SENSITIVE LOUDSPEAKER USING CARBON FIBRE DRIVE UNITS

SINGLE-ENDED CLASS A HEADPHONE AMPLIFIER

FREE D.I.Y. SUPPLEMENT No. 9
Audio valves with famous Brand Names of yesteryear such as MULLARD, MOV, GEC, RCA etc., are in very limited supply and their scarcity also makes them very expensive.

We at Chelmer Valve Company however provide high quality alternatives to these old makes. We have over 30 years experience in the supply of electronic valves of all types and during this time have established close ties with factories and sources worldwide.

For high fidelity use we further process valves from these sources using our specially developed facilities. After rigorous testing - including noise, hum, microphony, post burn-in selection and matching as needed - we offer this product as CVC PREMIUM valves.

A selection of the more popular types is listed here.

### Price list & Order Form for CVC PREMIUM Audio Valves

<table>
<thead>
<tr>
<th>Pre-amp Valves</th>
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| Total Exc. VAT         | ...        |      |             |
| VAT @ 17% (ECC)        | ...        |      |             |
| Total to Pay           | ...        |      | £           |

* Matching, if required; state valve types & if PAIRS, QUADS or OCTETS - Allow £1.00 per valve for this service.

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KIT NEWS
All that's new on the DIY hi-fi scene this month.

KLS3 THREE-WAY LOUDSPEAKER
Using high technology carbon fibre-cone drive units we've designed a super clean sounding three-way floorstanding loudspeaker. With high sensitivity and even impedance, it is ideal for low power, high quality solid state or valve amplifiers.

AUDAX DRIVE UNITS
Want to get your hands on the latest drive unit technology? Well here's your chance. There are ten super drive units to choose from including Carbon Fibre, High Definition Aerogel (HDA), and doped paper, as well as three soft dome tweeters.

BOOK REVIEWS
This month we take a look at a reprint of an original classic and a new book on solid state electronics.

THE WILLIAMSON AMPLIFIER
Reprinted from articles in Wireless World

THE ART OF LINEAR ELECTRONICS
By John Linsley-Hood

CLASS A HEADPHONE AMPLIFIER
Following numerous letters from readers about the circuit for a single-ended, Class A headphone amplifier, published with Richard Brice's April column, we've decided to give you full construction details.

DIY LETTERS
This month we tackle a range of letters including some practical advice from a reader who's built our KLS1 loudspeaker.
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HI-FI WORLD SUPPLEMENT AUGUST 1994
GOOD NEWS FOR USERS OF DECCA RIBBON TWEETERS

Dismayed to learn about the demise of replacement ribbons for Decca DK30 and London ribbon tweeters, electronics engineer H. Dawson has taken the matter into his own hands. Mr. Dawson has produced tooling to enable hand manufacture of these spares to the original mechanical and electrical criteria.

A service is offered to readers who would like to keep their Decca ribbons in service, prices as follows:

- London/Kelly Ribbon Insert £15.00 each inc. P&P (outright)
- £2-50 discount for old insert returned with outer frames re-usable.
- Will fit F.O.C. if owner stands postage both ways or brings the drive units in (by prior arrangement).
- All spares come with printed instruction sheet/care tips.

C.W.O., cheque or P.O. Delivery 10 to 14 days (small numbers only).

Write to:
Mr. H. Dawson
16 Copeman Rd,
Aylsham,
Norwich.
NR11 6JL

RETURN OF THE CONSTRUCTOR SERIES

KEF are making available three plans for new speakers to be built by the DIYer, based on the commercial Q60, Q80 and Q90. All three use KEF’s 8inch uni-Q driver which will be available separately, along with their 8inch bass driver and 8inch passive radiator (ABR).

THE SPEAKER CO.

The Speaker Co. now have prices for the Audax range of HDA units, which they will have available shortly. The 5inch midrange unit will be £46, the 6inch bass/mid £51, and the 8inch bass/mid £61. Other new units include the hi-fi range from professional manufacturer Precision Devices. The Speaker Co. will be stocking one 10inch, one 12inch and two 15inchs including the 600watt power handling 95dB efficient PD157. They will also be stocking a massive £620 21inch driver, telling us that most people buy them to use in cars!

Following the review of the Boxcalc package in our April Supplement, a demo version is now available for interested parties. Send an SAE to:

The Speaker Co.
Unit 9,
Waterside Mill,
Waterside,
Macclesfield,
Cheshire.
SK11 7HG
Tel: 0625 500507

HART ELECTRONICS

Hart Electronics, keen to entice more and more people into the DIY hi-fi scene, have put together a soldering practice kit for beginners. The kit includes a practice circuit board, solder and full instructions explaining the techniques behind soldering. Suitable for the absolute beginner, the kit costs £4.99 + £1.50 p&p.

Also from Hart, reprints of the original articles describing the Simple Class A amplifier designed by J. Linsey Hood in 1969 are now available. The eight page A4 reprint costs £2.50 + 50p postage.

Soft Start for Projects

A variable transformer may not instantly appeal to the DIYer, but for those who build their own valve amplifiers and other electronic projects they are extremely useful. Maplin have just introduced two, variable from 0-270 volts and with either 1A or 2A current capability. They are especially useful when switching on your electronic project for the first time, as the mains can be smoothly increased up to 240V, highlighting problems before full power is reached (we use one, ‘cos it beats going into the Anderson shunt before switching on). Prices are £29.95 for the 2A and £49.95 for the 8A version.

Also new from Maplin is a 70W power handling titanium composite tweeter. Priced at just £13.95 it is ideal for budget kit loudspeakers.

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Maplin Electronics
P.O. Box 3,
Rayleigh,
Essex.
SS6 8LR
Tel: 0702 554161

0293 531190 and the South West by Bugle Brand of Exeter (Tel: 0392 79217).

Richard Dawson of Crawley Audio is responsible for the design of Tabula Rasa’s new loudspeaker stands. There are a range of standard size stands to suit Tabula Rasa’s range of kit loudspeakers, along with a custom design service. Just complete a simple form and drawing and a quote for a custom built stand will be returned. Prices for custom stands are said to be no more than that you would pay for a similar ‘production’ stand.

Also in the pipeline are tripod style equipment racks with 10mm glass shelves, and a grille re-covering service.

Tabula Rasa
136 Kilnwood,
High Wycombe,
HP14 4UR
Tel: 0494 565116

HI-FI WORLD SUPPLEMENT AUGUST 1994
Dominic Baker uses a computer, spectrum analyser, saw and his grey matter to build a superb floorstanding loudspeaker.

Our third loudspeaker design, KLS3, was partly prompted by our 300B zero feedback valve amplifier. Whilst this amplifier gives terrific stage depth and detail, because of the higher than normal output impedance it is affected by variations in the load the loudspeaker presents. Most loudspeakers do not have a steady 8Ω impedance over the audio band. Instead, the load they present an amplifier varies with frequency. If, for example a loudspeaker with a high impedance in the bass and low impedance in the treble was used with a zero feedback amplifier, it would sound unusually dull. So an important aim for this loudspeaker, as with the High Definition 'speaker (KLS2), was a reasonably flat impedance curve.

But KLS3 needed more than just a flat impedance curve. 300B has a power output of just 28 watts, so these speakers had to be sensitive too. We wanted a minimum of 90dB for a nominal watt (2.8V) input at 1m. It also had to use modern, low colouration, super quality drive units, to be able to bring out the very best of 300B. Finally, the speaker had to have a flat frequency response, especially across the critical midband.

A 'speaker with high sensitivity and a flat impedance curve is an extremely easy load for any amplifier. This has several benefits, even for solid state amplifiers. The harder you work an amplifier, the more distortion it will produce. This loudspeaker will actually reduce the amount of distortion your amplifier produces for the same sound level. This is one of the many advantages of a high sensitivity loudspeaker.

These design criteria would have been very hard to meet even a few years ago, but the advent of high technology cone materials has allowed us to actually improve on the targets we set ourselves at the beginning of this project.
**THE DRIVE UNITS**

Audax have been researching and producing new materials at a rate of knots over the last few years, now offering drivers with paper, TPX, Kevlar, glass fibre, carbon fibre, HDA and HDI cones. For this reason we looked to them for the drivers for our latest kit design. We do plan to design a speaker using the HDA units within the next year, but for this project the carbon fibre units were best suited.

These have a high impedance, making it easier to design the overall loudspeaker for a flat impedance curve. They are also extremely light and stiff, giving them the high sensitivity needed. This modern material has improved break up characteristics over a paper cone, giving a smoother sound.

As with KLS1, we felt it important to keep the cone materials of each driver as similar as possible, to avoid obvious character changes, keeping tonal quality as even as possible. So a dedicated 4-inch mid-range carbon fibre unit was teamed with an 8inch carbon fibre bass cone. A three-way design was preferred for its superior mid-range clarity and projection, together with good bass drive and kick. A soft dome tweeter was considered to be the best tonal match to carbon fibre. Good soft dome tweeters also have the detailed and natural sound which we wanted.

The tweeter we picked again came from Audax. It was featured in the December '93 supplement, having a smooth response, high impedance and high sensitivity. It is a very nicely built unit, having a replaceable diaphragm and voice coil assembly should you do any damage. Being from the same manufacturer as the bass and mid-range units also makes it easier for the home constructor to obtain them.

**Midrange and Tweeter Drive Unit**

**Frequency Response**

![Graph of Midrange and Tweeter Drive Unit Frequency Response]

**Port Output/Low Bass Response**

![Graph of Port Output/Low Bass Response]

**The Bass Enclosure**

The cabinet was designed to give good, powerful low bass, hence its generous proportions. The bass cabinet is around 55 litres internal volume and is tuned to 40Hz using two 38mm diameter, 85mm long ports. I used a computer aided design package to come up with the initial dimensions and port size, which gave a good, but rather sterile bass quality. Using a combination of listening tests, and observing the changes altering the port size made on our Hewlett Packard HP3561A Spectrum Analyser, we were able to tune the bass to give exactly the character and bass quality we wanted.

You can see from the plot below how the ports extend the response from the front of the cone down to an impressive 17Hz at -3dB. Of course a close eye on the impedance curve was also important.

**Midrange and Bass Drive Unit**

The midrange driver sits in a sealed chamber, the walls lined with felt carpet underlay. The cavity is lightly stuffed with long hair wool which, in combination with the carpet felt, absorbs most of the sound reflected off the internal walls. I made the midrange chamber volume 3.5 litres, which rolls off the midrange unit acoustically at low frequencies. The rising impedance of the midrange unit towards low frequencies prevents it drawing power in the bass, so power handling is not affected. This makes the crossover simpler and more efficient.

It is important to seal this enclosure very well, using plenty of PVA glue in the joins and to block the hole the internal speaker cable passes through.

**The Midrange Enclosure**

![Graph of The Midrange Enclosure Frequency Response]

**The Cabinet Design**

Audax HM210C0 8inch bass unit. Audax HM130CO 4inch midrange unit Audax TW035M1 25mm fabric dome tweeter
VACUUM TUBES are BACK... and they sound better than ever!

Glass Audio is a quarterly journal designed for dedicated music lovers who've always known tube equipment sounds better than solid state.

The articles have special emphasis on construction with projects ranging from simple modifications of existing equipment, to restorations, to construction of the most sophisticated designs available today. The projects include schematics, parts lists and instructions. An annual feature is a world directory of international tube dealers and manufacturers.

Here's a sampling of recent articles: ST-70 with Solid-State Regulation, Rebuilding Tube Amps, An Electrostatic Headphone Amp, Greening the ReVox G36, Restore your Scott Tuner, Soft Start for Tubes, 70 Watts of McIntosh Power, Output Transformerless Amp, Vacuum Tube Voltage Regulator plus Vacuum Tube AC Feedback Amps.

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THE CROSSOVER

The crossover for this speaker had to be simple. More complex crossovers take power from the drive units, reducing sensitivity. Second order filters (6dB/octave) use few components (just two) and give a usable rate of roll off that, with careful alignment, is sufficient for good quality drive units.

The tweeter is fed from a second order high pass filter as shown in the circuit diagram below. The capacitor should be a high quality polypropylene, and the inductor air cored for cleanest and smoothest sound. A 5.6Ω resistor is used to attenuate the treble level down to match that of the midrange and bass, and it also helps to give a smooth impedance characteristic through the treble. This resistor gives a flat response to the loudspeaker, but it can be varied between 4.7Ω and 6.8Ω to suit personal tastes. The lower the value the brighter the treble will be.

Because the midrange cabinet was designed to mechanically roll off bass, no series capacitor is needed to filter any remaining bass from it. At the top end, a second-order low pass filter is used to roll off the upper midrange to match the tweeter. Use a high quality 2.2μF polypropylene capacitor in parallel with a 6μF Alcap for best results, along with an air cored inductor.

The bass driver is fed from a second order low pass filter. Both components have high values, so a reversible (bipolar) electrolytic capacitor has to be used, along with a high power ferrite cored inductor.

If you find the bass too heavy in your listening room, a low value series resistor can be used to reduce the bass level, say between 1-3Ω.

TWEAKING KLS3

Apart from the crossover tweaks already discussed, there are several other things that will affect the overall sound.

Firstly, the reflex ports can be made either longer or shorter to change the box tuning. Making the ports longer moves the tuning frequency downwards, giving a flatter and deeper bass response. But this will tend to excite small rooms, resulting in a boomy or overblown sound. In smaller rooms the ports should be shortened, which reduces bass depth and peaks bass higher up, giving more subjective speed and punch.

Spiking the cabinets to the floor with a suitable spike kit will improve bass definition too. Spike kits are available from most kit loudspeaker suppliers and from stand manufacturers such as Apollo and Target.

The tweeter used has a very wide dispersion characteristic. This gives them a spacious sound, but by gluing a thin piece of soft foam around the dome of the tweeter to restrict its dispersion and lessen reflection of walls and ceiling, images will also come into better focus too.

Being a three way speaker, KLS3 can be either single, bi or tri-wired. We'd recommend bi-wiring, connecting the tweeter and midrange together and driving the bass with a separate cable run. But for those with plenty of spare cable around, tri-wiring will bring a subtle improvement.

Good quality internal cable should be used to connect the crossover to the drive units, and because of the small quantity used it makes sense to use silver solder. We do not advise you to solder the wires to the tweeter however, as a touch to much heat will damage it.
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Tel:- 0243 537312
CONSTRUCTION

The cabinets are constructed from 25mm MDF, which results in a very solid and inert enclosure. It is easier and far quicker to cut all holes for drive units, ports, terminal dish etc before you start to glue the cabinet together. It also reduces the amount of dust inside the cabinets which can find its way into the open voice coils of the drive units. I glued all panels to produce a permanently sealed enclosure, subsequently inserting all items through the drive unit holes.

The plans below show the general construction. The speakers can conveniently be built up on one side panel, laid flat. After the front, rear, internal top and bottom panels are glued into position, I put on the other side panel and held it down with weights until the glue set. Remember to do a dry run first to check that all the panels fit snugly together. In my case, even though the MDF was cut by a professional woodworker, it had to be sanded to size for a perfect fit.

Using Evostick Resin-W, apply the glue to the edges of the panels. They can then be slid into place, their 25mm thickness being enough to stand steady without panel pins. Any excess glue that oozes from the joins can be wiped away lightly with a damp cloth.

To ensure that the panels are firmly pressed together, either place suitable heavy implements on top of the cabinet, or use thick, stretchy carpet tape wrapped around the cabinet to pull the pieces together. After this last step, check that the cabinet is square and that all the sides are square. The glue should still be wet enough to allow the panels to be gently pushed into line.

Once the cabinets are dry - overnight it is normally enough for the glue to reach full strength - they are ready for the internal damping to be fixed into place. Small squares of carpet felt should be glued to each of the surfaces in the midrange chamber, and onto the sides and back of the main bass enclosure. This helps to absorb the majority of the sound wave that would otherwise be reflected off the rear wall of the cabinet and back out through the drive unit.

The whole cabinet, including the midrange enclosure, is then lightly stuffed with long hair wool, to further absorb reflections and reduce the effects of standing waves. Of course, you are free to experiment with other forms of panel treatment: BAF and Deflex pads for...
Precision Audio Tubes

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The components can be fixed to the crossover board with PVA glue, but I find a hot-melt glue gun holds them in place just as well, but the glue is more easily removable.

The wires for the midrange unit have to pass through a small hole in the midrange chamber. It is very important to seal this hole either with hot-melt glue or PVA. The drive unit can now be soldered to these wires and screwed into the front baffle. The tweeter should have wires attached using slide-on terminals to prevent heat damage from a soldering iron.

Mount the crossover as shown in the diagram above. Because inductors, being magnetic components, have a field around them, they need to be spaced well apart and at right angles to each other to minimise inductive coupling. Again, a recommended layout is shown below.

Example. But we find that the combination of soft carpet felt glued to the panels together with long hair wool stuffing to be extremely good, as well as being cost effective.

Mount the crossover as shown in the diagram above. Because inductors, being magnetic components, have a field around them, they need to be spaced well apart and at right angles to each other to minimise inductive coupling. Again, a recommended layout is shown below.

**TESTING**

A simple test to reduce the risk of any damage to your amplifier when you first plug in, is to check that the impedance of the loudspeaker with a simple multimeter. Using the resistance setting they should measure around 4Ω (their DC resistance) across the terminals. If there is a short anywhere, this simple test will show it with a reading below 1Ω.

**Crossover Schematic**

- HF+ 5.6Ω
- HF- 0.33 mH
- MF+ 0.9 mH
- MF- 6µF
- LF+ 2.2µF
- LF- 12µF
- Alcap 120µF
- 12mH low loss inductor

**SOUND QUALITY**

**An independent view by David Harris**

On seeing the impressively large speakers which Dominic recently designed my initial feelings were that they would sound pretty dramatic, especially using high quality drive carbon fibre drive units. The lowest bass was reproduced with remarkable ease, possessing a nice, warm, rounded sound yet controlling the huge orchestral bass drum resonances heard on Stravinsky's Fire Bird suite extremely well. The bass remained both tuneful and rhythmic all of the time.

Vocals were handled very naturally, coming across as life-size with a nice crisp, dry edge to them. Seal could be visualised within the room when performing Whirlpool from his debut album, the KLS3s putting almost no strain on his vocal talent. Choral work also had a wonderful openness about it; Mozart's Mass in C carried such atmosphere that the listening room expanded towards concert hall size with the '3s keeping a tight focus on soloists throughout the piece. The sheer breeziness of their overall character was excellent.

Listening to a Ronnie Cuber Live at the Blue Note (CD) highlighted another of these speakers strong points - rhythm. They kept a tight, foot-tapping pace going relentlessly, cymbals crashed with quartz-locked accuracy leaving you to play 'air drums' from your armchair!

The KLS3s have a sweet, open sounding treble which gives a high definition to the midrange, painting a clear picture of the music. It could however be a little lightweight at times, cymbals occasionally lacking in body and depth, but all-in-all a welcomely inoffensive, delicate sound was produced. Imagery was particularly good. Vocalists and instruments had pin-point focus, generating a believable soundstage of excellent depth. On Sea's hit Killer the keyboards drifted their way in from about ten yards behind the speakers, the sound filling the entire room.

To sum up, the KLS3s can best be described as a very open sounding speaker possessing excellent qualities of imagery and rhythm and give the listener a good deal of insight into the scale of the music being played.
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WARNING

Be extremely careful when screwing drive units in and out of the cabinets. One slip with a screwdriver and they're useless. We recommend using cross head screws which reduce the chance of this happening.

Do not try and solder wires to the terminals on the tweeter. They are mounted on plastic which will melt if too much heat is applied, and the fine wires connecting the voice coil will vaporise, rendering the unit useless. Use small push-on receptacle clips.

PARTS LIST

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<th>Drive Units</th>
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| Audax TW025M1        | 5.6Ω*/5W, non-inductive    |
| Audax HM130C0        | 1-3Ω*/10W                  |
| Audax HM210C0        | 4μF polypropylene/50V min. |
|                      | 6μF Alcap/50V              |
|                      | 2.2μF polypropylene/50V min.|
|                      | 120μF Alcap/100V           |
|                      | 0.33mH air core (0.71mm wire)|
|                      | 0.9mH air core (0.71mm wire)|
|                      | 12mH ferrite core (0.5Ω)   |

*R1 can be raised or lowered to set treble level to individual taste. R2 is optional and can be used to attenuate bass in rooms where it may become overblown.

Reflex Ports

38mm diameter x 85mm length.

MEASURED PERFORMANCE

Using our standard third-octave analysis with a pink noise test signal the frequency response shown below is very flat and smooth. There is a small dip around 1kHz which can be seen more clearly on the high resolution near-field plot on page 9. It is not a crossover dip, more likely a cancellation caused by the rubber cone surround of the midrange unit.

This kind of smooth and flat frequency response was obtained by first using computer crossover and cabinet analysis packages, and then fine tuning with our FFT spectrum analyser. Of course, tuning was combined with listening tests to ensure that the result was subjectively an improvement.

The second frequency response plot shows the effect that driving KLS3 with a high output impedance (6Ω) amplifier would have, such as our own 300B zero-feedback valve amplifier. The midrange is pushed forwards slightly because of the impedance hump at this point, but still remains essentially flat.

The impedance curve is again very smooth, part of the aim of the design. This ensures that response variations due to high amplifier output impedance is kept to a minimum. The overall impedance figure of 9Ω and high 90dB sensitivity show what an easy load KLS3 is to drive.

KLS3 is suitable for a wide range of amplifiers including specialised designs with zero feedback. I'd suggest a minimum of 20 watts for good sound level in a normal sized listening room. DB

A pack of KLS3 drive units is available for £220. See page 17 for details.
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High Technology Drive Units
From Audax

At last, a chance to get your hands on the latest drive unit technology and materials. We'll be stocking a small range of quality drive units from specialist manufacturer AUDAX, including the carbon fibre units and fabric dome tweeter used in the kit KLS3 design in this supplement. All of the units selected below have been picked for high performance in domestic hi-fi loudspeakers. The cone drivers have solid cast chassis and gold plated terminals.

All of the units are supplied with full specification sheets complete with suggested bass alignment. Most units are held in stock for fast delivery. (Please phone to check).

TWEETERS

**TW02SM0 (25mm)**
- Sensitivity: 92dB
- Power: 55watts
- Recommended range: 1kHz-20kHz
- Comments: Good for two-way systems with 8inch bass units.

**TW02SM1 (25mm)**
- Sensitivity: 92dB
- Power: 70watts
- Recommended range: 2.5kHz-20kHz
- Comments: Suitable for three-way systems or with 6.5inch bass units.

**TW03X0 (35mm)**
- Sensitivity: 93dB
- Power: 70watts
- Recommended range: 700Hz-20kHz
- Comments: Use in sensitive two-way systems with 8-10inch bass units.

CARBON FIBRE UNITS

**HM130C0 (4inch)**
- Sensitivity: 90dB
- Power: 50watts
- Recommended range: 100Hz-5kHz

**HM130Z0 (6.5inch)**
- Sensitivity: 91dB
- Power: 70watts
- Recommended range: Bass-1.5kHz
- Comments: Excellent mid-range unit in three-way systems.

**HM170C0 (6.5inch)**
- Sensitivity: 91dB
- Power: 60watts
- Recommended range: Bass-3kHz
- Comments: Modern driver for high quality two-way systems.

**HM170Z0 (8inch)**
- Sensitivity: 91dB
- Power: 70watts
- Recommended range: Bass-3kHz
- Comments: Light and fast driver suitable for two-way or as dedicated bass in three-way systems.

**HM210Z0 (8inch)**
- Sensitivity: 91dB
- Power: 60watts
- Recommended range: Bass-2kHz
- Comments: Crisp and dynamic bass for two- or three-way systems.

DOPED PAPER UNIT

**HM17G0 (6.5inch)**
- Sensitivity: 91dB
- Power: 60watts
- Recommended range: Bass-3.5kHz
- Comments: Cast chassis doped paper unit with smooth response.

**HM17G0 (6.5inch)**
- Sensitivity: 91dB
- Power: 60watts
- Recommended range: Bass-3.5kHz
- Comments: Ultra stiff and light mid-range unit for three-way systems.

**HM17G0 (6.5inch)**
- Sensitivity: 91dB
- Power: 60watts
- Recommended range: Bass-3kHz
- Comments: Modern light and fast unit for two-way systems.

**HM210G0 (8inch)**
- Sensitivity: 91dB
- Power: 70watts
- Recommended range: Bass-2kHz
- Comments: Crisp and dynamic bass for two- or three-way systems.

**HM17G0 (4inch)**
- Sensitivity: 83dB
- Power: 50watts
- Recommended range: Bass-2kHz
- Comments: Cast chassis doped paper unit with smooth response.

**HM17G0 (4inch)**
- Sensitivity: 83dB
- Power: 50watts
- Recommended range: Bass-2kHz
- Comments: Cast chassis doped paper unit with smooth response.

**HM17G0 (4inch)**
- Sensitivity: 83dB
- Power: 50watts
- Recommended range: Bass-2kHz
- Comments: Cast chassis doped paper unit with smooth response.

AUDAX DRIVE UNITS

**PRICE LIST AND ORDER FORM**

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All prices are exclusive of postage & packing. For U.K please add £5.75 for a pair of tweeters or one chassis unit and £10 for anything above. Overseas please contact us for rates.

I enclose cheque/PO for £, made payable to World Audio Design Ltd.

I wish to pay by Visa/Access, please debit my account no:

Expiry date: [ ] [ ]

Name:

Delivery Address:

N.B. If delivery address is different to the credit card holder's, please supply both.

Tel:

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Wilmslow Audio Limited, Wellington Close, Parkgate Trading Estate, Knutsford, Cheshire, WA16 8DX, England. Tel: (0569) 650665 Fax: (0569) 650000
A compilation of original articles describing a classic valve amplifier, reviewed by Noel Keywood.

Theo Williamson worked for M.O. Valve Co after the war. He designed his renowned amplifier in 1947 and modified it in 1949, its claim to fame being very low distortion - a magical 0.1% figure - for what was, then, high power output (15 watts). The output tubes are KT66s, Kinkless Tetrodes from GEC now made in China and available from P.M. Components. The design was published in Wireless World and became well known in both America and Britain. It relied on the use of negative feedback globally applied, being one of the first amplifiers to do so. As such, it was something of a pioneering design, discussing concepts such as open-loop gain and stability criteria, doubtless helping a lot of design engineers reach an understanding of such matters in the process.

This 40 page book reprints his original design and a later modified version, plus answers to readers queries, circuits for tone controls, a radio feeder unit and even a cartridge pre-amp. It's the discussions of theory gathered together in one compact source that makes this book valuable and absorbing. Williamson also includes some transformer design equations, as well as winding data and section connection details - rare but valuable information that I've otherwise seen only in the increasingly costly and rare Radio Designers Handbook (long out of print). Since the real secrets of a good audio transformer lie in the way its sections are arranged, something we pore over for hours here to ensure our in-house designs reach high standards, especially in the notoriously difficult inter-stage driver transformer for example (300B), this book carries some real nuggets.

However, many people will also want to know what sort of amplifier they will end up with, should they build Williamson's design. In my view, it isn't ideal for beginners; Mullard came up with a simpler equivalent in the later 5-20 and we've produced an even simpler and more robust design in K588I that also delivers 20 watts at 0.1% distortion from kinkless tetrodes with global feedback. However, whether you do or do not intend to build the actual amplifier - and I know many people who've enjoyed doing so, even if one did gripe about latent instability and the difficulty of optimising phase compensation to avoid oscillation - the book itself is a delight from the period. It contains quantities of valuable information not now available anywhere, except in treasured hoards. So in reprinting this information, Old Colony Sound Lab of the States have made available the wherewithal for audio enthusiasts to once again get really involved in their pastime - and that's why we've chosen to sell this book in Britain.

Available from Hi-Fi World, see page 101.
ARK NOTE GENUINE COMPONENTS PAYS £ PRO UK VAT.

When planning the design for this, it is important to ensure that all layout elements are designed correctly to avoid incorrect component connections. The layouts are designed to be correct for various components used in the kit, including resistors, capacitors, transistors, and diodes. The kit is designed to be easy to assemble and use, with clear instructions provided for each step. If you have any questions or concerns about the design or assembly process, please contact us for assistance. We are available to help you through the process and answer any questions you may have. We hope you enjoy working on this kit and creating something unique and interesting. Thank you for your support of Audio Note products!
The best solder we have been told does not contaminate the speaker cables, but we are dubious about the high quality copper and 99.99% pure silver wire.

Ati-SIN silver single core 20 strand black mend 6N le copper speaker wire.

These handmade attenuators and switches are manufactured by several different companies.

The kit is sold in the UK with a 3% VAT.

My bank account name is Beyschlag I. I have 1% resistors up to 50:Ken, I have 503KOhrm.
At last! A book devoted to hi-fi design.

Noel Keywood gets reading.

As good books on audio gradually become scarcer, new ones of merit grow commensurately more valuable. The Art of Linear Electronics has many unusual attributes that mark it out as unusual and, nowadays, peculiarly valuable.

The author, John Linsley Hood, has been involved in audio design all his life, starting off with valves, he told me. Since much of this was within industry, the book is studded with valuable insights into apparently obscure practical concerns such as 'properties of switch and connector contact metals', in chart and discussion form. Not interested? Well, hold on. He builds on this by discussing capacitor and resistor construction, which is of growing importance in real hi-fi as we find that this factor, in conjunction with the materials used, has quite a significant effect upon sound quality in any circuit that is otherwise working well. Future engineers also need to be aware of such practical concerns as switch contact oxidation, which can blight a production run by warranty claims just a few years after purchase as products become unuseable.

Pondering on the way mass produced Oriental amplifiers seem almost by magic to go wrong after two or three years, whether this is deliberate in order to stimulate sales and what sort of long term damage may result in terms of perceived reliability, I value Linsley Hood's coverage of this topic. It's one important way in which his book differs from others, especially the otherwise superb Foundations of Wireless and Electronics by M.G. Scroggie.

Few modern electronics books bother to cover valves, yet this one penetrates quite deeply even into valve construction, coating materials, etc which was another surprise. And it includes valve amplifier theory and circuits, discussing with circuit diagrams the Quad II, McIntosh and Williamson circuits, for example.

However, Linsley Hood understandably and correctly in my view dedicates most of the book to modern solid state engineering techniques in audio, devoting an entire chapter to Feedback, negative and positive', for example. It is in this way that the book reveals its strictly audio perspective, hi-fidelity being very much to the fore, rather than just functional Consumer Electronics.

And that's another way in which the book is unusual - there are many books of a tutorial nature that discuss audio amplifier design, but with no special emphasis on designing for optimum sound quality. With his background in designing audio circuits for Wireless World magazine, John Linsley Hood is well acquainted with audio angst and argument, although the book keeps its feet on the ground in sheer engineering terms; silver foil capacitors and cables don't enter the picture.

MOSFETs are discussed, although I see a comment to the effect that they possess 'relatively high linearity', whereas audio designers of considerable experience - notably Tim de Paravicini (EAR) and Stan Curtis (Cambridge, Wharfedale, et al) - tell me otherwise. MOSFETs, I am told, have to be swamped by negative feedback, to which they are amenable due to their excellent gain/bandwidth product, before looking at all decent in audio terms. The book doesn't quite reach this level of detailed analysis and argument, but then that was doubtless not in its remit. It does cover an immense amount, including test equipment, noise and hum, tuned circuits and radio receivers, power supplies, component marking conventions and circuit impedance and phase angle calculations using the i operator.

Because of its rare, almost unique nature - I know of no other dedicated hi-fi design book - The Art of Linear Electronics is, for engineers or budding engineers, invaluable. At £16.95 (soft cover), when nearest equivalents lie in the £30-£80 range these days, it's also an extreme bargain in my view.

Available from bookshops or Hi-Fi World, see page 101.
HIGH QUALITY HEADPHONE AMPLIFIER

A high-quality, single-ended Class A headphone amplifier designed and explained by Richard Brice.

High-quality loudspeakers deserve a high-quality amplifier to drive them. In just the same way, high-quality headphones deserve their own dedicated amplifier designed to furnish them with the cleanest signal that it is practically possible to supply. Sadly, headphone amplifier stages in hi-fi separates, where they exist at all, are often engineered with an eye to simplicity and low cost, rather than with a view to providing an exemplary mini-power-amplifier. Because that's what a headphone amplifier really should be and it ought, therefore, to have as much care and attention-to-detail lavished upon it as a designer would when developing a state-of-the-art loudspeaker power amplifier. This choice confers two important advantages: it is simpler to build, and single-ended is widely regarded as the ultimate circuit configuration for audio signal handling.

I first suggested a Class A headphone amplifier circuit in my recorded Message column a few months ago. The circuit shown in Fig. 1 incorporates a number of improvements and embellishments over the original circuit and is sensitive enough to be fed from most sources, including cassette decks. Firstly, the output transistors are buffered by an extra PNP emitter follower which raises the input impedance seen by the op-amp driver and removes the need to fiddle with the bias resistors to achieve an optimum quiescent point, which was an awkward job required in the original circuit.

Secondly, and much more unusually, I have introduced an optional, secondary signal path through op-amps U2a and U2b. In order to understand the effect of this extra circuit, it's necessary to take a sideways look at some obscure psychoacoustics. In a nutshell, the extra circuit inverts the phase of the signal fed to one ear and the brain interprets this as a frequency-dependent delay effect. The result is that the stereo image, normally centred in the middle of the head, seems to spread out to fill the whole head with sound. Also, due to an effect known as binaural masking level difference, it is possible to detect
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World Radio History
instrumental lines at very low levels within the mix that would be inaudible if the signals arrived at the ears in-phase. The circuit may be used (and/or built) ignoring this phase-shifting circuit by ensuring LK1 and LK2 are fitted in the lower positions on the diagram. If LKI and LK2 are fitted in the upper position, the phase-shift is introduced. The inclusion of this link arrangement means constructors can be perceptual psychologists too and experiment for themselves!

A high-quality, glass fibre, printed-circuit board will be available from the Hi-Fi World offices for this circuit. The circuit requires a well-smoothed power supply of +/-12V d.c. at about 200mA per rail. A convenient and technically excellent solution would be to buy a complete, encapsulated power supply from Electromail (Tel: 0536 204555 Order No. 591-102, price approx £60).

**WARNING**
A final word of warning. When you have built the circuit, don't be tempted to get those headphones on and start to boogie before you have checked the voltages shown on the diagram above. Above all, don't fiddle with the circuit board, the components or power supply when you are wearing headphones which are plugged in. Accidentally moving or unseating a component might cause plops, bangs, cracks and thumps in the headphones which would subject your ears to high acoustic intensities and possibly damage your hearing.

### HEADPHONE AMPLIFIER PARTS LIST

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HI-FI WORLD SUPPLEMENT AUGUST 1994
LOOKING FOR A SYSTEM

Earlier this year I built a pair of IPL M3 speakers. They not only look good, but knock my old Mordaunt-Short MS20s for six! I've since built speaker stands to suit the IPLs, but unfortunately my 21 month old son does not allow me to leave the IPLs permanently set-up.

Secondly, I'm after your advice. Not concerning my son's desire to damage speaker drive units, but on the harder subject of CD players. The rest of my system comprises Pink Triangle LPT, Roksan Tabriz, Sumiko Blue Point, Audiolab 8000A.

I am pleased with the current performance from vinyl using the IPLs. The music is more often detailed and tuneful, with the individual instruments being more clearly defined when compared to the MS20s. The sound is not forceful in presentation - I like to 'relax' when listening to music.

I would ideally like a CD player capable of complementing my turntable. Am I asking too much? I have previously borrowed sub-£200 players and found them lacking. Unfortunately, my budget for this purchase is only £400 maximum. You have previously reviewed players like the Yamaha CDX-870 and Aura CD50 (black). Are these possibilities and do you have any other suggestions?

Andrew J. Dean
Milverton, Somerset.

Unfortunately you are asking the impossible if you want a CD player for £400 to match the performance of your £600+ turntable. I'd suggest that your best bet would be to go for a budget CD player for the time being and then add an external high quality D/A convertor at a later date as your CD collection increases. The Yamaha has a very smooth and neutral sound, and is possibly the closest in terms of tonal balance to the Pink Triangle turntable.

When the time comes

DPA's Little Bit II convertor would make a good choice, or maybe Pink Triangle will have a £300 DAC available by then. But as you've already taken an interest in DIY hi-fi, you could have a go at one of Audio Synthesis' superb kit DACs. These are tricky to build, and you'll need to have plenty of experience, but they do sound superb.

AFFORDABLE DIY HI-FI

I have been a regular reader of your Magazine since the issue with DIY Supplement No.2, which I must admit is the reason I began buying it. I have been following with some interest the development of your amps and loudspeakers.

Being, at the time of writing, unemployed, I sympathise with a recent correspondent who enquired if the (cheaper) amplifier kits from Maplin are worth considering. I thought that he and maybe others in a similar position might be interested in my experiences.

My system is as follows.

Main source is a Thorens TD160 turntable fitted with an SME 3009 arm and Ortofon VMS 20E (which is due to be replaced by a Goldring 1012GX when funds permit). This was bought second hand around 4 years ago. I also use an elderly Pioneer CT-200 cassette deck, but as yet no CD player.

All the rest of the system is
home built. The pre-amp is a three-stage Class A design with shunt feedback on the RIAA stage. This is based on a project in E.T.I. in 1982, the 'System A' modular amplifier by Stan Curtis. The power amp is built around a Maplin Project board using the LM 1875 op-amp. Both are supplied by an external power supply that provides 15-0-15 volts for the pre-amp and 17-0-17 volts for the power amp and is built around a large toroidal transformer with a regulated output.

The speakers are single driver transmission lines. See 'An Introduction to loudspeakers and enclosure design' by V. Capel, Babani Books BP256. I modified the design published as follows. The front, sides, top and bottom are made from 18mm MDF, with the sides being in one piece, not three as suggested. Internal partitions and the back are 12mm chipboard. The cabinet is glued and screwed together and is very solid. The internal partitions are held by a 12mm quadrant glued and pinned in

place. Wadding and speaker cable were obtained from Maplin. I estimate the cost of building these speakers at not more than £50 for the pair. All cables and interconnects are whatever I had around that was suitable; mostly rather lo-fi.

Is the result hi-fi? I don't know, but it sounds good to me. Everyone who has heard it has commented how clear and natural the sound is, one dedicated CD fan swearing that my records sounded clearer than his CDs. The only criticism that's been offered is that the bass is perhaps a bit light. But I wonder if in fact what is missing is the "one note" bass thump that some speakers seem to produce, and which is taken as being 'bass' by some.

The point of this letter is that it is possible to put together a listenable system that is within the reach of almost anyone, if they are prepared to do the sawing and soldering. If anyone would like more information, i.e. circuit/board layouts for the pre-amp, they are available on request.

Anthony Maughan Worthing, Sussex.

P.S. I think that my speakers pass the 'Tina Turner' Break Every Rule' Test.

BUILDING KLS-I

I thought you may find it of interest to hear from a satisfied nut.

I wrote to you and all the other hi-fi mags when I got my new EAR 834 amp, I was so pleased with it I got no reply from any of them. Well, as your magazine is the most interesting, because of the DIY Supplements with valves and DIY loudspeakers, I picked you to continue writing to.

If getting a new valve amp isn't interesting for you, what about a pair of home made transmission line speakers! Please at least read this one, or I will loose heart - I'm a very keen hi-fi nut.

Well, I've enclosed some photos for you - I hope they are O.K. Do you like the old collection of valves? I had some old MC4s and wasn't happy with the sound. Changing the amp made a big difference, but the small speakers weren't letting all that wonderful sound coming from my EAR 834 through, so I made my new speakers from a display cabinet (black Ash). It was hard work, but worth it. I am very pleased now with my new transmission line speakers. Internal wire is van den Hul D352 for midrange and bass, solid core for the tweeter.

Wire from the crossover, which is in a small box at the back of the speaker on the floor, to the amplifier is AQ Midnight 2. The separate black box stand is full of lead shot from work - very heavy. They are spiked of course.

I also got new phono leads made by Keswick Audio Research from my Hi-Fi Dealer in Doncaster, the Hi-Fi Studios. He is coming down to see my speakers and hear them for himself.

If you want any more detail on my speakers I am only too happy to help. Please let me know what you think!

Anthony Maughan Worthing, Sussex
customer (one of many, I'm sure). This is the story of how I became the proud owner of KLS-1 three way speakers.

After selling my much loved AE Is in early 1992, it was my intention to put this money towards a pair of somewhat larger boxes. My system comprised LP 2, lttok, Goldring Excel and Lentek integrated amplifier.

Then the plans decided to change without my permission. I just couldn't resist buying a pair of very reasonably priced Naim NAP135 power amps. The Lentek was put into use as a pre amp and once again I decided to purchase the full kit.

After a painfully long time the bank balance reached almost usable proportions. Then (I'm still not sure why) I bought it all on a 29" Trinitron, Surround Sound inc decoder and Panasonic stereo video.

More months of saving later, a Teac VRDS-10 caught my ear. I was quite impressed (lucky it didn't catch my eye first, whatever the yardstick may be, it's beauty can at best be described as more Margeret Thatcher than Naomi Campbell). I also heard it connected to a P.T. Da-Capo and bought the VRDS-10 on the basis of its upgradeability and fine performance as a stand alone player.

The following months were spent looking for a speaker that could match the mid-range of the AEIs, but go lower and not include anything that sounded remotely like a metal dome tweeter. Thanks to a very helpful local dealer, Bury Audio, I was able to hear and/or home dem the Shahanian Arc, Heybrook Quartet, Heybrook Sextet and ProAc Response Is. These were compared with previous experiences of Naim SBLs, Linn Isobanks and numerous others of varying shape, size, type, price etc. The nearest to meeting my criteria was either the ProAc (with REL sub woofer) or the Sextet. Unfortunately one was too expensive and the other a little bit reserved and laid back for my liking.

Well that's the background now down to the real business. The Tonigen ribbon tweeter produced the most impressive treble of any speaker I'd heard. How was I going to find my ideal speaker with this sort of limitation? Time was running out - I had to do something before some other irresistible goodie forced me into parting with my hard earned cash.

WIN A MAPLIN SOLDERING IRON KIT COMPLETE WITH A LENGTH OF SILVER SOLDER

The writer of the most interesting DIY letter each month will receive a superb Maplin soldering iron, stand, booklet on good soldering practice and a length of high quality silver solder.

Write in to: Hi-Fi World DIY letters, 64 Castellain Rd, Maida Vale, London W9 1EX.
the paint job was to be professionally done by a car restoration company. This would cost a further £200 so I felt a little extra effort on surface preparation was fully justified. As promised the machined panels all slotted together perfectly with minimal overhang. The process of assembling all 36 pieces and the crossover boxes was indeed a relatively painless process. The paint job is wonderful. But the drive home (60 miles) was rather stressful.

All the staff at Hi-Fi World continued to be supportive and helpful at all times. My only complaint would be an overuse of the phrase “I promise to call you back” (you never did!). Thankfully for us readers you are enthusiasts first and businessmen second. Although this may contribute to some frustration it is a mild criticism.

Anyway, all bits were eventually received and the whole caboodle glued, screwed and soldered together. At this point may I offer other constructors the benefit of my experience (mistakes) with a few tips.

1) Work out how you are going to connect the mid/treble units to the crossover before gluing the boxes together. I used Ortofon bi-wire cable and binding posts bolted through the MDF itself. With hindsight the binding posts should have been mounted on a metal plate screwed over a pre-cut hole in the back of the mid/treble enclosure before gluing took place.

2) If you intend to use spikes, reinforce the bottom of the bass enclosure in each corner with a triangle of MDF. If you don’t, you may drill right through and unseal the sealed design!

3) Use decent mounting cones for the mid/treble enclosure. My dealer supplied some interesting brass/carbon fibre items which work well and look very good.

4) If you are having the cabinets painted I found that a decent radius on every edge improved the aesthetics no end.

5) Beware the dreaded test disc! Despite the numerous warnings on mine about the high frequency tones, I managed to turn both tweeters into a very short, but irreversible fireworks display. Remember just because you can’t hear it doesn’t mean it isn’t there.

The sound produced had potential but was far from balanced. The following few weeks were spent experimenting with crossover values and enclosure stuffing density. A very prominent upper midband is now tamed and the bass frequencies enhanced at the crossover point. After all this experimentation I do feel satisfied that my speakers are better than anything that I’ve heard for £1,000 and probably much more. What adds to my satisfaction is that the finish would normally cost up to £500 extra on your average floorstanders.

My remaining doubts are bass depth and slight midrange coloration. However as DB’s pair sounded far more expressive and weighty in the lower registers, I guess it must be the system or room, probably a bit of both. The room, which is eighteen foot square with a low ceiling seems to suck out low frequencies. Also the Lentek, although a wonderful piece of British design, is a bit out of its frequencies. Also the Lentek, although a wonderful piece of British design, is a bit out of its depth and possibly an electrical mismatch for the Naim amps. The mid-range colouration will probably improve with the modifications you describe, further experimentation with stuffing and maybe trying Deflex panels!

In summary, I believe the kit is a very capable design that can produce excellent results. If you’re like me and can cope no longer with metal domes and long for a Sextet with balls, then the KLS-I may prove to be your saviour, but please don’t skimp on the finish. Even my cloth eared peasant friends can appreciate that. No matter what people may like to think, I believe the experience of owning and listening to hi-fi is enhanced if the equipment looks and feels quality.

I hope your magazine continues to provide its readers with more innovative kits and understandable technical information. I would like to dabble with active systems and long for the day when you design and build a high quality and user adjustable two or three way active crossover. This I am sure would enable the KLS-I to reach new levels of performance, if such an animal exists please let me know.

Meanwhile, who let that bloody baby put his grubby mits on my speakers? I don’t care if he likes looking at his reflection!

R. Cockman
Bury St Edmunds, Suffolk.

Phew! It all sounds as much effort as designing the original - and pretty costly too when two Tonijens go up in smoke. The crossover point problems may be due to component variations, including driver frequency response, something we cannot be certain about without testing large batches, which is obviously impractical.

The bass cabinets go very low and have a good bass punch, so I think you may well be suffering some room imposed limitations here.

The problem of midrange colouration I cannot understand - it is difficult to find an explanation. Neither driver nor cabinet should be responsible. Be careful you have not over-stuffed the chambers, especially just behind the drive unit, because then too much energy will be reflected back out through the cone. Damping needs to be made progressive, loose to begin with, but becoming steadily more dense as distance behind the cone increases. The cabinet walls must be covered with dense carpet felt too. Then you should find the midrange seamless, highly detailed and just about characterless. Good luck - I’m glad you like them. NK
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