and good stereo focus.

C13 Make: Ero Score: 68%

Type: MKC1862 LM

Value: 2.2µF 100V

Dielectric: Polycarbonate
Comments: Some mid coloration, good treble, tidy, well-integrated sound from this pinkish-purple component.

C14 Make: Alcap Score: 68%

Value: 5µF 50V

Dielectric: Non-polarised aluminium electrolytic

Comments: A Hong Kong-manufactured bipolar electrolytic designed for use in loudspeaker crossovers, this gave quite good stereo focus and depth with a pleasing overall balance but also a slight loss of clarity and definition.

C15 Make: Eurofarad Score: 65%

Type: EFD PP72R

Value: 2.2µF 160V

Dielectric: Polypropylene
Comments: Made in France, this gave some mild muddling of the sound, with bass a touch 'bumpy', treble slightly 'obvious' and muzzy, with some loss of focus.

C16 Make: RS Components Score: 65%

Type: RS 114-626

Value: 0.47µF 1000V

Dielectric: Polypropylene
Comments: Sound had some mild grain to midrange and HF, with good focus and depth.

C17 Make: RIFA Score: 65%

Type: Miniprint PHE280HF722

Value: 2.2µF

Dielectric: Polycarbonate?

Comments: The sound of this Swedish-made component was a touch 'loud' and forward, with a bright, slightly 'zitty' treble. Tight and well-defined, however.

C18 Make: Prosec Filmcap Score: 65%

Type: 85C

Value: 10000µF 100V

Dielectric: Aluminium electrolytic
Comments: A UK-made standard heavy duty power supply electrolytic, it gave some bass lumpiness, with a loss of depth and midrange definition. The sound was slightly defocused, with some LF 'fuzz'.

C19 Make: Prosec Filmcap Score: 63%

Type: 85E

Value: 10000µF 40V

Dielectric: Aluminium Electrolytic
Comments: A lower voltage high current reservoir cap designed to Denis Morecroft's specification, this gave a sound with some added hardness and a grainy effect, with the treble a touch bright. It was nevertheless fairly clear and well-focused.

C20 Make: STC Score: 58%

Type: ALT20A 103DD040

Value: 10000µF 40V

Dielectric: Aluminium electrolytic
Comments: A medium-grade reservoir cap with tag connections, this gave the sound some mid forwardness, with a loss of stereo depth and some bass 'boom'. There was a loss of stereo focus, plus an odd 'filtered', bandwidth-limited effect.

C21 Make: STC Score: 58%

Type: ALP20A 103DD040

Value: 10000µF 40V

Dielectric: Aluminium electrolytic
Comments: A multi-tagged version of C20, this gave a well-balanced sound, but with a hint of upper-range harshness.

C22 Make: RS Components Score: 56%

Type: RS115-168

Value: 2.2µF

Dielectric: metallised polyester
Comments: This orange capacitor gave some mid coloration with a 'honky' effect, but with fair stereo depth and a reasonable overall balance.

C23 Make: STC Score: 55%

Type: KA10A 103T040FF

Value: 10000µF 40V

Dielectric: Aluminium electrolytic
Comments: A modest power supply electrolytic, this gave a bland smooth effect, with a loss of dynamics. There was some loss of focus, with a touch of nasality. Treble was average; bass was somewhat soft.

C24 Make: C-U Score: 54%

Type: 2A 305K U-Con L

Value: 3.3µF 100V

Dielectric: Mylar
Comments: This Japanese capacitor is specially selected for audio. However, it gave some mid coloration and treble grain, with a loss of stereo depth.

C25 Make: Rubycon Score: 51%

Value: 3.3µF 100V

Dielectric: Mylar

Comments: This was a Japanese audio 'special', with Litz wire terminations. The sound was coloured in the midrange, with a general loss of depth

and definition, plus some 'grain' in the treble.

CAPACITORS: TEST TWO

This test was devised to see whether any correlation could be established between the rankings for the 10000µF power supply electrolytic reservoir capacitors obtained when they were used as coupling capacitors in Test One and those for their more normal use. A modest test amplifier, a Rotel RA820BX—a promising choice in view of its generally good sound and decent subjective transparency—was modified, bringing the power supply connections outside the case to facilitate quick and easy connection to a variety of reservoir capacitors. Aside from the substitution of the Rotel for the Audio Research amplifiers, no other change was made to the test system, although as the amplifier used for Test One cost 33 times the price of the Rotel, some doubt was expressed as to whether any audible results would be obtained. (Although the marking is to the same absolute scale as used before, the marks for each capacitor relate to its use in the Rotel, which scored 45% on this scale when unmodified.)

C12 Make: STC Score: 65%

Comments: More powerful, better defined bass; better treble detail and focus.

C9 Make: Prosec Filmcap Score: 60%

Comments: This Denis Morecroft-inspired cap gave a well-balanced sound, quite clear, with a sweet treble but slightly softened definition.

C10 Make: ROE Score: 60%

Comments: Good bass, depth and detail; quite dynamic, with clear treble.

C18 Make: Prosec Filmcap Score: 55%

Comments: This standard cap was generally similar to the Morecroft version, but had reduced definition and depth, and less clarity and attack in the treble.

C20 Make: STC Score: 50%

Comments: A small improvement over the standard capacitors fitted to the '820BX, but with reduced depth compared with the better types, as well as some muddling of detail, loss of bass definition and some 'boom'.

C10/C1 Make: ROE, bypassed with 5µF Sidereal Score: 62%

Comments: A surprising change in tonal balance occurred, considering that the plastic film capacitor represents just 1/2000th of the total capacitance. The tonal balance of the ROE shifted nearer to the pleasant neutrality of the Morecroft Prosec. Definition was still good, while subjectively the bass seemed a little 'slow'. Overall, the score remained almost the same.

CAPACITORS: TEST THREE

The results of this test are not presented in any great detail, but are interesting, nonetheless. In this test, the reservoir capacitors were used as low impedance power amplifier-loudspeaker couplings. Power levels were kept low to minimise reverse voltage effects as the electrolytics were being operated without any DC bias across them. The peak power level was 2W into 4ohms (Magneplanar MGII), with a mean level of 200-500mW ie, typically just 1.4V AC RMS.

All the capacitors used showed moderate differences in sound quality and all lowered the standard of replay when compared with the straight wire connection. The rankings

were very similar to those observed in Test One.

SUMMARY: TESTS 1, 2, 3

The three tests auditioned the sample capacitors, as appropriate, in a high impedance, small signal, coupling mode; in a low impedance, higher current, coupling mode; and as power supply reservoirs, 'outside' the signal loop of the test amplifier. In all three cases, significant differences in sound quality were observed.

Regarding the large power supply electrolytics, it was surprising to discover that each possessed an inherent sonic character or signature which was identified in each of the different modes of use, despite two of these being unorthodox, indeed out of context, in terms of their intended function as reservoir capacitors.

Another, perhaps surprising, finding was the clear subjective effect of different reservoir capacitors—all of the same nominal value—on the performance of the budget amplifier. Amplifier theory suggests that the size and impedance of the reservoir capacitors will have an effect on the amplitude of supply ripple and peak current capacity. However, no effects on sound quality are predicted. The generous common mode rejection inherent in modern transistor amplifier circuitry should impart an immunity to minor power supply changes. Conversely, our test results would indicate that the sonic differences due to power supply capacitors are almost as important as those due to the capacitors used for signal coupling applications.

ASSOCIATED TEST RESULTS

A) A similar test to the third test was carried out in Japan earlier this year, using another transistor amplifier with excellent common mode rejection. A panel of four skilled listeners comparatively auditioned an unseen pair of amplifiers, with one of these undergoing reservoir capacitor substitutions. Four makes of capacitor were tried, including Matsushita and Rubycon types. The ratings cannot be disclosed, but the results showed that each type imparted distinct and recognisable signatures to the amplifier's sound quality. One gave exceptional treble quality, for example, and a clear midrange, at the expense of a softened bass, while another was well-balanced, without being particularly outstanding in any one area. Another gave taut, firm low frequencies but a grainy treble, and the fourth was slightly soft at the frequency extremes, but excelled in terms of stereo depth and ambience through the midrange. The differences were reliably identified blind, though the panellists didn't reach any clear decision about which of the four was preferable.

B) Nearly all CD players use an output coupling capacitor, usually an inexpensive electrolytic, and experiments carried out over the last three years have shown that the sound quality of such a player can be altered and in many cases improved by substituting a better type. Where the following amplifier or preamplifier allows, the total removal of this capacitor gives better results still. Careful comparative listening, involving reference to a constant 'standard' player, has confirmed improvement to some degree of the sound quality of the following players by substitution or elimination: Sony CD-P101; Marantz CD-73; Yamaha CD-X1, CD-X2, CD-3 and related models; and the Akai CD-M88.

Similar modifications have improved the sound of Counterpoint SA-7 and Audio Research SP-8 preamplifiers. Corroboration

has been extensive, involving (certain of) the manufacturers concerned, many owners of CD players, and other writers.

C) In the January 1985 issue of *HFNR* (p93), I reported the results of a double-blind test involving two nominally identical Audiolab power amplifiers, where a small subjective difference was reliably identified between them. I was assured by the designers—in whom I have every confidence—that the only difference between the two was the addition of an input coupling capacitor, a good quality 3.3µF polycarbonate type, to give protection against excessive DC offsets on non-Audiolab preamps. This introduced a subsonic rolloff with a -3dB point at around 1Hz, this considered to be too low to be significant.

The results of this double-blind test confirmed the experience of the Audiolab designers, who had decided that the capacitor should be omitted except in cases where essential to block DC.

DOUBLE-BLIND TESTS

For this report, a series of double-blind tests was arranged, in order to provide some statistically solid data to support or deny the assertions concerning the effect on sound quality of the various capacitors auditioned earlier. The components under test—both nominally 2µF, but one pair a polyester film capacitor and the other a polypropylene, and channel matched to better than 0.1% accuracy—were cased to prevent identification either by the operator or the subject and labelled by number by an independent witness, who also supervised the unveiling at the end of the tests to see which was which.

Each pair of capacitors was soldered into a link between pre and power amplifiers, the system being the same as used for the less formal tests. Program was from CD, played on the Sony '552/702' combination. The results are to be regarded as interim, the time scale only allowing three test sessions. We shall be reporting on the results of further tests in a later issue.

The subjects this time were myself, my wife, and my colleague Paul Crook. Each subject listened alone, a separate operator selecting the switch settings on a random basis. The identity of the switch position itself was randomised prior to each set of presentations. After an initial listening session to determine listening levels etc, the subject judged a sequence of 14 presentations. Each time he or she had to decide whether this was the same as the previous one, or different. In addition, the subject was required to identify A and B presentations more positively, expressing a preference if possible.

Subject A scored 9 out of 13 for recognition of 'same or different' and 8 out of 13 for identification of the preferred unknown.

Subject B scored 8 out of 13 for recognition of 'same or different' and 10 out of 13 for identification of the preferred unknown.

Subject C scored 9 out of 13 for recognition of 'same or different' and 8 out of 13 for identification of the preferred unknown.

A control run, with A and B identical, gave results of 5 out of 13 for recognition of same/different and 7 out of 13 for preference ie, random scoring.

These results do not provide definitive proof. They do suggest, however, that under these double-blind conditions, all three subjects could reliably detect to some extent the subjective difference between the two plastic film capacitors under test.

Asked to rate the sounds of the two capacitors under test, one subject gave 70%

for the polypropylene and 50% for the polyester, a blind result in fair agreement with the subjective ratings reported earlier.

BRIEF TESTS ON RESISTORS

For interest's sake, some subjective tests were performed on resistors during the capacitor auditioning. Only a few types were tried, more generic than specific, and only in one application, namely as the 100ohm shunt loading function for an m-c cartridge, as reported on by Christopher Breunig a few months back (*HFNR* June 1985). The test cartridge was an Empire van den Hul MC1000 and the preamp an SP-8.

The judgments are arbitrary to some extent, based on the listeners' experience of sound quality 'improvement'. Even if the reader disagrees as to the true meaning of the observation—is it a change or an improvement?—the results do suggest that the resistors differ in their effect on the system's sound quality. Given the minute power and voltage levels involved in the test application, it is highly unlikely that thermal or voltage stress effects—which would result in the nominal resistance being modulated by the signal—are involved.

R1 Make: Holco Score: 91%

Type: 100ohm metal film Comments: Very small effect; tight precise stereo and good overall control.

R2 Make: RS Components Score: 86%

Type: 100ohm metal film Comments: Trace of 'muddle'; slight loss of space; a touch of treble grain and a softer bass.

R3 Make: Roederstein Score: 84%

Type: 100ohm metal film Comments: Good bass sound, with pleasing depth but a slight grain and 'zzz' in the treble. A slightly 'muzzy' effect in the mid-range.

R4 Make: Anonymous Score: 70%

Type: 100ohm carbon film, 1/4W Comments: 'Zitty' defocused sound; 'louder' and mildly fatiguing; grainy treble.

R5 Make: RS Components Score: 64%

Type: 100ohm carbon film 1/4W Comments: Defocused and grainy sound, with a loss of bass definition, stereo depth and focus.

We emerged from this brief series of tests feeling that while resistor differences were difficult to identify, significant differences were nevertheless present. The effects may well be different in alternative circuit positions and at different power and voltage levels, but in this application, only the Holco proved capable of loading the cartridge without apparently degrading the sound quality of the SP-8 preamplifier to some extent. The other four resistors were felt to reduce the sound quality sufficiently to make the question of optimum resistive loading for the cartridge irrelevant. They were best omitted altogether.

OVERALL CONCLUSIONS

Discussions with the designers and manufacturers of some of the finest audio equipment made today—conrad-johnson, Audio Research, Krell, Counterpoint, DNM, Naim, Sony Esprit, Audiolab and Mission—have revealed that their interest in the sound quality of so-called passive components goes back many years and that they have no doubts as to the effects capacitors can have regarding signal coupling, feedback equalisation and power supply use. As a group, they believe that, to a significant

proportion, the success of their products is due to the positive identification of capacitor 'sonic signatures' and the correct or optimum choice of component for each application. The high performance of their products certainly goes a long way towards justifying the contention that capacitors can produce effects on sound quality unrelated to their theoretical performance.

Walter Jung¹, Richard Marsh¹ and John Curl^{2,3,4}, to name but three widely-respected designers and electronic engineers, firmly subscribe to the view that capacitors exhibit important sonic differences, despite the views of others^{5,6,7,8}. Jean Hiraga was virtually a voice in the wilderness back in the '70s when he described audible differences due to passive components, but much of his pioneering work has since been verified and expanded upon^{9,10,11,12,13,14}. HFN/RR has rightly been cautious, but in the words of a current slogan 'We're getting there'.

I feel confident that the results reported in this article prove that nominally identical, supposedly good, capacitors do exhibit important sonic differences, which are relevant to high quality amplifier design. It even appears that the choice of passive component may have as much effect on the overall sound quality as the circuit design itself. Furthermore, the power supply reservoir capacitors affect the quality of the signal, and the addition of a high quality,

comparatively low value 'bypass' capacitor can offer a significant change. It is quite surprising that the effect of changing a power supply capacitor can be so readily heard—theoreticians will have to do some serious thinking here. To some extent, this provides additional evidence to support the contention, long held by some audiophiles and designers, that the power amplifier mains cabling, supply quality and source impedance may all be heard to contribute to some degree to the ultimate quality of the audio signal as it passes through the system.

It was also fascinating to discover that the inherent signature of a large power supply electrolytic could be detected by using it as a moderate power, speaker coupling capacitor or, better still, as a small signal coupling capacitor between, say, a CD player and an amplifier or a preamp and a power amplifier. Our tests would indicate that even the best electrolytics are some way behind the finest plastic film capacitors. However, a noteworthy discovery was the comparatively high quality of a commercial bipolar electrolytic used for loudspeaker crossovers when inserted between pre- and power amp. In general, it comfortably bettered the performance of most of the ubiquitous polyester film types.

I have made no attempt in this article to document the electrical and mechanical imperfections of practical capacitors. These

are generally well known but have been considered virtually irrelevant to audio applications. These aspects will be covered in HFN/RR in future articles by Ben Duncan and myself; in particular, I will be looking for some indication of reasons for the differences, using a series of measurements including a modified dielectric absorption test, as well as the Curl differential pulse analyser in conjunction with Fourier analysis. It would be rewarding to define the optimum specifications for audio quality capacitors—I hope we do!

- 1: WG Jung & R Marsh, 'Picking Capacitors', Audio Feb/Mar 1980
- 2: J Curl, 'Omitted Factors in Audio Design', Audio Sept 1979
- 3: J Curl, 'Omitted Factors in Audio Design', 1978 IEEE International Conference on Acoustics, Speech and Signal Processing, April 1978
- 4: J Curl, Letter to the Editor, HFN/RR August 1985
- 5: D Sell, Letter to the Editor, Wireless World, April 1984
- 6: D Sell, Letter to the Editor, Wireless World, April 1985
- 7: P Baxandall, reported in 'Comment', HFN/RR May 1985
- 8: P Baxandall, Letter to the Editor, HFN/RR July 1985
- 9: Y Cochet, 'Applications des Condensateurs à l'Audio', L'Audiophile 17, October 1980
- 10: JP Moncrieff, 'The Sonic Importance of Passive Parts', IAR Hotline 12, September 1981
- 11: JP Moncrieff, IAR Hotline 14, October 1981
- 12: B Duncan, 'A State-of-the-Art Pre-amplifier Part III', HFN/RR, July 1984
- 13: WMB Armstrong, Letter to the Editor, Wireless World, November 1984
- 14: D Morcroft, reported on by K Howard and A Gold, Hi-Fi Answers, August 1985

PASSIVE COMPONENTS

HFN/RR ACCESSORIES CLUB

Martin Colloms tests the HFN004 Black Head m-c step-up transformer, which we are offering for £44.95 plus £1.20 p&p

WHAT THE WORLD NEEDS IS... 'A £100 integrated tube amplifier' (from Kessler); 'More Mozart on CD from Mitsuko Uchida' (from Chooch); 'More tints behind the text in the magazine' (from Art Editor Gash); 'More copy submitted on floppy disc - and on time!' (from Production Editor Linda). The subject, of course, should have been what we were going to choose for this month's Accessories Club offer, but things were getting out of hand.

Pops pulled himself up from his customary slouch and crumpled the empty can of Singapore 'Tiger' beer: 'Enough, minions, I have a plan. What the world needs is... a moving-coil step-up device with a ridiculously low level of noise, a sensible 20dB or so of gain rather than the exaggerated 27-30dB featured by most commercial offerings, an input impedance of 100ohms or so, true high-end sound quality, and most important, a price under £50!'

The others were awed into silence - except for Kessler who immediately got on the phone and asked for Tim de Paravicini, the only man in the world who could deliver what Pops wanted, with no questions asked.

The transformer, for such it turned out to be, duly arrived, was christened (with due respect to Tim's epoch-making HEAD device and the official HFN/RR Accessories Club hue of black) the Black Head, and was dispatched to Martin Colloms for his verdict...

The Black Head m-c transformer

Most commercial m-c step-up transformers are either too expensive or offer excessive gain, the latter often leading to compromised performance, as well as an increased possibility of overload with inadequate amplifier m-m inputs. For the HFN/RR Accessories Club Black Head, transformer wizard



Tim de Paravicini came up with a design with an eminently sensible gain of 10, or 20dB, which could be housed in the same black box - made from real wood! - already used for the Flux Dumper and the Phase Shunter. The input and output sockets are gold-plated, and the user has to supply a short phono-to-phono lead to connect it to the moving-magnet input of his amplifier. The nearest commercial equivalent to the HFN/RR Black Head is made in Japan by Mitachi (Glanz) and was sold for a while as the Sony HA-T10. This is now available as the Otofon T-5 and also as a Glanz model.

I tried the Black Head in my reference system, using it to step up the output of an EMT vdh cartridge to feed my Audio Research SP-8 preamp. It was also used with a Linn Trak cartridge and a Rotel 820BX integrated amplifier.

The sound was slightly lightweight - a touch bright but highly controlled over the whole frequency range. Depth and focus of the stereo image were fine, while stage width was well translated. If kept away from large mains transformers, the hum level was satisfactorily low. The Black Head is a good example of its kind, with a performance up to a level of some commercial models costing £150.

In the lab, when the Black Head was fed from a 60mV source and loaded with 60k in parallel with 220pF, the voltage gain was 19.5dB ie, fractionally under 10. This should be perfectly adequate for all but the lowest output cartridges, such as some Otofons. Fed from this source, the frequency response was +0.1, -0.5dB, 10Hz-13kHz; with a lower source resistance and with the load capacitance reduced to 100pF, the upper -0.5dB limit improved to 20kHz. Channel balance was fine at 0.1dB.

Loaded with 60kohms, the input impedance was fine at 550ohms, and when sourced by 10ohms, the output impedance (at 1kHz) was sensible at 2k9. For a nominal 100mV output, the distortion was -95dB at 1kHz, while at normal operating levels, -100dB (0.001%) should be expected.

On the basis of these test results, I consider the Black Head to be a bargain, with a better performance than the majority of m-c inputs fitted to a number of current integrated amplifiers and preamplifiers.

Martin Colloms

ACCESSORIES CLUB

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CAPACITY TO CHANGE

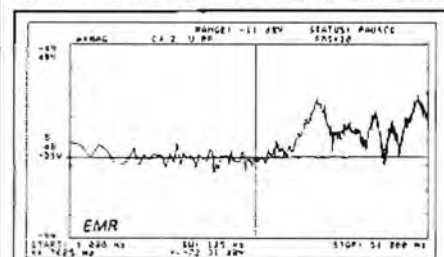
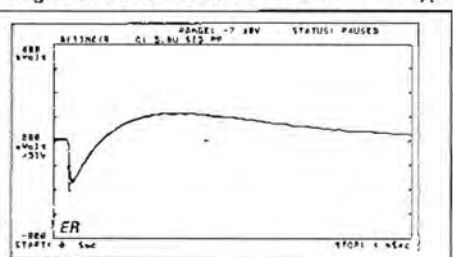
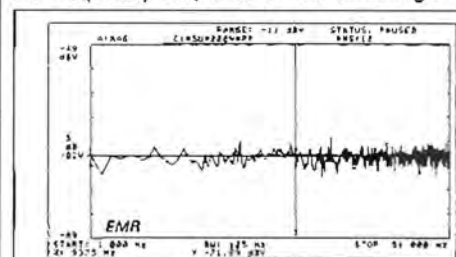
Martin Colloms with measurements and further listening tests on capacitors

IN THE FIRST CAPACITOR REPORT (October p35) I promised a range of capacitor measurements which I hoped would show up differences beyond the basic parameter of nominal capacitance itself. The article also described the results of a number of listening tests and I hope here to establish relationships between certain measurements and sound quality.

Four tests were chosen: dielectric absorption (DA); electro-mechanical resonance (EMR); nullified error signal (ES); and finally the frequency response of the error signal

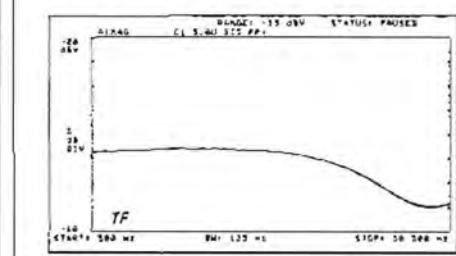
(FRes). The first, DA, is often mentioned in the literature, and concerns the electric 'memory' of the insulating dielectric of a capacitor. If a charged capacitor is discharged through a low resistance for a significant time, say greater than one second, the voltage should remain at zero when the short circuit is removed. In practice, even after prolonged discharge, some voltage returns, this being due to a degree of charge absorption into the dielectric. This is a fundamental flaw in capacitors, and the degree to which it occurs varies with the type

acoustic and mechanical output in response to an electrical input ie, they are piezo-electric. Furthermore, they will inevitably have a structural self-resonance. This resonance could colour the sound by putting back energy after the signal itself has passed. To explore these effects, relevant capacitors were fed an impulse from the FFT analyser, amplified to 14V pk, and current limited via a 40hm resistor (the test circuit gives -3dB, 45° at 10kHz for a typical 4µF component). The analyser bandwidth was 50kHz. The vibration in the capacitor body



C1 No significant vibration, a very good result, while on the impulse test, one top polypropylene is here nullified by another. The displayed error is at -45dBV on the transfer function (TF), with the pulse error shown at normal gain with a 4ms time-base. One cannot tell which capacitor is responsible for which difference, so no judgement is possible.

C4 Very good up to 12kHz, but with a moderate peak at 16kHz and some high frequency irregularities.



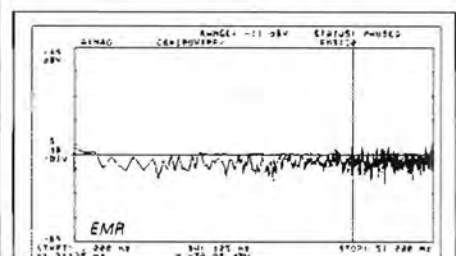
of construction. Our tests used the Jung arrangement as described in *Audio* (February 1980). Here, each capacitor was charged to 1.6V for two minutes, discharged via a 100ohm resistor for five seconds and the absorption voltage reappearing noted at 10, 20, 40 and 60second intervals. The quoted DA figure is given as:

$$DA (\%) = V C (1min) \times 16^{-7}$$

The second test is admittedly rather arbitrary and concerns the mechanical and piezo resonance properties of capacitors. It has been observed that capacitors emit an

was sensed by a very low mass accelerometer, the scaling remaining that of acceleration. Graphs of vibration were taken over a 100Hz - 50kHz span, with log frequency scaling.

The remaining tests, ES and FRes, made use of a high performance differential amplifier designed by Ben Duncan, using John Curl's method (see August p15). Verified by other tests, including DA measurement, a known good capacitor is used as a reference against which to balance unknown test capacitors. The difference signal (generated with a variety of sources from

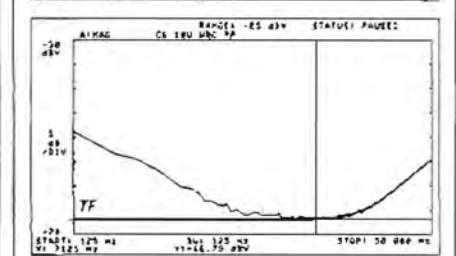
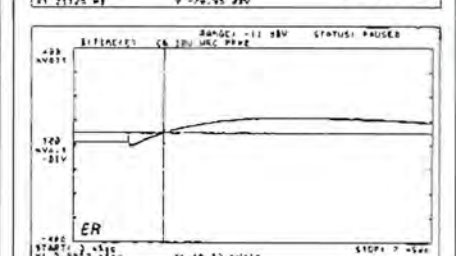


DA table: (1.6V charge voltage)									
C	Make	Sound %	10s(mV)	20(mV)s	40(mV)s	60s(mV)	DA	Type	
1	Sidereal 5µF	91	2.8	3.3	4.2	4.9	0.082	PP	
2	Ultracap 4µF	88	3	3.6	3.8	4.2	0.070	PP	
3	Ultracap 6µF	85	—	—	—	—	—	PP	
4	Ultracap 2µF	83	—	—	—	—	—	PP	
5	High Lambda 2µ2	83	12	13.2	15.6	17	0.28	PP?	
6	Wondercap 10µF	75	1.3	1.6	2.3	2.6	0.043	PP	
7	Soshin 3µ3	75	3.9	4.5	5	5.6	0.094	—	
8	WIMA 1µ5	70	2.6	3.2	4.2	5.4	0.09	PP	
9	Protec Filmcap 10000µF	70	52(33)	73(47)	100(52)	120(50)	2.0	EL(rev bias)	
10	ROE 10000µF	70	160	220	280	320	5.3	EL	
11	AWD 450µF	72	47	64	83	93	1.55	EL	
12	STC 10000µF	69	140	210	290	350	5.85	EL	
13	ERO 2µ2	68	6	7	8.8	10.3	0.17	PC	
14	Alcap 6µF	68	45	65	90	105	1.75	EL(reversible)	
15	Eurofarad 2µ2	65	1.5	2	2.5	3.6	0.06	PP	
16	RS µ47	65	3	4	5.6	7	0.12	PP	
17	RIFA 2µ2	65	5.8	7.2	9.3	10.4	0.17	PC	
18	Protec Filmcap 10000µF	65	30	60	90	110	1.84	EL	
19	Protec Filmcap 10000µF	63	80	85	116	135	2.25	EL	
20	STC 10000µF	58	180	250	348	390	6.5	EL	
21	STC 10000µF	58	—	—	—	—	—	EL	
22	RS 2µ2	56	6.1	9	12.5	15.4	0.26	PE	
23	STC 10000µF	55	120	160	200	230	3.8	EL	
24	C-U 3µ3	54	4.5	6	8	9	0.15	PE	
25	Rubycon 3µ3	51	4.6	6.3	8	9	0.15	PE	
26	Siemens 2µ2	58	10.4	16	24	35	0.59	PE	
27	Ultracap 4µF	94*	2.4	2.5	2.8	2.9	0.05	PP	
28	RS Tantalum 4µ7	62	72	100	125	140	2.3	Tant.EL	
29	PMT 4µF	58	1.5	2.5	4	5	0.084	PMT	
30	Solid Aluminium 4µ7	59	80	120	156	180	3.00	EL	

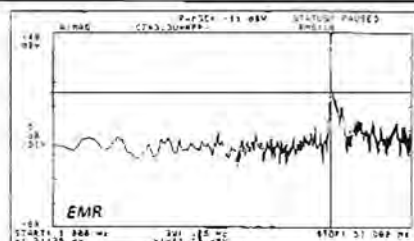
*With specified bypass

While there are some inconsistencies, as well as an obvious variation with capacitor type, the results do suggest that low DA is associated with good sound quality. Noting the voltage recovery with time, there is a distinct difference in curvature between the various types.

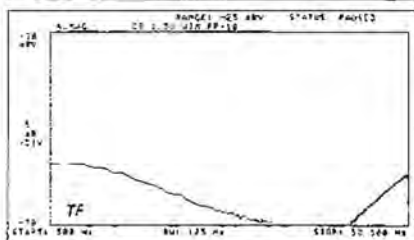
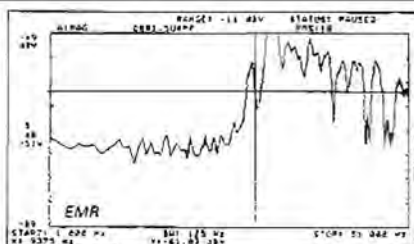
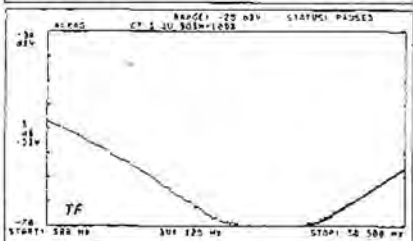
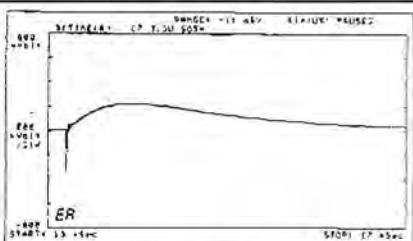
The lowest DA figures are down to 0.04%, while the worst reached 6.5% — a ratio of 160:1. The majority of the best sounding capacitors, say over 70% in sonic merit rating, had DA figures below 0.1%, while the average was nearer 1% for the group as a whole.



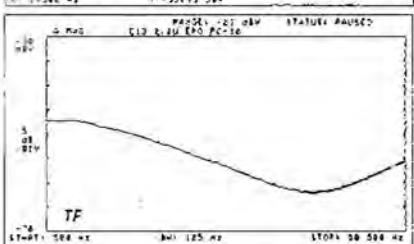
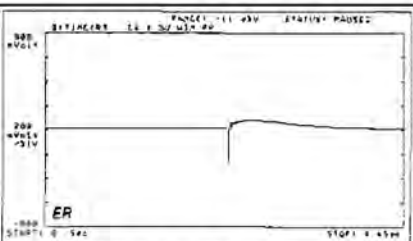
C6 This polypropylene is an original series Wondercap (a larger value than usual: 10µF) and shows no significant effect — a fine result. Note the impulse display is magnified by two yet the error is still tiny. The TF shows some unevenness but holds to a low level overall. Note the peak level of -48dBV.



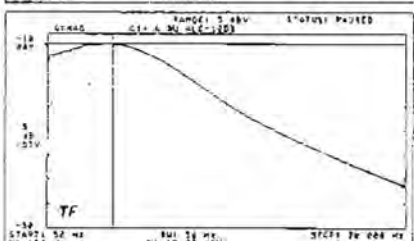
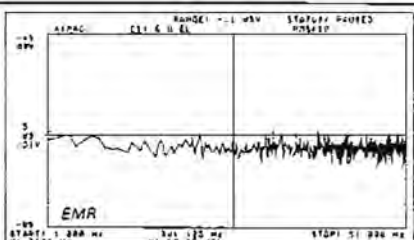
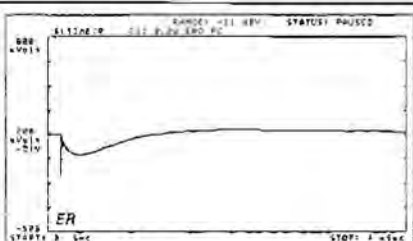
C7 This capacitor is clean in the audio range, peaking at 21.5kHz, while on the impulse graph, it is back to normal scaling, the early undershoot now being very narrow, while the secondary overshoot is of long duration. The TF result is a so good



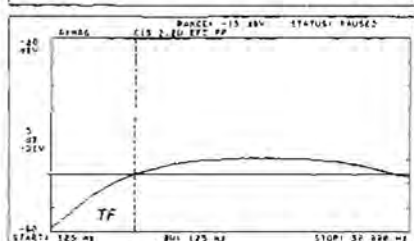
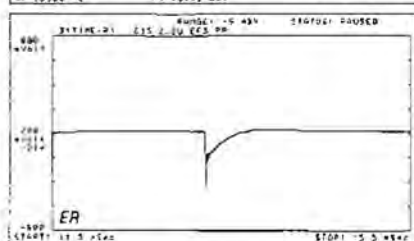
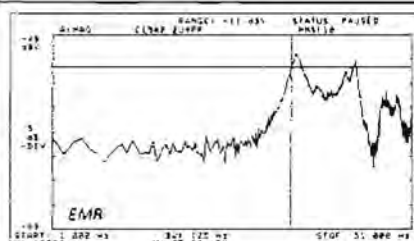
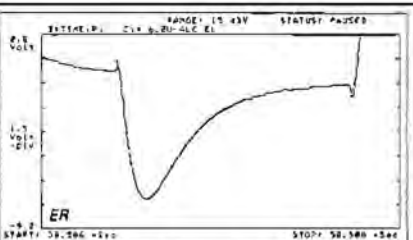
C8 A surprisingly high level of piezo vibration, with the first peak at 9kHz and considerable output above. The impulse test shows another good result with very low error. The narrow visible undershoot is well below audibility. The TF agrees well, displaying a low energy level throughout.



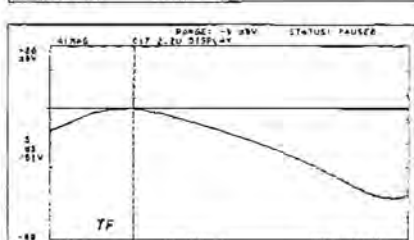
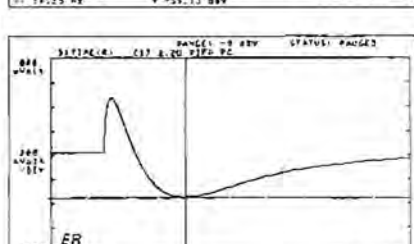
C13 Shows sharp multiple resonances at a fairly high level, the output rising at 10kHz and peaking from 14-5kHz upwards. The second graph shows another different pulsed shape, with a small error but with a slow undershoot.



C14 A typical result for a small electrolytic. The 'wet' construction and outer container block what little self vibration might exist. Note the scaling on the impulse response! 1.5V/div compared with the 0.2V div used normally. This electrolytic has huge, complex errors over a timebase extended by approx. 20ms. The TF peaks at just -12dBV at a low 150Hz

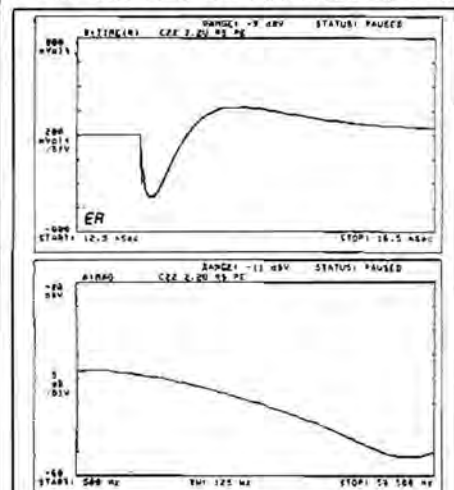


C15 While its DA was very good, its EMR was poor, with a strong peak at 14kHz, -60dBV. Top-rated components reach down to -70dBV here. Back to normality with the impulse response, the error is at upper frequencies, and the LF is good. In good agreement the error on the TF peaks at 5kHz at a moderate -40dBV.



C17 Another model with a promising DA but peaky vibration character.

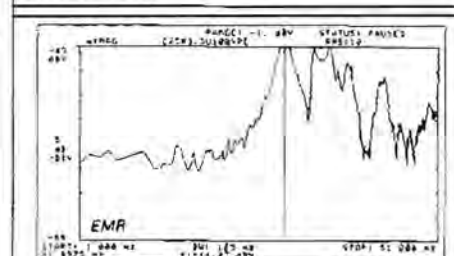
pulse and noise to music) corresponds to the difference in the time domain due to delayed errors in the test capacitor. The error is shown as a direct waveform resulting from a nulled step response and the difference was also obtained using noise to give a frequency response, TF. The latter may give a better idea as to how a particular capacitor



C22 Another weak film-type capacitor. The error is considerable, while the energy peaks broadly at 550Hz, -38dBV.

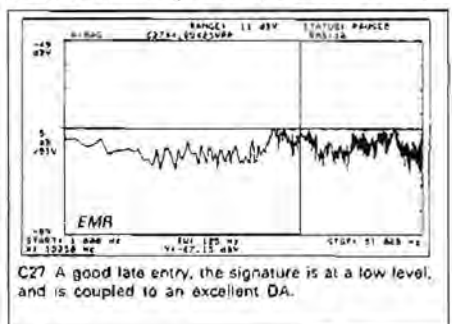


C24 This polyester 'sings' pretty loudly at 13.2kHz, reading -54dBV.

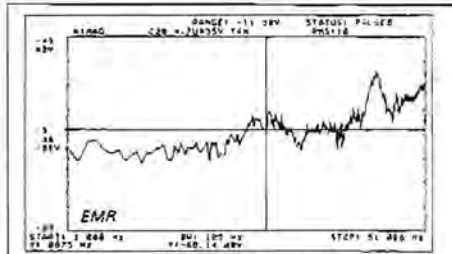


might sound by revealing any frequency 'consciousness'. At this stage the differential set-up could only be used for capacitors in the 0.5 to 10μF range. Vibration measurements were not appropriate for electrolytics due to their 'soft' construction, though interesting results were obtained for the small tantalum capacitor tested. The DA test was fine for all types from 0.5μF upwards, including the 10,000μF reservoirs.

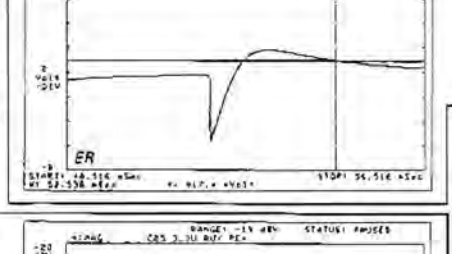
Before proceeding to the test results themselves, there is a correction to be made to the October listening results, as well as a few



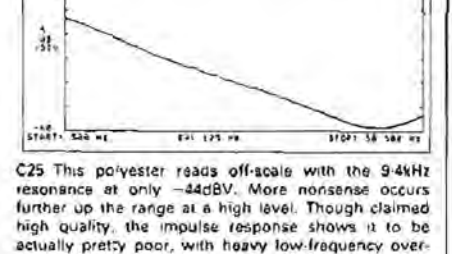
C27 A good late entry, the signature is at a low level, and is coupled to an excellent DA.



C28 A surprise! Tantalums have some mechanical resonance, mild around 9kHz and peaking strongly above audibility. Note the high 2V/div scaling on the impulse graph; the tantalum has large over- and under-shoot. The TF shows a high, broad energy level, just -16dBV!



C29 This polyester reads off-scale with the 9.4kHz resonance at only -44dBV. More nonsense occurs further up the range at a high level. Though claimed high quality, the impulse response shows it to be actually pretty poor, with heavy low-frequency overshoot around -35dBV at 250Hz.



C30: 4.7μF, 35V solid aluminium electrolytic. A phasey, deadened effect lacking dynamics. Loss of space and ambience, softened bass definition; 59%.

important additions.

Correction: C19 is a standard Proseco, not to the Morecroft pattern.

Additions, not in ranked order:

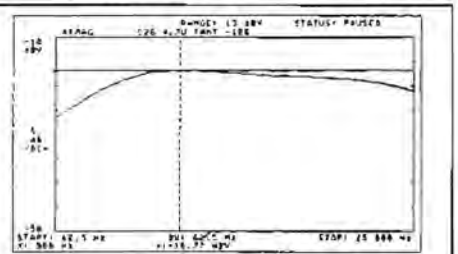
C26: 2.2μF 100V Siemens Polyester (block type). 58% A typical polyester sound.

C27: 4μF, 425V, Ultracap (latest) polypropylene. Very clean and clear; score 88%. Overall, no obvious aberrations. Transparent, well focused, dynamic. When UC bypassed it achieved a top rating of 94%.

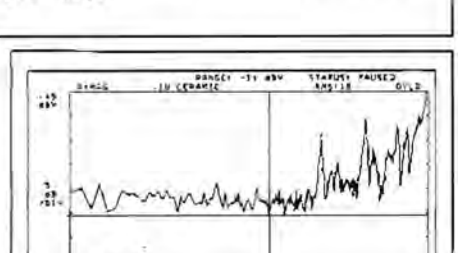
C28: 4.7μF 35V Tantalum (RS) electrolytic. Quite good tonal balance but with an 'artificial' effect, forward and thin with added 'glare'. Emphasised sharpness, some grit in the treble, though the bass was quite good; 62%.

C29: 4μF PMT plastic film (probably polypropylene). Brash, grainy sound, forward thin and topky - a disappointing result; 58%. On this component the fault may lie with the terminations.

C30: 4.7μF, 35V solid aluminium electrolytic. A phasey, deadened effect lacking dynamics. Loss of space and ambience, softened bass definition; 59%.



C31 Ceramic. Included for interest, this small ceramic could draw little current yet managed some rather lively resonances at high frequencies. Ceramics are known to exhibit strong piezo qualities.



C32 Ceramic. Included for interest, this small ceramic could draw little current yet managed some rather lively resonances at high frequencies. Ceramics are known to exhibit strong piezo qualities.

Conclusions

The finest capacitors have DA values of under 0.1%, low piezo electric effects, with a well damped mechanical self resonance and a low delayed error, the latter combined with a broad smooth character to the response transform of the error function. Different capacitors exhibit differing behaviour with differing sonic flaws. The response display of error function can suggest where the dominant coloration might appear. The time constant of the error pulse may also pinpoint specific problems. Note that the pulse errors displayed occurred in a very short time span - a few thousandths of a second - while the dielectric absorption effect is a much longer-

term aberration: 10-60 seconds and longer. The results suggest that electrolytics suffer from a general blurring and specific low-frequency problems, while polyesters have delay problems in the upper midrange, leading to 'nasality', 'glare' and related tonal aberrations. Polypropylene defects occur within a much shorter time-span and are generally much smoother than for other types.

The degree of these various effects is partly dependent on the dielectric stress, and this may be reduced by choosing higher voltage ratings than are strictly required. Depending on the application, other parameters such as equivalent series resistance (ESR), self resonant frequency (electrical),

series inductance peak current etc. will all also be important. For example, the two Proseco 10,000μF 100V capacitors were very similar on DA but the Morecroft version has rather better ESR at high frequencies due to reduced inductance. As it happens the best polypropylene capacitors are very good on these parameters too.

Ben Duncan will cover the technical side in the final article, to be published in a month or so, while John Atkinson will be reporting on the massive double-blind tests carried out at the Heathrow Penta Show.

Note: Certain polystyrenes are said to be excellent but we could not obtain sufficiently large values for test.†