Surround sound decoders — 2

Assembly, setting-up CD-4 unit, cartridge notes

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This article includes performance details of a CD-4 decoder using the QSI i.c., which includes preamplifier, phase-locked loop demodulator, a.n.r.s. expander and muting circuits. Spectrum analyser traces show performance of record-cartridge-decoder system for various extended-response cartridges. Subsequent articles by the same author will give circuits for QS and SQ surround sound decoders.

The construction of the demodulator is straightforward, but note the following points. Solder the link wires whose positions have been silk-screened on top of the board after soldering resistors into position, but before soldering the remaining components. Do not apply too much heat to the polystyrene capacitors; these 30 volt devices are closely wound and excessive heat will short the layers together.

The 12mH, 15mH and 18mH inductors are variable inductors which have been preset. They are either marked with their values or colour coded with paint (red — 12mH, green — 15mH and grey — 18mH). On no account should the pot cores be adjusted and each coil should only be handled by its case so as not to disturb the core.

Use insulated wire to connect remaining links (marked A to A, B to B, C to C, D to D, E to E, F to F, G to G and H to H on the board). These connections are best made on the copper side of the board.

In connecting the signal input to the board (points h and i on the switches to points h and i on the board), use screened cable but only earth one side of the lead. To stop possible r.f. breakthrough, loop small ferrite beads with three to four turns of wire and solder one end of this wire to the points on the board (marked h and i) with the other end going to the audio lead.

Connect the points on the switch positions to the similarly marked points on the board using insulated wire. Again it is preferable to make the connections on the underside of the board. (The positions to be connected are b to b, o to o, c to c, x to x, d to d, m to m, e to e, l to l. Points f, k, a and p are left unconnected.) The signal input leads to the selector switches are: tuner input to v (left) and w (right); auxiliary input to s (left) and t (right); tape input to g (left) and r (right), and disc input to g (left) and j (right).

Care must be taken not to create an earth loop; in particular the input socket earth must not touch the chassis. A separate earth line should be run from the mains socket earth to the earth of the power supply. And the board should only be earthed in one position i.e. an earth wire is run from the earth point on the board to the power supply earth. A 100nF capacitor should be soldered between the input socket earth and chassis. Run an earth wire from the chassis to the power supply earth terminal.

Connections for switches S_1 are best "hard-wired", depending on whether a magnetic or semi-conductor cartridge is used. (Note that on the p.c. board, the marking "S1E" correspond to S_{1b} in the circuit diagram. S4 on the board corresponds to S_2 in the circuit.)

When wiring is completed (do not forget the l.e.d. — anode to supply rail) mount the board in its box and connect up a regulated 13 to 14 volt supply line to the supply rail, but do not turn on. (A power supply is included in the kit available from Compcor; a circuit will be given with the next part and is suitable for the CD-4, QS and SQ decoders.)

Setting-up procedure

Connect the record player fitted with extended-response cartridge to the input jacks of the demodulator using low-capacity TV cable of approximately 50pF/metre. Limit the cable length to maintain a total capacitance of 100pF or less. Run a separate earth wire from the chassis of the demodulator to a screw or chassis of the turntable.

Switch on the equipment and place the pickup on band 2 of side 2 of the test record. If the demodulator is functioning and either of the two phase locked loops are in-lock, the l.e.d. should glow. Adjust the 4.7kΩ v.c.o. potentiometers so that the l.e.d. glows brightest. By turning the v.c.o.-adjust potentiometer ($R_{57,157}$) to either of the extreme positions, the l.e.d. will either go off or vary in intensity depending whether the other v.c.o. is in lock or out of lock.

Turn the test record to side 1, band 3. This gives the same music played sequentially out of each speaker. Turn down the front volume controls of your amplifier. Adjust the 1kΩ separation potentiometer ($R_{9,109}$) of the preamplifier for minimum loudness out of the respective rear channels when the announcer states the front channel sound. The announcer will state "left front channel" and music will follow. Adjust the left separation adjust to get minimum loudness from the left rear channel. Disregard the announcement of the rear channel music. Repeat the process for the right front channel announcement, this time tuning for minimum right rear channel loudness.

Alternatively, the white noise source on band 2 can be used. This is fully explained on the test record. Return to side 2 of the test record and place the cartridge anywhere from band 2 onward. Turn the balance control first to the left side and adjust the left hand side v.c.o. control for minimum distortion. Repeat the process with the balance control set for the right hand side.

Extended-response cartridges

The following nine cartridges were tested: Tenorel 2001SD, Audio Technica 12S, Nagaoka JT322, JVC 4MD20X, B & O MMC5000, B & O MMC6000, JVCX1, Pickering UV152400 and Pickering XUV4500. Each cartridge was tested in an SME arm with detachable headshell. Tracking weights between 1gm and 3gm were chosen depending on the

various manufacturers' recommendations. Using side 1, band 3 of the test record, the separation control was adjusted for minimum level out of each of the rear speakers.

Side 1, band 2 of the test record contains CD-4 encoded white noise. With the aid of an audio spectrum analyser, kindly loaned by Hewlett-Packard, the spectrum level of the front channel was measured and stored on the display. The analyser was then connected to the rear channels and the same passage of white noise was replayed and the spectrum level recorded on the lower trace.

The accompanying photographs, Fig. 11, show the relative levels between front and back for the left hand channels only, the top trace being the front channel and the lower trace being the rear channel. The difference in level is thus the separation obtained from the disc encoded material through the cartridge and demodulator.

Performance

Input level	0.7 to 14mV
Input impedance magnetic	100kΩ
semiconductor	2.2kΩ
Output level	300mV
Output impedance	less than 200Ω
Amplitude response baseband system	30Hz to 15kHz, −3dB
carrier system	30Hz to 12kHz, −3dB
Harmonic distortion baseband	less than 0.2%, at 150mV output (typically 0.05%)
carrier channel	less than 1%, at 150mV output, 1—10kHz
Power supply	12 to 15V, 130mA max

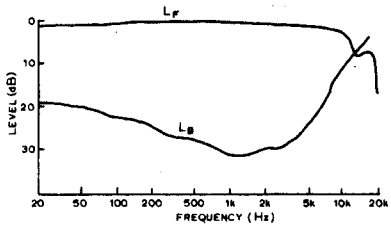


Fig. 13. Front-back separation measured using test bench generator. Sum signal delayed by 45μs with reference to the carrier signal.

Separation front-back	>30dB at 1kHz. See Fig. 13 for system separation
left-right	60dB at 1kHz
S/n ratio*	>60dB

*Measured using a virgin test record, containing an unmodulated and modulated (1kHz) carrier together with 1kHz baseband signal.

Components

Resistors All ¼W 5% carbon film

$R_{1, 101}$	47k
$R_{2, 102}$	100k
$R_{3, 103}$	10k
$R_{4, 104}$	150k
$R_{5, 105}$	15k
$R_{6, 106}$	15k
$R_{7, 107}$	15k
$R_{8, 108}$	2.2k
$R_{9, 109}$	1k pot
$R_{10, 110}$	20
$R_{11, 111}$	2.2k
$R_{12, 112}$	20
$R_{13, 113}$	330
$R_{14, 114}$	3.3k
R_{115}	150k
R_{16}	100k
$R_{17, 117}$	6.8k
$R_{18, 118}$	8.2k
$R_{19, 119}$	7.5k
$R_{20, 120}$	15k
$R_{21, 121}$	4.7k
$R_{22, 122}$	4.7k
$R_{23, 123}$	4.7k
$R_{24, 124}$	8.2k
$R_{25, 125}$	4.7k
$R_{26, 126}$	1k
$R_{27, 127}$	27k
$R_{28, 128}$	4.7k
$R_{29, 129}$	15k
$R_{30, 130}$	220k
$R_{31, 131}$	15k
$R_{32, 132}$	4.7k
$R_{33, 133}$	10k
$R_{34, 134}$	220k
$R_{35, 135}$	3.3k
$R_{36, 136}$	4.7k
$R_{37, 137}$	4.7k
$R_{38, 138}$	4.7k
$R_{39, 139}$	4.7k
$R_{40, 140}$	470k
$R_{41, 141}$	1.8k
$R_{42, 142}$	4.7k
$R_{43, 143}$	4.7k
$R_{44, 144}$	4.7k
$R_{45, 145}$	47k
$R_{46, 146}$	4.7k
$R_{47, 147}$	4.7k
$R_{48, 148}$	4.7k
$R_{49, 149}$	47k
R_{50}	1.8k
$R_{51, 151}$	560k
R_{52}	330
$R_{53, 153}$	2.7k
$R_{54, 154}$	1k
$R_{55, 155}$	330
$R_{56, 156}$	56k
$R_{57, 157}$	4.7k preset
$R_{58, 158}$	10k
$R_{59, 159}$	10k
$R_{60, 160}$	10k optional
$R_{61, 161}$	10k

Capacitors

Types E are electrolytic, PC Siemens B32540 polycarbonate, PE polyester, PS 30V polystyrene, and DC disc ceramic.

$C_{1, 101}$	3.3μ	16V	E
$C_{2, 102}$	200μ	10V	E
$C_{3, 103}$	4.7n	PS	
$C_{4, 104}$	22n	PC	
$C_{5, 105}$	0.47μ		E
$C_{6, 106}$	33n	PS	
$C_{7, 107}$	2.2n	PC	
$C_{8, 108}$	2.2n	PC	
$C_{9, 109}$	8n	PE	
$C_{10, 110}$	450p	PS	
$C_{11, 111}$	1.4n	PS	
$C_{12, 112}$	1.6n	PS	
$C_{13, 113}$	10n	DC	
C_{114}	3.3μ	16V	E
$C_{15, 115}$	2.7n	PS	
$C_{16, 116}$	2.1n	PS	
$C_{17, 117}$	960p	PS	
$C_{18, 118}$	3.9n	PS	
$C_{19, 119}$	6.8n	PS	
$C_{20, 120}$	3.3μ	16V	E
$C_{21, 121}$	7.2n	PS	
$C_{22, 122}$	10n	DC	
$C_{23, 123}$	3.3μ	16V	E
$C_{24, 124}$	100p	PS	
$C_{25, 125}$	100p	PS	
$C_{26, 126}$	0.47μ	16V	E
$C_{27, 127}$	2.2n	PC	
$C_{28, 128}$	0.68	PC	
$C_{29, 129}$	4.7μ	16V	E
$C_{30, 130}$	960p	PS	
$C_{31, 131}$	3.9n	PS	
$C_{32, 132}$	3.1n	PS	
$C_{33, 133}$	3.3μ	16V	E
$C_{34, 134}$	3.3μ	16V	E
C_{135}	100μ	10V	E
$C_{36, 136}$	10n	DC	
$C_{37, 137}$	6.2n	PS	
$C_{38, 138}$	800p	PS	
$C_{39, 139}$	3.3μ	16V	E
$C_{40, 140}$	68p	DC	
$C_{41, 141}$	10n	DC	
$C_{42, 142}$	6.2n	PS	
$C_{43, 143}$	800p	PS	
$C_{44, 144}$	3.3μ	16V	E
$C_{45, 145}$	68p	DC	
$C_{46, 146}$	10n	DC	
C_{147}	100μ	10V	E
$C_{48, 148}$	100μ	16V	E
$C_{49, 149}$	33μ	10V	E
$C_{50, 150}$	6.8n	PS	
$C_{51, 151}$	10μ	16V	E
$C_{52, 152}$	100n	DC	
$C_{53, 153}$	68p	DC	
$C_{54, 154}$	10n	DC	
$C_{55, 155}$	10n	DC	
$C_{56, 156}$	68p	DC	

Semiconductor devices

IC_1, IC_{101} Signetics QS5022
Tr_1 — Tr_4, Tr_{101} — Tr_{104} BC208A
D_1, D_{101}, D_2, D_{102} 1N4148
light-emitting diode TIL209, MLED650, or similar

Inductors

$L_{1, 101}$	15mH Toko 80016
$L_{2, 102}$	18mH Toko 80016
$L_{3, 103}$	12mH Toko 80016
$L_{4, 104}$	15mH Toko 80016
$L_{5, 105}$	100mH TDK 104J

A 10kHz bandwidth is displayed because, in all but one case, the separation fell below 5dB after 10kHz. The only exception was the B & O MMC5000 where 10dB of separation extended to 13kHz Fig. 12.

In addition listening tests were carried out using difficult CD-4 records. The following is a brief assessment of each cartridge.

Tenorel 2001SD. Separation of 18dB was attained at about 2kHz, but disappeared totally at 9kHz and reversed at 9.25 kHz. In the listening tests, carrier dropout occurred frequently with annoying results. Playing weights of close on 3gm were required with the result that the cartridge base nearly touched the record.

Audio Technica 12S. Peak separation of 18dB occurred at about 2kHz, decreasing to 5dB at about 8kHz and remained at such to 13kHz, where the low-pass filter in the demodulator started to take effect. A tracking weight of 1.8gm gave good results with little carrier dropout. This cartridge is available at discount stores for about £17 (including v.a.t.) and is the low cost cartridge I would recommend for the system.

Nagaoka JT322. This cartridge displayed 15dB separation at 2kHz, but this disappeared at about 9kHz. Its output at 2gm tracking weight was on the low side and it did not track difficult passages as well as the AT12S. This cartridge is available from its distributor in The Netherlands at a cost of about £22. The AT12S is a better bet.

JVC 4MD20X. This cartridge gave essentially similar results to the AT12S, but is about twice its cost. I would go for the AT12S in preference as I found little to choose between the two in performance.

B & O MMC6000. The MMC6000 has a recommended tracking weight of 1gm. I tried three of these cartridges and none functioned satisfactorily. The devices suffered from carrier loss particularly in the left channel. The latest sample I tried was found to be defective when played through B & O's own demodulator. I believe the cartridge should only be used in the tangential player for which it was designed; the SME arm has too much mass for such a delicate cartridge.

B & O MMC5000. The MMC5000 gave excellent separation results, as the extended separation trace of Fig. 12 shows. However, the maximum practicable tracking weight was 1.5gm and this was inadequate for an SME or similar type arm. The cartridge is ideally suited for the B & O 3400 unit which has a low-mass arm and can thus track at a lower weight more effectively. A pity, because this cartridge showed signs of excellence, but carrier breakup was too frequent for comfort. On consulting B & O they agreed that a low-mass arm would be needed to ensure effective tracking.

JVC X1. This cartridge gave 20dB separation between 2 and 5kHz, settling to about 5dB at 9kHz. Its tracking of CD-4 records at 1.8gm was excellent and its clarity was unequalled by any other cartridge except Pickering's XUV4500. This is indeed an excellent CD-4 cartridge and is available at some discount stores at about £50. For those who have the money, this represents very good value.

Pickering UV152400 and XUV4500. Both of these cartridges are very expensive. The UV152400 displayed similar separation characteristics as the AT12S but was clearly superior in tonal quality. However, it is more expensive than the JVC X1.

The XUV4500 was an excellent cartridge. Admittedly the separation exhibited in the photograph looks poor (about 10dB over the bandwidth displayed), but it is likely that this is because the delay time of this cartridge is shorter than that of the other cartridges tested (12μs for the XUV4500 against 25μs for the majority of the others). The demodulator is designed for a 25μs delay through the cartridge and any deviation from this will reduce separation. In listening tests I was not

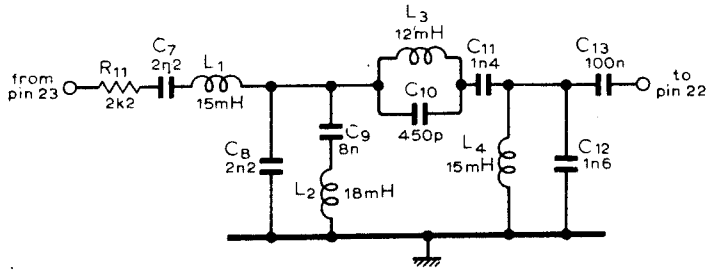
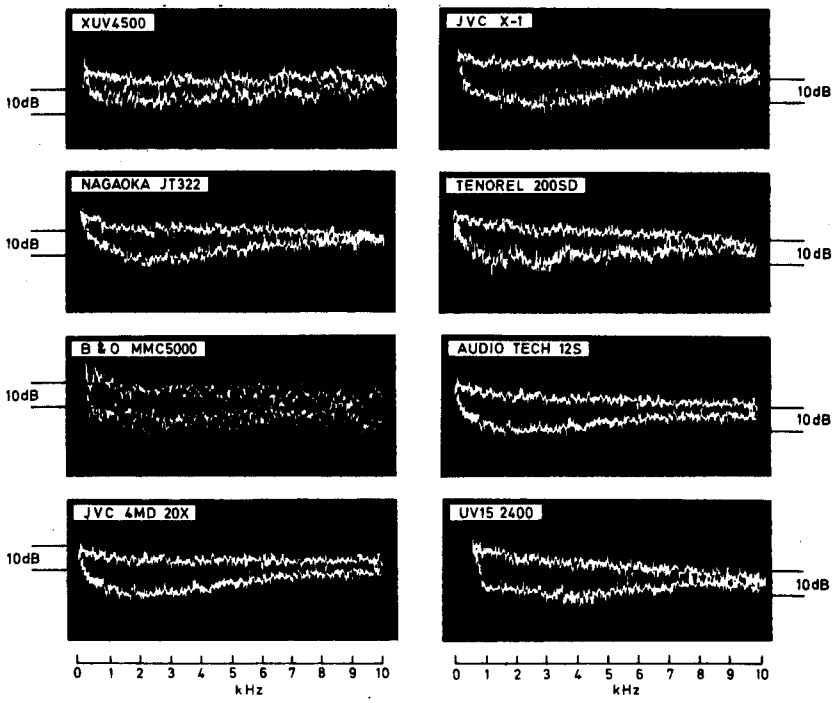


Fig. 10. Linear phase filter with delay of 32μs, 19-45kHz. Two of these filters are used in the circuit of Fig. 9.

Fig. 11. Spectra of the left front and left back demodulated signals from a white noise CD-4 encoded disc through selected cartridges and the demodulator.



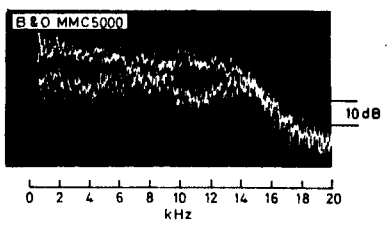
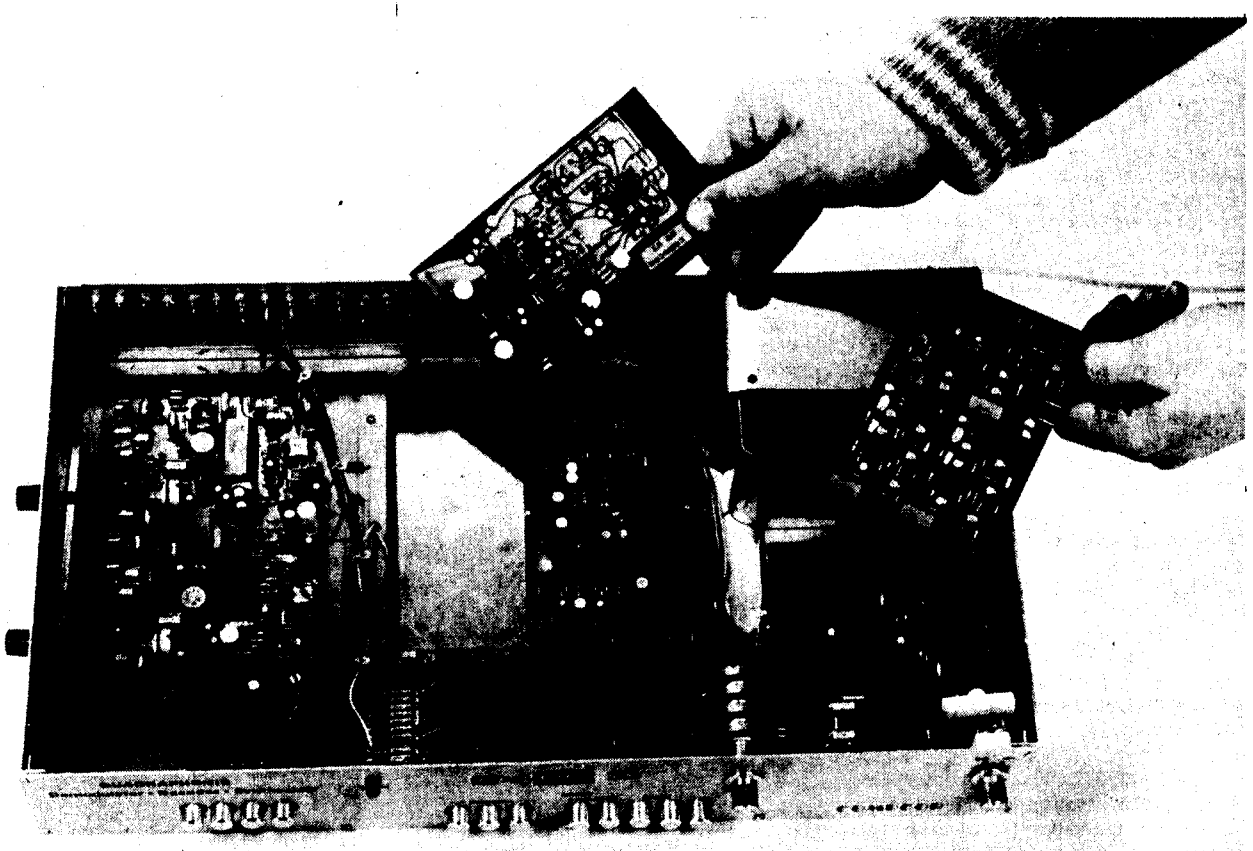


Fig. 12. Separation of 10dB or more extends to 13kHz in the case of the B&O mmc5000 cartridge.



One format of the surround-sound decoder incorporating CD-4 unit (left). A two-board SQ decoder is shown right, and a two-board QS decoder middle. There is space for a rear-channel, preamplifier and tone control, above the switchboard.

able to perceive any less separation through this cartridge when compared to the JVC X1. It performed equally as well as the X1 and proved superior on stereo discs to the X1. Both cartridges were tested using the difficult band of the Hi-Fi Sound 75 test record. The XUV4500 tracked this band perfectly, while the JVC X1 displayed some slight mistracking.

After carrying out extensive tests on the cartridges named, I would recommend the AT12S for budget systems and the JVC X1 for those who can afford it. In both cases a tracking weight of between 1.8 and 2.0gm proved optimal.

Correction. On page 45 of the June issue, the reference to C_{38} should be to C_{33}.

Acknowledgement. I should like to thank Lou Dorren of Quadracast Systems Inc. for the valuable help and guidance given in the preparation of this CD-4 project. Thanks too to Hewlett Packard for the loan of the audio spectrum analyser.

A kit of parts (except metalwork) may be obtained from Compcor Electronics Ltd, 9 Dell Way, London W13 8JH for £37 inclusive of v.a.t., packing, postage and insurance. The same price applies to overseas readers, and covers the cost of airmail postage. A test record produced by Quadracast Systems Inc is available for £4.20 inclusive from the same supplier.

A specially constructed case is available from Bazelli Instrument Cases, St. Wilfred's, Foundry Lane, Halton, Lancaster LA2 6LT for £10 (including v.a.t. and carriage) with fully punched panels or £8 unpunched. This case will house CD-4, QS and SQ decoders and power supply. A suitable case for the CD-4 module only is type B304, available from the same company for about £5 (unpunched) inclusive of delivery and v.a.t.

Announcements

Panduit Ltd of Sittingbourne, Kent, manufacturer of cable ties and DIN connectors, has announced the appointment of Vero Electronics Ltd, Chandler's Ford, Eastleigh, Hants, as the UK stockist and distributor for the Panduit range of DIN 41612 and 41613 one-piece and two-piece connectors.

Gould Advance Ltd has appointed J. Sinclair Ltd, 8 Dixon Place, College Milton North, E. Kilbride, Glasgow, G74 5JF, as the Scottish agent for Gould Advance power supplies and Gould Brush oscillographic recorders.

Ferrograph, Ferrograph Professional, Rendar and Wayne Kerr, formerly operating as separate companies within the Wilmot Breeden (Holdings) Ltd, are to trade collectively as **Wilmot Breeden Electronics Ltd.** Manufacturing facilities for the various product groups will remain at South Shields, Burgess Hill and Bognor Regis.

Laskys, one of Europe's leading hi-fi retailers, has announced a new service. All of Laskys' 35 branches will offer a **repair service for any hi-fi equipment,** provided that spare parts are available. You do not need to have purchased the equipment from Laskys.

Boosey & Hawkes Ltd has formulated a new subsidiary **Boosey & Hawkes (Electrosonics) Limited.** This follows the acquisition earlier this month of 50 per cent of Hammond Organ UK Ltd. Hammond will continue to be run by its existing management team who will also manage Boosey & Hawkes (Electrosonics). Boosey & Hawkes (Electrosonics) will market a range of electronic musical products both in the UK and overseas. It will be exclusive distributor of Leslie Speakers in the UK and will operate from new premises at St Albans, Herts.

Steatite Insulations Ltd, Hagley House, Hagley Road, Birmingham, B16 8QW, have announced their entry into the field of semiconductor devices in co-operation with **Toshiba (UK) Ltd.** The aim of the agreement is to broaden the UK penetration of Toshiba's semiconductors and to enable this by forming a semiconductor marketing department at the Steatite Group's headquarters in Birmingham.

In keeping with their involvement with the military electronics industry, **Sealectro Ltd,** Walton Road, Farlington, Portsmouth, PO6 1TB, manufacturers of precision coaxial connectors, insulated terminals and programming devices, have received approval by the Ministry of Defence to the recently introduced standard 05-21.

The UK agency for **Fuki Film magnetic tape** has been given to Belmont A/V Ltd, a member of the Pyser Group, at Fircroft Way, Edenbridge, Kent, TN8 6HA. The range of Fuki Film cassette and open reel tapes is available to the public from mid-May, 1976.

Uber Werke Munchen have announced that with effect from April 1st, 1976, a wholly owned subsidiary company, namely Uher Ltd, 24 Market Place, Falloden Way, London, N.W.11, will transact all business in the UK and Channel Islands under a distribution agreement.

Jermyn Industries, Vestry estate, Sevenoaks, Kent, will programme all National p.r.o.ms free of charge, providing the memories are purchased from them. They will also consider programming memories of other manufacture free of charge dependent on type of memory, application and complexity.