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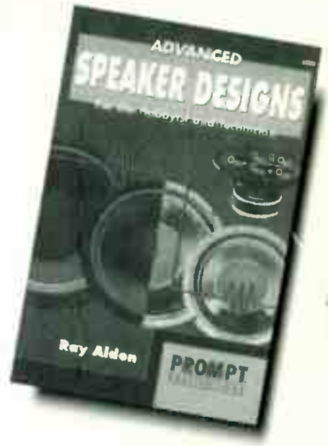

THIS MONTH'S BOOK REVIEW:
Advanced Speaker Designs by Ray Alden

SPEEDY BASS

CLEAN AND FAST!

Plus:
- *news, letters and more...*

Build a compact and sensitive loudspeaker

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Subscriptions & Back Issues
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+44 (0)1923 270833

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+44 (0)171 625 3134
Fax: +44 (0)171 328 1844

Contact Numbers
9am - 5pm Mon - Fri

Editor
Nick Lucas
+44 (0)171 625 8032
wad@hi-fiworld.co.uk

Sub Editor
Noel Keywood

Design & Production
Tyrone Taylor
+44 (0)171 625 3129
Fax: +44 (0)171 328 1844

Contributors
Richard White
Gary Devon

Photography
David Noble
+44 (0)171 625 3134

Sales and Marketing Manager
Amanda Sweeney
+44 (0)181 864 4760
Fax: +44 (0)181 864 4780

Accounts
Michael Ogazi
+44 (0)171 289 3533
Fax: +44 (0)171 328 1844

Credit Control
Louise Palfrey
+44 (0)1923 270833
Fax: +44 (0)1923 270833

Publisher
Noel Keywood

WORLD AUDIO DESIGN
Technical Manager
Nick Lucas
Tel/Fax: +44 (0)171 625 8032
wad@hi-fiworld.co.uk

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Comag Magazine Marketing,
Tavisstock Road, West Drayton,
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diy supplement/contents No54

NEXT MONTH

Coming next month in DIY supplement No.55 is our new budget KEL84 Stereo Integrated Amplifier, featuring upfront the triode/pentode ECF80 followed by two EL84 power output valves per channel in push-pull (ultra linear) on the output, thumping out around 15 watts into an 8 ohm load. The KEL84 has a classic look and a small footprint. This simple kit is a must for all those readers itching to start DIY, on a budget.

KIT & COMPONENT NEWS

MICRONAS INTRODUCE NEW MP3/AAC CHIP

Micronas, who claim to be the world leader in MP3 decoder ICs, recently announced a new decoder chip, the MAS3509F. Although not strictly for the D.I.Y. market, keep your eyes open, because this chip may well start to appear through specialist suppliers and electronic stores, especially on the internet.

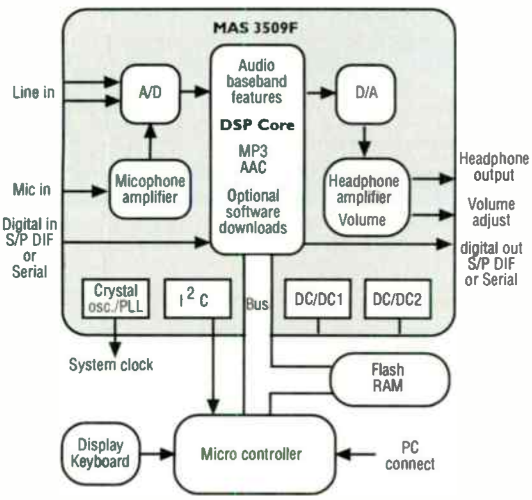
Their MAS3507D, an MP3 flash-player chip released in 1997, contributed to a world-wide revolution in MP3 by allowing companies to build players cheaply and quickly. Micronas claim to have sold no fewer than 2 million 3507s. One found its way to Japanese constructor Takeshi Akamatsu (http://elm-chan.org/) who has posted up a DIY feature giving details on how to build a player (see - http:// www2s.biglobe.ne.jp/~elm/ reports/mpc/report_e.html).

The new 3509 chip adds AAC decoding to the MP3 capability of the earlier 3507. Micronas interestingly point out that, in conjunction with their application board, the 3509 can interface SanDisk's Compactflash, Multimediacard and SD Card memory. By incorporating the SanDisk SD Card, the Micronas chip can handle SDMI compliant music from the major music groups. Hubertus von Janecek, marketing manager Advanced Audio for Micronas, said: "Micronas is gearing its MAS 3509F application board for future trends in digital audio. One of those trends in digital audio players is the increased usage of the MultiMediaCard and SD Card for memory. Not only do these cards make possible the design of tiny systems, but the SD Card also enables downloading and listening to music under a secured environment. SanDisk cards are rapidly gaining industry wide acceptance in music applications."

As Hi-Fi World reported last month, Panasonic recently introduced a range of SD Card AAC/MP3 players to the Far East market at the MAS2000 show. This technology has yet to reach Europe, even though Micronas is a Swiss/German company employing 1200 people and SanDisk are Californian. Fast acting DIYers could, with the new MAS3509 chip, beat the Japanese to it.

Gentlemen, man your soldering irons!

www.micronas.com



The new MAS 3509 chip from Micronas. There's a mic preamp so it can be used for voice recording and even S/P DIF (Sony/Philips Digital InterFace) for direct connection to CD players. Two DC/DC convertors step up battery volts to supply external chips. Flash RAM in the form of SD Card, Multimediacard or CompactFlash can be addressed. The DSP core can decode AAC as well as MP3 and will accept software download. The extras needed to make a player are also shown here.

NEW TUBES FROM ELECTRO-HARMONIX

Electro-Harmonix have a new 300B EH that they claim perfectly matches the a.c. and d.c. characteristics of Western Electric's original, so it can be substituted directly, without circuit modification. The 300B EH has a 40W plate dissipation and is directly heated (i.e. no cathode), like the original.

www.ehx.com

Ansar Supersound Polypropylene Axial Capacitor

Audio specific. For transparent & detailed sound with EXTREMELY low distortion. High purity imported metalised polypropylene Tol 5%

Part no	Description	L x 0 mm	Price
CPW100N	Ansar 100nF 630V	32 x 6.5	1.60
CPW150N	Ansar 150nF 630V	32 x 7.5	1.60
CPW220N	Ansar 220nF 630V	32 x 9.0	1.60
CPW330N	Ansar 330nF 400V	32 x 8.0	1.60
CPW470N	Ansar 470nF 400V	32 x 9.0	1.80
CPW680N	Ansar 680nF 400V	32 x 10.5	1.80
CPW1U0	Ansar 1uF 400V	32 x 12.5	1.80
CPW1U5	Ansar 1.5uF 400V	32 x 14.7	1.80
CPW2U2	Ansar 2.2uF 400V	43 x 14.8	1.80
CPW3U3	Ansar 3.3uF 400V	43 x 17.6	2.20
CPW4U7	Ansar 4.7uF 400V	43 x 20.7	2.50
CPW6U8	Ansar 6.8uF 400V	43 x 22.8	3.00
CPW8U0	Ansar 8uF 400V	43 x 26.5	4.00
CPW10U	Ansar 10uF 400V	43 x 29.5	4.00
CPW15U	Ansar 15uF 400V	55 x 34.1	5.50
CPW22U	Ansar 22uF 400V	55 x 39.3	7.00
CPW25U	Ansar 25uF 400V	55 X 42.0	7.50
CPW30U	Ansar 30uF 400V	55 x 44.7	8.50
CPW50U	Ansar 50uF 400V	83 x 46.0	11.50
CPW60U	Ansar 60uF 400V	83 x 51.7	13.50
CPW75U	Ansar 75uF 400V	83 x 55.1	19.00
CPW80U	Ansar 80uF 400V	83 x 56.8	19.50
CPW100U	Ansar 100uF 400V	115 x 55.1	20.00
CPW125U	Ansar 125uF 400V	115 x 60.9	26.00

Dual Polypropylene Smoothing Capacitors

To replace old electrolytics or for new designs. Wire tails.

Part no	Description	L x 0 mm	Price
CPW1616	Propyl 16+16 400V	100 x 50	25.00
CPW3232	Propyl 32+32 400V	115 x 61	30.00

Philips Polypropylene Axial 1%

Blue coated Film & Foil. Epoxy coated, low inductance metal foil & film. Supremely stable. Tolerance 1%

Part no	Description	Price
CPP47P	Propax 47pF 630V	0.40
CPP100P	Propax 100pF 630V	0.40
CPP150P	Propax 150pF 630V	0.35
CPP220P	Propax 220pF 630V	0.35
CPP330P	Propax 330pF 630V	0.35
CPP470P	Propax 470pF 630V	0.35
CPP680P	Propax 680pF 630V	0.35
CPP1N0	Propax 1nF 400V	0.45
CPP1N5	Propax 1.5nF 250V	0.45
CPP2N2	Propax 2.2nF 250V	0.45
CPP3N3	Propax 3.3nF 250V	0.45
CPP4N7	Propax 4.7nF 160V	0.50
CPP6N8	Propax 6.8nF 160V	0.50
CPP10N	Propax 10nF 63V	0.65
CPP22N	Propax 22nF 63V	0.75
CPP33N	Propax 33nF 63V	1.10
CPP47N	Propax 47nF 63V	1.30

Audio Electrolytics Radial

105 deg C +PLUS+ low impedance.

These superior electrolytics offer a low impedance path to the signal, resulting in a very open & detailed sound. The use of high temperature materials ensure that these capacitors enjoy a long & stable life.

Part no	Description	Price
1Y50	Lo Imp Hi Temp 1uF 50V	0.25
2U2Y50	Lo Imp Hi Temp 2.2uF 50V	0.25
4U7Y100	Lo Imp Hi Temp 4.7uF 100V	0.25
10Y63	Lo Imp Hi Temp 10uF 63V	0.25
22Y63	Lo Imp Hi Temp 22uF 63V	0.30
47Y63	Lo Imp Hi Temp 47uF 63V	0.35
100Y63	Lo Imp Hi Temp 100uF 63V	0.50
220Y50	Lo Imp Hi Temp 220uF 63V	0.75
470Y63	Lo Imp Hi Temp 470uF 63V	1.25
1000Y35	Lo Imp Hi Temp 1000uF 35V	1.50
2200Y50	Lo Imp Hi Temp 2200uF 50V	2.25
4700Y25	Lo Imp Hi Temp 4700uF 25V	2.50

Trobo High Ripple Reservoirs

Excellent for Audio. Long life. High reliability100VDC caps with screw terminals

10000uF: 50x87mm 8.97A ripple current
22000uF: 65 x 103mm 15.19A ripple current

Part no	uF/Voltage	Price
10000C100	10000uF 100V	20.00
22000C100	22000uF 100V	30.00

Alcap Bipolar Electrolytics

Axial leads 50V Tol. 10%
Primarily for use in speaker crossovers.

Part no	Description	Price
CAB1	Alcap 1uF	0.25
CAB2U2	Alcap 2.2 uF	0.40
CAB3U3	Alcap 3.3uF	0.40
CAB4	Alcap 4uF	0.40
CAB5	Alcap 5uF	0.40
CAB6U8	Alcap 6.8uF	0.50
CAB8	Alcap 8uF	0.50
CAB10	Alcap 10uF	0.50
CAB16	Alcap 16uF	0.65
CAB20	Alcap 20uF	0.65
CAB25	Alcap 25uF	0.65
CAB35	Alcap 35uF	0.65
CAB50	Alcap 50uF	0.75
CAB60	Alcap 60uF	0.85
CAB80	Alcap 80uF	1.00
CAB100	Alcap 100uF	1.10

Monacor Air Cored Inductors.

A range of professional air cored inductors for 8Ω or 4Ω crossovers/filters for use up to 300W. 1.2mm enamelled copper wire wound on air spaced plastic bobbins.

Part No	Specification	Price
P15	150μH 0.15Ω 8x19mm	£2.00
P22	220μH 0.15Ω 48x19mm	£2.50
P33	330μH 0.2Ω 8x19mm	£3.00
P47	470μH 0.25Ω 50x19mm	£3.50
P68	680μH 0.35Ω 59x19mm	£4.50
P100	1mH 0.4Ω 59x19mm	£5.50
P150	1.5mH 0.5Ω 70x30mm	£6.50
P220	2.2mH 0.6Ω 70x30mm	£8.00
P330	3.3mH 0.75Ω 70x30	£10.00

Monacor Ferrite Inductors

A range of professional high efficiency ferrite cored inductors with very low ohmic losses for 8Ω or 4Ω crossovers or filters for use up to 400W.
1.4mm enamelled copper wire (1.3mm on F1000) wound on plastic bobbin.

Part No.	Specification			Price
F220	2.2mH 0.15Ω	400W	55x31mm	£6.50
F330	3.3mH 0.2Ω	330W	65x39mm	£9.50
F470	4.7mH 0.25Ω	140W	65x30mm	£11.00
F680	6.8mH 0.35Ω	120W	65x39mm	£12.00
F1000	10mH 0.45Ω	100W	65x39mm	£13.50

High Quality Valves

Part No.	Description	Price
6550C	OUTPUT VALVE	£26.00
6L6GT	OUTPUT VALVE	£4.50
6SN7GT	OUTPUT VALVE	£4.50
6V6GT	OUTPUT VALVE	£3.95
ECC81	TRIODE	£4.50
ECC82	TRIODE	£4.50
ECC83	TRIODE	£4.50
EF86	LOW NOISE PENTODE	£9.90
EL34	OUTPUT VALVE	£8.50
EL84	OUTPUT VALVE	£3.50
GZ34	RECTIFIER	£6.50
KT88	OUTPUT VALVE	£20.00

Valve Holders - High Quality Valve Bases. Chassis Mounting With Screw Fittings.

Part No.	Description	Price
B9AC	B9A VALVE HOLDER CERAMIC	£1.50
B9AG	B9 VALVE HOLDER PORCELAIN PLUS GOLD PLATED PINS	£3.00
OCTC	OCTAL VALVE HOLDER CERAMIC	£2.00
OCTG	OCTAL VALVE HOLDER PORCELAIN PLUS GOLD PLATED PINS	£4.00

Fully Gold Plated Phono (RCA) Plugs with spring coil cable grip.

Part No.	Description	Price
PPG5A2	PAIR GOLD PLUGS for up to 5mm CABLE	£1.50 pair
PPG8A2	PAIR GOLD PLUGS for up to 8mm CABLE	£1.50 pair

Very High Quality Phono (RCA) Plugs

Very high quality satin grey metal with heavy gold plated connections. Top collet cable grip & PTFE insulators. Very low noise.

Part No.	Description	Price
PPG6H2	GOLD PTFE PLUGS for up to 6mm CABLE	£3.50 pair
PPG8H2	GOLD PTFE PLUGS for up to 8mm CABLE	£3.50 pair

Extra High Quality Gold Plated Phono Oxygen Free (RCA) Leads (pairs)

Highly flexible oxygen free cable with extra moulded-in control / grounding wire.

Part No.	Length/Colour	Price
LPP1QG	0.8 Metres/Green	£5.50
LPP2QG	1.5 Metres/Green	£6.50
LPP5QG	5 Metres/Green	£11.00

Bass Reflex Tuning Ports

A range of adjustable plastic ports for use in various sizes of loudspeaker cabinets. d=diameter L=adjustable length (mm)

Part No.	Dimensions	Price
R35	d=35L=110-210	£2.50
R50	d=50L=150-280	£3.00
R70	d=70L=128-245	£3.50
R100	d=110L=160-122	£5.50
R85	d=85 angled 45° for narrow cabinetsL=210-310	£6.50

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CLEAN & FAST!

GARY HOLLAND DESIGNS A COMPACT,SENSITIVE NEAR-WALL LOUDSPEAKER THAT SUITS BOTH VALVE AND TRANSISTOR AMPLIFIERS.

With KLS-14 we set out to design a compact loudspeaker that will work happily in most environments and with all types of amplifiers. In particular, it must be suited to valve amplifiers.

Designing a loudspeaker to work with both valve and semiconductor amplifiers raises several extra considerations. The output impedance of valve amplifiers is higher and the output power lower than their semiconductor counterparts. Consequently, a loudspeaker designed for valve amps must first of all be sensitive, and secondly present a friendly load impedance with as little reactance as possible to minimise risk of audible coloration. Happily, there are no trade-offs here. Solid-state amplifiers also prefer a friendly load and give a better performance too, so it's a worthwhile design aim.

Good sensitivity and even load impedance are just two of the requirements for our loudspeaker design. The others are as follows:

1) Compact but with good bass extension.
2) Room friendly; can be used close to walls.
3) Sounds good with semiconductor amps and valve amps.
4) Straightforward to build.

A Butterworth alignment is usually considered optimal for bass rolloff, but a higher target Q of around 1 was chosen to give a peak in the bass response. This will give the loudspeaker's bass a touch of slam and it will still sound good working away from walls.

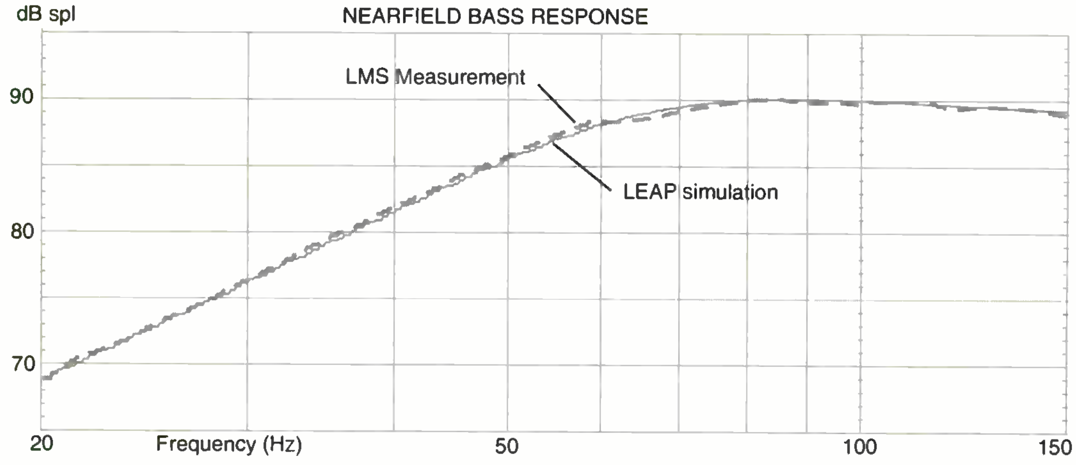
The next step is to find a bass unit that will work in the chosen cabinet. It has to be sensitive (powerful magnet and efficient motor) and well controlled in its working range, and also have electrical and mechanical parameters suitable for closed box workingis different to reflex working. These include a long voice coil travel because, unlike reflex loading, coil excursion in a sealed box design increases at system resonance. A higher Q unit is also needed for closed box systems to prevent over-damping the bass.

The first decision to make is what type of cabinet system should be used, reflex or sealed box ? While reflex designs offer deep bass, they can suffer with pipe resonances that extend right up into the midrange. This spurious noise can be as much as -10 dB below the main output, adding noticeable coloration. The problem of port resonances can be overcome, but at the expense of greater complexity, this design must be as straight forward as possible. I also want to exploit the lucid midrange that is one of the great strengths of valve amplifiers. Bass extension for a closed box design is not a great problem as long as the right drive unit/box combination and alignment is chosen. For the optimum choice between compactness and bass extension I chose 20 litres for the cabinet volume.'

After some searching an 8 inch unit from Seas emerged. It has a doped paper cone with a low loss rubber surround mounted on a low resonance magnesium chassis. A large diameter

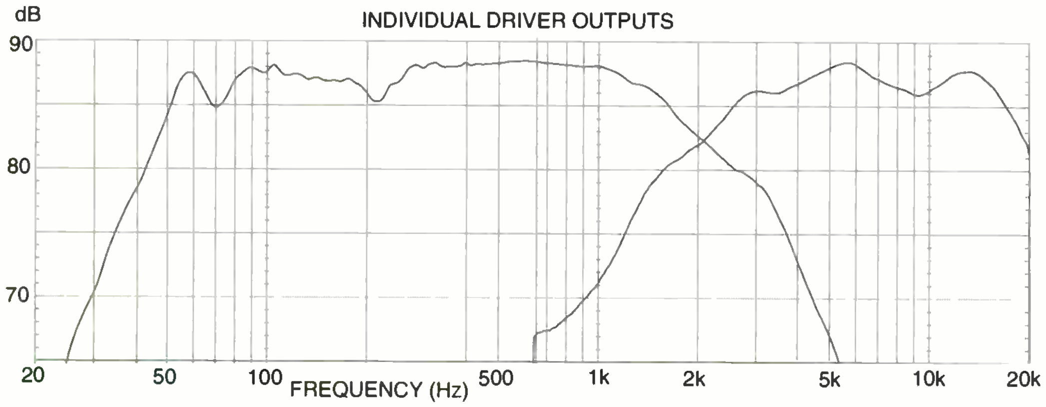
MEASURED PERFORMANCE

GRAPH 1



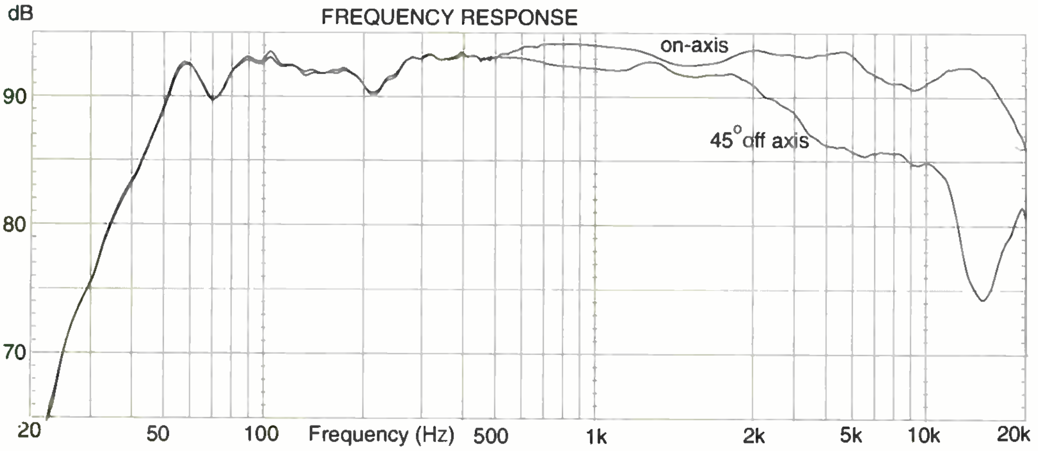
LEAP design software predicted a well damped bass response rolling off smoothly below 55Hz (-3dB). Nearfield measurement (LMS) showed real life response corelated perfectly. In use wall placement will lift bass level a little.

GRAPH 2



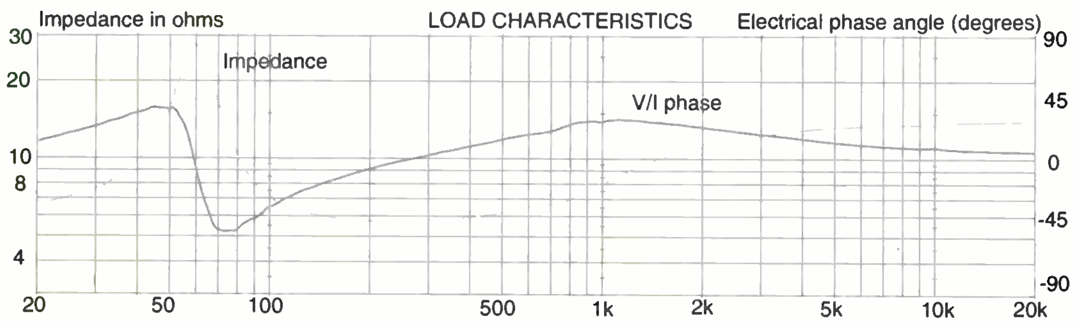
Measured at one metre the individual drivers roll in and out smoothly. It is important that there are no "throw ups" in the roll off region, to avoid colouration.

GRAPH 3



Overall frequency response of KLS-14 at one metre runs evenly from 55Hz up to 18kHz. Because the cabinet is "infinite baffle" bass rolls off less quickly than reflex, so low bass output is substantial for a compact cabinet. The horn tweeter rolls down above 2kHz, when measured off-axis.

GRAPH 4



Impedance of KLS-14 is smooth, demonstrating low reactance (energy storage) and phase angles. The load is resistive where there is no rate of change of impedance (point of inflexion), as this twin trace shows.

PERFORMANCE FIGURES

Frequency. response	
	50Hz - 18 kHz +- 3dB
Sensitivity	89dB
Nominal impedance	8 ohms
Minimum impedance	5.75 ohms
crossover. frequency	2.1 kHz
Rec. amp power	10 - 100 watts

The crossover region has a slight but fairly minor dip, this is due to the bass unit response dropping a little and then continuing its natural roll off. The treble unit takes over in the upper mid/lower treble region and runs quite smoothly up to 8 kHz, then dips a little. The 3dB resonant peak that existed has now been pulled down to the same level as the rest of the treble with the use of a Zobel network across the treble unit - see Graph 3 on p10.

The off-axis response (45degrees) shows the same on-axis trend until the tweeter cuts in. The increase in directivity caused by horn loading shows as falling response above 2 kHz. This means there willl be less reflected energy from room walls, floor and ceiling, so conversely direct enery will be in greater proportion. Consequently the speaker will be more tolerant of nearby surfaces. The amount of treble energy in this case can be altered by merely adapting the angle of the speakers - see Graph 3on p10.

Treble level will sound neutral with a valve amp. However, with brighter sounding semiconductor equipment there may be a need to lower the level, which may be adbjusted by varying the value of the resistor R2 in the treble section. A value of 10 ohms sets the output at 88 dB. If the value is increased to 12 ohms the treble output is lowered by 1 dB to 87 dB. Dropping the value to 8.2 ohms increases output to 89 dB.

LOAD IMPEDANCE

As a load KLS-14 is reasonably friendly. The box/driver resonance shows up at 60 Hz with a Q of about 1.0. From here the impedance drops to just under 6 ohms in the mid range area. At around 500 Hz the impedance curve starts climbing and levels out to about 14 ohms in the treble region. Overall there are no dramatic changes for an amplifier to cope with, which means little reactance - see Graph 4 on p10.

CONCLUSION

Nearly all the design goals I set out at the beginning have been achieved in this design. Although the KLS-14 loudspeaker has been conceived with valve amplifiers in mind, this design aims are equally suited to semiconductor amplifiers. The KLS-14 is easy to build and versatile, and will perform well with almost any amplifier in most normal environments with the minimum of fuss.

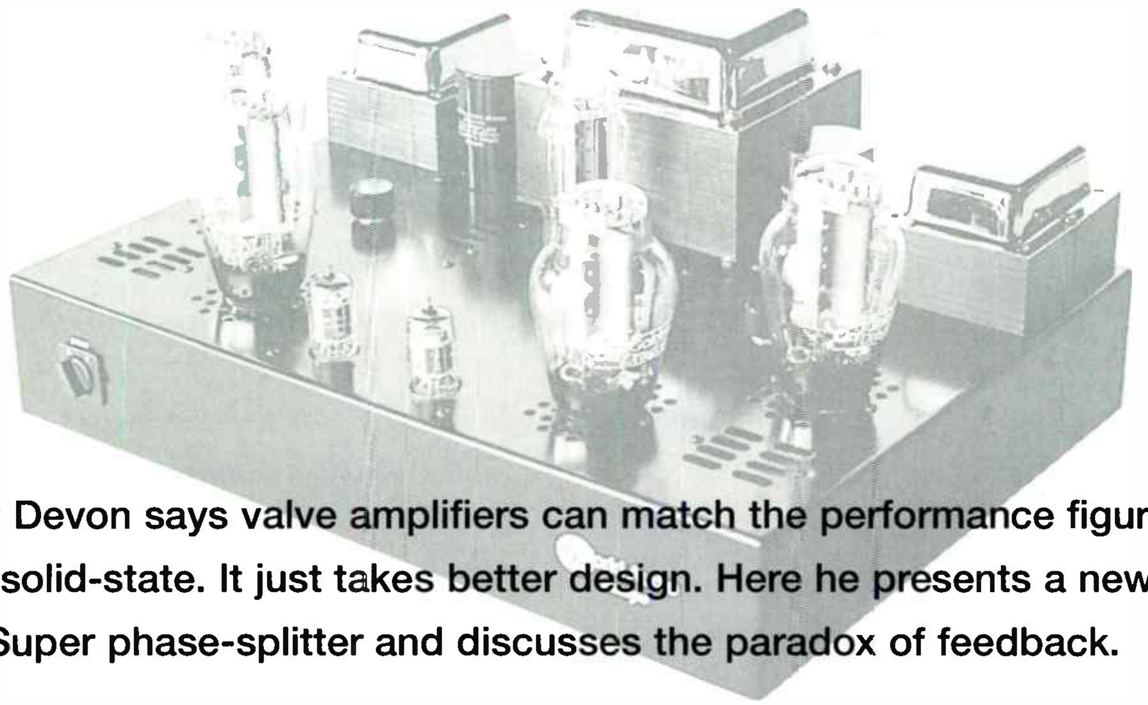
Gary Holland is a professional loudspeaker designer acting for companies worldwide.

Using industry standard techniques his work gives readers access to a professional design, as well as showing how commercial designers develop a modern loudspeaker, through theory and all-important measurement.

KLS-14 crossover components.

Bass unit	Seas CA21RE	x1
Treble unit	Vifa H26TG-35-06	x1
Wire	1mm stranded core	x1
Terminals	Bi-wire cup	x1
Wadding	Foam/long hair wool	
* All drive units/terminals to have gaskets *		
Inductors		
1mH	0.3ohms DCR, 1mm wire	x1
0.3mH	1ohm DCR air core	x1
Capacitors		
33mF	50v +-5% DF 4%	x1
8.2mF	50v +-5% DF 4%	x1
3.3mF	50v +-5% DF 4%	x1
Resistors		
10 R	10 watt	x1
6.8 R	7 watt	x2

GOING FOR BALANCE a new phase splitter



Gary Devon says valve amplifiers can match the performance figures of solid-state. It just takes better design. Here he presents a new Super phase-splitter and discusses the paradox of feedback.

In my last article (DIY Supplement No53, October 2000 issue) I outlined the valve phase splitter (or inverter) circuits in common use. These have appeared in classic circuits such as the Mullard 5-20, Williamson and so on.

It's been said that these circuits are as good as it gets for valve amplifiers. However, I have found that they have limitations. Problems arise from the fact that none of them achieve accurate balance between the two antiphase output signals. This increases even-harmonic distortion, as well as intermodulation distortion.

If the output transformer is well designed and constructed the cancellation effect of even-harmonics in a push-pull output stage functions well for the output valves alone, but not for earlier stages unless driven by a well balanced signal. Balance must be maintained over the full audio frequency range, a difficult proposition.

Most amplifiers include some degree of negative feedback. The benefit of negative feedback is diminished by the less-than-ideal performance of classic phase splitters because they limit the ability of the amplifier circuit to reject the distortion signal. One of the seeming paradoxes of negative feedback is that the amplifier requires good (theoretically it should be perfect) open-loop linearity for it to function. Therefore, any improvement to the phase splitter / drive circuitry will give a double benefit to an amplifier using loop feedback. Better open-loop linearity results in less distortion in the first place, but because the open-loop linearity is better the feedback will be more effective. The evolutionary sideline of feedback-free amplifiers avoids this paradoxical problem of course.

To achieve any particular distortion figure, less feedback will be required or, with a given amount of feedback, less distortion will be present.

Diagram 1

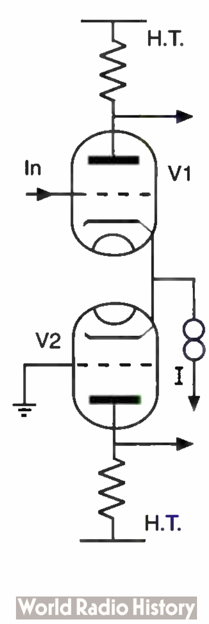


Diagram 1 - A classic long-tailed pair, which share a constant current source (I), or 'tail load'. This circuit arrangement is also used widely with transistors.

Reducing the even-harmonics changes the timbre of an amplifier. The result is a drier and crisper sound, with a more finely etched background. As the amplifier's linearity before feedback has been increased, intermodulation is also reduced so there is less background hash. This type of sound is far less "valve like", so to some it is less desirable.

I want to briefly outline methods which can be introduced to valve amplifier design where the measured performance can be made to approach or equal that of a solid-state amplifier. As with the previous phase splitter article I have included no equations as the intention is to provide reading material rather than a lesson in electronics.

The circuit toplogies I have developed are quite esoteric. I have held them close to my chest for some time. Perhaps someone else has done the same thing already, I do not know.

In the last article the long-tailed pair was introduced. Essentially there are two valves with a common cathode connection, as in Diagram 1. If the tail load is a perfect current source then any signal which is present at one anode *must* also be present 180 degrees phase shifted at the other. This is because the total current is shared by the two valves. If the current in one valve increases then it must decrease by an equal amount in the other.

This is the beginning of a perfect phase splitter. It only functions perfectly with a

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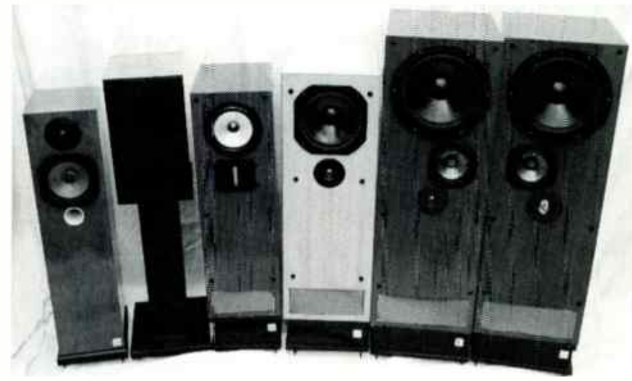

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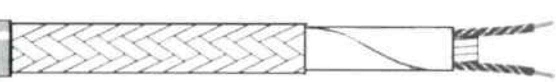

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constant current tail. This circuit also has the advantage of allowing good power supply rejection, as long as the following stages are also well balanced.

Such a stage loses a lot of gain (50% reduction) when driven by a single-ended input signal, which is the norm.

Diagram 2

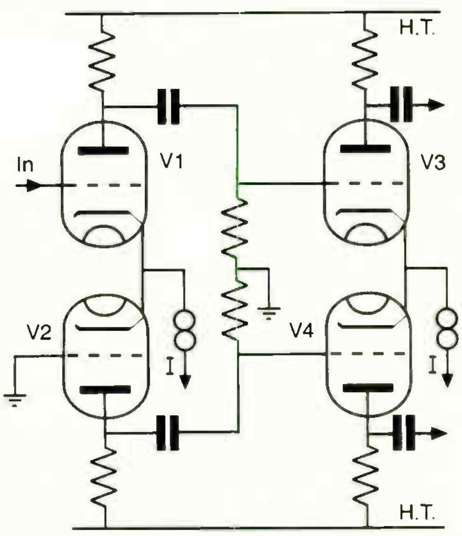


Diagram 2 - Two stages cascaded give good gain and balance, but introduce three LF time constants, limiting feedback.

What if we were to cascade two such stages to increase the gain to a point where feedback could be incorporated? See diagram 2. Now, dependant on the valves used, we will have as much gain as we would probably need. Also, any slight imbalance that appears from the first long tailed pair will be cancelled by the rejective capability of the second pair.

Diagram 3

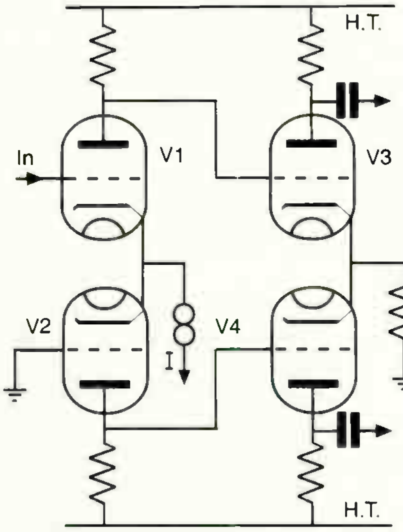


Diagram 3 - Direct coupling eliminates one time constant, allowing more feed-back to be applied.

The trouble with this arrangement is that when we apply feedback around the whole loop of a practical amplifier the low frequency stability isn't very good because we have three low frequency time constants within the loop. Firstly, the coupling capacitors from V1/V2 to V3/V4; then from V3/V4 to the output valves and finally the output transformer's finite primary inductance.

How about direct coupling the first stage to the second to eliminate one of the time constants, as in Diagram 3? It looks good on paper and now we only require a resistor as a tail load for the second pair. But we find that we have a problem when we use real world valves. Any slight difference between the anode voltages of V1/V2 is amplified by V3/V4 and the whole system has a serious DC offset. Also, we may need a seriously high anode voltage because the cathodes of the second long tailed pair are already at the potential of the first's anodes.

Somewhere between DC and AC coupling would seem to be the order of the day, as in Diagram 4. Now we are getting somewhere. We can apply a sensible DC voltage to the grids of the second long tailed pair, say 50V. Also, the coupling network allows decent low frequency stability, unlike pure AC coupling. What we have is effectively a low frequency step network. If we used two ECC83 valves in cascade the gain would be over 2000. That's quite a lot, unless triode output valves are used or we are looking at a ridiculously sensitive power amplifier. We could use lower gain valves maybe, or how about placing a local loop around our phase splitter/ drive stage, as in Diagram 5?

This circuit now has Super Balance right across the audio range and way beyond. The local feedback also reduces the effect of the low frequency step into the bargain, so bass quality is supreme. The extra resistors in the cathodes of V1/V2 help mop up any D.C. imbalance. The resistors marked Rf apply the local shunt feedback.

Overall feedback in a complete amplifier would be applied to the grid of V2 via a suitable attenuation network. An example amplifier is illustrated by diagram 6.

Diagram 4

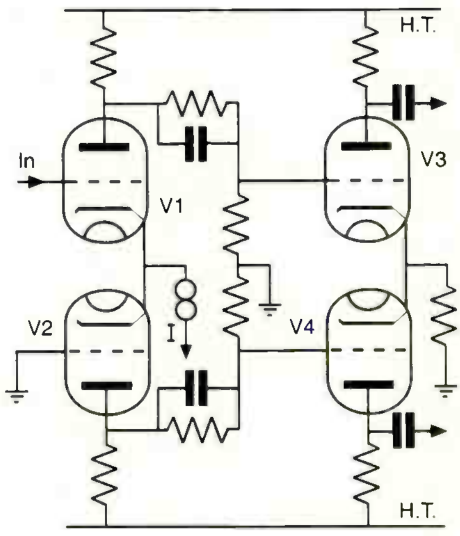


Diagram 4 - Direct coupling again, as in Diagram 3, but with resistors. Gain differences between V1 and V2 will be amplified by V3 and V4 to produce serious D.C. offset.

Diagram 5

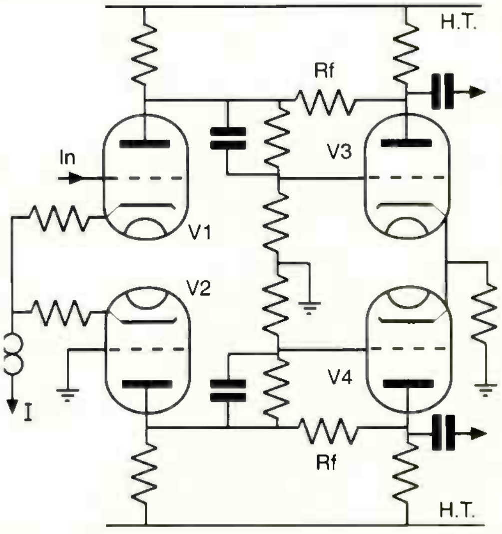
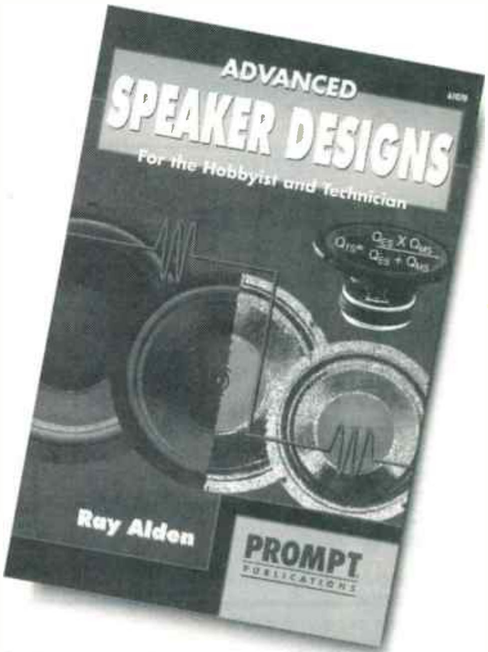


Diagram 5 - Adding local D.C. and A.C. feedback from anode of V3 and V4 back to the grids via resistors Rf gives 'Super Balance'.

ADVANCED SPEAKER DESIGNS



From the USA, author Ray Alden presents the calculations needed to design a loudspeaker. Noel Keywood gets his calculator out.

In the Preface of this book author Ray Alden tells us where's he's coming from. "After 27 years teaching maths...it was apparent there was hardly any course that applied mathematical abstractions". So "I began a one year course in 'speaker building". "Theory was taught and the 'speakers designed using mathematics". "Using scientific calculators you will be able to make quick work of complex equations". "The book will give you an intuitive feeling of how speakers work".

There's a place for this sort of book and, designing loudspeakers myself for Hi-Fi World, I quite like to have basic equations to hand. Nowadays computer programs are fast, sophisticated, relatively cheap and not prone to error. But there's always a need to sit down and plough through a few sums, all the same. Don't expect this book to answer all your loudspeaker design questions, especially if you prefer a practical approach and would rather avoid theory.

Having said all this, there is a need to know 'base theory".. In my view if you don't understand, for example, that reactive components store and return energy then you will never really understand what is going on in any loudspeaker, which is a giant collection of springs and masses, inductors and capacitors, all interacting. So a good base theory book, which this one attempts to be, is always welcome.

Ray Alden is no M.G. Scroggie. He speeds through the physics. The equations come thick and fast, with not much discussion about the mechanism they describe. To some extent this is an inevitability in a book that attempts to cover a massive subject in 124 pages. So by page 10 we've been through A.C. theory in a chapter entitled The Three Basic Components of Loudspeaker Design and by page 24 we've learnt how to obtain Thiele-Small parameters and measure the frequency response of a loudspeaker under Drivers Parameters. In truth these subjects demand books in themselves but the text here is concise enough and good as a guide.

A wry smile came to my face where Alden says "Your scientific calculator will handle exponents and logarithms very quickly. Don't be intimidated by this equation or any of the others that follow; it's just a matter of pressing the correct buttons"! You need to know how to handle the maths before pressing the buttons. The book is best for science students fluent with the not-too-complex maths involved, but keen to learn more about loudspeaker design. Which is what you would expect considering Alden's background. Its explanations of loudspeaker behaviour I would not dispute; the research appears careful. There are enough usefully concise explanations to make the book a valuable quick reference for equations and outline theory. On page 72, for example, I found a clear diagram of crossover orders and radiation phase angles.

Chapter 3 deals with "Sealed Enclosures" (infinite baffle) and Chapter 4 the much beloved Vented Enclosure, or reflex port loudspeaker. After these basic types comes a Chapter on Computer Aided Design, which concentrates solely on a programme called TOP BOX.

After a chapter on Subwoofers comes an all-important chapter on Crossovers. Again, it is concise and useful, but at 16 pages relatively short and by no means a complete guide. Crossover design is, ultimately, a juggling act, using the sort of theory provided within this book, but also measurement. KEF once adopted a rigorously mathematical approach to produce highly complex solutions, so it can be done this way, but then they started out with enormously sophisticated device models in the first place, before number crunching. I wasn't surprised to see Richard Small's name appear (p37) in this book; he worked at KEF in the 1970s, contributing substantially to this theoretical approach.

At the rear of the book there's a Chapter with seven loudspeaker build projects. It is very condensed and relies upon American Radio Shack drive units, since Advanced Speaker Designs was "Printed in the United States of America" and hails originally from Texas. As a note at the front of the book clearly states, the use of other drivers will produce different results, so the designs will be difficult to recreate by U.K. constructors.

Advanced Loudspeaker Designs fulfils a specific need, being best suited to engineering and science students, or those with a bent for maths. Nowadays computers usually take the work out of button pressing, but all the same it is useful to have a short, concise guide to the basic maths, like this one. Its concise technical explanations of how speakers work many will find valuable too I believe.

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This book is available from our World Library
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D.I.Y. LETTERS

Chris Logan from Sydney, Australia, asks about improving our Series II PHONO stage. and Gary Devon replies. Peter Moore builds and then modifies our KiT88 valve power amp..Check out his DIY web addresses.

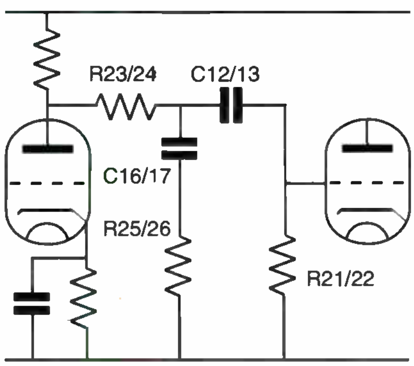
PREAMP QUERIES

It's a good idea to offer a modular pre-amp - Supplment 51, June 2000 - though I have a few queries about its design, and hopefully these are of interest to the readers.

Why the substantially larger load resistor - R29/R30 - for the second valve stage than that of the first stage, though still only a relatively small cathode resistor - R27/R28? Won't the combination result in the second stage being biassed in the non-linear portion of the valve's operation?

R6 in the power supply unit is shown as 0.1R. Would it not require a value of at least 1R there to be of any practical effect?

Apparently, a better defined bass sound can be achieved by placing the A.C. coupling capacitor differently in an RIAA circuit so there wil be less interaction bretweein it and the 3180uS time constant



section. Such placement necessitates repositioning the grid resistor also, so my alternative is above - Please publish the D.C. voltages at each of the valve's anodes and cathodes. It's most useful for builders to check to see if they have correctly assembled the kit and to ascertain if each valve is OK. Most builders will know such voltages may vary a little from the published values.

Whilst on the topic of valve circuits, are any of your contributors or readers able to sketch the basic circuit of the Loyez phase splitter? I cannot find it in the Radio Designers Handbook or elsewhere. I suspect it is a colloquial name for a well known circuit.

Thank you for your very interesting DIY Supplements.

Chris Logan,
Sydney,
Australia.

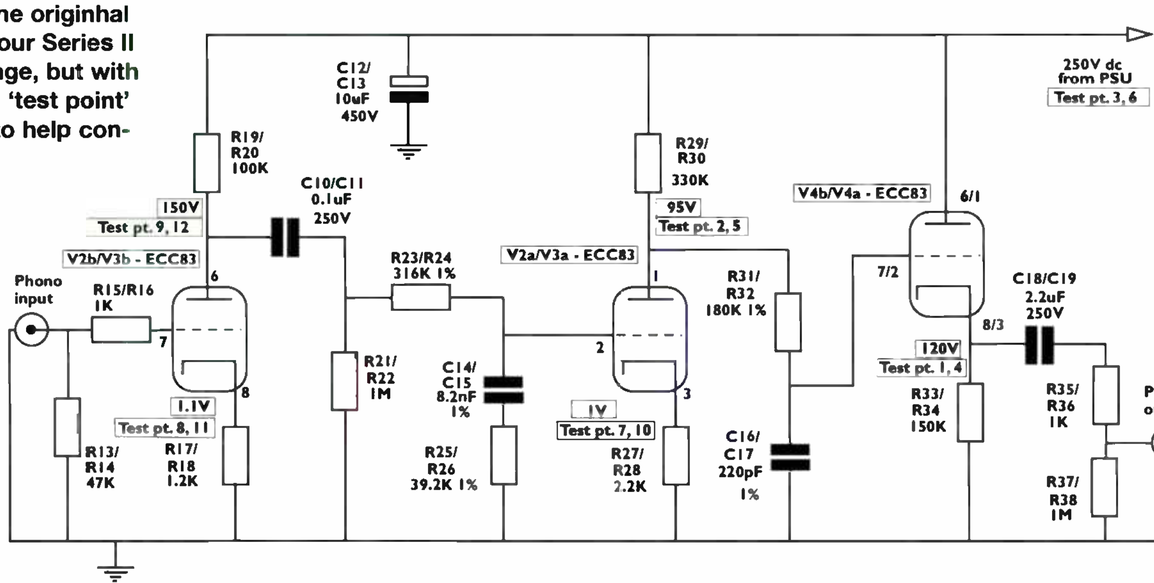
Thanks for the letter Chris, you have brought up some interesting points. As with anything there are many and varied ways of approaching an audio design. When it comes to the bottom line there are two major practical factors which must be considered.

1) The design must function as intended, and

2) all of the components used in the design must be operated within their physical limits.

There are improvements which could be made in terms of component quality and circuit sophistication, but if all of these were implemented we end up with a £10,000 super preamp which is no longer a practical proposition. A line must be drawn somewhere and in general we offer readers a

At right: the originhal circuit of our Series II Phono stage, but with additional 'test point' voltages to help constructors.



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good basic design upon which they can experiment if they so wish.

Another hidden danger of implementing 'improvements' is that unless those improvements are synergistic the final design ends up an expensive mess.

If I answer your questions one by one.

1) In the phono section the second stage operating conditions were chosen to give an anode voltage of approximately 100V. This voltage was chosen to DC bias the cathode follower, but without placing too much stress on the cathode follower heater-cathode insulation. The high load value gives a load line with a shallower slope, giving a greater, more linear swing at the lower anode voltage. Check out the operating condition on the ECC83 characteristic curves.

2) R6 is there to reduce the peak charging current into the reservoir capacitor. Only a small resistor is required as the peak currents are so high.

3) Rearranging the L.F. time constant network so that it appears before the DC blocking capacitor is a good idea in theory. The problem is that now we have the full anode voltage of the previous valve across the time constant capacitor when the unit is running, with the possibility of the full HT voltage across it when warming up. This presents problems when it comes to selecting components. A high accuracy polystyrene capacitor of 350V rating of the value required is not so readily available as the low voltage one chosen. The HF time constant before the cathode follower requires a far smaller value component which can easily be found at the required voltage. Hence the circuit being as it is.

4) We do publish voltages and there were some on the original diagram, although they were difficult to see because the diagram ended up smaller than ideal in terms of legibility. The same diagram, with larger type and additional test point info is published here.

I am not familiar with the 'Loyez' phase splitter. As you say, it could be a common type masquerading under a different guise.
Gary Devon

TWEAKING KiT88

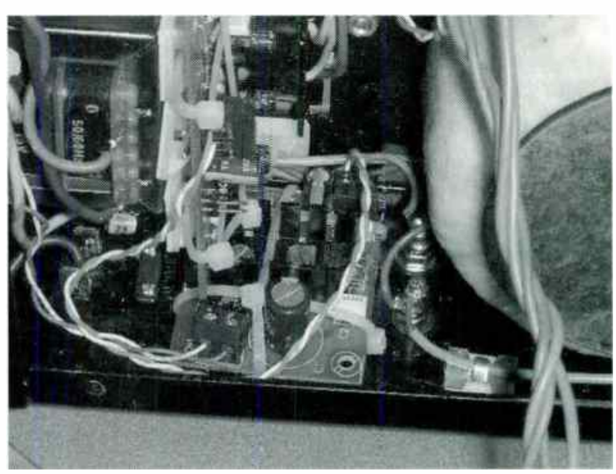
Any DIY or kit hi-fi is a haven for the tweaker. We all strive to obtain maximum performance. Let me recount my journey. I was fortunate to listen to your KiT88 prior to owning my own, something rare in DIY. I wouldn't say I was a expert in valve technology but I felt competent to build it with the safety precautions put in place by World Audio Design. I built three kits before this one.

It took me around seven hours to complete. Finally, switch on arrived and, like my previous kit amps, it worked first time. Around ten hours later it suffered an output tube failure, something that bemused me a little, since amps. built three years ago are still going strong. The WAD schematics give a 10% tolerance on voltage readings and I found I was close to these limits but not over.

A quick search on the internet proved one thing: how various valve manufacturers vary in claimed power ratings. The supplied JJ Teslas have one of the highest claimed limits. The JJs were replaced by WAD without quibble.

I also ran to my local Maplin and purchased four Chinese KT88s. When the anodes glowed cherry red these were swiftly returned too! Now I was understanding how component quality was critical for sound and reliability.

On the subject of valve configuration, many ways are available for a push-pull amplifi-



The switch on-relay board, nestling by the mains transformer. It delays switch on, allowing the heaters to warm up thoroughly before HT is applied.

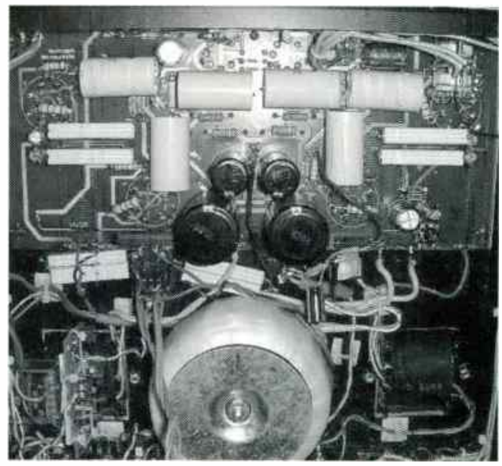
er like the KiT88. I believe the KiT88 uses a compound type bias - "a mixture of fixed and cathode bias". I have listened to both and feel that cathode bias alone offers a better overall balance and is less critical as regards valve tolerance. I removed components BR3, C4 and R5 and replaced R3 with a wire link; the four cathode resistors R13,14,15 &16 were replaced with 470Ω 11W - something near to GECs spec for their KT88.

Something I found useful was running the amp off a Variac; this helped me to measure voltages and evaluate the sound quality with less power. With the cathode resistors I noticed an increase in voltage across them as I approached full mains level so C9,10,11 &12 were replaced with 100V Black Gates - my first exotic capacitors. Now my amp was a little less powerful but, to my ears, smoother in presentation and still able to drive my Tannoy R2s to annoying levels if the urge arose.

Within the signal path I replaced the stock carbon pot with a Danish Audio stepped attenuator. I played around with the article in the December 1998 Hi-Fi World supplement on how to design a DIY stepper and had excellent results. Unfortunately, fitting this within the KiT88 was problematic so I opted to purchase the DACT with its surface mount resistors from Audiocom.

There is a wealth of exotic caps available from a few pounds to hundreds of pounds. Here I set about replacing all of the signal caps, not going for paper-in-oil at this time but 47uF 600V polyester caps from RS Components. With these I found vocals much more open and precise with lip smacking accuracy.

Moving onto configuration, I have now triode connected the KT88s, a simple process of removing grid resistors R6,12, 32 & 33 and fitting 100Ω 1W resistors between G2 & Anodes of each KT88. Keeping within GEC's recommendations the cathode resistors were replaced with 560Ω 11W.



Using Sovtek's KT88 I found a little redness in the anode although this was only on a single tube. To reduce B+ two 100Ω 17W resistors in parallel were put in line on both legs of the HT supply. I prefer the sound of valves with slightly less volts applied to them, IMO sounding warmer and less harsh.

In the pictures you will notice additional circuit boards; these offer a soft start and delay to the HT supply using two 50W 4K7 resistors bolted to the base. This drops HT until a relay triggers around thirty seconds after applying HT. Obviously, this doesn't offer extra performance to the sound but does protect the valves. Many commercial high-end amps do not have this feature.

That about wraps things up for now but I should mention some people who have given me assistance in understanding valve amps.

Thanks to following -

Nick Lucas
www.worldaudiodesign.co.uk
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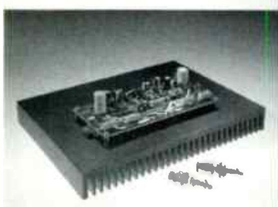

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W. Yorks. WF16 0NF
Tel. 01924 404088 Fax 01924 410069
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Golden Dragon

Precision Audio Tubes

Please enquire for any tube not listed. We have an inventory of over 2,500 different types in stock.

Golden Dragon High Quality Pre-amplifier Tubes

12AT7A/E81CC/ECC81	£ 6.95
12AU7A/E82CC/ECC82	£ 6.95
12AX7A/E83CC/ECC83	£ 6.95
12BH7A	£ 9.95
6DJ8/E88CC/ECC88	£10.95
6SN7GT/ECC33	£ 8.95

KT66R	£69.95 pr
KT88R	£69.95 pr
6550WA	£67.95 pr

Golden Dragon Triodes	Singles	Per matched pair	Per matched quad
2A3 4 pin	£22.50	£50.00	£100.00
2A3 Octal	£22.50	£50.00	£100.00
211	£28.50	£60.00	£120.00
811A	£11.50	£25.00	£50.00
845	£36.50	£75.00	£150.00
805	£36.50	£75.00	£150.00

Golden Dragon T300B Range

300B Super	£79.00	£160.00	£320.00
4.300B	£84.00	£170.00	£340.00
4.300B LX Super	£124.00	£250.00	£500.00

Golden Dragon Special Quality Pre-amplifier Tubes

E81CC-01	Gold Pins Low Microphony Low Noise		£10.50
E82CC-01	Gold Pins Low Microphony Low Noise		£10.50
E83CC-01	Gold Pins Low Microphony Low Noise	NEW	£ 9.50
E88CC-01	Gold Pins Low Microphony Low Noise		£14.50

Golden Dragon Power Tubes	Matched Pair	Matched Quad	Matched Octet
EL34 Super	£25.00	£50.00	£100.00
EL34M	£25.00	£50.00	£100.00
E84L (special quality EL84)	£12.50	£25.00	£50.00
EL156 Octal	£75.00	£150.00	£300.00
6L6WGB	£25.00	£50.00	£100.00
KT66	£25.95	£52.00	£104.00
KT66 Super	£65.00	£130.00	£300.00
KT88	£57.95	£116.00	£232.00
KT88 Special (Gold plated)	£67.95	£136.00	£272.00
KT90	£65.00	£130.00	£260.00
KT90LX	£75.00	£150.00	£300.00
350B	£29.95	£60.00	£120.00
6L6GC	£19.95	£40.00	£80.00
6550A	£42.95	£86.00	£172.00
6550A Special (Gold plated)	£64.95	£130.00	£260.00
50CA10	£84.95	£170.00	£340.00
807	£25.00	£50.00	£100.00

We have a vast range of tubes available from manufactures all over the world including rare and vintage types. an 80 page booklet of valves available is updated monthly and can be provided at a cost of £2.50 per copy U.K. £4.00/$7.00 rest of world or you may telephone our Sales Desk for a prompt quotation.

Prices exclude VAT and Carriage. Please add carriage charge of £2.50 for UK orders and VAT at 17.5%

P.M. COMPONENTS LTD, Selectron House, Jenkins Dale Industrial Estate, Chatham, Kent. ME4 5RD
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The Valve.
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Simply,
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For more information contact:
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