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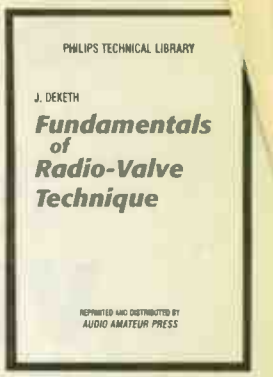
NOVEMBER 1999 No48



THIS MONTHS BOOK REVIEW:
J Deketh, Fundamentals of Radio-Valve Technique

Power House

KEL80 Monoblocs - 80Watts of pure valve power

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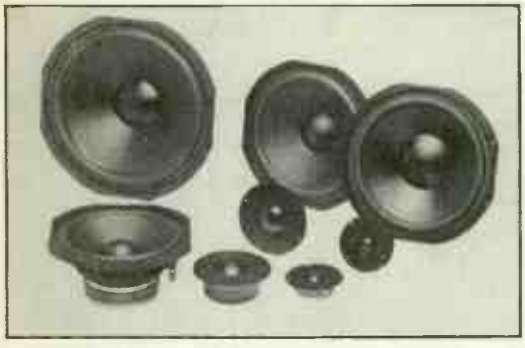

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IMEX HOUSE,
THE PARK BUSINESS CENTRE,
KILBURN PARK ROAD,
LONDON, NW6 5LF

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

Art Editor
Fredrick Dittlau
+44 (0)171 625 8032

Contributors
Jon Marks
Simon Pope
Richard White

Advertising Designer
Faiza Chunara
+44 (0)171 625 8033
Fax: +44 (0)171 328 1844

Photography
David Noble

Sales and Marketing Manager
Amanda Sweeney
+44 (0)171-328 2213

Accounts
Michael Ogazi
+44 (0)171 328 1711
Fax: +44 (0)171 328 1844

Credit Control
Louise Palfrey
+44 (0)171 328 1711

Publisher
Noel Keywood

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

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

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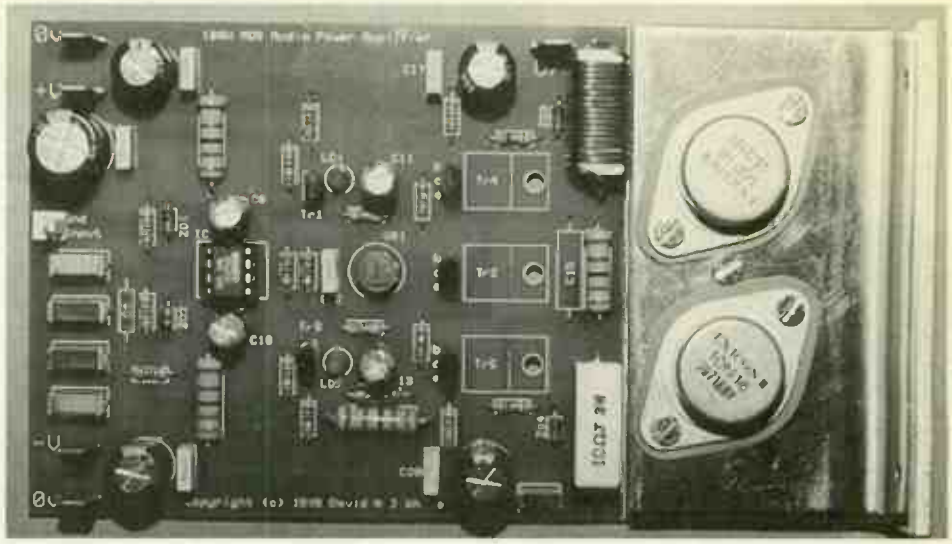
THE BIG NOISE

Daringly named kit firm White Noise have just added two new items to their expanding range of products.

Although more audio-conservative minds may boggle, White Noise's latest amplifier MOS250 is intended to produce (have a guess) 250 Watts steady-state into an 8Ω load. This solid-state power-house is available ready-made at £76.99, as a complete kit (£62.99), or else as a series of modules, or indeed simply as a PCB for you to source your own parts. Do remember that these prices apply to one channel only - you will need two for stereo.

Furthermore, White Noise's Active Power Supply kit may be just what the doctor ordered for the hum-afflicted. This device employs active filters to process the supply for a ripple-free DC output. The manufacturer claims this design is free of triangular-wave corruption. Active Power Supply kits are available in the same way as the MOS250 amplifier: ready-built and tested (£69.99), complete kit form (£54.99), plus modular or PCB form.

We hope to be looking some of White Noise's products in a future issue of Hi-Fi World's DIY Supplement. If you're unable to wait, a free catalogue is available from:



White Noise
11 Station Road
Bearsden
Glasgow
G61 4AW
Tel: 0141 942 2460

▲ They're not flying saucers, they're MOSFETs - The MOS100 Power Amplifier Module.

DRIVING FORCE

South Coast Speakers, well-known in the kit business are diversifying into the ready-made market with an interesting project: the 'Excalibur - reference'.

In contrast to most loudspeakers nowadays, the Excalibur - reference has no less than five drivers, plus a passive ABR unit. Driver details are:

1. Ribbon tweeter
2. 4.25in coated paper midrange
3. 5.25in uncoated paper midrange
4. 8in coated paper lower midrange
5. 10in doped paper driver
6. 10in doped paper passive radiator

No excuses for failing to move the air here!

South Coast say that the bass extension of the Excalibur - reference is 'to die for'; to test this for yourself in relative safety, contact:

South Coast Speakers
58 Wilton Road
Southampton, Hants.,
SO15 5SZ
Tel: 01703 703221
website: www.southcoastspeaker.co.uk

Hot stuff from Billington

Billington Export Ltd is pleased to announce that their latest Wholesale Valve Catalogue will be available in November 1999.

Also, for the adventurously curious, Billingtons also produce a catalogue of large and interesting display valves. (These items are large size, non-working items suitable for display purposes only). You can but ask!

Billington Export,
Units E1 & E2,
Gillmans Industrial Estate,
Billingshurst,
West Sussex RH14 9EZ
Tel: 01403 784961

Transform Your Kit.....

News from Audio-Links: the Scunthorpe-based company are offering a custom C Core and R Core type transformer service, individually made to order, for power supplies or mains isolation conditioners. Specimen prices are £165.70 for a 350VA model or £284 for a 530VA model. They offer a very low external field, extremely low harmonic generation and, because of its large precision core, avery high energy storage capacity betwwen cyclic peaks. In addition it acts as a huge mains filter, attenuating mains-bourne interference including r.f., h.f., and mains spikkes. Resulting in a much improved supply to equipment which is smoother, cleaner and far, far quieter.

In addition to this, Audio-Links stock the Danish Audio Connect CT1 attenuator priced £110.70. For the even more fastidious, Audio Links make their own attenuators, based on a switch by Elma of Switzerland. Contacts are hard gold plated directly onto copper contacts. Advantages claimed for these are better performance, increased choice of configuration and superior resistors (0.1% 15ppm).

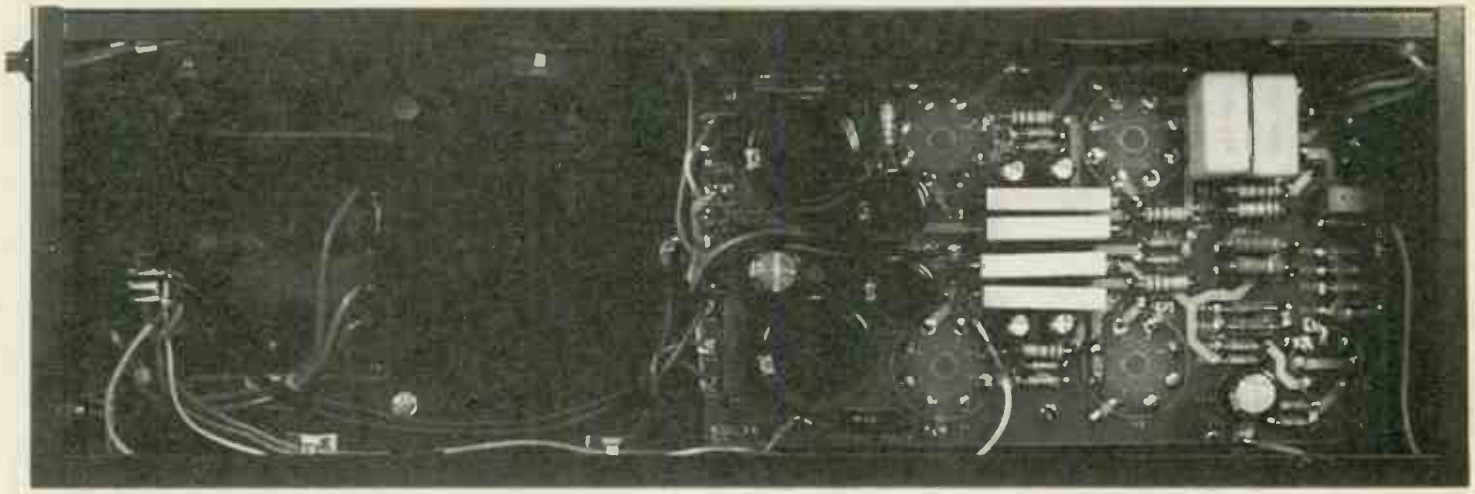
Three main options are available in mono or stereo form for Series or L Pad attenuators at present: switch (with wafers) only, complete 47 or 94 resistor kits; fully-built attenuator. Both the kits and the built versions are calculated for customer requirements, so the most useful sequence of steps can be readily customized. Audio-Links believe that they are at present alone in offering this service as standard.

The attenuators in both kit and built form are available in values: 5kΩ, 10kΩ, 20kΩ, 50kΩ, 100kΩ, 250kΩ, 500kΩ, 1MΩ.

Audio-Links
7 Fairmont Crescent
Scunthorpe
North Lincolnshire
DN16 1EL
Tel: 01724 870432

DOUBLE VISION

Nick Lucas **and** Gary Devon
pull the wraps off our latest tubular project, the KEL80 80Watt valve monoblocs.



▲ Internal view of KEL80. (Please note we will be providing BFA speaker terminals and not the XLR sockets shown here.

Following the success of our budget KEL34 40watt kit amplifier, we decided to apply the same thermionic formula to a 'bigger brother' design, and so the new KEL80 monoblocs were born. Heading up the input stage we have the wonderfully linear 6AU6 working into a 5687 phase-splitter. The output stage utilises two pairs of EL34 pentodes in parallel-push-pull mode, allowing KEL80 to turn out 80Watts into an 8ohm load, enough to drive almost any loudspeakers.

Since KEL80's output transformers have 4ohm as well as 8ohm taps, there's also the option of bridging two monoblocs. By connecting the signal inputs and the speaker outputs together in parallel, two 8ohm-tapped monoblocs will provide a full 160Watts of valve power into a 4ohm load. And with an input sensitivity at around 380mV for full output, the £590 KEL80s will happily partner both passive and active pre-amplifiers.

In keeping with our philosophy of affordability thanks to elegant circuitry, the KEL80 is a simple but highly effective design which its creator, Gary Devon, will discuss later.

TRANSFORMING KEL80.

The heart of any valve amplifier is the output transformer; cost-cutting or lack of expertise here will always show as inferior sound. To achieve a broad frequency response that will not waver even at full power, the OPT needs to be both large and carefully wound. Therefore KEL80 boasts a size 120-lamination, 2.5in. stack that weighs in at a chunky 6kgs.

Located ahead of the OPT is a 250VA toroidal mains transformer of a similar specification to that fitted to the KEL34, although this time it's encapsulated in a black can and mounted externally. Encapsulation further reduces electronic and mechanical noise on an already extremely quiet transformer.

ALL A-BOARD.

For ease of assembly, all of KEL80's parts (bar

KEL80 PARTS LIST (for 1 monoblock)

RESISTORS

POWER SUPPLY

R1	3.9K, 6W	1
R2	33K, 3W	1
R3	13K, 0.66W	1
R4	36K, 0.66W	1

SIGNAL

R5	100R, 1W	1
R6	100R, 1W	1
R7	180R, 7W	1
R8	180R, 7W	1
R9	3.3K, 0.66W	1
R10	3.3K, 0.66W	1
R11	100R, 1W	1
R12	not used	
R13	180R, 7W	1
R14	180R, 7W	1
R15	3.3K, 0.66W	1
R16	3.3K, 0.66W	1
R17	220K, 0.66W	1
R18	220K, 0.66W	1
R19	10K, 3W	1
R20a	68K, 1W	1
R20b	82K, 1W	1
R21	15K, 1W	1
R22	15K, 1W	1
R23	1M, 0.66W	1
R24	390R, 0.66W	1
R25	330R, 0.66W	1
R26	27R, 0.66W	1
R27	39K, 3W	1
R28	100R, 0.66W	1
R29	2.2K, 0.66W	1
R30	1K, 0.66W	1
R31	100K, 0.66W	1

CAPACITORS

POWER SUPPLY

C1	470uF, 450V	1
C2	470uF, 450V	1
C3	4700uF, 16V	1
C4	100uF, 63V	1
C5	100uF, 450V	1
C6	100uF, 450V	1

SIGNAL

C7	220uF, 25V	1
C8	220uF, 25V	1
C9	220uF, 25V	1
C10	220uF, 25V	1
C11	0.68uF, 630V	1
C12	0.68uF, 630V	1
C13	1uF, 250V	1
C14	470uF, 10V	1
C18	470pF, 160V	1

BRIDGE RECTIFIER

BR1	mains HT, 1200V, 1.5A	1
Semikron SKBB500C3200/2200		
BR2	bias, 200V, 2A	1
General Semiconductors 2KBP02M		
BR3	heater, 200V, 2A	1
General Semiconductors WO2G		

TRANSFORMERS

OUTPUT	E&I output transformer	1
MAINS	toroidal transformer	1

HARDWARE

Mains Switch	1
PCB fuse-holder	1
Fuse cover	1
Fuse, 1.6A, slow blow	1
Phono Socket	1
BFA speaker sockets	1
Mains Lead	1
Strain Relief	1
Feet	4
Wire (various)	
Screws (various)	
Octal PCB-mount valve base	4
B9A PCB-mount valve base	1
B7G PCB-mount valve base	1
Chassis	1

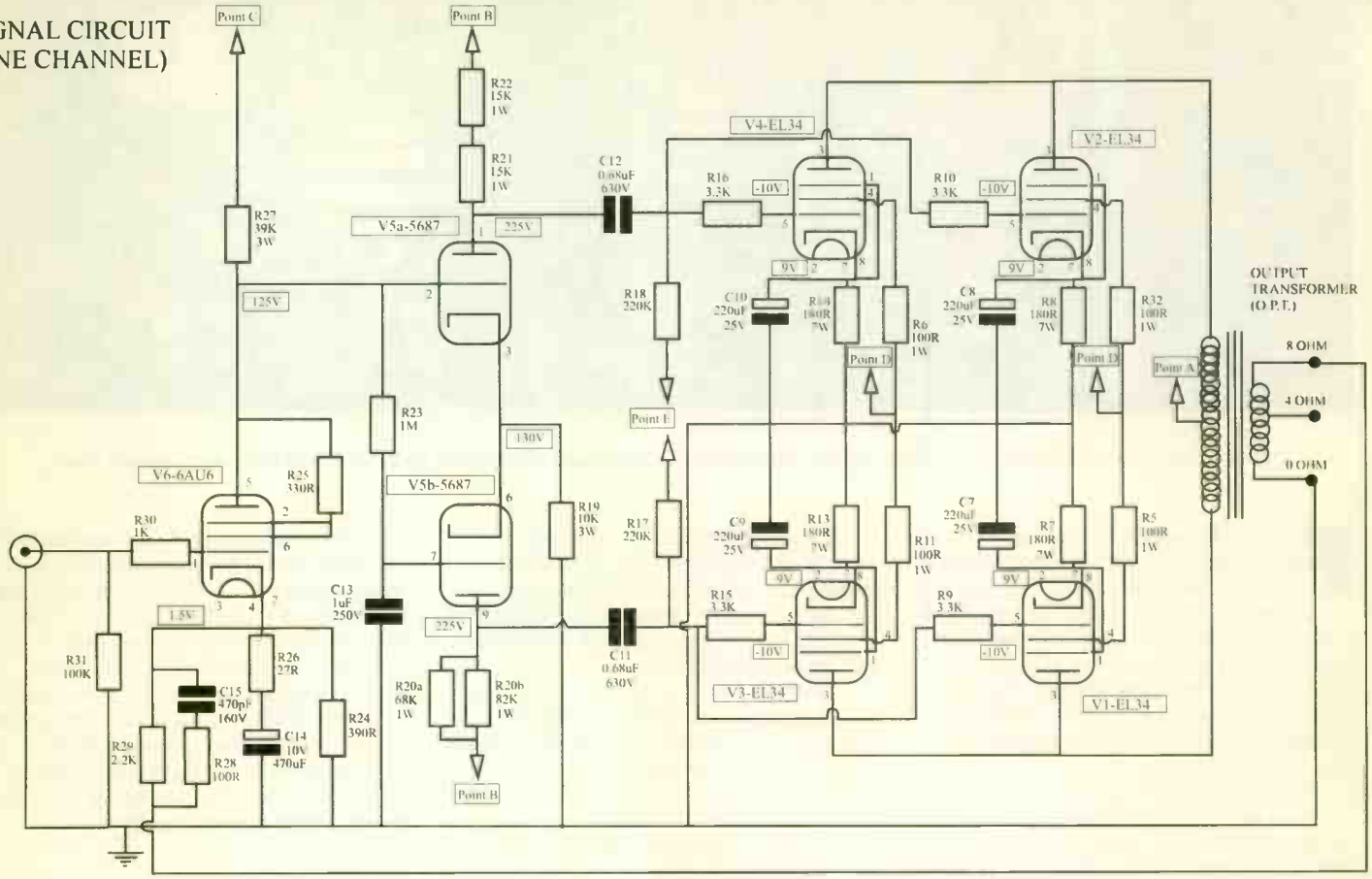
VALVES + PCB

Printed circuit board	1
Tesla EL34	4
6AU6	1
5687	1

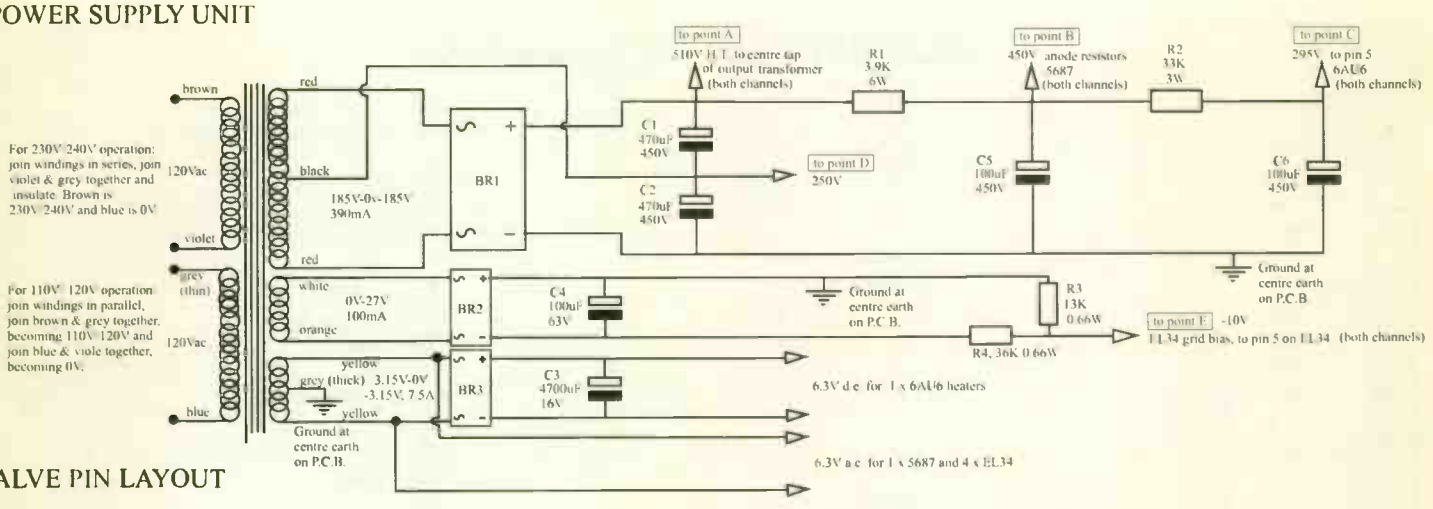
SAFETY GLOVES 1 pair

KEL 80 MONOBLOCK CIRCUIT DIAGRAM

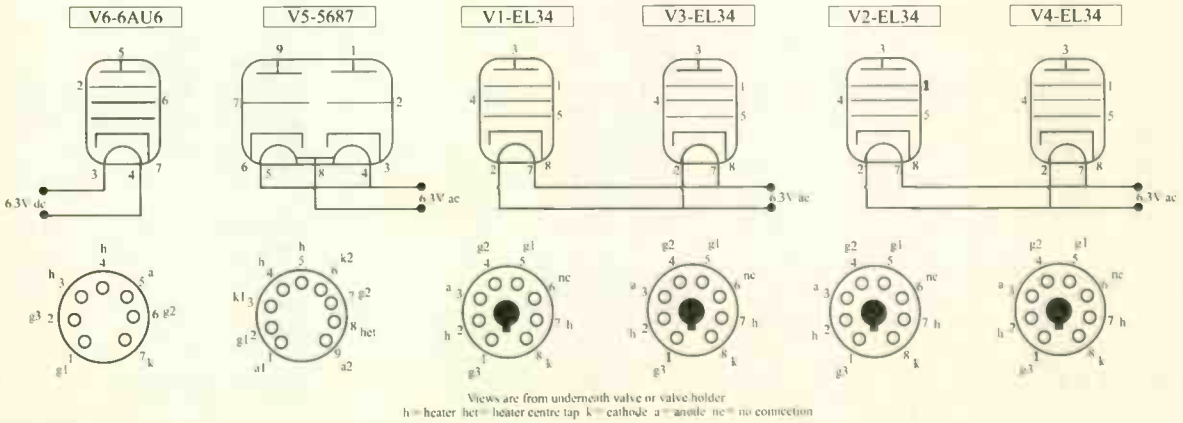
SIGNAL CIRCUIT (ONE CHANNEL)

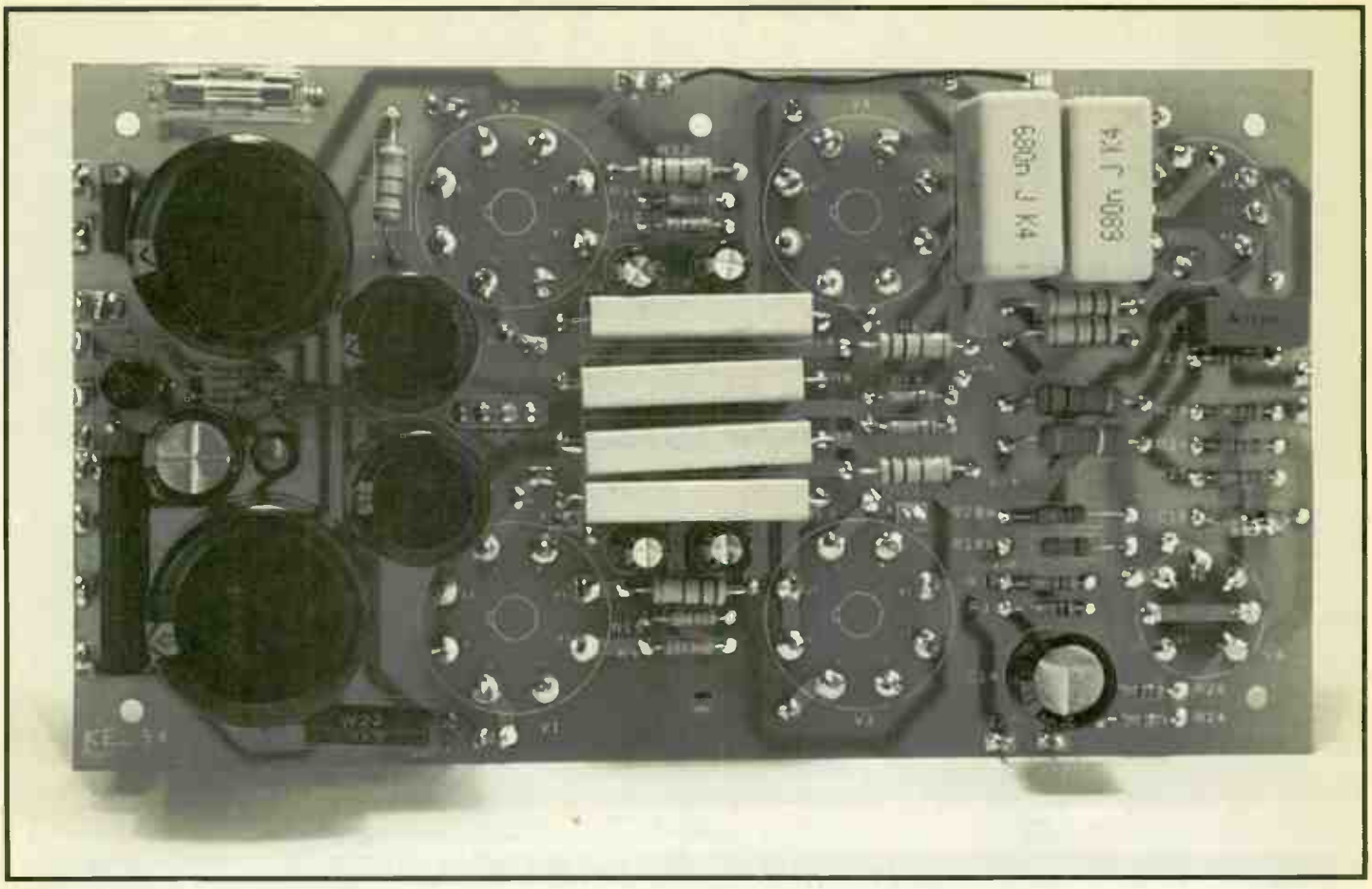


POWER SUPPLY UNIT



VALVE PIN LAYOUT





▲ Components-side view of KEL80 printed circuit board

the transformers, power switch, gold-plated BFA speaker sockets and the phono inputs) are located on a printed circuit board. This heavy-duty PCB measures 120mm by 215mm by 2.4mm thick, and is highly resistant to all those hard-core valve heads who insert their valves with sledge-hammer delicacy.

KEL80's external dimensions are 435mm(l) by 140mm(w) by 175mm(h) with the valves inserted. The chassis consists of a box and base plate in 16 swg steel beneath a black powder-coat finish topped off with white, silk-screened lettering. Robustly constructed, each monobloc weighs 12kgs.

Our valve selection includes the JJ-branded Tesla EL34, a very impressive performer with a beautiful tone and well-defined bass. The 6AU6 and 5687 are currently out of production, but never fear - there are plenty around, especially in the World Audio stores. The 6AU6s we use are of Russian origin, while the 5687s are American Sylvania types.

With the aid of the instruction booklet with its many diagrams, building KEL80 is straightforward. PCB population is 'electronics by number' thanks to the PCB tab illustration, and once the board has been completed, there are only 20 PCB-to-external connections via terminal pins. There is no need to set valve bias - all you have to do is make sure some speakers are wired up!

The high tension (HT) lines reach 500V, but don't let this scare you off. As part of the kit we provide electrical safety gloves that provide protection up to 650V. And as far as amplifier damage sustained through mis-assembly goes, rest assured that KEL80 is a rugged animal and will walk away unscathed from any short-term distress. We also provide a help-line number and e-mail address for all constructors' inquiries and, if the worst comes to the worst and you cannot get the amp running, we will sort out your problems for a nominal fee (around £50). NL

CIRCUIT DESCRIPTION.

KEL80's circuit is very similar to KEL34's in that it uses a triode-connected pentode, the venerable 6AU6, directly coupled to a common-cathode phase-splitter as its front-end. In this case, however, the phase-splitter is a 5687 double-triode, a high-transconductance, high-power, special-purpose valve from the US which features in our 300B kit too.

This valve was used to try to reduce the output impedance of the phase-splitter section as far as possible, in order to drive the input capacitance of the parallel EL34s. A cathode-follower could have been interposed between the phase-splitter and the output valves, but added complexity, including the extra power supply required, is invariably detrimental to the sound.

The 5687 is a really good-sounding valve, very powerful and somewhat dark. A 7044 will work equally well in there, giving a rather drier and brighter balance. Then there's the 'lean, mean, fighting machine' E182CC, which is very clear and strong.

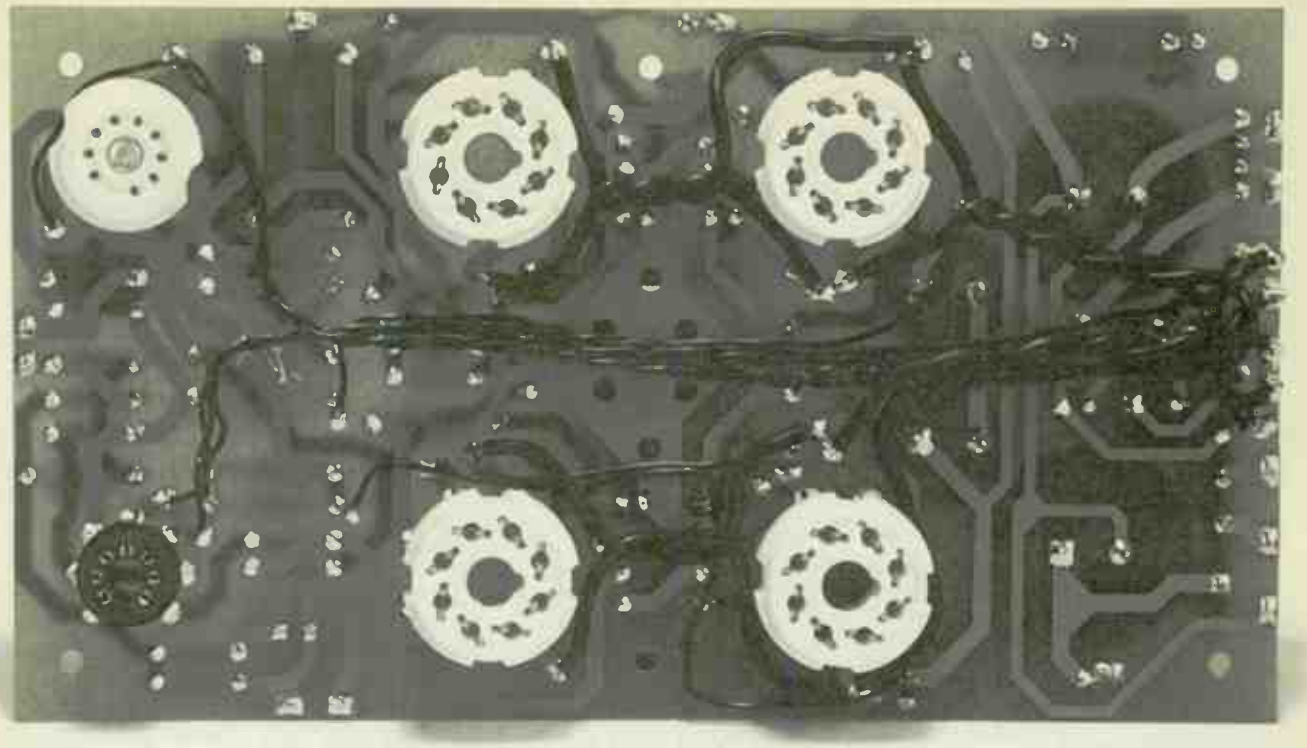
The output stage is four EL34/6CA7 valves in parallel push-pull, class AB. There is a good chunk of Class A available for regular listening levels, with the clout of 80watts available for musical peaks and annoying the neighbours.

RADIO ACTIVE.

KEL80's grid-stoppers are necessary to prevent parasitic oscillation when paralleling valves, especially high transconductance types like the EL34.

I once built an amp using two paralleled 211s in single-ended mode, and while testing the output stage using an external power supply, I found that my digital meter was going crazy whenever I tried to measure any voltages on the circuit. Worse, I noticed that the meter would read garbage if it got close to the circuit, without even being connected. Hmm, I thought, time to connect the scope. Lo and behold, I discovered massive oscillation at about 1MHz, and I mean MASSIVE - the anodes were swinging 2000V peak to peak! My meter, and even more disturbing, my body were being irradiated with high-power RF. I thought it was warm! Grid and anode-stoppers put paid to that situation though.

The feedback network is slightly different to KEL34's as it includes an extra couple of resistors to reduce the dissipation in R29, on top of a resistor to reduce the overall feedback at extreme high frequencies. The bass network is similar, with C14 increasing LF feedback. This can be modified to change the bass presentation. Small value will reduce the extension and give the bass a speedier sound, maybe for Dance, whereas a larger value would be good



▲ Valve-side view of KEL80 printed circuit board.

for organ music. However, there really aren't many speakers around which can take 80watts of power at sub-50Hz frequencies without flapping and making sounds like the morning after seven pints of Guinness and a curry (if you're unfortunate enough to know what I mean!)

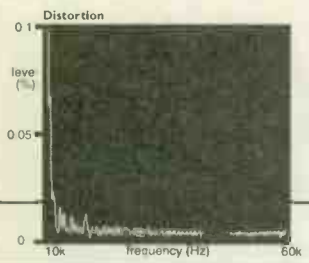
The power supply is all very down to earth, with the half-HT voltage feed to the screen grids of the EL34s. A regular capacitor-input filter with a solid-state bridge is used for rectification. Have fun! GD

Please note!

Please note that KEL80 Part 2 details what you get in the kit. The KEL80 kit is supplied in the same way as our best-selling KEL34 with 33 individually labelled and a clear instruction manual.

Measured Performance

Power output		78 Watts
Input Sensitivity		400mV
Frequency response		24Hz - 96kHz
Noise		-110dB
Distortion:		
	1 Watt	Full output
1kHz	0.012%	0.36%
10kHz	0.1%	1.2%



Listening Test

Just as we'd hoped, KEL80, our latest venture into monobloc valve technology, manages to combine tube refinement and brute power in a tasty two-box package Opening with some Classical pyrotechnics, I treated the amps to Verdi's *Overture* from *Nabucco*, played by the Philharmonia orchestra under Riccardo Muti Muti obviously couldn't wait to get home for his tea during this session, and the result is a blisteringly exciting performance. The KEL80s brought out the depth of the orchestration as only valve amplification can, crisp, solid bass and lightning-fast transients coupled with an addictive smoothness to percussion and violins. Emphasising musicality as well as power, woodwind phrasing and string vibrato were clearly audible. If you happen to prefer Rock or Dance music, fear not. Swapping from passive pre-amp to active, I resorted to **Pearl Jam** and the **Prodigy** to get the floor shaking. *Dissident* floated through the Magneplanars with real authority and cohesion, the KEL80s projecting this track clearly and powerfully so that it filled the room. The Prodigy's bass-fuelled repertoire can sound either awesome or awful, depending on the equipment used. It takes an amp with genuine control and grunt to bring out the full bass potential of *Mindfields*, and the KEL80s were well up to the job. They succeeded in reproducing that rare bass 'bounce' that is rarely found in valve gear and almost never in solid-state. **SP**

KEL80 monobloc amplifiers are available as a kit from Hi-Fi World:

	UK (inc. vat & p&p)	Overseas (exc. vat & p&p)
KEL80 - K240/120: (with valves) (2 off)	£590.00	£500.00
KEL80 - K240/120: (without valves) (2 off)	£520.00	£445.00

Call or fax Nick Lucas on: +44 (0)171 625 8032 (9am-5pm, Monday-Friday)
wad@hi-fiworld.co.uk

For overseas freight charges, please call, fax or e-mail.

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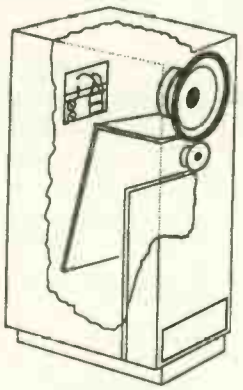
TOTAL KIT £506.00

FIVE TRANSMISSION LINE KITS



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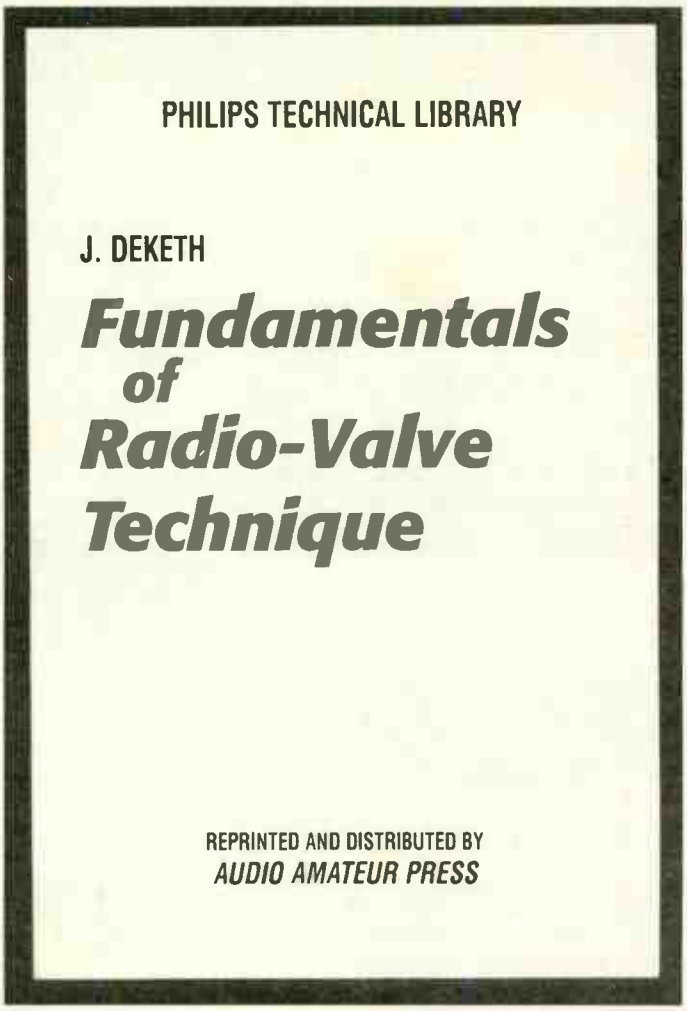
Fundamentals Of Radio-Valve Technique

By J. Deketh

Fundamentals Of Radio-Valve Technique by J. Deketh, a Philips Technical Library book, was originally published in 1949 by Philips of Holland, then one of the primary valve manufacturers in Europe. This reprint is by Audio Amateur Press and forms part of their extensive re-issue catalogue.

The book contains an in-depth examination of valve theory, manufacture and application, especially in radio circuits. It comprises 33 chapters organised in a logical manner progressing from essential principles to final applications, plus appendices. Chapters one to five introduce and develop the theory of electron emission and the behaviour of electrons in a vacuum. These chapters are short, snappy and very informative. I've not seen such a concise description of the fundamentals of emission from oxide-coated cathodes before, a very complex electrochemical process. Here the reader can assimilate the essentials without having to plough through acres of complex maths and technoblurb. Other interesting topics are the space charge which surrounds the cathode, and secondary emission.



THE NEXT FOUR chapters bring these fundamentals together in an explanation of the internals of the valve and how they are constructed during manufacture. Deketh goes step by step through the various procedures, backing up the text with plentiful pictures of strange machinery drawing glass and ladies hand-assembling valves. Chapters nine, 10 and 11 are equally concise in their coverage of the very basic concept and operation of a radio receiver, conventions in representing valves in circuit diagrams, and the nomenclature of the various types: diode, triode, etc. From here on in the author starts dealing with the 'meaty' bits, the more 'electrical' side of the valve. Transfer characteristics, amplification factor and transconductance are introduced, along with the behaviour of the various grids in the electron stream. Naturally the working of the valve under AC conditions is next on the agenda, with its internal capacities under the spotlight. Knowledge of how these arise and how they interact is vital for successful radio design, and they have a major impact at audio frequencies too. Chapters 15 and 16 will be of great interest to valve amp builders in the discussions of distortion and how it stems from the curvature of a valve's characteristic. These parts of the book are quite mathematical, although they shouldn't be beyond the understanding of someone with a good fundamental grasp of maths. The method of calculating the distortion which is going to be produced by a valve from its loadline is a very useful tool since it allows you to decide on a suitable load condition.

This idea is taken even further in the second of these two chapters, which goes into detail on the use of exponential series to represent the valve's geometric curvature in an algebraic form. The book's bias towards radio receivers means time is also spent going over modulation and intermodulation by the valve's curvature. In line with the logical layout of the sections, the power stage of the radio set comes under scrutiny next. This chapter is very good but it does get a bit too theoretical. The various modes of operation such as single-ended, push-pull, Class A and Class B are investigated in both triode and pentode form, albeit in an algebraic rather than a graphical manner.

CHAPTERS 18 and 19 explain the basics of rectification, the former with the rectification (detection) of a radio signal in a receiver. When the rectification theme progresses to power rectification, the treatment is again quite theoretical in nature, but towards the end of the chapter there are some great rules of thumb. The next four chapters are mainly of interest to radio enthusiasts, and cover oscillators, frequency conversion, gain control and automatic volume control in radio sets.

Next we come to a chapter on the noise generated by valves. This section involves some maths but, once more, you need to know this stuff when designing pre-amps. It opens by introducing the actual processes inside the valve which cause noise, and closes by providing some formulae with which to calculate it. Chapters 25 and 26 are dedicated to the short-wave properties of valves and tuning indicators, leaving chapter 27 to handle negative feedback. The coverage is necessarily mathematical, but the analyses are straightforward because only the general concepts are covered. The text explains why feedback is used - to reduce distortion of various forms - and the various forms it can take, as well as how it may be practically implemented. However, stability is only mentioned in the last section of the chapter, and isn't treated in depth.

THE FOLLOWING two chapters discuss the terrible twins of valve amplifiers, hum and microphony, and where and how these arise. The knowledge gained here will go a long way towards understanding and then eliminating them. Next is a couple of chapters which I believe are unique in a book of this sort. They examine the ageing effects which occur in a valve over its lifetime and the impact of secondary emission on valve performance. As Philips were such a vast valve manufacturer, they amassed a wealth of knowledge on these subjects. The penultimate chapter considers all sorts of power supplies for radio sets: batteries, AC/DC, and even in-car. There are no real high-power audio power amplifier supplies due to the fact that this book is primarily aimed at the table radio designer. The final chapter is just a few pages on receiver sensitivity.

The appendices are very comprehensive, with all kinds of information on resonant circuits, filters, skin-effect and so on. Overall this book is a 'must-have' for both the amplifier-builder and the valve radio enthusiast. It's quite technical, but a reference text like this has to be. Deketh was (or is!) obviously an expert engineer with an enormous amount of experience under his belt. This is apparent from the easy way in which he explains the various techniques discussed in the book and the intuitive way in which they are organised. GD

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Heater floatation

I've really enjoyed your magazine over the last few years, especially the articles on classic equipment. I have a particular interest in valve gear and the Quad ESL57 electrostatics, and appreciate the range of material you have provided and the levels of interest you have created - except for the consequent rise in ESL57 prices! These interests have led to the following notes and queries, initially spurred by a comment in one of Gary Devon's replies in the DIY letters section of the July issue. He noted that the performance of ECC82 Shunt-Regulated Push-Pull stages can deteriorate badly due to the heater/cathode insulation of the upper valve degrading. However, for some reason ECC83s and 6SL7s seem to be OK.

One of the problems with SRPP stages is that the cathode of the upper triode is at a large potential above earth, whilst the heater power supplies are usually earthed on one side or the other. This leads to a significant heater-to-cathode voltage. The manufacturer's specification typically sets a limit of about 180V maximum cathode-to-heater voltage for both the ECC82 and ECC83, with the cathode positive with respect to the heater (the limit is lower if the polarity is reversed). I suspect this factor is behind the deterioration, and that the reason the ECC83 and 6SL7 fare better is that they are higher impedance, lower current valves.

This hypothesis gets some support from the fact that the high-spec equivalents, the E82CC and E83CC, have different detailed specifications, with the maximum potential difference between heater and cathode of the E82CC being restricted to 100V. Jones (1995, below) has indicated that the main damage mechanism is bombardment by stray, positively-charged ions. The energy of such collisions, and thus the damage, will be increased for surfaces at greater negative potentials. Whilst on this subject, it is interesting to note that lesser voltages have been invoked in discussion of heater deterioration. There's the hypothesis that the use of DC for heaters leads to deterioration through the heater insulation 'creeping' under the influence of the roughly 6V potential across the length of the filament! Personally, I prefer DC, and real fanatics can always reverse the polarity from time to time.

As an important aside on DC voltage regulation, it is essential not to turn on the voltage too fast (high-current capability AC sources can also be hard on heaters). I chose an RC time constant of a few seconds for the heater voltage to come up to 6.1VDC. See also Jones (1995) on the topic of "cathode poisoning". The solution to the SRPP cathode deterioration problem is relatively simple, and involves floating the filament power supply for the SRPP valves at about 150V positive to earth. This should not stress the insulation on the heater transformer winding too much. The practice will improve conditions for the upper stages of any stacked-valve circuit, or a single-valve stage with high cathode impedance, such as the cathode-follower or concertina phase-splitter. I have put this into practice using a simple voltage-divider from the HT rail, guided by the suggestion that, for most configurations, no more than 150k should be used in the cathode circuit. For example, for three such stages on a 400V rail, a 50kohm to 83kohm divider (133k total, which runs at about 3mA and wastes only 1.2watts) should satisfy all requirements. I have successfully employed this method of supply with ECC83s (in cascode, cathode-follower and concertina phase-splitter topologies) and with the even lower voltage ECC88 (in cascode and cathode-follower), all from a regulated 410V rail. It sounds great and so far there are no valve problems after several years, so I hope it works for you too.

Richard Barton
rh.barton@btinternet.com

Reference:
Jones, Morgan (1995): "Valve Amplifiers", pp142-145
Available from the World Library

Thank you very much for your letter Dr Barton.

The ECC82 and ECC83 are very similar valves. They form part of a series which, if memory serves, was designed in the Fifties for widespread, low-cost commercial service in TVs, radios and audio equipment. They share identical anodes and cathodes, with the only differences cropping up in the grids. Of course, I could be wrong and the two types could have different cathodes, but the heater ratings are the same, suggesting that my brain hasn't totally given up the ghost yet.

It could be that the ECC83 is just as problematic as the ECC82. I've been lucky with the original Mullards I've used, but friends and colleagues agree that it mutates into a noisy, microphonic little so and so when used in SRPP or as a cathode-follower. The majority of the ECC83s I've tried recently have been the Russian-sourced items which obviously have good heater-to-cathode insulation as I've never had any real noise problems with them as SRPP front-ends or phase-splitters, even in

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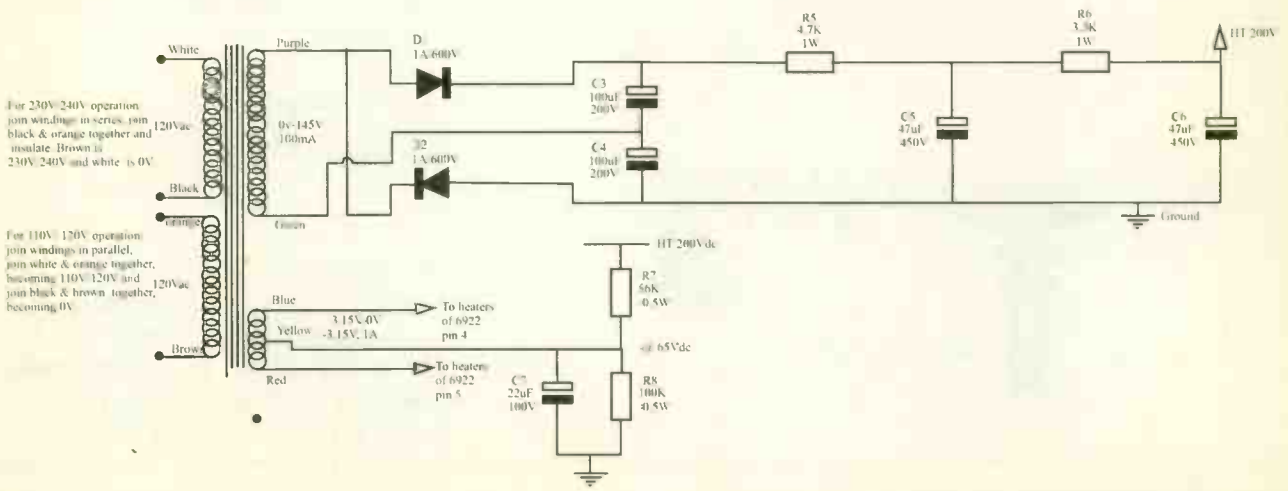

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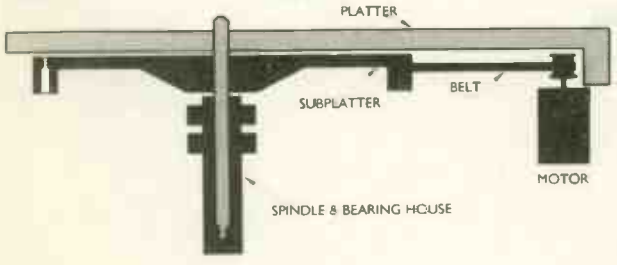

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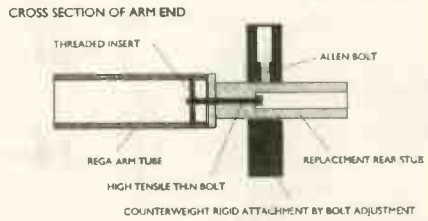

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Eventually all valves become noisy to a greater or lesser extent when they have a heater-to-cathode voltage present. A friend of mine, a well-known keyboard player, uses a modified Hammond organ as part of his set-up. The power stage has been removed and the output taken to a slave power amp from what used to be the phase-splitter. The 12BH7 employed there is always becoming noisy. The problem didn't show up when the output valves were driven from this point because of the higher signal level.

Heater-to-cathode degradation in indirectly-heated valves is caused by migration of metal from the cathode, and especially the heater, into the alumina insulation between the heater wire and the cathode. This reduces the insulating properties of the material in an erratic way. In fact, alumina is used in chemistry for chromatography, which relies on a similar effect - that different materials permeate into it at different rates, enabling their separation. This migration mechanism occurs over the life of the valve. If there is no potential between the heater and cathode, then not much usually happens apart from an increase in hum over time if AC heaters are used. But if there is a potential present, the result is popping and rustling noises. If you are only using the valve as a power amplifier phase-splitter, you're unlikely ever to notice. Believe me, it's a real pain at the input of a phono stage though!

The maximum recommended heater-to-cathode voltage exists not only for pure breakdown reasons, but more because of the fact that a DC potential across the heater-to-cathode insulation causes an electrolytic action which greatly exacerbates the migration of metal into the alumina. Mil Spec or similar specification valves have tighter ratings than their commercial equivalents because they have to be ultra-reliable. For example, the 5961,

5962, and 5963 valves were designed for applications such as servos at nuclear missile silos. A failure there could be a little embarrassing to say the least! To ensure extreme reliability, the heater voltage, heater-to-cathode voltage and anode power dissipation have to be tightly controlled. A more relaxed specification is permissible for commercial valves because failure wouldn't be so catastrophic. Using DC for indirectly-heated valves should cause no problems with heater-to-cathode insulation. On the other hand, difficulties can occur with directly-heated versions, especially those with dull emitters like the 300B, which have an oxide-coated filament. Indirectly-heated valves were developed to overcome the problem of not having the theoretical ideal of a uniform electrical potential over the emissive surface of the cathode. Various attempts were made at "unipotential cathode" valves, culminating in the type we know today, which has a heater wire inside a metal tube covered with an insulating aluminium oxide coating. The chemistry of the coating is very complex, and it partly relies on the electric potential from the anode for its operation.

The potential across the oxide layer reduces a small amount of the barium oxide to metallic barium. This permeates to the surface of the cathode to form a very thin, possibly monomolecular layer, and it is here that the electrons are emitted. With a directly-heated valve, the heater voltage can interfere with this effect. AC heaters allow an even coating of metallic barium to form over the surface of the filament. If DC is used, the coating will be uneven, lessening the maximum emissivity and shortening the life of the valve. However, there are many other mechanisms at play when it comes to valve life, and using DC is normally OK. Ion bombardment is not an issue for valves running anode voltages lower than 800V to 1000V because first, the vacuum should be very good, and second, any ions present cannot reach a high enough velocity to cause damage. In high-voltage, high-power transmitter valves, the anode dissipation is very high, so the vacuum will be worsened by emission of gas from the anode. On top of this, the high voltage accelerates the ionised gas to a sufficient velocity to destroy an oxide-coated cathode. This is why very large, high-voltage valves use a thoriated-tungsten or pure-tungsten bright emitter cathode, which is much less sensitive to damage but less efficient. When operating very high power transmitter valves, the heater voltage is reduced after the valve has run up in order to keep the cathode at the correct temperature. The bombardment effect imparts so much energy to the cathode that it causes it to heat up. The thermal shock to a heater wire when first turned on can be quite severe, causing it to fatigue and break, so some sort of slow warm-up device can be a good idea. The best is a PTC thermistor surge suppresser.

Cathode poisoning occurs when the oxide coating becomes contaminated and the metallic barium is either not produced or, when it is produced, it reacts with the contaminant. As I stated, the production of metallic barium relies on the anode voltage. For this reason, when there is no anode voltage present, or where the valve is reverse-biased into a cut-off condition, the cathode can lose its emissivity. Some valves, which were designed for computers, have a special cathode which can survive for long periods in a cut-off state. The E182CC is an example of such a valve.

Raising the heater supply to a positive voltage can help with heater-to-cathode breakdown when the cathode is also at a positive voltage, but watch out for the other valves on the same heater supply. If their cathodes are at an "earthy" potential, you can damage their cathodes while trying to rescue the others. GD

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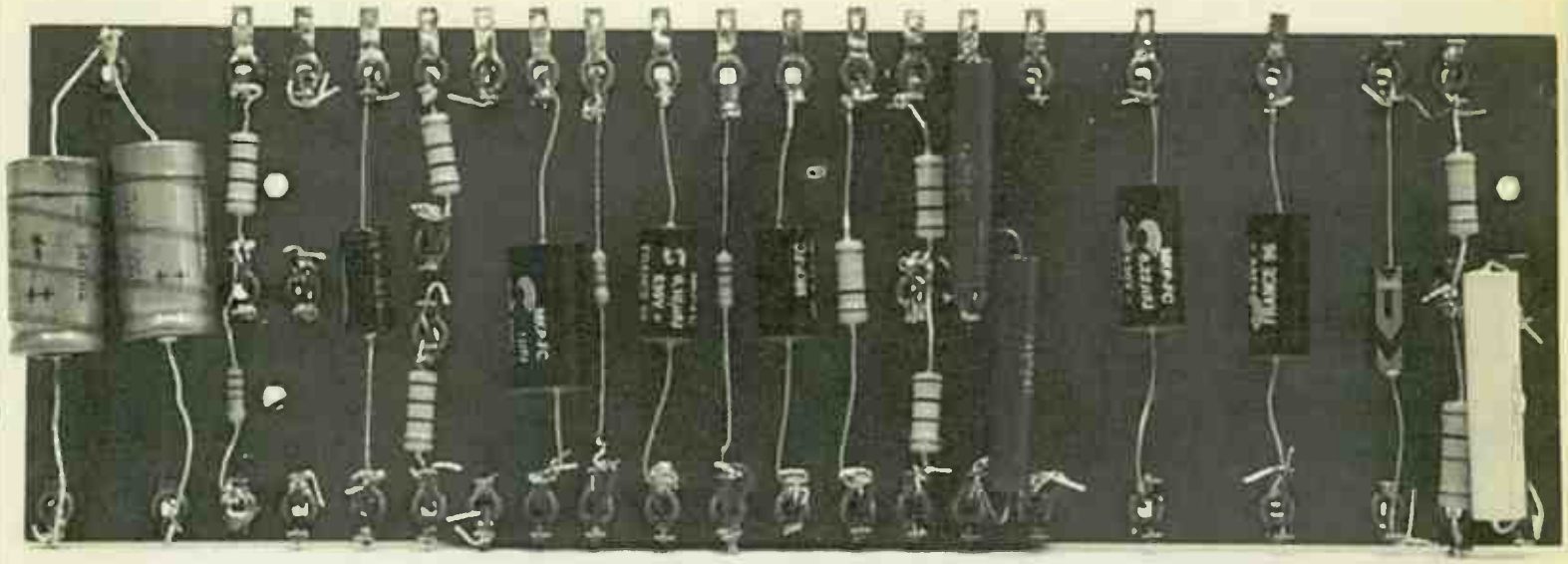


▲ Component-side view of TL12+ tag board (not fully completed).

Leak TL12+ rebuild

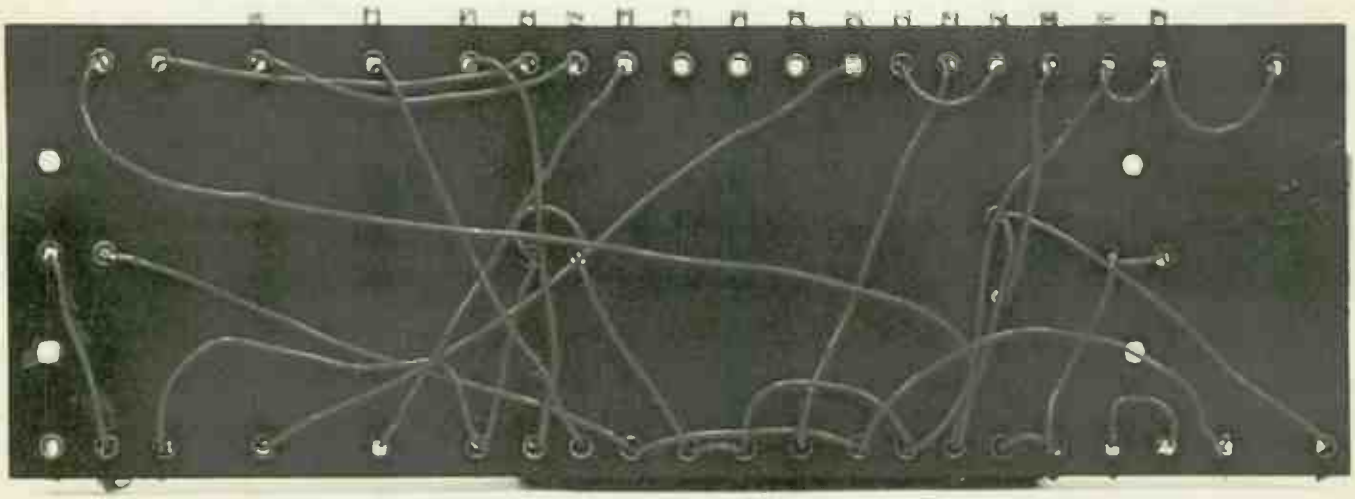
Dear Hi-Fi World, I am about to embark upon a rebuild of a pair of Leak TL12+'s and before I begin I would like some advice, knowing that there are a few valve heads bouncing around within the walls of Hi-Fi World Towers. Upon inspection of my newly aquired TL12+s I was amazed by the neatness of the hard wiring, so much so, it seems a shame to disturb them. But as neither amp works, something must be done. The previous owner said there were a few dry joints, he had managed to fix them a couple of times but had never reached a permanent solution, hence why I have them in my possession and he has a 150.00GBP of my hard earned cash. Anyway, my question is this, do I do as he has done and locate the dry joints and clear them up or do I go all out and do a major overhaul? Also, is it a good idea to change the components as well as they look a bit worst for wear? If so which do I use. To give you an idea of my capabilities, I built one of your marvellous K5881 push-pull amplifiers, just after it was released, for a friend of mine. I await your response eagerly.

Mr Douglas

I eagerly volunteered to answer this one as I was in a similar situation a month or so ago when I picked up a pair of TL12+s at a car boot sale, I will not tell you the price I paid for them; the guy who was selling them thought he was selling a pair of antiquated Christmas lights. They were not in good condition!

To answer your questions. Your Leak TL12+s are pushing 40 years old, and most consumer electronics nowadays have a lifetime of 10 years at the most. So your Leaks have done jolly well to get this far! Obviously, component quality has come on in leaps and bounds since then, with components now being specifically made for audio use rather than 'radio'. Obviously the original components are looking to be retired.

There is an argument that the Leak TL12+, or indeed any vintage gear, must have original type components. I feel that your Leak will not be much of a Leak when its components start failing! In this age of tweakers, modern audiophile components are numerous, well-documented and reliable. One component that I do rate from the original Leak TL12+ is the metallised paper signal capacitors; a similar type can

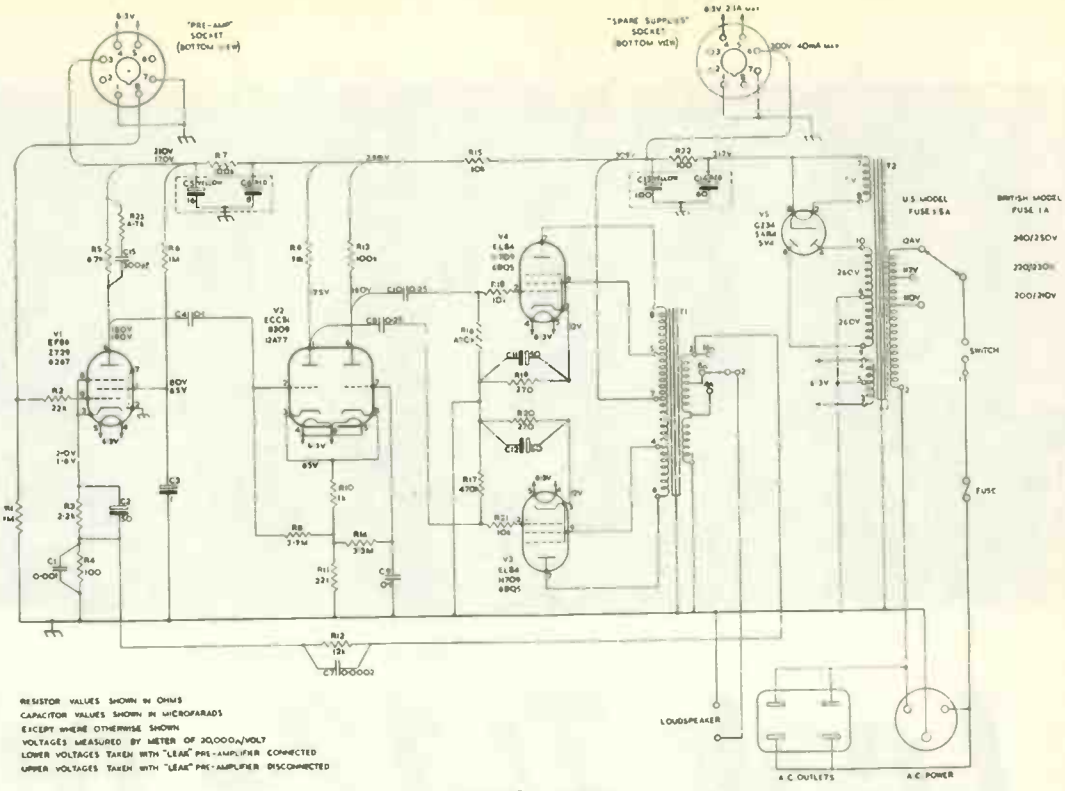


▲ Under-side view of TL12+ tag board (rewired).

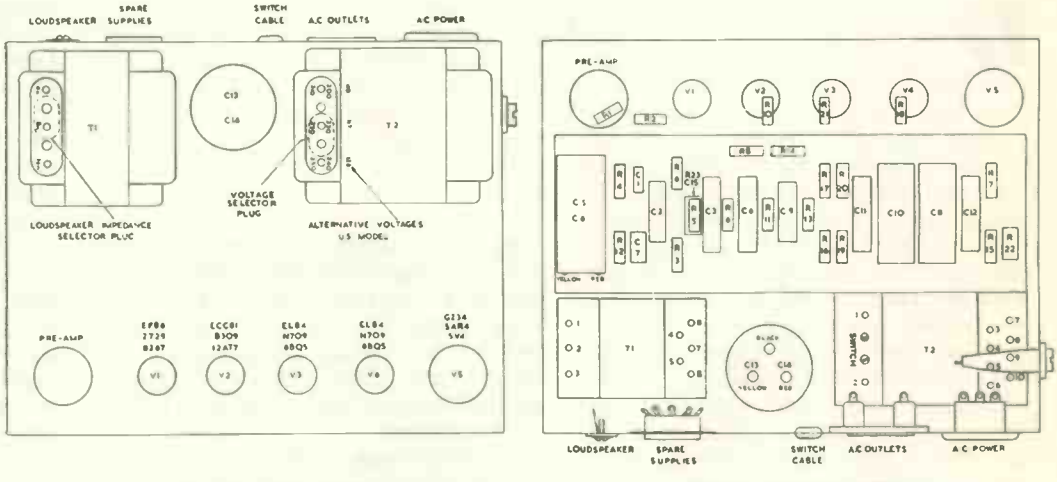
be purchased from Audionote. You can probably tell that I went for the major overall route. Not only a full component change but a rewire and a total valve socket change as well.

Component selection was based on a low-to-medium budget: I went for Solens Polypropylene for the signal capacitors and standard RS electrolytic capacitors for the smoothing caps. N.B Do not be tempted to overdo the capacitance here e.g. do not using a 200uF 450V instead of a 16uF 450V (C5) as you may give both the rectifier valve and the power transformer a very hard time. Similarly, don't overdo the values of the decoupling caps; this can cause the dreaded 'motor-boating' under unfavourable circumstances. For the remaining caps I used polystyrene capacitors for tonal clarity. For the resistors I have used carbon films - a proven winner for valve amps. Metal film resistors do have a tendency to give the sound a slight treble lift. For the wire I stuck to 1/0.6 silver plated copper wire for all low current connections and standard multistrand for heater wiring and speaker output connections. For the valve sockets I used chassis-mount octals from Billington, McMurdo, Part No. SOC 83 (these are of a brown colour not black) and the chassis mount B9A, part No. 9SOC9PMTD. These are close to the originals and fit the pre-drilled chassis snugly. Please note that Leak used self tapping screws for mounting the hardware. Preferring nuts & bolts, I increased the hole sizes slightly with a drill and bit. All the other hardware I kept original.

I tackled the rebuild by removing one of the tag boards, cutting all the connections at the board and using this as a template to rebuild the other. When cleaning up the board it is important to have good ventilation as the old solder has a funny smell and is not good for you! Also, tread carefully as the tabs on the board are very fragile. Leaving one amplifier with its wiring intact while I rebuilt the other was very helpful - it is imperative that you copy the wiring method particularly potentially confusing bits such as output transformer tag layout. Once you have one amplifier fired up and it is operating correctly, then's the time to start the rebuild of the other. The whole job took 25hrs, but as always, time and trouble taken here will give rich rewards in the long run.



CIRCUIT DIAGRAM



TOP CHASSIS VIEW

UNDER CHASSIS VIEW

▲ TL12+ circuit diagram and chassis layout.

For a copy of the TL12+ circuit and many other old Leak designs, write to L & W Services, 9 The Parade, Bramhope, Leeds, LS16 9AF, stating which diagram you need and enclosing GBP 4.00 per copy.

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