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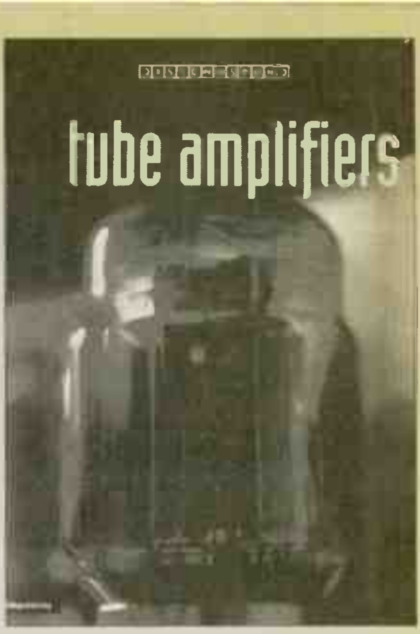
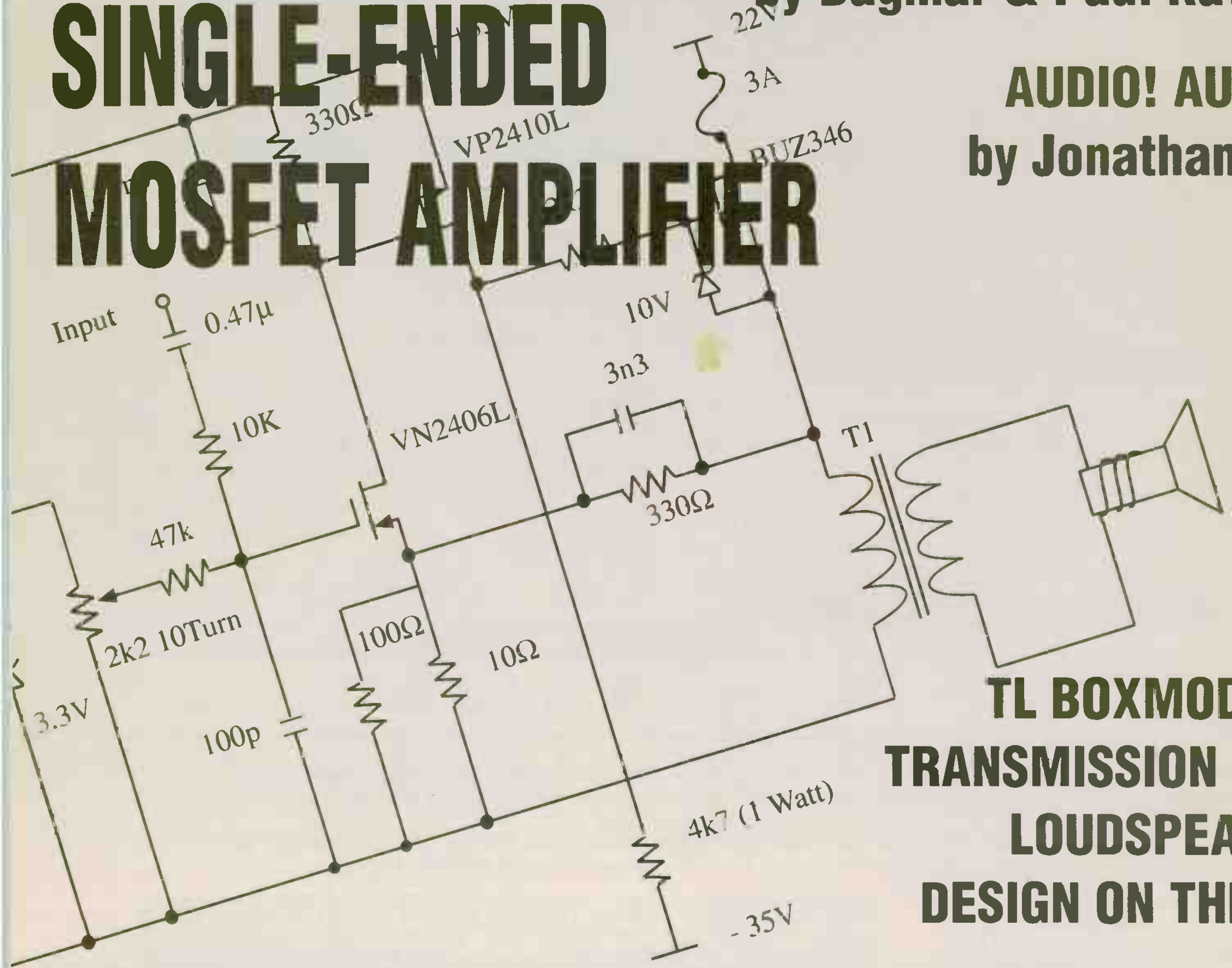


BOOK REVIEWS:

TUBE AMPLIFIERS
by Dagmar & Paul Kavsek

AUDIO! AUDIO!
by Jonathan Hill

UNIQUE 15W SINGLE-ENDED MOSFET AMPLIFIER



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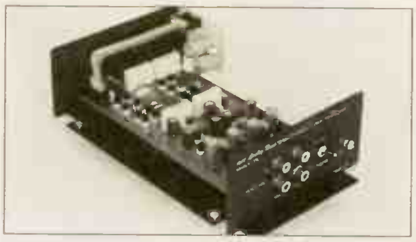
Why not buy the reprints and construction manual for the kit you are interested in to see how easy it is to build your own equipment the HART way. The FULL cost can be credited against your subsequent kit purchase.



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KIT *NEWS*

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1995 back issues of Speaker Builder, Audio Amateur and Glass Audio will be available from Falcon Acoustics from early February, 1996.

Besides IMP, Falcon are now also stocking Audiosuite test software, plus UK sourced Mitey Mike and Audiosuite input preamp kit. Also new is AIRR (Acoustic In Room Response) software which gives basic impulse testing with a Soundblaster 16 bit card for the PC.

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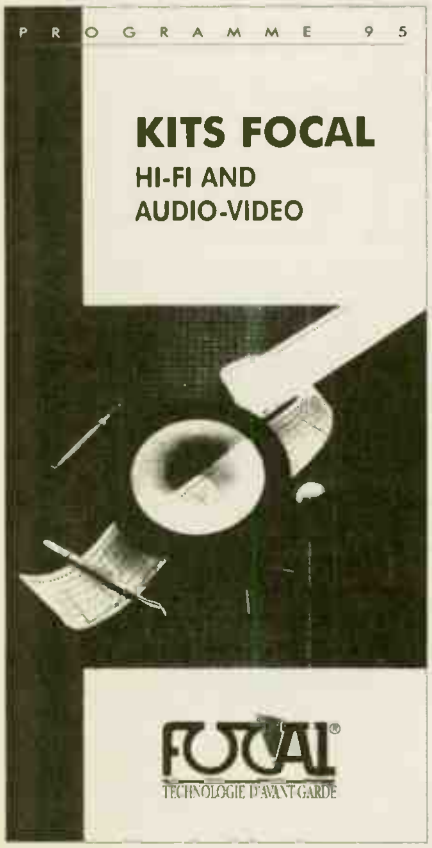

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The set consists of the three specially wound toroidal transformers, one for the power supply and two output transformers for a complete stereo system. Reprints of the circuit and article describing the amplifier design are available for £2.50 post free.

Price for the complete set of three transformers, including VAT is £99 plus £8 for standard post or £10 courier delivery in the UK.

Also, the Dynamic Range Control Module is a new unit available in kit form from Hart Electronics, offering useful extra facilities that can increase the listening pleasure from your hi-fi system. Quite simply it does exactly what its description implies, compressing or expanding the range of levels present in any signal so that none are louder or softer than you want.

The principles have been known for many years and have been used before, but until this new digital operating principle was devised by John Linsley Hood they have never come up to the standards of low distortion demanded by the serious audiophile, Hart say.

There are three main areas of use for this unit. Curbing the over exuberant range of some CDs, preparing special tapes for use in your car and restoring dynamic range lacking in some compressed signals.

The Hart Dynamic Range Control Module is easily constructed from the kit, all components fitting directly on the printed circuit board. Housed in a matt black casing, 228mm deep, 134mm wide and 63mm high, it makes an unobtrusive addition to your system.

It can be left in circuit permanently, as signals are simply routed through untouched when it is switched off. To preserve signal integrity an external power supply is used. Hart recommend their K2900 'Andante' linear technology audiophile supply.

The Dynamic Range Control Module is Hart Kit number K3550 and will be available in February '96. Price is £99.60. Power Supply K3550 is £89.75. Both prices include VAT. Postage is £3.50. Hart are at:

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BILLINGTON VALVE CATALOGUE

As you read this, a new 60 page valve catalogue is being compiled by Billington Export. It contains thousands of different types and comprehensive cross referencing information between different identifications, such as American valves and military CV numbers. Billington's told us they stock the SV811 power triode from Svetlana but are still awaiting delivery of Western Electric 300Bs. The catalogue is free. For more information contact:

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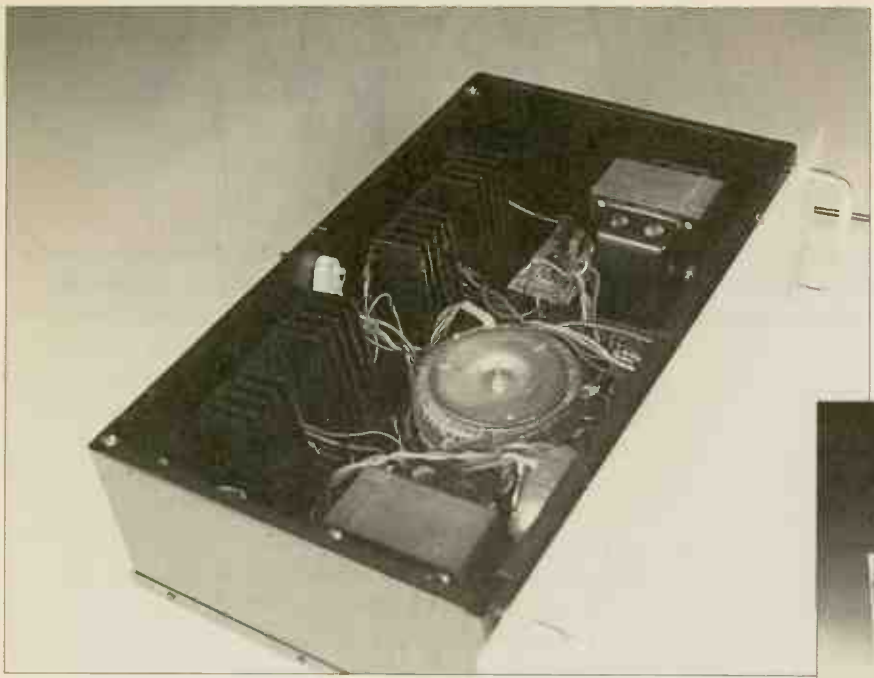
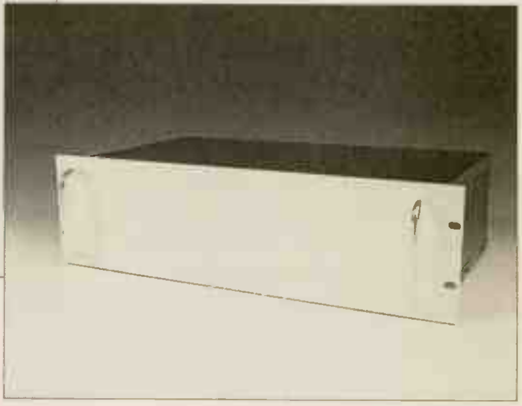


Our prototype was built in a Maplin rack mount case. There was plenty of space aroung the components, making build easy.



A SINGLE-ENDED MOSFET AMPLIFIER

Noel Keywood discusses the merits of Single-Ended working, using MOSFETs.

Many of you have asked us to design a Single-Ended amplifier using solid-state devices, rather than valves - so we have! The low efficiency of such amplifiers causes them to stream heat, which presents a host of problems. Andy Grove, designer of this circuit, has ingeniously produced an amplifier of high efficiency to minimise heat production. Its modestly sized heat sinks run bearably hot for 15watts of Class A power. It isn't a power house, but 15watts per channel is enough to make 90dB sensitive loudspeakers go quite loud. More power can be had from the design with little difficulty; our circuit is, in effect, a useable test bed, a great starting point for experimenters.

So why Single-Ended? Most listeners who have spent time in front of valve Single Ended amplifiers, myself included, feel they offer a more natural, relaxing and involving sound than push-pull types. There's some magic in S.E. working that yields a subtly richer and more detailed sound than that available from the everyday push-pull amplifier. However, efficiency is low, meaning power output is limited by practical difficulties such as heat dissipation. I should explain that SE working is very simple and has been universally supplanted by push-pull, now used in all modern amplifiers. These days, if you want an SE, you have to build one.

Single Ended output stages also produce more distortion than push-pulls, but this only becomes significant at higher output levels. I believe it's important that SEs, by their very nature, do not distort at the zero crossing point. As level goes down, so does distortion. In this respect, they are more ideal than push-pulls, which suffer rising distortion at lower levels, alleviated by Class A working and oodles of feedback. Crossover distortion is contrary to music; it rises as musical level declines and its harmonics extend far from the main stimulus, modulating in an unmusical manner. This is only made worse by the application of feedback. I strongly suspect the ear is sensitive to such dissonant signals.

A Single Ended amplifier is quite different. It produces more distortion, but of a type that closely matches the natural harmonic structure of musical instruments. It doesn't clash with them, so it isn't dissonant. I believe the distortion pattern is effectively swamped by music and tends not to clash with it in a fashion the ear finds jarring and unnatural. I was fascinated to see the way the harmonics of our design fell away smoothly with frequency and collapsed to virtually nothing below a few watts. There was quite obviously none of the modulation of distortion pattern that heavy feedback produces in push-pull amps. either.

I am not trying to say that distortion doesn't matter. On the contrary, you can hear distortion as muddle at high levels. In my experience, using our own sensitive carbon-fibre KLS3 loudspeakers which were designed for such amplifiers, SE amplifiers sound best when idling along at a few watts output, suggesting the presence of simple, low order harmonic distortion does not explain their unique sound quality. If it did, then they would sound better at high levels, where distortion is at its highest. Delivering a few watts output at 10kHz, this amplifier (Andy's version) produces around 0.2% of purely second harmonic distortion, which is subjectively innocuous.

It is as likely that SE amplifiers sound the way they do because they possess fewer parts and simpler circuits than push-pull types, so minimising component colourations. I should point out that to capitalise upon this, Andy deliberately kept his circuit simple.

I can't help also feeling that push-pull amplifiers may also cancel low level signals in the way they cancel distortion and supply rail hum. No such cancellation mechanism exists in SE amplifiers. Subjectively, they gain from this. A push-pull can sound "stripped bare", or stark, in comparison to a good SE. All the same, few manufacturers have the nerve to produce SE amplifiers, because they appear so impractical.

HOW THE CIRCUIT WORKS

by Andy grove

The circuit for my MOSFET single-ended amplifier is very simple. ZD1, C1 and Vr1 form an adjustable voltage reference for biasing the amplifier overall. Tr1 is the first stage. The input signal passes through the D.C. blocking capacitor C2 and the gate stopper R2. Tr1 is a simple single-ended common source stage with R4 as its load. C3 is part of the compensation and reduces gain with increasing frequency.

Tr2 is again a common source stage but using a P channel device to allow direct coupling. Tr2's load R6 is connected to a negative rail to give a full bipolar swing to the output FET Tr3.

TR3 is in source follower configuration driving the output transformer T1. DC and AC feedback are taken from the transformer's primary via R5 and C4, C4 being a compensation component to assure a clean square-wave.

The power supplies are very simple. Separate rails are needed to get the low current +/- 35V for the driver stage and +22V at 2A for the output stage.

The resistance of T1's primary winding is used to sense the DC current through Tr3 and this is fed back to Tr1. The downside of this is that as the winding heats the quiescent current changes, although after warm-up everything settles down. This means that the amplifier needs some setting up with a scope to optimise the output power. To do this connect an 8 ohm load of at least 20W capacity, switch the circuit on and adjust Vr1 for approximately 1.5V across T1's primary and then leave the amplifier for about 1 hour to heat up. Then use a 1kHz signal to make the amplifier clip on the scope, adjust Vr1 for maximum power output with symmetrical clipping, leave and then readjust 15 minutes later. You now have a 15W single-ended amplifier.

There are a few pure Class A, single-ended solid-state power amplifiers around but most use a constant current source as the output device's load. This results in very poor efficiency of 25% maximum, wrongly stated in many textbooks as the maximum theoretical efficiency of any single-ended amplifier. With these designs the transformer in my design is replaced with a current source connected to a negative rail. The minimum negative voltage required is the same as the positive voltage to achieve symmetrical clipping and therefore maximum efficiency.

The quiescent current in such circuits must be sufficient to supply the peak current in the load. Therefore, under ideal conditions, for a given supply voltage Vs and peak current Ipk the idle dissipation will be 2 x Vs x Ipk (2 x Vs because of the +/- supply rails needed). The power output is 1/2 x Ipk x Vs. The efficiency (power out/dissipation) is (1/2 x Ipk x Vs)/(2 x Vs x Ipk) = 0.25 or 25%. The problem here is a practical one. For any given power output the power dissipation into the heatsink will be very high, equalling P(W)/0.25. So a 15W amplifier needs to lose 60W into the heatsink. This will produce a lot of heat, necessitating very large heatsinks. For example, a modest 30W/channel amplifier will have to lose 240W of heat. This raises some severe difficulties. Heatsinks, complex alloy extrusions anodised black, are very expensive and losing waves of heat from them means using special casework, or a fan.

In my design the transformer, under ideal conditions, has no DC voltage across it (zero DC resistance), therefore it dissipates no power and only one supply rail is needed. The transformer stores energy in its magnetic field and releases it into the load to give the negative voltage swing. By way of contrast, a current source continually burns this energy off as heat. The dissipation with a transformer is now Vs x Ipk, the power output is the same as before and the efficiency is (1/2 x Ipk x Vs)/(Vs x Ipk)=0.5 or 50%.

With this efficiency a 30W stereo amplifier would dissipate 120W of heat in its heatsinks - far less than normal. So whilst transformers are shunned by most engineers nowadays, they offer many benefits, including improved efficiency in a circuit as specialised as this one. There are other benefits, notably loudspeaker isolation. There will be no D.C. output offset voltage and no chance of blowing your loudspeakers if something goes wrong in a DIY circuit like this one. The transformer has a simple 1:1 ratio, meaning it could be bifilar wound.

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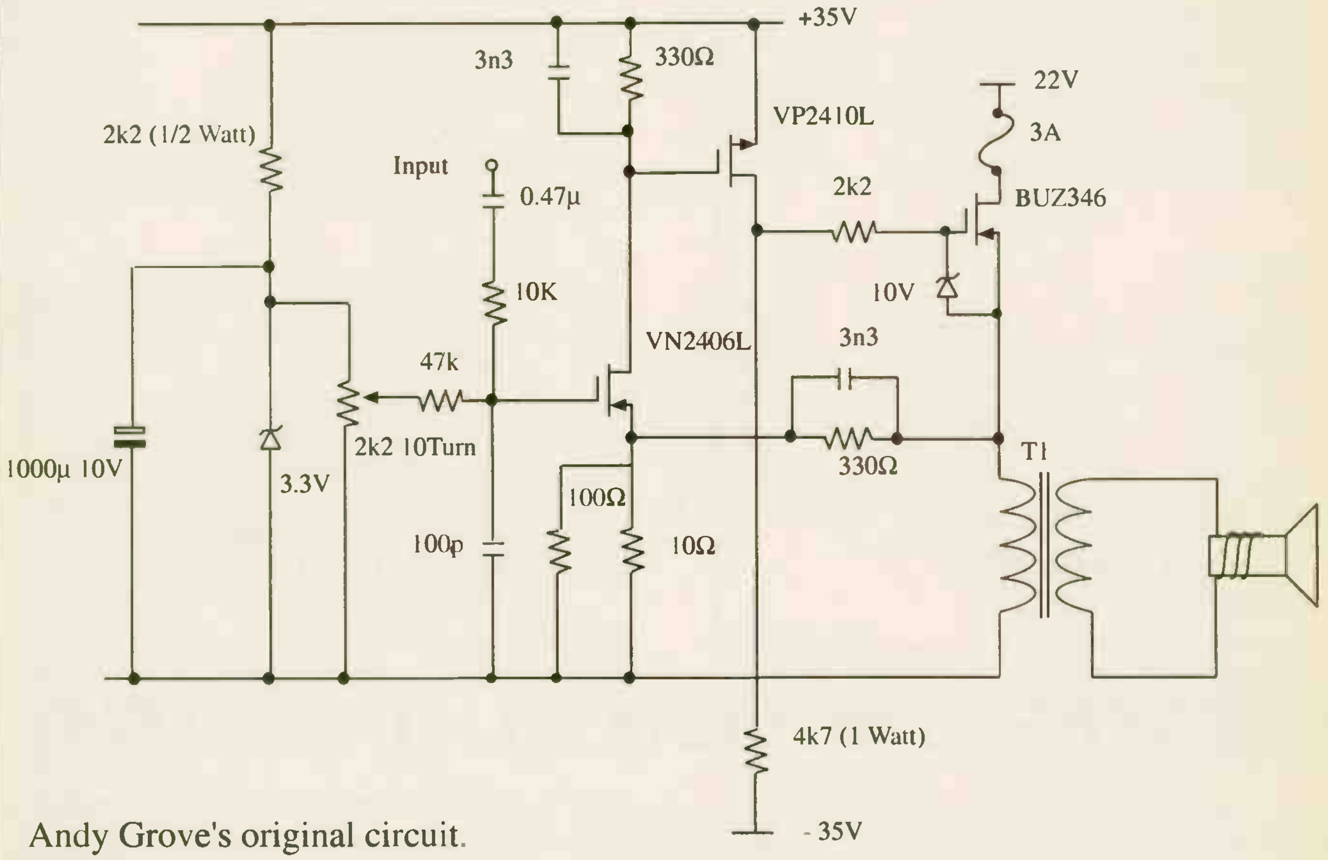
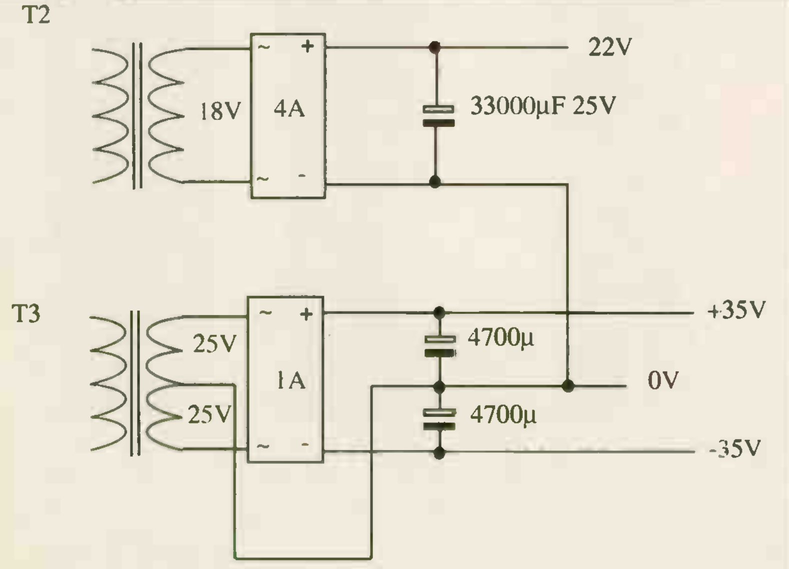
World Radio History

ANDY GROVE'S MOSFET SINGLE-ENDED CIRCUIT



Andy Grove's original circuit.



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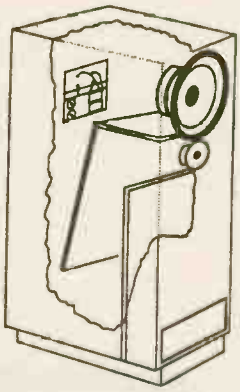

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SINGLE ENDED AMPLIFIER, VERSION 2 - BY CHRIS FOUND

This amplifier was very deliberately designed to be simple. In the commercial world, rather than on the test bench, I felt that it would benefit from various additions. It does make the circuit more complex and expensive, losing some of its purity of design, but it is more likely to work correctly first time, under all conditions, without a knowledgeable hand at the controls!

On all changes, Andy agreed that the additions would offer useful benefits. The only point we differ on is the amount of feedback to be used. I personally dislike large amounts of feedback (above 20dB) and low values of feedback resistors (<2.2kΩ), and I don't mind if distortion is quite high, so long as it is of a nice nature, i.e. 2nd harmonic.

Andy's circuit is very specialised. I felt it may cause problems to the builder and as the UK mains voltage has a wide operating range, you really have to be careful when designing such circuits.

One of the main areas I concentrated on was the control of the amount of current that is passed through each driver MOSFET. It was set high deliberately to obtain the necessary transconductance, but limiting the current to around 5mA through each driver is a safer bet in real life. This ensures that the driver MOSFETs work in a safe region, with a good safety margin for fault conditions.

Like all semiconductor devices, MOSFETs have quite wide operating characteristics, both between manufacturer and also batches. If you run these devices close to their maximum current and voltage ratings, some devices will work perfectly and others will be so wide, they will either not work at all or, in the worst case, go bang!

Changing the bias points around the circuit also changed all of the working parameters, but luckily, this was easily brought back into line by adjusting the bias preset for the first MOSFET. Andy has used D.C. feedback to stabilise the circuit. However, the amount of feedback that was originally applied I reduced considerably, which increased the distortion by a factor of 10. When viewed on the spectrum analyser, however, we found that it was primarily 2nd harmonic and nothing to worry about.

To reduce the chance of parasitic oscillations occurring within the feedback loop, it was decided to introduce gate stopper resistors to every MOSFET as a precaution.

The bias circuit for the input MOSFET was simple and this voltage may not be constant in all circumstances. As this controlled the operating parameters for the complete amplifier, its performance could change in relation to the mains voltage fluctuations. This could affect the sound at certain times of the day, especially within city areas.

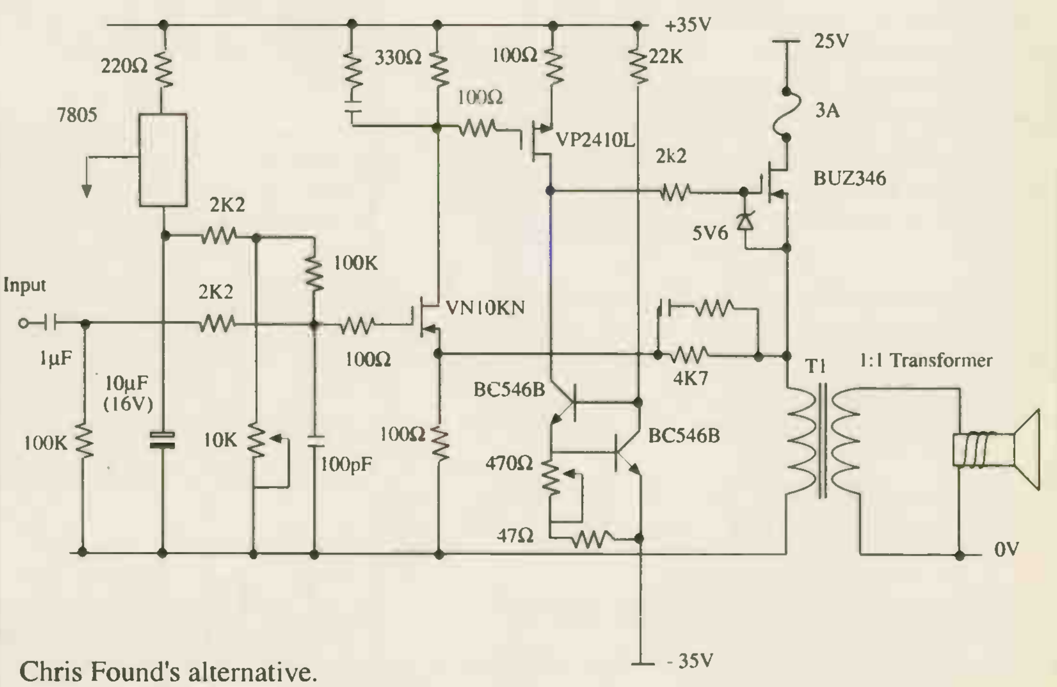
Improvement here was relatively easy. I decided to use a simple 5V voltage regulator. It offers two main advantages. Firstly, constant bias to the input MOSFET irrespective of power supply voltage and, secondly, a cleaner supply of bias, reducing the possibility of noise injection from the power supply affecting this stage.

Although the regulator is designed to tolerate up to 40V on its input, it does get hot when operating voltages are high, so a series current limit resistor was added to keep the voltage to the input of the regulator low enough to limit heat generation. This meant we could eliminate a heatsink for this device and still keep the price close to the original circuit.

To prevent over-voltage due to a fault condition destroying the output MOSFET, two components were added. There is a fuse in the drain of each output MOSFET which protects it above about 2A. This may seem quite low, but the amplifier will only produce about 15 -18watts output and therefore the fuse must protect the MOSFET for low loads, short circuits and serious overloading.

Additional protection is provided by a gate clamp zener diode, placed between the gate and source of the output device. This limits the maximum D.C. voltage potential to 10V across the junction and in so doing, stops the MOSFET from destroying itself should a driver FET or the constant current source go faulty.

Finally, the current tail for the driver MOSFET was added to provide a better negative swing and control the operating point of the output device, making it more stable with changing power supply rail voltages.



Chris Found's alternative.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BUILDING THE SINGLE-ENDED, TRANSFORMER COUPLED MOSFET AMPLIFIER, by Haider Bahrani

So you've read the theory, how about the practical? The most important bit with this design is where to put all the chunky bits. By this, I mean the heat sinks, capacitors and transformers. We've tried to put this amplifier together in the cheapest possible way to get the best results.

I've drawn a sketch to show how I put the amplifier together. I've also shown a suggested alternative for those of you who don't mind having an integrated amplifier and hot plate.

The box used is available from Maplin's and the heat sinks came from Electromail. Most of the other components should be available from either of the above, except for the output transformer, which can be ordered directly from us.

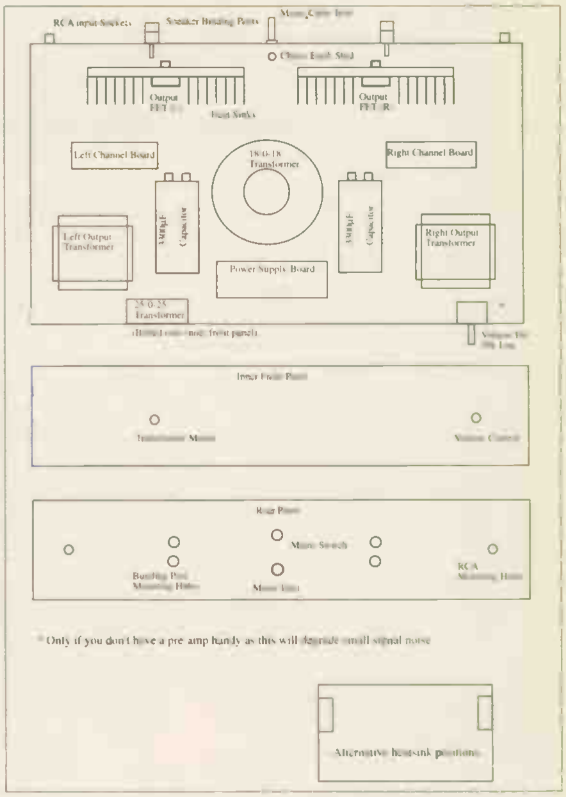
As shown, the heat sinks are mounted on brackets directly over the ventilation slots on the floor of the box. The sinks are mounted slightly off the tray itself to reduce the amount of heat transfer, by conduction, to the chassis. There are ventilation slots on the lid too, allowing convection currents to carry the heat away.

The power FETs are best mounted using Silicone Impregnated pads as these eliminate the need for silicone compound which can be a messy business.

The left and right channel amplifiers are on separate boards and positioned as close to the output transistors as possible. This also allows the input signal to take the shortest route to the boards. This does, however, lose some of its appeal if you decide to include a volume control.

The rest of the layout was devised to keep things as symmetrical as possible, low level signal conductors being kept as far as possible from the large signal ones. This includes the output transformer connections to the speaker terminals and boards.

Note that the layout shown does not correlate with the PCB layout given. This is because we initially built the amplifier on Vero Board, seen in the photograph.



* Only if you don't have a pre amp handy as this will degrade small signal noise

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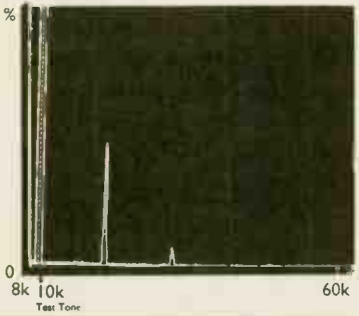

The distortion characteristic for Andy's circuit is identical to Chris's, which is shown above. However, the increased feedback of Andy's yields a figure of 0.05% @10kHz, whereas the lower feedback of Chris's gives 0.5% @ 10kHz, or ten times higher.

SOUND QUALITY

I was struck by the sheer warmth and ease of presentation displayed by this design. It sounded delightfully unforced, which made for very relaxed listening. Strings in particular came over with a richness of tone, but a sense of separation between instruments that was unmatched by today's push-pull designs, most likely due to lack of switching distortion in the crossover region between output devices.

Our prototype had absolutely no glare or hardness in its sound, it was deliciously sweet and easy to listen to, warm and open, rich in its portrayal of tonal colour and impressively able to yield the atmosphere within a recording. There were some defining moments in its audition that I felt summarised its basic character.

A telling old EMI recording of Wagner's Tannhauser, by the Philharmonia, was recorded in 1960. The string sections of the orchestra usually sound a little shrill and hard. Through this amplifier the effect was audible, but not painful on the ear. There was a sense of the distortion being revealed as parasitic to the music, rather than an intrinsic part of instrument tone. So violins didn't sound thin and screechy, so much as vibrant and real, but with some dissonant harshness creeping in from the recording equipment every now and then. This amplifier also gave the string sections an easy independence from each other that was beguiling; there was space around the musicians.

Its strong but fluid bass was also fascinating. Put these characteristics together and you have a grand, yet easy presentation, with superb reproduction of scale. Orchestras had size and power; there was none of that screechy, pinched sound that characterises mediocre push-pulls. **NK**

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[illegible]	[illegible]	[illegible]	4-8 Ohm		[illegible] SE	[illegible]
[illegible]	[illegible]	[illegible]	4-8 Ohm		[illegible] PSE	[illegible]

Group B

Recommended Valve	Max Cl A Power	Imp S-c	Imp	Size Weight	Max Current	Price Ex UK VAT
[illegible]	[illegible]	[illegible]	4-8 Ohm	[illegible]	[illegible] SE	[illegible]
[illegible]	[illegible]	[illegible]	4-8 Ohm	[illegible]	[illegible] SE	[illegible]
[illegible]	[illegible]	[illegible]	4-8 Ohm	[illegible]	[illegible] A SE	110.00
[illegible]	[illegible]	[illegible]	4-8 Ohm	[illegible]	[illegible] SE	[illegible]
[illegible]	[illegible]	[illegible]	4-8 Ohm	[illegible]	[illegible] PSE	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	150mA SE	114.00
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	114.00
[illegible]	50 watts	[illegible]	[illegible]	[illegible]	[illegible]	151.00
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	112.00
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] A PSE	2[illegible]7.00
[illegible]	2[illegible] watts	[illegible]	4-8 Ohm	[illegible]	1[illegible] A SE	[illegible]
[illegible]	[illegible]	[illegible]	4-8 Ohm	[illegible]	[illegible] SE	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] SE	[illegible]

NEW SE Product

Recommended Valve	Max Cl A Power	Imp S-c	Imp	Size Weight	Max Current	Price Ex UK VAT
[illegible]	[illegible] watts	[illegible]	4-8 Ohm		[illegible] A PSE	[illegible]

Group B

Push-Pull Circuits

Recommended Valve	Max Cl A Power	Imp S-c	Imp	Size Weight	Max Current	Price Ex UK VAT
[illegible]	15 watts	[illegible]	4-8 Ohm	[illegible]	PP	42.[illegible]
[illegible]	25 watts	[illegible]	4-8 Ohm	[illegible]	PP	[illegible]
[illegible]	[illegible] watts	[illegible]	4-8 Ohm	[illegible]	PP	[illegible]
[illegible]	50 watts	[illegible]	4-8 Ohm	[illegible]	PP	[illegible]
[illegible]	50 watts	[illegible]	4-8 Ohm	[illegible]	PPP	74.[illegible]
845	50 watts	[illegible]	4-8 Ohm	[illegible]	PP	114.00
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] PP	11[illegible]
[illegible]	100 watts	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Group C

Single-ended only

Recommended Valve	Max Cl A Power	Imp S-c	Imp	Size Weight	Max Current	Price Ex UK VAT
[illegible]	25 watts	2.5	[illegible]		90mA SE	[illegible].00
211/VT4 845	50 watts	10k	4-8 Ohm	160x140x140 mm	[illegible] A SE	4[illegible].00
3008	50 watts	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Group D

Pure Silver Wired Outputs

Recommended Valve	Max Cl A Power	Imp S-c	Imp	Size Weight	Max Current	Price Ex UK VAT
[illegible]	[illegible] watts	[illegible]	4-8 Ohm	[illegible]	90mA SE	[illegible]
[illegible]	[illegible] watts	[illegible]	4-8 Ohm	[illegible]	[illegible] A SE	[illegible]

The **AUDIO NOTE** [illegible] AUDIO NOTE [illegible] ONGAKU, KAGEKI, GAKU-ON or the KEGON [illegible] an ONGAKU costs £ [illegible]

AUDIO NOTE CHOKES & INDUCTORS.

Value	Size	Price Ex UK Vat
[illegible]		[illegible]
[illegible]		14.00
[illegible] to ONGAKU [illegible]		[illegible]
[illegible]		21.[illegible]
[illegible]		31.00
[illegible]	63x74x[illegible] mm	[illegible]
[illegible]	90x87x83 mm	38.[illegible]
[illegible]	[illegible]	[illegible]

[illegible]

AUDIO NOTE MAINS TRANSFORMERS.

[illegible]

Primary Voltages	Secondary HT Windings	Secondary Heater Windings	Price Ex UK Vat
[illegible]	[illegible]	[illegible] Amp 3.15 [illegible] 3.15 at 4 Amp	34.0[illegible]
[illegible]	0v 230v at [illegible] 4 Amp	0-12.[illegible] at 1 A 3.[illegible] at 4 Amp	61.30
[illegible]	[illegible] 0v 300v at [illegible] mA	12.[illegible] 0v at 1.5A 6.3v 0v at 800mA	46.[illegible] for 6J7 Tube Pre-amp [illegible]
[illegible]	[illegible] 250v at [illegible] mA	2.[illegible] at 1.5A [illegible] 6.3v at [illegible]	[illegible]
[illegible]	[illegible] 244v [illegible] 244v 310v at 200mA	3.15 [illegible] 3.15 at 4.5 Amp 12.[illegible] at 5 Amp	72.5[illegible]
[illegible]	[illegible] at 1 [illegible]	[illegible] at 4 Amp [illegible]	[illegible]
[illegible]	15[illegible] 5v at 5[illegible] A	5A 0v [illegible] at 2.5A	[illegible]
120v[illegible]	[illegible] at 200 mA	3.1[illegible] 3.[illegible] at 1 [illegible] at 3A [illegible] at 3A [illegible] at 3A	8[illegible]
[illegible]	1.7[illegible] at 5 [illegible]	3.15 [illegible] 3.15 at 2.5A	[illegible]
[illegible]	42[illegible] at 200mA	7.[illegible] 0v at 2A 7.[illegible] 0v at 2A 5.0v [illegible] at 3A	for [illegible] ONE & [illegible] THREE [illegible]
[illegible]	[illegible] at 200mA	[illegible] at 1.[illegible] at [illegible] A [illegible] at [illegible] A [illegible] 3A 7.[illegible] 0v at 3A 5v 0v at 2A	[illegible] For KASSAI [illegible]
[illegible] 100[illegible]	[illegible] 0v [illegible] at 200mA	[illegible] at 1.2A [illegible] at 1.[illegible] A [illegible] 3.25A 1.0v 0v at 3.25A [illegible] 0v at 3A 5v 0v at 3A 5v [illegible] at 3A 5v [illegible] at 3A 6.3v 0.6 [illegible] at 1.25A	1[illegible].00 For ONGAKU [illegible]

[illegible] £ 4[illegible] [illegible] **AN** [illegible]

VACUUM TUBE VALLEY

[illegible]

POSITIVE FEEDBACK.

[illegible]

COMPLETE KITS

[illegible]

[illegible] 15 watts Class A [illegible] £ [illegible]

[illegible] £ 5[illegible].0

[illegible] Class A [illegible] £ [illegible]

October 1996

[illegible] 15 watts Class A [illegible] 2 250.00 [illegible]

[illegible] Class A [illegible] £ 4[illegible].00 [illegible]

[illegible] 1996

[illegible] £ [illegible] [illegible]

AUDIO NOTE OUTPUT TRANSFORMERS.

[illegible]

A) [illegible]

B) [illegible]

C) [illegible]

D) [illegible]

[illegible]

[illegible]

[illegible]

On a [illegible]

AUDIO NOTE PAPER IN OIL SIGNAL CAPACITORS

[illegible]

[illegible] AUDIO NOTE paper in oil capacitors [illegible]

[illegible]

Value	DC Voltage	Size	Price ex. UK Vat
2.2nF	[illegible]	2[illegible]x9 mm	11.85
[illegible]	[illegible]	[illegible]	2.[illegible]
[illegible]	[illegible]	2[illegible] mm	5.45
[illegible]	400 volt [illegible]	21x9 mm	5.45
[illegible]	[illegible]	2[illegible]x9 mm	5.4[illegible]
[illegible]	[illegible]	2[illegible]x9 mm	5.45
[illegible]	[illegible]	21x9 mm	5.45
[illegible]	400 volt	2[illegible]x9 mm	[illegible]25
[illegible]	[illegible]	[illegible]	5.45
[illegible]	[illegible]		5.95
[illegible]	[illegible]	3[illegible]x11 mm	6.15
0.0[illegible]	400 volt	[illegible]x14 mm	4.25
[illegible]	[illegible]	[illegible]x14 mm	[illegible]25
[illegible]	400 volt	[illegible]x14 mm	4.75
[illegible]	[illegible]	[illegible]x16 mm	6.05
[illegible]	[illegible]	[illegible]x16 mm	5.15
[illegible]	[illegible]	[illegible]x18 mm	5.85
[illegible]	400 volt	[illegible]x18 mm	6.35
[illegible]	[illegible]	[illegible]x18 mm	7.95
[illegible]	[illegible]	[illegible]	8.55
[illegible]	[illegible]		[illegible].15
1 uF	[illegible]	53x24 mm	12.65
[illegible]	400 volt	[illegible]x24 mm	14.95
[illegible]	630 volt	[illegible]x9 mm	2.95
[illegible]	630 volt	[illegible]	2.95
[illegible]	630 volt	20x9 mm	2.95
.001 [illegible]	630 volt	1[illegible]x9 mm	2.95
[illegible]	[illegible]	2[illegible] mm	2.95
[illegible]	630 volt	21x11 mm	3.45
[illegible]	[illegible]	21x11 mm	3.45
[illegible]	630 volt [illegible]	[illegible]	5.45
[illegible]	630 volt	[illegible]x11 mm	3.75
[illegible]	630 volt	32x11 mm	3.95
[illegible]	[illegible]	[illegible]x14 mm	6.85
[illegible]	630 volt	[illegible]x15 mm	4.25
[illegible]	[illegible]	[illegible]x14 mm	6.25
[illegible]	630 volt	[illegible]x14 mm	4.25
[illegible]	[illegible]	[illegible]	4.25
[illegible]	[illegible]	[illegible]	4.35
[illegible]	630 volt	[illegible]x11 mm	4.35
[illegible]	[illegible]	[illegible]x16 mm	4.35
[illegible]	630 volt	[illegible]x16 mm	4.35
[illegible]	[illegible]	[illegible]x18 mm	4.35
[illegible]	[illegible]	[illegible]x18 mm	4.35
[illegible]	630 volt	[illegible]x18 mm	4.55
[illegible]	[illegible]	[illegible]	6.65
[illegible]	630 volt [illegible]	42x16 mm	7.75
[illegible]	630 volt	42x18 mm	5.45
[illegible]	630 volt	[illegible]x18 mm	7.25
[illegible]	630 volt [illegible]	5[illegible]x19 mm	9.45
[illegible]	[illegible]	5[illegible]x22 mm	8.15
[illegible]	630 volt	52x22 mm	7.25
[illegible]	[illegible]	4[illegible]x25 mm	7.45
[illegible]	630 volt	52x[illegible] mm	[illegible].95
[illegible]	630 volt [illegible]	52x26 mm	[illegible].85
[illegible]	[illegible]		1[illegible].45
1uF	[illegible]		15.15
[illegible]	[illegible]	[illegible]x11 mm	4.55
[illegible]	[illegible] volt	50x26 mm	6.95
[illegible]	[illegible] volt	6[illegible] mm	11.65
[illegible]	[illegible] volt	[illegible] mm	[illegible].85
[illegible]	[illegible] volt	72x[illegible] mm	6.75
[illegible]	[illegible] volt	[illegible] mm	[illegible]
[illegible]	2[illegible] volt	[illegible] mm	11.55
0.1mF	4000 volt	[illegible]	[illegible].75

All AUDIO NOTE paper in oil signal capacitors are [illegible] paper in oil capacitors [illegible] AUDIO NOTE paper in oil signal capacitors is steadily expanding, so [illegible] for values that you do [illegible]

AUDIO NOTE PAPER IN OIL COPPER & SILVER FOIL SIGNAL CAPACITORS

[illegible] 99.99% pure [illegible]

AUDIO NOTE COPPER FOIL PAPER IN OIL CAPACITORS.

Value	DC Voltage	Size	Price ex UK Vat.
0.00[illegible] mF	630 volt	[illegible] mm	11.55
[illegible] mF	630 volt	2[illegible] mm	11.55
0.0082mF	630 volt	[illegible] mm	11.55
[illegible] mF	630 volt	[illegible] mm	12.15
[illegible]	630 volt	[illegible] mm	13.75
0.047 mF	630 volt	2[illegible]x16 mm	15.35
0.1mF	630 volt	3[illegible]x22 mm	15.85
[illegible]	630 volt	[illegible] mm	18.15
[illegible]	630 volt	[illegible] mm	22.45
[illegible]	630 volt	[illegible] mm	[illegible]
[illegible]	630 volt	[illegible] mm	[illegible]
1mF	630 volt	[illegible] mm	[illegible]

AUDIO NOTE SILVER FOIL PAPER IN OIL CAPACITORS.

Value	DC Voltage	Size	Price ex UK Vat.
[illegible]	630 volt	[illegible]	41.00
[illegible]	630 volt	[illegible]	[illegible].00
[illegible]	630 volt	[illegible]	[illegible].00
0.22mF	630 volt	1[illegible]x45 mm	105.00
0.47mF	630 volt	25x45 mm	155.00
1mF	630 volt	3[illegible]x40 mm	423.65

AUDIO NOTE SILVER FOIL SIGNAL CAPACITORS

[illegible] ONGAKU, KEGON, GAKU-ON and [illegible] at Audio Note [illegible] Japan. These capacitors use a [illegible]

Value	DC Voltage	Price ex UK Vat.
[illegible]	[illegible] volt	1[illegible].00
[illegible]	500 volt	211.[illegible]
[illegible]	[illegible] volt	[illegible]6.75
[illegible]	500 volt	645.75
[illegible]	[illegible] volt	[illegible].75

AUDIO NOTE PAPER IN OIL RESERVOIR CAPACITORS.

[illegible]

Value	DC Voltage	Size	Price Ex UK Vat
[illegible]	[illegible] volt	[illegible]x55 mm	20.75
[illegible]	[illegible] volt	[illegible]x72 mm	33.[illegible]
[illegible]	[illegible] volt	[illegible]x72 mm	41.75
[illegible]	[illegible] volt	[illegible] mm	45.[illegible]
4uF	[illegible] volt	[illegible] mm	4[illegible].[illegible]5
4uF	[illegible] volt	[illegible] mm	[illegible].75
[illegible]	[illegible] volt	[illegible] mm	[illegible]
[illegible]	[illegible] volt	[illegible] mm	[illegible]
1[illegible]	[illegible] volt	10[illegible] mm	1[illegible].75
[illegible]	[illegible] volt	[illegible] mm	[illegible]

AUDIO NOTE ACID & CLORIDE FREE SILVER SOLDER.

[illegible]

Weight/Measure	Price Ex UK Vat
50 [illegible] or about 9 [illegible] 1 [illegible]	19.[illegible]5
1 [illegible] of 1 [illegible]	2[illegible]0.85

AUDIO NOTE CABLES & WIRES.

[illegible]

Gauge	Insulation Material	Price per Meter Ex. UK Vat.
[illegible]	Polyurethane	[illegible].75
[illegible]	Polyurethane	22.75
[illegible]	[illegible]	24.95
[illegible]	[illegible]	27.85
[illegible]	[illegible]	31.75
[illegible]	[illegible]	[illegible].75

[illegible]

AUDIO NOTE 15 [illegible] 0.09mm 99.99% Silver Wiring Wire

[illegible]

Cost per [illegible] £ 22.[illegible]

AUDIO NOTE CDEX INTERCONNECT CABLES.

Type/Colour code	Construction	Price per Stereo Meter Ex. UK Vat
AN-A [illegible]	[illegible] copper [illegible] coax	15.3
AN-[illegible] red	[illegible] copper [illegible]	29.7
AN-S [illegible]	[illegible]	84.2[illegible]
AN-[illegible]	[illegible] coax	1[illegible].[illegible]
AN-Vx [illegible]	[illegible] coax	[illegible]2.9

AUDIO NOTE SPEAKER & WIRING CABLES.

Type/Colour code	Construction	Price per [illegible] Meter Ex. UK Vat
AN-[illegible] green or red	[illegible]	6.85
AN-B [illegible]	[illegible]	12.34
AN-L [illegible]	[illegible]	25.11
AN-[illegible]	[illegible] 15 [illegible]	[illegible]
AN-[illegible]	[illegible]	99.[illegible]

PTFE Insulated Silver Plated Copper Wires

We can also provide [illegible] They cost £ 1.[illegible] per meter [illegible]

AUDIO NOTE HIGH QUALITY STEPPED ATTENUATORS & SWITCHES

[illegible] AUDIO NOTE [illegible] the best [illegible] controls and switches [illegible] 48 steps and with [illegible]

Type	Value	Price Ex. UK Vat
[illegible]	[illegible]	2[illegible].75
[illegible]	[illegible]	221.75
[illegible]	[illegible]	2[illegible].75
2 [illegible]	6 [illegible]	98.75
4 [illegible]	6 [illegible]	1[illegible].75

AUDIO NOTE HIGH QUALITY CERAMIC VALVE BASES.

All of our valve bases are [illegible] quality, made from [illegible] and using the best [illegible] They are recommended as upgrades to most old valve amplifiers and should be an essential part of any DIY project.

Type	Mounting	Plating	Price Ex UK Vat
4-pin [illegible]4 for 300B/2A3/[illegible]A	Chassis	Gold	8.25
4-pin [illegible]4 for [illegible]A	Chassis	[illegible]	7.25
14-pin [illegible]4 [illegible]	[illegible]	Silver	[illegible]4.75
4-pin [illegible]4 [illegible]	[illegible]	Silver	4[illegible].95
14-Pin [illegible] 4 [illegible] 211 [illegible]	[illegible]	[illegible]	1[illegible].95
15-pin UY5 for [illegible]	[illegible]	[illegible]	9.7[illegible]
7-pin B7 [illegible] OA2	PCB	[illegible]	6.15
7-pin B7 for [illegible] OA2	PCB	Gold	7.85
7-pin B7 for [illegible] OA2	Chassis [illegible]	Silver	6.75
7-pin B7 for [illegible] OA2	Chassis [illegible]	Gold	7.[illegible]
8-pin [illegible] for EL34 [illegible] 6L6 etc	Chassis	[illegible]	5.[illegible]5
8-pin [illegible] for [illegible] 6L6 etc	Chassis	Gold	8.65
9-pin B9A for ECC[illegible] 5687 6350 etc	PCB	Silver	3.85
9-pin B9A for ECC[illegible] 5687 6350 etc	PCB	Gold	5.[illegible]
9-pin B9A for ECC[illegible] 5687 6350 etc etc	Chassis [illegible]	Silver	4.45
9-pin B9A for ECC[illegible] 5687 [illegible] etc etc	Chassis [illegible]	Gold	6.75
9-pin B9A for ECC[illegible] 5687 6350 etc etc	Chassis [illegible]	Silver	4.[illegible]5
9-pin B9A for ECC83 ECC88 5687 6350 etc etc	Chassis [illegible]	Gold	[illegible]
TOPCAPS			
[illegible]	For 807 [illegible] etc	[illegible]	9.75

[illegible] "industrial grade" ceramic valve bases.

Industrial Grade Valve Bases

Type	Mounting	Price Ex UK Vat
8-pin for EL34 [illegible] 6L6G	Chassis with bracket	1.45
9-pin for ECC83 ECC88 5687 [illegible]	Chassis with shroud	1.85

AUDIO NOTE CERAMIC STAND OFFS

In most [illegible] valve power amplifiers it is frequently difficult to get the HT and heater rails [illegible] directly heated triodes like 211 [illegible] AUDIO NOTE [illegible]

Type No	Number of Tags	Height/Length	Solder Connection	Chassis Fixing	Price Ex UK Vat
AN-42[illegible]	1	25.5 mm	[illegible]	Screw [illegible] bolt	1.4[illegible]
AN-422	[illegible]	1[illegible].4 mm	[illegible]	Screw [illegible] bolt	[illegible]
AN-423	1	22.6 mm	[illegible]	Screw [illegible]	[illegible]41
AN-452	2	Adjustable 17mm	[illegible]	[illegible]	2.42
AN-453	3	Adjustable [illegible]	[illegible]	[illegible]	3.[illegible]
AN-[illegible]	5	Adjustable [illegible]	[illegible]	[illegible]	4.[illegible]
AN-458	8	Adjustable [illegible]	[illegible]	[illegible]	5.7[illegible]

[illegible]

AUDIO NOTE SELECTED AUDIO VALVES.

[illegible]

Standard Stock Items.

Type No	Type	Price Ex. UK Vat
[illegible]	[illegible]	[illegible]

[illegible]

Resistors

[illegible]

Beyschlag

[illegible]

HOLCO

[illegible]

SHINKOH Tantalum Film Resistors

[illegible]

AUDIO NOTE 1/2 WATT TANTALUM RESISTORS.

[illegible]

The 1/2 watt Audio Note tantalum resistors are £1.50 each

AUDIO NOTE 1 WATT TANTALUM RESISTORS.

[illegible]

AUDIO NOTE PRECISION CARBON FILM RESISTORS.

[illegible]

ALLEN BRADLEY 1 Watt 5% Carbon film Resistors.

[illegible]

HIGH WATTAGE WIRE WOUND RESISTORS.

[illegible]

Wattage	Value	Tolerance	Price excl. Vat
[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

BLACK GATE ELECTRON TRANSFER High Performance Graphite foil capacitors

[illegible]

IMPORTANT NOTICE!

PLEASE NOTE. THE PRICE LIST FOR BLACK GATE CAPACITORS IS A GUIDELINE ONLY. DUE TO THE CONTINUOUS STRENGTHENING OF THE JAPANESE YEN IT IS IMPOSSIBLE TO PRINT UP-TO-DATE PRICES MONTHLY. SO ASK FOR PRICE WHEN YOU ORDER.

Value	Voltage	BG-Type	Suggested Use	Price Ex. UK Vat
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

POTENTIOMETERS.

[illegible]

Volume Controls

Impedance	Construction	Price Ex. UK Vat
[illegible]	[illegible]	[illegible]

[illegible]

Impedance	Construction	
[illegible]	[illegible]	[illegible]

Balanced Controls

[illegible]

STANDARD TYPE SWITCHES

[illegible]

STANDARD ELECTROLYTIC CAPACITORS

[illegible]

Value	Voltage	Size	Price Ex. UK Vat
[illegible]	[illegible]	[illegible]	[illegible]

RCA, BNC, BANANA PLUGS, RCA SOCKETS, SPEAKER & GROUND TERMINALS & LOUDSPEAKER SPADES

RCA PLUGS.

[illegible]

RCA SOCKETS.

Type	Mounting	Price Ex. UK Vat
[illegible]	[illegible]	[illegible]

BNC PLUGS & SOCKET.

Type	Price ex. UK Vat
[illegible]	[illegible]

Banana Plugs, Loudspeaker Cable Spades, Chassis Loudspeaker Terminals

Type	Price Ex. UK Vat
[illegible]	[illegible]

[illegible]

FERRITE RINGS.

[illegible]

AUDIO NOTE Moving Coil, CD Line & Input Matching Transformers

[illegible]

Type	Colour Code	Primary/Secondary Impedances - Main Use	Price Excl. UK Vat
[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

AUDIO NOTE CHASSIS SETS.

[illegible]

Type	Size	Price Excl. UK Vat
[illegible]	[illegible]	[illegible]

[illegible]

AUDIO NOTE COMPLETE KITS.

[illegible]

KIT ONE

[illegible]

KIT TWO

[illegible]

KIT THREE.

[illegible]

KIT FOUR

[illegible]

PRE-AMPLIFIER KIT.

[illegible]

AUDIO NOTE (UK) Ltd. Unit C Peacock Industrial Estate, Lyon Close, 125-127 Davigdor Road, Hove BN3 1SG
East Sussex, England Telephone 01273 220511/6 (lines), fax 01273 731498
RUSSIAN Federation, contact ESOTERICA Ltd. Tel. 095 917 4305, Fax. 095 917 6762
HUNGARY please contact Martin Audio, 54. U. Raday hz 2 H-1092 Budapest, HUNGARY. Tel/Fax. 01 215-2012
HOLLAND please contact de Jong Components, 2 Reggestraat, NL-6704 MT Helmond. Tel. 04920 14461 Fax 14773
USA please contact Angela Instruments, 10830 Guilford Road, Suite 309, Annapolis Junction, MD 20701. Tel 301 725 0451, Fax. 301 725 8823
FRANCE please contact IMEXCO, Paris. Tel/Fax. 1 4539 4987 PQ 01 18 1 986

[illegible]

Circuits, Valves & Basic Technical Information.

[illegible]

SOUND PRACTICES

[illegible]

VISA Access MasterCard AMERICAN EXPRESS

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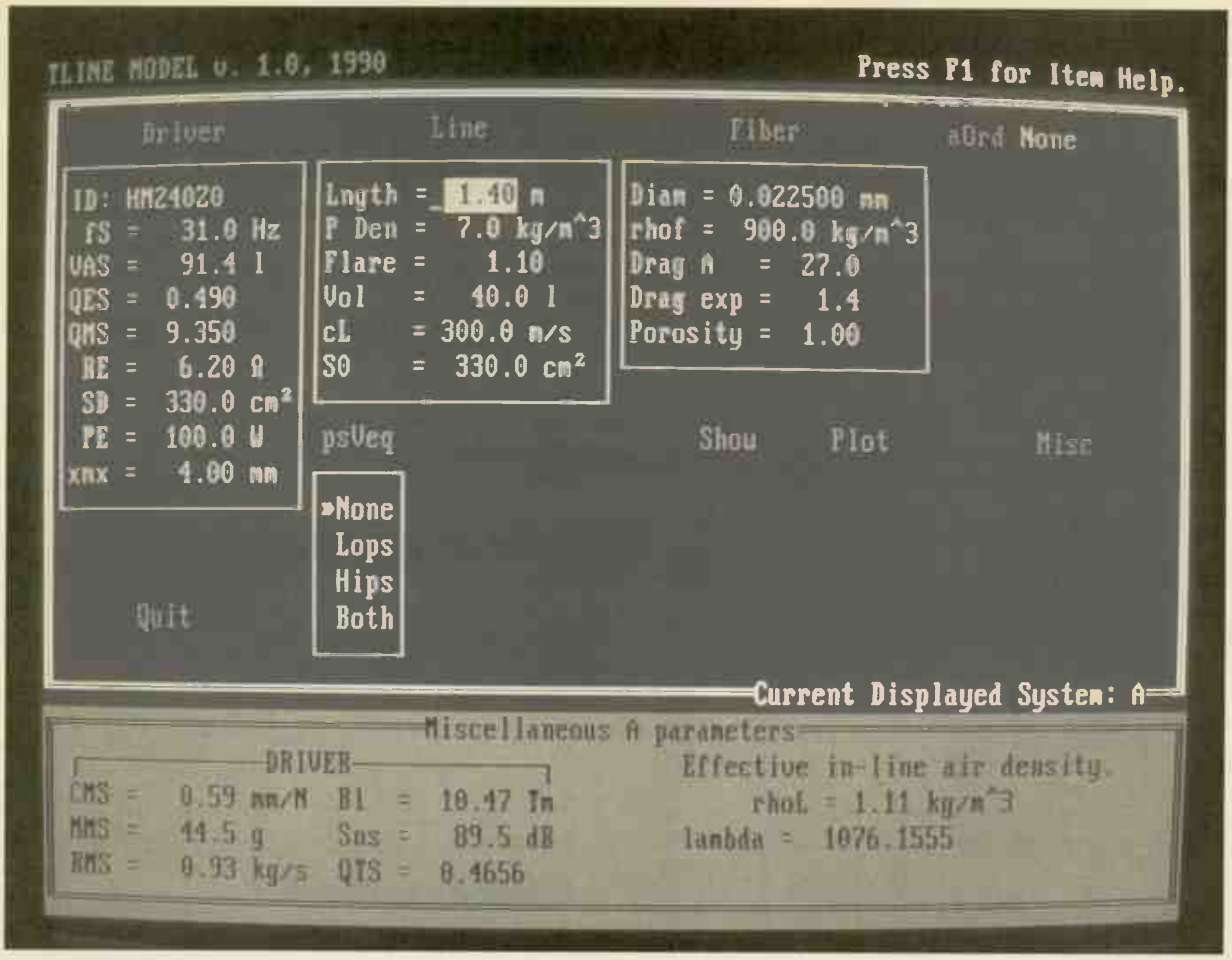
Fax. +44 01273 731498

Sales +44 01273 885511

AUDIO NOTE



```
TLINE MODEL v. 1.0, 1990                              Press F1 for Item Help.

      Driver              Line                 Fiber            aOrd None
 ID: HM24020         Lngth =  1.40 m       Diam = 0.022500 mm
  fS =    31.0 Hz    P Den =  7.0 kg/m^3   rhof =  900.0 kg/m^3
 VAS =    91.4 l     Flare =    1.10       Drag A   =  27.0
 QES =  0.490        Vol   =    40.0 l     Drag exp =   1.4
 QMS =  9.350        cL    = 300.0 m/s     Porosity =  1.00
  RE =    6.20 Ω     S0    =  330.0 cm²
  SD =  330.0 cm²
  PE =  100.0 W      psVeq                        Show     Plot         Misc
 xmx =    4.00 mm
                      »None
                       Lops
                       Hips
      Quit             Both

                                           Current Displayed System: A
                      Miscellaneous A parameters
            DRIVER                         Effective in-line air density.
 CMS =   0.59 mm/N  Bl  =  10.47 Tm             rhoL = 1.11 kg/m^3
 MMS =   44.5 g     Sns =   89.5 dB        lambda =  1076.1555
 RMS =   0.93 kg/s  QTS =  0.4656
```

TRANSMISSION LINE LOUDSPEAKERS

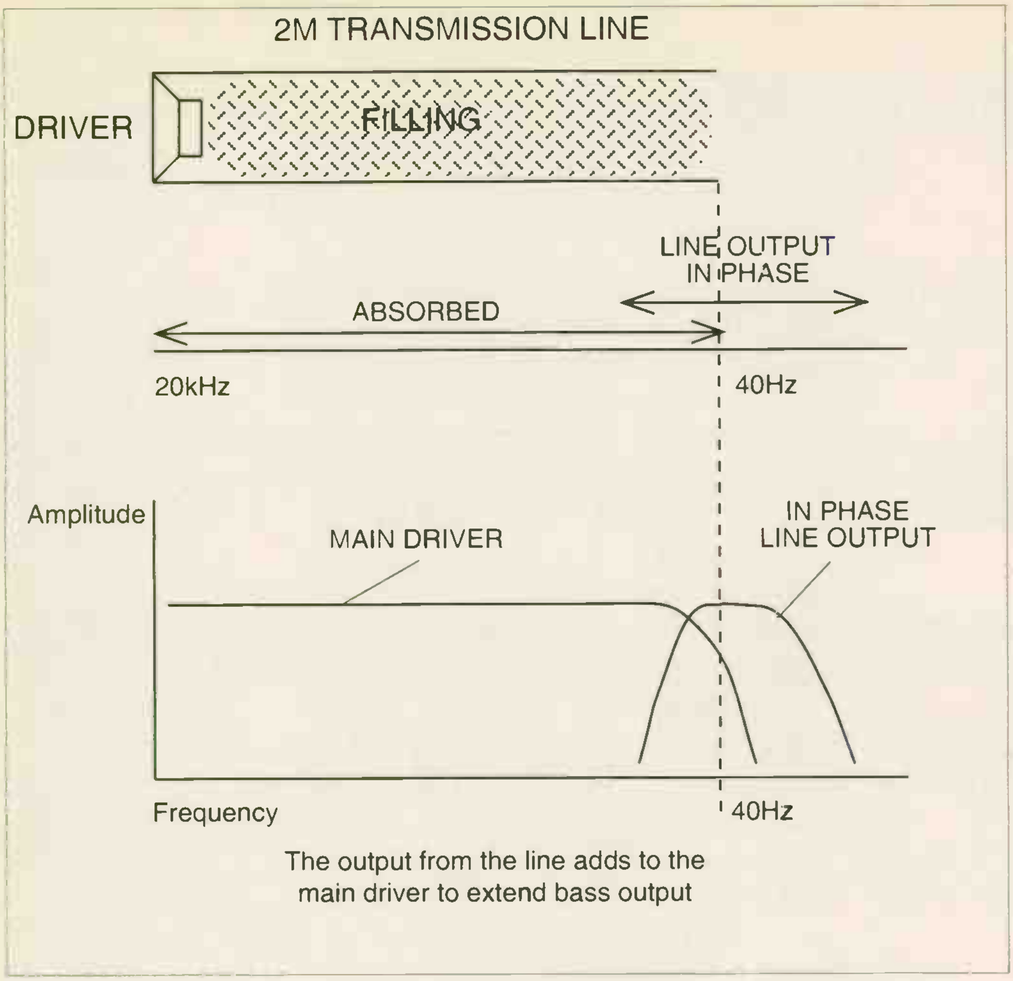
Dominic Baker reviews Robert Bullock's TL BoxModel, a transmission line loudspeaker design package for the PC

Transmission line loudspeakers have long been a strong favourite among hobbyists. Their attraction is enhanced by mystique around the basic principle, which is a comparatively recent one. But what seems to compel most constructors is the promise of deep, gut thumping bass.

There are few commercial transmission line loudspeakers. IMF used to specialise in them and TDL are now the most active in this field. Their loudspeakers are known for extraordinarily deep and powerful bass.

THEORY

In theory, a transmission line should, acoustically, extend to infinity, allowing it to absorb all of the energy from the rear of the cone. This provides a perfectly resistive termination to the driver. A practical approach to building this kind of transmission line would be to make the line long enough to absorb the rear energy down to the lowest frequency to be reproduced. However, for domestic hi-fi this has its problems, namely size. The line length relates to



The output from the line adds to the main driver to extend bass output

In our example, a 2m transmission line is used. The 1/4 wavelength of 2m corresponds to a frequency of 40Hz. At this frequency, the output from the transmission line is in phase with the output of the main driver, adding to its response to extend bass.

the frequency you are trying to absorb, so to reproduce a frequency of 40Hz, which has a wavelength of around 8m, the line will need to be at least this long.

PRACTICE

A practical transmission line loudspeaker is quite different to what theory suggests. The energy that emerges from the end of the transmission line is below the cut off frequency, and will either add to or subtract from the main response, depending on its phase. Frequencies having a 1/2 wavelength corresponding to the length of the line will be in phase with the front radiation of the driver and add to the system response.

A. R. Bailey found that a filling of long hair wool at a density of around 8kg/m3 not only served as an efficient absorber for the line, but at low frequencies appeared to reduce the speed of sound by 50% in the line. This is a very important point. The delay in a line of given length appears to be twice as long when stuffed, so in effect, for the same cut-off frequency the line length can be halved.

So, in theory the line needs to be comparable to the wavelength of the lowest frequency you wish to reproduce, say 8m for 40Hz. A more practical approach is to allow the rear radiation to add to the forward radiation. Then the line can be 1/2wavelength long. For a 40Hz lower limit, this line need only be 4m long. The discovery by Bailey that the speed of sound can be slowed by 50% with long hair wool, allows this length to be halved, making it a much more practical 2m long. This last system is what is used in just about all commercial and home-brew TL designs.

TL BOXMODEL

With the cost of high performance PCs coming down by the day, computer aided design packages for designing audio equipment are getting more and more plentiful for the enthusiastic DIYer. We've already seen numerous loudspeaker modelling packages, mainly for simple reflex or sealed types, but some have branched out as far as isobaric, passive radiator and parallel/series combinations of drivers.

The calculations for these packages are all fairly simple, and can be handled with pen, paper, and calculator if need be. And they should be, initially at least, to gain an understanding of what the parameters mean and how they are derived. This gives invaluable insight into the world of loudspeakers. A good computer package though can open your eyes up to a whole new world in a matter of minutes. Because of the time and complexity involved in manual calculation you are unlikely to get far without computer aided design.

This world of CAD loudspeaker enclosure design allows you to vary the box size, port tuning frequency, ports and their size, ambient temperature, box losses, barometric pressure and more at the click of a button, observing the predicted response - amplitude, phase, impedance, maximum SPL, driver excursion, etc on screen. Powerful stuff, and invaluable to any enthusiast craving knowledge at high speed.

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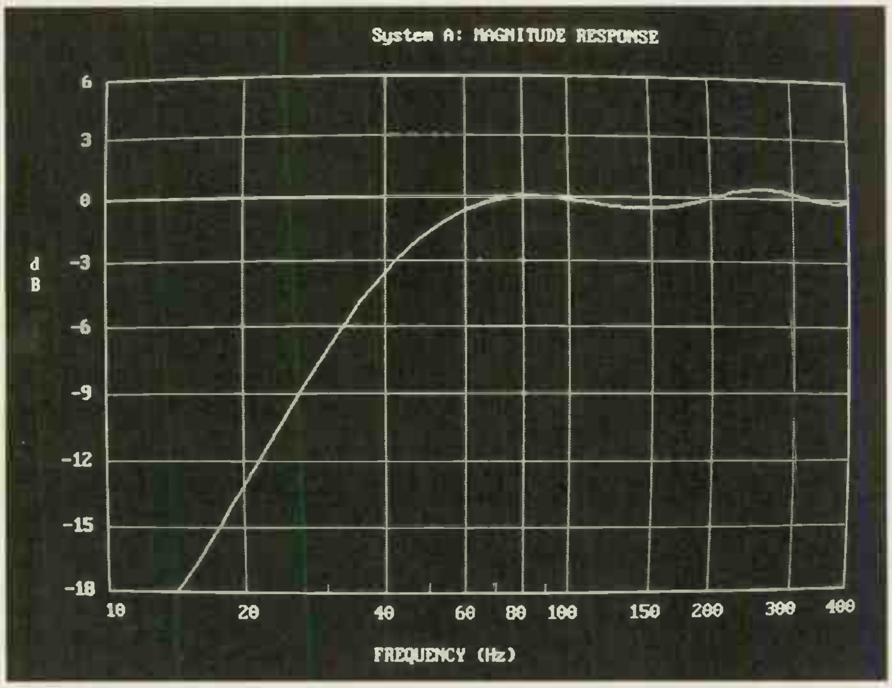
World Radio History

across a similar package capable of modelling a transmission line loudspeaker in the same way. Transmission lines are a bit of a black art; apart from a few guidelines, like those found in Quick and Easy Transmission Line Design by Larry Sharp, there is little real information of any serious weight. Home builders normally have to follow their instincts, pick which advice they feel is most relevant and take the plunge, fine tuning their design perhaps over several years.



So a computer package that uses the traditional and easy to obtain Thiele-Small parameters to predict the performance of a transmission line loudspeaker is something of a find for the TL enthusiast. TL BoxModel is written by Robert Bullock, a man for whom I am gaining increasing respect as I stumble across more of his work. It is similar to BoxModel (reviewed in DIY Supplement 19) in operation, but uses a computer model of a transmission line loudspeaker system that uses the acoustic model proposed by Bradbury (The Use of Fibrous Materials in Loudspeaker Enclosures, JAES, vol. 24, pp. 162-170, 1976).

TL BoxModel is designed for the IBM PC or a compatible, with at least 256K of memory (RAM) and DOS 2.x or higher. This means just about any PC in working order today, and it also means that if you don't already have a PC there is no need to be disheartened. A PC of this spec. will set you back around £100 second hand, maybe even less with a little searching around.

If you are intending to live your life around TL BoxModel, it is worth using a PC with a maths co-processor, since the program uses calculations involving floating point maths which will otherwise slow things down. Having said this, even a machine with the basic spec. above will turn out four simultaneous graphs in around three minutes - or while you make a cup of tea.

USING TL BOXMODEL

Using TL BoxModel is reasonably simple, but newcomers to transmission line loudspeakers would do well to read as much as possible about the subject. A lot in this package has been left to the operator to make decisions upon, leaving a lot of scope for improving and fine tuning your results. But equally there's room for error and confusion.

Luckily, I had Tony Seaford of Marton Music on line for help. He has experimented with many TL loudspeakers and told me this package accurately predicts results very similar to their measured performance. His first piece of advice, and probably the most valuable, was: make sure you pick the right driver. High Q drivers tend to work best in a TL, so aim for a Qts of around 0.45-0.6.

Set the packing density to around 8kg/m3 which, if you are using long hair wool, will slow the speed of sound by around 50% so that a 1/4 wavelength line can be used. Pick a sensible starting point for the line length, around 2m corresponds to a 1/4 wavelength of 40Hz. From experience, Tony has found that with a taper of 1.3, the output from the line will match well with the output from the front of the driver. Reducing the taper to 1.1 will increase bass output, and increasing it to 1.5 reduces it. It is best to use a taper of 1.1 or more to prevent standing waves in the line. The line exit should be set to equal the driver cross sectional area.

Once these parameters are set, you are free to experiment and fine tune the result. A small coupling cavity between the driver and the line, although space consuming, will tend to give a smoother response and deeper bass. As a guideline, for an 8" driver a volume of around 20litres works well.

Tony finds that the default values for Hollofil fibre match long hair wool reasonably well, although he did say that making the stuffing density around 80% of what the package predicts consistently works well in practice. If you intend to use any other type of filling, the exact parameters should be available from the manufacturer concerned.

Other than this, TL BoxModel is relatively straightforward, allowing you to experiment quickly and easily whilst viewing the results on screen. For the TL enthusiast, it is an invaluable tool, giving an insight into how the various parameters affect performance. You'd struggle to ever make sense of this on paper. I have only one criticism. The instructions, which come as text files in the package that you have to print out, are brief to say the least, hence the need for a good book to accompany this package.

TL BoxModel	**£50.00**

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World Radio History

TUBE AMPLIFIERS

reviewed by Noel Keywood

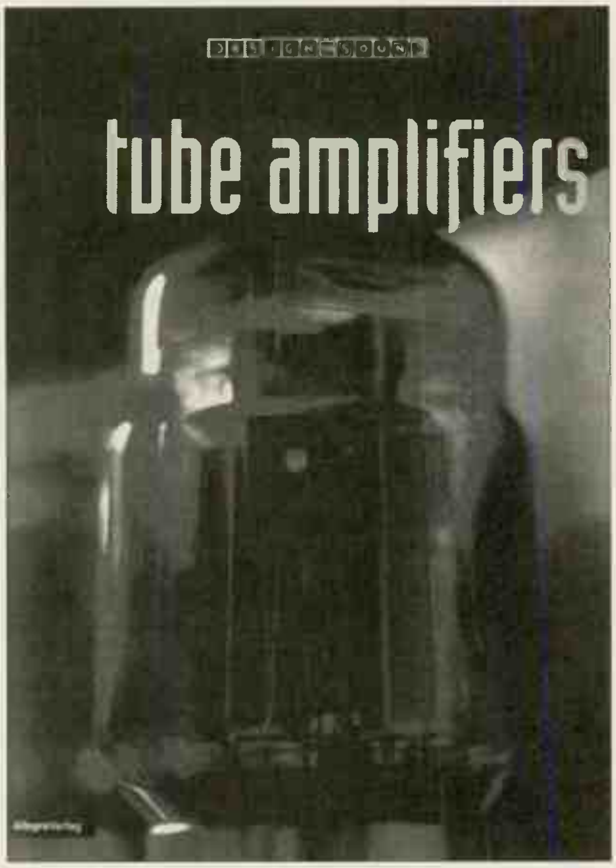
These days the valve, or vacuum tube I should perhaps say, is moving firmly into the mainstream of high fidelity. The interest, time and effort being invested in its revival are shown by this book, which is a visual tribute more than a technical treatise. Printed on heavy, high quality white paper, it's a coffee table ode to the tube. The publishers use lavish print quality to reveal, in rich colour and fine detail, the aesthetics of tube amps from around the world.

Introductions by Paul Kavsek and, especially, Ludwig Flich, identify the essence of the tube's attraction, without engaging in polemic. Their sentiments reflect what seems to be a universal appeal, for tube amps are springing up in what must be frightening profusion for anyone whose business is based on little black things that go 'phut'.

In case by now you are wondering, this book is published in Austria. It contains numerous designs alien to UK shores, such as the kitsch Grundig Fine Arts CD preamplifier. When you reflect upon the fact - reflect being the right word because Fine Arts products are smothered in gold plate for the German market - that Grundig are a part of Philips, the fact that even the big boys are starting to take this thing seriously is demonstrated here. Just over the page lies Taiwan's Compass 300B, from Golden Wave, a new one to me. Japan's Ongaku is shown, America's VAC and many, many more glossy, plated and bejewelled behemoths, covering 160 pages, which makes about 80 in all.

There is variety aplenty, but curiously an unusual number of the designs produce 100watts. This is interesting, since in their day only PA amplifiers using GEC DA70s and such like aimed for such stratospheric powers. At home, in the heyday of the hi-fi valve amplifier, 20watts was considered enough. Many of the amps pictured here are, then, designed for today's world, where disposable incomes can cope with, even demand, items built like a gold plated Forth Road Bridge.

It is here this book's coverage jars a little on my senses. Valve amps that seek to mimic transistor amplifiers generally sound a lot worse in my experience and, irrespective of any conspicuous extravagance, fail to deliver the sonic goods. I suppose my real fear is that if people are sold expensive pups, then the valve revival is likely to fizzle out pretty quickly, misrepresented by those who understand little about valves and care even less about what they can offer, other than a quick profit (or so they think). Being in a position of designing, testing, reviewing and listening to valve amplifiers, my fears are shaped by experience.



Not included in the book are rarities like Gaku-On and Marantz's latest wonder (they're also a part of Philips!), but rather a selection of what is currently available. Nor are there any prices, which reduces the Wow! factor somewhat. Up front, however, taking pride of position on the first colour spread is a lovely acknowledgement to Harold Leak: a picture of the workmanlike Leak TL10 Point One, now a classic. Many are still in use of course and their owners usually swear by them. Once a valve man, always a valve man, at least with an amplifier of this nature.

Britain's Graham Tricker has contributed to a technical introduction that aims to provide a simple understanding of the history, construction and technical development of the tube, which in his terminology becomes the valve once again. Many circuit topologies are drawn in outline and even output transformerless configurations are mentioned, although not in detail.

Tube Amplifiers is a colourful compendium of modern valve amplifiers, beautifully pictured, to tempt all those who have just discovered their existence and are curious to learn more. It brings home forcefully just how much activity there is around the world and how different in style most valve amplifiers are from the modern black box.

Tube Amplifiers is available through the Hi-Fi World library.

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Technical specification: dual mono construction, 40W / channel, 12Hz to 25kHz power bandwidth, distortion<0,1%, five line level inputs, tape output, 230/240V mains input.

Amplifier circuit board: board only £49.50; component pack (including valve bases), add £63; populated board £125; full valve set, add £45. Power supply board: board only £20.50; component pack, add £44; populated board £66. Input board: board only £15.50; component pack, add £16; populated board £33.

The output transformers are configured for McIntosh connection and have excellent low frequency reponse, and have primary reflected impedance of 3800Ω. Full connection instructions provided. Price £70. The mains transformer is wound for dual mono construction, as this gives superior isolation between channels which sharpens imaging and eliminates inter-channel ground loops in the amplifier. Primary 0-230-240V. Secondaries 2x295V@0.25A (0.4A int.),2x70V@30mA, 2x70V@5A. Price £60. Other primary voltages can be supplied to special order. Reference book giving connection diagrams, specifications, as well as circuits for using these transformers, £5.

The chassis, comprising main chassis and transformer cover, is hand polished, welded 1/16" stainless steel - NC machine tooled for a perfect fit and clean finish. Each kit also includes a mesh valve cover and baseplate, finished in semi matt black. Price £310. Also available in mild steel finished in black, £195. For those who wish to use one of these high quality chassis for their own projects, details of the chassis are given in the 4040 manual, £6.50.

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Circuit board: board only £25; component pack, add £37.50: populated board £70; full valve set £20.

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The chassis (main chassis and transformer cover) is made from mild steel. Each kit comes complete with mesh valve cover and base plate, finishe din black, Price £110. For those who wish to use high quality chaassis for their own projects, details of the chassis are given in the P2 manual, £6.50.

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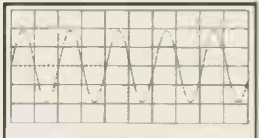
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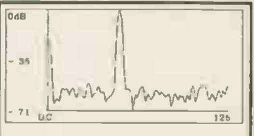

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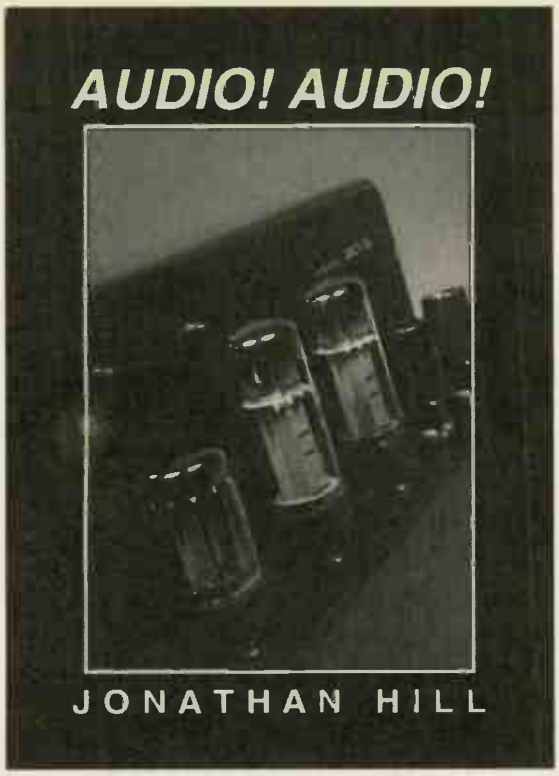


AUDIO! AUDIO!

- the British hi-fi spotter's directory of classic audio amplifiers & control units by Jonathan Hill, Technical Editor, John Howes. Reviewed by Dominic Baker.

In Jonathan Hill's preface to Audio! Audio! he marks his position by saying "hi-fi's golden age spanned the 1950s through to the 1960s". This really embraces vintage audio, rather than the full span of audio history stretching from the thirties to the present day. As an organiser of and visitor to vintage audio fairs, including the Audiojumble organised by his Technical Editor John Howes, Jonathan Hill is a vintage buff.

Since John Howes is also a collector of vintage audio, with a fantastic collection of equipment, enough to fill a museum it's rumoured, it is easy to see they're both keen and well grounded in the subject. This enthusiasm lies behind the book.

Audio! Audio! is basically a collectors guide, listing vintage audio amplifiers, valve and transistor, between the period 1945-1972. It is one of the most complete guides available, listing over 150 manufacturers and some 800 products. The listings are headed by the manufacturers name and address, and in some cases a brief note about the company. For example for H. J. Leak & Co. "The trademark, 'Point One', which is widely associated with this company, was originally applied to the first audio power amplifier having a total harmonic distortion as low as point one of one percent. This dates back to June 1945, when, as a result of wartime research in his laboratory, H. J. Leak revolutionised the performance standards of audio amplifiers and designed the original 'Point One' series, beginning with the Point One Type 15".

"At a time when 3 or 4 percent distortion was commonplace in amplifiers, the news of this almost distortionless amplifier was at first greeted with scepticism by the electronics industry. But Leak's figures were subsequently confirmed by the National Physical Laboratory and soon became an accepted world-wide standard. Together with the Williamson circuit and amplifiers produced by Lowther and Quad, Leak amplifiers were at the forefront of a developing British hi-fi industry which by the late 1950s was renowned throughout the world".

The 'Point One' was indeed a landmark product in the evolution of amplifier design, and like a few other innovative and unique products listed in Audio! Audio, I felt it deserved a more detailed description, a circuit diagram maybe, showing the triple loop feedback system Leak used to get such low distortion.

Individual products are listed, together with a couple of lines worth of basic description. This includes an indication of the dates that a particular product was on sale and its original price in pounds, shillings and pence. Younger readers needn't worry though, John Howes includes a conversion table to modern pounds with decimal pence.

There are brief technical details too, where possible giving power output, inputs and their sensitivity, the valve line up and transformer output impedance taps. In some cases more information is provided, but descriptions are kept short, probably due to the number of amplifiers covered.

The brief introductory paragraph carries two graphs, one showing a comparison between valve and transistor amplifiers available on the market between 1945 and 1970, showing the sudden take-over of transistors around 1966. The second graph covering the same period shows in more detail the break down of valve amplifiers; mono and stereo integrated and power amplifiers shown separately. This is interesting, but little more.

Following on are a couple of pages on record equalisation curves used through the 1950s, and a short history of the valve and how it was developed. I suspect space was at a premium here, because although there is enough of a description to get a feel for how the valve developed through its life, this chapter could certainly have been expanded on further.

It would have been nice to see circuit diagrams for some of the more original or innovative designs, and a description of what they achieved. It would have been even better if each caption could have carried a picture, and a ranking system for their rarity/value would also have been valuable. It must have been a mammoth task just to assemble the information here though, but hopefully Jonathan will expand on this work in future, building it into an invaluable reference guide. As it stands though, it is still the most complete listing of its kind we have come across.


GLASS AUDIO
CONTENTS
READING GLASS

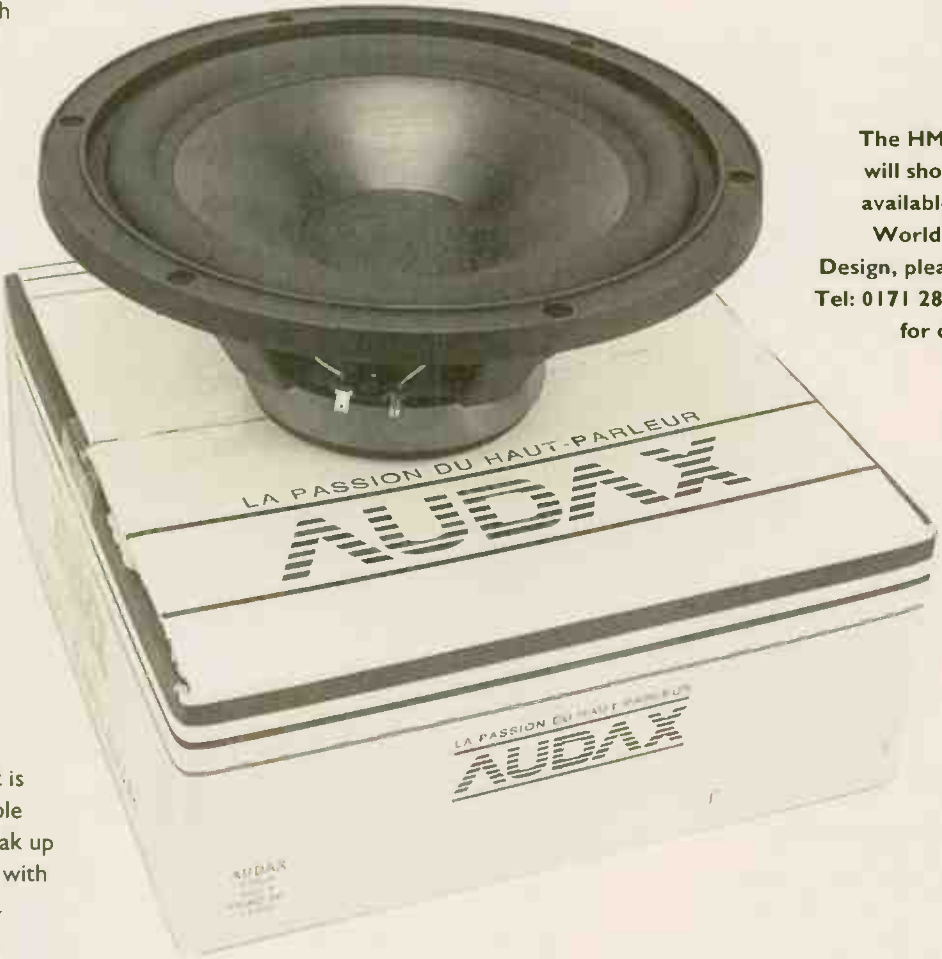
AUDAX HM240Z0

Dominic Baker takes a look at a brand new 10" High Definition Aerogel bass unit from Audax.

DRIVER PARAMETERS

Nominal Impedance	Z	8Ω
Minimum Impedance	Zmin	6.5Ω
DC Resistance	Re	6.2Ω
Resonance Frequency	Fs	31Hz
Total Q Factor	Qts	0.46
Equivalent Cas air load	Vas	91.4x10-3m3
Effective Piston Area	Sd	3.3x10-2m2
BL Product	BL	10.51NA
Power Handling	Pnom	100W
Sensitivity	n	89dB

Audax have recently introduced a new drive unit to their range of High Definition Aerogel (HDA) drivers, a 10" bass driver. This is the largest driver in the HDA range, promising deep and powerful bass. We ran a few tests to give DIYers an idea of its potential, which are detailed here along with the driver's Thiele-Small parameters.



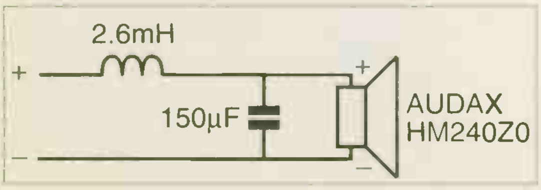
The HM240Z0 will shortly be available from World Audio Design, please call Tel: 0171 289 3533 for details.

EXAMPLE CROSSOVER

I quickly found the HM240Z0 an easy driver to control. A simple 2nd order crossover comprising a 2.6mH series inductor and 150µF capacitor across the driver's terminals gives a very flat and useable response as shown in the plot below. The -3dB point is 450Hz in this example, a sensible point well away from cone break up but high enough to match well with just about any midrange driver.

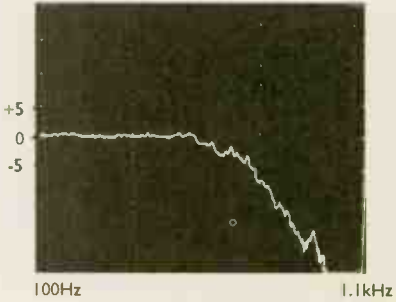
EXAMPLE ENCLOSURE

In a 60 litre reflex enclosure tuned to around 30Hz, the HM240Z0 reaches 35Hz (-3dB). This is plenty low enough to play fundamentals well. The HM240Z0 will go a lot lower in a bigger enclosure, but I stuck to a limit of 60 litres because it is a sensible size for a domestic loudspeaker. If you decide to follow this guideline, start with a port of 70mm diameter and 150mm length.



A simple 2nd order filter using the circuit shown to the left gives a very smooth response rolling off at 450Hz, as shown in the plot on the right.

Frequency Response



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D.I.Y. Letters

ELECTROSTATIC LOVE

I was intrigued to read your article on the Quad/Celestion SL-6000 system in the December edition of Hi-Fi World. I auditioned just such a system about four years ago, but ruled it out on the grounds of cost and domestic unacceptability.

I then had the good fortune to read about the modifications and rebuilds of Quad equipment by Peter Lindley. Not only were his stacked electrostatics a sonic revelation in terms of deep bass, they were also beautiful to look at.

True, these speakers will not deliver cat-scaring, seismic bass but in 99 cases out of 100 they prove more than adequate in the window-rattling department.

For me, stacked Quads are the only answer and involve a lot less sheer heartache than the route to sonic Nirvana you describe in your article.

Andrew Mackay
Malvern,
Worcestershire

Stacked Quads are a legendary arrangement and represent a form of audio purity we could hardly criticise. But they are somewhat intrusive.

Our DIY articles are meant to stimulate ideas and experimentation. They are not offered as definitive solutions, a crazy notion in a field that is so subjective.

In that particular article, the Quad high pass section offers a purist high pass filter with equalisation, based around just one FET, the highly effective VN10KM, that offers around 120dB of dynamic range. Experimenters can use this for many purposes.

The other idea we want to keep alive is the bass dipole. Celestion took this only so far before deciding it was best abandoned. Our view is that it could have been better developed. We hope to return to the bass dipole to show how this can be done. Behind me lie two massive, high performance Audax bass drivers. Soon they'll find a role in life! ***NK***

REFLEX ACTION

I want to make a new cabinet for my KEF CD7 speakers (B139/B110/T33A) and wish to make them taller with a smaller foot print, i.e. approx. 1000mm high x 300mm x 300mm.

Although the speakers were originally an infinite baffle design and there was a transmission line design, is it worth considering reflex design?

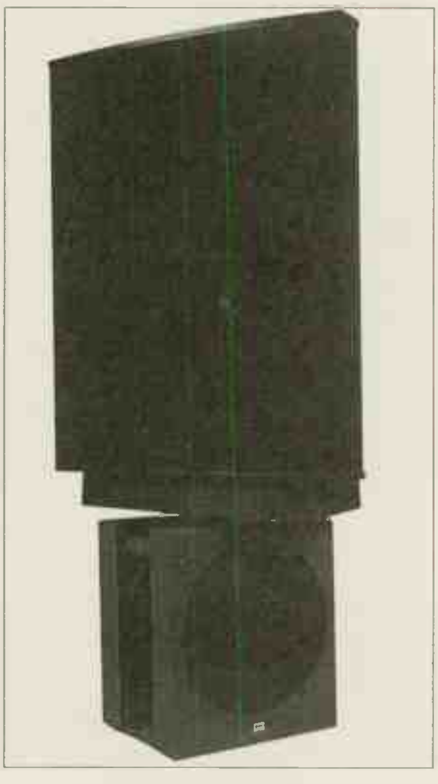
If the bass section in each cabinet is approximately 67 litres, what diameter and length of port should be used and would a front or rear position port be best?

W J Parish
Bromley,
Kent.

A drive unit that works well in an infinite baffle is unlikely to give good results in a reflex enclosure. Generally, drivers with a total Q factor (Qts) less than 0.38 favour reflex loading, giving flattest and deepest bass. Drivers with Qts greater than 0.38 tend to work better in a sealed box.

Interestingly the KEF B139 has a Qts of exactly 0.38, so may well perform well in either a sealed or reflex enclosure. However, knowing this driver I would stick with a sealed cabinet, where you should get fastest and best bass quality. The B139 has a heavy cone which, along with the deep bass it is capable of producing, also

▶▶



We designed our own crossover to match Quad's ESL-63s with Celestion's SL6000 subwoofers. We hope to have our own dipole subwoofer running shortly.

gives it a tendency to sound heavy and slow. The extra damping of the air spring in a sealed box will help minimise this and should give best subjective results. **DB**

VALVE RECTIFICATION

This is, I am afraid, a letter begging some information.

1. I need to specify HT to yield 500V @ 180mA when using bridge connected paralleled EZ81s and π-network filter.

2. The PM6 units for my Lowther Acoustas have shot suspension. However, I do not know, nor can I find out, the address of Lowther Manufacturing Limited. Any idea how much recovering will cost for these units?

I would appreciate it if you could furnish me with the above information, then I can get on with constructing an S.E amplifier (EAR 859 but with valve rectification, hence the question) and finally get the Acoustas back into use. My Castle Richmonds can then be used for a second system.

The main system will consist of Garrard 401, Odyssey RP1, Decca Gold cartridge, home built preamp with valve regulated supply. This is a bit of a hybrid of the above mentioned SE power amp and the Lowthers.

Second system for second hand mono and 78s: Goldring '88', Decca MkI and MkII head, 78 head. Lowther MkIV home built min. tone controls, Lowther LL15s MkI - very nice amp this - and the Castle Richmonds. Also, a cheap Onkyo cassette deck. No CD player for the simple reason that I have no CDs

David Eggleston
Dundee,
Scotland.

A simpler approach would be to use a single valve rectifier capable of handling 500V @ 180mA, the GZ37 being one such example. These are cheap and in plentiful supply, so this would be a good choice. It is impossible to be precise about voltages, because unknowns such as transformer regulation affect final results. You'll have to experiment. We can only give guidelines here.

Firstly, the GZ37, like most Mullard rectifier valves, needs a 5V heater supply, in this case providing 2.8amps.

You will need to use limiting resistors in the anode circuit of the rectifier. The value of these will depend on the mains transformer you use. The total resistance, made up of this resistor and the effective resistance of the mains transformer, must be above 200Ω or so for the GZ37. The effective resistance of the transformer will be in the region of 100-150Ω, so a safe value to start with for this series resistor will be around 100Ω.

The GZ37 itself, like any valve rectifier, will drop volts - expect around 60V or so across it.. If you start with a DC line requirement of 500V, you'll need in AC RMS of 353V. At 0.18A the surge limiting resistor will drop 18V, the valve itself will drop around 60V so the transformer must supply around 430V AC RMS. The exact voltage will depend on the value of the capacitors you use and the DC resistance of the choke in the π-filter. Aim for a 450V-0-450V AC RMS transformer (on-load).

I hope you can see from this that what you propose to do, although it looks straightforward, is a good deal more complex. To get it right, you will probably need to build several prototypes.

Your second question is a little easier to approach, Lowther can be contacted at:
PO Box 184,
Sidcup,
Kent. DA14 4NL.
Tel: 0181 300 9166. **DB**

There are some hidden X factors in power supplies that conspire to defeat accurate calculation. In particular, transformer behaviour under the short term current draw of a capacitor input filter, which a π-filter has, can affect final DC volts, as can the value of the output capacitor used. The text books are surprisingly coy about all this. You'll have to experiment, since we can only give you rough guidance. **NK**

UPGRADE MISSION

I am writing in response to the crossover conversion of Mission 760i 'speaker in the December issue. I've been using this 'speaker for more than a year now, powered by Mr. Jones's 10 watt Class A transistor amplifier (June issue supplement).

In addition to the gold-plated bi-wireable terminals, I've changed the capacitors and also the 'door bell' wires used in it. For the capacitors, instead of using the cheap

Letter of

DUAL VOICE COILS?

I read with great interest your design for the KLS6 loudspeaker in the August '95 Supplement. However, there are still a couple of queries I would appreciate your views on.

Firstly, upon contacting the Australian distributor for Audax I was made aware that in addition to the bass/mid driver you specify for this speaker (HM210Z0), Audax can also supply a dedicated bass driver (HM210Z2).

This driver appears to have better bass extension and an even flatter response up to the crossover point than the HM210Z0, as well as a lower resonance frequency and higher BL factor. Its sensitivity is rated at 89dB.

Could this unit be substituted into the KLS6 design to give improved bass performance over what is described as the weakest area of the speaker (merely very good) in David Price's review?

If this is the case, could you please outline any changes that would be required to the crossover, port lengths etc. and what effects this would have on the speakers overall specification.

Secondly, on the midrange/treble response plot there appears to be a severe dip at the crossover point. Is this as severe as it looks and what effect if any does this have on the sound?

Finally, as the drivers are available here, is it possible for you to supply the crossover kit separately?

Peter Jeffries
Highett Victoria,
Australia.

The Z2 version of the HM210 is a dual voice coil model. It does 'appear' to have better bass, 'appear' being the operative word. If you look at the impedance curve you will note that this response is for the two 8Ω voice coils connected in parallel, giving effectively a 4Ω loudspeaker.

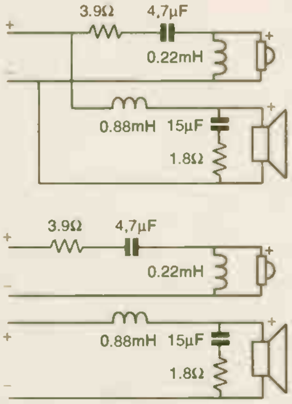
supplied Alcap, I used audio grade polypropylene capacitors available from Maplin Electronics. For the internal wiring, I used silver-plated 'speaker cable from the same company on the HF unit and QED 79 strand cable on the bass/mid unit.

On the HF unit I found that the treble level is still too high for my hearing. An attenuation with a 3.9Ω 7W wire-wound resistor in series with the tweeter (between the inductor-capacitor junction and positive tweeter terminal) finally did the trick. For the bass/mid unit, I found that the original capacitor value produces great bass, but with less bass lines. Changing the value to 1.5µF improves bass lines, with satisfactory bass attack. For me, I prefer the latter configuration.

The 1.5µF capacitor is not available at Maplin. However, you can order one (or two) from Cricklewood Electronics Ltd. Changing the capacitors means that you have to alter the crossover 'board' inside the 'speaker because of the relatively big size of polypropylene capacitors.

Lastly, don't be sad if the 'speaker sounds bright after the conversion. It takes some time for the capacitors to run-in, and be prepared to change its name to 760iSELEMV! (Special Edition Limited Edition Modified Version).

Happy D.I.Y.ing,
Pok Loh
Leeds.



How to bi-wire your Mission 760is. Many of our readers already have, and with good results too.

Adding a second series resistor to the treble arm of the crossover for your Missions will decrease treble level, but it will also effect the response smoothness. Normally the effect this has is to not only drop treble level, but also to roll off high treble. You may well have a shallow dip in the upper midrange/lower treble as a result, but this will serve to soften the sound which you seem to prefer.

Again, decreasing the 15µF capacitor on the bass driver may well have unbalanced the response. This will mis-tune the filter, probably resulting in a higher -3dB point and slower roll off. This may well reveal more of the upper harmonics of bass lines, but conversely you will be using the driver closer to its break up region, which may be heard as a coarseness.

It is not normally advisable to make such modification 'blind' without test equipment. In this case you may well have achieved a balance which you prefer, but I doubt if it's accurate and is likely to be inconsistent with different forms of music. Obviously, we encourage DIY, but some simple test equipment is necessary in cases like this which will enable you to make a far better job of the modification, and gives even wider scope for improvement. ***DB***

The Month

The Z2 appears to have better bass because it is drawing twice the current.

The lower resonant frequency is almost certainly a result of the extra mass of having two voice coils. The higher BL factor is also explained by the increased current demanded by a 4Ω load. Also worth noting is that although its sensitivity appears to be equivalent at 89dB, it is less efficient. In fact, as far as the amplifier is concerned, it would only produce 86dB for the same power level as an 89dB 8Ω unit.

It is indeed possible to use this Z2 driver in KLS6, but the crossover will have to be re-designed and the impedance curve will dip lower in the bass, so it won't be such an easy load as far as your amplifier is concerned.

We can supply the crossover components separately, but you should be able to find a supplier of these components locally. As you can see from the final 1/3 octave plot on page 15 of that Supplement, there is no dip in the crossover. The plot you are referring to is a high resolution plot of the tweeter and midrange driver taken individually, and then laid onto the same screen. It does not show how they sum at the crossover point, only the smoothness of the individual responses. ***DB***

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BASS BINS

Following on from your KLS6 speaker design, I would like to pick your brains. I was thinking of using Audax's new HM210Z0 drive unit, but in a transmission line enclosure. The idea is to make two 15-20 litre enclosures to go beneath my existing speakers in a similar style to Wilson or the Rogers AB1 arrangement.

This will provide both a true full-range speaker, for a modest outlay, and an interesting upgrade path in the form of active crossovers and bi-amping etc. At this stage I have only decided on a few of the design considerations. Firstly, the enclosures will be made from 25mm MDF with the base shot filled, and the existing speakers will have a low frequency cut-off in order to prevent them working too close to their lowest Hz output.

My system as it is comprises of a Trichord clocked Technics SLP 777 ▶▶

CD, a Rotel RB/RC870BX pre-power and Celestion 100 speakers which are bi-wired with Audioquest Indigo cables. I like the way the Celestions behave with the Rotel, but the Rotel can be really pushy with them when the music programme calls for some window rattling.

My main question now is: as you have done all the sums with this Audax unit, does it lend itself better to transmission line enclosures or to the reflex design as you have used it for your KLS6?

Colin Parish
Riverside Close,
Bedford.

Your best bet really would be to follow the plans for the bass section of KLS6. This cabinet has been optimised and validated using our test equipment and over many hours of listening. This optimisation process really is where a lot of the effort lies. The original design concept is easy to come up with; fine tuning it to get the result you want is always the lengthy bit. This should ensure that you get good results with the minimum risk and effort, allowing you to sit down and enjoy your music. **DB**

TREBLE EXTENSION

I have 99% completed a set of Lowther Acousta 'speakers, a task I would not recommend to anyone except the most enthusiastic of home constructors. The speakers in question have been constructed in M.D.F to specification from original plans, with the addition of baton and gusset type bracing to the large horn panels. In total there are 114 components (including originals).

The PMBA used, although good, was found lacking in frequency range (Brios Feb. '95) as I am still young enough for mine to extend slightly beyond 10kHz. The lack of top end would be a concern, therefore I am considering the addition of an HF unit run from extra terminals with a series capacitor, so they can bi-wired for extra HF if desired.

If this is a good idea could you recommend a good HF unit that you may have come across on your travels? These units are expensive and an unknown quantity as far as I'm concerned, no more than £100 a pair. As you will appreciate, the fitting of this unit is best done before fitting the front panels (the last panels!)

The units were bought second-hand, boxed and unused. I have been using them in a conventional sealed enclosure for some time. Lowther recommend them not to be boxed for more than 6 months. They were 3 years old when I bought them. They are working fine, but have a slight brown tinge where the voice coil is attached to the cone. Is this just normal heat discoloration?

I'm using Quad IIs for amplification and was thinking of replacing the components for new ones, but do not want to meddle with the original wiring as it's still in good working condition, with the original colours still visible. Is this worth it? If so can you recommend some reasonably priced types.

J.R. MacKay
Hornchurch,
Essex.

Finding a tweeter is not going to be as easy as it sounds. The Lowther drivers are very high quality, and very sensitive. To get a tweeter of similar quality and with the high sensitivity needed you will probably have to look at compression drivers or slot tweeters. For advice on which would be most suitable contact Kevin Scott at Definitive Audio, Tel: 0115 981 3562. He uses Beyma and Vitavox drivers, both of which should fit the bill nicely. **DB**

In your Quad II valve power amplifiers, only replace components that have drifted off value or have failed. You'll need to check all DC voltages to determine this, working from a circuit diagram. Modern components can give quite a different sound, cheap ones often sounding nasty. Aim to use carbon film resistors, not cheap metal films, and only audio grade polypropylene capacitors, like Solens or VITAs. Ideally, for best results, special components, like paper-and-oil dielectric capacitors should ideally be used, available from AudioNote (Tel: 01273 220511). **NK**

CAVITY SICKNESS

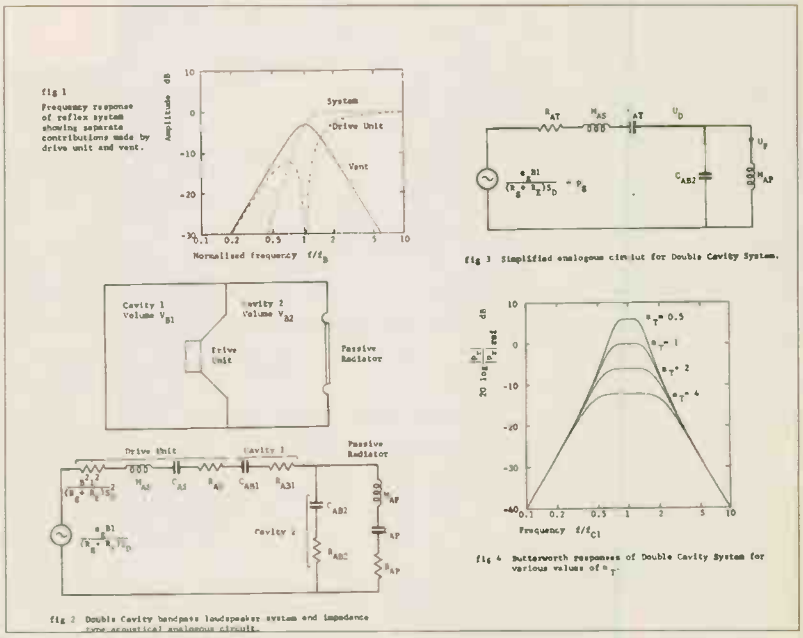
For over thirty years I labour with brick house sized reflex cabinets and infinite baffles, folded horns and columns, paralines and tricolumns you needed the kitchen chair to peer into. Concrete pipes, sand filled baffles and chipboard boxes the dog used as a kennel at night.

Then this bloke David Purton writes his little booklet; 'Coupled Cavity Handbook'. Wilmslow Audio put it in the post under plain wrapper for a fiver. The 19" cubes are flat down to 20Hz within excess of 100dB capability and 100 watts power handling and the pair cost less than £200 to build.

Now I only built them to please my wife, because she needed some indoor plant pot holders, but they make noises like a double decker bus and exactly match my Kans for sensitivity on pink noise. Is there a Nobel Prize for services to Hi-Fi?

Chris Bolwell
Gwynedd.

Coupled-cavity working is a topic we covered in our November issue, with regard to the test of Technics' SB-M300 loudspeakers. It was developed by KEF in the early Seventies and is now used in all their Reference Series loudspeakers to give good bass. Shamefully, in my view, Technics offer no acknowledgement of this, trying to disguise its origins by applying their own acronym, DDD (Dual Direct Drive), which means nothing. All the same, Coupled Cavity working is interesting and offers good performance, as Technics have discovered. **NK**



KEF research paper on coupled-cavity loading

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