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FEBRUARY 2000 No49

THIS MONTH'S BOOK REVIEW:
Bruce Rozenblit
Audio Reality

PLUS:
KEL80 PART II

TOP OF THE CLASS

KiT88 36Watt Class A Valve Integrated Amplifier Kit

Golden Dragon

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KT66 Super	£65.00	£130.00	£300.00
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KT88 Special (Gold plated)	£67.95	£136.00	£272.00
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HARMONY IN A TUBE

New-York-based valve suppliers Electro-Harmonix have just announced their interpretation of a much-loved stalwart, the EL34. This pentode's EH suffix signifies that it differs from the common-or-garden variety in its "gold-plated grids, uniquely-tuned, bi-polar cathode cover that optimises electron focus to the plate. . . and a secret tri-alloy plate material that virtually eliminates distortion and odd-order harmonics. The result of these modifications is claimed to be a smooth response and exceptional linearity typical of tubes from such hallowed names as Mullard and Telefunken.

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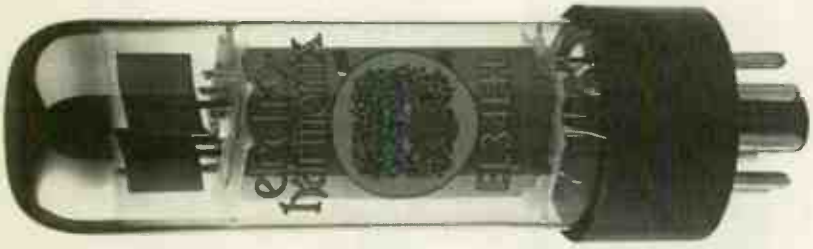
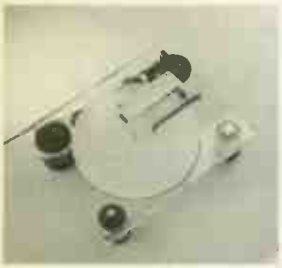
E-mail: www.ehx.com



IN A SPIN OVER ANALOGUE



Audiomeca Au/RA G7ECZ

If you're as passionate about your turntable and LP collection as some of our readers, you might want to surf on over to The Turntable Galleria http://www.geocities.com/Hollywood/Hills/4133/ttg.html) Entry is by a very large (and slow to download) first page that's bulging with more pictures of decks and arms than you can shake a stick at. Cast an eye over Dynavector's beautifully-engineered DV705 tone-arm or take a look at the heavyweight Analog Audio Systems V with twin arm-riggers.

The index page reveals sections on buying second-hand and LP care as well as a series of technical articles. The list of links contains sites such as the Vinyl Zone (which has equipment reviews and DIY articles prefaced by a picture of Immedia's gorgeous Revolution turntable) and a couple of Quad enthusiasts' pages amongst a slew of others. Here are three inserts to wet your appetite . . .

SpJ LaLuce NL

Clearaudio Master Reference G

DRIVING ME CRAZY

If you're more into woodworking than soldering, there's a myriad sites worth paying a visit to. When it comes to dream drive units, both Fostex and Pioneer make some very tasty devices. You can find the former at their Japanese page on: http://www.fostex.co.jp/jpn/INDEX/INDEX.html and the latter at: http://www.pioneer-eur.com/products/tad/th4001.htm. If you thought 15in. was big for a woofer, check out Fostex's huge FW800 80cm driver! And if you'd like to start putting together a subwoofer design yourself, there's always the subwoofer DIY page at: http://www.spiceisle.com/audiodiy/talkshop/

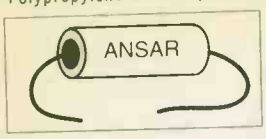
Fostex FW800

On a smaller scale, this Japanese company also manufactures esoteric compression drivers with matching horns and full-range twin-cone units.

Pioneer's high-end Technical Audio Devices consist of a number of cost-nearly-no-object compression units with matching horns and the outrageous PT-R9 ribbon tweeter, designed with Super Audio CD and DVD-Audio in mind - it has a frequency response which extends out to over 100kHz! Well, we can all dream, can't we?

Fostex Sigma range

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 D 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	120.00
CPW125U	Ansar 125uF 400V	115 x 60.9	26.00

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To replace old electrolytics or for new designs. Wire tails

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CPW1616	Propyl 16+16 400V	100 x 50	25.00
CPW3232	Propyl 32+32 400V	115 x 61	30.00

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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	Progax 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

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Part no	Description	Price
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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

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10000uF: 50x87mm 8.97A ripple current

22000uF: 65 x 103mm 15.19A ripple current

Part no	uF/Voltage	Price
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Axial leads 50V Tol. 10%

Primarily for use in speaker crossovers.

Part no	Description	Price
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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

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Part No	Specification	Price
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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

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Part No	Specification		Price
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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

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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

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OCTP	OCTAL VALVE HOLDER PHENOL	£1.50

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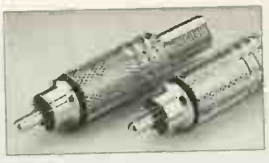

Part No.	Description	Price
PPG5A2	PAIR GOLD PLUGS for up to 5mm CABLE	£1.50 pair
PPG8A2	PAIR GOLD PLUGS for up to 8mm CABLE	£1.50 pair

Very High Quality Phono (RCA) Plugs

Very high quality satin grey metal with heavy gold plated connections. Top cofet 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

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

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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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TRAVELLING HIGHWAY 88

The KT88 is one of the all-time classic valves. Nick Lucas and Gary Devon introduce its latest incarnation, our KiT88 integrated amp.

To give all you DIYers out there some food for thought over the Millennium break, we at World Audio have come up with something a little special. You may feel that we have been concentrating on the push-pull genre of amplifiers of late, and you would not be far wrong. The simple truth is that this configuration has remained extremely popular as it provides the clarity, realism and musicality synonymous with valve amps, with the vital addition of the sort of serious punch that almost all single-ended designs lack. And, as a general rule, first-time constructors reach for push-pull to drive their medium-efficient speakers before moving on to more esoteric single-endeds and horns. To quote the Mod Father, Jon Marks, who incidentally is back within our hallowed DIY Supplement as the Sub Editor, "If you are going to do a push-pull amplifier, you have got to use the KT88." The rest is history. We thought we would bring the Millennium in with a bang, so we went to town on the KiT88. The circuit is basically that of the KEL34 with a few minor adjustments to incorporate the KT88 valve. A ground-up re-design was not deemed essential as the prototype sounded so good during early development. Output power is 36watts into an 8ohm load in pure Class A operation. The front-end consists of the 6AU6 pentode strapped as a triode, while an ECC82 double-triode forms the phase-splitters, a proven dynamite combination.

POWER HUNGRY - The KT88 is a power-hungry valve - its heaters consume no less than 1.8Amps at 6.3Volts AC which, along with the other tubes here, loads the heater winding of the mains transformer to a total of nine Amps. We have set the quiescent point of the KT88s so that the anode dissipation of all four is 35watts each. Once rectified, the HT is then pushing out 350mA at 500Volts under load. These figures may seem high, but by thermionic standards this is nothing. We commissioned our guru Gary Devon for a

fresh pair of E/I output transformers, no holds barred, and he came up with some gems on a 78-lamination, two-inch stack (twice the height of KEL34's output transformers). He opted for a single 8ohm tap on the secondary as multi-tapping here can degrade the sound.

HEAVY METAL - The chassis is very similar to KEL34's, although the depth had to be increased by 25mm to improve heat dissipation around the region of the mains transformer. To carry the weight of the hardware (approximately 14kgs of transformers) we had to move up to 2mm mild steel and step away from the U-clamp shell chassis to a stronger five-sided box with a flat base plate. To add the Millennium touch, we decided to crown the KiT88 with a 6mm, silver-anodised alloy fascia that bolts onto the black, powder-coated chassis. Inset into the front panel are three control knobs, chrome plated and custom made to a very high standard. This provides a beautiful finish to a beautiful sounding amplifier. As the KiT88 chassis has the same physical layout to the KEL34 chassis I am offering a "KEL34 facelift" kit at a cost of £75.00, this includes the front plate, the three control knobs, fixing screws, a rotary mains switch with fitting washers and a template for the drilling of the four holes. The KiT88 chassis dimensions are 330mm(w) by 300mm(d) by 190mm(h) with valves inserted. The KiT88 has four line-level inputs, including a tape loop, which are switchable from the front panel. All phono sockets are gold plated, as are the BFA speaker sockets. We have opted for an IEC mains input and supply a matching lead. Also on the rear panel is an earth post.

WHICH VALVE? - When it came to valve selection, we were already decided on the 6AU6, an NOS (New Old Stock) type from Russia, and the ECC82 from European manufacturers. Searching for a modern KT88, we tried Tesla, Sovtek, Svetlana, standard Chinese and Chinese GEC copies to name but a few. Eventually we settled on Tesla's JJ type for its excellent sound quality, strength and reliability.

PCB SPEAK - The KiT88 PCB is basically the same as KEL34's, albeit with the octal valve bases turned 100 degrees anticlockwise so that the red heater light is clearly visible to the listener. I would like to thank Paul Payne for this tip. The board is still made from high-grade FR4 material with a green solder-mask, which reduces the chance of stray solder blobs making unwanted links and causing problems later. It is clearly labelled and easy to populate. Since it's 2.4mm thick, it's extremely rigid as well, so there won't be any breakages when valves are inserted or removed.

THE KIT - KiT88 is simplicity itself to build - 30 individually-labelled parts bags help avoid confusion during PCB population, and the instruction manual has a strong emphasis on diagrams. For those prospective builders who are put off by 500V DC HT lines, we do provide safety gloves rated at 650V DC to prevent any possibility of electric shock. And as far as amplifier damage sustained through misassembly goes, the KiT88 is built to last. If you get truly stuck, we have a help line manned 9am to 5pm weekdays and a full back-up service. Please note that the second part of this article in the next Supplement will detail the parts list, what you get in your kit and outline the build sequence. **NL**

CIRCUIT DESCRIPTION BY GARY DEVON - KiT88 is a tuned-up version of the KEL34 kit, but this time using the KT88 output valve instead of the original EL34.

The EL34 is a pentode which has a true five-electrode structure, developed originally and patented by Philips. Their invention was the addition of the fifth electrode, the suppresser grid. This removed the kink in the characteristic curves found with tetrodes, which was caused by secondary emission from the anode. Tetrodes were fine for low amplitudes because the operating conditions could be arranged so that the anode voltage swing never traversed the kinked part. But at high amplitudes, serious distortion would occur. Plus, the kink was a negative resistance region, which can cause parasitic oscillation. The presence of the high potential on the screen grid also allows for a far greater current to flow through the valve at low anode voltages, now usable because of the new suppresser grid. This has the effect of greatly increasing the power efficiency of output valves, allowing a larger power output from a given anode dissipation than a similarly-rated triode. Philips and Mullard's range of power pentodes left the rest of the world's manufacturers far behind when they were first introduced, furrowing brows across the Atlantic in the US. RCA therefore developed a cunning and highly effective way to circumvent the Philips patent whilst retaining the advantages of higher power efficiency and low distortion - they developed the "Beam Tetrode".

Instead of placing another grid between the screen grid and the anode, they put in what are known as "beam-forming plates". These plates literally form the electron stream into a focussed beam, and, through carefully-designed geometry, a "virtual cathode" is formed which reflects the secondary electrons back to the anode, thereby removing the kink from the characteristic curves. RCA also accurately aligned the screen grid with the control grid. This decreased the current drawn by the screen grid because a shadow is thrown by the wires in the control grid onto the wires of the screen. This Beam Tetrode or Kinkless Tetrode structure is what GEC used in their KT range of power valves, the best known of which are the KT66 and KT88. In comparison, the KT88 is a much more expensive valve than the EL34. It has a higher anode dissipation of around 35watts to 40watts, although the JJ or Tesla types which we recommend have a higher allowable dissipation limit of around 50watts due to the addition of extra fins on the anode.

The EL34 was introduced as a way of getting a large amount of power cheaply, and as such it works fantastically - it must be one of the most popular power valves ever, in Europe and even in the ultra-patriotic USA. The 6L6 just couldn't keep up with it.

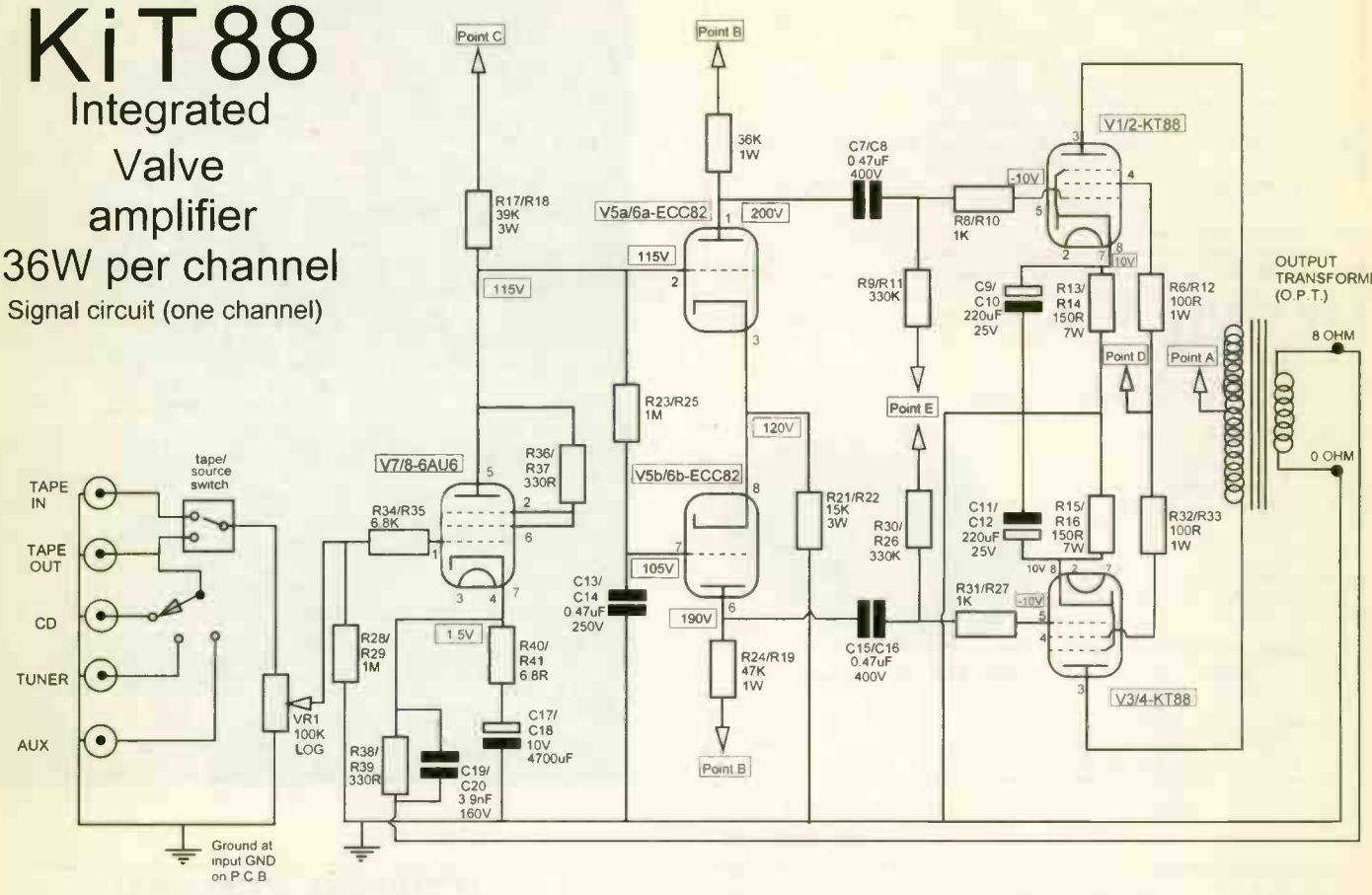
The KT88 was a development of the KT66 and TT21, with the benefits of extra power dissipation and higher transconductance. It was much more of a "no-compromise" valve than the EL34, and even knocked the stuffing out of the 6550 from Tung-Sol. Although the power output of KiT88 is similar to KEL34, the extra allowable dissipation of the KT88s allows for pure Class A operation. Any last vestige of crossover or switching distortion has thereby been eliminated, as both valves will always be conducting.

Class A amps are the winners when it comes to low-level detail, smoothness and consistency across the audio spectrum. The KT88 is also a much less fuzzy and gritty customer than the EL34. It's rather

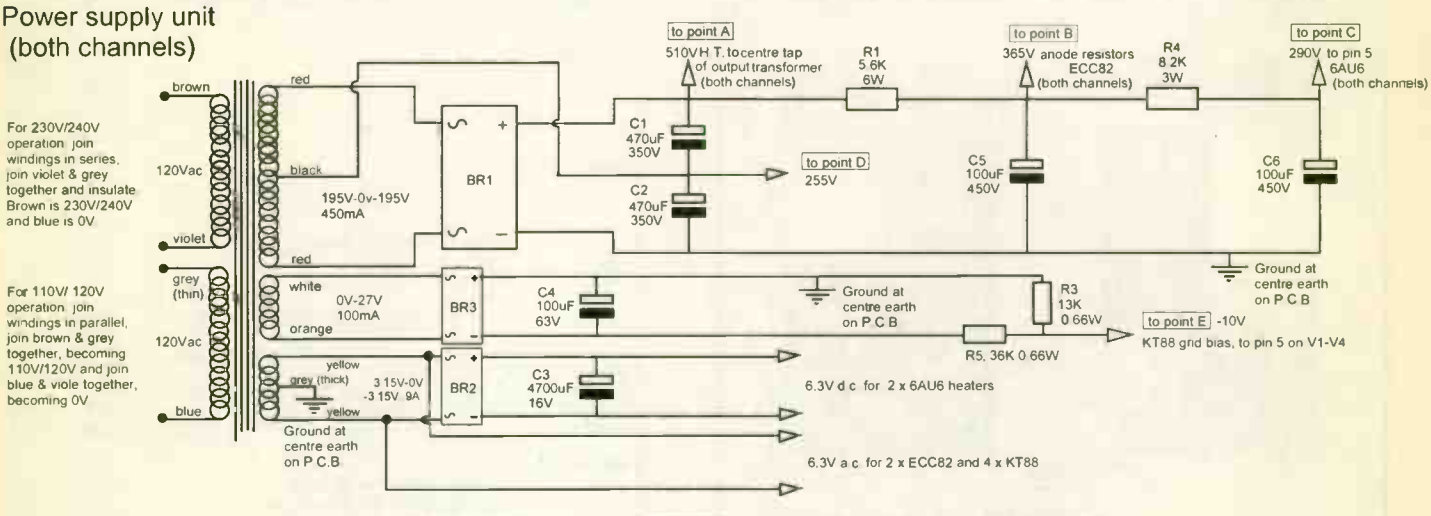
KiT88

Integrated Valve amplifier 36W per channel

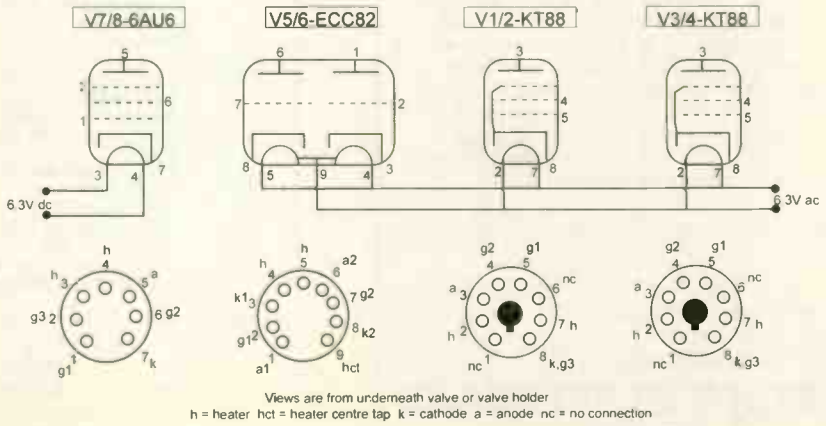
Signal circuit (one channel)



Power supply unit (both channels)



Valve pin layout



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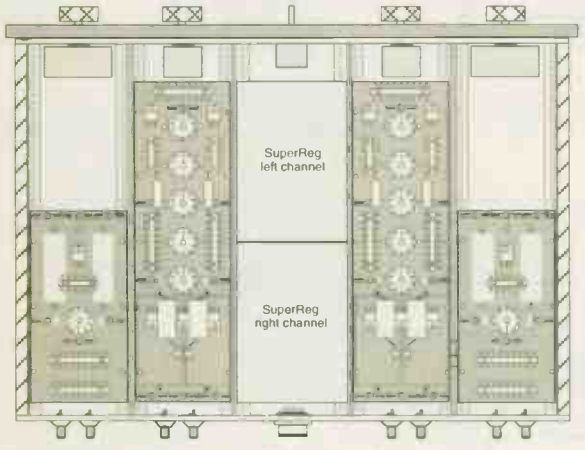

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like a comparison between a Subaru Impreza and a Ferrari 550 Maranello. Both look similar on paper, but. . . The topology of the KiT88 is more or less the same as the KEL34, with a triode-connected 6AU6 at the input followed by a cathode-coupled ECC82 phase-splitter. The compound-bias scheme is still used for the output valves as this cuts distortion and gives a better efficiency figure due to a reduction of the back-biassing effect at high signal amplitudes. This effect is, of course, less pronounced with a Class A amplifier, but when it comes to absolute quality, it's best to use it.

The KiT88 has a larger mains transformer to deliver the extra juice to the KT88s, and the output transformer is a new design which has a bigger stack to allow for better bass power output before saturation. Overall, the KiT88 is a more "high-end" proposition than KEL34, in spite of the latter's pedigree. KiT88 gives the sonic purity of Class A and a decent power output, enough to drive real-world speakers. **GD**

SOUND QUALITY

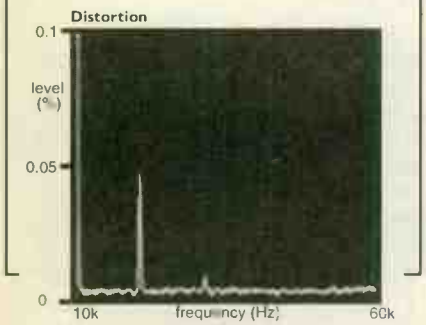
Jamo's Concert 8 loudspeakers and Class A amplification tend not to make happy partners due to a bit of a mismatch in the supply and demand for current. In other words, a typical outcome is: "Nice mid and treble, shame about the bass." However, KiT88 just laughed in the face of this problem and pulled a series of surprisingly fast, meaty basslines out of its trickbag when dealing with Suzanne Vega's Nine Objects Of Desire album. As if this wasn't enough, the mid and treble were nice too - cymbals had a deliciously natural, golden shimmer without sounding soft, and vocals were extremely transparent and crisply defined. All in all, not a bad start.

Thanks to its crystal-clear recording, Cirrus' Land's End Jazz CD boasts the sort of ambience and tonal richness Pop tracks can only dream about. KiT88 didn't hang around when it came to exploiting the virtues of its four output valves on numbers such as 'Leaves' and 'Suspect Sustain'. Saxophone had a wonderfully smooth, realistic character, and acoustic guitar mixed speed with harmonic richness to very impressive effect.

Even Drum 'n' Bass evidently enjoyed its trip through those world-famous kinkless tetrodes. Asian Dub Foundation and Moloko showed no sign at all of the sluggish, woolly bottom-end and poorly-delineated bass beats that most valve amps are to blame for. Which makes the KiT88 an all-round, high-end bargain whose ability to peel back the layers of a song is matched by its unfailing musicality. **JM**

MEASURED PERFORMANCE

Power	36watts
CD/tuner/aux.	
Frequency response	11Hz-75kHz
Separation	71dB
Noise	98dB
Distortion	0.03%
Sensitivity	400mV
dc offset	none



The KT88 is a power tetrode with a great reputation. Developed by GEC, it was designed to handle audio, the main criterion at the time being low distortion. It had to have what engineers call a "linear transfer characteristic" and GEC were successful in achieving this. Our distortion figures clearly underline this, with just 0.03% distortion at 1W/1kHz and, more surprisingly, little increase at 10kHz to 0.05% - a very low figure. A similar performance existed at high outputs, distortion rising to just 0.2% second harmonic, which is innocuous sounding.

High frequency distortion is affected by the output transformers distributed capacitance and the valves ability to meet high frequency current demand. Here the KT88 and our custom output transformer offer a virtually unmatchable result for a valve amplifier. A large core lets the amplifier swing full output at low frequencies without serious distortion setting in. This provides solid bass, free from the soft, wallowing quality common with valve amps. Frequency response was wide, stretching from 11Hz up to 75kHz. Subsonic response has been rolled down to lessen the likelihood of core saturation occurring.

As valve amplifiers go this one offers one of the best measured performances I have come across. It is a testament to GECs grasp of the problems when designing the KT88, one of its last audio power valves. Just as important though is the transformer with which the KT88 is paired. Ours offers superb results. **NK**

KiT88 integrated amplifier is available as a kit from Hi-Fi World

	uk (inc. VAT & p&p)	Overseas (exc. VAT & p&p)
KiT88 - K240/120 (with valves)	£440.00	£375.00
KiT88 - K240/120 (without valves)	£325.00	£275.00
KEL34 - facelift	£75.00	£65.00

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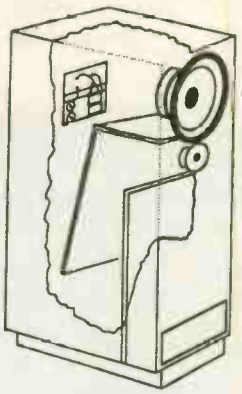

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A RETURN TO MONO

Nick Lucas pulls the final wraps from our new KEL80 kit valve monoblocs.

Scouring the hi-fi market for a pair of high-performance, low-cost, powerful valve monoblocs, I discovered there's really not a lot to choose from, especially after the unfortunate demise of Audio Innovations and their 1000 series amps. Thus KEL80 (introduced in November's DIY Supplement No.48) is a welcome arrival on the home-build scene judging from feedback like the e-mails reprinted here.

This second article on the kit contains a brief description of the build sequence (in the form of an excerpt from the easy-to-follow instruction manual), an overall view of the instructions and a look at the contents of a KEL80 kit.

THE BUILD SEQUENCE

1) FIXING THE HARDWARE TO THE CHASSIS

The initial stages are straightforward enough and revolve around fitting the massive mains and output transformers, the On/Off switch, the gold-plated phono sockets and the BFA speaker terminals. These last were specified instead of 4mm banana plugs as, according to European Safety Regulations, a two-pin continental mains plug will fit into a 4mm socket, which is deemed unsafe. The new terminals will accept a 3.5mm diameter, hollow banana plug (referred to as a BFA plug) or a 1/4in. or 5/16in. spade. There is also a 3.5mm hole to take bare wire. Still, if you prefer a more traditional arrangement, the chassis holes will accommodate 4mm binding posts.

2) POPULATING THE PRINTED CIRCUIT BOARD (PCB)

The KEL34, HD83 and KEL80 owe their ease of construction to the fact that all the valve bases and electronic components sit on the PCB rather than needing to be hard-wired. Additionally, all the parts are supplied in separately-labelled bags, which means less chance of putting the wrong bit in the right place. The PCB itself is double-sided, so all joins require soldering to its upper as well as lower surfaces (except for the electrolytic capacitors). Component orientation is very important when it comes to these caps, the bridge rectifiers and the octal valve bases. The high-power resistors also have to be a good 10mm off the PCB surface to avoid tarnishing it.

3) VALVE HEATERS AND INTERCONNECTIONS

Once all the components are sitting nicely, the valve heaters can be wired up. Heaters, and especially those of the output tubes, carry plenty of current. To avoid over-stressing PCB tracks, we chose point-to-point wiring for this area. Each valve base PCB section has pin pairs, or just a single pin, to allow simple wiring direct to the PCB. Due to the compact size of the PCB, it was essential to incorporate four external wire links, each of which join two circuit parts together. These are referred to as 'interconnections'.

4) CONNECTING UP THE PCB

The PCB fits snugly into the case, held securely in place by six stand-offs. As we now use PCB terminal pins in our kits, all 19 external connections are easy to make without having the board hovering in space while you wire them up.

5) NON-PCB CONNECTIONS

All that remains now is to hook up the mains lead to the On/Off switch and the output transformers to the speaker terminals.

(6)TURN ON FOR MONOBLOC HEAVEN

Insert all the EL34 valves, ensuring that they are correctly orientated. Connect up a dummy load, whether it happens to be an old pair of speakers or a high wattage 7-10 ohm resistor. Bear in mind that you'll need a pre-amp, be it active or passive, to

control the signal level.

Once you've fired up the KEL80s, get ready to check your test voltages. But before you do so, remember to put on the safety gloves provided. Build time is approximately six hours per monobloc. If you do encounter any problems, turn them off and carefully check your work for any unsoldered pins or misplaced components. Believe me, 99% of all malfunctions are down to silly mistakes. Should you encounter real difficulties, then you are welcome to call the help line. Alternatively, for a nominal fee, we will arrange for the amplifier to be collected, fixed, thoroughly checked and returned to yourself in full working order.

What you see is what you get . . . the contents of the KEL80 kit

FEEDBACK FROM HAPPY CUSTOMERS

Peter Moore says: I must say how impressed I am with the KEL80s.The build was straightforward (a tad over nine hours) and all parts were easily identified by the numbers on the bags. I populated both boards at the same time, but final assembly was finished individually.

After testing using a dummy load, I was eager to connect up. The sound from these amps is just amazing for under £600. Often, magazine listening tests leave a lot to be desired, but Simon Pope's description was bang on target.

My system consists of a Marantz CD-17, Sony JA30ES and JB920 MiniDisc recorders, Monitor Audio PMC703 speakers and my previous amps, the attractive Aura CA200/PA200 pre/power combo. This went some time ago after I built the Velleman K4040, a nice-sounding amp whose bass could be slightly flabby and loose.

The KEL80s ooze tight bass and open mid/treble, and a second mortgage is not required to re-tube when the time comes, unlike some of the more exotic amps on the market. What's more, they are well capable of coping with a wide variety of music and they really start to sing after only a few hours.

Peter Moore
pete.m@solarcom.in2home.co.uk

Pip Eastop says: I wanted to upgrade my amplifier to something which would do justice to a wonderful pair of speakers I bought a few years ago - the Harbeth K6s. A friend, who makes all his own hi-fi, put a lot of energy into persuading me that I would be happiest with a valve amp.

Convinced by his enthusiasm alone - never having heard a really good quality domestic amp, transistor or valve - I had been looking around for a year or so when he e-mailed me with details of the KEL80.

He told me that this was the kit to buy, assuring me that there would be excellent after-sales technical help by phone. Putting my faith in his recommendation, I ordered the KEL80 kit. The package arrived within a week and I opened it with fear and trepidation. When I read the first paragraph of the instruction manual my heart sank: Lethal voltages exist in this amplifier.

Even though this is one of our simplest kits, in terms of construction, please do not attempt to build it unless you have some understanding of valve circuitry. .' This was bad news, for I knew nothing at all about any kind of electrical circuitry. If it hadn't been for the reassuringly thick rubber gloves included in the kit, I think I would have sent it straight back.

I spent many days reading bits of the manual and taking occasional peeps at the various bags of parts, wires, transformers, the PCBs, the valves and casing. I couldn't believe that I was going to tackle the assembly alone, so I procrastinated and wondered what I was going to do. It wasn't until my 11-year-old daughter, Emily, persuaded me to make a start that things began to happen.

She helped me get going by reading the instructions to me in an encouraging way and rummaging for and identifying various bits in the 35 numbered bags.

After a surprisingly short time we had mounted the transformers and fitted the mains cable, phono sockets and speaker posts. Now it was time to start soldering stuff onto the PCB. On the recommendation of Nick Lucas, the World Audio technical help man, I had obtained a 25watt Antex soldering iron, some suitable pliers, wire strippers, wire cutters and some solder.

Also, on the sensible advice of a Maplin's shop assistant, I bought a little Velleman kit (£5) for the novice. When constructed, this would flash its LEDs if it detected sound. From making this I learned how to handle my soldering iron and make nice looking solder joints on a PCB. When it was finished, despite the fact that it wouldn't work no matter how loud I shouted at it, I felt confident enough to start mounting all the bits and pieces on the KEL80 PCBs.

My initial nervousness soon wore off and, before long, my pride and joy was the soldering in of all 12 valve bases - a beautiful job, although I say it myself. These feelings of smug expertise came to an abrupt halt, however, when I tackled the heater wiring. I was grateful for the photo in the Hi-Fi World Supplement

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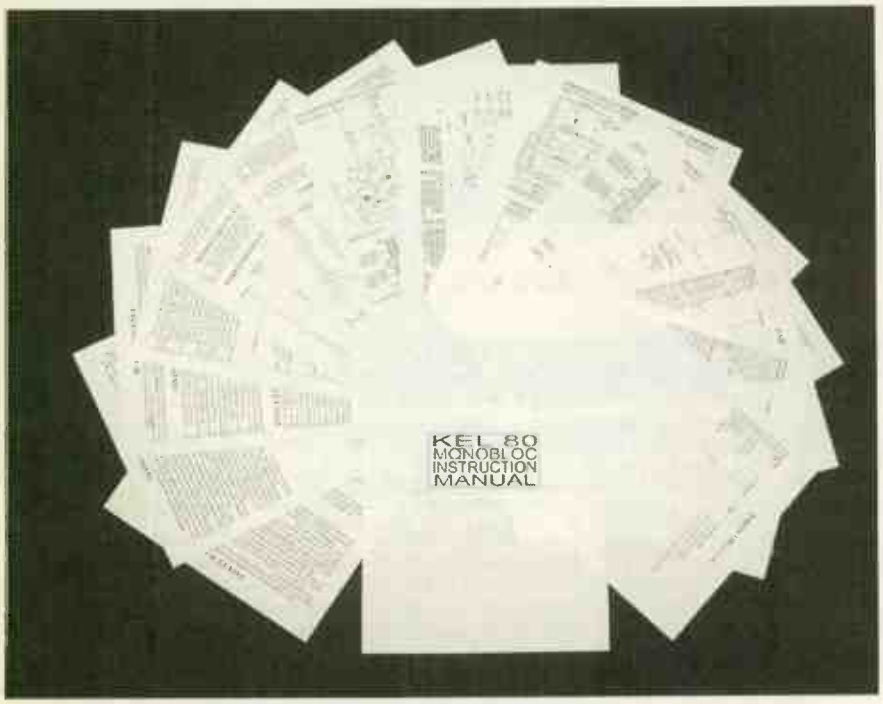


The KEL80 instruction manual

which showed the tangle of birds' nests I would have to create. Still, I have to admit that I called the help line to overcome a crisis of confidence.

At this point I would like to thank Nick Lucas for his seemingly limitless patience in dealing with me - an obvious imbecile when it comes to anything electrical. After the first couple of calls, I realised that he was not going to laugh at me down the phone. From then on I called him often, he was extremely helpful and at no time made me feel stupid.

Having finished adding stuff to the PCB, it was then time to connect great bunches of coloured wires to it. I found the soldering here a bit more difficult, and only managed it because of the all practice I had while soldering things to the PCB. The instruction manual could not have been clearer and before long I was ready to plug one of the amps in and switch it on to test the voltages.

At this point I needed Nick's advice again - I had never used a multimeter before and had no idea what to do with it. After a thorough telephone briefing, I took a few slow, deep breaths to calm myself (this had the opposite effect and sent my pulse racing), and donned the splendid gloves, big enough for a gorilla, which were going to save my life. They instantly filled with highly conductive sweat.

Gingerly, I plugged the amp into the mains and then, relieved to find I was still alive, switched it on while shielding my face and jumping back a few feet. Nothing happened. Not a peep. Phew, what a relief - I could bin the lot and get on with my life! No, I had plugged in my soldering iron instead by mistake.

Once I had the amp powered up, to my astonishment all the valves began to glow orange. The rest of the story is about many phone calls to Nick Lucas, trying to find out why the voltages were not right.

In retrospect, having resorted to taking my finished amplifiers to Nick's workshop for him to test, I would offer the following advice to any beginner contemplating jumping in at the deep end like I did: DON'T WASTE YOUR MONEY AND YOUR TIME BUYING A CHEAP MULTIMETER! The voltages were mostly fine - my multimeter had been miles out. There was nothing much wrong with my work apart from a little carelessness in checking my resistor soldering

So, how do the KEL80s sound? First, I must tell you that, having built these gorgeous heavyweight boxes with my own virgin hands, I am unashamedly biased. But they are infinitely better than the little 12-year-old Naim Nait I was using before. Suddenly my Harbeth speakers have found their voice - I was expecting to be able to detect a difference, an improvement of some sort, but instead I am simply blown away by the sheer visceral reality of the music. The music in my living room has popped out into jaw-dropping 3D, and the bass-end seems to extend right down into an infinitely deep abyss. Within an hour of first hearing them, my wife and I had already sampled a minute or two of music from at least 30 CDs! We could not stop compulsively trying out more and more from our varied collection (everything is there except Country and Western). When I shut my eyes and listen, the music seems to come from all around the room rather than obviously from the speakers, as it used to. How does this happen? I don't know - I'm no amplifier builder. I am a performing musician by trade, a horn player, so I know a little about acoustics, at least how recording venues sound in reality. I am amazed at the ability of these amplifiers to recreate the acoustic settings of any recording. One last observation - which may be the most telling: it is now noticeably more difficult than it was to stop listening to my CDs!

Pip Eastop
pip@eastop.net

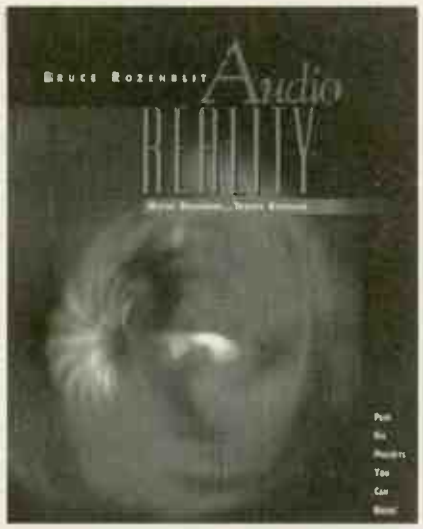
AUDIO REALITY BY BRUCE ROZENBLIT

Reviewed by Gary Devon.

Audio Reality is divided into two portions, number one, theory ("Audio Science") and number two, practice ("Projects"). The first of these is then further sub-divided into parts which progressively introduce the reader to the concepts of audio electronics, together with a large serving of the author's philosophy of audio. The subjects are explained in a fairly logical sequence, and in an audio-relevant way, if there is such a thing!

Opening the book are the subjects of electricity, conduction and electric fields, Bruce writing his way through these in an easily-comprehensible way. There are no mathematical formulae, just words and pictures. The actual mechanics behind the processes of conduction are explained very clearly, using the "water in a pipe" analogy and others like it. These concepts are applied to loudspeaker terminals, wires and so on, so that the reader can better make up his or her mind when it comes to choosing types for a project. The author also constantly attempts to dispel the hype associated with audio connectors through sound engineering sense. The following brief section on insulators paves the way for the introduction of the concept of capacitance, how it operates in an electrical circuit, and how it affects cables. Next, inductance and skin effect are covered succinctly before reactance and impedance are dealt with in greater depth. This is because Bruce discusses the importance of both to speaker cable performance (or speaker/amplifier/cable interaction) and investigates their impact on sound quality.

Naturally enough, Bruce then moves on to interconnect cables in a conventional engineering discussion where in great emphasis is given to grounding and avoiding hum. This leads on to the subject of balanced lines, and the use of input transformers. From here on in, the book's contents are less fundamental, instead handling topics such as power supply requirements, isolation transformers and damping systems. The author delves into the compatibility of components within a hi-fi system,with sections on the problems encountered by the amplifier or pre-amplifier when driving real-lifeloads.



The vacuum tube is introduced next, with the concepts of space charge and so on explained briefly. Bruce's projects, which appear later on, are all thermionic, so a compact intro to the valve's operation is handy for newcomers who don't wish to plough through a whole text book.

As part one of the book draws to a close, the dreaded negative feedback is discussed in engineering terms -how it works and why Bruce thinks that it is beneficial to audio amplifiers.

Last but not least are pieces on acoustics and perceived sound. They may not be particularly lengthy, but at least they go through the basics without resorting to masses of equations.

Part two of the book begins with instructions on how to build valve amplifiers, and five projects to experiment with. Included are tips on soldering, wiring layout and so on, as well as the reassurance that constructing a valve amplifier is not a black art reserved for specialist engineers. The projects themselves are quite interesting. Heading the list is an Output Transformer-Less (OTL) design, "The Transcendent OTL", which uses EL509 output valves. This amplifier relies on Bruce Rozenblit's own patented circuit, which claims to overcome some of the problems previously associated with these amps. Personally, I doubt this topology actually performs as claimed - I think somewhere a mistaken assumption has been made. Still, it probably works OK.

The second project is the "Grounded-Grid Pre-amp", which centres around a cathode-coupled circuit whose output side is connected as a Shunt Regulated Push-Pull with local feedback.

We go on to the "Super-Compact 150 Watt Amp", which again sports EL509s. These are really meaty valves,and reasonably priced too, so this could be a good one to build. The circuit is quite conventional -cathode-coupled phase-splitter with regulated screen supplies, American-style.

The "Single-Ended With Slam" employs three 6550 output valves connected as cathode-followers to the out puttransformer. This is an unusual approach, but one that gives a lower impedance to drive the transformer.

The end product is definitely a cast-iron, V8 SE amp, nothing like the Bonsai Japanese single-endeds. Finally Bruce offers the "Grounded-Grid Cascode Phono Pre-amp", whose topology is similar to that of the line-stage project. This, and all of the other projects, come with full constructional advice and test procedures, along with parts lists for going shopping in the catalogues. The end of the book consists of Bruce's patent for his OTL topology, which is written in patent language. You can try it if you like, but you'd be better off reading the circuit description which accompanies the project.
Overall, Audio Reality is an interesting and entertaining book. Bruce uses humour to good effect, and his personality and philosophy are liberally spread over the writing like chilli sauce, which gives it a more personal feel.

By the way, Bruce has a manufacturing company, Transcendent Sound Inc, and the projects in the book are versions of equipment from that company, so they should have been tested in the field. It may even be possible to find reviews of the amps in some American magazines, if you are wondering what they might soundlike. The projects are designed with Bruce's values in mind, so they should drive most loudspeakers and be reliable. GD

Audio Reality by Bruce Rosenblit is available from World Library, see page 68 for order form book code 1640 cost £21.50 + £2.25 UK p+p

SINE-ING ON

Richard White considers AF generators for the amateur and looks at Iso-Tech's IFG100 stepped frequency oscillator.

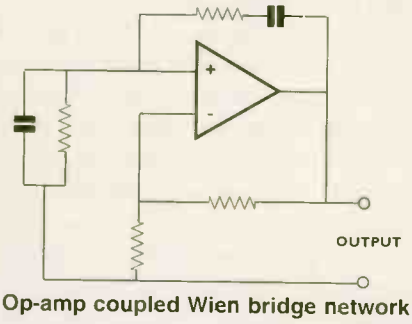
Despite the far more sophisticated techniques now used for measuring audio equipment, as far as the home experimenter is concerned, the game begins with an AF oscillator, or frequency generator.

Since amplifier designers spend much time and care ensuring that their designs will not oscillate ('unconditionally stable' is the expression), one might be forgiven for thinking that an audio oscillator practically makes itself! The difficulty lies chiefly in control: here is a fine line to be trod between letting things simply howl and killing the oscillation altogether.

For many years, the amateur's practical oscillating circuit has been based on the feedback connected Wien bridge network.

In the simplest terms, all that happens in a circuit of this sort is that the capacitors gain and lose potential at a rate governed both by the capacitance and by the value of resistance. None of this would work if a capacitor could be charged instantaneously. It is the finite time taken for a given capacitor to be charged through a given resistor which allows its use for generating regular waves. By varying the component values, either by changing the resistors or the capacitors, the oscillation frequency is also changed.

Various practical applications of the circuit have been tried out over the years, including using two generators and mixing the outputs to achieve a sort of heterodyne resultant wave. This device gained popularity because it required only minimal frequency change in one oscillator to produce a large frequency change in the output



Op-amp coupled Wien bridge network

Nowadays, the most common practice is to use the plain Wien network, with fixed capacitors, and to vary the frequency by ganged variable resistors. This approach is much more tolerant of component quirks and is the basis of most inexpensive signal generators currently on the market. The necessary control of the amplitude of the oscillation, to prevent PA-type 'howl', is taken care of by a self-heating thermistor which automatically trims signal level by passing more or less feedback as its element temperature

varies. Simple and effective.

Now for the fly in the ointment, It would be idle to deny that the carbon track potentiometer commonly used for varying resistance is in any way a top-of-the-range device. My experience with inexpensive AF generators is that not only does it become difficult to set a given frequency, owing to the vagaries of wear on the pot's tracks, but it also becomes impossible to track through a frequency band without the signal being interrupted, coming and going with every tiny movement of the frequency knob. It was this practical irritation which led me to explore the possibility of fitting some sort of stepped attenuation in place of the wretched pot. This soon began to look expensive and I fairly rapidly came to the conclusion that either improving the model I had, or else making something from scratch, would incur much time and not a little money.

As if in answer to my prayers, the Iso-Tech IFG100 turned up. This little device is about the size of a pocket calculator and has many advantages for the amateur, not the least being its extreme simplicity. Instead of the aforementioned unreliable potentiometers, the IFG100 has 23 click settings which double up to provide 46 fixed frequencies between 20Hz and 150kHz. The steps appear to be somewhat arbitrary but the increments work out to either three or four per octave, which is fine enough for most amateur work. Signal attenuation is by slide switch (-20dB) and a knob for fine adjustments. Setting the signal amplitude does not affect the level of the oscilloscope synchronizing output.

In use, I have found the device to be reliable and easy to use. At the sacrifice of a continuously variable frequency control, the IFG100 provides a handy selection of accurate (±3%) spot frequencies, with a choice of either sine or square waveform. Let's face it, when you're doing a bit of home testing, the last thing you need is an AF generator which needs testing itself!

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DRAWING A LINE

My first attempt at building a valve amplifier was just over 20 years ago. It featured a 30P19 line output tetrode from a scrapped TV set. The other innards - smoothing caps, etc - were enough to put together the rest of the amp, with the exception of a Radio Spares universal output transformer.

The heater supply came from a small, 25volt transformer which was actually the TV's output transformer connected to the mains. There was no mains transformer - the amp was connected directly to the wall socket via a salvaged solid-state diode. **(THIS IS, HOWEVER, POTENTIALLY LETHAL, AND SHOULD NOT BE ATTEMPTED BY OTHER DIYERS - JM)**

The amp had a tone control and a 1M ohm volume pot. It drove a 12in. Goodmans' driver, probably from the late Forties. The source was an old Garrard turntable with a crystal pick-up.

The first time I turned the amp on, I used a very long stick as there were no fuses in the round-pin plugs! It didn't explode - there was just a buzz and a hum from the speaker plus a lovely blue glow coming from the valve. I put on a record and was taken aback by how loud this little single-ended amp sounded. I was only 14, and to me it was magic! Now, two decades on, having owned much classic valve equipment, I've built a stereo amp with PL504 line output valves (£3 each) with an ECC83 driver and a proper mains transformer.

Having finished constructing it, I was told it would distort terribly as line output valves are only switches. Plus, it was only

Gamma Rhythm: The 211 transmitter triode is a very popular candidate for single-ended and push-pull use.

a zero-feedback single-ended with just 110 volts on the anodes as they are apparently low-impedance types.

However, the sound quality is as good, if not better, than that of many alternatives I've compared it to. Does anyone else use line output valves? Am I on the right track?

Mr T Gibson, Kent.

Your early experiments with valves sound very similar to mine. The first amplifier I built was a single-ended N37, I think. I'm not sure because I seem to remember that there was very little left of the print on the valve - it could have been an M87! The amp was just a single pentode connected up as a triode with a 5U4G rectifier valve. I had no data on the valves - I just bought a box of them at a jumble sale - so I had to look inside the bottles to work out which pin did what. That amp worked as well, much to my surprise. I hooked it up to the output of a radio and powered a projector extension speaker with it. My parents complained at the noise coming from the shed - great! There is absolutely no reason to reject TV line or frame output valves. In fact, some types were dual-purpose, audio and TV. Special audio types are usually constructed to have low microphony and low noise, but of course this only really matters with small-signal valves; output valves are a lot less susceptible to noise because the level is far higher.

Today, a lot of RF and TV valves are used in audio amplifiers; in the US, the 6DJ8 or ECC88 is just about standard issue for pre-amps. Over here in the UK, the EAR 509 uses TV line output valves. The legendary Ongaku from Japan uses a 211 transmitter triode, and the list goes on. I think that you should carry on experimenting with your circuits, and don't let people put you off. Try to get some valve data - you could buy a copy of the Vade-Mecum, which will enable you to compare the characteristics of different valves and make your own mind up as to which types to try. ***GD***

TURNING BACK TIME

Constant upgrading of hi-fi components is expensive (what a revelation!) and not always justified, particularly with electronics. If you have, say, an amplifier around 15-20 years old, which was a good example of the technology of its day, it's worth bearing in mind that a high proportion of its price (and that of any replacement you might buy) lies in the amortisation of development costs, marketing and distribution expenses, and (naturally) a profit margin for the manufacturer.

Much of the amplifier itself, particularly the case, fixing hardware, etc, won't deteriorate, and many components (transformers, transistors, etc) can last for very long periods of time. Although circuit topology has moved on, the performance attainable from a well-designed late-Seventies or early-Eighties amplifier is still comparable to all but the most expensive of current units. Thus, if you are competent with a soldering iron and can obtain (and read) a circuit diagram, you can transform your old amp with audiophile components.

The biggest gains can be made with parts like new power supply, signal and decoupling capacitors, Schottky rectifier diodes, and phono and speaker connections. Resistors can be replaced too, but major sound-enhancers like Vishays are expensive.

It's possible to buy suitable candidates for a rebuild at boot fairs or from second-hand hi-fi shops for not much money. I ravaged an Exposure VIII power amp (vintage 1980 I believe), stripped out fuses from the power supply (not the mains side!) and speaker output lines, and replaced them with auto-resetting circuit breakers. I changed all caps in the circuit and fitted gold-plated phono sockets (ditto speaker connectors). In addition - and this is a critical part - I went over

While there are some classics out there, not all older equipment is worth the time and money involved in modding it.

the circuit board resoldering every joint. A high proportion of equipment failures after three to five years is down to soldered junctions drying out. A quick run round with the iron (surprisingly few joints in total on a power amp board) pays big dividends. Result? The amp now sounds like a £500 unit, and all for a cost of about one tenth of that! Further big improvements included doubling up the power supply (extra transformer, two extra reservoir caps and four new Schottkies) and putting it in a separate case. OK, that cost an extra £50 plus the case, but it was well worth it. Basically, the message is: think twice about buying an expensive new amp, especially if you have an oldie but goldie in your loft!

David, psychomet@easynet.co.uk

There's probably no better way to get great hi-fi on the cheap than to rebuild venerable but possibly classic electronics. However, while this holds true for quite a lot of amplification, CD players and 'speakers can be much more hit and miss. Older digital equipment, if it was flagship gear when first sold, can be resuscitated for use as a heavyweight transport with the addition of a new master clock and/or digital output board.

Most older DACs should be left to rest in peace, unless you want to take on a modification which could turn into a labour of love rather than a cost-effective update. Of course, there are exceptions: the old TDA1541 multi-bit converter has a strong following for its musicality, particularly if it's the specially-selected, high-grade chipset.

On the whole, though, a modern kit DAC such as one of Sonic Frontiers' would most likely be a better bet. Aged loudspeakers should be looked at in pretty much the same light. On a lot of them, the drivers will be getting geriatric, and you can be almost certain of having to re-surround or re-cone drive units. Having said that, get a good, low-mileage pair, and re-wiring them and fitting audiophile components can transform their sound.

Again, a generally more reliable approach is to go for a well-engineered new kit and fill it full of the tasty parts you would otherwise have transplanted into a second-hand buy. ***JM***

CLOCKING ON

With many people still interested in improving the performance of their CD players, I would like to share a design for a high-performance clock that should give a considerable boost in sound quality. It's not expensive and is pretty easy to build, provided you have some experience with a soldering iron.

The oscillator usually found in CD players, particularly older models, is pretty basic, resembling the circuit described in Figure 1. The CMOS inverter is functioning as a linear amplifier and is usually integrated onto the DAC chip or digital filter. This means that the oscillator is subject to power supply noise generated by the rest of the player, producing jitter.

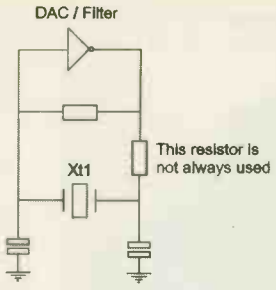

Fig. 1 Basic oscillator

A considerable improvement can be made simply by constructing this same circuit with an individual inverter powered from its own supply. However, even better results are obtainable with a dedicated crystal oscillator chip, in this case the Motorola MC12061.

This clever little device is designed so that frequency stability is highly immune to variations in supply voltage, and requires the addition of very few extra components to build the complete circuit. For fans of techno babble (like myself), it features Automatic Gain Control, a balanced analogue output stage and series-mode oscillation. AGC regulates the amplitude of oscillation in order to prevent clipping, a major cause of phase noise in standard clocks. It is suitable for use at frequencies from 10MHz to 20MHz (most CD players operate at either11.2896MHz or 16.9344MHz). Performance is further enhanced by using a fast rise-time digital buffer at the output. The 74AC04 is faster, but the HC version performed just as well to my ears and is less critical of circuit layout

Ideally, for guaranteed optimum performance, high-speed circuitry should be built on a purpose-designed PCB with a ground plane, although I successfully built my first prototype on Veroboard. Advice on circuit design and layout was given by Guido Tent in an excellent article in a recent DIY Supplement.

Basic points to remember are:1) The active devices should be decoupled as close as possible to their power supply pins with low-inductance capacitors; 2) Keep tracks short, and the circuit in general compact. The original oscillator (resistors, ceramic capacitors and crystal) first needs to be removed from the player. Now construct the circuit as described in Fig.2, using the original crystal. Only one will work (XT1). Which one must be determined either by experimentation or with the help of a circuit diagram,if you have one.

Either build a dedicated PSU for the oscillator or hook it up to the main player PSU - the output of a 7808, 7812 or 7815 voltage regulator will do fine. Run the supply wire close to the PCB ground plane, or use coax, to reduce RF pick-up.

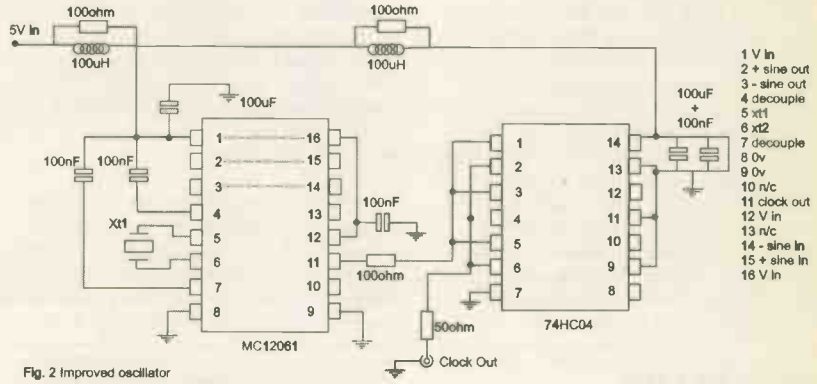

Fig. 2 Improved oscillator

As mentioned earlier, noise on the supply line is a major cause of jitter, so it's important to keep the power supply as clean as possible. Sanyo Os-Cons make excellent low-noise decoupling capacitors. It may also be worthwhile experimenting with high-grade regulators and battery power.

Having said this, after trying different power supply configurations (including batteries), I found very little, if any, increase in performance. I believe this is due to the MC12061's intrinsic immunity to supply noise. Since it uses series-mode oscillation, if you use a parallel-cut crystal as found in most players, it will work at a frequency a few ppm down. This isn't a problem at all unless you use a phase-locked loop (jitter buster) between transport and DAC, in which case the PLL might have trouble locking on. If so, you will need to get a series-mode-cut crystal from a manufacturer. Otherwise, don't worry.

So, what does it sound like? I have found that, with a range of different machines, it provides excellent results. All the usual consequences of reduced jitter are in evidence - music simply sounds more naturally right and cohesive. Instruments gain a tangible solidity, and front-to-back sound staging becomes more realistic.

Daniel Espley Gloucester

P.S. The MC12061 can be obtained from Viewcom (tel:0181 471 9338).

We've actually got a couple of commercial clocks in for audition at the moment - one from Audio Com and the other from Acoustic Precision. Fitted to a Pioneer DV-505, the first of these is currently sounding very good, and we have high hopes for the second too

On the topic of power supplies, I have found that batteries (especially lead/acid types) can be disappointing in analogue gear when running through regulators such as the 78XX, 79XX or 317/337 series. However, this isn't because of the battery - power your circuits from an unregulated battery and the result is much better than fitting a cheap, basic regulator. ***JM***

THE WEB AND WAVES

I am interested in building some speakers utilising quarter-wave loading (devised by Paul Voigt), as used in some Castle loudspeakers. My father has a pair of Chesters and a pair of Howard S2s, both of which sound very nice. Do you know of any books on the subject? I intend to use Audax HM170Z0 drivers, and possibly a set of ribbon tweeters from IPL Acoustics. I have free access to the Net, so I would also be interested in any web sites on the subject. **Matthew St John Smith**

One very interesting site which deals with building loudspeakers is http://melhuish.org/audio/fullrange.htm. As you can see from the URL, the focus is very specifically on single, full-range drivers (Lowther, ATD, Fostex and many, many others), but there is also information on quarter-wave loading as this is a very popular way of squeezing bass out of this sort of unit. ***JM***

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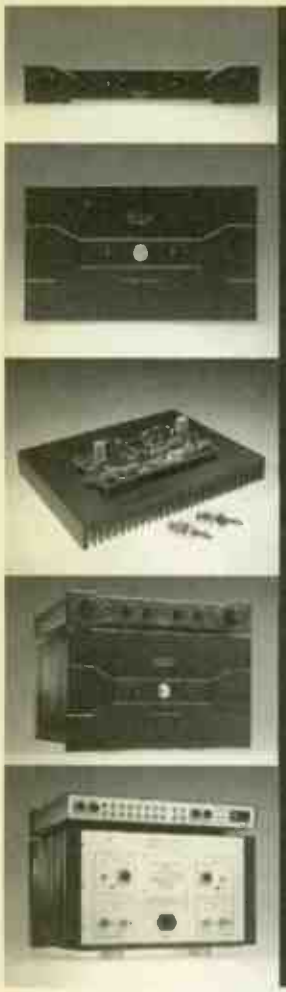

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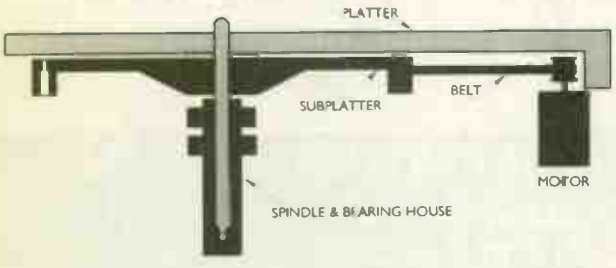

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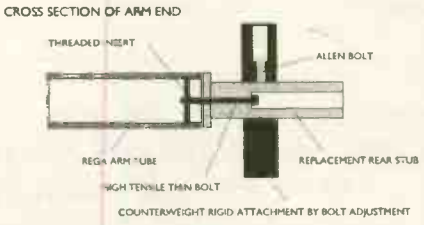

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