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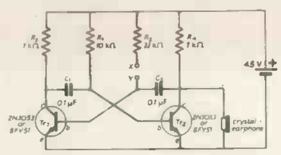

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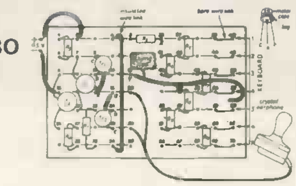

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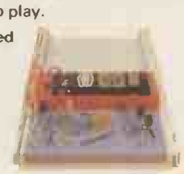

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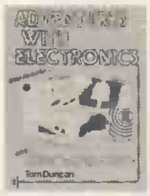

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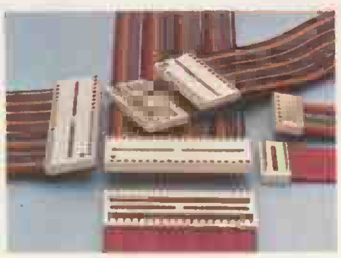

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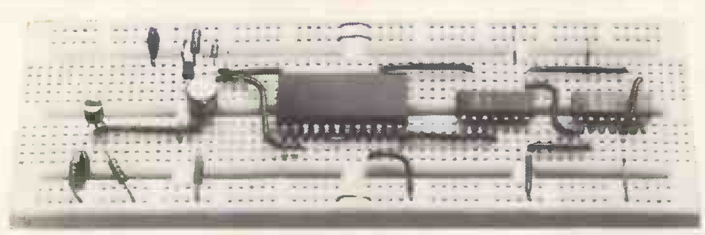

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May 1981

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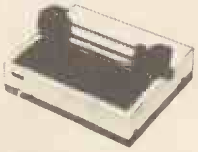

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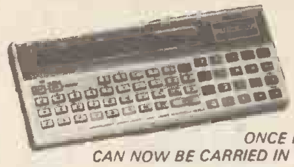

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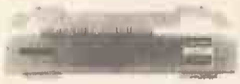

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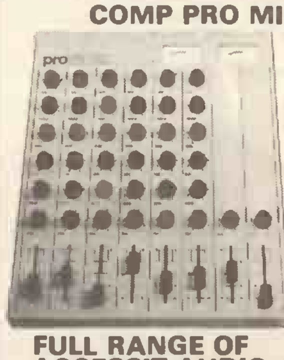

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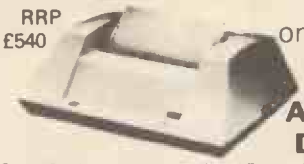

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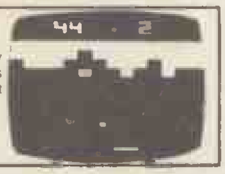

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Looking to the future, and not so far ahead at that, we shall reach a time when the musician's essential training will include a basic computer course. Already there are many popular micro-computers offering peripherals of software and hardware that allow music composition and notation. Despite the initial outlay of a suitably advanced system for the serious composer, the digital computer, with its large memory storage and potential for analysing as well as synthesising sounds, is destined to be the most powerful and flexible musical instrument ever invented; and it is likely to bring fundamental changes to instrument design and music-making. Over the coming months we shall continue

by Mike Beecher, Editor
Electronics & Music Maker.

to look at micro-computers that make music and feature instruments that are the most technologically advanced.

Although our instrument review this month looks at an expensive organ it is gratifying to know that our hobby of electronics gives us the opportunity to make music with the minimum financial resources. Our Matinee Organ project, in particular, has proved extremely popular with over 60 complete kits ordered in the first week of publication.

Our six electro-music projects in this issue should also prove useful items for musicians (and school music), and are very easily put together on a standard piece of Veroboard — we've given you one free on the front cover to start you off! Using the tone generator, radio and metronome through the mixer and amplifier, you could even have a lot of fun experimenting and recording — just like the avant-garde composers of yesteryear such as Stockhausen (see Record Review).

Some of our forthcoming projects related to music will undoubtedly give you a few surprises. Science fiction could well be reality with touch-controlled equipment, unusual shapes and computer speech and music bursting forth from every corner of the house! Certainly instruments will become controllers and intefacers as well as being more palatable to string and wind players — and, of course, electronics hobbyists!

Mike Beecher

Letters

**Send to: Reader's Letters, Electronics & Music Maker
282 London Road, Westcliff-on-Sea, Essex SS0 7JG.**

Dear Sir,
I have your new 'Electronic & Music Maker copy and I think it is just what is wanted, its first class! I am more than interested in constructing your 'Matinee' Organ project, having always been organ-minded but the price of the commercial models are way beyond my reach! Being retired now, I have time to pursue my hobby in the electronics organ line.

W. H. Huckerby,
Eastleigh, Hampshire

Dear Editor,
A thoroughly excellent magazine, a great pity to cut out the coupon. I am looking forward to the next issue, and wish you great success with your magazine.

M. R. Coundley, Pontypridd

Dear Sirs,
Well done on producing an excellent magazine. I especially liked the feature 'Basically BASIC' and found it easy to understand and to learn from. Keep up the good work.

S.G. Maclaren, Edinburgh

Dear Editor,
Would it be possible to set one of your experts the task of designing a small mixer, for those of us who wish to extend our musical capabilities to tape without spending a fortune? A mixer with 4 inputs and that records on an ordinary cassette would be adequate.

Adrian Smith,

The signal mixer on page 36 is a simple but effective device for this application and the veroboard is supplied free with this issue. A more professional device is planned for a forthcoming issue and will have separate channel faders and equalisation.

Dear Sir,
I have read with interest numbers one and two of Electronics and Music Maker and I think the idea of a combination of electronics and music is a very good one. It is worth every bit of 65 pence.
I also think the standard of projects are very high, and I hope it will stay this way.
Best of luck with this new idea, and thank you for a brilliant magazine!

S. Trease, Edwalton, Notts

Dear Sirs,
Two words, great and thankyou. This magazine is a step in the right direction. Two reasons, firstly I am no expert when it comes to electronics — in fact I'm a non starter. This magazine is so straightforward I can understand it and is a pleasure to read. Secondly, the Vienna LP album offer is just what was needed to fill the gap in my record collection.
These two factors have led me to order the parts required for the Syntom.
Good luck in the future and keep up the good work.

D.G. Fargher, Rainford

Dear Sir,
I'm sure you will already have been inundated with letters of praise for the new magazine. May I add yet another, for it shapes up well and ought to be a winner in this fast developing field.
As one of the founder members of E.O.C.S. I am particularly interested in organ matters and the use of the M108 chip is most welcome in the Matinee organ series.

C.D. Kirk, Isle of Bute

Dear Sir,
May I take this opportunity to say that I greatly enjoyed the first issues and look forward to number 3. Keep up the standard!
I think that your idea of producing demonstration tapes is a very good one, especially for people like myself who do not get the opportunity of hearing and comparing organ sounds etc. unless we take a trip to Liverpool or some other big city. If you can bring the sound to the readers' home by post I am sure that this would save a lot of time and effort.

F.C. Wilde, Isle of Man

Dear Editor,
I must congratulate you on the first edition of E&MM. Your 'meat-to-gravy ratio' is high, and your proof-reading is obviously being done more carefully than that of some other electronic journals — though I was somewhat puzzled to see in the Parts List on page 44 that Maplin now seem to be able to supply five-minute presets!
Keep up the standard and you've got a winner!

E. Jones, Shropshire

NOISE REDUCTION UNIT

by Dr David Ellis

Ideal for the home or semi-professional recording studio, a four-channel compander offering 30dB improvement of signal-to-noise ratio, simultaneous encoding/decoding and LED peak indicators.

It's on the cards that within the next five years there'll be a sixteen-track digital cassette recorder, complete with a touch control mixer, in a box the size of Teac's Portastudio. Even now, at the top end of the synthesizer spectrum, there's a new Crumar programmable polyphonic synthesiser with built-in digital recorder (but yet to arrive in this country) and the amazing Synclavier II complete with sixteen-track digital memory and every editing facility under the sun, a snip at a mere £16,000!

The great advantage of digital recording is the absence of noise, and, if one's working with digital instruments, as in the case of the above polysynths, then there's no A/D conversion before the sounds are committed to 'tape'. However, at what might be described as the tail end of the analogue era, most of us are stuck with trying to get the best possible sound out of our trusty Revoxes, Teacs, or whatever. The main problem with such machines is their annoying habit of burying your latest creation under a blanket of tape noise as soon as you depart from the first tape generation. And, with the new Teac 3440, the basic quality is so fine that some way of preventing the build-up of tape and machine noise seems a pretty logical step to take.

Noise reduction systems reduce the irritating noise of tape hiss and so on by an encode-decode process. Quiet sounds, especially those at the top end of the spectrum, are easily swamped by tape hiss, so an encoder is used to artificially boost these signals before they are recorded. During playback the reverse process decodes the recorded sound back to its original state and rids the music of tape-generated noise. Up until recently, noise reduction systems have fallen into three distinct types: Dolby B (domestic), Dolby A (professional) and DBX (professional). However, the near future is likely to see a confusing proliferation of other systems offering various degrees of noise suppression, including: Toshiba's Adres system, Telefunken's High-Com and Telcom, Sanyo's Super D, Dolby's C and HX systems and Tandberg's Dyneq. If there's any sense in this race to the pinnacle of perfect music reproduction, then hopefully there'll be some common standards of operation agreed upon! Table 1 gives the S/N ratios obtainable from various recording mediums with and without different types of noise reduction.

The various systems of noise reduction available at present basically work on the principle of complementary compression of the on-tape signal and expansion of the off-tape signal. Compression involves reducing the dynamic range of the material that is being recorded, so that, with a 2:1 compression ratio, if the input to the compressor increases by 12dB, then the output of the compressor (on-tape signal) will increase by only 6dB. Conversely, expansion involves increasing the dynamic range, so that an increase of 6dB in off-tape level will result in a 12dB increase fed to a subsequent mixer, thereby restoring the original dynamic level of the music. At the same time, the noise introduced in the recording chain, in particular tape hiss, will be rendered inaudible on expansion since this unwanted signal is not subject to the initial compression treatment and is therefore expanded downwards way below the lowest dynamics of the music signal. This process is illustrated in Figure 1.

Another feature of the compression/expansion process is that it allows the recording of signals with a dynamic range

Recording medium	Noise reduction	S/N ratio	Comments
Cassette (Sony TCK55 II)	- Dolby B	57dB	
	+ Dolby B	67dB	Above 4 KHz
	+ Dolby C	75dB	Above 1 KHz
	+ HighCom	75dB	Above 1 KHz
Four-track tape (Teac 3440)	No noise reduction	55dB	
	+ E&MM unit	85dB	Above 30 Hz
Two-track tape (Studer)	No noise reduction	70dB	
	+ Dolby A	80dB	Above 20 Hz

Table 1. Comparison of Noise Reduction Systems.

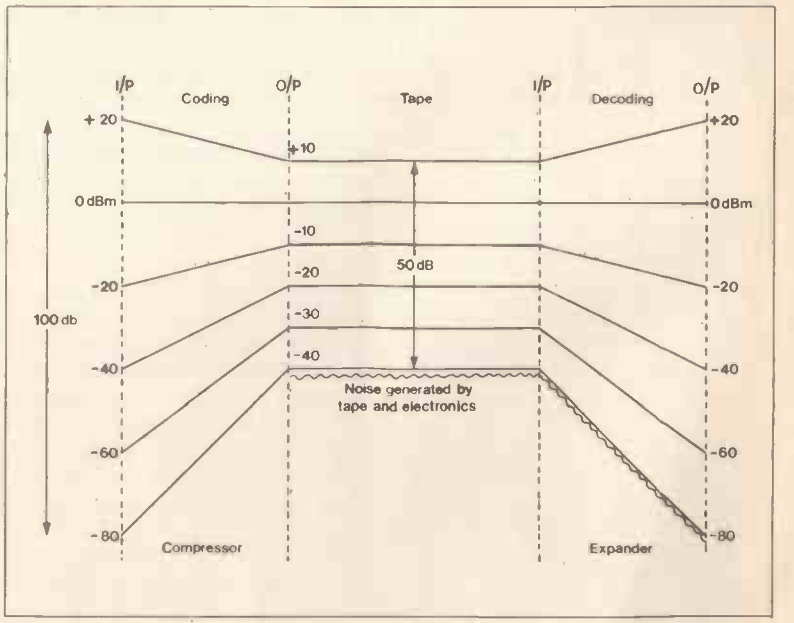
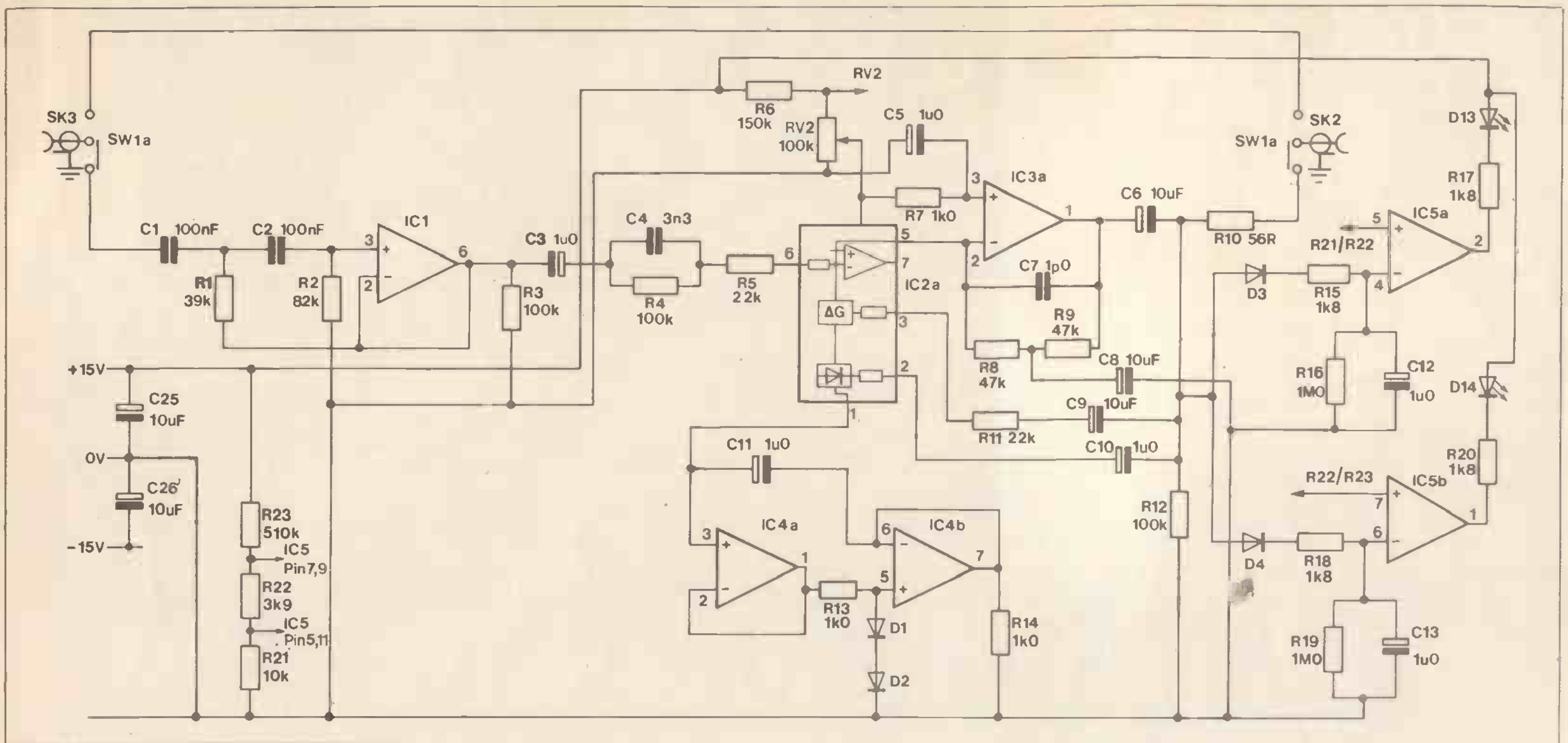


Figure 1. Operation of a compression/expansion system.



approaching the limits of audibility, i.e., 100 to 120 dB. However, since modern-day musical experiences tend either to be restricted to the bottom end of the dynamic range (muzak) or stuck at the top end (rock and heavy metal), this facility may be more theoretical than practical!

With careful shopping it should be possible to make the complete four-track unit for around £55.

Circuit

The circuit diagram for the compressor and expander is shown in Figure 2. The power supply circuit is given in Figure 3.

The compressor input is routed via SW1a, either directly to the output in the 'out' position, or to C1 in the 'in' position. IC1 and associated components form a second-order high pass filter with a 12 dB/octave roll-off below 30Hz. This removes sub-audible signals (infra-sonics) that might be generated from record warps or sub-octave tracking VCO's. The reason for this filtering is that once audio frequencies descend towards DC, the response of tape recorders drops-off dramatically, and on playback a signal compressed in response to high level low frequency signals will be expanded, resulting in phantom modulation by the missing low frequency component lost during recording. The output of the filter is AC-coupled to a simple RC network (C4, R4) which forms a high frequency pre-emphasis circuit providing a 12 dB treble boost. Without this pre-emphasis, and corresponding de-emphasis

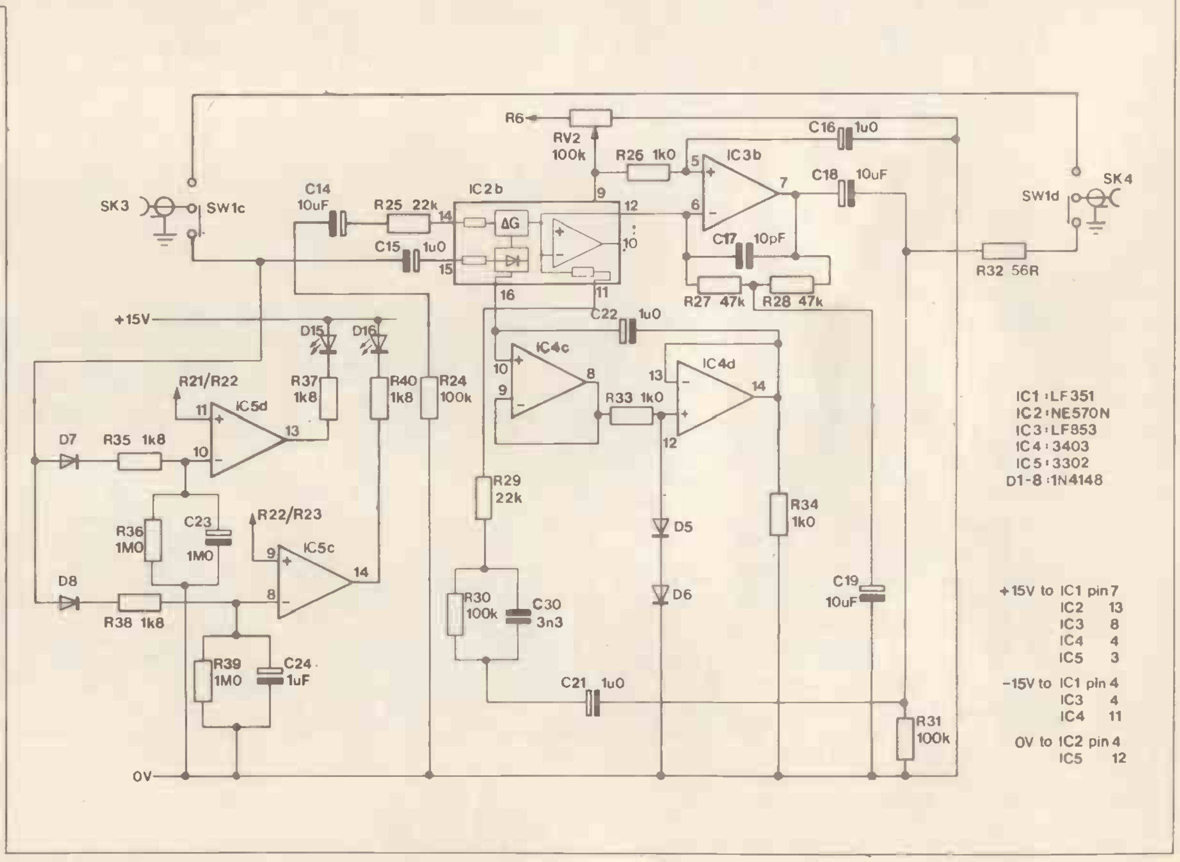


Figure 2. The circuit of the compressor and expander.

in the expander, a low level signal may be swamped by high level bass frequencies and typically results in a 'heavy breathing' or pumping effect as the expander attempts to adjust the gain accordingly. The signal is then applied to one half of the NE570 (IC2a) configured as a compressor using an internal variable gain cell and full-wave rectifier as well as an external output op-amp (IC3a). The variable gain cell is similar to a standard operational transconductance amplifier (OTA), except that, unlike OTA's, it is 'linearized' and therefore insensitive to temperature changes as well as offering low noise and low distortion performance. The signal at the output of IC3a is rectified and the resultant control voltage used to adjust the variable gain cell. By placing the gain cell in a feedback loop with the op-amp, a variable current generated in proportion to the input signal is used to adjust the overall gain of the op-amp. A 6 dB increase in output level produces a 6 dB increase in the gain of the variable gain cell, and, since this is effectively an expander inserted in the feedback loop, results in a 12 dB increase in feedback current to the input of the op-amp. Consequently, an increase in input level of 12 dB results in only a 6 dB increase at the output of the op-amp, thereby yielding the desired 2:1 dynamic range compression.

The current from the full-wave rectifier is averaged by an external filter capacitor (C11) with the result that the gain control is made proportional to the average value of the input signal. The speed with which this gain adjustment is made determines the transient response of the compressor and is a product of the value of the filter capacitor and an internal 10k resistor. The value of 1uF for C11 yields good transient response at average signal levels. However, at low signal levels, the gain of the op-amp increases and any mistracking that occurs between the compressor and expander will be magnified by the high gain levels. To improve tracking at low dynamic levels it is necessary to provide a level-adaptive circuit that speeds-up

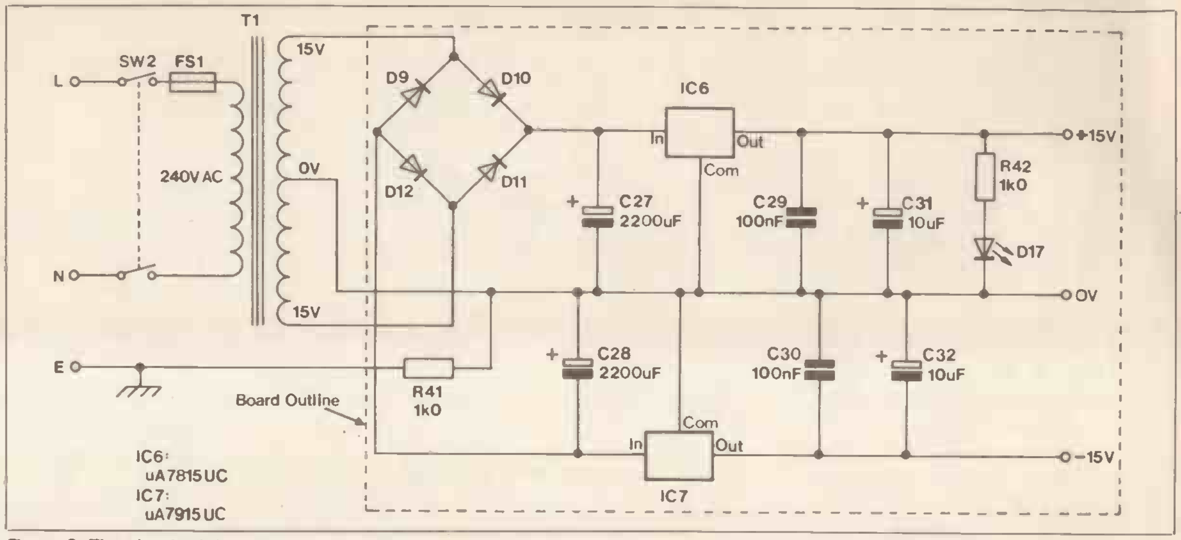


Figure 3. The circuit of the power supply.

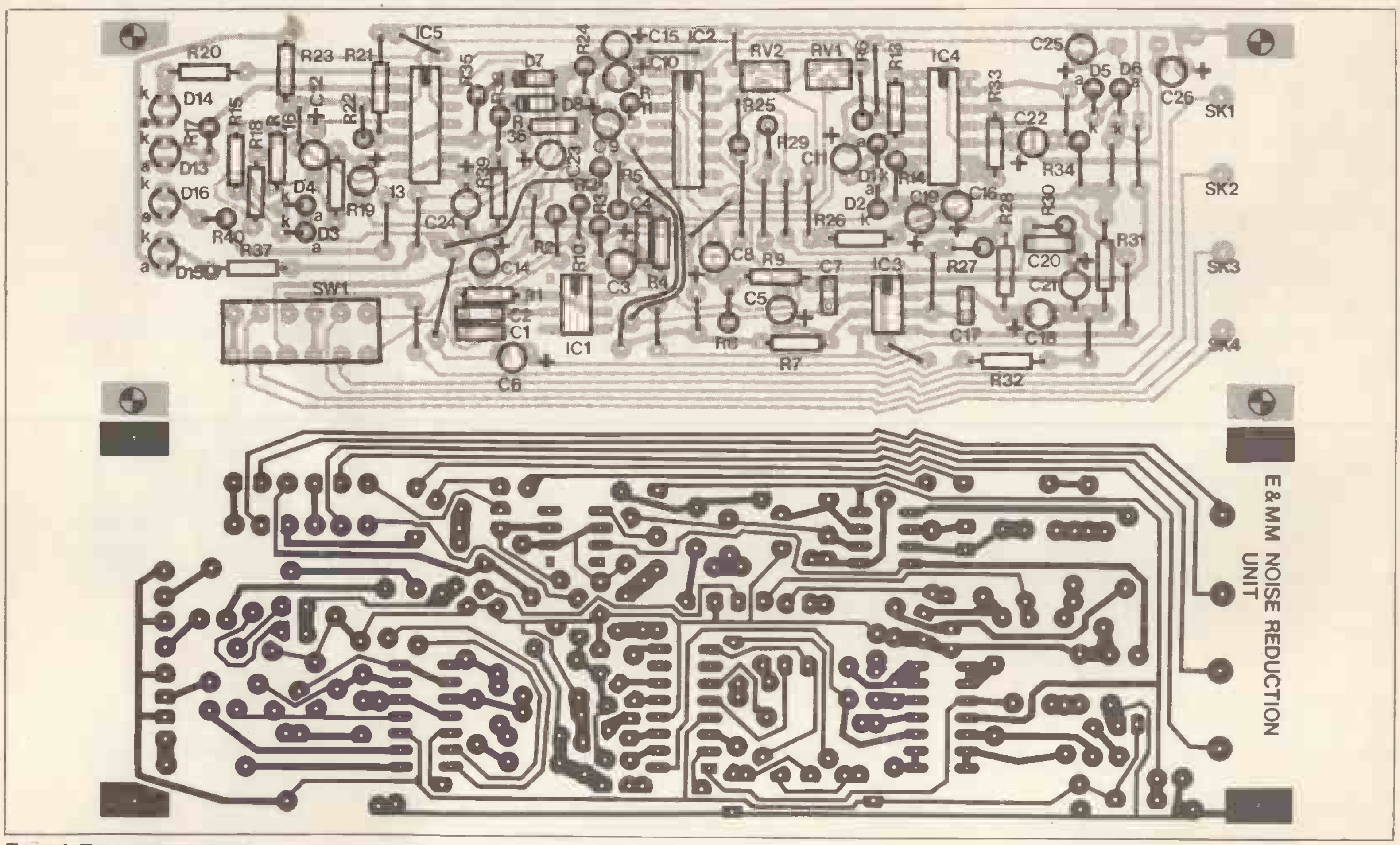


Figure 4. The compander PCB.

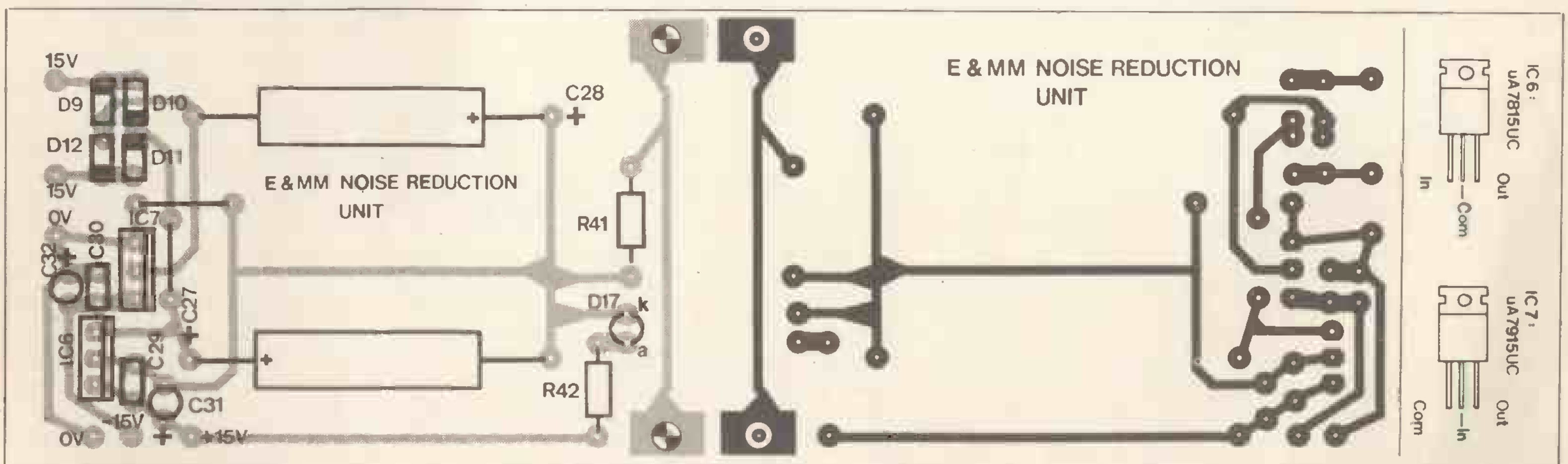


Figure 5. The power supply PCB.

the response time. This feature is derived from the circuit built around IC4a and b with series diodes (D1, D2) shunting the output of IC4a to ground.

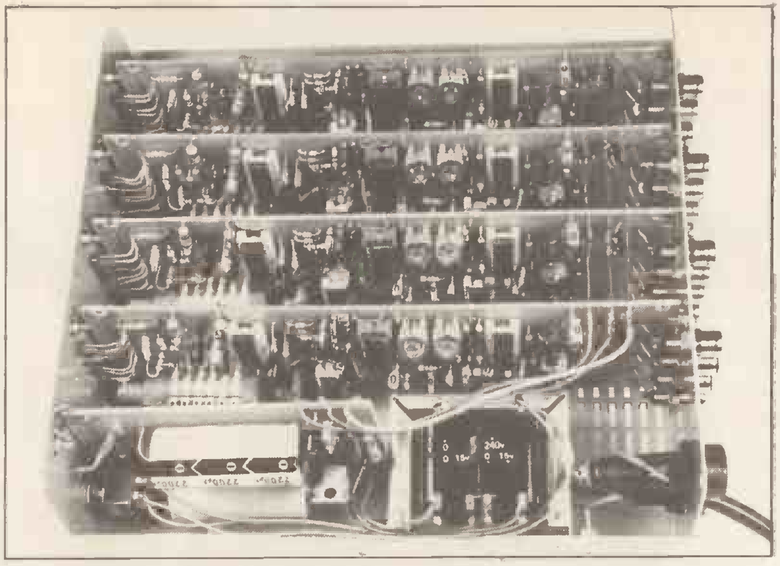
The RCR network (R8, C8, R9) around the op-amp, IC3a, provides DC feedback to bias the output at DC. C7 is an external compensation capacitor to provide stable operation over the audio bandwidth. It may seem curious to use an external op-amp when the circuit diagrams indicate that the NE570 has its own. This is because the op-amps in this IC are equivalent to 741-types with slew rate, noise, bandwidth, and output drive capability that aren't really adequate for demanding audio situations. With weak signals, the compressor circuit operates at high gain and the NE570 op-amp runs out of loop gain. Furthermore, a slew rate of 600mV/us means that high frequencies will suffer. By using a J-FET op-amp, such as the LF351 with a slew rate of 13V/us, these problems are eliminated. Additionally, the output swing can be larger since IC3a is powered by a dual supply rather than from the single-rail supply required by the NE570.

The non-inverting input of the NE570 op-amp is biased by an internal reference voltage of 1.8V. In the case of the external op-amp, IC3a, this is accomplished by tying it to pin 8 via an RC decoupling network (R7, C5) which filters out noise from the NE570 reference voltage. Pin 8 also serves another important function, that of providing the means for trimming distortion generated by IC2a. Even harmonic distortion is produced by voltage offsets in the variable gain cell, and RV1 enables adjustment of the offsets for minimum distortion.

The function of R10 is to isolate the output of IC3a from the potential capacitive load of a long length of screened cable connected to the compressor output which could lead to oscillation. SW1b selects the 'in' or 'out' mode of operation.

Comparators IC5a and b provide an indication of the signal level at the output of the compressor. The inverting inputs receive the half-wave rectified output signal which is compared with reference voltages derived from the potential divider network, R21, R22 and R23. C13 and R19 determine the fast attack/slow decay operation of the comparators. IC5a and b respond to signal levels of, respectively, -3 dBm and 0 dBm.

The expander configures the other half of the NE570, IC2b,



Internal layout of the Noise Reduction Unit.

Rear view of the case showing connections.

with a different arrangement of the various blocks. Once the off-tape signal has been routed via SW1c to C14, the signal is applied to comparators, IC5c and d, to provide an indication of off-tape levels, and simultaneously to the full-wave rectifier and variable gain cell. The rectifier produces a control voltage that is used to adjust the gain cell, with a response time determined by the level-adaptive circuit of IC4c and d tied to the rectifier filter capacitor (C22). An RC network (R30, C20) is connected in parallel with the op-amp, IC3b, to provide a treble cut of 12 dB, therefore de-emphasizing the pre-emphasized signal emerging from the compressor via the tape recorder. When the input signal increases by 6 dB, the gain cell control current is raised by a factor of 2, resulting in an increase in gain of 6 dB. Since the input of the external op-amp, IC3b, is derived from the gain cell, the output level increases by 12 dB, giving the required 1:2 dynamic range expansion. RV2 enables adjustment of gain cell offsets for minimum distortion, as in the compressor. Finally, R32 isolates the output of IC3b from subsequent screened cable, and SW1d selects the mode of use.

Construction

The unit is designed on a modular basis so that each PCB provides simultaneous compression and expansion for one channel. Single sided PCB's have been used to keep the cost down, though double sided PCB's could easily be made from the layouts provided, eliminating 29 links from each one. The PCB's have been specifically designed to fit into a West Hyde TEKO ALBA case, order code TEK A22L. This particular case has the dual advantage of colour (lobster red) and price (£3.60 + VAT), both of which have a brightening effect in these dull and inflationary times! If you see red at the idea of lobster-coloured electronics, alternative colours (black, TEK A22K and grey, TEK A22G) are available.

In order that decoding should be the exact inverse of coding, it is important that components are well-matched. This is obviously no problem with resistors, but the notorious variability of electrolytic capacitors necessitates the use of closer tolerance components such as the minielectrolytics available from Maplin. These capacitors offer ±20% tolerance at half the price of conventional tantalum types.

PCB designs and component overlays for the main board and PSU are given, respectively, in Figures 4 and 5. The threaded phono sockets suggested for the unit have the dual advantage of small physical size, enabling them to be fitted as rows of four on the back panel, and compatability with the connectors normally encountered in using Teacs and Revoxes. These sockets are mounted on the rear panel and connections to the signal pins made by short lengths of unscreened wire from the relevant holes on the PCB's.

The PSU is utterly standard, though it's important to note that mains earth is connected directly only to the front panel and indirectly via a 1k0 resistor (R41) to the 0V line. This should prevent the build-up of any hum loop when using the noise reduction unit with earthed equipment. Power line busses can be connected from the PSU to all four main PCB's.

Setting-up and use

The unit requires very little setting-up apart from adjustment of RV1 and RV2. The output level of a mixer is adjusted so that the compressor 0 dBm LED's fire with louder dynamics. The record level is set to match the optimum requirement of the tape being used. Playback levels are then adjusted so that the expander 0 dBm LED's fire at the same level as the compressor 0 dBm LED's. This level matching isn't critical since the level-adaptive response time circuits take care of possible mistracking, but it does ensure really accurate decoding of the encoded signal.

A couple of points to note: the unit will not reduce the noise present in a noisy signal presented to the compressor input (this is territory best served by dynamic noise limiters) and any difference in the signal between compressor output and expander input introduced by the recording process will be exaggerated by expansion, including such horrors as common-or-garden drop-outs. Therefore to get the best out of the unit scrupulous attention should be paid of alignment and cleaning of tape heads!

To optimise the distortion levels of the unit, apply a 1V RMS (equivalent to +3 dBm) 10 kHz sinewave to the input of the compressor and expander in turn and adjust RV1 and RV2, respectively, for minimum distortion of the waveform viewed on an oscilloscope. This adjustment can also be carried out without testing equipment, but does require a good ear to get the audibly cleanest waveform.

Using the unit should be simplicity itself and basically you should be able to plug it in and forget all about it. Judging by the comments of two recording studios using the unit, it appears to be gentle and uncomplaining by nature, just like the ideal wife (or husband)!

Modifications

Apart from noise reduction, these circuits can also be adapted for use as a general purpose compressor-expander. The first modification to be made is to add a pre-emphasis/de-emphasis 'defeat' switch, bypassing C4 and R4 in the compressor and taking C20 and R30 out of circuit in the expander, so that the frequency response of the compressor or expander remains substantially flat. With this modified circuit, 2:1 compression can be performed on excessively wide dynamic range signals (guitar, piano, etc.) to get a more punchy sound, and 1:2 expansion can be carried out on previously compressed material (much rock music) to increase the dynamic range. However, this degree of compression or expansion is excessive for all but special effects and some means of altering the gain adjustment ratio is necessary. This is easily accomplished by introducing some variable feedback into the circuits using a couple of dual-ganged 4k7 potentiometers and some 4k7 resistors (see Figure 6). It should be possible to make these adaptations without too much destruction, but it will be necessary to break two tracks on the PCB, ie. that joining the track from C9, C10 and R12 with R10, and that from C15 and C14 to SW1a. It is important to note that the ganged potentiometers are connected so that the two halves operate in opposite directions.

The resistors and pots required to adapt a single compander board appear in the separate Modification Parts List.

With these adaptations, the compressor and expander sections will offer, respectively, a compression ratio adjustable from 1:1 to 2:1 and an expansion ratio ranging from 1:1 to 1:2.

Such a unit is similar to that marketed by dbx in the USA, and can be very useful in adding a bit of guts to that reluctant electric piano, or whatever. The dbx expander is claimed to restore the original dynamic range to recordings compressed during transfer to vinyl. I'd make no such claims, but it can be effective on some internally compressed keyboards and also yields interesting results if used with some of the over-compressed heavy rock and heavy metal discs around today! **E&MM**

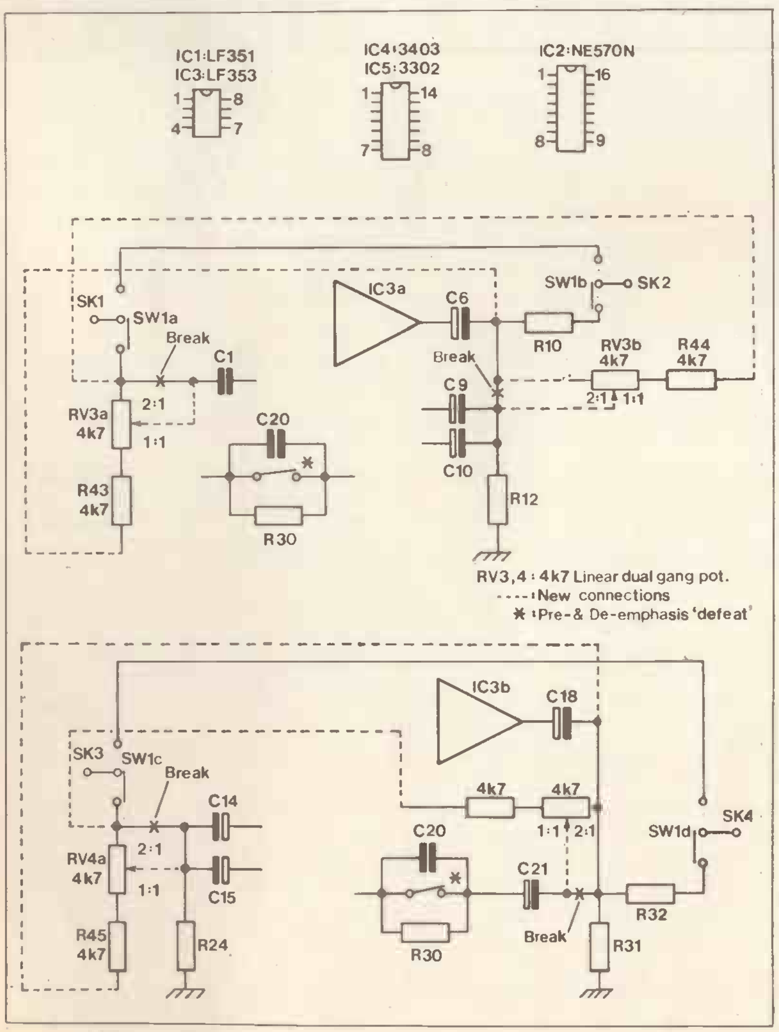


Figure 6. Modifications.

PARTS LIST

Resistors — all ⅓W 5% carbon unless specified.

R1	39k	4 off	(M39K)
R2	82k	4 off	(M82K)
R3,4,12,24,30,31	100k	24 off	(M100K)
R5,11,25,29	22k	16 off	(M22K)
R6	150k	4 off	(M150K)
R7,13,14,26, 33,34,41,42	1k0	32 off	(M1K0)
R8,9,27,28	47k	16 off	(M47K)
R10,32	56R	8 off	(M56R)
R15,17,18,20 35,37,38,40	1k8	32 off	(M18)
R16,19,36,39	1M0	16 off	(M1M0)
R21	10k 2% oxide	4 off	(X10K)
R22	4k7 2% oxide	4 off	(X4K7)
R23	510k 2% oxide	4 off	(X510K)
RV1,2	100k vert. s-min. preset	8 off	(WR74R)
Capacitors			
C1,2	100nF carbonate	8 off	(WW41U)
C3,5,10,11 12,13,15,16 21,22,23,24	1u0 50V mini-electrolytic	48 off	(YY31J)
C4,20	3n3 carbonate	8 off	(WW25C)
C6,8,9,14 18,19,25,26	10uF 25V mini-electrolytic	32 off	(YY35Q)
C7,17	10pF ceramic	8 off	(WX44X)
C27,28	2200uF 25V axial electrolytic	2 off	(FB90X)
C29,30	200uF mini disc ceramic	2 off	(YR75S)
Semiconductors			
IC1	LF351	4 off	(WQ30H)
IC2	NE570N	4 off	(QY10L)
IC3	LF353	4 off	(WQ31J)
IC4	3403	4 off	(QH51F)
IC5	3302	4 off	(QH48C)
IC6	uA7815C		(QL33L)
IC7	uA7915C		(QL36P)
D1-8	1N4148	32 off	(QL80B)
D9-12	1N4002	4 off	(QL74R)
D13,15	0.2 in. LED, green	8 off	(WL28F)
D14,16,17	0.2 in. LED, red	9 off	(WL27E)
Miscellaneous			
	Compander PCB	4 off	(GA30H)
	Power supply PCB		(GA31J)
	DIL socket, 8-pin	8 off	(BL17T)
	DIL socket, 14-pin	8 off	(BL18U)
	DIL socket, 16-pin	4 off	(BL19V)
S1	Push switch, 4-pole	4 off	(FH68Y)
	Switch button	4 off	(BW13P)
S2	DPDT toggle, sub-miniature		(FH04E)
SK1-4	Phono sockets	16 off	(YW06G)
	Chassis fuseholder, 20mm		(RX96E)
FS1	250mA fuse, 20mm		(WR01B)
	8BA ¼in. bolts		(BF08J)
	8BA nuts		(BF19V)
	8BA solder tags		(LR02C)
	Connection wire		(BL09K)
	Stick-on feet	set of four	(FW38R)
	Mains cable 3 amp	3 m	(XR01B)
	Cable grommet		(LR48C)
T1	Transformer 0-240v prim., 0-15V, 0-15V sec., 10VA		(LY03D)
	Case, Teko Alba TEK A22L		*

*The Teko Alba TEK A22L case is available from:
West Hyde Developments Ltd., Unit 9, Park Street Industrial Estate, Aylesbury, Bucks. HP20 1ET Tel: (0296) 30441
Price £4.23 + VAT + P&P

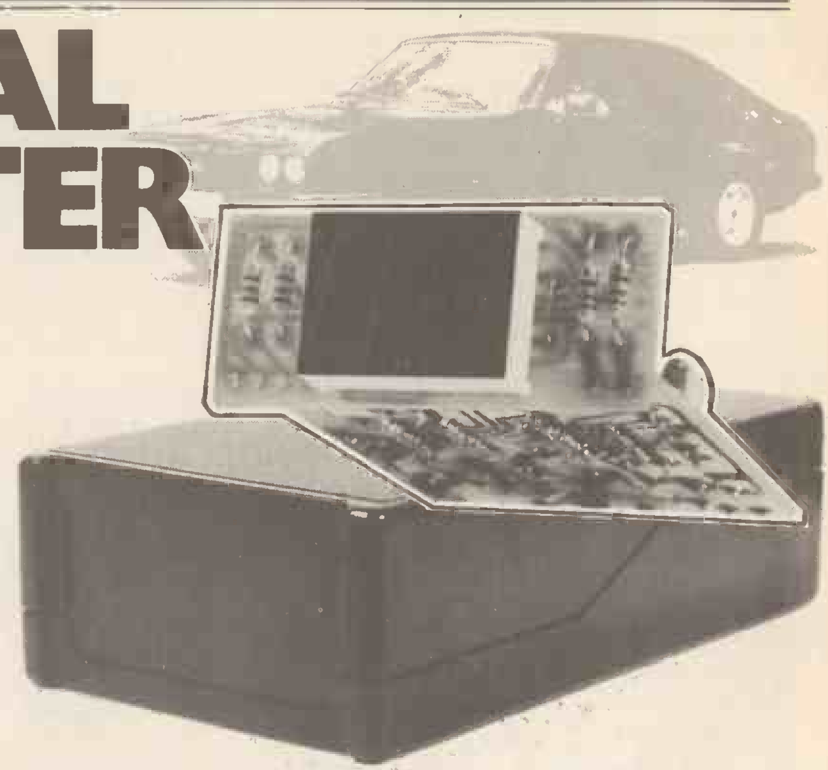
MODIFICATION PARTS LIST

Resistors — all ⅓W 5% carbon unless specified

R43-46	4k7	4 off	(M4K7)
RV3,4	4k7 lin. pot dual gang	2 off	(FW84F)

CAR DIGITAL TACHOMETER

by Peter Marriott



In these days of ever-higher motoring costs the unit described here will help the driver to change gear at the most advantageous point to save fuel and extend engine life. Anyone using a car to tow a trailer or caravan will also benefit by being able to make the best use of the torque available from the engine.

Conventional tachometers give a display of engine speed on a milliameter, usually with a scale of about 270° arc. Pulses produced by the action of the contact breakers are integrated and fed to the meter to give an analogue display of engine revolutions. The disadvantages are that an average reading is displayed, which can easily lag behind rapid speed changes, and the meters tend to be somewhat fragile.

The tachometer described overcomes both of these disadvantages by counting pulses and displaying engine revolutions over a very short time, the digital display being continuously updated. Two digits display the number of revolutions x100. The unit is designed for negative earth cars. If you are not sure of the polarity on your car a glance at the owners manual or even at the battery connections will tell you.

As can be seen from the photographs, the case chosen gives an extremely professional looking unit, with only one hole needing to be drilled. Construction is very straightforward, using two printed circuit boards which fit directly in the case without the need for mounting bolts, so the project can be tackled by any but the most inexperienced constructor.

Circuit

The complete circuit is shown in Figure 1. Pulses produced by the make-and-break action of the engine contact breaker points are fed to IC1a which is a dual Schmitt trigger monostable, the other half being used elsewhere via a resistor/capacitor network composed of R1, R2 and C1. This network helps to smooth out any high voltage spikes which may be present on the contact breaker pulses. The zener diode D1 limits the input pulse at IC1a to 4.7 volts, to avoid any damage to the device. To prevent any false triggering due to contact points bounce (produced when the points do not open and close cleanly) the monostable period is set to 3 milliseconds by R3 and C2. This chosen time also means that the monostable is ready for retriggering by the next pulse and so the maximum count for a 4-stroke, 4 cylinder engine is limited to 10000 r.p.m. — a speed not often attained on normal road cars! The maximum count of 10000 r.p.m. corresponds to 20000 pulses/minute and the time for 1 pulse is 60/20000 seconds or 3 ms. A higher engine speed would not allow enough time between pulses for triggering of the monostable. This design is for 4 cylinder cars only and anyone using it on a 6 or 8 cylinder car would have to modify the count period accordingly, or use a compensating factor on the

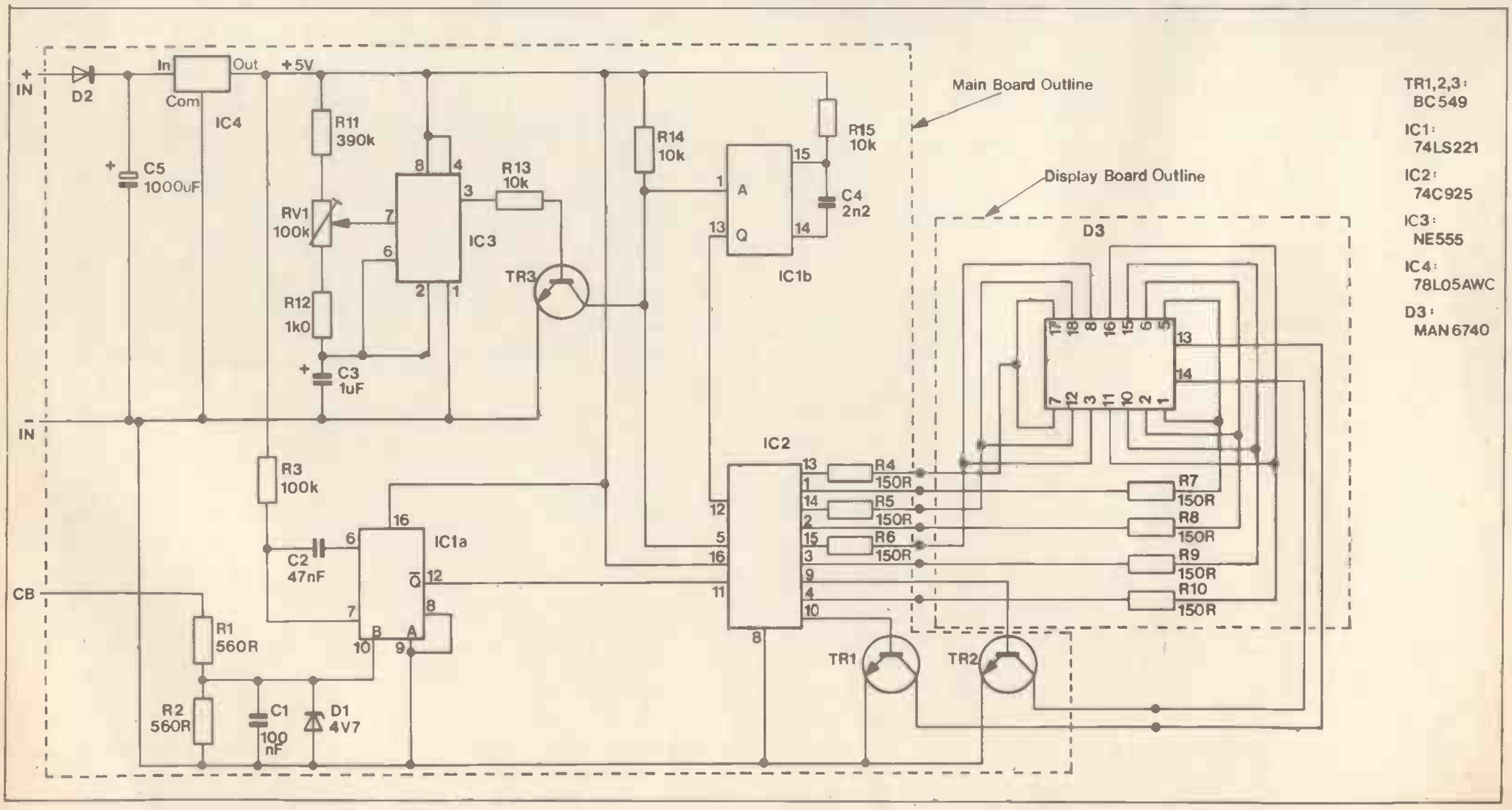


Figure 1. Circuit diagram of Digital Tachometer.

readings — not easy to do while driving!

The output pulses from IC1a, pin 12, are fed to the count input, pin 11, of IC2. This is a 4-digit counter with latch and reset. It drives the multiplexed 2-digit display directly, with transistors TR1 and TR2 selecting the digit and resistors R4—R10 limiting the segment current.

The counter requires latch pulses to give a sensible reading and these are provided by IC3, TR3 and their associated components. IC3 is the ever useful 555, used as an oscillator whose frequency is controlled by RV1. The oscillator output waveform, arranged so that there is a long high and a short low period, is inverted by TR3 so that a short high is achieved. This short pulse is used to control the latch on the counter integrated circuit IC2, so that when this input goes high the information in the counter is transferred to the internal latch and displayed. The short pulse is also used to trigger the monostable IC1b whose output pulse is used to reset the counter so that it starts counting from 00 again. Use of a separate monostable to reset the counter ensures that the reset pulse always occurs after the latch pulse so that a true reading is displayed.

Because the voltage (nominally 12 volts) on a car varies slightly with engine speed, integrated circuit IC4 is used to regulate this to 5 volts. This is used to supply IC1, IC2 and IC3 and is important for stability of the oscillator (IC3). Diode D2 and capacitor C5 remove noise on the supply.

Construction

The Digital Tachometer is constructed on two PCBs: the main board and the display board. The display board is mounted at 90° to the main board by veropins and holds the display so that it can be viewed through the filter at the end of the case.

Begin construction of the main board by fitting the resistors, capacitors, preset and three veropins, making sure C5 is the right way around. Then solder in the transistors, regulator (IC4) and diodes, paying attention to the orientation. The flats on the packages of TR1-3 and IC4 all face the furthest away long edge of the main PCB.

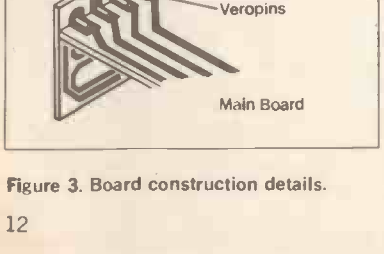


Figure 3. Board construction details.

Fit the sockets for the DIL ICs. IC2 is a CMOS device and costs over £7.00, so don't be tempted to economise on a socket for this one. Insert the other ICs but leave IC2 until the display board is completed and soldered to the main board.

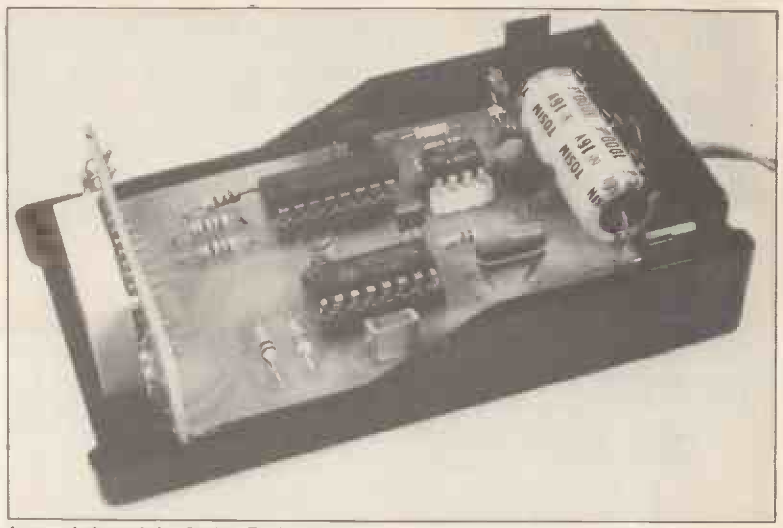
Fit the resistors and veropins to the display board, with the latter inserted from the component side. Be careful not to strip the pads off when doing this and push them home with the soldering iron before soldering them on the track side. Next fit the display. For some reason best known to the manufacturers, this has no formal package orientation mark, the device number being the only guide. This is on the same side as pin 1 and faces downwards on the completed unit. Solder the display in position.

The display board should now be fitted to the main board at right-angles by soldering the pins to the pads provided on the edge of the main board. This method of construction is shown in Figure 3. Fit IC2 to the main board, taking the normal precautions for CMOS devices, and solder long wires for power and input signal to the three pins, labelling the function of each wire at the end that will connect to the car electrics.

The metal front plate of the West Hyde case is replaced by a piece of red filter cut to 24 x 49 mm with a pair of scissors or craft knife. This slots neatly into the case, which is moulded in two sections. Drill a hole in the back for the wires and proceed to setting-up before fitting the boards in place and clipping the case sections together.

Setting Up

One advantage of a digital over an analogue tachometer is the ease of setting-up and calibration. Only one adjustment (RV1) needs be made and, barring accidents, will prevail for the life of the unit. This setting ensures that the oscillator runs at the correct frequency, and the method of calibration depends on the equipment available. Calibration against another tachometer is possible, setting RV1 to give a display of 30 when the standard tachometer reads 3000 rpm. If you have access to a signal generator, set the frequency to 100Hz and the output level to maximum (more than 4.7v). Connect this signal to the I/P pin on the PCB and adjust RV1 to give a reading of 30. Should the output of the signal generator be less than 4.7V, calibration may still be possible by feeding the output directly to pin 10 of IC1a.



Internal view of the Digital Tachometer.

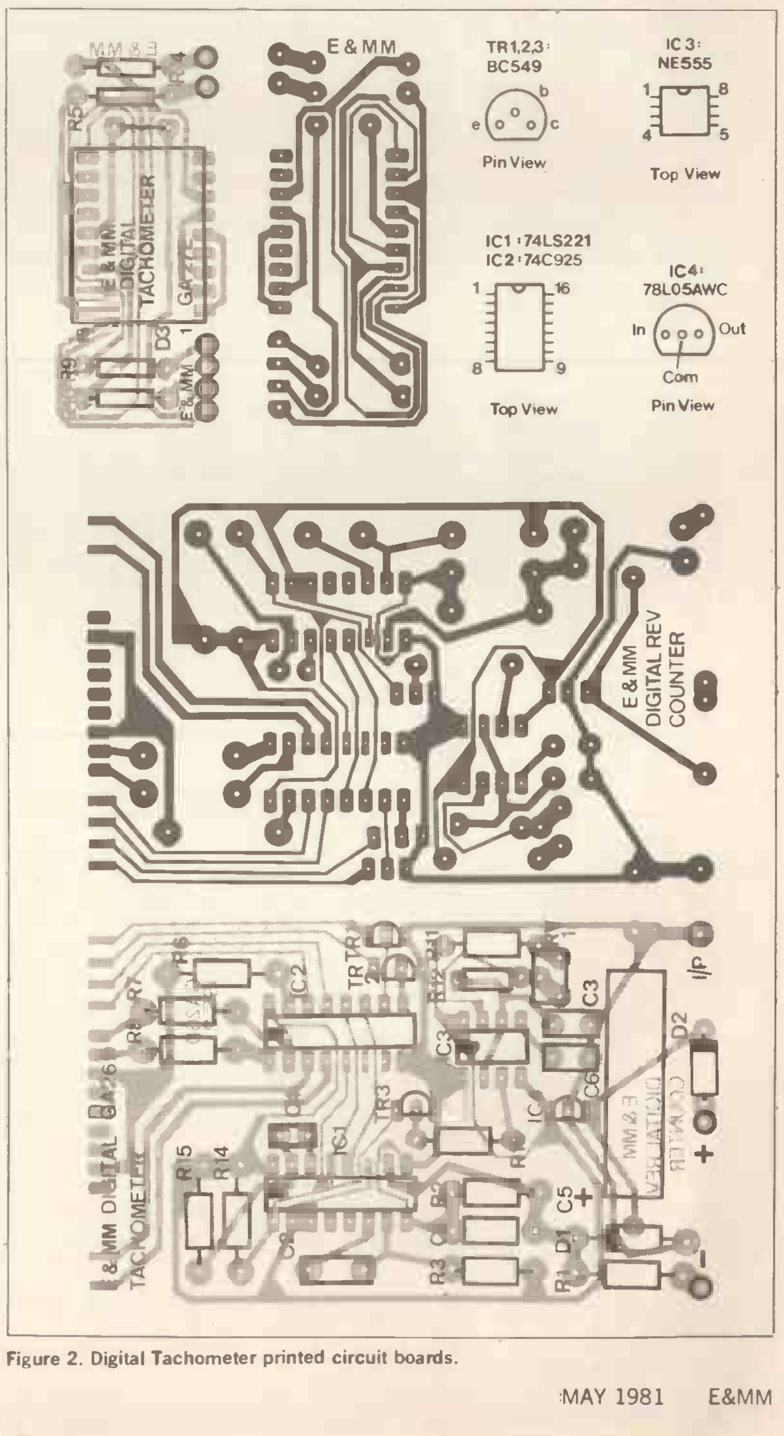


Figure 2. Digital Tachometer printed circuit boards.

Calibration can be carried out against the mains frequency by using a transformer and bridge rectifier as shown in Figure 4 to provide a 100Hz signal. RV1 is adjusted to give a display reading of 30, or 36 if the mains supply frequency is 60Hz. The power supply section of an existing piece of equipment can be used in the same way if the rest of the circuitry is disconnected from the output of the bridge rectifier.

Fitting the unit to the car

After calibration, the unit is ready to be fitted to the car. It is impossible to give detailed fitting instructions for every car but the following notes may be helpful.

a) It is a good idea to try the unit in various positions for best readability, using adhesive tape, until you are satisfied.

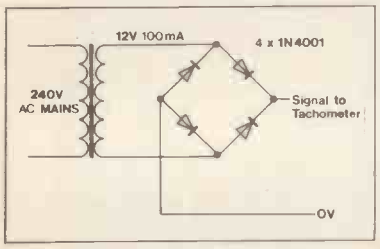


Figure 4. 100Hz calibration source.

b) Having decided on the best position use double-sided tape, adhesive pads or two pieces of velcro-tape, one glued to the unit and one to the car dashboard. All of these methods, of course, mean that the unit can be removed easily and the dashboard cleaned and left unmarked.

c) Alternatively, use self-tapping screws through on half of the case into the dashboard. This works well, but unless you can utilise existing screw holes you will be left with holes in the dashboard if you decide to remove the unit.

The three leads must pass into the engine compartment and it is important that they be protected by a rubber or plastic grommet. It may be possible to squeeze them through an existing cable entry or you may have to drill a new hole, but either way make sure they are protected.

Any suitable fused positive feed point and any adjacent earth can be used. Most cars have spare connecting points, usually with ¼" Lucar or blade type connectors for fitting auxiliary equipment, or you could use an in-line fuse holder and lamp fuse. The I/P lead must go to the 'CB' terminal on the iginition coil. If this is not marked and you cannot identify it from the owners manual ask your dealer. Coils have several types of connection, Lucar, screw terminals or push-on caps.

In any case make a protessional connection using 'piggy-back' type Lucar connectors (which allow two connections on one terminal), solder tags or Scotchlok connectors. If in doubt consult your local automobile electricians. Fix the leads neatly to existing harnesses using tape or tie-wraps.

E&MM

PARTS LIST

Resistors — all 5% ⅓W carbon unless specified.			
R1,2	560R	2 off	(M560R)
R3	100k		(M100K)
R4-10	150R	7 off	(M150R)
R11	390k		(M390K)
R12	1k0		(M1K0)
R13-15	10k	3 off	(M10K)
RV1	100k Vert. S-min. preset		(WR74R)
Capacitors			
C1	100nF polyester		(BX76H)
C2	47nF polycarbonate		(WW37S)
C3	1uF 35V tantalum bead		(WW60Q)
C4	2n2 ceramic plate		(WX72P)
C5	1000uF 16V axial electrolytic		(FB82D)
C6	10nF disc ceramic		(YR73Q)
Semiconductors			
IC1	74LS221		(YF86T)
IC2	74C925		(QY08J)
IC3	NE555		(QH66W)
IC4	uA78L05AWC 5V 100mA regulator		(QL26D)
TR1-3	BC549	3 off	(QQ15R)
D1	4.7V 400mW zener diode		(QH06G)
D2	1N4001		(QL73Q)
D3	MAN 6740 Double-digit, common cathode display		(BY68Y)
Miscellaneous			
	8-pin DIL socket		(BL17V)
	16-pin DIL socket	2 off	(BL19V)
	Main PCB		(GA26D)
	Display PCB		(GA27E)
	Case, Bocon BOC 706 (94 x 54 x 24mm internal)		*
	1mm Veropins		(FL24B)
	Red display filter		(FR34M)
	Connection wire		(BL09K)

*The Bocon Major BOC 706 case is available from: West Hyde Developments Ltd., Unit 9, Park Street Industrial Estate, Aylesbury, Bucks, HP20 1ET. Tel: (0296) 20441. Price: £3.57 + VAT + p.&p.

BI-PAK The Professional approach

TRANSISTORS

AC107	25
AC125	30
AC126	22
AC127	22
AC128	20
AC128K	26
AC132	26
AC141	26
AC141K	40
AC142	26
AC142K	40
AC176	24
AC176K	40
AC187	25
AC187K	40
AC188	25
AC188K	40
ACY17	50
ACY18	50
ACY19	50
ACY20	50
ACY21	50
ACY22	50
AD130	75
AD140	70
AD142	85
AD143	85
AD149	70
AD161	40
AD162	40
AD161/162 M/P	80
AF114	50
AF115	50
AF116	50
AF117	50
AF118	65
AF124	50
AF125	50
AF126	50
AF127	50
AF139	38
AF239	42
AL102	1.90
AL103	1.80
ASY26	50
ASY28	50
ASY29	50
AU104	1.90
AU110	1.90
AU113	1.90
BC107	10
BC107A	11
BC107B	11

BC107C	12
BC108	10
BC108A	11
BC108B	11
BC108C	12
BC109	10
BC109A	11
BC109B	11
BC109C	12
BC113	16
BC114	17
BC115	18
BC116	19
BC116A	20
BC117	20
BC118	17
BC119	29
BC120	35
BC125	25
BC126	30
BC132	18
BC134	18
BC135	18
BC136	20
BC137	20
BC138	28
BC139	32
BC140	25
BC141	28
BC142	25
BC143	25
BC144	40
BC145	46
BC147	09
BC148	09
BC149	09
BC150	20
BC151	22
BC152	20
BC153	25
BC154	19
BC157	10
BC158	10
BC159	10
BC160	26
BC161	38
BC167	11
BC168	10
BC169	10
BC169C	11
BC170	09
BC171	09
BC172	09
BC173	09

BC174	15
BC175	35
BC177	14
BC178	14
BC179	14
BC180	12
BC181	10
BC182	10
BC182L	10
BC183	10
BC183L	10
BC184	10
BC184L	10
BC186	15
BC187	18
BC207	11
BC208	11
BC209	12
BC212	10
BC212L	10
BC213	10
BC213L	10
BC214	10
BC214L	10
BC225	26
BC226	36
BC237	13
BC238	14
BC239	15
BC251	16
BC251A	16
BC261	18
BC300	30
BC301	28
BC302	29
BC303	28
BC304	28
BC307	13
BC327	12
BC328	13
BC337	13
BC338	13
BC384	14
BC440	30
BC441	30
BC0	32
BC461	32
BC477	20
BC478	20
BC479	20
BC546	10
BC547	10
BC548	10
BC549	11

BC550	14
BC556	14
BC557	13
BC558	13
BC559	14
BCY30	80
BCY31	80
BCY32	85
BCY33	80
BCY34	80
BCY70	14
BCY71	15
BCY72	15
BCZ10	70
BCZ11	70
BCZ12	70
BD106	50
BD115	50
BD116	50
BD121	65
BD123	65
BD124	75
BD131	35
BD132	35
BD131/132 M/P	80
BD133	40
BD135	35
BD136	35
BD137	35
BD138	36
BD139	38
BD140	38
BD139/140 M/P	80
BD155	50
BD175	60
BD176	60
BD177	68
BD178	68
BD179	75
BD180	75
BD185	68
BD186	68
BD187	75
BD188	75
BD189	78
BD190	78
BD195	90
BD196	90
BD197	95
BD198	95
BD199	99
BD200	99

BD201	80
BD202	80
BD201/202 M/P	1.70
BD203	80
BD204	80
BD203/204 M/P	1.70
BD205	80
BD206	80
BD207	80
BD208	80
BD222	47
BD225	47
BD232	85
BD233	65
BD234	55
BD235	55
BD236	58
BD237	65
BD238	65
BD239A	50
BD240A	50
BD239A/240A	1.00
BD240	45
BD241	45
BD506	38
BD508	38
BDX32	20
BDY11	1.30
BDY17	1.80
BDY20	80
BDY55	1.40
BDY56	1.60
BF115	25
BF117	50
BF118	75
BF119	75
BF121	50
BF123	60
BF125	50
BF127	60
BF152	25
BF153	25
BF154	22
BF155	35
BF156	28
BF157	28
BF158	28
BF159	28
BF160	28
BF162	24
BF163	30

BF164	50
BF165	50
BF167	24
BF173	24
BF177	24
BF178	25
BF179	30
BF180	30
BF181	30
BF182	30
BF183	30
BF184	22
BF185	22
BF186	26
BF187	26
BF188	32
BF194	10
BF195	10
BF196	12
BF197	12
BF198	15
BF199	16
BF200	30
BF222	90
BF224	20
BF240	17
BF241	18
BF244	28
BF257	30
BF258	30
BF259	35
BF262	60
BF263	60
BF270	36
BF271	31
BF273	36
BF274	38
BF324	35
BF336	34
BF337	34
BF338	38
BF371	26
BF457	37
BF458	37
BF459	38
BF594	30
BF595	28
BF596	28
BFR39	24
BFR40	25
BFR41	25
BFR50	25
BFR52	25

BFR62	24
BFR79	28
BFR80	28
BFW10	55
BFX29	25
BFX30	30
BFX84	24
BFX85	26
BFX86	26
BFX87	26
BFX88	26
BFX90	55
BFY50	20
BFY51	20
BFY52	20
BFY53	20
BFY90	80
BIP19	38
BIP20	38
BIP 19/20 M/P	80
BRY39	39
BSX19	20
BSX20	20
BSX21	21
BSY95	13
BSY95A	13
BU105	1.60
BU105/02	1.95
BU204	1.40
BU205	1.40
BU208	1.90
BU208/02	2.25
GP300	40
MJ480	95
MJ481	1.05
MJ490	95
MJ491	1.15
MJ2955	90
MJE340	50
MJE370	55
MJE371	60
MJE520	45
MJE521	65
MJE2955	90
MJE3055	65
MJE3440	52
MP8113	52
MPF102	60
MPF104	35
MPF105	35
MPSA05	20

MPSA06	20
MPSA55	20
MPSA56	20
ND120	18
OC19	85
OC20	1.85
OC22	1.50
OC23	1.50
OC24	1.35
OC25	1.00
OC26	1.00
OC28	90
OC29	95
OC35	90
OC36	90
OC41	20
OC42	22
OC44	24
OC45	20
OC70	24
OC71	15
OC72	24
OC74	26
OC75	30
TC76	35
OC77	50
OC79	40
OC81	22
OC81D	24
OC82	24
OC82D	30
OC83	26
OC84	38
OC139	80
OC140	80
OC169	80
OC170	80
OC171	80
OC200	46
OC201	95
OC202	1.20
OC203	85
OC204	90
OC205	1.15
R2008B	2.50
R2010B	2.60
TIC44	29
TIC45	35
TIP29	30
TIP29A	55
TIP29B	42
TIP29C	44
TIP30	38
TIP30A	40

TIP30B	42
TIP30C	44
TIP31	38
TIP31A	40
TIP31B	42
TIP31C	44
TIP32	38
TIP32A	40
TIP32B	42
TIP32C	44
TIP41A	44
TIP41B	46
TIP41C	48
TIP42A	44
TIP42B	46
TIP42C	48
TIP2955	60
TIP3055	50
TIS43	22
TIS90	20
TIS91	22
TIS92	22
UT46	20
ZTX107	10
ZTX108	10
ZTX109	10
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ZTX301	12
ZTX302	16
ZTX303	16
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ZTX330	15
ZTX500	13
ZTX501	12
ZTX502	16
ZTX503	12
ZTX504	25
ZTX531	25
ZTX550	25
2N388	36
2N388A	56
2N404	20
2N404A	24
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2N527	50
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2N599	46
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2N697	24
2N698	30
2N699	32
2N706	10
2N706A	12
2N707	48

2N708	14
2N711	30
2N717	30
2N718	25
2N718A	50
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2N727	29
2N743	20
2N744	20
2N914	20
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2N930	18
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2N1305	28
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2N1307	35
2N1308	40
2N1309	40
2N1599	35
2N1613	28
2N1711	30
2N1889	45
2N1890	45
2N1893	40
2N2147	75
2N2148	70
2N2192	38
2N2193	38
2N2194	38
2N2217	25
2N2218	25
2N2218A	28
2N2219	28
2N2219A	30
2N2220	20
2N2221	20
2N2221A	22
2N2222	20
2N2222A	20
2N2368	18
2N2369	14
2N2369A	14
2N2411	26
2N2412	25
2N2646	47
2N2711	22
2N2712	22
2N2714	22

2N2904	24
2N2904A	26
2N2905	24
2N2905A	26
2N2906	18
2N2906A	20
2N2907	20
2N2907A	22
2N2923	15
2N2924	15
2N2925	15
2N2926G	10
2N2926Y	09
2N29260	09
2N2926R	09
2N2926B	09
2N3010	20
2N3011	20
2N3053	22
2N3054	45
2N3055	42
2N3402	21
2N3403	21
2N3404	29
2N3405	42
2N3414	16
2N3415	16
2N3416	29
2N3417	29
2N3614	1.00
2N3615	1.05
2N3616	1.05
2N3646	09
2N3702	09
2N3703	09
2N3704	09
2N3705	09
2N3706	10
2N3707	10
2N3708	09
2N3708A	09
2N3709	09
2N3710	10
2N3711	10
2N3771	1.40
2N3772	1.60
2N3773	2.20
2N3819 (FET)	18
2N3820 (FET)	35
2N3821 (FET)	60

2N3823 (FET)	60
2N3903	12
2N3904	12
2N3905	12
2N3906	12
2N4058	12
2N4059	14
2N4060	14
2N4061	12
2N4062	12
2N4220 (FET)	35
2N4284	28
2N4285	28
2N4286	28
2N4287	28
2N4288	28
2N4289	28
2N4290	28
2N4291	28
2N4292	28
2N4293	28
2N4860 (FET)	60
2N4923	65
2N5135	10
2N5138	10
2N5172	14
2N5194	56
2N5245	40
2N5294	50
2N5296	50
2N5448	12
2N5457 (FET)	32
2N5458 (FET)	32
2N5459 (FET)	35
2N5551	36
2N6027 (P.U.T.)	34
2N6121	70
2N6122	70
2N6289	70
2S301	50
2S302	43
2S302A	43
2S303	56
2S304	71
2S305	80
2S306	80
2S307	80

DIODES

AA119	08	BB104	30	BY176	75	OA79	10
AA120	08	BAX13	07	BY206	30	OA81	10
AA129	09	BAX16	08	BY210/600	09	OA85	10
AAY30	09	BY100	22	BYZ10	45	OA90	07
AAZ13	15	BY101	22	BYZ11	45	OA91	07
AAZ17	15	BY105	22	BYZ12	40	OA95	07
BA100	10	BY114	22	BYZ13	40	OA182	13
BA102	20	BY124	22	BYZ16	41	OA200	08
BA144	09	BY126	11	BYZ17	36	OA202	08
BA148	15	BY127	12	BYZ18	36	IN34A	07
BA154	12	BY128	16	BYZ19	36	IN60	06
BA155	14	BY130	17	OA5	60	IN914	04
BA156	14	BY133	21	OA10	35	IN916	05
BA173	15	BY156	08	OA47	08	IN4148	04
BA248	16	BY164	51	OA70	08	IS44	05

74 SERIES TTL

7400	14	7437	30	7485	95	74153	65
7401	12	7438	30	7486	28	74154	1.00
7402	12	7440	15	7489	1.95	74155	70
7403	12	7441	60	7490	36	74156	70
7404	13	7442	60	7491	75	74157	70
7405	13	7443	1.00	7492	50	74160	90
7406	28	7444	1.00	7493	56	74161	90
7407	28	7445	90	7494	75	74162	90
7408	20	7446	90	7495	65	74163	90
7409	20	7447	65	7496	65	74164	1.00
7410	13	7448	65	74100	1.10	74165	1.00
7411	20	7450	15	74104	50	74166	1.00
7412	22	7451	15	74105	50	74167	2.30
7413	30	7452	15	74107	32	74174	90
7414	50	7453	15	74110	46	74175	80
7416	28	7454	15	74111	60	74176	85
7417	28	7460	15	74118	95	74177	85
7420	14	7470	32	74119	1.20	74180	90
7421	32	7472	28	74121	36	74181	2.30
7422	24	7473	32	74122	46	74182	85
7423	28	7474	30	74123	60	74184	1.35
7425	28	7475	44	74124	60	74190	1.00
7426	30	7476	35	74136	65	74191	1.00
7427	28	7480	48	74141	60	74192	95
7428	34	7481	95	74144	2.50	74193	1.00
7430	14	7482	70	74145	80	74194	90
7432	28	7483	68	74150	1.00	74195	90
7433	36	7484	95	74151	65	74196	95

CMOS

CD4000	18	CD4021	1.05	CD4042	78	CD4081	26
CD4001	19	CD4022	95	CD4043	88	CD4082	26
CD4002	20	CD4023	23	CD4044	88	CD4085	90
CD4006	92	CD4024	70	CD4045	1.50	CD4093	70
CD4007	22	CD4025	20	CD4046	1.10	CD4501	28
CD4008	80	CD4026	1.50	CD4047	95	CD4502	1.20
CD4009	40	CD4027	48	CD4048	65	CD4503	70
CD4010	48	CD4028	80	CD4049	45	CD4506	70
CD4011	22	CD4029	1.00	CD4050	45	CD4507	60
CD4012	22	CD4030	55	CD4052	80	CD4508	2.95
CD4013	45	CD4031	2.00	CD4054	1.25	CD4510	99
CD4014	84	CD4034	1.95	CD4055	1.25	CD4511	1.15
CD4015	84	CD4035	1.20	CD4056	1.35	CD4516	1.10
CD4016	42	CD4036	3.30	CD4068	25	CD4518	1.00
CD4017	80	CD4037	95	CD4069	25	CD4520	1.00
CD4018	85	CD4038	1.15	CD4070	29	CD4528	1.10
CD4019	45	CD4040	95	CD4071	25	CD4531	1.50
CD4020	99	CD4041	78	CD4072	25	CD4561	1.00

VOLTAGE REGULATORS

MVR7805-MVR7824	all 59p Ea.
MVR7905-MVR7924	all 63p Ea.
78L05-78L24	all 28p Ea.
79L05-79L24	all 55p Ea.
LM309K	1.25
UA79MGHC	2.50
LM320 15v 12v, 15v 24v	95p Ea.

74 LS SERIES TTL

74LS00	13	74LS78	46	74LS165	1.20	74LS279	85
74LS01	13	74LS83	68	74LS166	1.70	74LS280	2.40
74LS02	15	74LS85	75	74LS168	1.80	74LS283	85
74LS03	15	74LS86	38	74LS169	1.80	74LS290	90
74LS04	15	74LS90	38	74LS170	2.50	74LS293	1.00
74LS05	22	74LS91	1.10	74LS173	95	74LS295	1.90
74LS08	21	74LS92	68	74LS174	95	74LS298	1.50
74LS09	21	74LS93	58	74LS175	95	74LS299	3.50
74LS10	20	74LS95	95	74LS181	2.70	74LS323	3.50
74LS11	22	74LS96	1.10	74LS183	2.80	74LS324	1.90
74LS12	26	74LS107	40	74LS190	95	74LS325	3.00
74LS13	34	74LS109	70	74LS191	95	74LS326	3.20
74LS14	50	74LS112	38	74LS192	95	74LS327	3.10
74LS15	34	74LS113	38	74LS193	95	74LS348	1.80
74LS20	18	74LS114	38	74LS194	95	74LS352	1.50
74LS21	26	74LS122	68	74LS195	85	74LS353	1.50
74LS22	32	74LS123	60	74LS196	1.00	74LS365	45
74LS26	38	74LS124	1.60	74LS197	85	74LS366	55
74LS27	35	74LS125	45	74LS221	1.00	74LS367	62
74LS28	35	74LS126	45	74LS240	1.60	74LS368	80
74LS30	18	74LS132	60	74LS241	1.60	74LS373	1.45
74LS32	22	74LS136	50	74LS242	1.60	74LS374	1.45
74LS33	34	74LS138	60	74LS243	1.60	74LS375	1.10
74LS37	28	74LS139	68	74LS244	1.50	74LS378	1.20
74LS38	28	74LS145	1.15	74LS245	2.20	74LS386	75
74LS40	25	74LS147	2.00	74LS247	1.20	74LS393	1.10
74LS42	55	74LS148	1.60	74LS248	1.20	74LS395	2.00
74LS47	72	74LS151	70	74LS249	1.20	74LS398	2.70
74LS48	80	74LS153	68	74LS251	1.20	74LS399	2.00
74LS49	90	74LS155	65	74LS253	90	74LS390	1.40
74LS51	24	74LS156	80	74LS257	90	74LS670	2.50
74LS54	28	74LS157	60	74LS258	1.10	COMPUTER LC.s	
74LS55	28	74LS158	60	74LS260	85	2114L-3	2.40
74LS63	1.40	74LS160	85	74LS259	1.50	2708	3.50
74LS73	30	74LS161	75	74LS261	4.00	2516/2715-5v	4.90
74LS74	30	74LS162	1.00	74LS266	72	4116	2.25
74LS75	38	74LS163	90	74LS273	1.65		
74LS76	38	74LS164	90	74LS275	3.50		

LINEAR I.C.'s

CA270BE	95	LM324N	48	709P	35
CA280Q	95	LM337T	1.35	UA710C	40
CA3011	98	LM339N	65	72710	30
CA3014	1.75	LM348N	90	UA711C	32
CA3018	65	LM380	85	72711	32
CA3020	1.75	LM381	1.45	UA723C	45
CA3028	80	LM382N	1.20	72723	45
CA3035	2.30	LM384	1.45	UA741C	24
CA3036	1.00	LM1458	42	72741	24
CA3042	1.60	LM3900	58	741P	17
CA3043	1.85	LM3909N	70	UA747C	60
CA3046	70	LM3914N	2.20	72747	60
CA3052	1.60	LM3911N	1.20	UA748	35
CA3054	1.10	MC1304	1.90	748P	35
CA3075	1.50	MC1310P	1.45	SN76013N	1.60
CA3080	65	MC1312	1.70	SN76023N	1.65
CA3081	1.50	MC1350	1.20	SN76110	1.50
CA3085	95	MC1352	1.40	SN76115AN	1.90
CA3089	2.00	MC1469	2.70	SN76660N	90
CA3090	3.60	MC1496	90	TAA550B	35
CA3123E	1.50	NE555	20	TAA621	2.00
CA3130E	90	NE556	55	TAA661B	1.50
CA3140E	48	NE561	3.80	TAD100	1.30
LF351N	55	NE562	4.00	TBA120B	70
LF353N	88	NE565	1.20	TBA540	1.40
LF356N	90	NE566	1.50	TBA641A	2.20
LH0042CH	2.25	NE567	1.70	TBA800	85
LM301A	25	72702	46	TBA810S	95
LM334	1.60	UA703C	25	TBA820	70
LM308	75	UA709C	25	TBA920Q	2.50
LM309K	1.25	72709	46	TCA270S	1.40
LM317H	2.50			ZN414	90

SILICON RECTIFIERS

200mA		IS020 100v	10	IN5408 1000v	25
IS920 50v	06	IS021 200v	11	6 Amp	
IS921 100v	07	IS023 400v	13	BYX38-300	45
IS922 150v	08	IS025 600v	14	BYX38-600	60
IS923 200v	09	IS027 800v	16	BYX38-300R	45
IS924 300v	10	IS029 1000v	20	BYX38-600R	60
1 Amp		IS031 1200v	25	10 Amp	
IN4001 50v	04½	3 Amp		IS10/50 50v	30
IN4002 100v	05	IN5400 50v	11	IS10/100 100v	35
IN4003 200v	06	IN5401 100v	12	IS10/200 200v	40
IN4004 400v	06	IN5402 200v	14	IS10/400 400v	45
IN4005 600v	07	IN5403 300v	15	IS10/600 600v	50
IN4006 800v	07	IN5404 400v	16	IS10/800 800v	70
IN4007 1000	08	IN5405 500v	17	IS10/100 1000v	85
1.5 Amp		IN5406 600v	18	IS10/1200 1200v	95
IS015 50v	09	IN5407 800v	28		

THYRISTORS

1 Amp — TO39 CASE		THY5A/100v	45	THY5A/400vP	50
THY1A/50v	34	THY5A/200v	50	THY5A/600vP	60
THY1A/100v	38	THY5A/400v	57	THY5A/800vP	70
THY1A/200v	42	THY5A/600v	60	10 Amp — TO48	
THY1A/400v	50	THY5A/800v	75	THY10A/50v	45
THY1A/600v	65	5 Amp — TO66		THY10A/100v	50
THY1A/800v	78	THY5A/50v	36	THY10A/200v	55
BT101/500R	80	THY5A/100v	45	THY10A/400v	60
BT102/500R	80	THY5A/200v	50	THY10A/600v	80
BT106	1.25	THY5A/400v	57	THY10A/800v	1.10
BT107	93	THY5A/600v	60	16 Amp — TO48	
BT108	98	THY5A/800v	75	THY16A/50v	65
2N3228	70	2N3525	77	THY16A/100v	80
3 Amp — TO66		BTX30/50L	40	THY16A/200v	90
THY3A/50v	35	BTX30/400L	70	THY16A/400v	1.20
THY3A/100v	37	BT116	1.50	THY16A/600v	1.50
THY3A/200v	40	C106D	38	THY16A/800v	2.00
THY3A/400v	50	BTY79/400R	95	30 Amp — TO49	
THY3A/600v	60	5 Amp — TO220 PLASTIC		THY30A/50v	1.30
THY3A/800v	75	THY5A/50vP	35	THY30A/100v	1.50
5 Amp — TO64		THY5A/100vP	45	THY30A/200v	2.95
THY5A/50v	36	THY5A/200vP	47	THY30A/400v	4.00
				THY30A/600v	4.20

TRIACS & DIACS

2 Amp — TO39		4 Amp — TO202		6 Amp — TO220	
TR12A/100v	30	TR14A/400v	55	TR16A/100v	45
TR12A/200v	42	8 Amp — TO220		TR16A/200v	52
TR12A/400v	50	TR18A/400v	64	TR16A/400v	60
10 Amp — TO48		10 Amp — TO220 PLASTIC		12 Amp — TO220	
TRI110A/100v	55	TRI10A/400P	68	TRI12A/400v	70
TRI10A/200v	80			DIACS	
TRI10A/400v	90			BR100	20
				D32	20

ZENER DIODES

400W 1.3V-39V	all at 8p
1.3W 1.3V-100V	all at 15p
10W 1.3V-100V	all at 35p

BRIDGE RECTIFIERS

1 Amp RMS		2 Amp RMS		6 Amp RMS	
BR1/50v	20	BR2/50v	35	BR6/50v	75
BR1/100v	22	BR2/100v	40	BR6/100v	80
BR1/200v	25	BR2/200v	44	BR6/200v	88
BR1/400v	29	BR2/400v	50	BR6/400v	95
		BR2/1000v	65		

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AL30A 10w R.M.S.
AUDIO AMPLIFIER MODULES

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AL60 25w R.M.S.
AUDIO AMPLIFIER MODULE
25 Watts RMS

£5.15

SPM120 STABILISED POWER SUPPLIES
SPM120/45
SMP120/55
SMP120/65

£6.38

AL80 35w R.M.S.
AUDIO AMPLIFIER MODULE

£8.07

S450
STEREO FM TUNER
Fitted with phase lock-loop

£25.56

Stereo 30
COMPLETE AUDIO CHASSIS

7 + 7w R.M.S.

£21.09

GE100 Mk2.
10 CHANNEL MONOGRAPHIC EQUALISER

£23.00

AL120 50w R.M.S.
AUDIO AMPLIFIER (With integral heat sink and short-circuit protection).

£13.14

AL250 125w R.M.S.
POWER AMPLIFIER

£19.60

SPM80
STABILISED POWER SUPPLY

£4.84

VPS30
REGULATED VARIABLE STABILISED POWER SUPPLY

£7.60

MONO PRE-AMPLIFIERS

MM 100. Supply voltage 40-65v Inputs: Tape, Mag P.U. Microphone Max output 500mv. **£12.43**

MM 100G. Supply voltage 40-65v inputs: 2 Guitars. Microphones Max output 500mv. **£12.43**

PA100
STEREO PRE-AMPLIFIER

£17.65

PA200
STEREO PRE-AMPLIFIER

£18.24

STA5. 5 watts per channel Stereo Amplifier. Kit consisting of: 2xAL20 amplifiers, 1xPA 12 pre-amplifier, 1xPS12 power supply, 1x2036 transformer and necessary wiring diagram **£19.52**

STA10. 10 watts per channel Stereo Amplifier. Kit consisting of: 2xAL30 amplifiers, 1xPA12 pre-amplifier, 1xPS 12 power supply, 1x2036 transformer and necessary wiring diagrams. **£20.63**

STA15. 15 watts per channel Stereo Amplifier. Kit consisting of: 2xAL60 amplifiers, 1xPA100 pre-amplifier, 1xSPM80 power supply, 1x2034 transformer, 2xcoupling capacitors for 8 ohms 470mfd 30v and necessary wiring diagram. **£36.76**

STA25. 25 watts per channel Stereo Amplifier. Kit consisting of: 2xAL60 amplifiers, 1xPA100 pre-amplifier, 1xSPM120/45 power supply, 1x2040 transformer, coupling capacitors for 8 ohms 470 mfd 45v, 1xreservoir capacitor 2200mfd 100v and necessary wiring diagram. **£40.50**

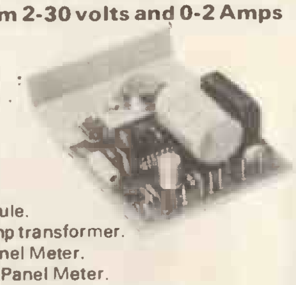
STA35. 35 watts per channel Stereo Amplifier. Kit consisting of: 2xAL80 amplifiers, 1xPA200 pre-amplifier, 1x2035 transformer, 2xcoupling capacitors 470mfd at 50v for 8 ohms, 1xreservoir capacitor 2200mfd 100v and necessary wiring diagram. **£45.76**

STA50. 50 watts per channel Stereo Amplifier. Kit consisting of: 2xAL120 amplifiers. 1xPA200 pre-amplifier, 1x2041 transformer, 2xcoupling capacitors 1000mfd 63v, 1xSPM 120/65, 1xreservoir capacitor 3300mfd 100v and necessary wiring diagram. **£59.89**

STA100. 100 watts per channel Stereo Amplifier. Kit consisting of: 2xAL250 amplifiers, 1xPA200 pre-amplifier. 2xSPM 120/65 power supplies, 2x2041 transformers, 2xcoupling capacitors 1000mfd 100v and necessary wiring diagram. **£84.68**

Stabilised Power Supply Kit
Variable from 2-30 volts and 0-2 Amps

VPS30



Kit includes:
- 1 – VPS30 Module.
- 1 – 25 volt 2 Amp transformer.
- 1 – 0-50v 2" Panel Meter.
- 1 – 0-2 Amp 2" Panel Meter.
- 1 – 470 ohm wirewound potentiometer.
- 1 – 4K7 ohm wirewound potentiometer.

Wiring Diagram Included.

HARDWARE IN PACKS OF 25

839	0BA 1" Bolt	0.70
840	0BA ½" Bolt	0.40
842	2BA 1" Bolt	0.35
843	2BA ½" Bolt	0.30
844	2BA ¼" Bolt	0.32
845	4BA 1" Bolt	0.28
846	4BA ½" Bolt	0.20
847	4BA ¼" Bolt	0.18
848	6BA 1" Bolt	0.24
849	6BA ½" Bolt	0.18
850	6BA ¼" Bolt	0.20
851	0BA Solder Tags	0.20
852	2BA Solder Tags	0.16
853	4BA Solder Tags	0.14
854	6BA Solder Tags	0.12
855	0BA Full Nut	0.42
856	2BA Full Nut	0.26
857	4BA Full Nut	0.18
858	6BA Full Nut	0.18
859	0BA Washer	0.12
860	2BA Washer	0.09
861	4BA Washer	0.09
862	6BA Washer	0.09

FUSE HOLDERS

506	20mm Chassis Fuse Holder	0.14
507	1¼" Chassis Fuse Holder	0.14
508	1¼" Car in line Fuse Holder	0.12
509	20mm Panel Fuse Holder	0.26
510	1¼" Panel Fuse Holder	0.32

FUSES:

Quick Blow 20mm:		
611	150mA	0.06
612	250MA	0.06
613	500MA	0.06
614	800MA	0.07
615	1 Amp	0.06
616	1.5 Amp	0.07
617	2.0 Amp	0.06
618	2.5 Amp	0.06
619	3.0 Amp	0.06
620	3.15 Amp	0.07
621	5.0 Amp	0.06
Semi Delay: 20mm		
622	100MA	0.07
623	250MA	0.07
624	500MA	0.07
625	1 Amp	0.07
626	1.6 Amp	0.07
627	2 Amp	0.07
628	2.5 Amp	0.07
629	3.15 Amp	0.07
630	5.0 Amp	0.07
Quick Blow: 1¼"		
631	250MA	0.06
632	500MA	0.06
634	800MA	0.06
635	1 Amp	0.06
636	1.5 Amp	0.06
637	2.0 Amp	0.06
638	2.5 Amp	0.06
639	3 Amp	0.06
641	4 Amp	0.06
642	5 Amp	0.06

PS12 POWER SUPPLY MODULE

Power supply for AL20A-30A, PA12, S450 etc.

Input A.C. Voltage 15–20V.
Output D.C. Voltage 22–30V approx. (Dependent upon input.)
Output Current 800mA maximum.
Dimensions 60x43x26mm.

£1.65

Transformers are not included with power supplies.
SPM 120 Range also require reservoir and output capacitors.

BP124. 5 watt 12v max. – Siren Alarm Module. **£3.85**

GE100MK11. 10 channel mono-graphic equaliser, complete with sliders and knobs. **£23.00**

VPS30. Variable regulated stabilised power supply 2-30v 0-2 amps **£7.60**

PS250. Consists – 1 capacitor & 4 diodes for constructing unstabilised power supply for AL250 to 125 watts **2.90**

TRANSFORMERS

2034. 1.7 amp 35v. Suit SPM80. **£4.90**
2035. 2 amp 55v **£6.65**
2036. 750mA 17v. Suit: PS12. **£2.85**
2040. 1.5 amp 0-45v-55v. Suit: SPM120/45, SPM120/55v. **£6.45**
2041. 2 amp 0-55v-65v. Suit: SPM120/55, SPM120/65v. **3.46**
2039. 1 amp 0-20v. Suit Stereo 30. **£3.50**
2043. 150mA 15-0-15v. Suit: SG30. **£2.40**

ACCESSORIES

139. Teak Cabinet. Suit: Stereo 30, 320x235x 81mm. **£7.00**
140. Teak Cabinet. Suit: STA15, 425x290x 95mm. **£9.50**
FP100. Front Panel for PA100 & PA200. **£1.80**
BP100. Back Panel for PA100 & PA200. **£1.60**
GE100FP. Front Panel for one GE100MK11. **£1.75**
2240. Kit of parts including Teak Cabinet, Chassis, Sockets and Knobs etc. (To house STA15 Amplifier). **£19.95**

Full data sheets are available FREE on request, please enclose a S.A.E.

PA12
STEREO PRE-AMPLIFIER

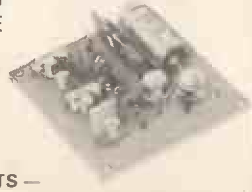
£8.55

MPA30
MAGNETIC CARTRIDGE PRE-AMPLIFIER

£3.27

BP124 SIREN ALARM MODULE

American Police screamer powered from any 12 volt supply into 4 or 8 ohm speaker. Ideal for car burglar alarm, freezer break-down, and other security purposes.



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SPECTRUM SYNTHESISER

Part 3 of this constructional series describes the Low Frequency Oscillator and the Voltage Controlled Oscillator section.

by Chris Jordan

Low Frequency Oscillator

The Low Frequency Oscillator (LFO) of a synthesiser provides periodic waveforms for the control of other modules to produce modulation of pitch, timbre, amplitude etc. When the synthesiser is being used other than for simple melodic playing, the LFO is often the main control source, and must have a wide frequency range and a choice of precise waveforms. The Spectrum LFO has a range of over 1000:1, from 0.04Hz (25 seconds per cycle) to about 42Hz. Sine, triangle, ramp, and square waveforms are available, plus two additional step-type waveforms, one giving a new random voltage on each cycle, the other producing a wide range of repeating sequences. A green LED flashes to indicate the LFO cycle and is very useful for quickly checking or setting the rate. Particular attention has been paid to waveform precision, and good symmetry is retained over the frequency range. Unlike many other designs, no setting up is required.

Circuit

Figure 1 shows the circuit of the LFO. It is based around IC8, IC9a, TR8 and TR9, which form a precision triangle and square wave generator. IC8 is an integrator driven by the voltage at the wiper of RV6, the Rate control.

A low input bias current op-amp must be used for IC8 to preserve waveform symmetry since a bipolar device would drain the input current significantly at low frequencies, causing differing charge and discharge rates for C16.

IC9a is a comparator which reverses the voltage at the integrator input when its output reaches thresholds set by R100,101, so the integrator output ramps up and down between fixed levels generating a triangle wave. IC9a drives TR8,9 which are configured as an additional complementary pair output stage driving the integrator and from which feedback to IC9a is obtained. Since TR8,9 invert the output of the op-amp and R101 takes the signal back to the inverting input, the feedback is positive, causing the output to be either high or low and giving the comparator hysteresis. An additional output stage is used because the maximum and minimum output voltages of the op-amp are unpredictable and rarely symmetrical. This would give unequal times for the two halves of the cycle and waveforms which were not precisely symmetrical about 0V, since the thresholds are derived from the output of the comparator circuit.

The method of producing the rampwave is rather unusual. The triangle and square waves are mixed and half-wave rectified by IC9b. Since only positive output values are allowed, the signal is 'cut off' at zero volts when the square wave is high i.e. when the triangle wave is falling. The result is a positive going half-wave rectified ramp wave, which gives a complete ramp wave when the triangle wave (and an offset) is added, producing a slope during the 'flat' half cycle and half-cancelling the slope during the other half.

The sine wave is generated by D24-27 and associated resistors. Minimum harmonic content of a sine wave used for control purposes is not as important as smoothness of the waveform — it should have no sharp changes of gradient and should slow down gradually towards the peaks. This is achieved by two parallel diode shaping networks which act on the triangle wave. As the voltage increases on positive half cycles, D25 conducts first, and then D26 conducts just before the peak, with D24,27 acting on negative halves. The sine wave is produced by mixing the two components by R126,128 at IC10b. S2b selects the output waveform, with IC10b and its input resistors mixing the components for the ramp and sine waves and ensuring that all waveforms have the same level. The output of IC10b is the '+LFO' signal, and this is inverted by IC12a to give '-LFO'.

The 'LFO MAN' output gives the selected waveform at a level controlled by the jostick y-axis. RV7 is the joystick pot, acting as potential divider fed by +LFO and buffered by IC12b. Normal pots have a low resistance remaining between the wiper and the track connection when at the end of their travel — this 'end resistance' would leave a small signal at LFO MAN when the joystick was 'off', and this could be a nuisance when using extreme modulation depths. RV8 introduces a small amount of +LFO to the inverting input of IC12b, allowing the residual signal to be cancelled out

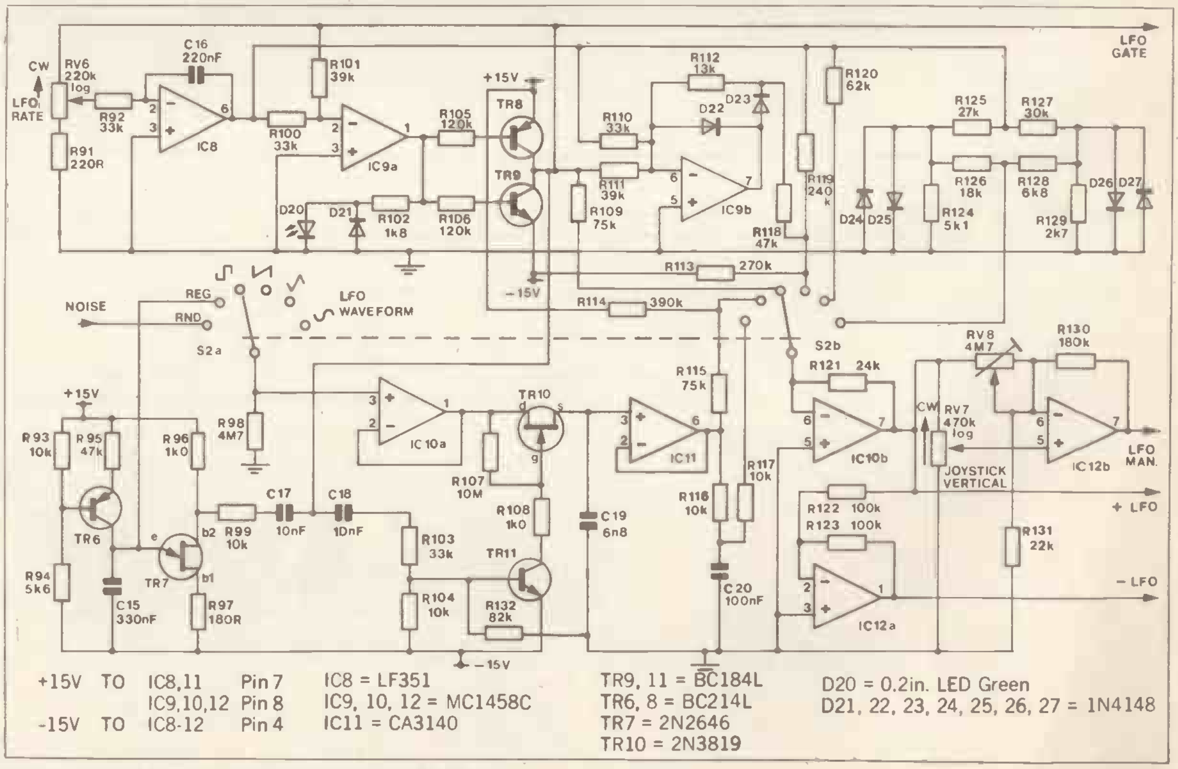

Figure 1. Circuit diagram of the Low Frequency Oscillator.

and giving a very wide range of modulation depth control. This is also helped by using a log. pot. for RV7 since joysticks only move the wiper over a small section of the track and making this the 'steep' end of a log. pot. increases the effect.

The regular and random LFO waveforms are step-type functions which change level abruptly at the beginning of each cycle and remain fixed until the next cycle starts. They are produced by the sample-and-hold circuit around C19 and differ in the type of input to the sample-and-hold (S/H). The random waveform has the output of the noise generator as its source, producing a new random voltage in the range ±2.5V every cycle. The regular waveform is more complicated since the source is periodic — a 20Hz rampwave which is synchronised to the main LFO. This is generated by the oscillator around TR6,7 and C15. TR6 is a constant current souce, linearly charging C15. When the voltage on C15 reaches +5V,TR7, a unijunction transistor, turns on and discharges it to -10V via R97, from where it begins to charge again. With the regular waveform output selected, S2a connects C15 to IC10a, which buffers the ramp wave signal. TR10 is the S/H switch, normally kept off by TR11 which holds its gate negative. Upon the LFO square wave going negative at the beginning of a cycle, the pulse from C18 turns TR11 off and TR10 is allowed to conduct. C19 charges to the value of the input signal, and at the end of the sample period, which lasts about 1 ms, TR10 turns off again and the charge on C19 is held until the next sample. IC11 is FET-input op-amp connected as a voltage follower, buffering the voltage on the capacitor. A low input bias current device is necessary to minimise the drain on C19, achieving a low voltage 'droop' between successive samplings.

The output of IC11 is fed to IC10b where the S/H waveform can be selected by SW2, with the values of R114, R115 chosen to produce a ±2.5V output signal from the -10,+5V range of the sampled voltage. With SW2 in the 'Random' position, the signal is low pass filtered by R116,C20 which removes the burst of noise that appears while the sample-and-hold FET is on. Though this is only 1ms long, it could breakthrough into the audio chain when using large modulation depths of VCF cutoff frequency or VCA amplitude.

The effect of sampling a constant frequency rampwave at a regular rate is to produce complex repeating sequences of voltages, the sequence length and type being determined by the sampling and sampled frequencies. This is often used to produce note sequences by modulating a VCO with the sample-and-hold output, but suffers from the disadvantage that the slightest change in sampling frequency or the frequency of the sampled waveform changes the effect. In practice it is very difficult to get a precisely repeating sequence, rather than one which has a repetitive 'theme' that steadily changes as a part of a truly repeating sequence with a much longer period. In other words, the results are often too complex and uncontrollable to be useful, and some method is needed to restrict the S/H wave-

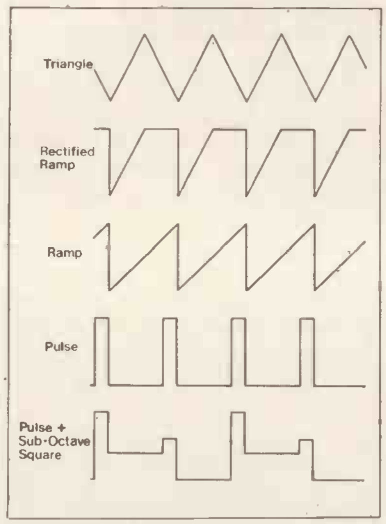

Figure 2. Basic VCO waveforms.

form to shorter repeating sequences. The Spectrum is unique in providing this, and does so by prematurely resetting the rampwave oscillator if it is near the end of its cycle when sampling occurs. Referring back to the LFO circuit diagram, this is achieved by C17,R99 which couple pulses from the LFO square wave to base 1 of TR7, the unijunction transistor in the rampwave generator. When the square wave goes low, the reset threshold of TR7 is effectively reduced by about 1 volt, so if the voltage on C15 is above +4V at this instant, the ramp wave is reset early and the sample-and-hold receives the voltage at the start of the next ramp cycle, i.e. -10V. The rampwave generator then runs normally until the next time it falls above +4V on a sample, whereupon it is reset and the sequence is repeated exactly. The time taken for this to occur depends upon the frequency ratio, but since the synchronisation is quite weak, sequences from very short to quite long are easily obtained and very long sequences are terminated when the premature reset condition arises.

The LFO square wave is sent to the envelope generator and shaper separately from the waveform selector switch and modulation routing, where it can be used to gate the envelopes repeatedly.

VCO's and Associated Circuitry

The Voltage Controlled Oscillators (VCO's) are the heart of the analogue synthesiser, and to a great extent determine the overall quality of the instrument. In exponential synthesisers they must be carefully designed to give an accurate and temperature compensated control scale; this normally makes them the most expensive sections and requires complex setting up.

In most small synthesisers the Voltage Controlled Filter is the primary timbre-determining section, with variations between designs responsible for the characteristic sounds of different instruments. The VCO's play a

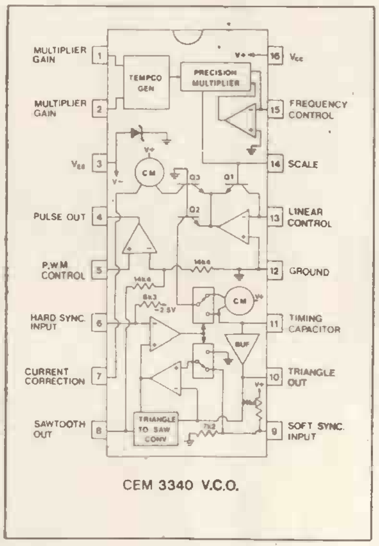

Figure 3.

lesser part in tone forming, with a limited choice of basic waveforms available to the player. The Spectrum synthesiser incorporates design techniques never before used in an instrument of this type to provide a very wide range of different timbres from the oscillator section by using the two VCO's in combination.

A unique feature is the ability of one oscillator to sound at harmonics of the other oscillator only — when used with the regular and random LFO waveforms this provides sequencer effects that can be transposed from the keyboard. This and other applications present new musical possibilities not previously open to players of low-cost synthesisers.

Circuit

Figure 4 shows the circuit diagram of the Voltage Control Oscillators (VCO's) and noise generator, which together form the source of audio signals for the synthesis of all available sounds. The oscillator control circuitry and the sections that combine the VCO signals by frequency modulation, synchronisation, and ring modulation are also included.

Each VCO uses the CEM 3340 IC, which is specifically designed for this kind of application, allowing a versatile and precise VCO to be built with great improvements in cost, component count and specification over discreet designs. The CEM 3340 was fully described by Charles Blakey in 'IC's for Electromusic', E&MM March '81, so except where its usage in this design is unusual, we shall not discuss it in great depth here. The internal diagram is shown in Figure 3. The device is an exponential VCO with linear FM, sync, and pulse width control inputs. In Figure 5, IC15 and IC16 are the basis of VCO 1 and VCO2 respectively, and pin 15 of each is the exponential control input. This is a virtual earth summing node so each of the required signals for VCO pitch control are routed to this point via a resistor whose value which determines the control relationship (the amount of pitch change for a given voltage change). With the scale trim presets correctly set, 100k gives the required keyboard control relationship of 1V/Octave. the key CV signal is fed to VCO1 and VCO2 via R162 and R163 respectively, which are 100k 1% metal film resistors with a temperature co-efficient of 100ppm/°C. The precision is not important since the scale is trimmed, but the low temperature co-efficient is required to ensure that the control relationship remains constant with varying temperature. IC15 and IC16 are internally compensated for temperature changes, but stability of external control signals is just as important where it affects control scale.

The VCO CV interface socket accepts an external voltage from a device such as a sequencer for additional precise control of the VCO's. The voltage is buffered by IC7b and fed to pin 15 of IC15 by R147,R164 and RV21, and to pin 15 of IC16 by R148,R165 and RV22. Though 100k 1% resistors would give a control scale as precise as that for the keyboard, the external CV must match key CV for scale exactly, so RV21 and RV22 are included. S5, RV15,S7, and R157-161 perform the modulation routing for the VCO's. S5 selects the source from among the envelope generator, low frequency oscillator, and noise generator, and RV15 controls the depth of modulation from 0 to 5 octaves when controlling pitch. A logarithmic pot. is used to provide fine control at low modulation depths. S7 selects the modulation function from pulse width, where at maximum depth the range is 50%, either VCO, or both VCO's simultaneously. The 'Off' position enables a modulation effect to be preset and then switched in when required.

The controller enables the joystick or an external device to control either or both oscillator pitches, pulse width, or filter cut-off frequency with variable depth. IC14a amplifies the voltage from the wiper of RV13, the x-axis joystick pot. With the controller in/out socket unused, RV14 controls the amount of joystick voltage modulating the function selected by S6. The joystick voltage is available at the controller socket for control of additional equipment, or a foot pedal wired as a variable resistance to earth can be connected to control the selected function. The joystick voltage can be overridden by patching in a voltage from an external low-impedance output. A signal from a high-impedance output will be mixed with the joystick voltage.

Each VCO has a range selector switch which transposes the pitch up or down over a total range of six octaves. The voltages for the different ranges are provided by the potential divider composed of R133-138, RV9-12. S3 and S4, the range switches, select 0V for 64', 2.5V for 32', 5.0V for 16' and so on to 12.5V for 2', the top setting. The basic pitch for 64' is set by the positions of RV17 for VCO1 and RV18 for VCO2, each of which applies a fixed control voltage to its respective VCO control input. The basic pitch for 32' is then set by RV19 for VCO1 and RV20 for VCO2, with the rest of the ranges having their own presets in the potential divider. The selected voltages are not sent directly to the VCO's but are buffered by IC13. This prevents the currents taken by R145, RV19 and R146, RV20, from affecting the voltages on the divider, which would otherwise cause the position of the range switch of one VCO to effect the pitch of the other. C27 stores the last selected voltage while S3, which must be break-before-make to avoid shorting out sections of the divider, is between switch positions. On many synthesisers, changing the oscillator range causes a spurious pitch to be generated, which often appears as an annoying 'blip' if a note is sounding. C27 maintains the pitch during the changeover and allows perfect octave switching while playing. C28 performs the same function for VCO2, and R141, R142 are included so that upon either range being changed, the charge currents of C27 and C28 are kept low enough to eliminate any perceptible momentary pitch drop due to drain on the divider.

One special feature of the CEM 3340 is the linear frequency modulation (FM) input, which allows the frequency of the VCO to be modulated by an audio frequency signal for the creation of new timbres. The current at this input (pin 13) is multiplied by the exponentiated pitch control voltage, so that a constant percentage FM depth is maintained over the range of the oscillator (see 'Advanced Music Synthesis', E&MM March '81). This is ideal for a keyboard-based synthesiser such as the Spectrum, since it allows a FM tone to be set up and played from the keyboard in the same way as a simple waveform. S8 is the FM & Sync function switch. In the 'FM' and 'FM + Sync I' positions, the triangle output of VCO1, from IC19a, is fed to the linear FM input of IC16. C36 removes the DC offset from the triangle wave and is arranged with R190 before S8 and RV28, the FM Depth control, so that the depth can be altered without the charge on C36 changing and causing a brief unwanted frequency shift. The value of R183 has been chosen to give just under ±100% frequency modulation depth with RV28 at maximum.

The CEM 3340 is equipped with synchronisation inputs which can be fed with pulses from another VCO to lock the VCO's to the same frequency. The 'hard sync' input accepts positive and negative going pulses which cause the triangle wave to reverse direction during its rising and falling sections respectively. The 'soft sync.' input gives access to the potential divider that produces the upper threshold voltage for the triangle wave, and by applying negative pulses to this

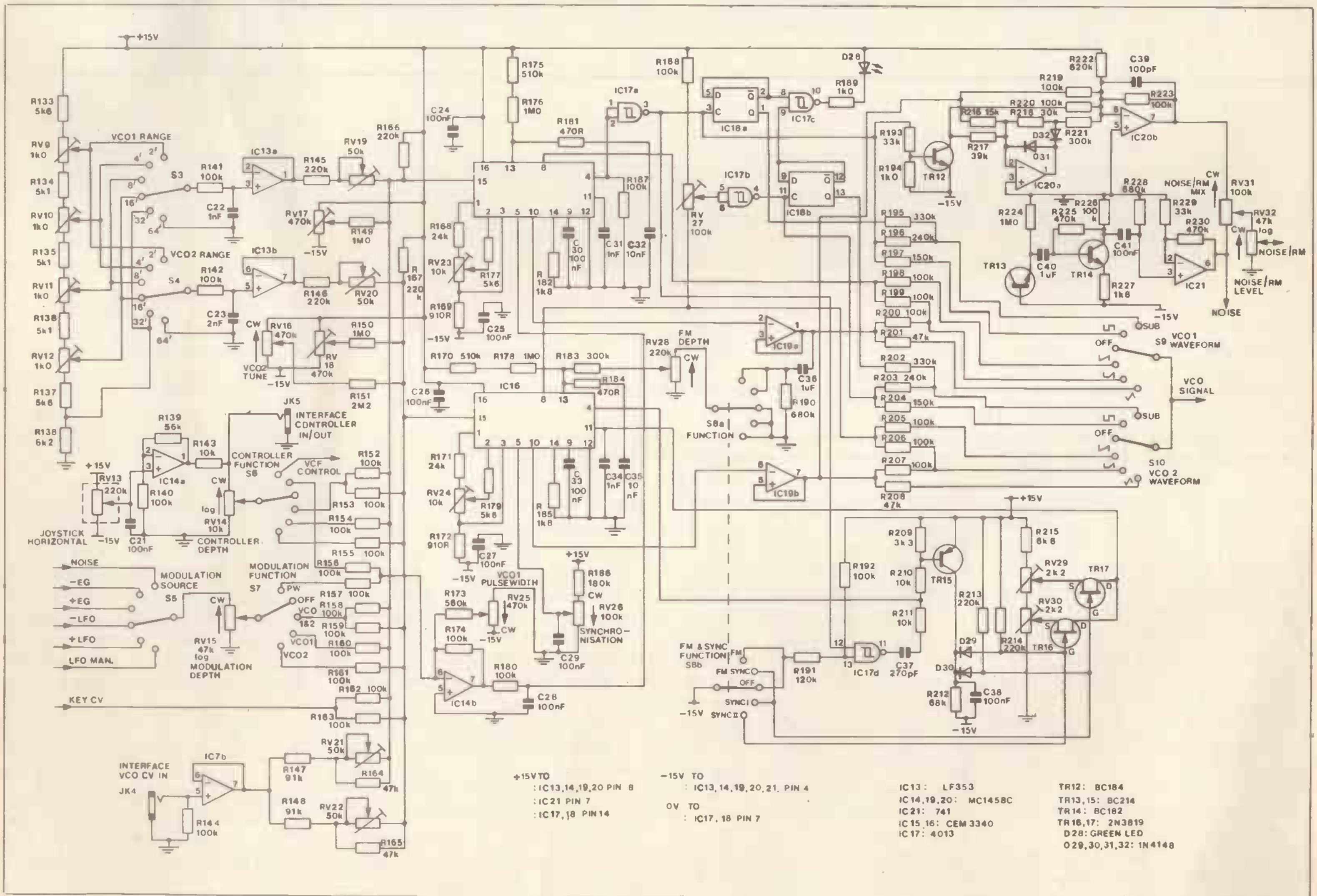

Figure 4. Circuit diagram of the VCO's and associated circuits.

point the triangle wave is reversed at its upper peak when it reaches the point at which the input pulses cause the threshold to drop below the level of the waveform. Neither of these methods provide true synchronisation since this relies on the waveform being reset to a fixed point each time, rather than merely reversing its direction. The sync inputs provided do enable the waveform to be synchronised to the frequency of the input pulses, so strictly it is correct to call the effect synchronisation, though 'hard' and 'soft' normally refer to different degrees of the same effect, with hard sync causing unconditional reset of the waveform, and soft sync causing reset if the waveform value at that time is in a particular range, usually above a certain level. The synchronisation facilities provided on the CEM 3340 are unsuitable for the creation of new waveforms, the most useful property of true sync, so the Spectrum uses additional circuitry to achieve this.

The synchronisation circuit appears in the bottom left hand corner of Figure 4. S8b is the pole of the FM & Sync Function switch that controls this circuit. When sync is off (in the 'Off' and 'FM' positions) pin 13 of IC17d is held low blocking the pulse wave from VCO1, the 'master' oscillator. When sync is selected, the pulse wave is inverted by the NAND gate and the falling edges are differentiated to give 10us wide negative pulses that turn TR15 on. TR16 and TR17 are FET's that provide a low resistance path from C34, the integrator capacitor of IC16, to the potential divider R215,RV29,RV30 when either gate is allowed to go high. Without sync selected, the FET's are held off by R212 via D29 and D30. With S8 in the 'Sync I' or 'FM + Sync I' position, the gate of TR17 is connected to -15V holding it off, but on each sync pulse R213 is allowed to turn on TR16, and C34 discharges to the voltage set by RV30. With Sync II selected TR16 is held off and TR17 discharges C34 to the voltage on the wiper of RV29. Hence at the end of each cycle of VCO1, VCO2's waveform is reset to one of two positions depending on which type of synchronisation is selected.

As can be seen from the internal diagram of the CEM 3340 the voltage on the integrator capacitor at pin 11 is buffered to drive the comparator, triangle wave output, and ramp wave shaping circuit. The comparator switches the threshold and direction of the triangle waveform when the selected

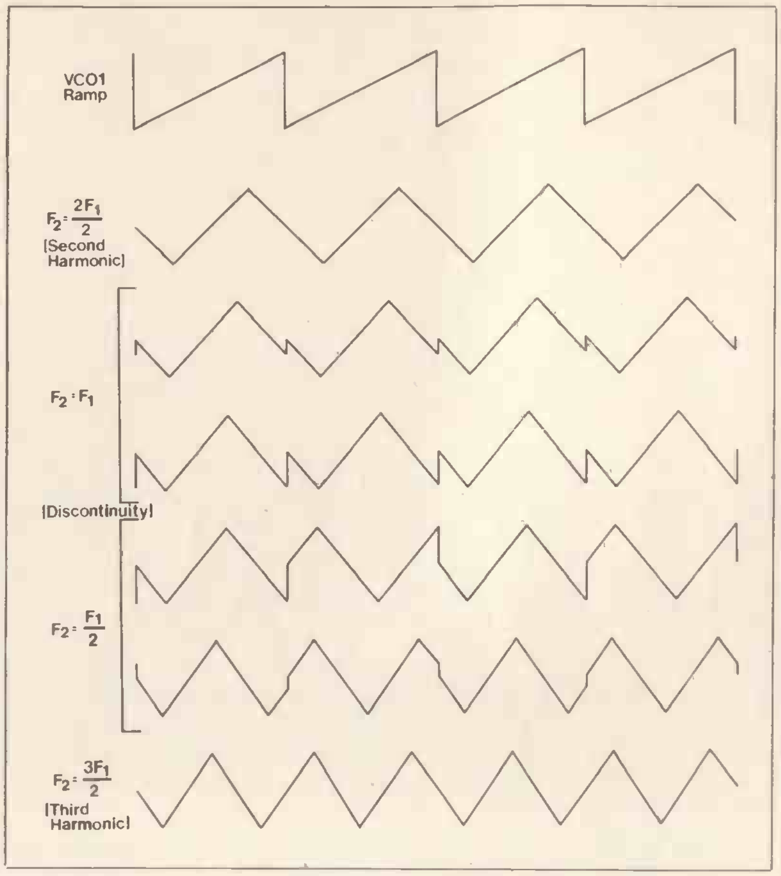

Figure 5. Sync II.

threshold is reached. The buffer produces an offset of about -1.6V and since the comparator refers to the output of the buffer, the voltage on the capacitor ramps between approx +1.6V and +6.6V. RV30 is set to return the buffered waveform to just below 0V, corresponding to about 1.6V on its wiper. This makes sure that the internal comparator is set to its rising state by the waveform crossing the lower threshold. Hence Sync I causes the triangle wave to begin an upward slope from its minimum value at the end of each VCO1 cycle. Sync II differs in that the triangle wave is set to its midpoint and proceeds in the same direction as before the sync pulse, i.e. the comparator state is unaffected. This means that slight changes of frequency that bring the VCO2 triangle wave to a peak before the sync pulse, where the sync pulse previously caught the waveform just before it reached the top, cause discontinuities in the tone and pitch of the sound. This is a feature of the pitch quantizing effect of Sync II, where the pitch of VCO2 jumps from one harmonic to the next as the control voltage to VCO2 is increased. As a result of the fact that alternate sections of the waveform between sync resets are inverted if the sync occurs on alternate rising and falling slopes, there is an inherent divide-by-two so the harmonics generated are really those of the sub-octave of VCO1. Figure 5 shows some examples of Sync II waveforms, those between the second and third harmonics of the sub-octave of VCO1. Note that as the rate of VCO2 is increased harmonics of the VCO1 fundamental increase in amplitude until the period is suddenly doubled with the introduction of the sub-octave component and from there on the harmonics diminish until the triangle wave is restored at a higher frequency.

Sync I produces a smooth change in timbre as VCO2 is swept, since each time sync reset occurs, the cycle starts in the same way. This makes it more useful for timbre modulation, whereas Sync II is best for pitch effects. One of the simplest uses is to generate the effect of a full-wave rectified ramp wave which can be modulated from a complete ramp to a triangle wave from the triangle output. On other synthesisers this is accompanied by a volume change, the triangle wave being half the amplitude of the rampwave, but with synchronisation the level remains fixed over the range, and of course the waveform shape can be swept much further in both directions. As the rate of VCO2 is decreased, a diminishing rampwave is produced giving a new method of amplitude modulation. As it is increased, the band of accentuated harmonics sweeps up the spectrum. Figure 6 shows some Sync I waveforms obtained from the triangle output with different relationships between the rates of the two VCO's.

So far we have only considered hard synchronisation, where the VCO2 cycle is restarted on every cycle of VCO. This gives the output of VCO2 the same period as that of VCO1, or in some cases of Sync II, double that. If the natural frequency of VCO2 is adjusted to a multiple of the VCO1 frequency, it will produce its natural waveform though beating effects are eliminated and a slight change of either frequency will introduce components of the VCO1 waveform into VCO2's output revealing the true period. Soft synchronisation causes reset only if VCO2 is past a particular point in its cycle and enables the pitches to be locked in musical intervals corresponding to fractional frequency ratios such as 3:2 (a perfect fifth), 4:3 (a perfect fourth) and 5:4 (a major third). Conventional discreet rampwave oscillators achieve soft sync by putting pulses on the ramp's upper threshold in the same way as the Spectrum LFO produces its regular S/H waveform. The Spectrum VCO's use a more advanced method which allows precise sync in ratios as low as 500:499 for example, where the VCO2 waveform is reset once every 500 cycles. Such weak synchronisation is heard as a series of clicks rather than an actual change of VCO2's pitch, but intermediate settings can give complex waveforms suitable for imitating many elusive sounds with complex harmonics such as those of engines, creaking doors etc. The synchronisation control in the FM & Sync section varies the depth of Sync I or II from zero (equivalent to no sync selected by the function switch) through increasing depths of soft sync to hard sync at the maximum setting.

The Synchronisation control uses the pulse wave facility of the CEM 3340 to inhibit reset until the rampwave of VCO2 has passed a certain point in its cycle. Reference to Figure 3 shows that the pulse wave is normally derived from the rampwave by comparing it with the voltage at pin 5, the pulse width modulation input. The output at pin 4 is an open NPN emitter, which is high while the ramp waveform is below the PW control voltage. This output is connected to the junction of R210,R211 in the base circuit of TR15 so for the first portion of VCO2's cycle the TR15 is held off and the sync pulses are prevented from resetting the cycle.

The proportion of the cycle for which sync reset is inhibited is determined by the setting of RV26, the Synchronisation control, which supplies a variable voltage to the PW control input. With the synchronisation control at 0 (>5V at pin 5) no sync reset can occur. At 10 (0V at pin 5) the PW output at pin 4 has no effect and every sync pulse causes reset (hard sync).

Figure 7 illustrates an example of how soft synchronisation (using Sync II) locks the pitch of the slave VCO (VCO2) in a musical interval with that of the master VCO (VCO1), in this case a fourth (a frequency ratio of 4:3). The sync pulses and waveform at the base of TR15 include positive going pulses (produced by the rising edges of the pulse wave) but these have no effect on circuit operation so are omitted for simplicity. Without the synchronisation operating, the ratio of the VCO frequencies would be 39:30, a flat 'perfect' fourth. The dotted line shown against the VCO2 ramp wave represents the level at the PW control input of IC15, pin 5, and corresponds to a setting of 3 on the Synchronization control. While the ramp is below this level the base of TR15 is held high, blocking the sync pulses. The phase of the higher frequency VCO2 waveform advances until a sync pulse coincides with the portion of the ramp above the dotted line, and the VCO2 waveform is reset to zero (point 'A'). This brings the ramps into phase, and until the sync pulse is again successful (point 'C'), VCO2 runs freely. Though the fourth above VCO1's pitch is heard clearly in the output of VCO2, the actual pitch of VCO2 is two octaves below this, at the lowest common denominator of the two frequencies. In practice this can be eliminated by tuning VCO up until a near perfect triangle or ramp is produced, with the sync pulses just catching the end of each fourth cycle, but since the extra components form a third note at the root of the chord it is often left in to produce richer sounds.

When using soft synchronisation, the PW output of IC16 turns TR15 off as soon as the reset takes the ramp waveform below the voltage on the wiper of the sync control (the dotted line). This would cause the new cycle to begin at some point above 0V (or with Sync II above 2.5V) depending on the point it was at before the sync pulse. C38 is included to keep the FET on for a short time after the reset turns TR15 off, ensuring that C34 discharges to the voltage on the

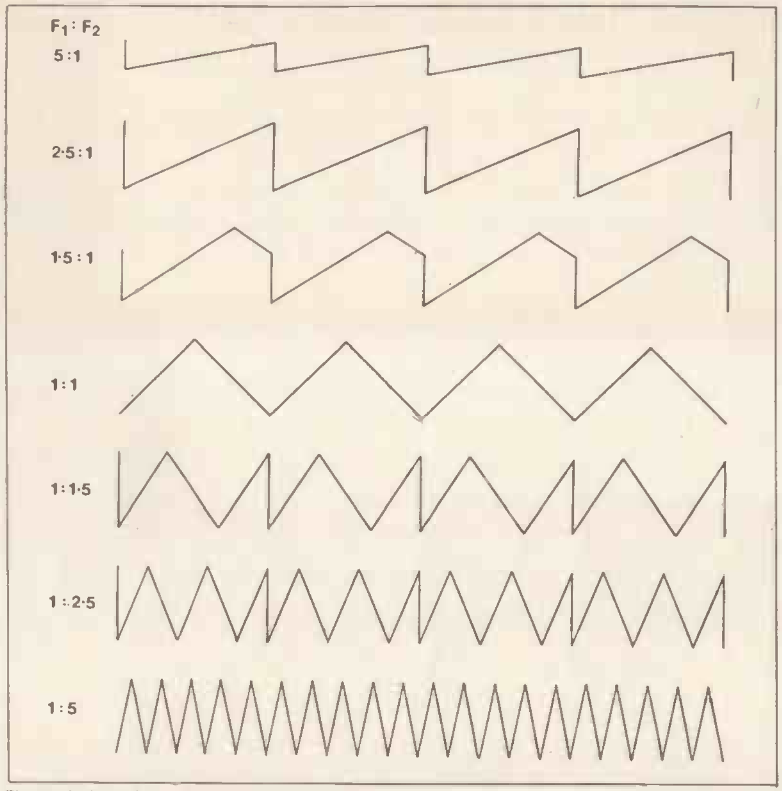

Figure 6. Sync I.

potential divider.

The pulse wave output of VCO1 is variable from 0 to 50% by the Pulse Width control and from 0 to 100% with modulation. IC14b sums the voltages from the PW control, modulation routing and controller. The output is low-pass filtered by R180,C28 before being fed to the PW control input of IC15. This is to prevent stray feedback from the pulse output causing a fast burst of pulses on the falling edge which would confuse the sub-octave generator. C29 performs the same function on IC16, preventing spurious synchronisation pulses. The pulse output at pin 4 of IC15 is pulled down by R187 (being an open NPN emitter). The waveform is sharpened up by IC17a, a Schmitt NAND gate connected as an inverter, and used to clock the flip-flop IC18a. This produces a square wave of half the frequency, which is mixed with the pulse wave to give the sub-octave waveform.

The flip flop input would oscillate with the slow edges of the raw pulse output of IC15, so the schmitt gate is necessary for proper division.

The pulse output of IC15 is the source for the synchronisation circuit, so the sync effect can be turned on and off by modulating the PW through 0%. Hence, for example, the joystick can be used to bring in parallel harmonies or the free phase sound of unison oscillators could be introduced by the envelope generator as a note decays.

The VCO2 pulse is derived from the rampwave by IC17b. RV27 allows its width to be set between 0 and 65% at the setting up stage. VCO2's sub-octave waveform is generated by IC18b.

The ramp wave outputs of IC15 and IC16 are used directly and the triangle wave outputs are

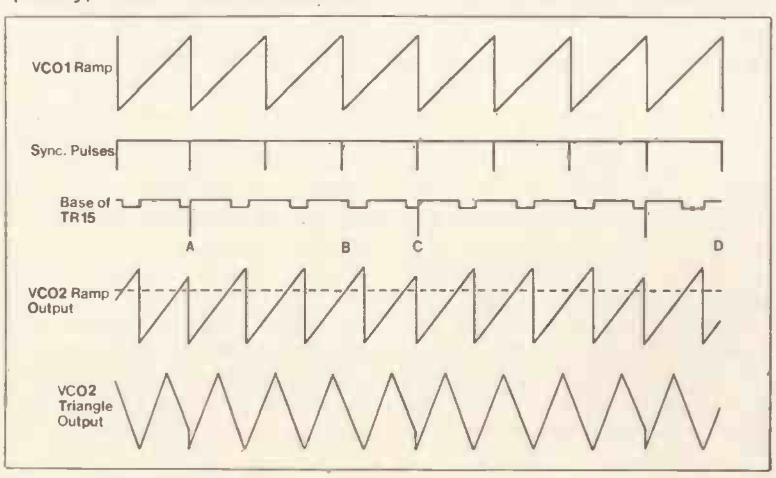

Figure 7. Soft synchronisation.

buffered by IC19a and b respectively. The half-way rectified ramp waveforms are produced by mixing the triangle and ramp waves in equal proportions. S9 and S10 are the waveform selector switches for the two oscillators, and connect to a virtual earth summing node in the VCF circuit. R195-208 are chosen to give equal peak amplitudes for the different waveforms.

The two sub-octave square waves are NAND-ed to provide the drive to the tuning LED. When the waveforms are out-of-phase, the output is high and the LED off. Advancing phase difference due to slightly different frequencies produces a pulse wave that varies from 100 to 50% width, displaying the beats as fluctuating LED brightness.

The ring modulator is based around IC20 and processes the pulse wave of VCO1 and the triangle wave of VCO2 to produce complex non-harmonic sounds. It functions in a similar way to the ramp wave shaper of the Spectrum LFO by inverting the triangle wave about its midpoint when the pulse wave is high, and leaving it unchanged when low. This constitutes four quadrant multiplication of the value of the triangle wave by the value of the pulse wave (-1 or +1). When the pulse output is low Tr12 is off and the triangle wave is inverted with a gain of 2 by IC20a. The output is mixed with the original triangle wave of half the amplitude and opposite phase by IC20b. With the pulse output high the collector of TR12 is at -15V and the output of IC20a is positive. This reverse biases D32, and no signal reaches IC20b via R221. The original triangle wave is inverted by IC20b and shifted by the current through R220. The output of IC20b is the required product.

The noise generator is quite conventional, using the thermal noise of a semiconductor junction as a source. TR14 amplifies the noise on the emitter of TR13 to about 4mV p-p, which is boosted to ±2.5V by IC21. RV31 mixes the noise and RM signals and RV32 controls the amount sent to the VCF section. The noise signal is also sent to the LFO and modulation routing sections.

Part 4 will describe the remainder of the circuits, including the VCF, VCA's and Envelope Generators.

Since the Spectrum article began, we have had many enquiries from readers wishing to begin construction immediately. We strongly advise waiting until Part 5 is published, by which time the main parts list and full construction details will have appeared.

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PART 3: Construction of the Power Supply Unit and Main PCB

In this part we shall describe how to make the other two printed circuit boards in the Matinée: the power supply and the main PCB. Once these are complete, there are only 40 to 50 wires to be connected and the electronic construction is finished. First we shall look at the power supply which drives the whole organ.

Power Supply Construction

Fit the twelve Veropins in the positions marked by the large circles around the holes on the PCB. Push the pins firmly into the PCB from the track side and solder them. Insert the resistors, capacitors, presets and bridge rectifiers referring to the parts list and legend on the PCB. Ensure that C1,2,3,7,8 and BR1 and 2 are put in the right way round. The five capacitors have an indent around one end of the body and this is the positive end. Solder all these parts to the PCB. Do not mount the regulators at this stage.

The power supply unit (PSU) bracket should now be made as shown in Figure 11. This is supplied ready-made in the kit but may be bought as a separate item. Cut about 10cm off the piece of 32-strand brown wire and strip a piece of sheath off each end. Twist the strands tightly together at each end, apply the soldering iron and quickly run solder onto the strands to hold them together. All the wires used in the Matinée should be prepared first in this way.

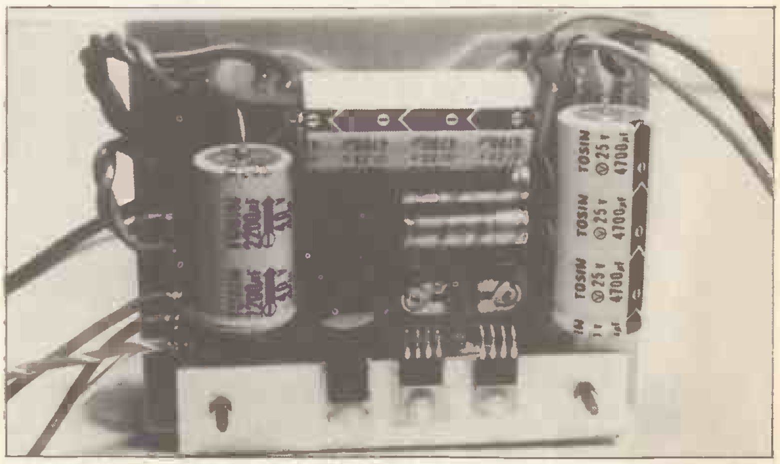
With no fuse in the fuseholder, wrap one end of the brown wire around the end tag and solder. Fit the fuseholder to the PSU bracket, then fit the grommet in the end hole as shown in the photograph. Take the piece of two-core mains cable and strip off about 10cm of the outer sheath. Strip and tin the blue and brown wires as described earlier then push the cable through the grommet and solder the brown wire to the other tag on the fuseholder.

Cut two 30cm lengths off the 32-strand green wire and 20cm off the black, blue, brown, red and white wires. With reference to Figures 12 and 13 connect and solder the two green wires to the tag marked 'SCR' on the transformer and the other five wires to the five tags on the other side of the transformer. Bolt the transformer to the PSU bracket using 4BA nuts, bolts and washers as shown in the photograph.

Take one of the green wires out of the bracket through the grommet then solder the blue wire from the mains cable to the tag marked '0' next to 'SCR' on the transformer. Solder the brown wire from the fuseholder to the tag marked '240' on the transformer. Twist the two wires from the 0 and 22V tags together and twist the other three wires together.

Fit the three regulators to the PCB; note that the type numbers are very similar, so take care to fit the right one in the right position. (The pin out details are shown in Figure 14). The leads of the regulators have to be bent at 90° (see

Completed power supply unit.



PSU circuit board mounted on bracket.

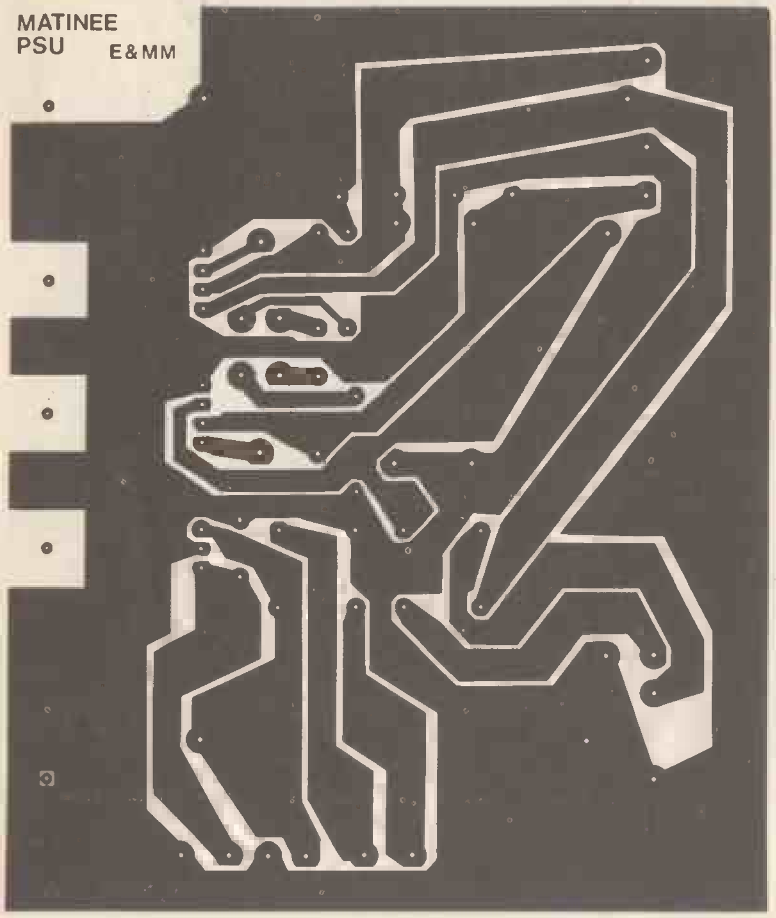


Figure 9. Power supply circuit board.

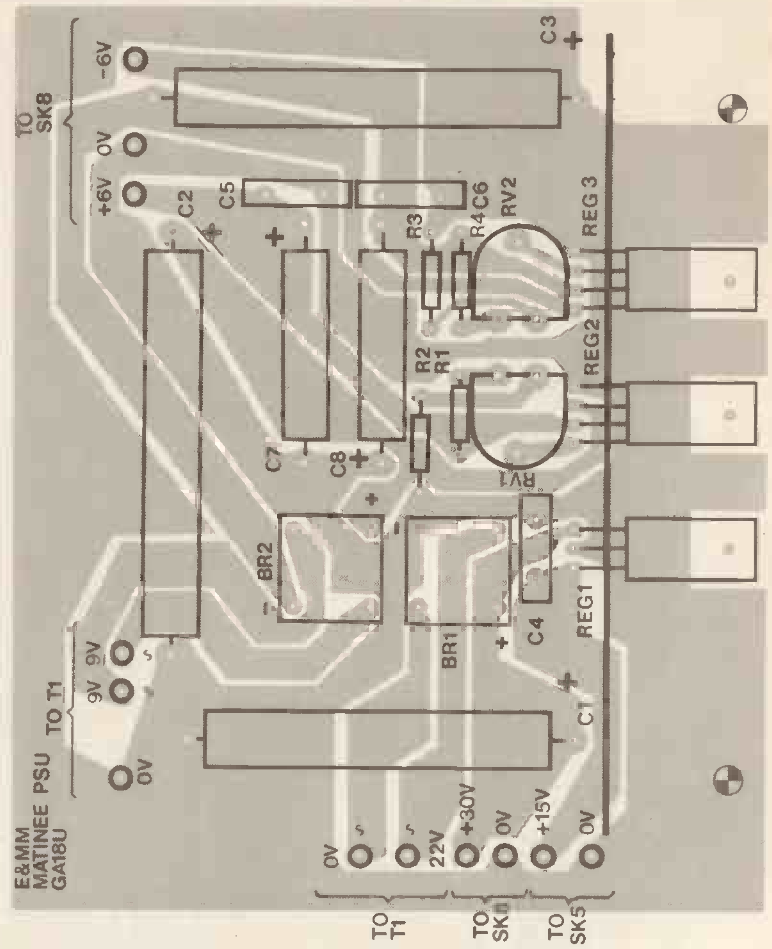


Figure 10. PSU PCB component layout.

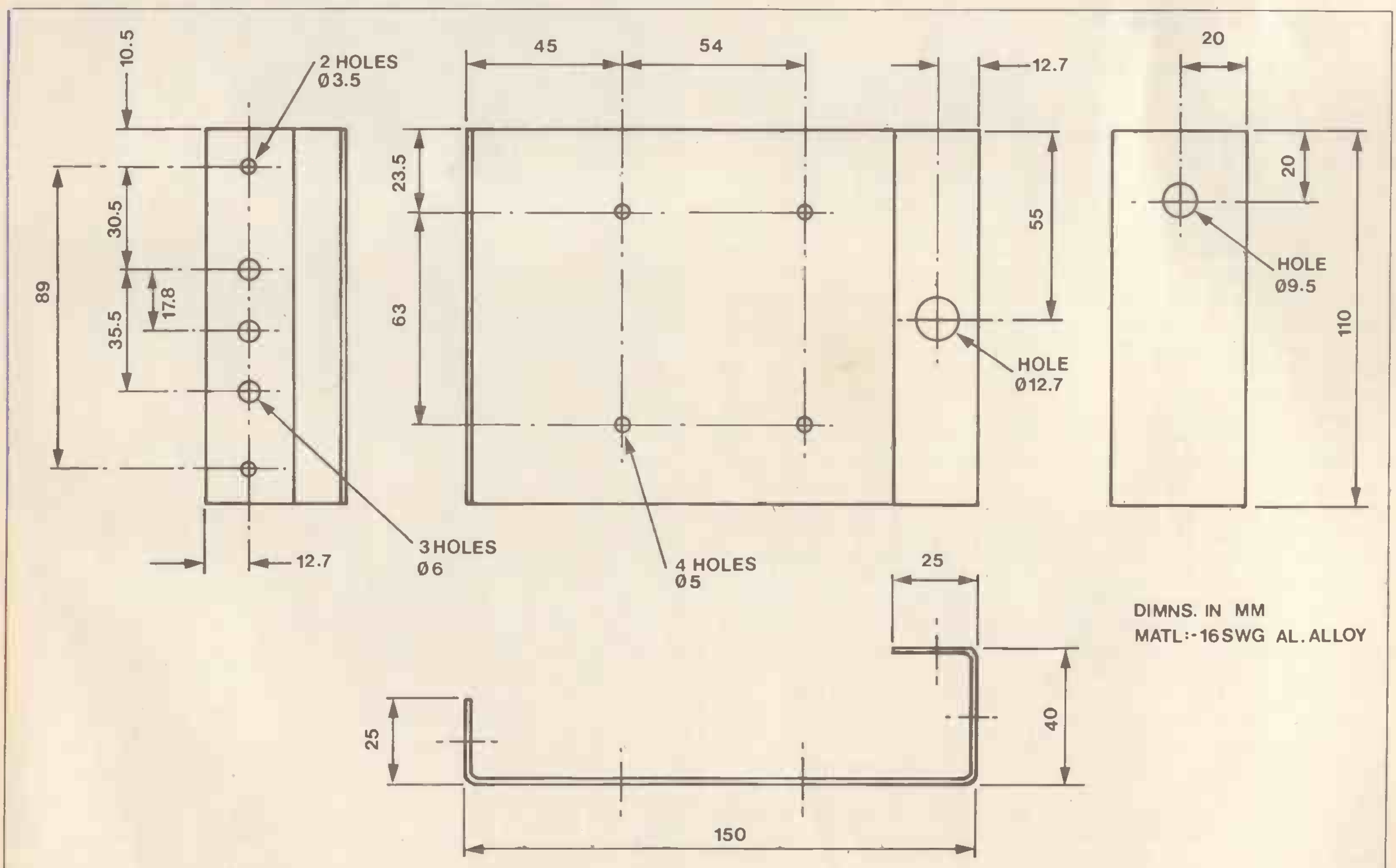


Figure 11. PSU mounting bracket.

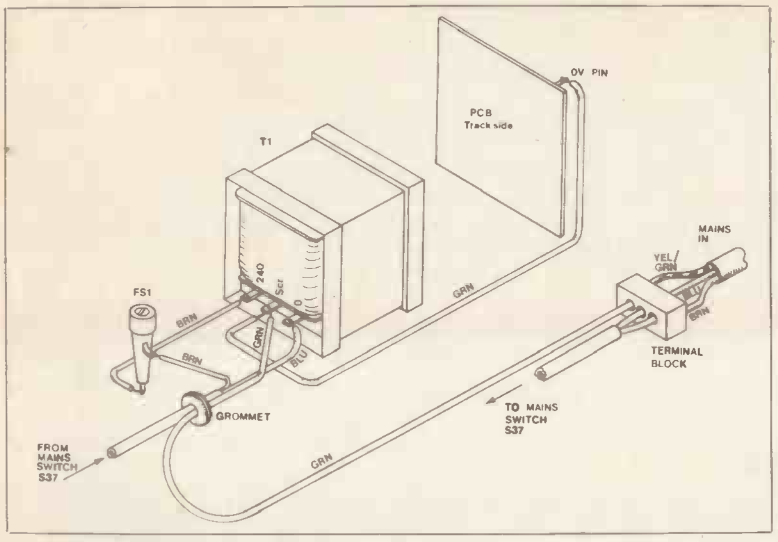


Figure 12. Transformer primary wiring.

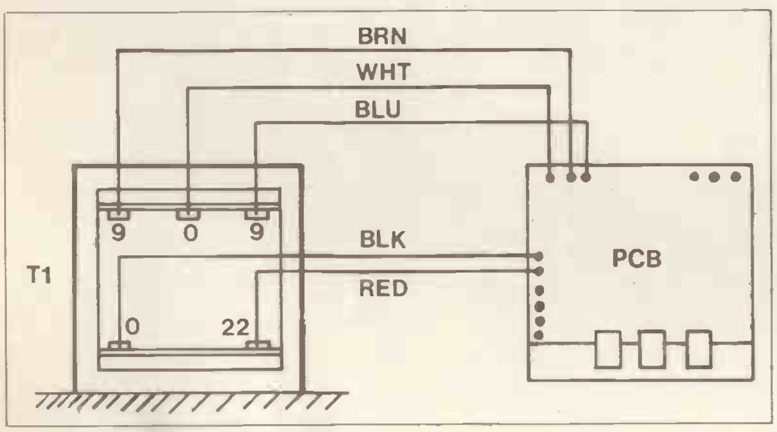


Figure 13. Transformer secondary wiring.

Figure 15) then soldered to the PCB so that the holes in the metal tabs are directly above the holes in the PCB. The metal back of the regulator needs to be about 2mm from the board. Smear the mica washers with Thermpath or any silicone grease, then fix the PCB and regulators to the PSU bracket as shown in Figure 15. Bolt the PCB to the PSU bracket using two 6BA nuts, bolts and washers in the two outer holes. One of these bolts connects the 0V on the PCB to the chassis.

Connect the green wire from 'Scr' on the transformer to the top left-hand pin on the PCB. Note that the white wire from the other side of the transformer also connects to this pin. Connect the other four wires as shown in Figure 13. Finally strip and prepare one end of the remaining piece of each colour of the 32-strand wire and connect to the remaining seven pins on the PCB as shown in Figure 16.

Now check all the connections, referring to the diagrams. Ensure that no strands of wire are sticking out anywhere. It is most important that all wires are connected as described. Do not attempt to cut down on the numbers of wires by connecting 0V points together. All the wires shown are essential. It is equally important not to add additional wires. Do not link 0V points together unless the diagrams show that a wire is fitted there. It is particularly important to note that the two points marked '0V' on the secondary of the transformer must *not* under any circumstances be connected together.

We have deliberately designed the PSU bracket so that the connections to the transformer primary and the fuseholder are rather inaccessible. All the dangerous voltages in the PSU are in this area and although this unit will normally be inside the organ cabinet and out of the way, whilst testing is in progress it will be accessible and we have therefore taken precautions. Using the folded PSU bracket, all the tags at mains potential are both tucked away and close to the earthed chassis.

Power Supply Circuit

The circuit shown in Figure 16 operates as follows. Mains (live and neutral) via the mains switch S37 are connected to the primary of T1 which is protected by a 1 amp fuse (FS1). The transformer has two secondaries, isolated from the primary by an electrostatic screen.

One secondary is 22V AC that is full-wave rectified by BR1 and smoothed by C1. This produces approximately 30V, DC. An unregulated output from here supplies the audio power amplifier on the main PCB, and the input to REG 1 is also taken from this point. REG 1 is a 15V, fixed voltage regulator and C4 is provided to inhibit high frequency oscillation and promote stability. This 15V supply is used in the reverberation spring driver circuit on the main PCB.

The other winding on the transformer provides an 18V, AC centre-tapped supply. The 18V is full-wave rectified by BR2 and the positive output is smoothed by C2 and fed to REG 2. This is a variable, positive-voltage regulator whose output voltage is set by the voltage on its control pin. this can be adjusted by RV1 whose range is limited by R1 and R2. The +6V output is smoothed and stabilised by capacitors C5 and C7.

The negative output of BR2 is smoothed by C3 and fed into REG 3. This is a variable, negative voltage regulator, otherwise similar to REG 2. Its voltage is adjusted by RV2 and R3 and R4 limit the range. C6 and C8 smooth and stabilise the -6V output. The 6-0-6V output from the PSU form the main voltage rails for the organ, driving the vast majority of the circuits on the main PCB.

POWER SUPPLY PARTS LIST

Resistors — all 5% ½W carbon unless specified.			
R1	820R		(M820R)
R2	4k7		(M4K7)
R3	2k7		(M2K7)
R4	5k6		(M5K6)
RV1,2	Hor. S-min. preset 1k0	2 off	(WR55K)
Capacitors			
C1	2200uF 40V axial elect.		(FB91Y)
C2,3	4700uF 25V axial elect.	2 off	(FB96E)
C4,5,6	100nF ceramic disc	3 off	(BX03D)
C7,8	470uF 10V axial elect.	2 off	(FB71N)
Semiconductors			
BR1	S04 bridge rectifier		(QL10L)
BR2	S005 bridge rectifier		(QL09K)
REG 1	uA7815UC		(QL33L)
REG 2	uA78GU1C		(WQ79L)
REG 3	uA79GU1C		(WQ94C)
Miscellaneous			
T1	Transformer, 0-240V prim., 9-0-9V, 0-22V secs., 2A		(YK03D)
S37	DPST Neon rocker switch		(YR70M)
FS1	1A fuse, 20mm		(WR03D)
SK5	Minicon 6-way latching socket housing		(BH65V)
SK8	Minicon 5-way latching socket housing		(BH66W)
	Minicon socket terminal	11 off	(YW25C)
	Safuseholder 20mm		(RX96E)
	PSU PCB		(GA18U)
	Mounting kit	3 off	(WR23A)
	Veropin 2141	12 off	(FL21X)
	PSU bracket		(YK04E)
	3-Way 5A terminal block		(HF01B)
	Grommet, small (⅜in.)		(FW59P)
	13A Mains plug		(RW67X)
	Thermpath small		(HQ00A)
	2-Core 3A mains cable	3m	(XR00A)
	3-Core 3A mains cable	3m	(XR02C)
	32/0·2 wire black	2m	(XR32K)
	32/0·2 wire blue	2m	(XR33L)
	32/0·2 wire brown	2m	(XR34M)
	32/0·2 wire green	3m	(XR35Q)
	32/0·2 wire red	2m	(XR36P)
	32/0·2 wire white	2m	(XR37S)
	32/0·2 wire green/yellow	2m	(XR38R)
	Woodscrew No. 4 x ¼in.	2 off	
	6BA, ½in. nylon bolt	3 off	(BF75S)
	6BA nylon nut	3 off	(BF80B)
	6BA, ½in. bolt	2 off	(BF12N)
	6BA nut	2 off	(BF18U)
	Shakeproof washer	2 off	(BF26D)
	4BA, 1in. bolt	4 off	(BF04E)
	4BA nut	4 off	(BF17T)
	4BA shakeproof washer	4 off	(BF25C)

All the parts listed above are included in the kit available from Maplin Electronic Supplies Ltd.

Please note that buying all the parts separately will be considerably more expensive than buying it at the special kit price.

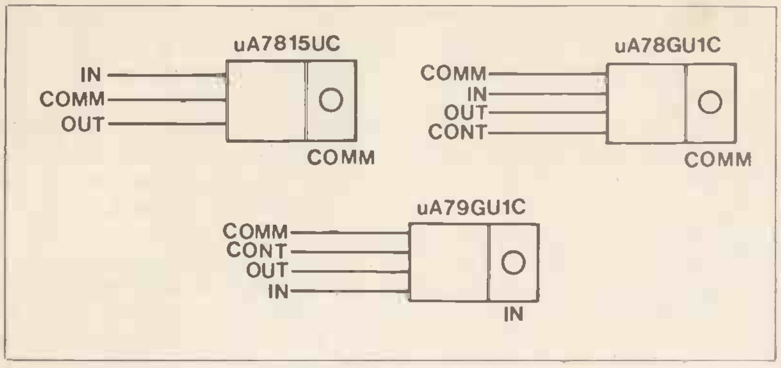


Figure 14. Regulators (viewed from above).

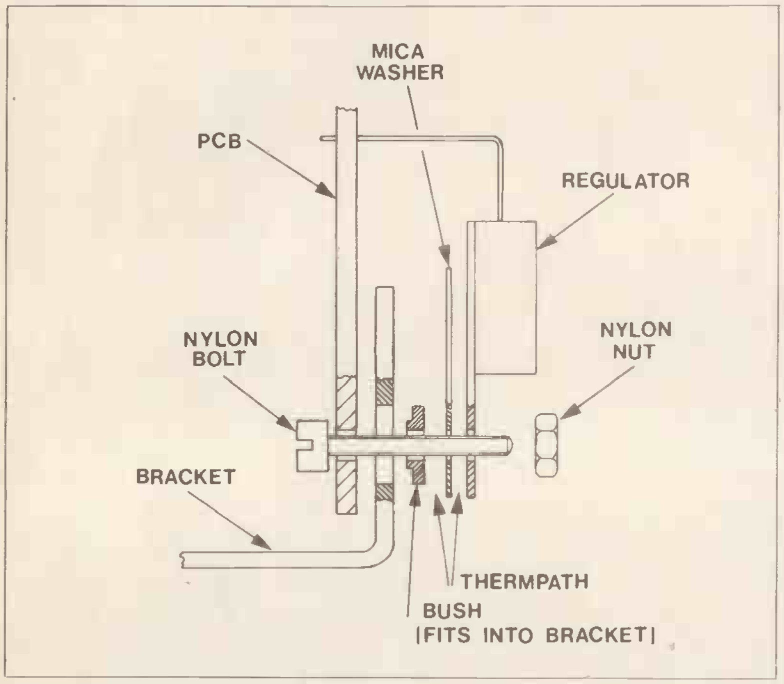


Figure 15. Mounting the regulators.

Main PCB Construction

Well over 90% of the circuits and components in the Matinee are located on the main PCB. This very large board measures over 3ft by 10in and has track on both sides. The board is printed with a solder resist which will help constructors keep solder off parts that should not be soldered. The component side of the PCB, which we shall call the topside, has most of the component designations marked on it and the switch side, which we shall call the underside, has a few switch designations and many pin circles marked on it.

In many places the track on one side of the PCB has to be connected through the board to the track on the other side. The board could have been made with plated-through holes but this is a very expensive process unless the board is manufactured in vast quantities. This board would have cost over £30 more than it does, had it used plated-through holes. In our case the tracks have to be linked with track pins. These pins are supplied in strips and are inserted from the underside as shown in Figure 17. After snapping off the strip (17b) push the pin firmly into the PCB. Insert ten pins, then solder on both sides. By inserting and soldering in batches of ten a balance is achieved between constantly changing jobs and doing so many at once

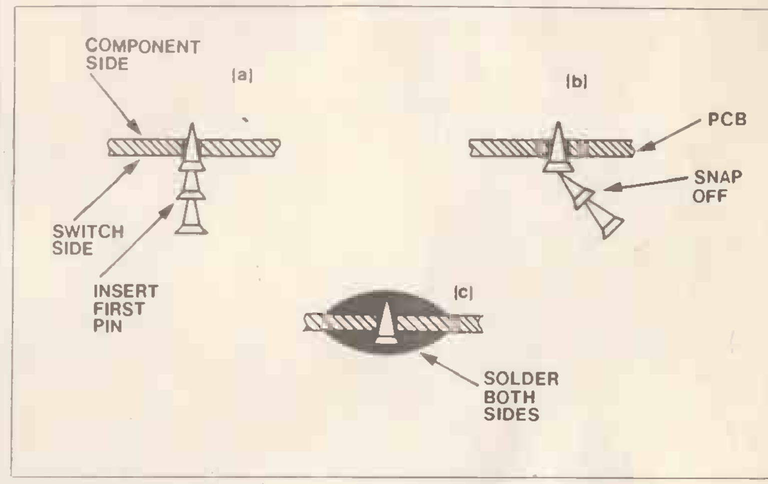


Figure 17. Fitting track pins.

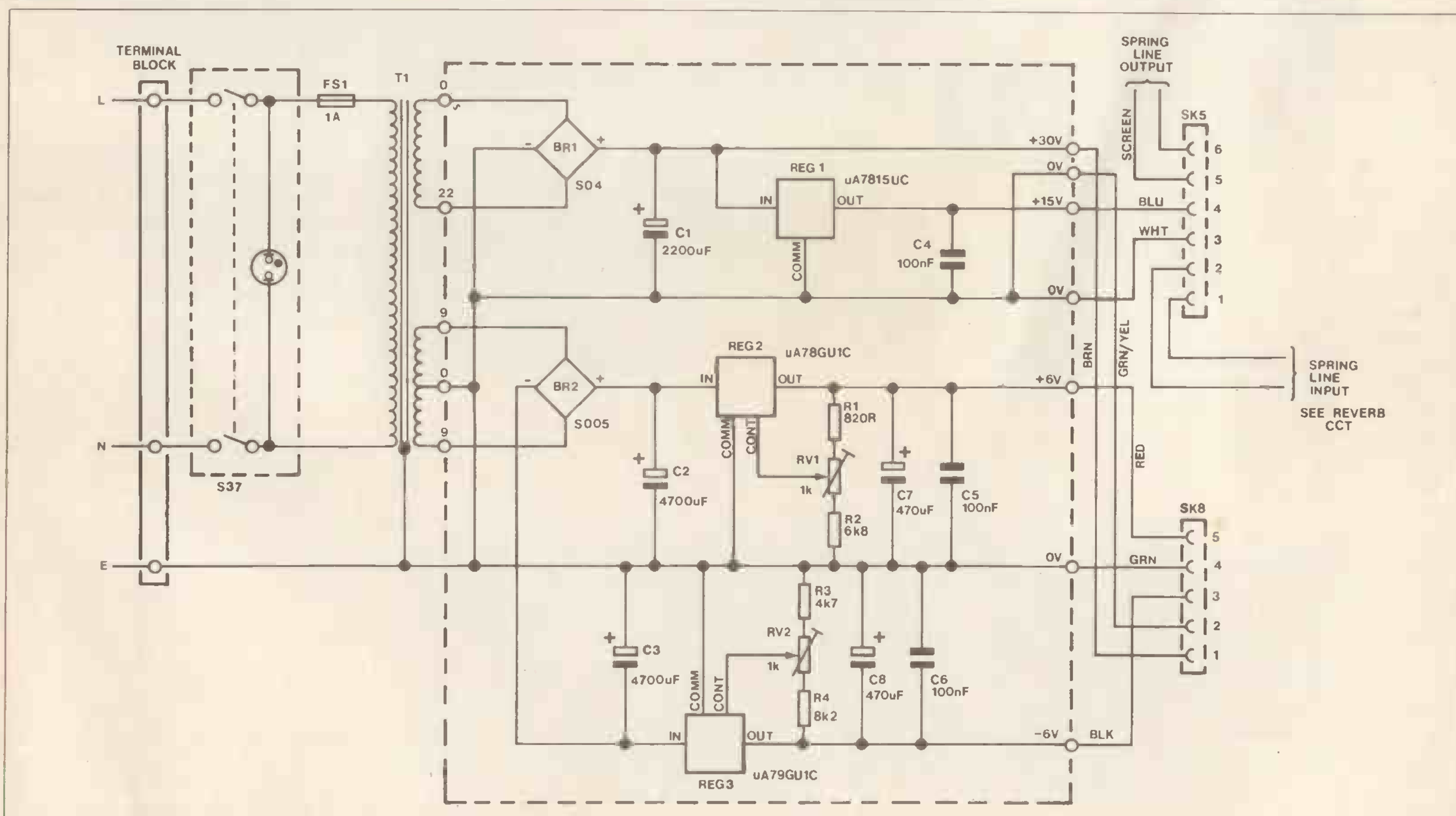


Figure 16. Circuit diagram of the power supply.

that one pin somewhere misses being soldered. The positions for all the track pins are marked with circles on the PCB.

A few holes are marked on the underside of the PCB with little squares. Veropins are fitted in these holes. Ensure that they are pushed firmly into the PCB then solder on the underside only. Four Veropins have to be put in the PCB from the topside. Again they are marked on the PCB with little squares, but are soldered on the topside only.

We are now ready to start fitting the components to the PCB. It is advisable at this stage to sort out all the components, first to check against the master component list (supplied with the kit) that you have received the correct quantities of all the parts, and second, to help as a double-check that you have put the correct parts in the correct places. The resistors are the most difficult things to sort, but this may be speeded up by sorting first into piles of resistors having the same colour third band. This is the band next to the gold tolerance band that is on one end of every resistor. Before you start, make sure that you can differentiate between the gold, yellow and orange colours printed on the resistors. An identification chart is supplied with the kit to make it as easy as possible for you.

All the following components are fitted to the topside of the PCB and soldered underneath unless stated. Fit all the resistors, double-checking continually that you are putting the right values in the right places. Fit all the diodes ensuring that the end with the band around the body or, if there are several bands, the end with the thicker band, is inserted next to the '+' marked on the PCB.

Next fit all the capacitors. The tantalum types have a '+' marked on the body above one lead and are inserted so that this lead is next to the '+' on the PCB.

The electrolytics are fitted so that the lead at the end having the identation around the body is next to the '+' on the PCB.

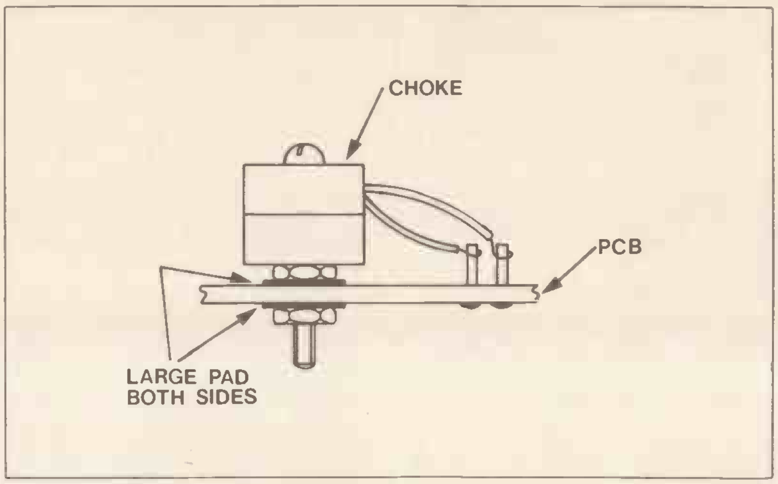


Figure 18. Fitting chokes.

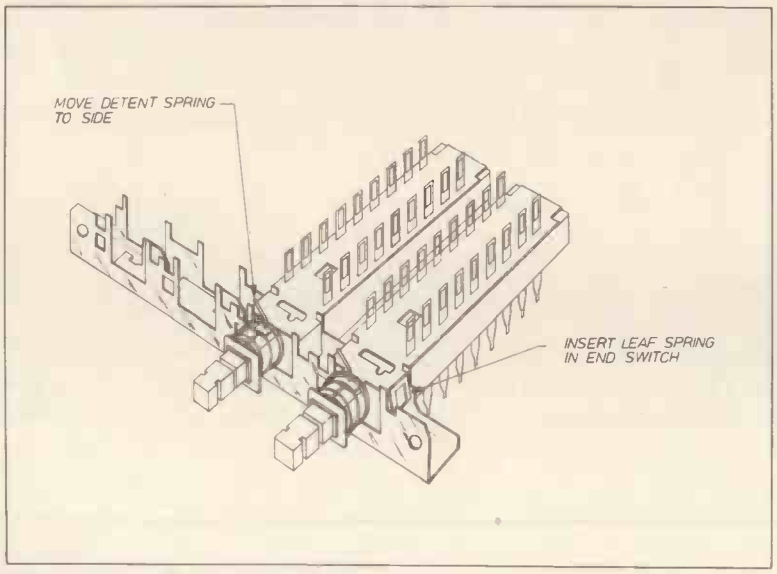
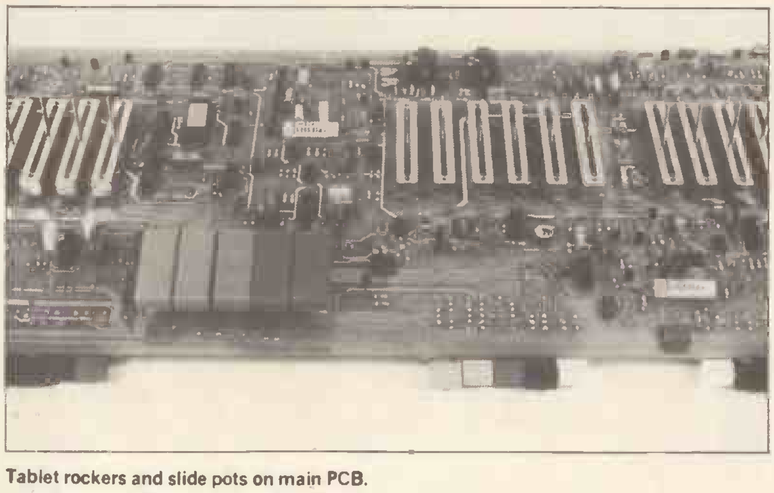


Figure 19. Latchswitch assembly.



Tablet rockers and slide pots on main PCB.

The transistors all look very much alike so make sure you have sorted them correctly before starting to fit them. It is most important particularly with the BC212L's that, when viewed from above, the D-shaped top of the transistor corresponds with the 'D' shape printed on the PCB. This may necessitate bending the centre lead of the BC212L forwards or backwards to suit.

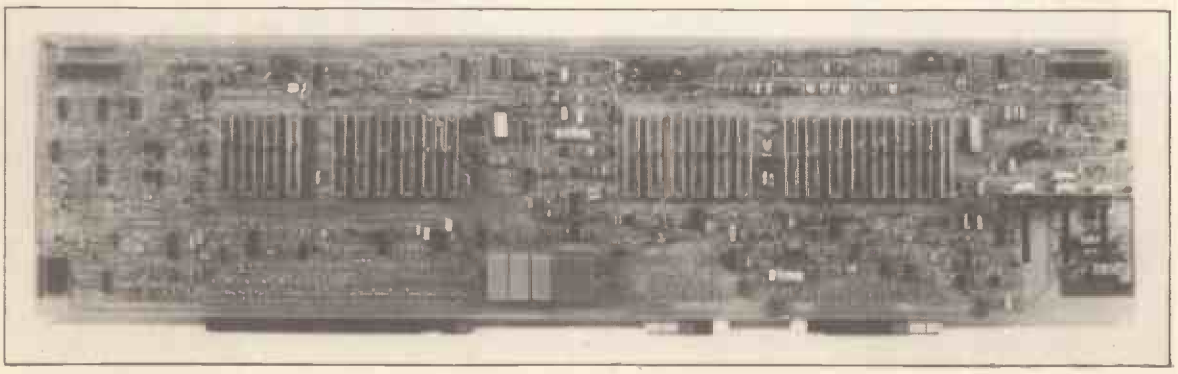
Fit the four integrated circuit sockets in the positions marked IC1, IC4, IC24 and IC44. Solder chokes L2 and L3 to the PCB, then bolt the rest of the chokes to the PCB as shown in Figure 18. The two flying-leads must be soldered to the adjacent Veropins but it does not matter which lead is connected to which pin. Fit the presets, then mount the tablet rocker-switches. The two on the right are red, the two on the left are grey and the centre one is orange.

Assembling The Switch-Banks

There are three switch-banks to make up: a 16-way; a 9-way and a 5-way. First, assemble the 16-way bracket. Hold the bracket as shown in Figure 19 and place a 4-pole latchswitch (12 tags on each side) in the extreme left-hand position with the printed circuit tags downwards and the solder tags upwards. Bend over three of the four lugs on the mounting frame (leave the front-left one) to hold the switch in position. Fit another 4-pole latchswitch in the next position in the same way, then slide the 15-way return bar into the frame so that the bent-up lug slides into the slot in the side of this switch. Now fit a further 13 identical switches. Before fitting the last switch, carefully press the return spring between the two plastic mouldings as shown in Figure 19. After fitting this switch, carefully lift the rear of the detent spring with a small screwdriver and hook it over the left-hand side of the switch. Do not remove the detent spring altogether. Repeat this on all the switches except the extreme left-hand switch.

Test the switchbank. Press any one of the right-hand fifteen switches. It should lock in and at the same time release any other of these fifteen switches previously pressed. Check all fifteen switches. The extreme left-hand switch however, should lock in when pressed once and release when pressed again without affecting, or being affected by, any other switch in the bank.

The 5-way switch bank does not require a return bar or return spring; each switch locks and re-



Topside of the main PCB.

leases independently. Fit two 2-pole latchswitches (6 tags on each side) to the left of the bracket and 4-pole latchswitches in the three positions to the right. Do not move the detent spring on these switches.

Assemble the 9-way switch-bank with a 4-pole switch in the most left-hand position, then a 6-pole switch (18 tags on each side), then a 2-pole switch, then another 2-pole switch. Now slide in the 6-way return bar and continue fitting the switches; a 6-pole next and then four 2-pole switches. On the most right-hand switch, fit the return spring as before. Move the detent springs to the left on the six most right-hand switches then test the switch-bank. These six switches should interlock whilst the other three should lock and release independently.

The three assemblies should now be carefully fitted to the PCB ensuring that all the pins seat tightly down on the PCB. These switchbanks mount on the underside of the PCB and are soldered on the topside.

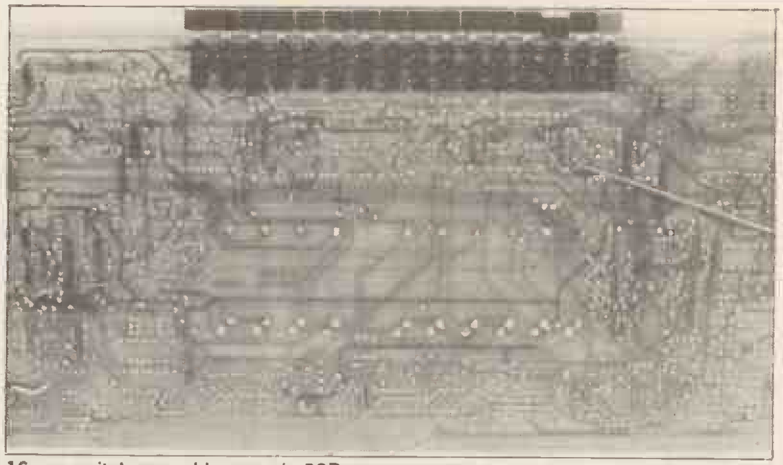
Completing the Main PCB

Remove the slide-pots from the drawbar assemblies and fit the pots to the PCB. Ensure that they seat tightly on the PCB and are perfectly upright when soldering.

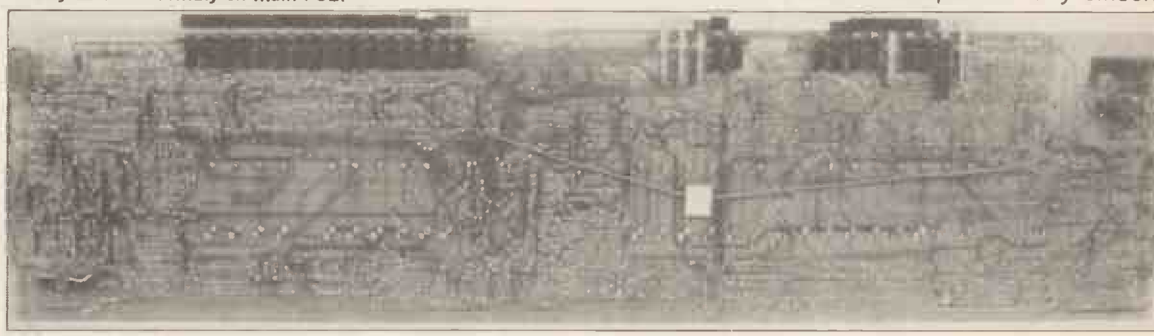
The pot. mounting bracket should now be made as shown in Figure 20. This is supplied ready-made in the kit but can be bought separately. Fit the three rotary pots to the pot mounting bracket with the tags down and the spindles on the same side as the feet. The dual-gang pot mounts in the centre, the 10k log above the larger foot and the 470k lin above the smaller foot.

Cut twelve pieces of hook-up wire (7-strand) each 36mm long and strip 10mm of sheath off each end, so that the insulated piece is 16mm long. Solder one piece to each of the twelve tags on the three pots. Bolt the bracket to the PCB using 6BA nuts, bolts and shakeproof washers through the two end holes. Connect the twelve wires to the twelve pins on the PCB. Each pin is directly beneath the tag on the pot to which it is to be linked.

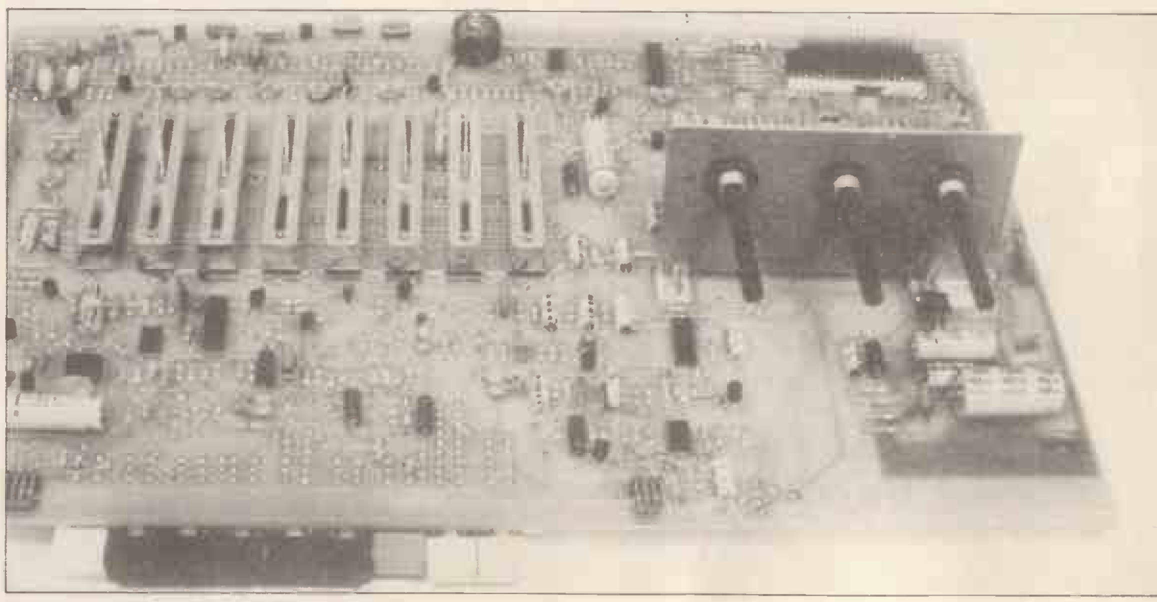
Fit IC16 and align it so that the hole in the tab is directly above the remaining hole on the pot bracket. Smear the back of the IC with Thermpath or any silicone



16-way switch assembly on main PCB.



Underside of the main PCB (the piece of screened cable is held down with a quickstick pad, but on your PCB provision is made for two Tie-Wraps).



Pot mounting bracket from the front.

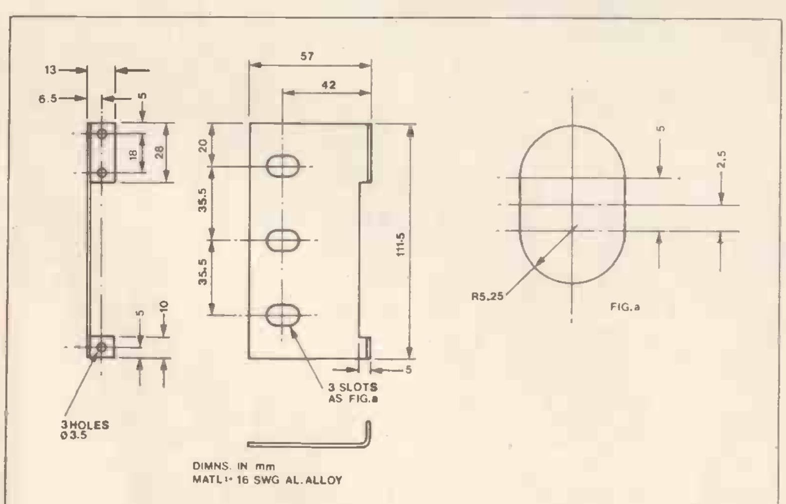
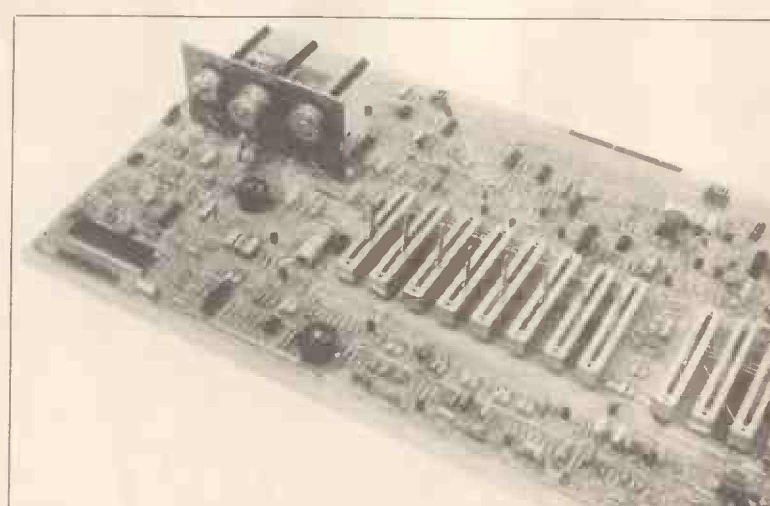


Figure 20. Pot mounting bracket.



Pot mounting bracket from the rear.

grease then bolt down using a 6BA nut, bolt and shakeproof washer. Note that no mounting kit is required with this IC.

Fit IC38 noting that no heatsink is required. Now solder the rest of the ICs to the PCB. At this stage, do not unpack the four ICs that plug in the IC holders. Finally, fix the nine plugs to the PCB taking care to ensure that they are the right way round as shown on the legend and in the photographs.

One connection now has to be made on the underside of the PCB by a piece of screened cable. Each end of the cable is connected to one of the pairs of pins on the underside of the PCB as shown on the legend and in Figure 21.

We shall describe the rest of the interwiring of the Matinee in Part 4 but for experienced constructors we include in this issue the interwiring diagrams, Figures 22 and 23, so that virtually all the construction may be completed in one go if desired.

Banjo Repeat Circuit

The Banjo Repeat Circuit is part of the upper manual circuit, and is shown in Figure 24.

The input to the banjo en-

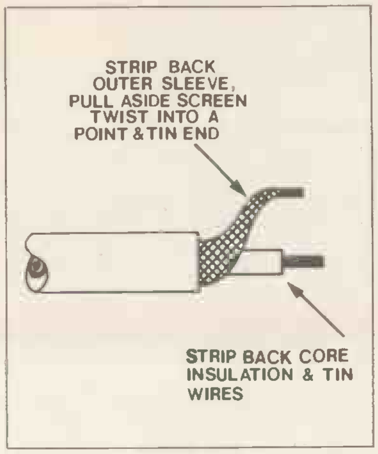


Figure 21. Screened cable connections.

BANJO REPEAT CIRCUIT PARTS LIST

Resistors — all 5% ⅓W carbon unless specified			
R384,515	100k	2 off	(M100K)
R385,386,389,391,392	1k0	5 off	(M1K0)
R387	1k2		(M1K2)
R388	5k6		(M5K6)
R390	33k		(M33K)
R393	22k		(M22K)
R394,395	10k	2 off	(M10K)
RV33	Drawbar, green, 22k lin.		(BR99H)
Capacitors			
C129,131	100nF polycarbonate	2 off	(WW41U)
C130	1uF 63V axial elect.		(FB12N)
C132	470nF 35V tantalum		(WW58N)
Semiconductors			
D139	1N4148		(QL80B)
TR40	BC327		(QB66W)
TR41,43	BC548	2 off	(QB73Q)
TR42	TIS43		(QL19V)

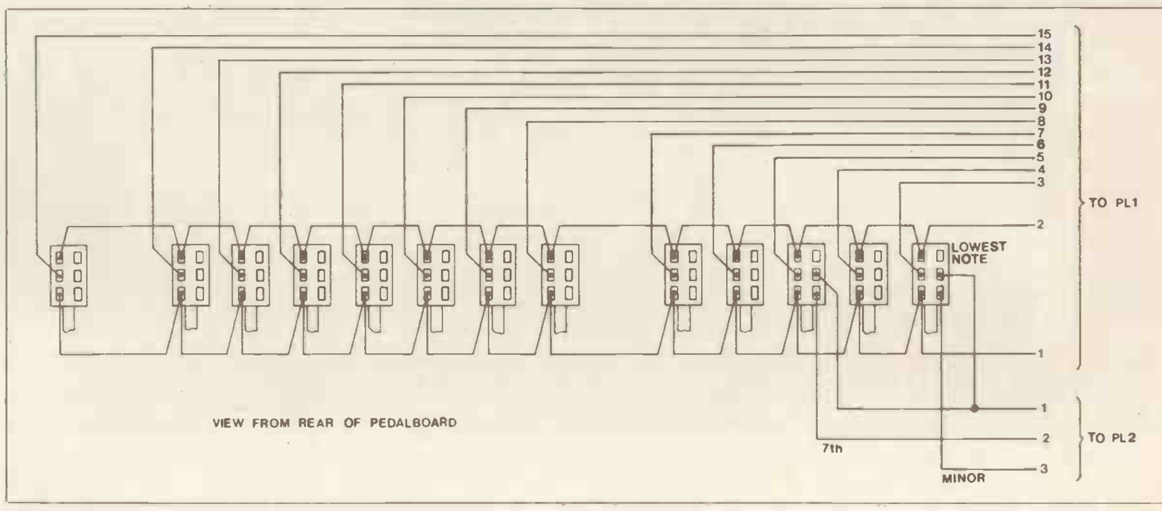


Figure 23. Pedalboard wiring.

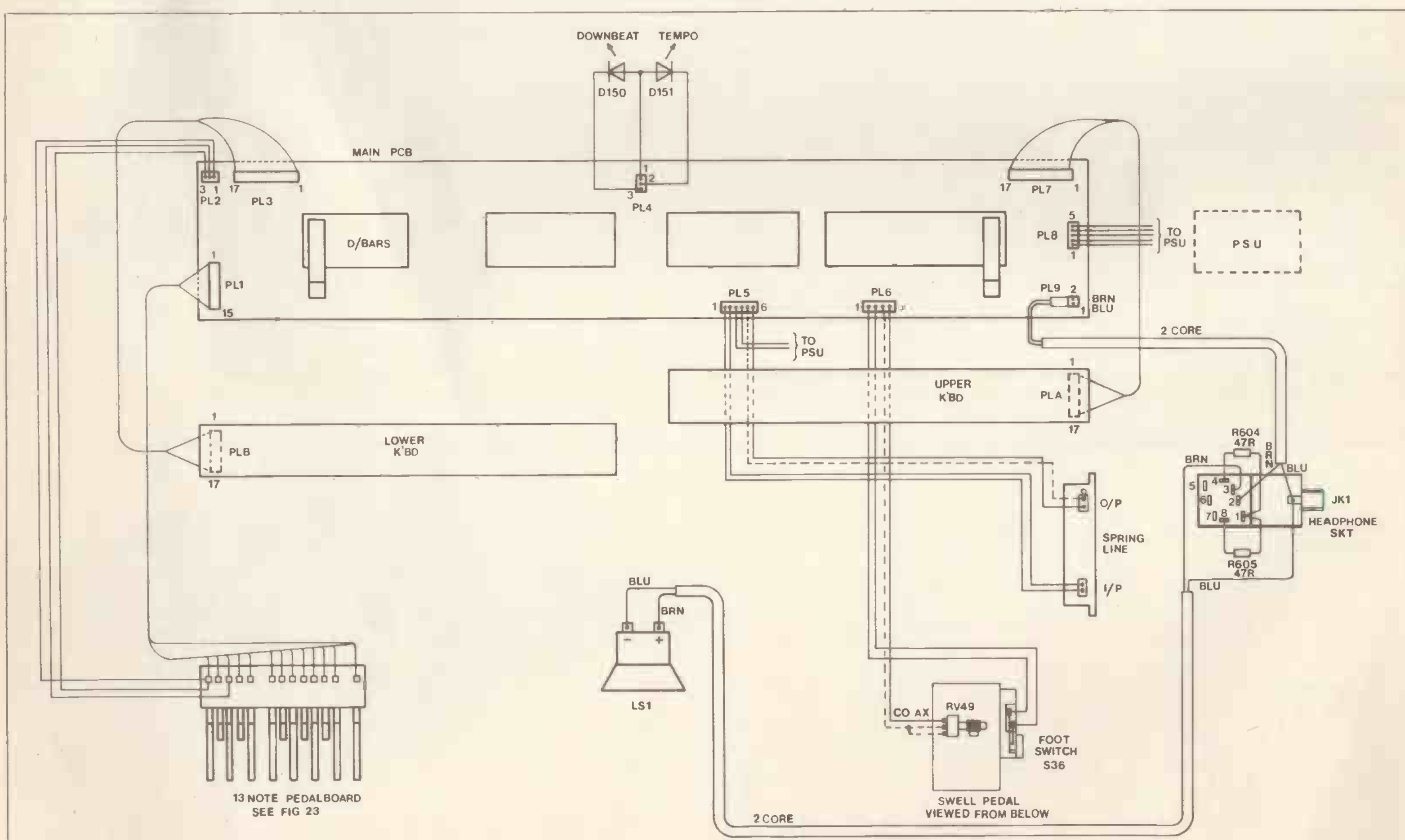


Figure 22. Interwiring.

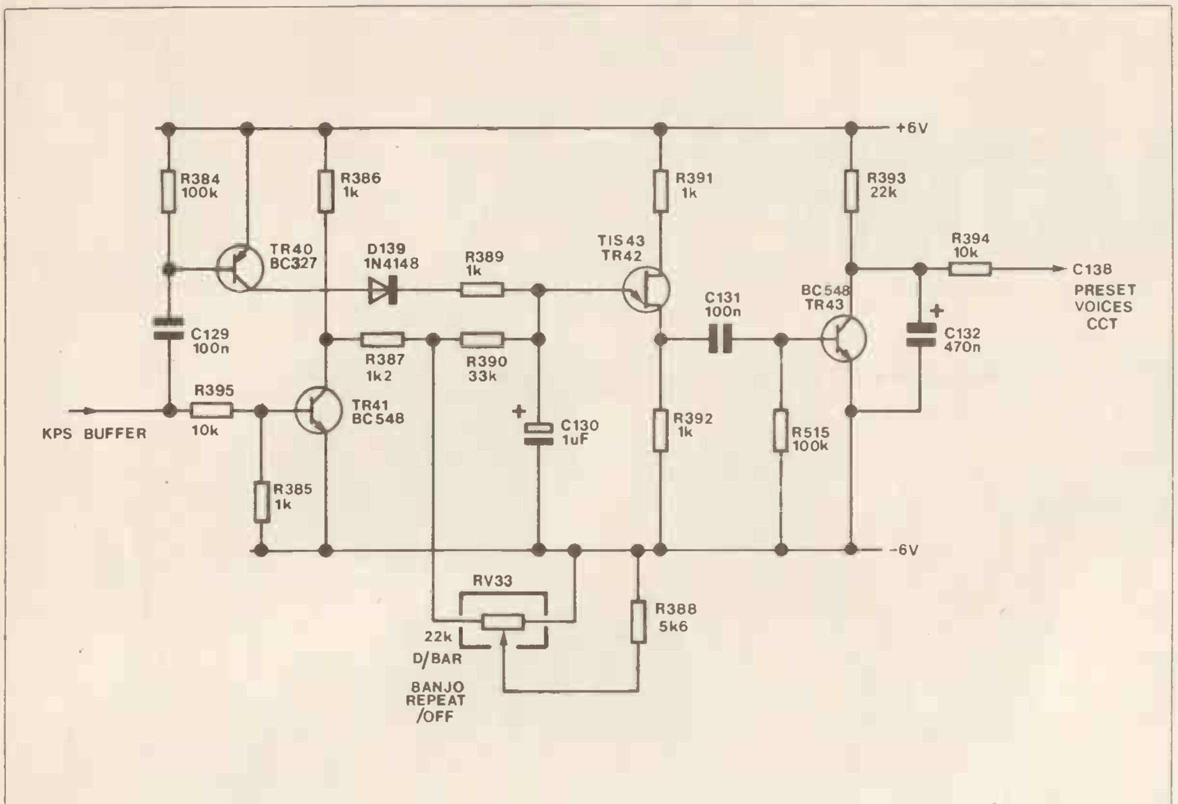


Figure 24. Banjo repeat circuit diagram.

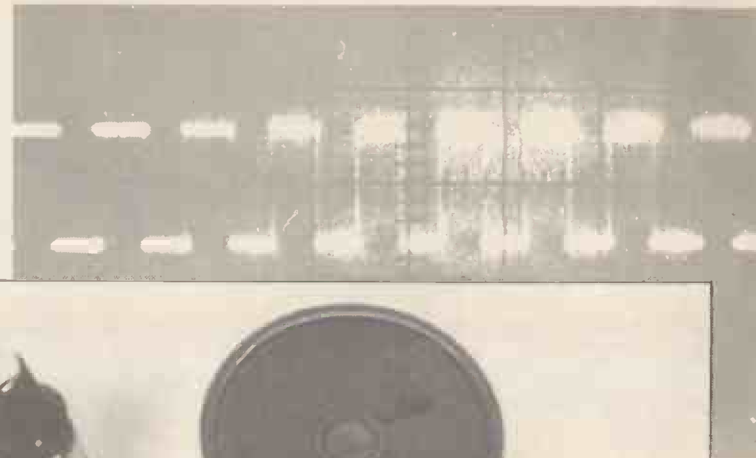
velope shaper goes via the banjo repeat circuit and is triggered by TR43 under the control of the unijunction oscillator TR42. The rate of oscillation depends on the charge on C130 and this is determined by the setting of the banjo repeat rate drawbar. The range of this drawbar is from no repeat to about twenty repeats per second. When a key is depressed KPS goes negative and TR41 turns off. C130 now begins to charge via R386, R387 and R390. TR40 is momentarily switched on and forces C130 to charge more quickly through D139 and R389 allowing the oscillation to begin. Otherwise there would be a noticeable decay before the first note was heard after a key had been pressed. The oscillator is now under the control of C130, R386, R387, R390 and RV33. If RV33 is off then TR42 fires just once because of the pulse from TR40, but is then held just off by the values of the resistances in the normal charging chain. The output of the preset voices VCA goes to the effects volume drawbar: RV17.

The preset voice cancel switch SW27, in addition to inhibiting the control voltage to the upper manual organ voices when a preset voice is selected, also prevents the preset voices VCA from operating when SW27 is operated i.e. when no preset voice is selected.

In Part 4, we shall describe the interwiring, and setting-up of the electronics. We shall also describe the pedalboard circuits and begin to describe the circuits of the lower manual and rhythm generator.

E&MM

TONE GENERATOR



Vero Project 1

Useful test and sound effects oscillator with a frequency range of over 20:1 and a built-in speaker

This useful tone generator covers the range between 150Hz to 3.5kHz approximately with a single, continuously variable control; this range can easily be extended if required. The unit has a built-in, high-impedance speaker but an output socket is also provided for connection of an additional speaker having an impedance of 25 ohms or more, or some form of signal processor. The circuit can also drive a low impedance speaker, 8 ohms giving 1 watt RMS or 3 ohms giving 2 watts RMS, but will require a power supply capable of 100 to 200mA. The output of the tone generator is a good quality square wave.

The Circuit

The circuit diagram of the tone generator is given in Figure 1. As with the Metronome project in this issue, the TDA2006 power amplifier is used as an oscillator but in this case it runs at audio frequency and generates an output waveform with equal length 'high' and 'low' states (a square wave). R3 provides feedback to the non-inverting input of IC1, introducing hysteresis and causing the output to be in one of two states, high or low. When it is high, C2 is charged until pin 2 reaches the threshold set by R1-3, and the output goes low. C2 is then discharged until the lower threshold is reached; IC1 then reverts to the high state. This action repeats, generating a square wave having its frequency controlled by the charge rate of C2 and hence the setting of RV1.

Output socket JK1 is a 3.5mm jack having a break contact which disconnects the internal loudspeaker when a plug is inserted. The output signal level is approximately 7 to 8 volts peak to peak.

The current consumption of the unit is 25 to 30mA when using the internal loudspeaker, and about 12mA with no load or a high impedance load across the output.

Construction

The Veroboard layout and wiring of the tone generator are shown in Figure 2. Construction of the component panel is simple as there are no breaks in the copper strips and it is only necessary to drill the two 3.3mm diameter mounting holes (which take M3 or 6BA fixings) prior to soldering the components into position. The preformed leads of IC1 should be bent apart slightly before fitting.

The maximum frequency can be increased by reducing the value of R4, the lower frequency limit can be reduced by increasing the value of RV1.

Robert Penfold **E&MM**

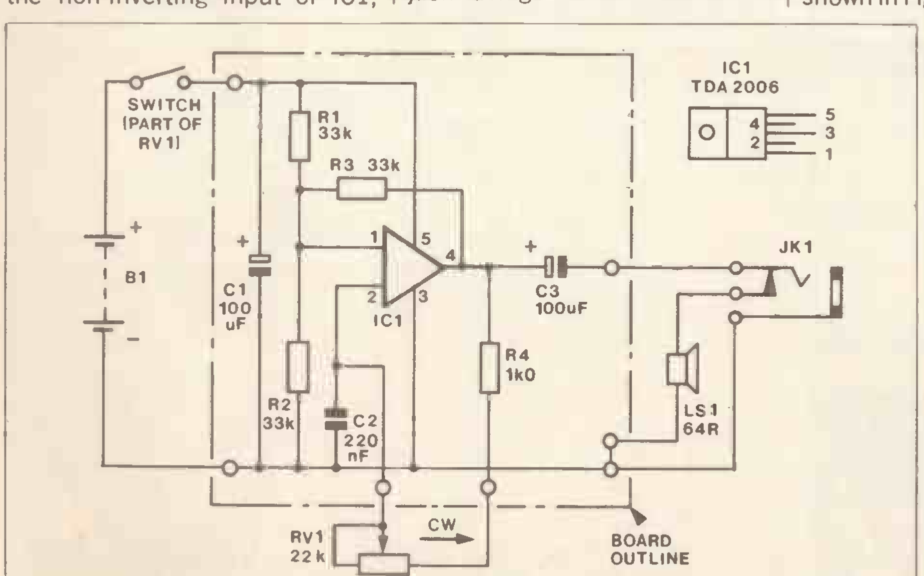


Figure 1. The circuit diagram of the Audio Tone Generator.

PARTS LIST

Resistors — all ⅓W 5% carbon unless specified

R1-3	33k	3 off	(M33K)
R4	1k0		(M1K0)
RV1	22k lin. pot. with switch		(FW03D)

Capacitors

C1,3	100uF 10V aerial electrolytic	2 off	(FB48C)
C2	220nF polyester		(BX78K)

Semiconductor

IC1	TDA2006	(WQ66W)

Miscellaneous

LS1	Loudspeaker, 66mm dia. 64 ohm impedance	(WF57M)
	Plastic or metal case	
	Veroboard, 24 holes by 10 strips, 0.1in. matrix	(FL06G)
JK1	3.5mm switching jack socket	(HF82D)
B1	PP6 battery	
	PP3 connector	(HF28F)
	Knob	
	Connection wire	(BL09K)

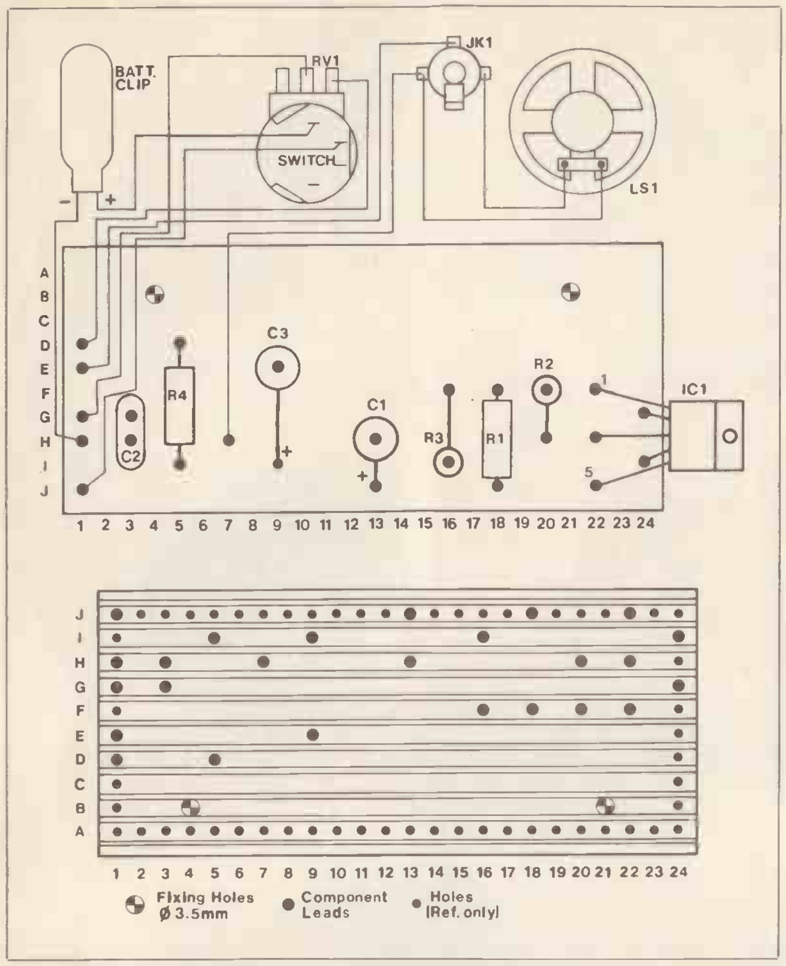
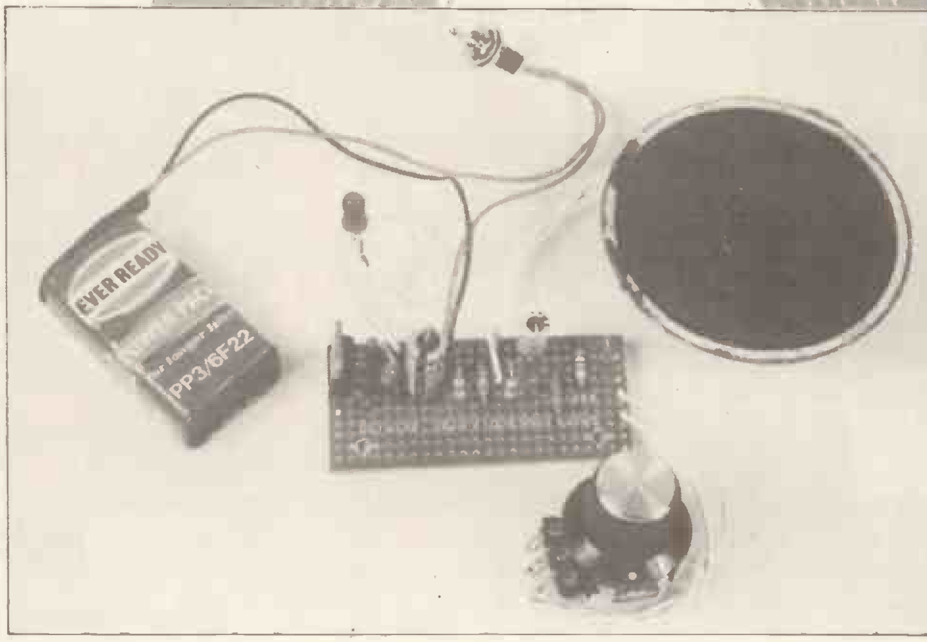


Figure 2. The Veroboard layout and wiring of the Tone Generator.

TEST AMPLIFIER

Vero Project 2

High-gain audio amp with speaker and many applications



It is surprising how often a simple audio power amplifier can be useful when building and servicing electronic equipment. Amplifiers of this type can also be useful for incorporation into more complex items of equipment and can serve as headphone or guitar practice amps. The design described here gives a maximum output power of about 150mW RMS into a high impedance loudspeaker, and requires only about 25mV RMS (into approximately 200k) at the input to produce full output.

The Circuit

The only active device used in the circuit is a TBA820M integrated circuit, as can be seen from the circuit diagram which is shown in Figure 1. The TBA820M is a small, class B, audio power device which requires few discrete components.

RV1 is the volume control which also biases the input of IC1. The input signal is coupled to RV1 by way of DC blocking capacitor C2. The closed loop voltage gain of IC1 is determined by an internal feedback resistor and discrete resistor R1, the specified value for R1 giving a voltage gain of about 112 (41dB). C1 is the main supply decoupling capacitor and C4 decouples the supply to the input stage of IC1.

R2 and C7 form a Zobel network that aids the stability of the circuit. C5 is used to introduce negative feedback at high frequencies which rolls-off the high frequency response of the circuit, also to improve stability. C6 provides DC blocking at the output of IC1.

Under quiescent conditions, the current consumption of the amplifier is only about 4mA, but rises to 20mA or so at high output levels.

Construction

Details of the Veroboard component panel and wiring of the amplifier are shown in Figure 2. C2 is not mounted on the component panel as it is more convenient to wire it direct between SK1 and RV1. Do not run input and output leads right next to each other as this could result in poor stability. Also, be careful not to overlook the three link wires connecting the panel components.

Robert Penfold **E&MM**

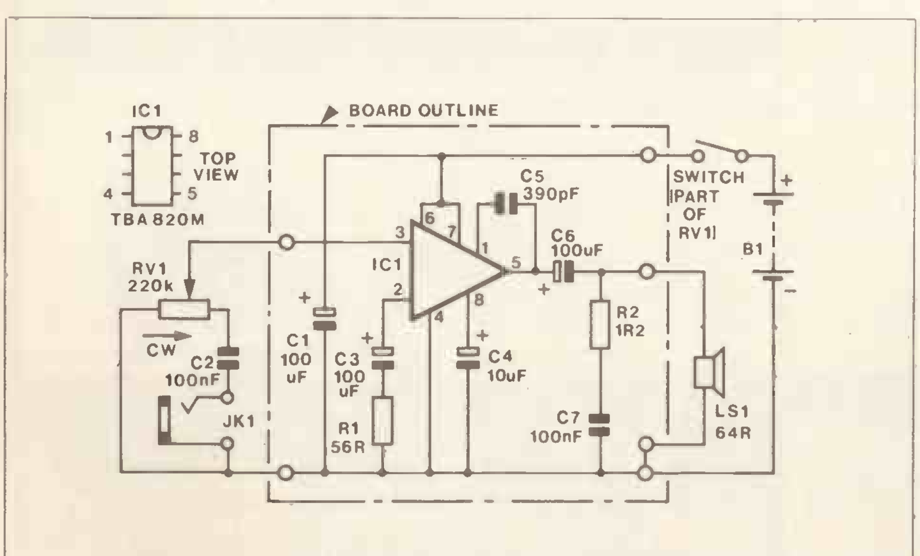


Figure 1. The circuit diagram of the Test Amplifier.

PARTS LIST

Resistors — all ⅓W 5% carbon unless specified.

R1	56R		(M56R)
R2	1R2		(M1R2)
RV1	220K log. pot. with switch		(FW67X)

Capacitors

C1,3,6	100uF 10V axial electrolytic	3 off	(FB48C)
C2,7	100nF polyester	2 off	(BX76H)
C4	10uF 25V axial electrolytic		(FB22Y)
C5	390pF ceramic plate		(WX63T)

Semiconductor

IC1	TBA820M	(WQ63T)

Miscellaneous

LS1	Loudspeaker, 66m diameter 64R impedance	(WF57M)
	Veroboard, 24 holes by 10 strips, 0.1 in. matrix	(FL06G)
JK1	3.5mm miniature jack socket	(HF82D)
B1	PP3 battery	
	PP3 connector	(HF28F)
	Connecting wire	(BL09K)
	Knob	
	Plastic or metal case	

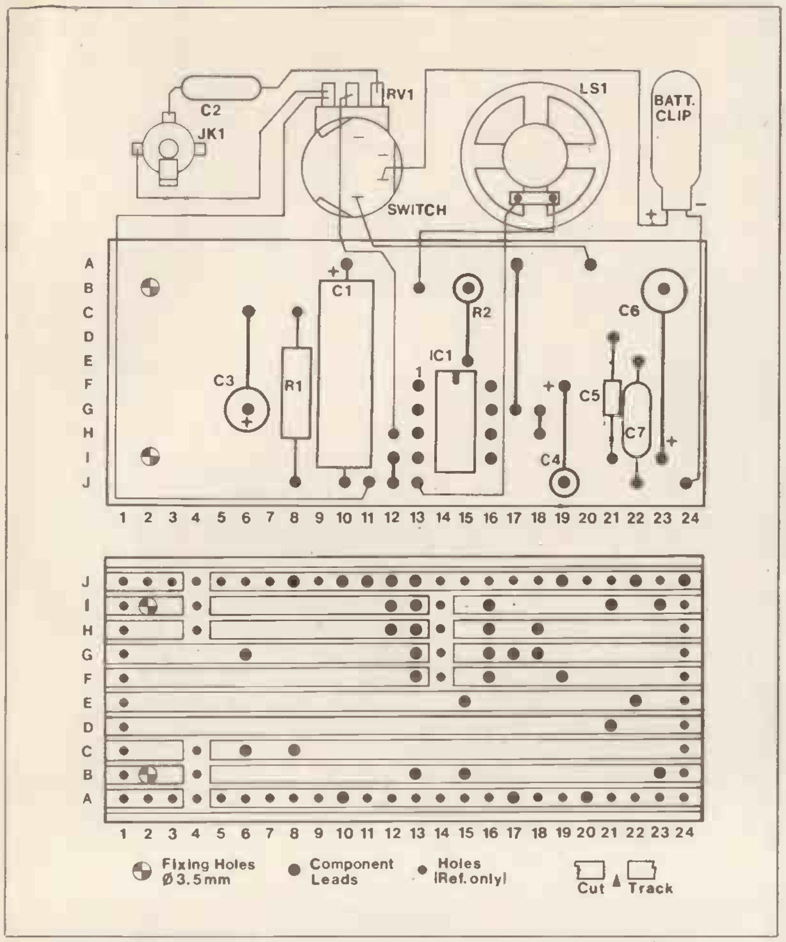
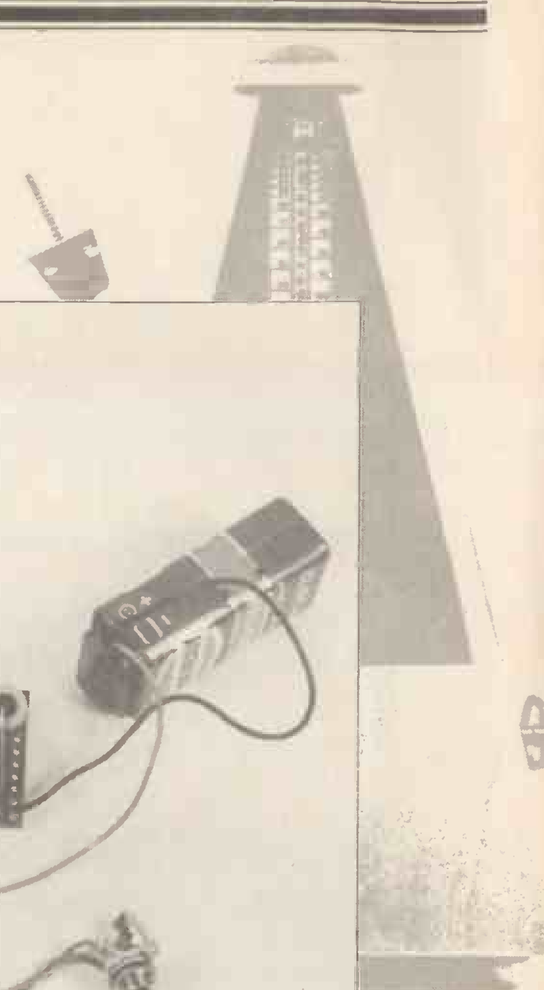


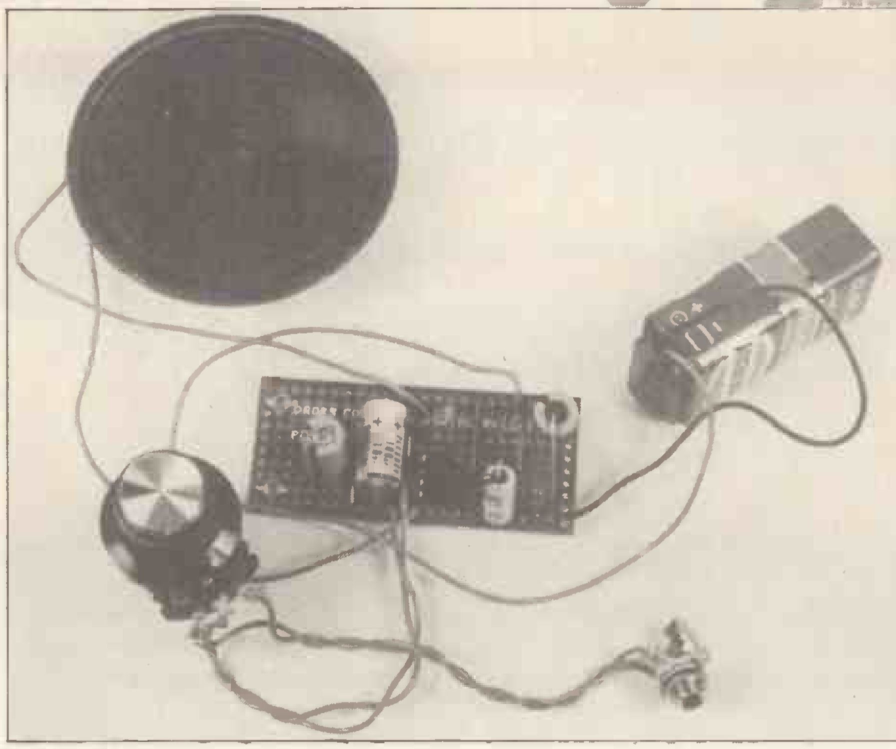
Figure 2. The Veroboard layout and wiring for the Amplifier.

METRONOME

Vero Project 3

Single IC design with visual beat indicator — ideal for home musicians





Originally, metronomes were purely mechanical devices which used a pendulum and a clockwork mechanism to produce a 'click' sound at regular intervals to help musicians play at the correct tempo; sheet music often has metronome marks which indicate the required number of beats per minute. The device was invented by Maelzel, a friend of Beethoven, well over 150 years ago. Apart from the click sound, the pendulum also gives a visual indication of the beat rate. This is important when it is likely that the sound of the metronome will be drowned by the volume of the instrument.

Although electronic metronomes are considered novel, they have been in existence for quite a few years. Most, like the unit featured here, provide a sound which is similar to that provided by their mechanical counterparts, and give some form of visual indication of the beat rate as well. In this case a light emitting diode (LED) flashes each time a click is produced by the unit.

The Circuit

Refer to Figure 1 for the complete circuit diagram of the metronome. The circuit is based on a TDA2006 integrated circuit (IC1) which is really designed for use as an audio power amplifier. It is quite a versatile device though, and could be regarded as an operational amplifier having a class AB output stage capable of delivering output currents in excess of 1 Amp. It has inverting and non-inverting inputs, and these are pins 2 and 1 respectively.

R1, R2 bias the non-inverting input of IC1 to half the supply voltage but the effect of R3 must also be taken into account, and will normally modify this voltage. If the output of IC1 is fully negative, R3 is effectively connected across R2 and reduces the bias voltage to one third of the supply. If the output of IC1 is fully positive, R3 is effectively shunting R1, and the bias voltage is raised to two-thirds of the supply.

At switch-on, C2 is completely uncharged and the inverting input of IC1 is therefore at the negative rail potential. IC1 is being used here as a sort of voltage comparator — its output will go negative if the inverting input is at

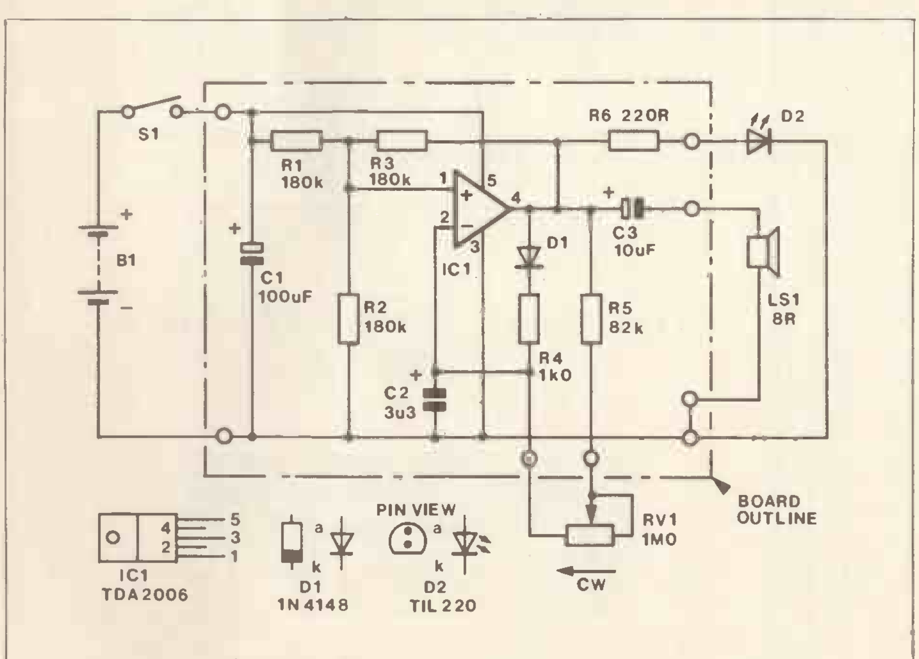


Figure 1. The circuit diagram of the Metronome.

PARTS LIST

Resistors — all ¼W 5% carbon unless specified.

R1-3	180k	3 off	(M180K)
R4	1k0		(M1K0)
R5	82k		(M82K)
R6	220R		(M220R)
RV1	1M0 lin. potentiometer		(FW08J)

Capacitors

C1	100uF 10V axial electrolytic	(FB48C)
C2	3u3 35V tantalum	(WW63T)
C3	10uF 25V axial electrolytic	(FB22Y)

Semiconductors

IC1	TDA2006	(WQ66W)
D1	1N4148	(QL80B)
D2	0.2in. LED, red	(WL27E)

Miscellaneous

S1	SPST sub-miniature toggle	(FH00A)
LS1	Loudspeaker, 66mm dia. 8R impedance	(WB13P)
	Plastic or metal case	
	Veroboard, 24 holes by 10 strips, 0.1in. matrix	(FL06G)
	LED clip	(YY40T)
B1	PP6 battery	
	PP3 connector	(HF28F)
	Knob	
	Connection wire	(BL09K)

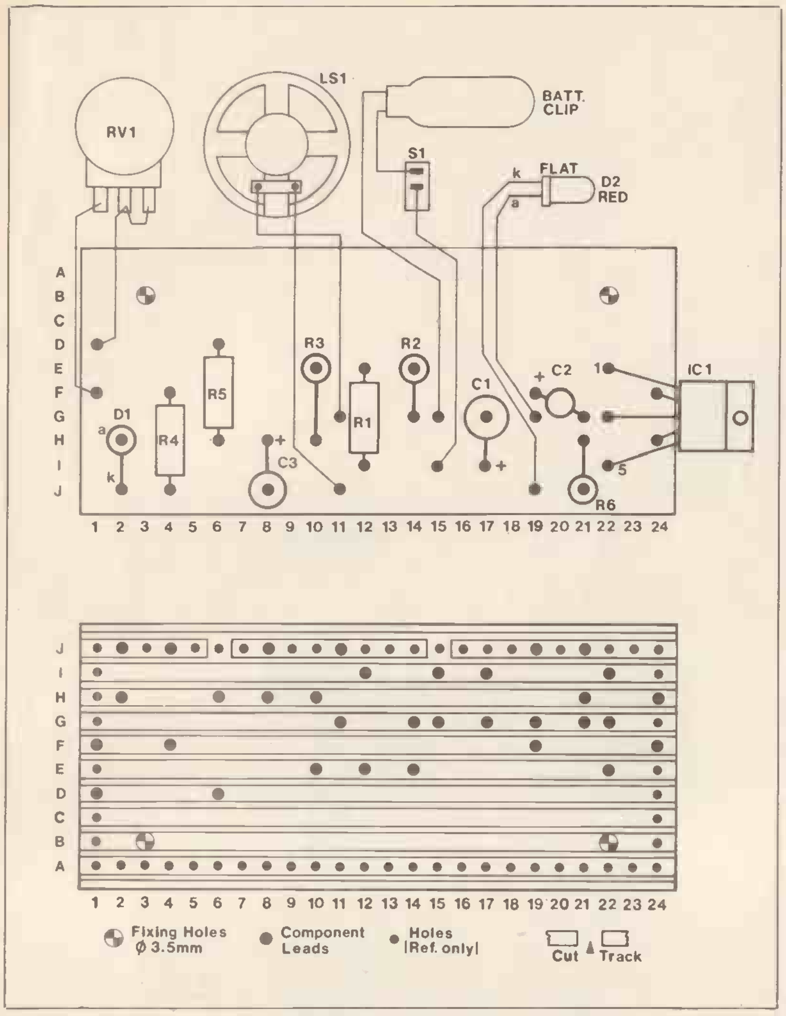


Figure 2. **The Veroboard layout and wiring of the Metronome.**

a higher voltage than the non-inverting input, or positive if the comparative input states are reversed. Thus IC1's output initially goes fully positive.

This results in C2 being charged from the output of IC1 via D1 and R4 and, to a lesser extent, through the relatively high resistance path provided by R5 and RV1. When the charge on C2 exceeds two thirds of the supply voltage the inverting input is at a higher voltage than the non-inverting one. IC1's output therefore starts to swing negative and the coupling through R3 to the non-inverting input results in the voltage at the latter being reduced as well. This increases the difference between the two input voltages, sending the output and non-inverting input further negative. This positive feedback causes the output to rapidly go fully negative, leaving the non-inverting input at one third of the supply voltage.

C2 now starts to discharge but it can only discharge through RV1 and R5 since the path through R4 is blocked by D1. Thus the discharge time is relatively long and is determined by the value of RV1, which acts as the tempo control. When the charge on C2 falls below one third of the supply voltage, the output of IC1 starts to swing positive and the regenerative action results in it almost instantly going fully positive. C2 then rapidly charges through D1, R4 and R5, RV1, as was the case at switch on and the circuit goes through this cycle continuously, with a series of brief positive pulses being generated at the output of IC1. C3 couples these to the loudspeaker which produces the required clicks. The pulses are also used to drive LED indicator D2 via current limiting resistor R6 so that each click is accompanied by a flash from D2.

The current consumption of the circuit is about 12mA.

Construction

Figure 2 shows details of the Veroboard panel and the wiring of the unit, which is all straightforward.

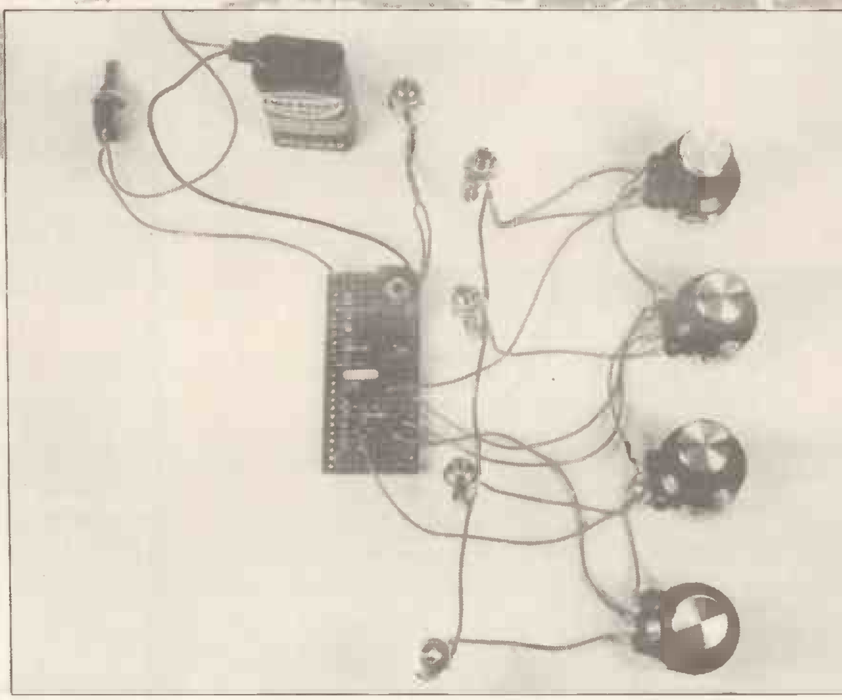
A scale, calibrated in beats per minute, should be marked around the control knob of RV1 using rub-on figures, and it is advisable to use a large control knob and scale because the scaling is non-linear and will otherwise become excesively cramped at the top end.

Robert Penfold **E&MM**

SIGNAL MIXER

Vero Project 4

Versatile mixer design based on a low-noise op-amp suitable for microphones and instruments



When it is required to apply two or more signals to a single input, it is unlikely that good results will be obtained by simply connecting all the signals direct to the input. This action is more likely to give rise to problems such as a low impedance signal dominating the others, which become virtually short circuited by its low source impedance, and affects the levels of the others.

A simple mixer is needed in order to avoid these problems, and the design described here can be built with up to four channels. There is a high input impedance (about 800k) at all four inputs so that there is minimal loading of the signal sources applied to the unit. The output impedance of the unit is low, and it can be employed with any normal amplifier or tape recorder without loading of the output causing any problems. The maximum voltage gain from any input to the output is about 7dB (a little over two).

The Circuit

The mixer design is based on an op-amp, and Figure 1 shows its circuit diagram. IC1 is used as an inverting amplifier but there are four input resistors connected to the inverting input, one for each input. The output therefore responds to the sum of the input signals rather than to just a single input, and the required mixing action is produced. R7 is the feedback resistor and has a higher value than the input resistors (R1-4) giving a small amount of voltage gain. RV1 to RV4 are controls which enable the amplitudes of the input signals to be adjusted individually. C2 provides DC blocking at the input to

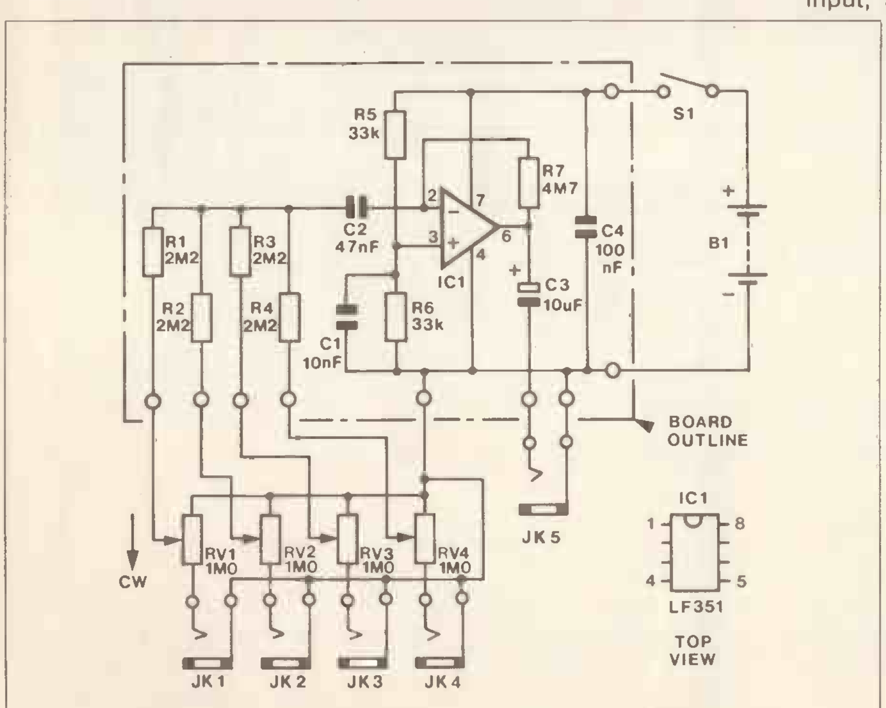


Figure 1. The circuit diagram of the Signal Mixer.

PARTS LIST

Resistors — all ⅓W 5% (10% over 1M) carbon unless specified

R1-4	2M2	4 off	(M2M2)
R5,6	33k	2 off	(M33K)
R7	4M7		(M4M7)
RV1-4	1M0 log. pot.	4 off	(FW28F)

Capacitors

C1	10nF ceramic plate		(WX77J)
C2	47nF polyester		(BX74R)
C3	10uF 25V axial electrolytic		(FB22Y)
C4	100nF polyester		(BX76H)

Semiconductor

IC1	LF351		(WQ30H)

Miscellaneous

S1	SPST subminiature toggle		(FH00A)
	Metal case		
	Veroboard, 24 holes by 10 strips, 0.1in. matrix		(FL06G)
B1	PP3 battery		
	PP3 connector		(HF28F)
JK1-5	3.5mm jack sockets	5 off	(HF82D)
	Knobs	4 off	
	Connecting wire		(BL09K)

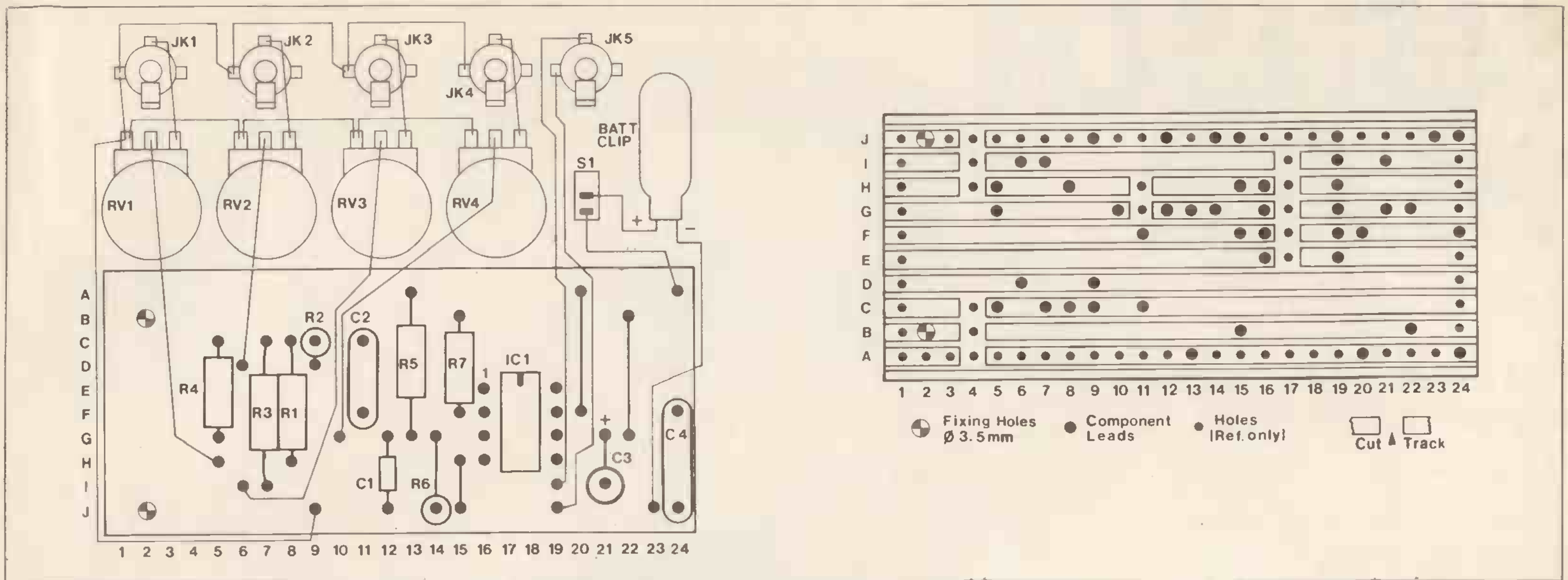


Figure 2. The Veroboard layout and wiring of the Mixer.

IC1. A 'virtual earth' is formed at the inverting input (pin 2) of IC1, this effectively isolates the four inputs and their potentiometers from each other so that there is no interaction.

R5 and R6 are used to bias the non-inverting input of IC1 to half the supply voltage, this gives a quiescent output voltage which is also at this potential. This permits an output signal level greater than 2 volts RMS before the output signal becomes clipped and seriously distorted. C1 prevents stray feedback to the non-inverting input at high frequencies which would cause instability. The current consumption of the circuit is approximately 2mA, and a PP3 size, 9 volt battery gives many hours of operation.

Construction

The Veroboard layout and the wiring details of the unit are shown in Figure 2. The component panel is straightforward but note that there are thirteen breaks to be made in the copper strips before soldering in the components, and three wire links on the component side of the board. Rotary potentiometers and 3.5mm jack sockets were used on the prototype but slider types and/or alternative connectors can be used, if preferred.

The unit should be housed in a metal box to minimise stray pick-up.

If a three channel mixer is required, omit RV4, JK4 and R4. Similarly, if a two channel mixer is needed, RV3, JK3 and R3 should also be omitted.

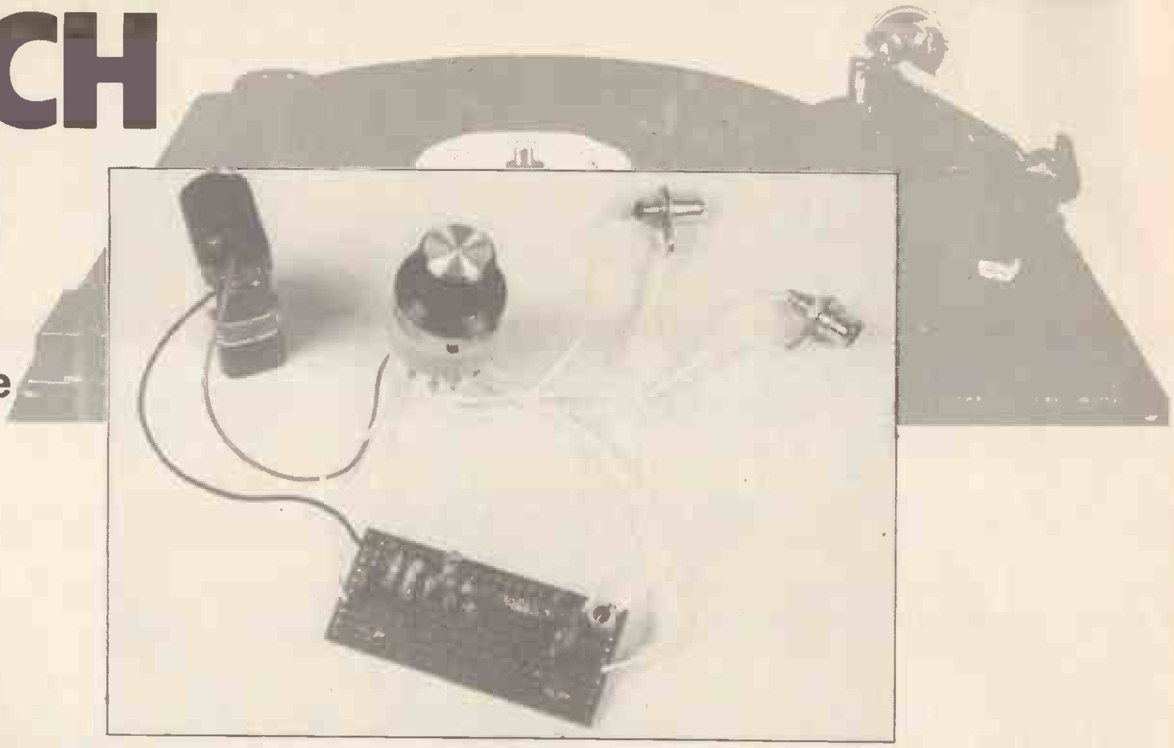
Robert Penfold

E&MM

SCRATCH FILTER

Vero Project 5

Hi-Fi add-on to reduce surface noise from records



Although records are capable of very high quality reproduction, with use there tends to be a gradual decline in fidelity due to record wear and an accumulation of minute dust particles in the grooves. This results in a loss of treble signals, plus the generation of a substantial amount of high frequency noise (mainly the all too familiar 'clicks' and 'pops').

When playing records that are severely affected in this way it is usually beneficial to use a scratch filter. This attenuates the highest treble frequencies and therefore gives a reduction in the noise. It also cuts treble in the programme material, but this disadvantage is usually more than outweighed by the reduction in noise and subjectively there is an overall improvement in quality.

For the best results it is necessary for a filter of this type to give little attenuation below the cut-off frequency, and a very rapid roll-off above this frequency. This necessitates the use of an active filter such as the one featured here. Its response starts to roll off at about 4.5kHz, reaching the -6dB point at 6kHz and the attenuation is nearly -40dB at 20kHz.

The Circuit

The circuit, which appears in Figure 1, uses a conventional arrangement. TR1 is a field effect transistor used in the source follower made and gives approximately unity voltage gain. It is biased by R1 and R2 via R3-R6, and R7 is the source load resistor.

The filtering is provided by R3 to R5, and C2 to C6. R3, R4, C3 and R5, R6, C5 form straightforward RC low pass filter. At low and middle frequencies C2 and C4 effectively have an infinite impedance, and no significant effect on the signal. This is simply because any change in voltage at the input to TR1 is matched by a similar change in voltage at the output. As C2 and C4 are connected between these two parts of the circuit, there is a constant voltage across them so they are ineffective. This technique is known as 'bootstrapping.'

At high frequencies the two filter sections produce losses that result in a lower signal level at the output than at the opposite ends of C2 and C4. In consequence there are further losses due to R3, C2 and R5, C4 forming additional filter sections. This gives a steep slope (about 20dB per octave) above the cut-off frequency.

S1b provides on/off switching and is ganged with S1a & c which bypass the unit when it is switched off. The current consumption of the circuit is only about 1mA.

Construction

Figure 2 shows the Veroboard layout and wiring of the Scratch Filter. There are three breaks to be made in the copper strips. Of course, two boards are required for a stereo unit, one for each channel. It is advisable to use a metal case for the unit so that the circuitry is screened from sources of electrical noise, including mains hum.

Ideally the Scratch Filter should be connected between the pre- and power-amp stages of the amplifier or receiver, and a tape monitor socket can be used if available. This allows the unit to be switched in and out from the front panel, and so the bypass switching of the filter may be omitted.

Robert Penfold E&MM

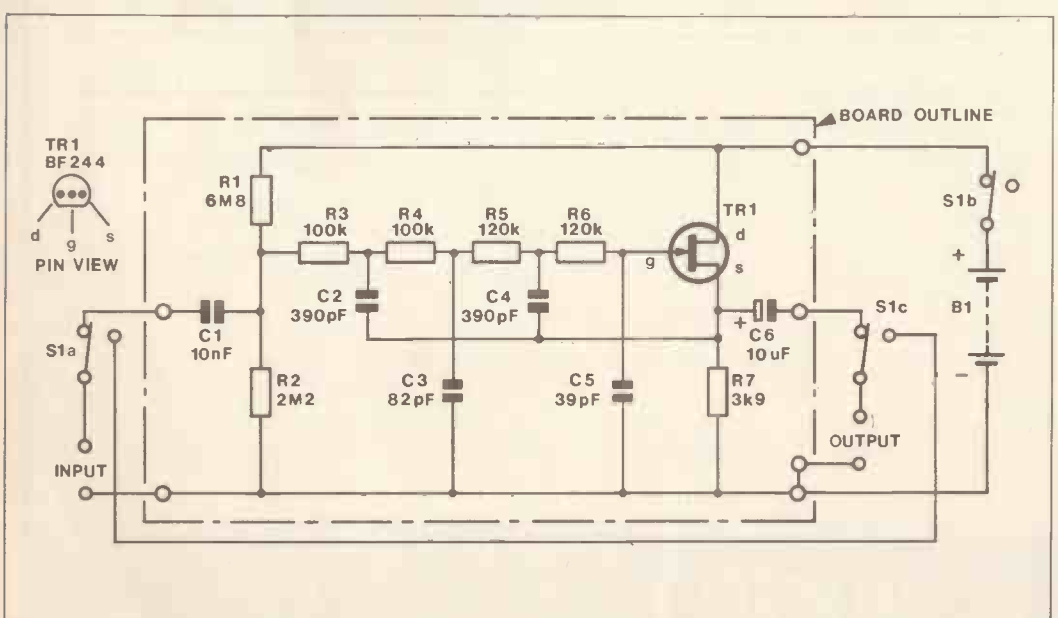


Figure 1. The circuit diagram of the Scratch Filter.

PARTS LIST

Resistors — all ⅓W 5% carbon unless specified

R1	6M8 10% ⅓W		(M6M8)
R2	2M2 10% ⅓W		(M2M2)
R3,4	100k	2 off	(M100K)
R5,6	120k	2 off	(M120K)
R7	3k9		(M3K9)
Capacitors			
C1	10nF polyester		(BX70M)
C2,4	390pF polystyrene	2 off	(BX52G)
C3	82pF ceramic plate		(WX55K)
C5	39pF ceramic plate		(WX51F)
C6	10uF 25V axial electrolytic		(FB22Y)
Semiconductor			
TR1	BF244		(QF16S)
Miscellaneous			
S1	Rotary switch, 3-way 4-pole		(FF76H)
B1	PP3 battery		
	PP3 connector		(HF28F)
	Veroboard, 24 holes by 10 strips 0.1in. matrix		(FL06G)
	Metal case		
	Input and output sockets		
	Knob		
	Connection wire		(BL09K)

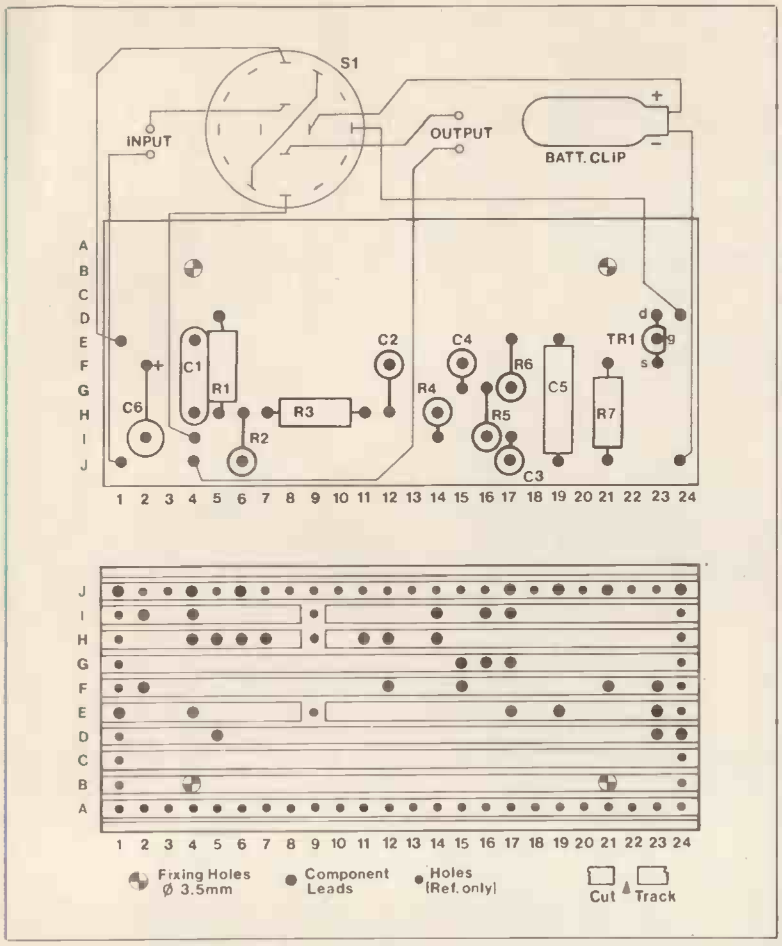
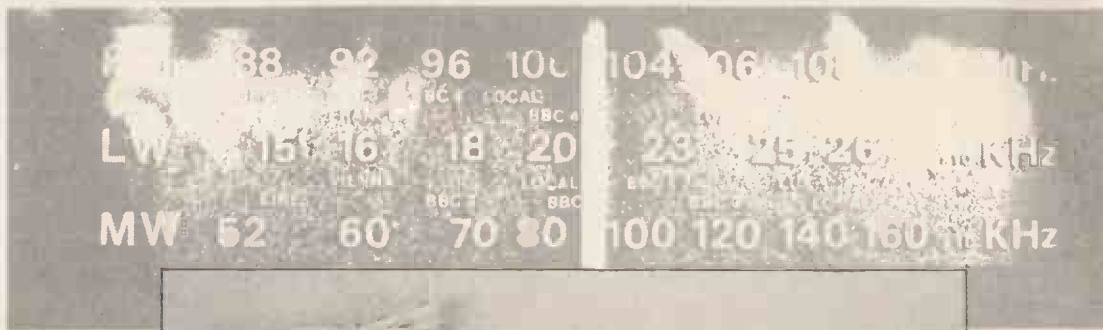


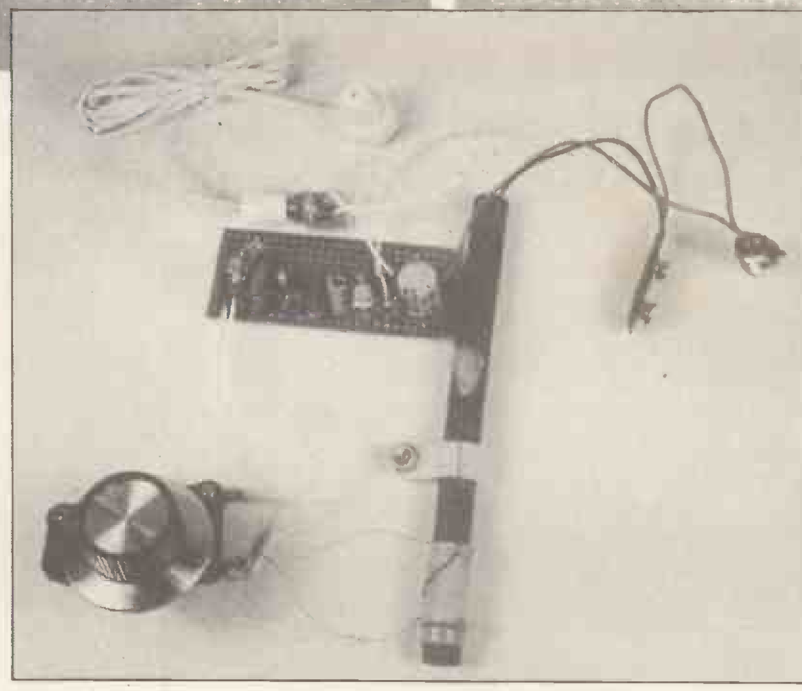
Figure 2. Constructional details of the Scratch Filter.

MW RADIO



Vero Project 6

A simple battery powered TRF receiver for use with magnetic earphone or headphones



This simple radio receiver covers the normal medium wave broadcast band and although a very simple circuit is used, good sensitivity is obtained. The output is designed for a low impedance magnetic earphone but inexpensive low impedance headphones (with the two phones used in series) can be used for higher quality. The set is cheap to run, using two HP7 cells, which give many hours of use, since the circuit current consumption is only about 20mA.

The Circuit

The circuit is the tuned radio frequency (T.R.F.) type where the received signal is amplified, demodulated, and the resultant audio signal amplified before being fed to the earphone. Most commercial receivers are of the superhet type where the received signal is converted to an intermediate frequency (I.F.), giving high gain and good selectivity, which is then demodulated and amplified. The main drawback of using a T.R.F. set is comparatively poor selectivity but performance is adequate for use on the M.W. band. In general T.R.F. receivers have lower sensitivity than superhet types but in this case the use of a high gain integrated circuit ensures good sensitivity. The advantages of a T.R.F. design are low cost, simplicity, and the fact that

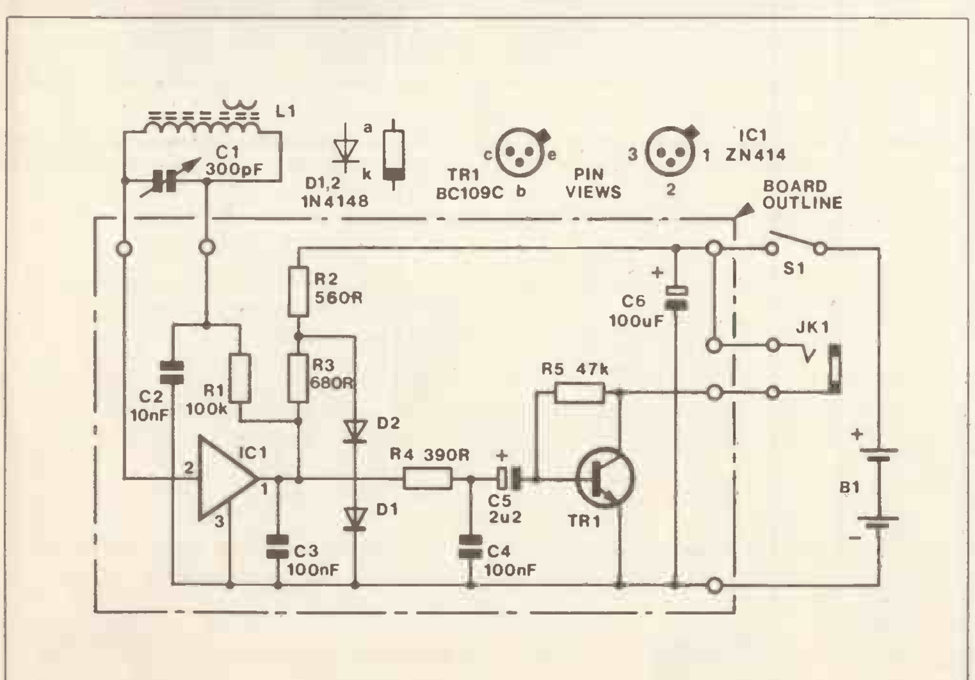


Figure 1. The circuit diagram of the M.W. Radio.

PARTS LIST

Resistors — all ⅓W 5% carbon

R1	100k			(M100K)
R2	560R			(M560R)
R3	680R			(M680R)
R4	390R			(M390R)
R5	47k			(M47K)

Capacitors

C1	300pF solid dielectric, variable		(FF50E)
C2	10nF polyester		(BX70M)
C3,4	100nF polyester	2 off	(BX76H)
C5	2u2 63V axial electrolytic		(FB15R)
C6	100uF 10V axial electrolytic		(FB48C)

Semiconductors

IC1	ZN414		(QL47U)
TR1	BC109C		(QB33L)
D1,2	1N4148	2 off	(QL80B)

Miscellaneous

L1	Denco MW5FR ferrite aerial		(LB12N)*
S1	SPST miniature toggle		(FH00A)
	Plastic case		
	Veroboard, 24 holes by 10 strips, 0.1in. matrix		(FL06G)
JK1	3.5mm miniature jack socket		(HF82D)
B1	HP7 cells	2 off	
	2 x HP7 battery box		(YR60Q)
	Low impedance magnetic headphones (with 3.5mm jack)		
	Connection wire		(BL09K)

*The Denco MW5FR ferrite aerial is available from:
Denco (Clacton) Limited,
355, Old Road,
Clacton-on-Sea,
Essex.
CO15 3RH
Tel: (0255) 22807

Price £1.06 + VAT + 30p P&P.

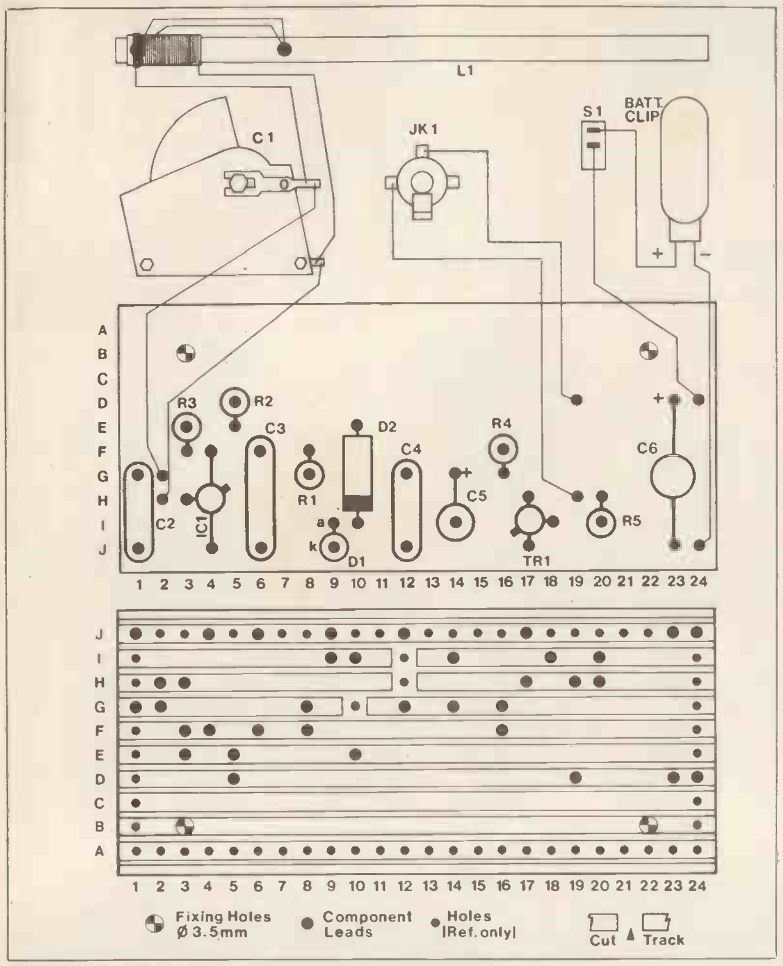


Figure 2. The Veroboard layout and wiring of the unit.

no complicated alignment is needed once the set has been completed.

Figure 1 shows the circuit of the receiver. IC1 is a device specifically designed for use in a medium wave T.R.F. receiver (although it can be used in other applications), it provides radio frequency (R.F.) amplification, demodulation and automatic gain control (A.G.C.). The A.G.C. action produces a reduction in gain when strong signals are received — this reduces the risk of strong signals overloading the device, and boosts the signal from weak stations. Another benefit is that it counteracts fading of stations due to atmospheric effects.

IC1 is biased by R1 via the ferrite aerial coil, L1. C2 couples one end of the aerial coil to earth and the other end connects direct to the input of IC1. As IC1 has a high input impedance the aerial can be coupled straight to its input, and the small coupling winding on the ready made ferrite aerial is not used. C1 is the tuning capacitor.

The positive supply to IC1 is provided via R3, the load resistor for the demodulator section, and is derived from D1, D2 and R2. The diodes are forward biased and drop 0.6V each, generating the required 1.2V supply.

C5 couples the demodulated audio signal to the input of a common emitter amplifier, TR1. This transistor is biased by R5 and the earphone acts as the collector load.

Construction

The Veroboard layout and wiring of the radio are given in Figure 2. The ferrite aerial can be mounted on the board or to the interior of the case using a 9.5mm P-clip. A plastic case should be used as a metal case would shield the ferrite aerial from the R.F. signal. The circuit is from the R.F. signal. The circuit is powered from two HP7 cells wired in series, and these are fitted into a plastic battery holder, with a PP3-type connector. The aerial coil should be positioned at one end of the ferrite rod in order to give the correct frequency coverage, with the two leads from the unused winding of the aerial trimmed off or glued to it.

The ferrite aerial supplied by Maplin is type MWLW5FR, and since the LW coil is not needed it should be removed.

Robert Penfold E&MM

Starting Point

by Robert Penfold

As it is hoped this series will show, it is within the capabilities of practically anyone to gain a good basic understanding of electronics. For those whose main interest is electronics construction, design, or servicing, it is probably best to concentrate mainly on the characteristics of the various components and the way in which they are employed in practical designs, rather than on the detailed theory of their operation. This approach is used in this series, and it should enable even absolute beginners to quickly and easily grasp an understanding of electronic circuits. Each part of the series will be accompanied by a simple constructional project which will demonstrate the practical application of the theory that has been covered, as well as being a useful and worthwhile piece of equipment in its own right.

Capacitance

Capacitors are an essential part of virtually every electronic circuit, and you will only very rarely (if ever) come across a practical circuit which does not contain at least one. The circuit symbol for an ordinary capacitor is shown in Figure 1, and this also gives details of symbols for special types of capacitor which will be dealt with later on. For the moment we will only consider ordinary (fixed value, non-polarised) capacitors.

Basically, a capacitor is an extremely simple component and merely consists of two conductors separated by an insulator. In practical capacitors the two conductors are normally in the form of two metal plates made from thin foil, and the insulation, known as the 'dielectric,' is often a thin layer of plastic (polystyrene, polyester, etc.), although other dielectrics, such as paper and ceramic materials, are in common use. In the capacitor circuit symbol the two parallel rectangles represent the plates and the space between them represents the dielectric.

Although at first sight a capacitor may seem of little or no practical use, it does actually have the important and very useful property of having the ability to store electric charge. If we take the simple circuit of Figure 2, with S1 in the 'charge' position the battery is connected across the capacitor. The positive terminal of the battery attracts free electrons from the top plate of the capacitor while the lower plate is fed with electrons from the negative battery terminal. This results in the capacitor almost instantly charging to the same voltage as the battery, and the current flow then ceases. An important point to note here is that although a current flowed into one battery terminal and out of the other and there was an apparent current flow through the circuit, no current actually passed through the capacitor. The dielectric prevents any continuous current flow through the component.

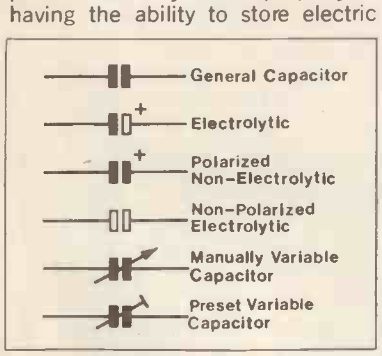


Figure 1. Capacitor circuit symbols.

If S1 is now set to the 'discharge' position the capacitor is able to return to a state of equilibrium by forcing an electron flow from the bottom plate to the top plate of the capacitor through S1. This gives another apparent current flow around the circuit, but in the opposite direction to the original one, and again no current actually flows through the capacitor.

Thus a capacitor is able to store an electric charge, and then deliver the stored electricity into a circuit. The amount of electricity that can be stored in a capacitor is governed by several factors, including the size of the plates and the effectiveness of the dielectric. The value of capacitors is measured in 'farads,' and one farad is equal to an input of one coulomb to give a charge potential of one volt. In other words, if a capacitor is charged at 1 amp for one second (or an equivalent charge equal to 1 coulomb) and a charge voltage of 1 volt is achieved, its capacitance is 1 farad.

The farad is far too large for use in general electronics and the units normally used are micro-farads (uF), nano-farads (nF), and pico-farads (pF). These are equal to a millionth of a farad, a thousand millionth of a farad, and a million millionth of a farad respectively. Thus a capacitor having a value of 10nF for example, could also be correctly said to have a value of 0.01uF or 10,000pF.

In addition to capacitance value, capacitors also have a voltage rating — this voltage is the highest that can safely be applied across the component. A higher voltage could easily result in dielectric insulation breaking down giving a virtual short circuit through the capacitor. Even within the working voltage of the component the dielectric's insulation properties will not be perfect. The resistance between the two plates is known as the leakage resistance, and any charge on the component will gradually leak away through this if it is not discharged through some other path. Like resistors, capacitors also have a tolerance rating on their value.

Time Constants

If a battery is used to charge a capacitor the charging occurs almost instantly due to the high charge current that the battery is able to provide. If a resistor is added in series with the capacitor, as shown in Figure 3, the charge current is reduced and the capacitor charges more slowly. The time taken for the capacitor to charge to the battery voltage depends on the values of the resistor and capacitor, and increasing the value of either increases the charge time.

The time taken for the charge to reach 63% of the input voltage is CxR seconds with C in farads and R in ohms, or for greater convenience in practical calculations C can be in micro-farads and R can be in megohms. The time taken for the capacitor to fully charge (or, more accurately, to achieve a voltage equal to 99% of the input voltage is 5xCR seconds.

If the circuit of Figure 3 is switched to the discharge mode, the resistor now slows up the discharging of the capacitor. It takes CR seconds for the charge voltage to fall to 37% of its initial value, and 5CR seconds for it to drop to 1% of its initial value.

When charged or discharged via a resistor the voltage across a capacitor does not rise or fall in a linear fashion. If we consider the charging action first, initially the full input voltage will be present across the resistor, giving a high charge current. As the charge voltage on the capacitor rises, the share of the input voltage taken by the resistor reduces, as does the charge current (as dictated by Kirchhoff's voltage law and Ohm's law). As time passes, the voltage across the capacitor rises more and more slowly, as shown in the graph of Figure 4. The capacitor charges 'exponentially.'

A similar effect is produced when a capacitor is discharged through a resistor, with the charge voltage falling fast at first, and then gradually slowing up as the voltage across the resistor (and hence the discharge current) diminishes. This is also

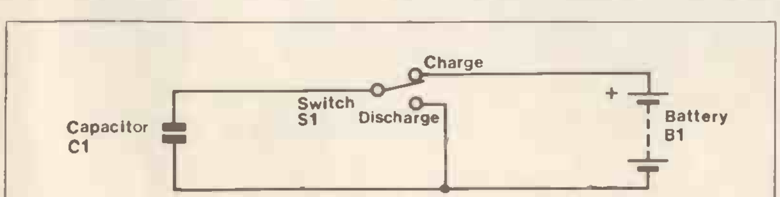


Figure 2. Demonstration of charge storage by a capacitor.

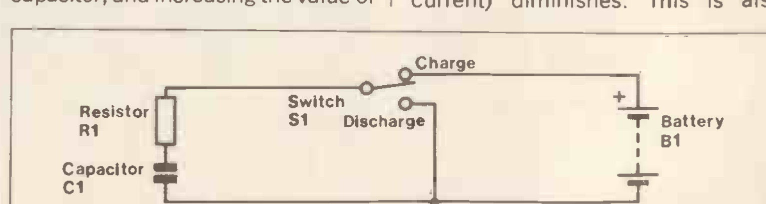


Figure 3. Charge and discharge of a capacitor via a resistor.

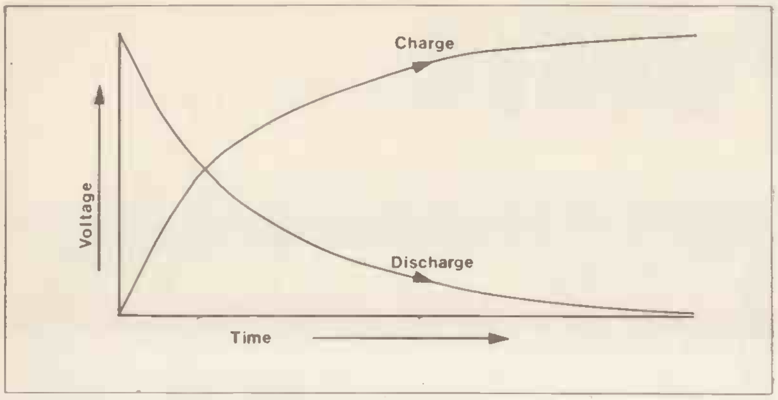


Figure 4. Exponential charge and discharge of a capacitor.

shown in the graph of Figure 4.

Parallel Capacitance

If two or more capacitors are connected in parallel, a charge source has to charge all the capacitors in the network, and the combined charges of all the capacitors are then available if a discharge circuit is connected. Thus the total capacitance of parallel-connected capacitors is simply the sum of the individual capacitance values.

When connected in series, capacitors provide a value that is less than the highest single capacitance value in the series circuit. The equation for two capacitors connected in parallel is:

$$C_{total} = \frac{C1 \times C2}{C1 + C2}$$

For more than two series connected capacitors the combined capacitance is given by the equation:

$$C_{total} = \frac{1}{\frac{1}{C1} + \frac{1}{C2} + \frac{1}{C3} + } \ldots\ldots$$

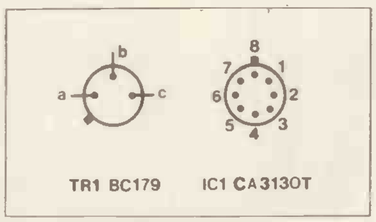
This is very much the same as calculating parallel resistance, and will not be considered in greater detail.

Simple Timer

Probably the most obvious use for a capacitor is in a timing circuit of some kind, and this is indeed a common use for capacitors. Our constructional project this month is a simple electronic timer which is suitable for use as a kitchen timer, or for other similar, non-critical timing applications. It sounds an audible alarm some preset time after switch-on, and the timing range is continously variable from 30 seconds to 5 minutes.

The complete circuit diagram of the timer unit is shown in Figure 5. Here we will be primarily concerned with circuitry to the left of IC1, and the rest will not be considered in detail at this stage. The purpose of the transistor TR1 is to switch on the buzzer if pin 2 of IC1 is at a higher voltage than pin 3, or switch the buzzer off if it is not.

Pin 3 of IC1 is fed with a fixed potential from the voltage divider comprised of R3, R4 and connected between the supply lines. The voltage can be adjusted from half the supply voltage to the full supply voltage by means of RV2.



TR1 and IC1 pin views

Pin 2 of IC1 is fed from the supply lines via a resistor-capacitor network which consists of RV1, R2 and C1. At switch-on C1 will obviously be in an uncharged state, and zero volts will be fed to pin 2 of IC1. Thus initially the buzzer will not be activated.

The voltage across C1 (which is also the voltage fed to pin 2 of IC1 of course) will gradually increase, and eventually it will become higher than the voltage fed to pin 3 of IC1 by RV2. The buzzer is then activated and the audio alarm signal is produced. There are two variable factors which affect the time taken before this happens, one of which is the setting of RV2. The higher the voltage this supplies to pin 3 of IC1 the longer it takes the voltage across C1 to exceed this. The other factor is the setting of RV1, with the time taken for C1 to reach a given charge voltage increasing and decreasing as the value of RV1 is raised and lowered respectively

In practice, RV2 is adjusted so that there is a delay of 30 seconds after switch-on before the buzzer sounds when RV1 is set at minimum resistance (a delay of just under 1.4CR seconds). This gives a nominal delay time of 5½ minutes with RV1 at maximum, but due to component tolerances this time will vary somewhat from one example of the circuit to another. It will normally be within the range of 5 to 6 minutes. RV1 is the delay time control, and in practice the dial is calibrated so that the required delay can be easily set.

When the on/off switch S1 is set to the off position S1a discharges C1 through R1 very rapidly so that the unit is ready to operate again almost instantly. Without this a residual charge might be left on C1 and this would shorten the subsequent timing run of the unit. R1 is needed to limit the discharge current of C1 to a value that does not damage S1.

The capacitor used in the C1 position needs a fairly high capacitance, and one that is not really practical for an ordinary capacitor as it would be physically very large as well as being difficult and very expensive to manufacture. Higher value capacitors are normally of the elec-

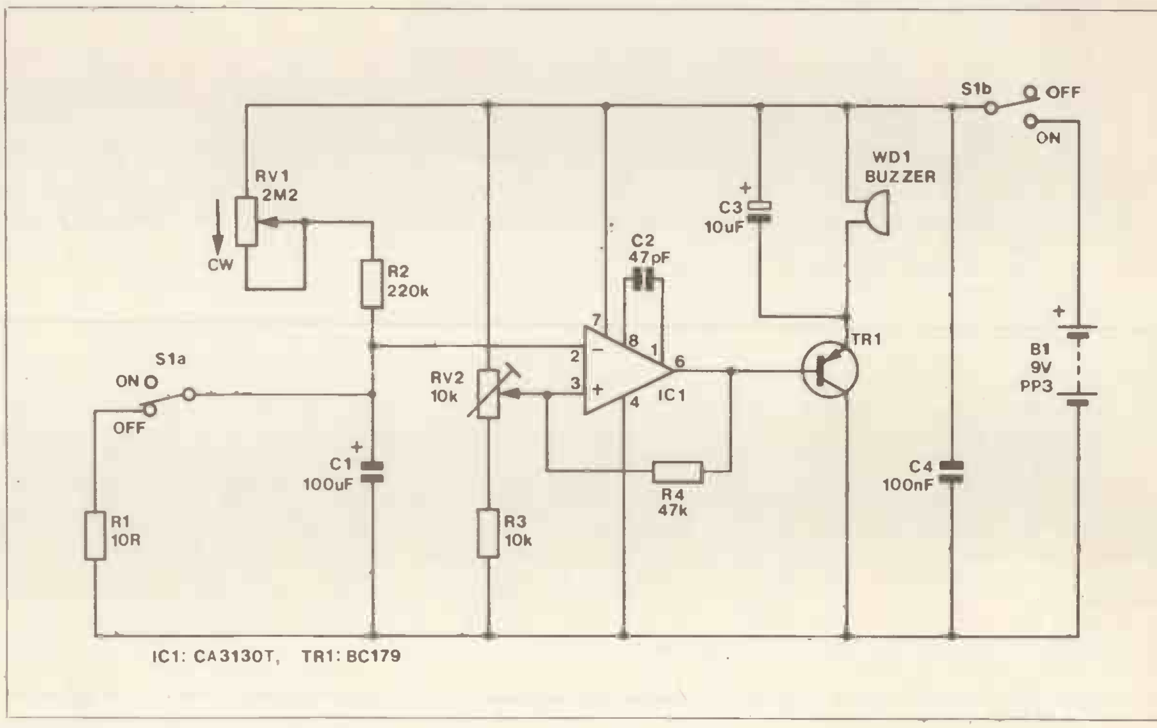
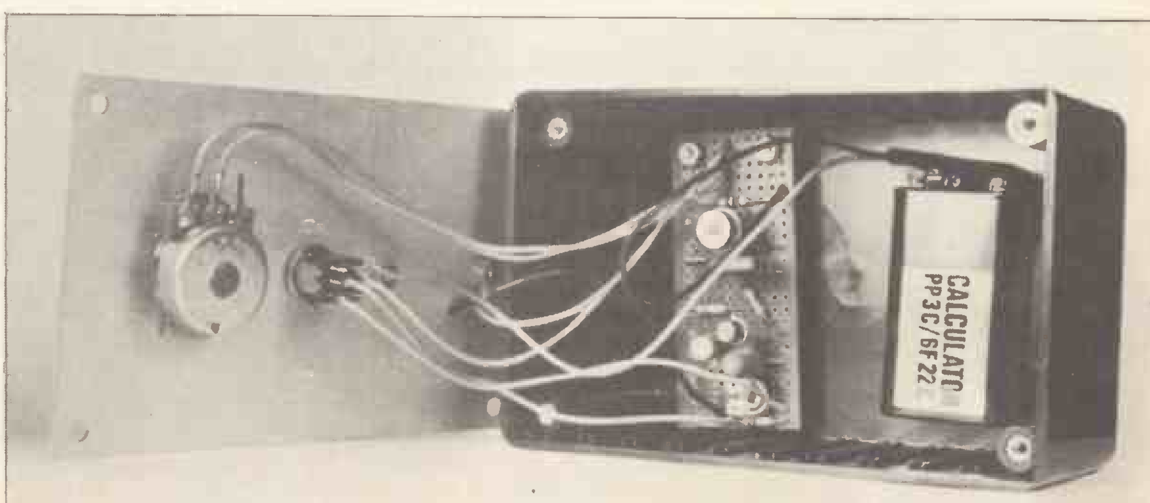


Figure 5. The circuit diagram of the Timer.



The Timer unit.

trolytic type, and these are generally far smaller than would be possible with a non-electrolytic type of the same value, and can be produced quite cheaply. An electrolytic is not ideal for use as C1 in this circuit as they do have a few important drawbacks.

One disadvantage is that they must be fed with a supply of the correct polarity or the dielectric will not form properly and the component will have a very low leakage resistance. This is not really a problem here since C1 is always fed with the same supply polarity. Of greater importance here is that even when fed with a supply of the correct polarity the leakage resistance of an electrolytic is still relatively low. This would tend to leak away the charge current, extending the delay. The tolerance of electrolytics is also rather high, which would cause widely varying delay times from one unit to the next.

The component used for C1 is a tantalum bead type which although rather expensive when compared to an electrolytic of similar value and working voltage, has a lower tolerance and high leakage current. Tantalum capacitors, like electrolytics, are polarised components, and can be damaged if connected the wrong way round.

Supply Decoupling

Earlier in the series we discussed internal resistance of batteries, and the fact that supply voltage changes with variations in current. These voltage fluctuations can cause circuits to malfunction, and this is usually combatted by adding a decoupling capacitor across the supply. When the supply is heavily loaded the capacitor gives up some of its charge and minimises the drop in supply voltage. When the supply is lightly loaded the capacitor recharges, maintaining the loading on the supply and preventing its voltage from greatly increasing. It thus has a stabilising effect on the supply voltage, though this method is only usable if there are fairly rapid changes in loading as the capacitor would otherwise have to supply current for a long period of time, needing an excessively high value.

C4 is the supply decoupling capacitor for this circuit, and C3 provides a similar function for the buzzer.

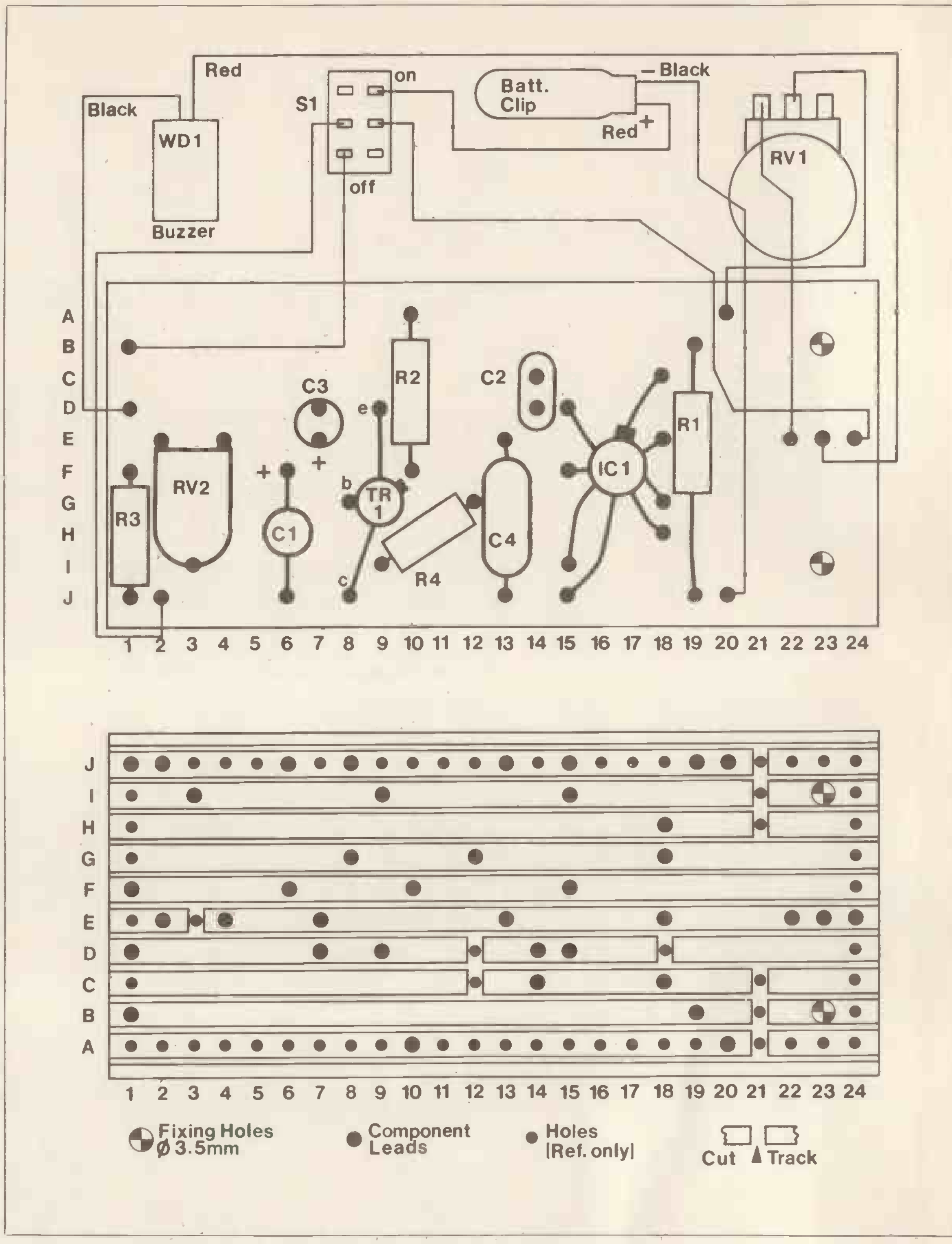


Figure 6. Constructional details of the Timer.

Construction

The unit will comfortably fit into a metal panel box type M4004 or any case of a similar size (111 x 78 x 48mm). S1, RV1, and the buzzer are mounted on the front panel, and the latter requires two 2.5mm diameter holes for the 8BA mounting bolts, and a 3.5mm hole for the two leadout wires. The buzzer can be used as a template when marking out the hole positions.

Figure 6 shows the 0.1 in. Veroboard layout and wiring of the timer. The only point to note in the construction is the fact that IC1 is a MOS device and as such can be damaged by high static voltages. Handling should be kept to a minimum, the device should be left in its protective packaging until needed, and it should be the last component to be fitted to the board. Solder it in position with a soldering iron having an earthed bit, or unplug the iron from the mains just before use.

When initially testing the unit start with RV2 at a central setting and RV1 at minimum resistance (fully anticlockwise). RV2 is then trimmed by trial and error to give a time delay of exactly 30 seconds. Clockwise adjustment of RV2 shortens the time delay; anticlockwise adjustment increases it. Rub-on numbers can be used to produce a calibrated scale around the control knob of RV1, with the calibration points determined empirically.

E&MM

PARTS LIST

Resistors — all 5% ⅓ watt carbon unless specified.

R1	10R	(M10R)
R2	220k	(M220K)
R3	10k	(M10K)
R4	47k	(M47K)
RV1	2M2 lin. pot.	(FW09K)
RV2	10k Hor. S-min. preset	(WR58N)
Capacitors		
C1	100uF 10V tantalum	(WW79L)
C2	47pF ceramic plate	(WX52G)
C3	10uF 35V PC electrolytic	(FF04E)
C4	100nF polyester	(BX76H)
Semiconductors		
IC1	CA3130T	(QH28F)
TR1	BC179	(QB54J)

Miscellaneous

S1	DPDT ultra-min. toggle	(FH99H)
B1	PP3 battery	
	PP3 connector	(HF28F)
	Veroboard, 24 holes by 10 strips, 0.1 in. matrix	(FL06G)
	Metal Panel Box M4004	(WY01B)
	12 volt buzzer	(FL40T)
	Control knob	(YX02C)
	Insulated hookup wire	(BL00A)
	6BA ½" bolts	(BF06G)
	6BA nuts	(BF18U)
	8BA ½" bolts	(BF09K)
	8BA nuts	(BF19V)

Micromusic

A series that focuses on using the popular microcomputers for making music.

Learning morse by computer -- ---- .-. ... . Graham Knight

The two previous editions of Electronics and Music Maker have detailed the versatile musical capabilities of the Sharp MZ-80K microcomputer. Some of the readers who purchased the Maplin cassette were quite amazed by the range of sound effects which can be programmed on the MZ-80K from Basic. The main program this month utilises the variety of note durations and the seven tempos in a unique way to make up an interesting method of learning the morse code with the assistance of a computer.

The thirty two line program takes less than 1K of memory and can be run on any Sharp MZ-80K microcomputer — regardless of the memory size available. The dots and dashes which make up the morse code are entered as DATA statements in lines 23 to 32. Line 23 contains the code for the letters A,B,C, D and E; line 24 contains F,G,H and I; line 25 contains J,K,L,M and N; line 26 contains O,P,Q and R; line 27 contains S,T,U, V and W; line 28 contains X,Y and Z. Similarly lines 29 to 32 contain the numbers 0 to 9. It is most important that care is taken in entering these DATA lines as they define the dots and dashes which will be both displayed on the screen and heard coming from the MZ-80K speaker.

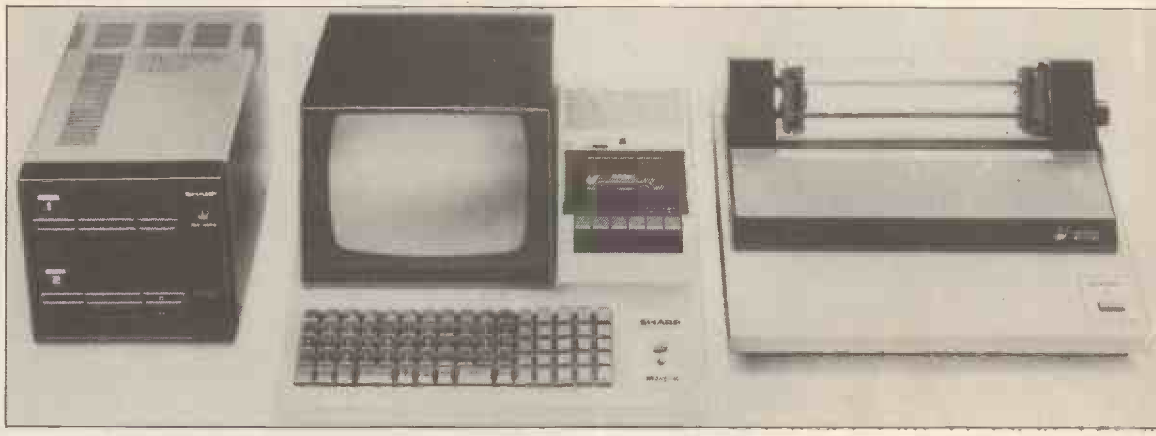
Once entered and run the program can be used to learn morse by both sight and sound. Seven different learning speeds are controlled by the TEMPO as defined in line 5 and line 7. The printing of the morse characters on the screen is achieved by reading the DATA and printing the value of C$ (line 17) and the morse sounds are generated by the MUSIC statements in lines 18 and 19. After selecting a learning speed between 1 and 7 simply enter the message you wish to hear on the MZ-80K keyboard, press the carriage return key and the morse code for your message will then be heard and displayed on the screen.

The program is quite a simple one but is capable of further expansion. The 32 line version only caters for the letters of the alphabet and for figures. Some enthusiasts may wish to expand the DATA lines and make the other appropriate changes to add punctuation marks, currency symbols, etc. It would also be possible to use the program to generate morse to feed the microphone circuits of a transmitter — morse could then be sent by simply entering the messages on the keyboard of the MZ-80K.

Readers who liked the previously published program which generated whistles, trimphone rings, engaged tones, etc have asked for guidance in using the POKE commands, and the second program shows how to control the sounds produced from the Sharp Basic for musicians to experiment with.

The program allows the user to enter a frequency in Hertz and the Sharp will then play it and display the appropriate POKE values for locations 4514 and 4513. The program will generate tones and display these values over a range from 16Hz to 3,900 Hz.

Table 1 will assist readers who are more accumstomed to musical notation and the POKE values are given for 36 notes to start you off. E&MM



NOTE	POKE 4514 value	POKE 4513 value
C	29	220
#C	28	48
D	26	156
#D	25	28
E	23	180
F	22	96
#F	21	32
G	19	240
#G	18	208
A	17	196
#A	16	196
B	15	212
C	14	238
#C	14	24
D	13	78
#D	12	142
E	11	218
F	11	48
#F	10	144
G	9	248
#G	9	104
A	8	226
#A	8	98
B	7	234
C	7	119
#C	7	12
D	6	167
#D	6	71
E	5	237
F	5	152
#F	5	72
G	4	252
#G	4	180
A	4	113
#A	4	49
B	3	245

Table 1

```
1 DIM L$(26),N$(9)
2 FOR A=1 TO 26:READ L$(A):NEXT
3 FOR A=0 TO 9:READ N$(A):NEXT
4 PRINT"C  LEARNING MORSE BY SIGHT AND SOUND"
5 INPUT "±±ENTER SPEED (1-7)";S
6 IF (S<1)+(S>7) THEN GOTO 4
7 TEMPO 8-S:PRINT"±±NOW ENTER MESSAGE IN LETTERS AND FIGURES":PRINT
8 INPUT M$:PRINT:FOR S=1 TO LEN(M$)
9 A=ASC(MID$(M$,S,1))-64
10 IF A=-32 THEN MUSIC "R5":PRINT " "::GOTO 21
11 IF A>0 THEN 13
12 X$=N$(A+16):GOTO 15
13 IF (A<1)+(A>26) THEN 8
14 X$=L$(A)
15 FOR A=1 TO LEN(X$)
16 C$=MID$(X$,A,1)
17 PRINT C$;
18 IF C$="." THEN MUSIC "¬A2R2"
19 IF C$="-" THEN MUSIC "¬A5R2"
20 NEXT A:MUSIC "R2":PRINT" ";
21 NEXT S:PRINT"±±".
22 GOTO 8
23 DATA ".-","-...","-.-.","-..","."
24 DATA "..-.","--.","....",".."
25 DATA ".---","-.-",".-..","--","-."
26 DATA "---",".--.","--.-",".-."
27 DATA "...","-","..-","...-",".--"
28 DATA "-..-","-.--","--.."
29 DATA "-----",".----","..---"
30 DATA "...--","....-","....."
31 DATA "-....","--...","---.."
32 DATA "----."
```

Program 2. Frequency Finder.

```
1 REM GM4HCO FREQUENCY FINDER PROGRAM
2 LIMIT24552:TEMPO7:MUSIC"R0"
3 FORJ=24553TO24560:POKEJ,Y:NEXT
4 DATA205,27,0,50,240,95,201,0
5 FORJ=24565TO24572:POKEJ,Y
6 NEXT:DATA 58,0,0,50,252,95,201,0
7 INPUT"C±GIVE FREQUENCY IN HERTZ ";F
8 IF(F<16)+(F>3900)THEN7
9 P=(1000/F)*998.67
10 A=INT(P/255):B=INT((P/255-A)*255)
11 PRINT"C±";F;" Hertz"
12 PRINT"±POKE 4514,";STR$(A)
13 PRINT"±POKE 4513,";STR$(B)
14 POKE4514,A:POKE4513,B:USR(68)
15 PRINT"±±Press R to restart.
16 GETQ$:IFQ$="R"THEN RUN
17 GOTO16
```

Program 1. Learning Morse using MUSIC command.

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- STRING FUNCTION FOR TEXT I/O.
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- USER MACHINE CODE INTERRUPT HANDLER INTERFACES WITH BASIC.
- XBUG.
- DATA CASSETTE FILE HANDLING IN BASIC

TANGERINE
COMPUTER SYSTEMS LIMITED
Forehill Works
Forehill Ely Cambs England Tel: (0353)3633

The Apple Music System

Reviewed by
Dr David Ellis

The Apple Music System is something of a quantum jump when compared to other microprocessor-controlled music synthesis systems. It's almost like a giraffe being given the evolutionary gift of a long neck enabling it to feast off the forbidden fruit on higher branches! Not that digital synthesis has been exactly forbidden, but, with this system, the price at least makes it feasible to have your own digital music synthesis set-up without having to sell house, possessions and, quite probably, your soul.

The basic hardware needed to start off would be an Apple II with 48K RAM, a monochrome VDU, a 5¼" disc drive plus controller, a Silentype graphics printer, and, most importantly, the Music System itself comprising additional hardware and software (Figure 1). At UK prices, you'd be lucky to have change from £2,000; that may sound a lot, but just wait and see what unfolds before your eyes!

Figure 1. The complete Apple Music System comprising 48K Apple II, MH Music System (light pen included), 2 Disc Drives, Silentype Printer and VDU.

Figure 2. The 2 MH System boards are plugged into the 2 left hand peripheral connectors in Apple II.

The Apple II is a sensible basis for any computer music system, for, at the present state of Apple Computers Inc. on the US stockmarket, together with the exponentially-increasing selection of peripherals and software for Apple computers, this firm is sure to coast with ease into the next century.

The Music System peripheral is manufactured by Mountain Hardware Inc. and consists of two boards which plug into adjacent peripheral connectors on the main board of the Apple II (Figure 2). The hardware comes complete with a light pen and a stereo pair of phono output sockets for connection to an audio system (Figure 3). The two boards enable the synthesis of sixteen individual voices implemented by the same number of digital waveform generators.

Figure 3. The Mountain Hardware Music System package, comprising 2 PCBs, 2 Diskettes and manual.

The present software enables three programs to be run to achieve three stages of music production:

1. MUSIC EDITOR — this inputs data into COMP files and is 'designed to approximate the process of composing a musical score on regular music staff paper.' The following functions are included:
(a) Input and editing of data.
(b) Display of musical scores.
(c) Printing musical scores.
(d) Loading and saving compositions.

2. MUSIC MERGER — this merges small COMP files created with the MUSIC EDITOR to create larger COMP files (and little fishes are eaten by bigger fishes...)

3. MUSIC PLAYER — this plays the data created by the MUSIC EDITOR and joined together by the MUSIC MERGER. The following functions are included:
(a) Conversion of COMP files to PLAY files.
(b) Change of instrument assignment, either using predefined IDEF and WAVE files (offering instrument definition and waveform identity, respectively), or (and this is where the fun really starts) by defining one's own instrument definitions.
(c) Re-assignment of speaker location for each part.
(d) Cancelling the performance during playing.
(e) Saving the composition.

Music Editor/Merger

Entering music into the system via the MUSIC EDITOR is actually a lot more complicated than it sounds on paper. To a well-practised hand, writing a note on manuscript paper is a more-or-less deft combination of a circular note head and a stroke and a flick for the note tail. With EDITOR, there are rather more steps involved:
1. Select octave from C0 to C7 (where middle C = C2) by using the LH game paddle control.
2. Select note value from a main commands menu (Figure 4) displayed on the lower portion of the screen using either the RH paddle control or the light pen.
3. Select note using a pitch cursor operated by the LH paddle control (Figure 5).
4. Write that note by pressing the LH paddle button.
5. Select and write accidentals from the main commands menu if necessary.

And that's not including the initial selection of clef, key and time signa-

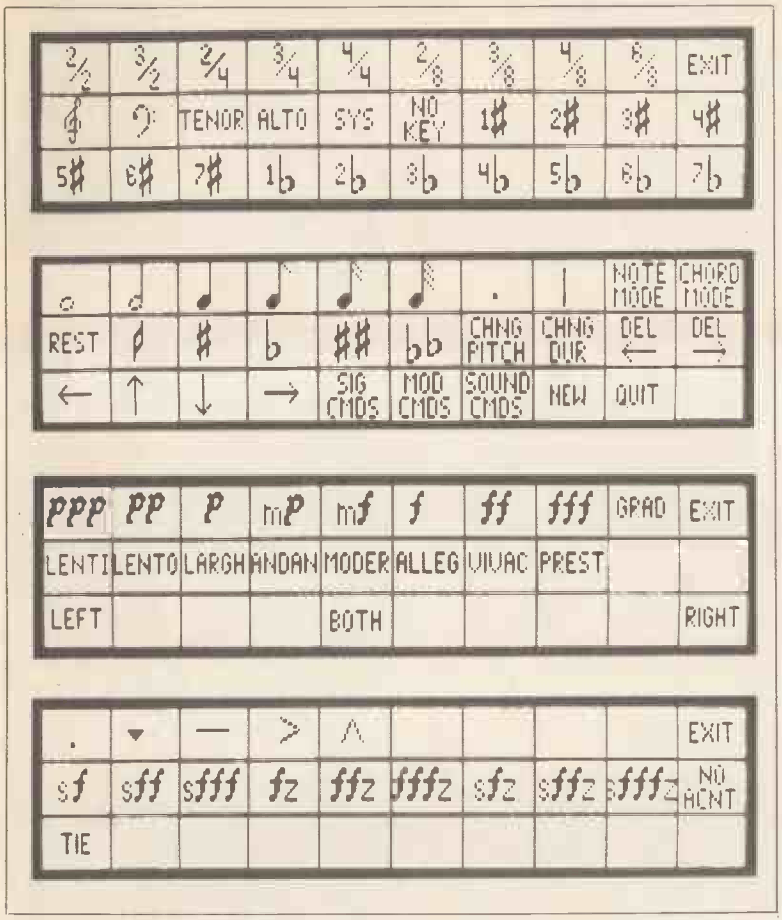

Figure 4. Lower Screen Menus. From top to bottom: Signature Commands, Main Commands, Sound Control, Note Modifier.

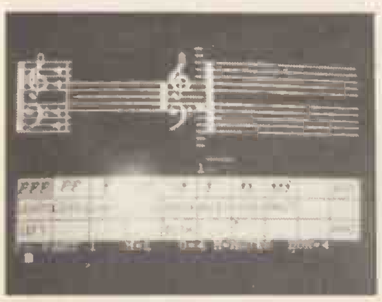

Figure 5: Upper screen shows pitch cursor, lower screen has one of the available menus.

tures from the signature commands menu and the later selection of slurs, accents, dynamics and tempo from note modifier and sound control menus. Personally, I find using the pitch cursor to select notes rather too reminiscent of those maddening telly games and I'd much prefer to see an additional pitch menu from which notes can be selected by using the light pen. Perhaps the RH side of the stave displayed on the upper screen (Figure 5) could include a note pool — or even something reminiscent of the Clangers' note tree! Luckily, all or most of this can also be accomplished by keyboard entry, but that's definitely not for beginners!

The end product of writing some trial parts is seen in Figure 6. These illustrate a number of peculiar idiosyncrasies of the EDITOR: firstly, groups of notes (e.g. ♩♩ or ♩♩♩♩) aren't available; secondly, slurs appear an inch above the notes that they link; thirdly, dynamics appear an inch below the notes.

Once the first part of a composition has been entered, it's then possible to go on to the next part of typing ADDP PART 2 and x parts later the entire piece can be printed on the Silentype printer. However, the music always appears one part at a time, whether on the screen or out of the printer! This may be adequate for providing instant parts to feed ravenous musicians, but isn't much help if you want to see how your magnum opus is jelling together. The MUSIC EDITOR seems to presuppose either that you've already scored the piece on paper, in which case one-line-at-a-time printing isn't exactly the end of the world, or that you create music horizontally (i.e., you write 'toons'), in which case you're more-or-less obliged to throw the vertical (i.e. chords) or contrapuntal baby out with the bathwater. That's assuming that you're not another Mozart whose right hemisphere in the cerebral cortex probably consisted of biological bubble memories . . .

What's more, even if you do the sensible thing of arranging the parts above each other in the score (as I've done in Figure 6), this doesn't really help very much as some parts appear to be more equal than others in the sense that bar lengths vary according to the number of notes contained therein.

Other useful additions would be a repeat command ('/.) and automatic bar lines. Dynamic control is very flexible, and, apart from accents and the like, it's also possible to assign relative dynamic levels to notes by entering a value from 0 to 127 on the keyboard. Absolute dynamic levels (ppp to fff) are also possible, but, as far as we could make out, it isn't possible to perform a gradual dynamic transition along the standard notational lines of a crescendo, pp < mf, or a decrescendo, mf > pp. We may be wrong, here, as there is a GRAD option on the sound control menu, but no mention of this appeared in the accompanying manual. A bit frustrating, this!

The Music Player

Having loaded the MUSIC PLAYER with a COMP file we're now in a position to do some rather interesting things with the outpourings of our fevered imagination. The transition from the COMP file into the real McCoy is a two-stage process; firstly, the data from the MUSIC EDITOR/MERGER has to be compiled by getting all the parts and the names assigned to them together in one place, or what with a bit of patience will become the PLAY file. If you refer to Figure 7, the two LH columns of the display represent the compiled parts. In our case, we were really boring and kept to monophonic lines for each part (indicated by the numbers in parentheses in the PART column) and made no assignment of names to individual parts (hence PART 1-9 in the NAME column).

Figure 7. The PLAY file has now been compiled from the COMP file.

The next stage is where instruments are assigned to the parts and some decisions are made as to where we want the instruments to come from, speakers-wise. Assuming that for the moment we're sticking to the MUSIC PLAYER predefined IDEF files, we can assign instruments from the list shown in Figure 8. Note here that some instruments use more oscil-

Figure 6. Trial parts printed by the Silentype Printer from the Music Editor. Note the two possible print sizes.

lators (digital waveform generators) than others. We need to watch this with the eyes of a hawk.

Remembering that there are a total of sixteen voices, and bearing in mind that the LH and RH channels each get eight, we'll end up with the Music System's equivalent of a slap on the face with a wet kipper if we try to assign brass to all nine parts of the test piece! Indeed, if you look at Figure 8 and add up the numbers of oscillators you'll find ten assigned to the LH channel and nine to the RH, and that just ain't on.

Once these choices have been made, the instruments can then be bonded to the music, forming the PLAY file, either by playing the score or by saving it on diskette. The imitative quality of the IDEF file is remarkably good, as you'll be able to hear from the second example on the E&MM demo cassette (No. 2).

So far, so good, but now comes the interesting part, the instrument definer program that permits additive synthesis. Additive synthesis is derived from the compilation of a waveform as the sum of harmonic components, or, to put it another way, any periodic waveform may be described as a sum of simpler harmonically-related waves. The Apple II can be used to combine a fundamental frequency with the harmonics at particular amplitudes in the form of a waveform table which is used to drive each digital waveform generator. Since the D/A converters used in the Music System operate with 8-bit resolution, each wave-form table is described by only 256 bytes which limits the accuracy with which complex waveforms can be generated. This is one of the reasons why it's necessary to use multiple waveform generators for instruments like brass and woodwind. The instrument definer program allows you to reprogram the harmonic profile up to the twenty-fourth harmonic for a particular waveform (Figure 9) and will then load and plot the resultant product of additive synthesis.

Having defined a new waveform, it's then possible to construct a suitable envelope for the new instrument using the same program. For the attack portion of the envelope there are fifteen points over which amplitude versus time can be defined for the waveform. This is pretty sensible as attack is the most important feature in the perception of timbre. Sustain is then specified by an exponential parameter, and decay by a linear or logarithmic function. One trouble is that all the programmed harmonics have to follow the same envelope which really doesn't reflect natural synthesis. An instrument like the gong shows a longish attack time before there's a swell of even harmonics, but these harmonics decay in an uneven fashion and it's this behaviour that gives the gong its characteristic bloom. It's this aspect of additive synthesis where the Fairlight CMI really rules supreme with the potential to draw individual envelopes for up to thirty-two harmonics. It'll be interesting to see whether new software for the Music System provides this facility or something approaching it.

A Chart Of Instrument Definitions

Name	Number of Oscillators	Octave Range	Waveform Files	Description
ORGAN	2	0-7	IDEF.ORGAN WAVE.ORGAN1 WAVE.ORGAN2	full keyboard range
CLARINET	3	2-5	IDEF.CLARINET WAVE.CL1 WAVE.CL2 WAVE.CL3	sounds like woodwind from G2 to G5
BASS	1	1-2	IDEF.BASS WAVE.BASS	sounds good up to G3
GONG	2	1-5	IDEF.GONG WAVE.GONG	see note 1.
DRUM	2	1-3	IDEF.DRUM WAVE.SINE1 WAVE.DRUM2	good bass drum from G1 to G3 see note 2.
WOOD BLOCK	2	1-4	IDEF.WOODDRUM WAVE.SINE1 WAVE.DRUM2	see note 3.
BRASS	3	2-4	IDEF.BRASS WAVE.BRASS1 WAVE.BRASS2 WAVE.BRASS3	see note 4.
PIANO LOW	1	1-3	IDEF.PIANOLOW WAVE.SAWTOOTH12	G1 to G3
PIANO MID	2	3-5	IDEF.PIANOMID WAVE.SAWTOOTH16 WAVE.SINE2	C3 to C5
PIANO HI	2	4-6	IDEF.PIANOHIGH WAVE.SINE1 WAVE.SAWTOOTH12	G4 to G6 and beyond
CYMBALS	2	2	IDEF.CYMBALS WAVE.NOISE WAVE.UGLY	B2 or C3
CLAVICHORD	2	0-7	IDEF.CLAVICHORD WAVE.CLAVICHORD WAVE.NOISE	full range

Figure 8.

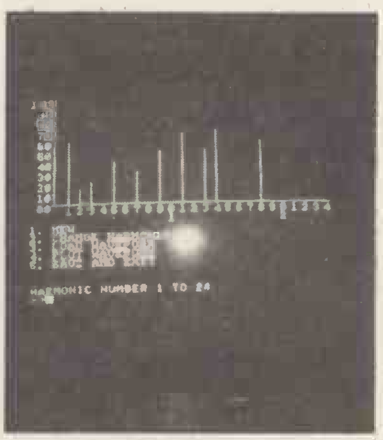

Figure 9. Harmonic profile of an altered instrument (Gong) taken from the IDEF file.

Conclusions

It's obvious that the present Music System is geared towards the compositional side of music-making, and so any peripherals that could be added to switch the balance to real-time synthesis would be very welcome. One obvious addition would be a fast A/D converter allowing analysis of analogue information and subsequent driving of the Music System in conjunction with additional input from the Music System operator. Even though the Apple II is limited to 8-bit resolution, and therefore prone to quantization error, the A/D + D/A interface produced by Mountain Hardware has a superfast conversation time which permits high frequency analysis and could therefore be a valuable add-on to the Music System with appropriate software.

So far, though, all pitch information is derived without the musicians' conventional interface, the piano-type keyboard, which means that it's impossible to perform real-time synthesis. Alpha Syntauri will shortly be introducing a polyphonic keyboard to the UK that interfaces with the Music System and should offer programmable presets, envelope control on each voice, and a velocity-sensitive keyboard. However, the cost of this is likely to be on the high side. If you remember last month's discussion of the PAIA 8700 Computer/Controller, you'll recall that this is a 6503-based system and could therefore be an ideal keyboard interface for the Apple Music System.

This is certainly something I'll be following up. E&MM too, will soon be presenting a system that's micro-based and, despite its versatile programming facilities, of low cost.

At present, the Music System is not widely available in the UK and to do this review it was necessary for me to take advantage of the hospitality of Microsense Computers Ltd. of Hemel Hempstead, the sole distributors of Apple over here. The afternoon spent with the system only scratched the surface of its quite remarkable potential and the considerable amount of nit-picking that I've indulged in is only because I think it's so good. Also, a good number of the apparent shortcomings may be due in part to 'green' operators rather than actual system deficiencies. I would like to proffer my sincere thanks to Andrew Seymour of Microsense for putting up with me and being such an enthusiastic guide around the system. It should perhaps be pointed out that Mountain Hardware have only recently updated the software of the Music System and the preceding night before my visit to Microsense was the first time that the new software had been tried out! As the hardware and initial software was introduced only six months ago in the States, it is perhaps unfair to be over-critical. Furthermore, Mountain Hardware are committed to continued development and support of the Music System, so I'm confident that exciting times lie ahead.

An intriguing aspect of the Music System is that it really makes you aware of the complexities of music-making. As a composer, I intuitively use the whole gamut of natural parameters that make up a modern musical vocabulary, grammar and syntax, but it's rare that I take the time to examine the raison d'être of all this. Three hours with the Music System has made me only too aware that I take too much for granted and I really look forward to reappraising all this once I have my own Music System. Perhaps, in a future E&MM article, I'll be able to pass on what I've learnt — that's if anyone wants to listen!

Finally, I must apologise for the not-so-great quality of the examples on this month's demo cassette; unfortunately, the vast range of Apple peripherals doesn't include such things as common-or-garden cassette decks, and so the music had to be recorded on my interview cassette machine. Don't be put off; the quality of the real thing is superb! **E&MM**

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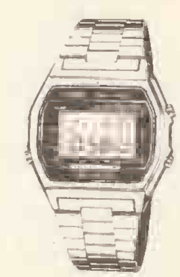

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USING MICROPROCESSORS

Peter S. Kershaw B.Sc.

The aim of this series of articles is to teach by example the basic principles of microprocessor hardware and software to the level at which the reader will be able to understand, modify and even design microprocessor-based projects.

In the first two parts of this series we have looked at how binary numbers are manipulated and at the structure and use of the Z80 microprocessor. This month we examine the representation of alpha-numeric text and discuss some types of software.

Hexadecimal Numbers

We have already compared denary (base 10) and binary (base 2) numbers. Whilst binary numbers are simplest for computers to manipulate they are particularly unsuitable for human use. When reading and processing long strings of ones and zeroes the chances of error are very high. There was just such a mistake in Part 1 of this series! However, hexadecimal (base 16) numbers may be used as a convenient representation of binary data. Just as denary numbers require ten digits (0 to 9) hexadecimal, or hex, numbers require sixteen digits. We use 0 to 9 and A to F. Table 3 shows the relationships between denary, binary and hex numbers.

Denary	Binary	Hex
0	0000	0
1	0001	1
2	0010	2
3	0011	3
4	0100	4
5	0101	5
6	0110	6
7	0111	7
8	1000	8
9	1001	9
10	1010	A
11	1011	B
12	1100	C
13	1101	D
14	1110	E
15	1111	F
16	10000	10
17	10001	11
18	10010	12 etc.

Table 3. The relationship between denary, binary and hexadecimal numbers.

It can be seen that one hex digit corresponds to four binary digits. Thus, one eight-bit byte may be represented by two hex digits:

1001 0101
D 5

This is easily converted back to denary:

$00D5_{16} = (0x16^3) + (0x16^2) + (13x16) + (5x1) = 213_{10}$

Familiarity with hex numbers is soon gained with use. For practice, verify the following, converting from denary to hex and back again:

i. $2A_{16} = 42_{10}$
ii. $300_{16} = 768_{10}$
iii. $6DC8_{16} = 28{,}104_{10}$

Representing Text

The most commonly used code for representing alphanumeric characters is 7-bit ASCII (Table 4). The 128 codes are in the range 00-7F16. 00-1F and 7F are control codes passed, for example, between a teletype and computer. Some examples are 0A (line feed), 0D (carriage return) and 7F (delete). The other 95 codes are printing characters, including space (20). As an example of their use, the ASCII codes for 'E&MM' would be:

22 45 26 4D 4D 22

In UK character sets, # is sometimes replaced by £. Whilst other coding systems (such as EBCDIC and BAUDOT) are still encountered, ASCII is nearly always used for microprocessor work.

Let's leave number systems for now and move on to look at some ways of writing software.

Microprocessor Software

We have seen that microprocessors work with binary data (which we may represent in hex). This means that program instructions must be given in binary. The kind of instructions which the Z80 microprocessor recognises include 'add registers,' 'store in memory,' etc.

Each instruction is represented by a one- or two-byte code. When used in a program, the instruction code will be followed by the data required to carry out that instruction. This may be one data byte or two address bytes. In instructions such as 'add register B to register A' no additional data is required. Consider the following example:

Instruction	Instruction Code	Instruction Data
Load reg. A from address 1000_{16}	3A	00 10
Add 30_{16} to register A	C6	30
Add A to A (multiply by 2)	87	
Store reg. A in address 1001_{16}	32	01 10
Halt	76	

Notice that addresses specified as instruction data are written with the high and low bytes reversed, so 10 00 becomes 00 10. Some processors use this format, others enter addresses the other way around. The instructions are described and the codes (158 of them for the Z80) are listed in various publications. These include the Z80 Programming Manual by Mostek and Z80 Assembly Language Programming by L. A. Leventhal.

The program above would take the number is memory location $1{,}000_{16}$, add 30_{16} to it, double the result then store it in memory location $1{,}001_{16}$ and halt. The program could be placed in memory (ROM or RAM) starting at any location (say 0800_{16}) as follows:

Address	Data
0800	3A
0801	00
0802	10
0803	C6
0804	30
0805	87
0806	32
0807	01
0808	10
0809	76

The program counter in the processor must first be set to 0800_{16}. Then, as each instruction is read, the program counter automatically moves to the next instruction. Note that the processor cannot distinguish between instruction codes and data, so a missing data byte will cause instructions to be used as data and data to be interpreted as instruction codes!

Assembly Language and Assemblers

In the previous example, the program was written using long instruction descriptions and laboriously converted to hex 'by hand.' Using long and arbitrary descriptions may be ambiguous and coding by hand is slow and prone to errors. The first problem is solved by the use of assembly language and the second by an assembler.

Assembly language is a set of instruction mnemonics ('opcodes') and rules, specific to the processor used, in which one line of code corresponds to one machine instruction. The assembler is a program which converts the assembly language code ('source code') to hex machine language ('object code'). Normally, the program is written on a microcomputer using an editor program. This numbers all the lines and allows the programmer to change individual lines.

The example program above would be written for a Z80 assembler as follows:

Line No.	Label	Opcode	Operands	Comments
0001	START	LD	A,(1000H)	;Load data
0002		ADD	A,30H	
0003		ADD	A,A	
0004		LD	(1001H),A	;Store result
0005		HALT		;and halt

The 'load' opcode (LD) is used to load the data and to store the result (most other processors 'load' *from* memory and 'store' *to* memory — the Z80 always uses 'load' opcode in either case). The opcode must always be present unless the line is only a comment; the number of operands is determined by the nature of the instruction. Comments, which follow a semicolon, are optional and have no effect upon the program. However, they are absolutely essential in making a program understandable. Documentation of programs generally will be discussed in detail later. Labels are discussed shortly.

The brackets in line 1 indicate that the contents of location 1000_{16} are loaded into register A, rather than the number 1000_{16} (which is too large anyway and would be truncated to 10_{16}). The H suffix denotes hexadecimal data. Some assemblers use a $ prefix ($1000). Other common suffixes are Q for octal (base 8), B for binary and D for decimal (decimal is usually the default).

When the programmer instructs the microcomputer to assemble the program, the following output is obtained:

Line No.	Address	Object Code	Label	Opcode	Operands	Comments
0001	0000	3A 00 10	START	LD	A,(1000H)	;Load data
0002	0003	C6 30		ADD	A,30H	
0003	0005	87		ADD	A,A	
0004	0006	32 01 10		LD	(1001H),A	;Store result
0005	0009	76		HALT		;and halt

Two columns have been added; the address of the program counter and the assembled object code.

Certain assembler instructions are also available which do not generate any object code but which are instructions to the assembler itself. These are called pseudo-ops. For example, if the 'origin' instruction ORG 0800H were placed before line 1 of the example, the starting address of the assembled code would be 0800 instead of 0000. Other commonly used pseudo-ops will be met in later examples.

Program Jumps and Labels

It is nearly always necessary to execute a program in an order other than that in which it is written. This may be because some section of code is executed several times or as a result of some previous action which causes a decision to be made. In order to change the order of execution, 'jump' or 'branch' instructions are used. The instruction JP 0880H will cause 0880 to be loaded into the program counter and execution will continue from there. Consider the following very simple counting program:

```
                0800   3E 00     LD    A,0      ;Clear counter
                0802   3C        INC   A        ;Increment counter
                 .      .         .
Other            .      .         .
instruc-         .      .         .
tions            .      .         .
                0850   C3 02 80  JP    0802H    ;Jump back
```

In the JP (jump) instruction, the jump address has been given in hex. If it is a jump forward, the address cannot be written in until the rest of the program has been written and assembled. Furthermore, if an extra instruction were inserted at the beginning of the program all the jump addresses would have to be changed. The assignment of labels solves these problems:

```
0800   3E 00               LD    A,0
0802   3C         LOOP     INC   A
 .      .                   .     .
 .      .                   .     .
 .      .                   .     .
 .      .                   .     .
0850   C3 02 80            JP    LOOP
```

The assembler assigns the value 0802 to the label LOOP and inserts that value in the object code when that label is encountered. If a change is made in the program, one merely reassembles it.

Values may also be assigned to variables, using the EQU (equate) pseudo-op:

```
CONST1  EQU       32H
         .
         .
         .
        ADD       A,CONST1
```

This will cause 32H to be added to register A. The variable CONST1 may be used several times during a program. To change the value at each occurrence it is necessary only to change the equate statement.

The rules governing which characters and how many may be used in a label vary according to the particular assembler, but they are usually flexible enough to allow descriptive labels to be chosen (eg. MPLY for a multiply routine).

So far, we have seen only an unconditional jump instruction. However, the power of the computer lies in its ability to make decisions. Conditional jump instructions allow us to change the order of execution according to the results of a previous operation. For example, consider a routine which executes ten times then continues with the rest of the program (Figure 6). This is achieved by the following program segment:

```
        LD      A,10
LOOP    .
        .               ;Routine XYZ
        .
        DEC     A
        JP      NZ,LOOP ;Jump if non-zero
```

The JP NZ instruction will cause a jump to occur if the zero flag in the condition-code register (described last month) is not set. It will only be set if the result of the previous instruction (decrement A) was zero. Various conditional jump instructions are available, using the other condition code flags.

The Z80 also has a set of conditional and unconditional relative jump (JR) instructions. The byte following the opcode is a 2's-complement offset from the start of the next instruction. As a single offset byte is used instead of the two-byte absolute address, less program space is used. Also, if a routine is moved around in memory the relationships between addresses within that routine do not change, so relative jumps which stay within the routine do not change. The range of offsets is -126 to +129 bytes.

When a program is assembled, the assembler will tell you if certain types of errors are present: for example if the offset of a relative jump is too long or if an invalid opcode is used. The assembler will not, of course, tell you whether or not the program will work — it doesn't know what you want the program to do.

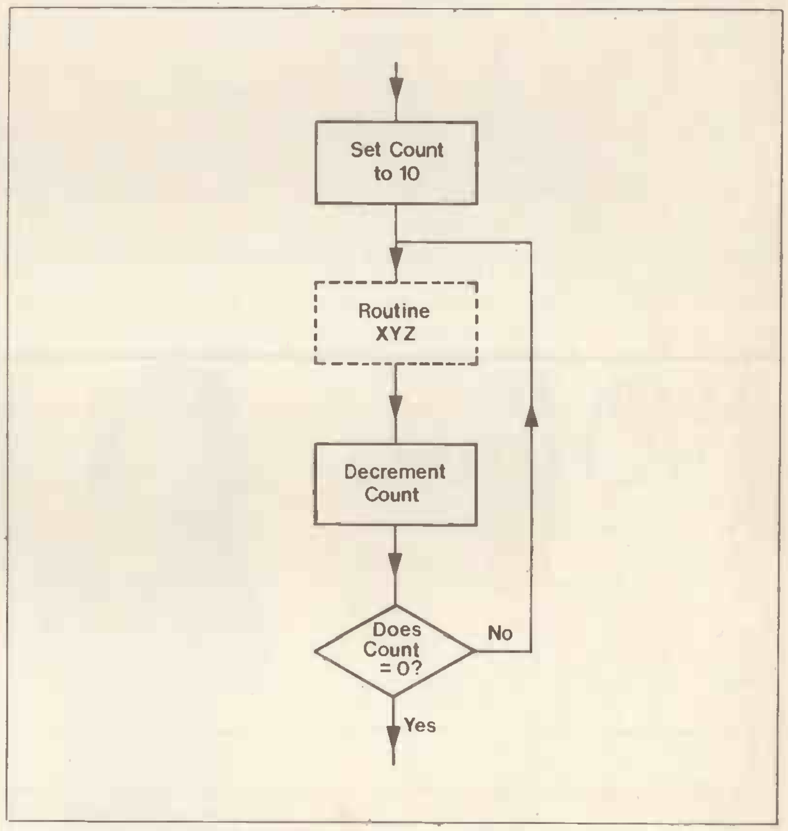


Figure 6. The use of a conditional jump.

High-Level Languages

Whereas a line of assembly language code corresponds to one machine code instruction, a line of high-level language code generally corresponds to several machine instructions. High-level languages are used to make complex programming tasks simpler.

The simplest and most common language available to the micro-computer user is BASIC. This is usually presented in the form of an *interactive interpreter*. This means that the user communicates directly with the BASIC software. If at any time, for example, the user types:

```
PRINT 7+2
```

the answer 9 will be printed on the terminal almost immediately. An example of a BASIC program to print all the integers from 1 to 100 and their squares would be:

```
10   FOR     N=1 TO 100
20   PRINT   N,N*N
30   NEXT    N
40   END
```

English-like statements are used and the lines are numbered to facilitate editing. At any time the use may type RUN and the program will be executed.

The interpreter is effectively a collection of machine code modules, each representing a function. Each instruction is carried out in turn. For example, each time line 20 is reached, the PRINT module is branched into, and it handles the sequence of events required to print the list of variables. Thus, no intermediate object code is produced. The interpreter goes straight from the program to the result. This means that very little memory space is required to run a BASIC interpreter which is one reason that it is so common on small microcomputers. For more details of the BASIC programming language see the 'Basically BASIC' series elsewhere in this magazine.

Of more interest to the writer of applied microprocessor software, however, are high-level language *compilers* such as Pascal, PL1 and FORTRAN. All these languages are more complex and more versatile than BASIC. In particular, FORTRAN (from FORmula TRANslation) is widely used for mathematical and scientific work. They are non-interactive compilers, which means that after the program is written it must be compiled into object code. This is done by replacing each high-level instruction with an object code module wherever it occurs. Thus, if the Pascal instruction WRITELN (write line) occurs 100 times in a program, the WRITELN module will appear 100 times in the object code. It may then be run on the microprocessor.

Note that when a processor is presented with some object code to execute, it cannot tell whether the source code was written in Assembler, FORTRAN, Pascal or any other language. This means that instead of writing our complex software in assembler and assembling it we could write it in a high-level language and compile it.

Which Programming Method to Use

The main advantage of writing software in a high-level language is the time which can be saved. Fewer instructions and less detail are required and documentation is simpler. Also, programs are more portable; standard language syntax ensures that FORTRAN written on one microcomputer will run on another, although some small changes may be required in practice. Furthermore, there are standard high-level language programs for the programmer to use, saving even more programming time.

Now for the disadvantages. High-level language compilers need more memory to run and they are therefore only available for the larger, disc-based microcomputers. Secondly, the syntax for these languages is fairly complex and it can take some time to become skilled in their use. Thirdly, because standard modules are used the object code is not the most efficient in terms of speed of execution or memory usage. Often, where speed is important the most repeated and therefore critical parts of the program are written in assembler, whilst the bulk is written in a high-level language. Lastly, programming in assembler gives more control over the hardware of the microprocessor system. I have heard it said that assembler 'lets you get at the pins.'

So what programming method should you use? The answer depends on your requirements and resources. Hardly anyone hand-assembles programs that are more than 10 instructions long. As long as you have a microcomputer of some sort, assembler programs are available very cheaply and the increase in programming speed is enormous. For long programs where speed and memory requirements are not critical high-level languages may be used to cut down programming time: however, you need to have access to a machine with high-level language capabilities which will produce object code for the processor you wish to use. A 'self-compiler' (or self-assembler) produces code to run on the processor which does the compiling. a 'cross-compiler' or assembler produces code for a different processor.

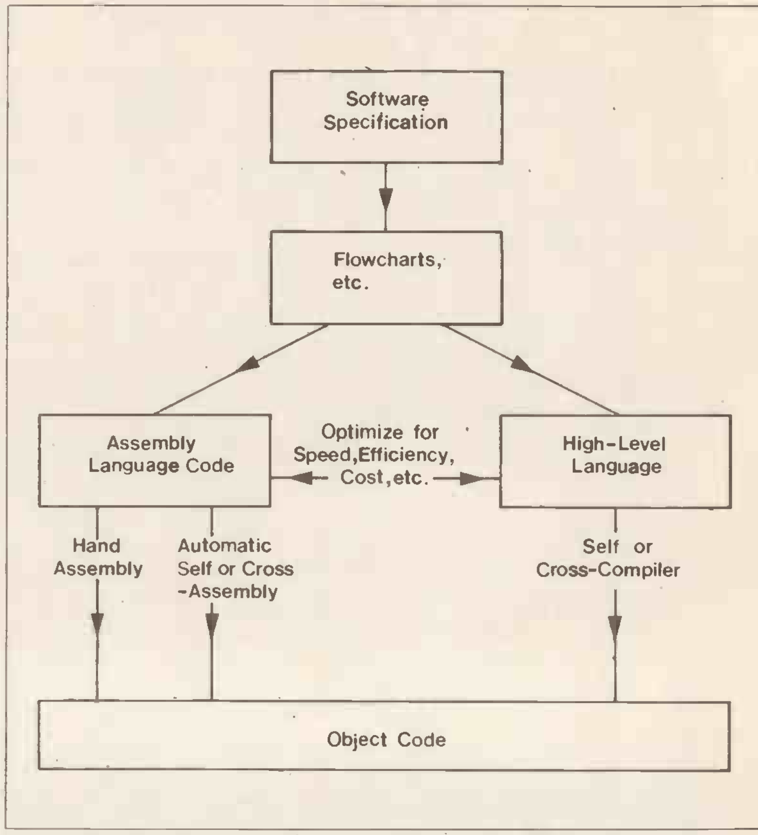


Figure 7. Summary of the ways in which microprocessor software may be written.

The various software design options are summarised in Figure 7. For most medium-sized applications, assembly language remains the most attractive option and it will be used for the examples in this series. However, as memory devices become cheaper and software accounts for a higher proportion of the cost of a product, high-level languages are being used in a wider range of applications.

Next month, we will look in more detail at the Z80 instruction set and at some other general points which will prepare us for the first complete design exercise.

E&MM

LSD	MSD 0	1	2	3	4	5	6	7
0	NUL	DLE	SP	0	@	P	‘	p
1	SOH	DC1	!	1	A	Q	a	q
2	STX	DC2	"	2	B	R	b	r
3	ETC	DC3	=	3	C	S	c	s
4	EOT	DC4	S	4	D	T	d	t
5	ENQ	NAK	%	5	E	U	e	u
6	ACK	SYN	&	6	F	V	f	v
7	BEL	ETB	'	7	G	W	g	w
8	BS	CAN	(	8	H	X	h	x
9	HT	EM	)	9	I	Y	i	y
A	LF	SUB	*	:	J	Z	j	z
B	VT	ESC	+	;	K	[	k	(
C	FF	FS	,	<	L	/	1	:
D	CR	GS	-	=	M	]	m	)
E	SO	RS	.	>	N	↑	n	—
F	SI	VS	/	?	O	-	o	DEL

Table 4. ASCII (American standard code for Information Interchange).

BASICALLY BASIC

Graham Hall, B.Sc.

This regular series will attempt to teach BASIC to those who would like to use it for any home, business, scientific or musical application, but have no previous programming experience.

This month we resume our examination of the BASIC language by first looking at some more examples of how the LET statement can be used.

If you looked at the small BASIC program at the end of last month's article you would have noticed that a LET statement was used not only to initialise a variable but also to change its value later in the program. Let us have a look at the program:

```
10 LET S = 0
20 LET C = 1
30 LET S = S + C
40 LET C = C + 1
50 PRINT S
60 PRINT C
70 END
```

Lines 10 and 20 are examples of initialising a variable to a numeric constant.

> NUMERIC CONSTANT — A number which remains the same during the operation of a BASIC program (e.g. 5, = 1,0.314 are all constants.).

There is a restriction on the size of a constant used in BASIC imposed because of certain limitations of the computer. Most personal computer systems have room to store constants of up to eight digits in length. Thus, the constant 54329876 or = 54329876 is allowed but 543298761 is illegal because its length is nine digits. There are two ways that the computer may deal with a number of illegal length, it may either abbreviate it to a legal length or return an error message.

> TRUNCATION — The abbreviation of a number of illegal length to the maximum length allowed by the computer. (e.g. 54329876<u>1</u> would be truncated to 54329876 by a computer which only allowed constants of eight or less digits).

When small decimal numbers are used as constants, truncation can cause problems due to lack of precision. For example, consider an illegal constant

0.19766989987

this will be truncated to 0.19766989 so the 987 at the end of the constant is lost. The second number is not as precise as the first and may lead to inaccurate results if it is used in a calculation. However, for most problems this degree of accuracy is not required.

Exponential Notation

BASIC also allows decimal numbers to be written in exponential notation (also called scientific notation). Using exponential notation the number is expressed as a constant (called the mantissa) multiplied by the appropriate power of ten (the power is called the exponent). For example, 1000 can be expressed as 1×10^3 (i.e. 1 x 10 x 10 x 10). Here the mantissa is 1 and the exponent is 3; the 1 has been multiplied by 10 raised to the third power. 1 x 10 x 10 x 10 is the same as 10 x 10 x 10 and also 100 x 10, so in exponential form this becomes 10×10^2 and 100×10^1. (Note: 10 raised to the power of 0 is defined as 1). Positive decimal numbers less than one can also be expressed in exponential form by using a negative exponent. A negative exponent shows that the mantissa is multiplied by the reciprocal of 10 raised to the power of the exponent. (The reciprocal of a number is defined as 1 divided by the number itself).

E.g. The reciprocal of 1000 can be expressed as 1×10^{-3}

(i.e. $\frac{1}{1 \times 10 \times 10 \times 10} = 0.001$)

This can also be written as $10 \times \frac{1}{10 \times 10 \times 10 \times 10}$ and as $100 \times \frac{1}{10 \times 10 \times 10 \times 10 \times 10}$ which is the same as writing 10×10^{-4} or 100×10^{-5}.

In BASIC the power of 10 is often represented by a special character, usually 'E,' so 1×10^3 written in BASIC becomes 1E3 and 1×10^{-3} as 1E-3 BASIC also imposes a size restriction on numbers expressed in exponential notation. The length of the mantissa is limited by the same restriction applied to constants expressed in normal format (usually eight digits in length). The size of the exponent is also limited by the type of system.

> OVERFLOW — overflow occurs when the computer executes a program that generates an oversize constant. This usually causes the program operation to stop and an error message to be displayed on the terminal. An example of how overflow can occur is by dividing any constant by 0.
>
> UNDERFLOW — the opposite to overflow. A constant generated by the program that is too close to 0 for the computer to handle.

Once you become familiar with this form of notation you will find it a quick and convenient way of expressing either very large or small decimal numbers. (NOTE: a comma is never used in BASIC numbers. If you tried to type in the statement: 10 LET A = 1,000 the interpreter program would return an error message).

Simple Expressions and Arithmetic Operators

Lines 30 and 40 are both examples of how to use a LET statement to assign the result of an arithmetic expression to a variable.

> ARITHMETIC EXPRESSION — a collection of constants and/or variables joined together using one or more arithmetic operators.
>
> ARITHMETIC OPERATOR — BASIC enables the use of five common mathematical operations. The symbol used to denote the operation is called the 'arithmetic operator.' The operations are addition, subtraction, multiplication, division and exponentation. Figure 1 shows a table of arithmetic operators.

BASIC symbol operator	Arithmetic operation	Example	Description
+	addition	X + Y	add Y to X
-	subtraction	X - Y	subtract Y from X
*	multiplication	X * Y	multiply X by Y
/	division	X / Y	divide X by Y
^ or ↑ or **	exponentiation	X ^ Y	raise X to the Yth power

Table 1. Arithmetic operators allowed in BASIC and examples of their use.

Later in this series we shall examine how BASIC evaluates expressions with more than one arithmetic operator according to operator priority.

Line 40 is an example of an equation which assigns the result of an expression to the variable C. The expression part of the equation is 'C + 1' and means that the constant 1 is added to the value of the variable C. The result of this arithmetic operation replaces the previous value of the variable C. This C is incremented by 1. If an expression contains a variable which has not been initialised the BASIC interpreter program automatically assigns the value of that variable to 0.

When the program reaches line 60 the value of C will be output to the terminal by the PRINT statement. Initially C was assigned to 1, it was then incremented by 1 so its new value is 2. Therefore the number displayed on the terminal is '2.'

Now we will look at line 30. This is an example of an equation where the expression consists of two variables. The computer will translate line 30 as 'put into the memory location named S the result of adding the contents of location S to the contents of location C.'

When the program reaches line 50 the PRINT statement outputs the value of S to the terminal. A '1' will be displayed because S contains the result of adding S, which was initially 0, to C, which was initially 1.

Most versions of BASIC allow the LET part of an assignment operation to be left out. A LET statement could be written as

10 S = 0

Throughout this series the LET statement will always have the 'LET' part included to avoid possible confusion.

Now we are almost ready to completely convert the algorithm devised last month to calculate the average of the counting numbers from 1 to 10 into a BASIC program to give us an answer to the problem. First we must introduce the BASIC IF and GOTO statements.

The GOTO statement

UNCONDITIONAL BRANCH — a jump to a specified line number within the program. It is unconditional because a decision is not made to determine whether the branch is taken.

A GOTO statement is used in a BASIC program to implement an unconditional branch. We can modify our existing program to include a GOTO statement as follows:

```
10 LET S = 0
20 LET C = 1
30 LET S = S + C
40 LET C = C + 1
44 PRINT C
45 GOTO 30
50 PRINT S
60 PRINT C
70 END
```

Try running the new program to see if the same results are printed on the screen. You will find your terminal will appear 'dead' because the program contains an 'infinite loop.' Consider what happens each time line 45 is encountered — the GOTO statement sends the program directly back to line 30. Prove this is happening by adding the statement

44 PRINT C

and re-running the program. A list of numbers starting at 2 and increasing in steps of 1 until the overflow limit of your computer will be output to the terminal.

Obviously we need a way of stopping this kind of loop. This is where the IF statement can be used.

The IF statement

The IF statement used together with a GOTO statement is used to make a conditional branch (it also has other uses which will be examined later in this series).

CONDITIONAL BRANCH — a condition is checked and a decision made to determine if the branch is to be taken.

Let's modify our program to include an IF statement which will control the number of times lines 30, 35, 40 and 45 are performed.

```
10 LET S = 0
20 LET C = 1
30 LET S = S + C
35 IF C = 10 THEN GOTO 50
40 LET C = C + 1
45 GOTO 30
50 PRINT S
60 PRINT C
70 END
```

The IF statement on Line 35 is equivalent to the question contained in the diamond decision box on the flow diagram shown last month (i.e. 'does C = 10'). Note that in this context the '=' is being used as a comparison operator and not as an assignment operator as for the LET statement. Lines 40 and 45 represent the branch taken if the answer to the question 'does C = 10' is 'NO.' Now the loop is performed ten times at which point C has been incremented by steps of one to the value of 10 and S contains the sum of all the numbers from 1 to 10 inclusive. The IF statement compares C with 10, the result is true so a jump is made to line 50, the value of S and C will be displayed on the terminal and the program will stop.

At last we are almost there! The only operation left to perform to calculate the average is to divide S by C. Using the division operator to perform this calculation lines 50 and 60 can be replaced with the lines:

```
50 LET A = S/C
60 PRINT A
```

Using a REM statement to allow comments to be inserted and the PRINT statement to output a message, the final program is:

```
5 REM AVERAGING PROGRAM
10 LET S = 0
20 LET C = 1
30 LET S = S + C
35 IF C = 10 THEN GOTO 50
40 LET C = C + 1
45 GOTO 30
50 LET A = S/C
60 PRINT"THE AVERAGE OF";
65 PRINT"COUNTING NUMBERS"
70 PRINT"BETWEEN 1 AND 10 IS"; A
80 END
```

Line 60 introduces another use of the PRINT statement. The message contained in quotation marks is called a 'string' and is printed exactly as written (the quotation marks themselves are not printed). Line 70 prints the string followed by the contents of A (*not* the character A because it is not contained within the quotes). The semicolon means that the string and the value of A are to be printed on the same line. The REM statement is used to allow comments to be added. These are ignored by the computer and serve only to make the program easier to understand.

We have now completed our first useful BASIC program. It would be instructive to compare the final version of this program with the flow diagram of the algorithm to see just how closely related they are. The only action which is not shown on the flow diagram is the printing of the messages. Now it is more obvious why first a problem should be tackled by devising an algorithm and a flow diagram before trying to write a program.

E&MM

COMPUTING NEWS

THAT MAN AGAIN

So you thought £100 was cheap, well you were wrong, Clive Sinclair publicly launched his new baby the ZX81 at Microsystems 81 and the response, despite Microsystems 81's trend towards business computing, was impressive, as was the machine. The stand was swamped, particularly on the Friday when in fact a small number of machines were actually on sale.

The price? An amazing £69.95 (including V.A.T.) built! The ZX80 is, it is claimed, currently outselling all other personal computers put together in the U.K. and the ZX81 should be another winner. It is built into a case of ABS plastic which is a considerable improvement on the ZX80's 'chocolate box liner.' Many other improvements have also been made.

ZX81 incorporates a Z80A micro and 8K of BASIC in ROM which now includes floating point arithmetic and more scientific functions. A print driver facility has been added making hard copy possible and an ability to operate in fast or normal modes is incorporated, fast being four times the speed of normal. The biggest improvement is the ability of the ZX81 to compute the display simultaneously, which allows moving, flicker-free graphics. Other improvements in the graphics area include the addition of a screen plotting area of 64 by 44 pixels, thus giving 2,816 plottable points, each point can be turned on or off using PLOT or UNPLOT.

Saving and loading of programs is now somewhat better with the introduction of file names and the ability to search the tape for the required program.

A comprehensive 200 page instruction manual is provided with the machine, which includes a new course in BASIC programming.

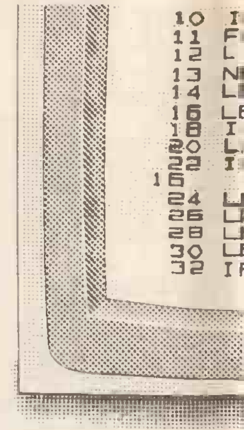
The new 8K BASIC ROM used in the ZX81 will shortly be available to ZX80 users and will be provided with a new keyboard template and operating manual. This will enable ZX80 owners to have all the facilities offered by the ZX81, with the exception of flicker-free graphics.

A ZX series compatible printer will be available in June 1981 for around £50. It offers full alphanumerics across 32 columns plus sophisticated graphics. Special features include COPY, which prints out exactly what is on the T.V. screen, without further instructions.

E&MM

New! Sinclair ZX81 Personal Computer.

Kit: £49.95 complete



Built: £69.95 complete

Reach advanced computer comprehension in a few absorbing hours

1980 saw a genuine breakthrough – the Sinclair ZX80, world's first complete personal computer for under £100. At £99.95, the ZX80 offered a specification unchallenged at the price.

Over 50,000 were sold, and the ZX80 won virtually universal praise from computer professionals.

Now the Sinclair lead is increased: for just £69.95, the new Sinclair ZX81 offers even more advanced computer facilities at an even lower price. And the ZX81 kit means an even bigger saving. At £49.95 it costs almost 40% less than the ZX80 kit!

Lower price: higher capability
With the ZX81, it's just as simple to teach yourself computing, but the ZX81 packs even greater working capability than the ZX80.

It uses the same micro-processor, but incorporates a new, more powerful 8K BASIC ROM – the 'trained intelligence' of the computer. This chip works in decimals, handles logs and trig, allows you to plot graphs, and builds up animated displays.

And the ZX81 incorporates other operation refinements – the facility to load and save named programs on cassette, for example, or to select a program off a cassette through the keyboard.

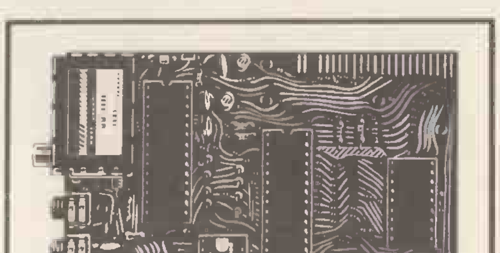
Higher specification, lower price – how's it done?
Quite simply, by design. The ZX80 reduced the chips in a working computer from 40 or so, to 21. The ZX81 reduces the 21 to 4!

The secret lies in a totally new master chip. Designed by Sinclair and custom-built in Britain, this unique chip replaces 18 chips from the ZX80!

Kit or built – it's up to you!

The picture shows dramatically how easy the ZX81 kit is to build: just four chips to assemble (plus, of course the other discrete components) – a few hours' work with a fine-tipped soldering iron. And you may already have a suitable mains adaptor – 600 mA at 9 V DC nominal unregulated (supplied with built version).

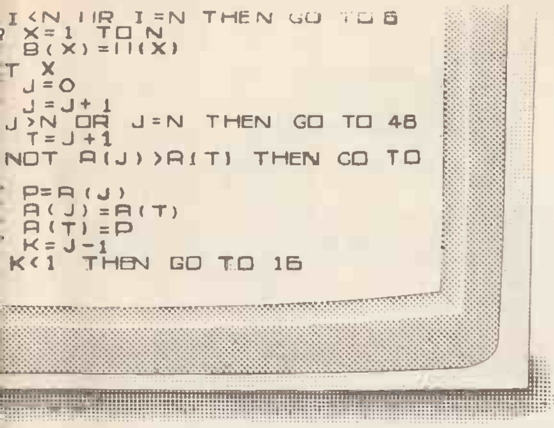
Kit and built versions come complete with all leads to connect to your TV (colour or black and white) and cassette recorder.



Proven micro-processor, new 8K BASIC ROM, RAM – and unique new master chip.

New Sinclair teach-yourself BASIC manual

Every ZX81 comes with a comprehensive, specially-written manual – a complete course in BASIC programming, from first principles to complex programs. You need no prior knowledge – children from 12 upwards soon become familiar with computer operation.



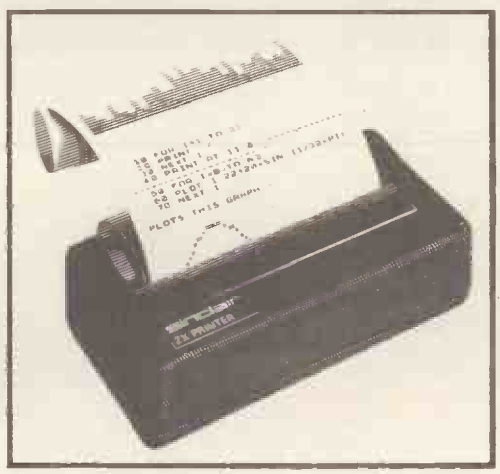
If you own a Sinclair ZX80...

The new 8K BASIC ROM used in the Sinclair ZX81 is available to ZX80 owners as a drop-in replacement chip. (Complete with new keyboard template and operating manual.)

With the exception of animated graphics, all the advanced features of the ZX81 are now available on your ZX80 – including the ability to drive the Sinclair ZX Printer.

Coming soon – the ZX Printer.

Designed exclusively for use with the ZX81 (and ZX80 with 8K BASIC ROM), the printer offers full alphanumerics across 32 columns, *and* highly sophisticated graphics. Special features include COPY, which prints out exactly what is on the whole TV screen without the need for further instructions. The ZX Printer will be available in Summer 1981, at around £50 – watch this space!



16K-BYTE RAM pack for massive add-on memory.

Designed as a complete module to fit your Sinclair ZX80 or ZX81, the RAM pack simply plugs into the existing expansion port at the rear of the computer to multiply your data/program storage by 16!

Use it for long and complex programs or as a personal database. Yet it costs as little as half the price of competitive additional memory.

New, improved specification

- Z80A micro-processor – new faster version of the famous Z80 chip, widely recognised as the best ever made.
- Unique 'one-touch' key word entry: the ZX81 eliminates a great deal of tiresome typing. Key words (RUN, LIST, PRINT, etc.) have their own single-key entry.
- Unique syntax-check and report codes identify programming errors immediately.
- Full range of mathematical and scientific functions accurate to eight decimal places.
- Graph-drawing and animated-display facilities.
- Multi-dimensional string and numerical arrays.
- Up to 26 FOR/NEXT loops.
- Randomise function – useful for games as well as serious applications.
- Cassette LOAD and SAVE with named programs.
- 1K-byte RAM expandable to 16K bytes with Sinclair RAM pack.
- Able to drive the new Sinclair printer (not available yet – but coming soon!)
- Advanced 4-chip design: micro-processor, ROM, RAM, plus master chip – unique, custom-built chip replacing 18 ZX80 chips.

sinclair ZX81

Sinclair Research Ltd,
6 Kings Parade, Cambridge, Cambs., CB2 1SN. Tel: 0276 66104.
Reg. no: 214 4630 00

How to order your ZX81

BY PHONE – Access or Barclaycard holders can call 01-200 0200 for personal attention 24 hours a day, every day.

BY FREEPOST – use the no-stamp-needed coupon below. You can pay by cheque, postal order, Access or Barclaycard.

EITHER WAY – please allow up to 28 days for delivery. And there's a 14-day money-back option, of course. We want you to be satisfied beyond doubt – and we have no doubt that you will be.

To: Sinclair Research Ltd, FREEPOST 7, Cambridge, CB2 1YY. **Order**

Qty	Item	Code	Item price £	Total £
	Sinclair ZX81 Personal Computer kit(s). Price includes ZX81 BASIC manual, excludes mains adaptor.	12	49.95	
	Ready-assembled Sinclair ZX81 Personal Computer(s). Price includes ZX81 BASIC manual and mains adaptor.	11	69.95	
	Mains Adaptor(s) (600 mA at 9 V DC nominal unregulated).	10	8.95	
	16K-BYTE RAM pack(s).	18	49.95	
	8K BASIC ROM to fit ZX80.	17	19.95	
	Post and Packing.			2.95

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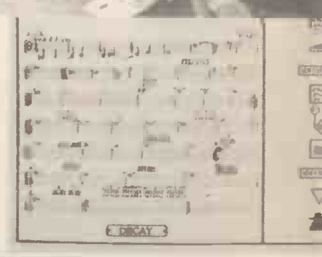
TIM SOUSTER

Electronic Music Composer



Tim Souster's interest in electronic music began at an early age when experimenting with sound through ring modulators. The sounds he used were from traditional instruments. His use of electronic devices as treatments led to further experiment over many years with synthesisers and computers for the process of making electronic music. His involvement with such composers as Stockhausen, Berio and Henze inspired him to form his own electronic music groups, "Intermodulation" and then later "0dB."

Since his educational background never really concentrated on mathematics and electronics, he has not found it easy to tackle the technical aspects of producing electronic music, but like so many musicians today has learnt through the job of composing what his electronic instruments can do. His visits to Stanford University in California to study electronic composition at the now world-famous Center for Computer Research in Music and Acoustics posed quite a problem when he found that trigonometry was part of the course work! Tim comments that 'very often there are people who can invent machines or processes on the back of an envelope with a few equations and prove to you logically that it will work, but in fact couldn't make the machine work in a month of Sundays.'

He feels that his own forte is being pragmatic — he couldn't say how a particular transistor or IC is functioning, but if he has an electronic instrument to use he will exploit it intuitively, in an applied way. For example, with his present modular synthesiser system he gets a feel for what the sections do by experiment.

Serge Tcherepnin designed this complex system for him, which can be provided in kit form to your own specification. Having chosen the configuration of each panel, the panels and complete units are built up in San Francisco by the Serge company and then sent to the buyer. Tim preferred, as you might guess, to have the units pre-wired at the factory. He finds the system extremely versatile with virtually all the functions voltage controlled — including waveshaping, phasing, depth of modulation, portamento and ring modulation. One module he's waiting for is the digital control unit which gives 32 simultaneous control outputs enabling him to do a lot more pre-programming.

Tim moved from Cambridge to London last year having given up teaching to become full time composer, and as he says, 'You can't really do that unless you're a Peter Maxwell Davies or Richard Bennett!' A few years ago he met Laurence Aston, at the time working for Transatlantic Records but now running Original Records. Tim wrote the music for the 'Hitch-Hiker's Guide' albums which were produced by Laurence and have been very successful, showing his approach to a more commercial style of composition and this helped financially with getting the studio started.

Another piece of music that was successful was "Soundtrack at the British Genius Exhibition" for an exhibition at Battersea Park in 1976. This piece was an audio /visual soundtrack in 5 channel playback and this is currently another area of his 'bread and butter' work. Having established a firm source of income, Tim is now doing more original material in his own studio entirely using synthesisers.

So his day-to-day work as an electronic music composer can be of a more commercial nature, such as arrangements of rock and popular music, or they can be his more serious compositions. He obviously hopes that one will pay for the other and points out that he doesn't want to work exclusively with electronic sound sources because parallel to his studio work he still writes a lot of music for concerts. He much prefers live works and sees tremendous potential in the combination of the sound world of electronics with the live gesture of performance. He recently wrote a piece for "Electric Phoenix," an interesting vocal quartet that use their own electronic set-up of ring modulators, filters and analogue delay line devices. The music was for 4-voice performance integrated with 4-channel tape recording in Tim's studio. Thus his work always comes back to electronic resources in some shape or form and like most electronic compositions is always a one-man job.

Because of Tim's limited background in electronics he has had a lot of help from Turnkey, a London company that specialises in setting up studios. An important item from them was a "patch bay" rack that allows signal lines to be interconnected from one central point very easily. Serge also built for Tim a special interface module on the synthesiser that matches up triggers and control voltages in the various electronic equipment.

Instruments

Tim points out that all the units themselves are 'nothing new in particular but it's the interconnection of each to make a unique combination that is important. There's the Roland JP4 and Vocoder Plus VP330, which I find fantastically useful — especially the vocoder for treating other instruments. I'm not just interested in singing and playing into it but like to feed in another synthesiser as the program source whilst putting pre-recorded voices from tape into the mic input. This enables me to build up multi-channel voices in advance — I


The treatments rack.


The main keyboard rack.

did this in my vocal piece for Phoenix. First I recorded the singers on to the 4-track Teac and then fed the composite signal through a D.I. box into the mic input of the Vocoder. The keyboard is by-passed with an external source such as a noise output or complex wave shape from the Serge synthesiser and you can get the most incredible sound colour mixes — it's something that I want to investigate further.'

'Then I use the trusty old Minimoog which I've always used from my "0dB" group days.'

Tim stresses that it is important for him to have several instruments that offer a range of completely different sound sources — in fact, he often wakes up in the middle of the night with a new idea for interconnecting different synthesisers, and then he falls asleep again and forgets it, only to spend next day trying to remember it again!

Another instrument he uses a lot is the Roland MP700 Electric Piano, nearly always adding some kind of treatment to its sound from a flanger or graphic between the piano and its cabinet amp, before the chorus effect even gets on to it. Then when it reaches the mixing desk he often uses it on foldback to a pitch transposer (or harmoniser), simply to thicken the final sound rather than change pitch. There's a parody of a heavy metal band on one track of the second Hitch-Hiker album and this was all done on the Roland piano with a fuzz pedal!

Finally, his Serge synthesiser completes his sound making instruments and provides all the extra sound effects he needs. Certainly, for Tim, the overall concept of this synthesiser provides an immense range of possibilities and he finds many of its effects quite difficult to control — 'It's more for experimental music because you can set up a patch and listen to it do the most incredible things.' The patch cords are also a good idea, for they terminate on banana plugs that slot into each other so that you can send a single control voltage to several modules without having to use multiple jack-linked sockets. There's a touch-activated keyboard sequencer that is laid out as 16 x 4 small printed squares that have more than one layer of c.v. outputs, so you can join up the sequence lines to play in parallel or serial format and specify the reset point. There is a control pot for each square to set its pitch over the whole audio range.

This part of the Serge can be used to control his MXR Pitch Transposer so that any music signal going through the MXR can be raised or lowered in semitones by touching the appropriate squares.

It's interesting that all these items are commercially available and that Tim's own style is formed in many respects by the precise way he uses them, although there is obviously a degree of customisation in his interface facilities.

Tim's main instruments are keyboards (originally piano and church organ) and viola. He recognises that for musicians using multiple keyboard set-ups, feet are almost as important as hands, especially if you can play a pedal-board.

Treatments

One 19" rack holds the three main devices used for extra treatments — first, the MXR Pitch Transposer, an instrument similar to the well known Eventide Harmoniser. 'It does what its name suggests, putting any type of audio signal up or down in pitch and works very well providing you don't jump too big an interval — even a 5th up you'll hear that the sound has been treated because of the limited sample rate and the way it regurgitates it with a slightly metallic edge. Nevertheless, its voltage controlled input is great for modulating pitch via a synthesiser and it can completely transform speech and music. Pitch intervals are dialled up from four very useful touch-sensitive control presets, either in semitones or as a ratio to zero (normal pitch), and these allow rapid transposition during a piece. A 'Regeneration' control then gives variable feedback resulting in interesting chains of transposition.

Next there is the Lexicon 'Prime Time' digital delay unit — an expensive item but essential as far as Tim is concerned to give to separate time delay outputs from one input signal. It can also bounce outputs from either or both of the two available inputs from one channel to the other. He got a liking for this sound as a means of producing artificial echo from using a modified Rexox when he was at Keele University. It was a mod suggested by David Allen, late of 'Gong' and Soft-Machine.'

There's a Roland Rack Flanger he likes for synthesised bass that was used on the Hitch-Hikers LPs and numerous other effects boxes dotted around the studio. A 'Great British Spring' from Turnkey hangs on the studio wall and provides all his main reverberation. The Serge synthesiser is very much a multiple effects box as well, with its V.C. wave multipliers and phasing.

The mixing desk he uses is a Soundcraft Series 2, 16 into 8 and accounted for quite a lot of his costs in setting up the studio.

Sound amplification comes from a Quad 405 stereo amplifier and a couple of JBL 4313 speakers. In addition, a back pair of KEF speakers are used for monitoring when working on four channel pieces, powered from a Quad 303 amp.

Most of Tim's classical work is conceived in quad and he is much in favour of surround sound, however it is produced. 'The artistic potential of it is still practically untouched in popular music and for concert performance of electronic music multi-channel production has been common-place over many years.'

Tim has had to purchase all the studio items himself — a big outlay these days — and has not been able to skimp on the quality of equipment because it is not practical to re-record electronic music, except for the final mixdown which could be done in a recording studio situation. He confesses that he has been known as a "strange avant-gardist" and only recently has turned his composition towards more "accessible" rock music. He's not too pleased that he has been forced to make this move and feels that the spirit of adventure should always be present and must be acceptable for new music to develop, rather than simply aim at cast-iron certainties.

He likes to use the oscilloscope to check waveshapes and other synthesiser functions, although he relies on listening to check for correct levels and distortion.

Recording

The Teac Tascom 88 8-track recorder is used to lay the tracks, with DBX noise reduction added. When these are filled, Tim often puts a rough mix onto the Teac 4-track which has its own DBX system and then these 4-channels are dumped back again onto the 8-track leaving another 4 tracks ready for further use.

A digital multiplex clock gets over the problem of auto locating tape cues by sending a digitally encoded pulse signal to track 1 of the Tascom (every second or ½ second) which will then play back off the tape (so it's ideal also as a click track) and return to the clock for display as a 4-digit reference number.

The final mix is made in stereo on the Revox B77. For any work out of the studio there's a stereo portable: the JVC KD2 cassette recorder, with ANRs and super ANRS. Some Accessit boosters are used for matching the 8-track level to the Soundcraft mixer during monitoring.

In terms of experimenting with synthesiser control during recording, Tim has been trying out the Roland 'Dr. Rhythm' box. This has two pulse outputs that he can dump onto tape

TIM SOUSTER

Tim Souster read music at New College, Oxford from 1961 to 1964. In 1965 he became a music producer with BBC Radio 3, specialising in contemporary chamber music and working with Stockhausen, Berio and Henze among others. In 1967 he left the BBC to become a freelance critic in both rock music and contemporary classical music, and during the period 1968 to 1969 he concentrated on composing and performing. In 1969 he was appointed composer-in-residence at King's College, Cambridge, a post which he held until 1971. At Cambridge he joined forces with Roger Smalley to form the electronic music group, Intermodulation; during the next seven years they performed extensively in the U.K. as well as touring Germany, Poland, France and Iran. Between 1971 and 1973 Tim worked with Stockhausen as his teaching assistant at Cologne State Music High School. This was followed by a year in Berlin where Tim became composer-in-residence on the West Berlin Artists' Programme. In 1975 he was appointed as Leverhulme Research Fellow in Electronic Music at Keele University. During 1976 he formed the group 0dB with Peter Britton and Tony Greenwood.

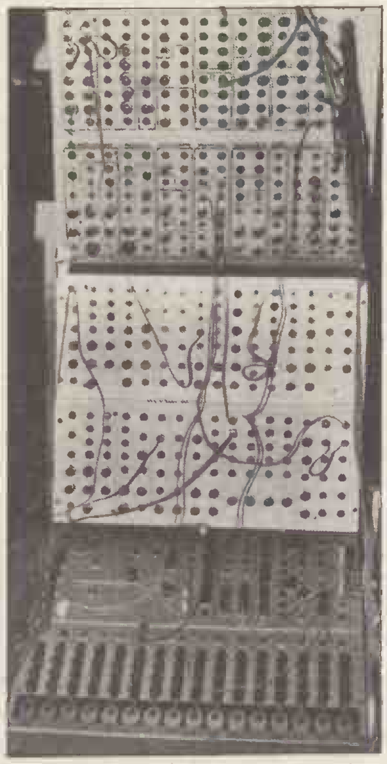

The recording area.

and then he uses these to control the Serge functions and synchronise effects.

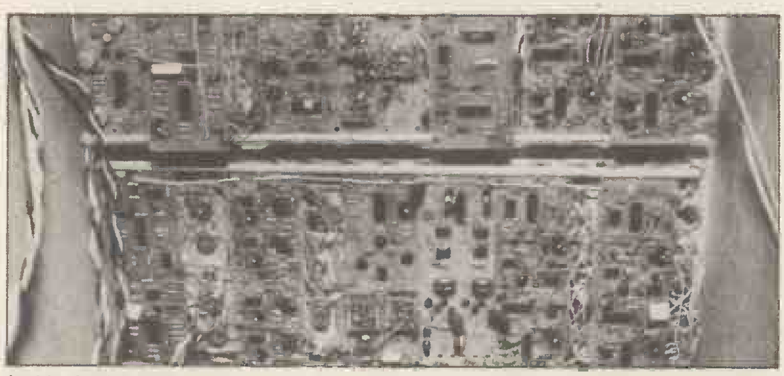
Composition

'Interfacing is a prime part of creativity' agrees Tim, 'making connections between things is like composition itself. The very word "composition" means "putting things together." In counterpoint and harmony, putting together the notes was the key thing. In electronic music it's finding new circuits and new ways of connecting different sound making devices. After all, some of the early experimental American composers, like Frederic Rzewski and Gordon Mumma, always used to say that soldering the first jack plug was all part of the piece! What you have to be careful about is that you don't get swamped so much in technology that you're always developing a device that will do some fabulous thing and you never get time to actually use it. So I tend to buy off the shelf and concentrate on the business of composition.'

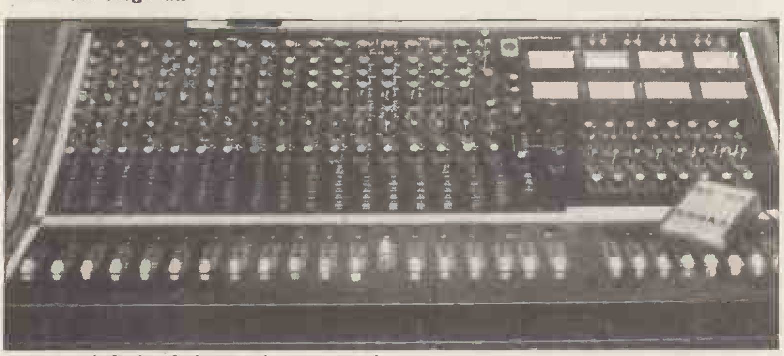
Since Tim took part in the performance of Stockhausen 'Sternklang' we've reviewed in this issue, I asked him about it.



The Serge Synthesiser.



Inside the Serge kit.



Soundcraft Series 2, 16 into 8 mixing desk.

The Studio.

'It's one of those scores where the parts can be realised in lots of different ways — the proviso is that each singer or player has to be able to produce and filter the overtones of their sound. It's really an extension of the work called 'Stimmung' (Tuning) which is for 6 voices and uses a vocal technique of producing overtones in a whole series above the fundamental note. In Sternklang, exactly how the sound was produced was immaterial — you could have a trumpet with a wah-wah note through a pick-up and other people were using EMS VCS3 synthesisers. I was using a viola with a pick-up and a VCS3 filter.

'It was mixed down in a Paris studio and we were sectioned off in our little areas and multi-channel recorded. Then Stockhausen spent several days mixing all this, bringing up one group after another as if describing an imaginary walk between the different groups in a park.'

I asked how he felt about the great length of the piece, which is over 3½ hours. Tim feels that 'music is there to take people out of their normal time-scales. The whole of life could be reduced to a smaller time-scale but it would become intensely boring. Our musical rituals in the West are still extremely short in comparison with the rest of the world and 'Sternklang' does establish its own time-scale and I like that.'

Whenever he hears the music, it reminds him of sitting in damp parks waiting for the next cue, freezing and cursing the mosquitoes — while some of the crazy tuning could have come from a "mad minstrel orchestra in central Bulgaria!"

Hitch-Hikers Guide to the Galaxy

This was originally a book by Douglas Adams that has since been produced for BBC radio and television, stage show and as a double album. There's also a sequel to the Guide on a further LP entitled "The Restaurant at the End of the Universe."

Both Tim and Paddy Kingsland of BBC Radiophonic workshop (featured in Electronics & Music Maker March Issue) were responsible for the music and effects for the different presentations. Tim arranged the BBC opening theme music 'The Journey of the Sorcerer' by Berni Leadon and also wrote all the music for the LP record.

The signature tune used on the television was built up in the normal way using synthesiser over-dubs. The particular version we were discussing is not on the LP's but is available as a single. There's quite a lot of voice vocoder treatment in it, with JP4 arpeggios going into the vocoder so that the overall shape goes from low to high from the vowel sounds changing from "aah" to "eeh."

If you listen carefully you can hear the cymbal sound changes at one point into a sustained 'ssh' sound from Tim that's fed in the vocoder mic with the JP4 going through it. The bass part is also occasionally transformed into a low voice note by this method. The sitar-like sound really comes from a banjo with "stereo phased backwards reverb!" Each note is preceded by a pre-echo of itself, done by simply turning the tape over, recording the (now backwards) banjo part through the reverb unit onto another track, then reversing the tape again for playback. Roland vocoder "strings" fill the background.

On our E&MM cassette No. 2 you can hear another technique used in the Hitch-Hiker — the stereo bounce echo from the Lexicon Prime Time, as the JP4 plays a slow arpeggio sequence. There's also the MXR Pitch Transposer, showing its effect on voices — just as used on the albums, but with an Eventide Harmoniser. Then echo is added from the Prime Time with its modulation oscillator switched in to give sliding transpositions on the voices.

An interesting example of a rhythm track is given because the distinct bass line you can hear is not really there at all — it's synthesised drums going through a digital delay at certain delay times (controlled by hand), and it's the inter-relationship between the times which are producing the frequencies by difference tones and feedback. The second rhythm is produced from a drum machine fed into the Serge synthesiser, with the pulses being used to produced different instruments — often sounding like artificial tablas.

When composing his music, Tim sometimes writes in detail but prefers to jot down basic tracks and then experiment with the recorded version of these during overdubs without further notation. Much of his commercial work is tied to scripts, but will in fact sound quite acceptable without the dialogue.

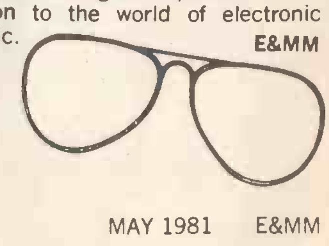
He doesn't use patch cards for the Serge because it would take him too long to insert all the details — so he just notes the particular modules in use. He would love to be able to notate tone-colours in some kind of conventional way — 'if there was an agreed form for writing down a note which had been fed through a distortion pedal, flanged, filtered, transposed and digitally delayed you'd be okay, but there isn't.'

Tim's immediate plans are to win himself enough time to put together completely new material for his own album done in a 24-track studio. He still likes the combination of electronic and acoustic sounds and this will keep him happy for a long time.

If you want to hear some of his most commercial work to date, then take advantage of our special offer this month for the Hitch-Hiker's Guide LP's — the quality is superb! If you're an avid collector of electronic music (and who isn't!), Tim has kindly agreed to sell his last few copies of "Swit Drimz" LP at £4.99 each through E&MM. It's definitely a collectors item, with computer speech, jazz orientated electronics and the avant-garde music of our front cover.

All from a British composer who is already making an important contribution to the world of electronic music.

E&MM



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SOUND ON STAGE

Ben Duncan

The best Rock musicians are not good because they use exotic instruments, but because they have developed a sensitivity for what is good. A cornerstone of this sensitivity is 'knowing your instrument'. This involves much more than being on intimate terms with your Stratocaster; really, 'your instrument' is you, the guitar, your amplifier and the PA — and in some exalted cases, even the audience can become your instrument. Here, we're concerned primarily with the parts of the instrument that are electronic — the instrument amplifiers and the PA. The series is a spiral — after the basics have been explained, we'll return to focus on both the more advanced and the more refined aspects of each topic.

Guitar Amplifiers

If a newcomer to Rock, your first instrument amplifier has to meet the difficult criteria of being cheap, and simple enough not to overwhelm or confuse, and at the same time, being reliable and versatile enough so as not to limit your expression. If you're already firmly committed to a well-defined style of music (eg: HM) or performance (eg: Cabaret), then choosing an amplifier *can be* simply a case of copying the professionals. The amp. should give you access to all the sounds your brand of music requires; end of story! However, many musicians are fired by creative aspirations, being more concerned with the enrapturous magic of sound than rigid categories, and require an amplifier which will allow them to indulge freely in the mutual exploration of their instrument and their own mind. Paradoxically, the first stages of this exploration are best achieved with a simple amplifier; otherwise there's a danger of missing the wood for the trees. Whatever amplifier you buy, you will soon outgrow it, and until you have found your way, a simple amplifier will do no harm to creativity *and* won't turn out to be an unnecessarily expensive mistake if you decide to reverse direction.

Your amplifier is really as much a part of your guitar as the machine heads; what does it do? Most obviously, it makes the sound of the strings audible. Indeed, this is sometimes its sole purpose. However, the effect is little different from an acoustic guitar, yet only two other effects can vividly extend the potential of the instrument.

Firstly, the amplifier's tone controls can powerfully influence the relationships between the fundamentals and the harmonics — and therefore alter the tonality, the 'bite' and the 'roundness' of the sound. Other aspects of the amplifier — such as the overload characteristics and the input impedance can influence the upper harmonics, with similar effects.

Secondly, the amplifier can be overloaded, to produce 'dirty', 'raunchy' sound. Although the result is known and feared as *distortion* in musical reproduction equipment, in the context of the instrument amplifier — a *generator* of music — the effect is best thought of as 'harmonic generation'. The ratios of the fundamental to the odd and even and high and low harmonics generated by overdriving exerts a crucial, powerful and emphatic effect on the character of the sound. The overdriven sound can be produced in the input or output stages of an amplifier, or by the speaker, or any combination of the three; they are all different, and their 'sound' varies with level and tone control setting. The critical and complex nature of the overdriven sound largely accounts for the legendary name of certain amplifiers. Overdriving also generates spurious and therefore dissonant notes which are largely devoid of meaning in conventional western music. This effect, known as *intermodulation* tends to make the sound loud, 'full' and 'muddy'; it is part of the classic 'fuzz' sound.

With these modifications to the original sound, the nature of the amplifier's ability to control the sound intensity is radically altered. At very high sound levels, the amplifier can make the modified sound of the guitar seem larger and more real than life itself; the sound suddenly has the bizarre potential of multidimensionality. High levels also bring sharp, 'attackish', transient and other subtle sounds into prominence, and alter tonality, as perceived by the ear; we hear the fundamentals of the electric bass and the high harmonics of the lead guitar better at Rock concert levels. And unlike acoustic instruments, we can easily reduce the level of an electric instrument, often without grossly upsetting the nature of the sound. So the volume control(s) can also give us quiet access to sounds normally only available by playing the instrument aggressively at extremely high levels.

Naming the knobs and sockets

Input gain	= Volume
Tone	= Top cut, Treble cut
Mid	= Presence
Tone controls	= Equalisation
Sensitivity	= Boost
Master volume	= Output gain, Volume
Line output	= Slave output, Line, 'Link Out'
Echo Send	= Send, Effects Send
Echo Return	= Return, Effects Return
Power Amplifier	= Output stage

Knobs and Sockets

Perhaps the first rule about guitar amplifiers is that they should not be shared, poverty regardless! Apart from creating a muddy sound, the result is to limit individualism and ironically, to destroy a band's coherence. Nonetheless, many guitar amplifiers feature two channels, and whilst the spare may be a useful gig-saver should another amplifier give problems, the *key* purpose is to extend the range of sounds available to the guitarist. The reasons begin inside the guitar. The output voltage and impedance of guitar pickups are simply very nebulous quantities — the voltage varying between 10mV and 2 volts (a 200 fold variation) depending on how you play. Your amplifier has to be able to handle these variations in input level, and, at the same time, provide a clean or dirty sound on demand. Hence the two input sockets — or a single switched input socket — marked 'high' and 'low'; the high sensitivity input can be readily overloaded for a dirty sound, whilst going into the 'low' input makes it possible to play loud and clean without overloading the amplifier.

Essentially, these inputs differ only in degree, so it may well be possible to achieve a dirty sound on the low sensitivity input if a 'loud' pickup is used, and vice versa. This underlines the desirability of checking that any amplifier you aim to buy is matched to the sensitivity of the pickup it will be working with. Ideally, the volume control shouldn't require extreme settings to achieve clean and dirty sound on the low and high sensitivity inputs respectively. If either sound cannot be readily achieved, then the pickup and amplifier are obviously incompatible in so far as sensitivity is concerned. Amplifiers are frequently chastised for being 'not 100 watts' when the pickup and/or the preamplifier are simply too insensitive to drive the amp to its full potential. This is analogous to rejecting an MGB for lack of speed without discovering the purpose of the accelerator pedal!

Dual input sockets may also provide a variation in the amp's treble again, possibly in conjunction with high/low sensitivity sockets, but more commonly in the form of a 'bright'/'mellow' switch. When a guitar pickup is fed into a low impedance, the signal is damped, making the sound 'rounder', quieter and more mellow. The latter effect is often superfluous because the treble response (where the upper harmonics lie) is usually already awkwardly attenuated by the shunting effect of the guitar tone and volume controls and the curly connecting lead; the 'bright' input or switch is a means of correcting this deficiency — it simply boosts the high frequencies. The result can also be attained by avoiding the treble attenuation in the first place — or equally it can be achieved with well designed tone controls.

Some amplifiers have only a single channel — 'bright' versus 'normal' and 'high' versus 'low' sensitivity, plus any built in effects being selected by switches or sockets common to the channel. Strictly there is no need to provide separate channels for these functions, but it makes life more convenient if rapid changes in effect can be achieved simply by plugging the guitar into the alternative channel, with the controls preset and therefore ready for action. The multichannel amplifier is essentially a convenience for pre-ordained, high speed acts; it's not essential if your forte is laid back, improvised Reggae for instance!

The tone (or 'equalisation') controls on a guitar amplifier are fundamentally similar to those on a hi-fi system. However, the guitar amplifier's controls should provide a greater range of gain variation to enable you to boost — or cut — with *emphasis*. And the frequencies at which these controls have most effect are attuned to the electric bass/guitar rather than a composite music signal. Whilst a midrange control is very useful, the effect of carefully designed and sensitively applied bass and treble controls alone can be effective enough. It is easy to feel, with a few broad and magnaminous test sweeps, that these controls are limited in their ability to create original sounds — but exploration of the whole instrument will usually reveal that the creative limitations lie mainly in the mind. In other words, simple tone controls which you can *feel* instinctively on stage will initially give you a far greater fluency and insight into the potential of your instrument than other, more versatile yet complicated methods of tone control.

The master volume control has a considerable mystique which it does not deserve. It is usually nothing more esoteric than a pot wired between the equalisation and output stages of the amplifier. It's used to limit the output power and hence the loudness of the amplifier, whilst the channel (or input) volume control is wound up to produce distortion in the stages *prior* to the power amplifier. Thus, dirty sound can be produced without the usual by-product — deafening sound levels. Ignoring the humanitarian aspects of the master volume control, it greatly enhances the range and precision of overload effects. For decibel deprived dirty sound, only the input stages will be overloaded, but brain damage regardless, output stage overload has a character of its own, and the two

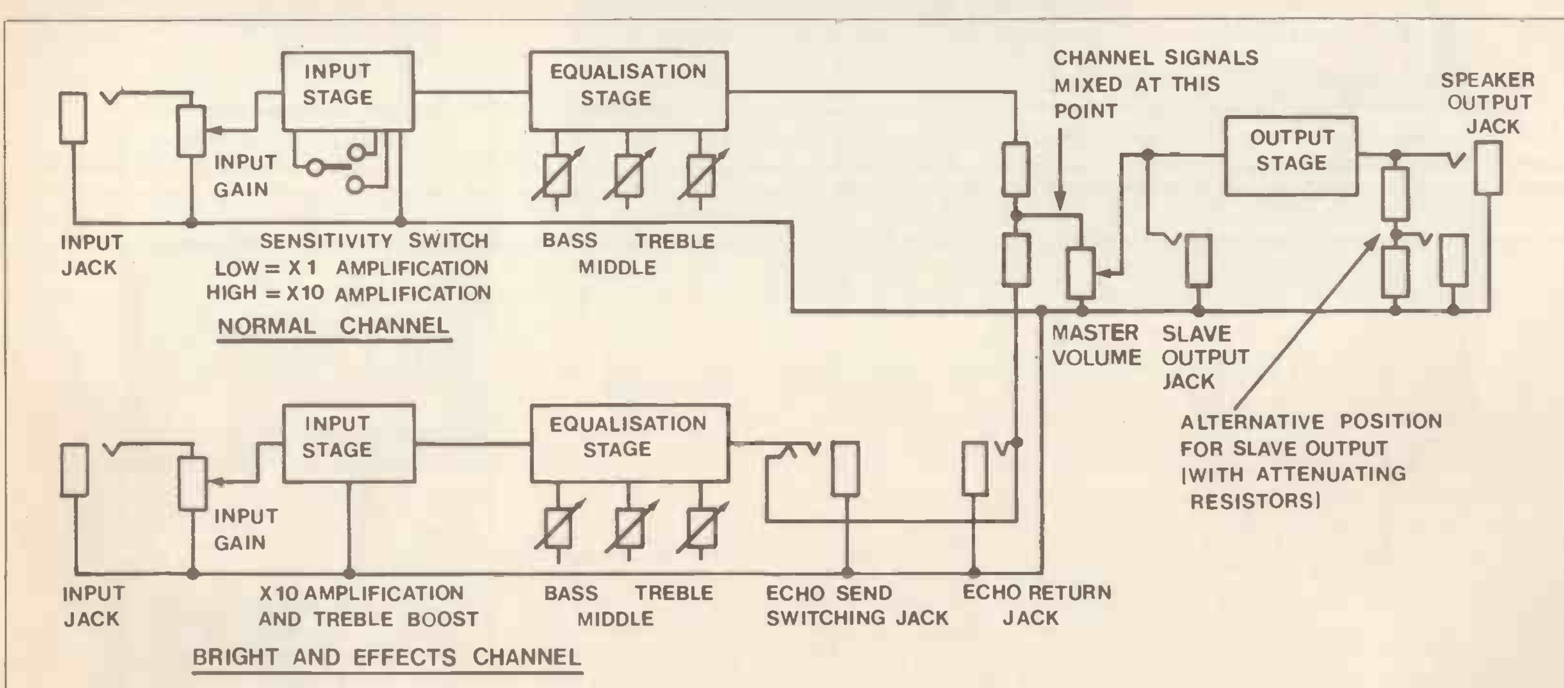


Figure 1. Block Diagram of a typical guitar amplifier.

extreme control settings (channel volume down, master control up, *versus* channel volume up and master control down) can give very different sounds, with a wide range of cacophonous melodies to explore at the intermediate control settings. It's far better to choose an amplifier with a master volume control than one with an esoteric equaliser or other gimmick.

Lurking on the rear panel of your amp is an array of sockets, the functions of which may be a source of bewilderment to you owing to the frequently idiosyncratic labelling. The sockets variously termed 'slave', 'line output', 'link out' are all similar in function — they provide an output of intermediate (or *line*) level which can be fed to auxillary power amplifiers ('Slaves' or 'Slave amplifiers') to extend the power capabilities of your amplifier. Equally, they may be used to feed a tape machine, a demo-studio mixing desk or a PA system.

Many effects boxes work admirably when linked between the guitar and amplifier, but if for instance you require echo or reverb, it's beneficial to add these after the signal has been amplified to *line* level. The signal must pass through the effects unit and then back into the amplifier — usually via a socket marked 'echo return' or 'return'. Obviously, the signal requiring reverb or echo must be prevented from passing through the amplifier directly, thus the socket from which the signal is derived (usually marked 'echo', 'echo send' or 'send') is arranged to break the signal path when a plug is inserted. These sockets operate at essentially the same level as the slave output and are usually wired immediately before the master volume control. Slave output sockets, however, are usually connected *after* the master volume control, so their output level mimic's the level from the amplifier's own speaker. Unfortunately, if any part of your music's character depends on overdriving the amplifier's output stage or speaker, then this aspect will obviously be missing from the 'slaved' output signal unless you are fortunate enough to be using an *identical* guitar amp as a 'slave'. Some instrument amplifiers derive a 'slave' signal from the loudspeaker socket, via an attenuator which prevents the high power herabouts from vapourising all your auxillary gear! This method has the advantage of including the sound of the overdriven output stage in the signal sent to the 'Slave' amps, so it's useful for recording (see the E&MM Direct Inject Box Project in last month's issue), or boosting the merchants of dirty sound; but the conventional 'slave' output, wired immediately after the master volume control will always provide a cleaner, quieter signal, essential for more cultured guitar sounds. And clearly, neither type of slaving can include the sound of an overdriven speaker.

In the next part, we'll look at loudness, power and loudspeakers.

E&MM

Guide to Electronic Music Techniques

Lawrence Casserley

Basic Tape Techniques

Most people are familiar with the tape recorder as a means of storing and recalling sounds, but the tape recorder can also be a powerful means of transforming and manipulating sounds once they have been stored. Much of the earliest work in Electronic Music and Musique Concrete relied almost entirely on a few basic techniques for manipulating recorded sounds.

Before examining these techniques it is necessary to go into a few points about different types of tape recorders, as some machines will make some of these operations difficult (although probably not impossible if you use a bit of ingenuity). First of all, it is desirable that your tape recorder runs at at least two speeds (if more than two, so much the better). Secondly, it will be necessary to get access to the play-back head of the machine for editing purposes (See Figure 1). On some machines this can be difficult, but removing some of the head covers will usually make it possible. Another problem with editing on some machines is that the playback head is inoperative unless the recorder is in 'Play' mode. You may be able to get round this by running the tape the wrong side of the capstan shown in Figure 1 (try it, the first time with a bit of tape you don't need, in case of disasters!). Lastly, there is the technical matter of head configurations. Many domestic tape recorders are designed so that two programmes can be recorded, one in each direction of the tape, in order to save on tape costs (all cassette recorders use this approach). While this may be fine for some applications it is undesirable for this sort of work for two reasons: first, if you are going to edit the tape, it is not much good having another programme going the other way, and, second, one of our most powerful transformations, reversing the material, is impossible on a machine designed specifically not to do this! (Figure 2 shows you why). If your machine records in this way then you will probably have to resort to some sort of modification, for example, some machines have room to fit an extra playback head. If your tape recorder has some or all of these drawbacks, don't despair, get to know the idiosyncracies of your machine and learn how to get round them (or even turn them into advantages). Obviously if you have a more professional machine the scope is wider (and two machines are more than twice as good), but part of the idea of this sort of music is doing what you can with what you have available. A lot of amazing things have been done with the most primitive equipment.

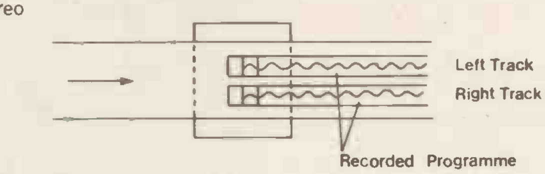
The only other items you will need for the experiments below are microphone, splicing gear and some imagination.

1 Erase head — always the left-hand head.
2 Record head on 3-head machines (not fitted on 2-head machines).
3 Playback head (Record/Playback head on 2-head machines).

NOTES. The playback head is always the right-hand head. When you hear the sound you want, it will be at the point indicated by the arrow.
If you thread the tape behind the capstan, you may be able to get the tape in contact with the heads without it being pulled by the capstan.

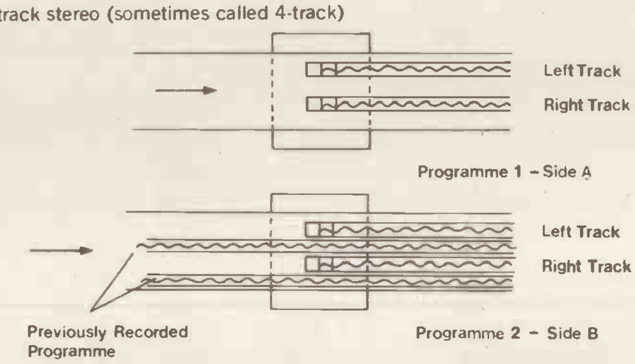
Figure 1. Tape head arrangement.

1) ½-track stereo



If you turn the tape over and play in reverse the tracks will be swapped over but you will hear the sounds backwards.

2) ¼-track stereo (sometimes called 4-track)



Previously recorded programme 1 material is not heard when the tape is reversed.

Figure 2. Track configurations.

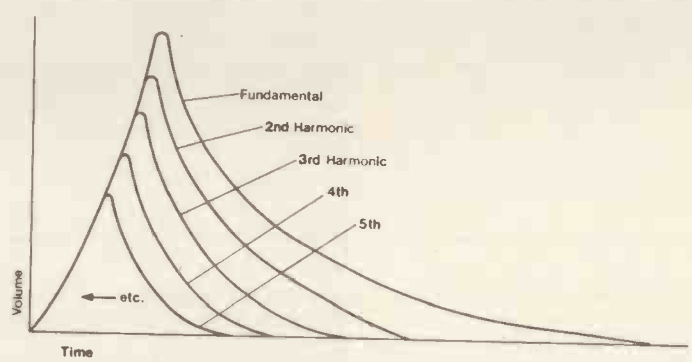


Figure 3. Simplified diagram of piano envelope (all percussive sounds are essentially similar).

So, what are the possibilities?

If you have recorded a sound, or succession of sounds, it will be represented on tape as a magnetic analogue of the original waveform. Normally one would want to reproduce these sounds in a manner closely approximating the original. But, having stored this information, there are other ways of reproducing it. For example, if you replay the tape at a different speed, a number of things are altered. If you replay something faster the tempo will be quicker and the pitch higher, but other, less obvious, changes will occur. If you try this with singing you will find that the characteristic vibrato is speeded up producing the "Chipmunk" effect; or, if you slow it down, the vibrato becomes a slow wavering of pitch — try it. Also you will find that different timbres can be produced — a slowed-down soprano does not sound like a tenor, a speeded up bassoon does not sound like an oboe; also, slowed down high-register guitar is different to low-register guitar, and vice-versa. This is caused by the particular resonances of the instruments concerned, but don't get tied down in the technicalities, experiment with the sounds.

The second technique is reversing the tape. Naturally events now occur in the reverse order, but what effect does this have on the sounds? Much of what the ear understands about sounds is concerned with envelope — the way sounds change in time. In other words we interpret things in relation to what happened last. So if we reverse those envelopes our perception of the sounds can be altered drastically. For example, a single sustained note on a piano is characterised by a sharp attack and a long, exponential decay. Reverse it and a very different sound occurs. One of the characteristics is that the upper harmonics die away more quickly. In reverse you can hear these harmonics gradually coming in (Figure 3) followed by a 'clonk' at the end (the attack) — try it.

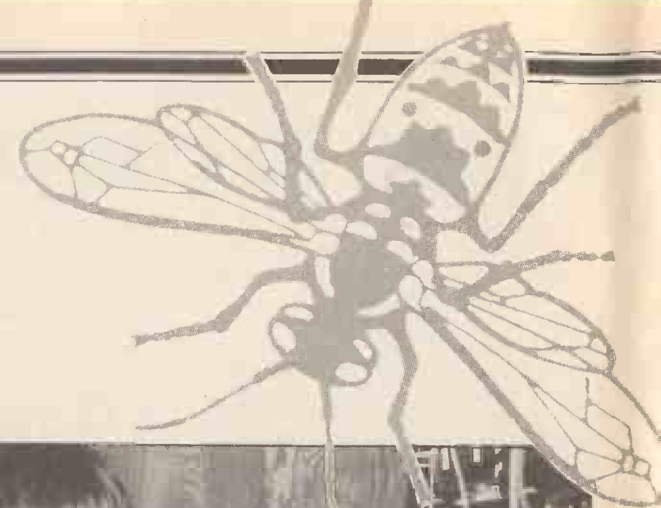
Or reverse some ordinary speech — not only does it not make sense but it sounds like a completely different language — why? The characteristic inflections and the envelopes of the sounds are reversed. Another idea — try to record speech so it will be intelligible in reverse (by speaking the words in reverse) — it's hard — and the results will make the Daleks seem quite human!

Next, you can extract particular sounds, groups of sounds, or particles of sounds from their contexts and rearrange them into new contexts. For example, tape a passage of speech and try to separate the vowels onto one tape and the consonants onto another — if you don't know how to separate them listen to the tape at reduced speed — these techniques can help you to learn about sounds as well as manipulate them.

This leads to the concept of editing, or joining together, sounds from different tape sources. Any sound (or part of a sound) that can be extracted from one tape can be spliced to any sound from another tape and this is where composition comes in. Try to build those sounds you've found into something that means something to you.

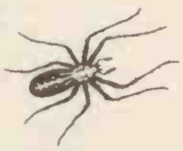
Let's look at two things that might help. If you can join bits of tape together, you can join them into a continuous loop and this loop can be (within reason) any length from fast repeated notes or figures through ostinatos to extended passages; or loops may be speeded up drastically to produce new timbres — try this over several stages.

Finally, you will want to superimpose one set of sounds onto another. How you do this will depend on the facilities you have available. If you have a twenty-four track recorder you can simply record each layer onto a different track, and mix it down, but, assuming that you have more humble facilities, as long as you have some way of copying one recorded track onto another and mixing in new sounds (many tape recorders provide for this) well then, the sky's the limit — think about it! **E&MM**



INDUSTRY PROFILE

Electronic Dream Plant Limited



Twelve miles away from the centre of Oxford, right in the middle of the country, is the Electronic Dream Plant, owned by Adrian Wagner. For two and a half years this company has been producing the Wasp synthesiser which offered several innovative features such as its portability and a full complement of variable controls including two oscillators and a digital touch sensitive keyboard, considering its very low cost.

At first the complete synthesiser was built at EDP, including the assembly and final testing, although more recently some of the large scale production is done through a local factory. The attractive country house that forms the base for EDP has been converted to accommodate assembly, workshop, test area and stores.

The Company name came as a result of Adrian moving from London to set up a recording studio with the title 'Electronic Dream Plant.'

Soon Chris Huggett, a technical engineer, joined him at Oxford and development began on a very cheap synthesiser. In fact, the final instrument became a little more expensive than planned, so this was called the Wasp and they have only recently finished their original idea, the Gnat.

Chris had initially little knowledge of synthesiser techniques and relied on Adrian to suggest the make-up of the instrument. Very quickly, they came up with a digital keyboard prototype that could be battery powered and yet still remain stable in terms of pitch generation, by means of a digital code for each note. From the start they found that because they were developing on what was for them entirely new ground, they would arrive at an easier, or better alternative to previous design ideas for synthesisers. The Caterpillar Keyboard Controller in many respects came about as a result of suggestions from users of the original Wasp and the subsequent development to overcome various problems.

Adrian finds that designing is very much trial and error, just like composing a piece of music. One fundamental design feature that was required for the Wasp was the use of a single circuit board for ease of construction and the first production Wasps were made in September 1978. Much to everyone's surprise and delight the 100 units made were sold in 3 hours from one London shop, and this immediately caused some problems in getting another batch ready. The actual business of manufacturing at that time was quite new to Adrian and he found it very difficult to keep all the components in stock for production to continue.

'The Wasp's success is due to two reasons' states Adrian. 'Partly the price and then its appearance, looking like a toy. The latter is important because it's not oppressive and it has no complication about it, with controls reading from left to right. The plastic case was chosen for economy and the touch keyboard was the only way we could keep the final price right down. This type of keyboard can also be used by non-keyboard musicians — drummers and guitarists often use it as an extra effects box.'

The keyboard design is not related to the early EMS Synthi-A keyboard, but was more like the action of a Theremin, working through capacitance sensitivity. The design allows any part of the note outline drawn on the keyboard to function by touching with a finger, and with careful adjustment can be played by moving the finger across the notes even without touching.

Adrian admits that production went badly at first and they knew that there was a big risk taking on production of a complete product. Rather than go to a major manufacturer, where changes would be difficult once the production model was made (there have already been 10 major modifications made to the Wasp over 2½ years), they tried to do the whole job themselves and soon found the main problem was in the supply of the components. Since then they've had to put out extra production to local factories to cope with their three extra instruments: the Deluxe, the Caterpillar and the Gnat.

The Wasp and the Spider

The Wasp synthesiser was one of the first instruments to be completely

Adrian Wagner.

Prototypes being assembled.

Adding the final top-soldering by hand.

The completed Wasp Synthesiser board.

portable and playable anywhere, through its built-in speaker. Nine volt d.c. power can be from standard or ni-cad batteries, or via a regulated battery eliminator. There's even been a jam session in Shaftesbury Avenue with rock stars busking on the Wasp!

It was designed to contain all the basic features for synthesising sound. Adrian emphasises the need for 2 oscillators, noise, control modulation and a filter section that is not just low pass type, which tends to make layers rather muddy when multi-tracking. The Wasp has low, band and high pass filters with proper 'Q' control of each.

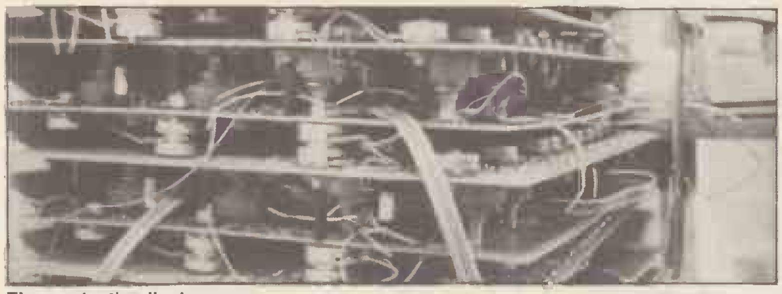
The Spider Sequencer came out over a year ago at Olympia and was a great success because of its large memory storage and cheapness at £199 compared with other current designs.

The Spider was designed to operate in two modes, the first being 'real' time with 84 note storage capacity. Unlike other sequencers that rely on you to set the clock fast enough to take the quickest notes you play, this mode stores exactly any note or silence up to 5 seconds duration before using up the next 'note,' (by holding on, off and wait times in digital form). In 'pulse' time it acts like a conventional sequencer that uses pots to set each note pitch, except that it is set instead from the Wasp keyboard step by step with a maximum of 252 notes and can then be synchronised to pulses from the tape recorder for multi-track work. Notes can be deleted, extra spaces inserted, and a lot of people have been using the Roland Dr. Rhythm Unit with the sequencer to get rhythm and bass backing.

Adrian feels that the Wasp and its accessories will always be useful because of the linking facilities between instruments by means of the digital coding system. Links are made through a 7-pin DIN socket and there are 6 bits of TTL that hold the key code and 1 bit for the trigger. This makes connection to a micro through its parallel input/output port quite easy, without the need for A to D or D to A conversion. The coding system also allows the Caterpiller to operate four Wasps and still have a separate 'voice' patching facility. Programs can be dumped on cassette and the Spider only uses ½K of storage to remember 252 notes.

Incidentally, choosing names for instruments can be difficult with many ending up as a code number. Adrian prefers a 'friendly' image for his products and so chose the insect names for monophonic and bird names for polyphonic instruments.

Since the Wasp sells at £199 (having had a price increase of £1 since it was launched!), the next step was to try and bring out another instrument even cheaper, and so the result was the 'Gnat' which sells at £99. This has most of the Wasp features and a single oscillator that can be made to sound like two oscillators. It has a low pass filter and several functions have been put on individual knobs to save space. Every component is circuit-board mounted including the speaker and this has cut the cost down considerably.


The production line!


Testing the new Deluxe Wasp.


Adrian checks a batch of Wasps.


The original Wasp synthesiser.


The Spider Sequencer.

New products

The Wasp DeLuxe was then brought out with a mechanical keyboard and wood finish case, and the Caterpillar is another new product that enables four individual Wasps or Gnats to be controlled from its 4-voice keyboard and will only cost £149.

It has taken a long time to get the scanning right for the Caterpillar — the keyboard is scanned every 4 microseconds in both directions and puts 'keydown' information into a memory 'stack.' A logic programme then sorts out the stack. There are 3 modes of key assignment — the first is called note priority, selecting notes one after each other for synths 1,2,3,4. Second is unison with every last note played going to every synth and the 3rd is the most interesting called 'Sequence' which switches every note you're holding down at any time to each Wasp. So four Wasps and a 3-note triad can give you instant Mozart style chords by putting the fourth synth up an octave on oscillator pitch from the rest. The actual note that is chosen for the fourth synth depends on the order of notes selected at the instant of playing and so will vary. On the other hand, cyclic operation can be effected to make note allocation to each synth in the order 1234-2341-3412-4123 etc., and when each of the Wasps has a completely different sound the results can be very interesting and totally unique. There's also a selection of holds on the machine as well, with unison hold, note priority hold and cycle hold. Note priority hold means that you can hold 3 notes down and whatever you do with the 4th note will always go to the 4th Wasp. The 'cycle' hold will keep each note on — always holding four notes as, for example, you play arpeggios up and down the keyboard.

Future developments

Having developed a range of instruments that merges into the polyphonic field, EDP is now concentrating on this for the future. Later on this year Adrian hopes to bring out a 4-voice programmable synth with a 4-voice type of 'Spider' selling at £595 and £345 respectively. The 'poly' version of the spider will enable block chord composing as well as the conventional linear style and has full editing facilities. One of its planned innovations is controllable offset that gives time variation (or rubato) within a bar without affecting the total bar count. This in theory is quite simply done by pushing notes further down the memory stack and inserting a space. It will hold 2000 notes divided equally for the four voice layers. Besides full edit controls the sequencer also records settings of sounds using the multivoice. You still have to select the pitch and the oscillator waveform on each synth but you can record various parameters on the spider, making it like a preset programmable device. For example, you could store up to 250 single sound parameters on Voice 1 along with 250 notes on Voice 2. This information can then be dumped onto cassette thus providing basic programming facilities for the Wasp through the Spider. Control of filter frequency envelope and the parameters on the envelope will also be storable on the Spider itself. Connection to the Wasp will be via a multi-way connector so that other Wasps and Spiders can be linked to it, which again builds up the 'Electronic Dream Plant' studio even further.

So the combination of a Caterpillar plus four programmable Wasps leads towards a complete polyphonic synthesiser system. 'Our real dream,' says Adrian, 'is the Eagle, a sixteen voice, totally programmable, floppy disc storage system that is totally micro based. Both the planned polyphonic Spider and the four voice unit have their own micros that are linked through tri-state input/output devices thus keeping the link wires to a minimum.'

Adrian originally considered having his own dedicated chips made but found that it was too expensive and would also restrict further development. So he tends not to think in those terms but more towards microprocessors, and EPROMs. In fact, the original Spider used an EPROM because he was still waiting for the CMOS 87C48 chip to come out to replace it.

It is possible to interface the Wasp to a micro and the company publish a data sheet showing details for linking


Part of the Adrian's recording studio.


The Caterpillar 4 voice keyboard controller.

The Gnat Synthesiser.

to several of the currently popular systems. You can play another voltage controlled instrument by connecting it to the control voltage output on the Spider (which has a D to A converter), and if, for example, you want to use a sound on another synthesiser then the Wasp first programmes the Spider and you can then download onto the other instrument. The Spider interfaces with most synthesisers through its CV and Trigger outputs. Both the range and scale of CV output can be altered (there's an exponential converter built in) and triggers can be positive or negative-going.

'We've even received comments that the Spider's CVs can improve the stability of other synths keyboard pitch control — especially where a resistor network is being used — simply because of its digital coding that interfaces through a Ferranti 10-bit D to A converter chip.

'The Spider is not mains powered,' explains Adrian. 'It runs off batteries which last about 1½ hours — because we wanted it to be as portable as the Wasp. Even if the battery runs out, you have up to 2 hours to put in a new one without losing its memory.

'The Eagle will have sound analysis with its 32-bit micro up to 40K, so you will get 25K worth of frequency which is well above audio range. The micro itself will run at 12 MHz and that's 50 MHz in terms of 8-bit! That starts to become very interesting because we are looking in terms of an additive synthesiser, not a subtractive synthesiser, providing a total computer-controlled set of sound waves on top of each other. We plan to have a full colour graphics display on it which will give a music print-out.'

Adrian emphasises that the Eagle will take a long time to develop and it's half a dream at the moment, with only the initial stages completed.

'We are at the stage where you can print out music and we've been doing a lot of extra research at Oxford University. A printer peripheral will enable it to be used as a composing aid because you also can play the music, edit the music, put a full score in if you wish and ask it to print out the parts at the same time. The whole Eagle System will cost around £5,000. Although this is a high price we are trying to make our products cover the whole range of musical synthesis and we obviously expect our very cheap synthesisers to be our main items at present, and yet they will benefit from the advanced technology of the Eagle as prices of chips come down. I can envisage that a synthesiser costing £500 in 10 years time will have all the facilities you'll ever need!'

Coming back to micros, the Spider is the only one that actually uses one at the moment, with the logic for the new Caterpillar operating from an 8035 Intel chip.

'The synthesiser is now an instrument,' says Adrian, 'that can be used by virtually everybody. The important point is that pro-musicians bought them at the beginning but now there are more than 250 shops, including Dixons, stocking Wasps and Gnats for the future.

'Schools are buying them for classroom use — you can connect them altogether to the teacher's instrument that is played whilst pupils operate the controls and we are now providing complete recording/synth studios for educational use based on the Wasp and Teac's Portastudio M-144. Many schools not only want them for their music lessons, but for drama and science as well. It's interesting to note that science departments may well pay over £100 for one oscillator unit — when a digital oscillator on the Wasp is better value because of the other things that go with it. We found that in one school we put a Wasp into, within 2 weeks 10 pupils had gone out to buy their own.

'For a couple of months we put the Wasp out in kit form, but we found that people made errors in soldering its 4½ thousand connections. It's easy for us using a flow soldering machine — you put a board in at one end and it goes through a flux and then it is heated and the whole lot is soldered in one go, taking only 10 seconds (in fact, it took 8½ hours in the early days for our assembly workers to hand-solder a board). It has 48 chips, and the top soldering connections are quite tricky to do. All connections including sockets are made direct to the main board, again for economy.

'There are very few links from one side to the other so in practice the underneath is flow-soldered and then the top is hand-soldered taking about 20 minutes. Readers may not realise that through-hole plating costs three times the amount of money as "double-sided" and you can get a lot of failures. Also, if you have an IC to take off with through-hole plating it's practically impossible.

'One of the main reasons for the Wasps' success is that at first glance people thought that it was a toy, because it has an unconventional appearance. But of course the electronics inside make that machine really versatile as a synthesiser and that's why a lot of professional musicians have used them: Oscar Peterson used three Wasps in a recent broadcast and really enjoys their touch sensitivity. It's gone into many other areas — you have DJ's using them in discos to create sound effects, and theatres use them for off-stage noises. This is where the noise generators score for they are digitally-derived and in conjunction with the Sample and Hold (called 'Random' on the Wasp) will produce sounds of rain water and storm effects, as well as rhythmic control of the filter cut-off frequency (listen to E&MM's demo cassette).

'At the beginning we started the project on £3,000 — now we've got National Research Development Corporation backing which is absolutely marvellous for us. This government institution has helped us overcome a lot of the difficulties we've had in extending our business, especially as the research and design costs so much money and getting in stock can take all your capital overnight.'

I asked Adrian if he anticipated that everybody would be making music in some form in the future, just for enjoyment, with synthesisers from the Electronic Dream Plant coming in all shapes and sizes. 'Very much so,' replies Adrian — 'we are going to go down market as well as up market at the same time, but the important thing is to go down market as we hope within the next two years we'll find a synthesiser around £50 dropping to around £20 in 5 years time. Not a preset organ, but a controllable synthesiser because I don't call "presets" synthesisers; it has to be controllable.

'I see synthesisers not replacing but being very much on a parallel with conventional instruments. Now that people are starting to understand them they are blending more with other instruments, because they are becoming more compatible in terms of dynamic range and emotional colour. I've even had one person from an RAF military band actually looking at the prospect of having their marching musicians all playing synthesisers!'

Adrian Wagner's Music

Having taken a little rest in the past year from music to get the Wasp off the ground, Adrian is now working on an album called 'Carousel.' He is very keen to set up his own electronic music record label, not for special 'elitist highbrow' music but for anyone that has something substantial to say in electronic music (E&MM hopes to have an electronic music competition later in the year). Electronic music is here to stay and it just needs time and more development for people in all walks of life to accept it.

Adrian sees EDP being very competitive in the immediate future and Japanese and American companies have tried to copy and bring their prices down into his bracket. 'So for once we have the opportunity to really forge ahead, making sure we do not make any mistakes and that's quite a big challenge!'


You can listen to Adrian playing the Wasp with the Spider sequencer and an excerpt of his own electronic music from his 'Disco Dream' LP on our E&MM Demo Cassette No. 2. The LP is not on general sale and Adrian is offering it to E&MM readers at £1.99 inc. post, packing and VAT. Send your cheque to 'Electronic Dream Plant (Oxford) Ltd.', Red Gables, Stonesfield Road, Combe, Oxford OX7 2ER. It's ideal for something different at discos and worth having in your electronic music collection from the listening angle alone — provided you don't mind a good strong beat and occasional girl vocals. **E&MM**

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INSTRUMENT REVIEW

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Lowrey MX-1 Electronic Organ

It seems a definite turning point has now been reached in the marriage of organ, synthesiser and computer. No longer does the organ aficionado, whether amateur or professional, have to take a less than perfect reproduction of an instrument. The developments in micro-technology can now make possible the duplication of traditional orchestral and popular music instruments so that it is difficult to know which is the original. I must be one of many people who watched the BBC TV 'Parkinson' show recently and literally couldn't believe that the sounds I was hearing came from one single instrument — the Lowrey MX-1. It was expertly played by Harry Stoneham, although I doubt whether even he needed to concentrate all his skills to make the instrument create an electronic orchestral sound of such complexity. In fact, all you've got to do is play a single 3-note chord on the lower manual and select your orchestral combination, from Big Band to Baroque, and away you go! And it's not just the realism of the instrument voices, it's the way each instrument plays counterpoints, harmonies and rhythms ideally suited to it.

All this and much more is achieved at a price — the MX-1 costs £13,950 — although Lowrey have already introduced a new range of 'Micro-Magic' organs, starting with the Fiesta at £855, that no doubt benefit from this new technology.

The conception of this remarkable instrument first started about five years ago in Chicago, Illinois at the Lowrey Organ Division of Norlin Music Inc. It first emerged in the UK at last year's music trade fair, having been on sale in America for a year, and the reception it received was tremendous — we all looked for the hidden tape recorder with no success! Certainly, the implementation of a huge amount of micro-chip circuitry in one home organ cabinet has created a system that could well become the ultimate dream for many home organists — but no doubt there are more innovations to come. Many of the ICs are custom LSI chips developed by Lowrey — for example, there's the Serial Interface Controller which is virtually a microprocessor in itself.

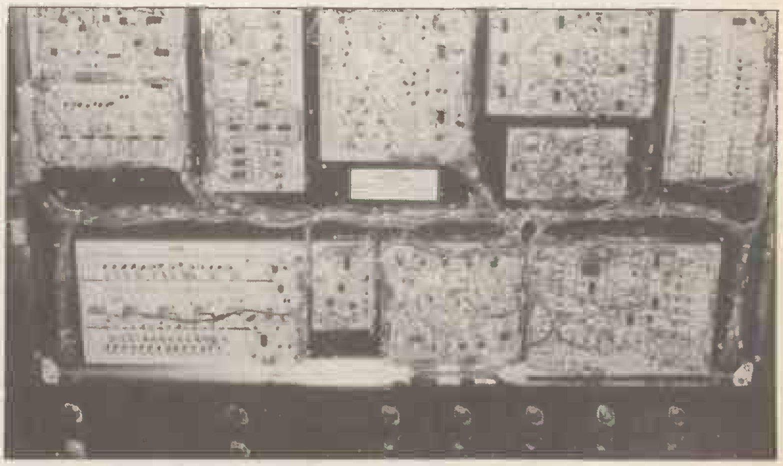
I spoke to Braham Digdgelli, Service Manager for Lowrey U.K. at Braintree, Essex, and he commented that although the design was wholly done in America, he is able to provide feedback from the British point of view. Braham then proceeded to give me an enthusiastic survey of the MX-1 that took no less than three hours!

Controls and layout

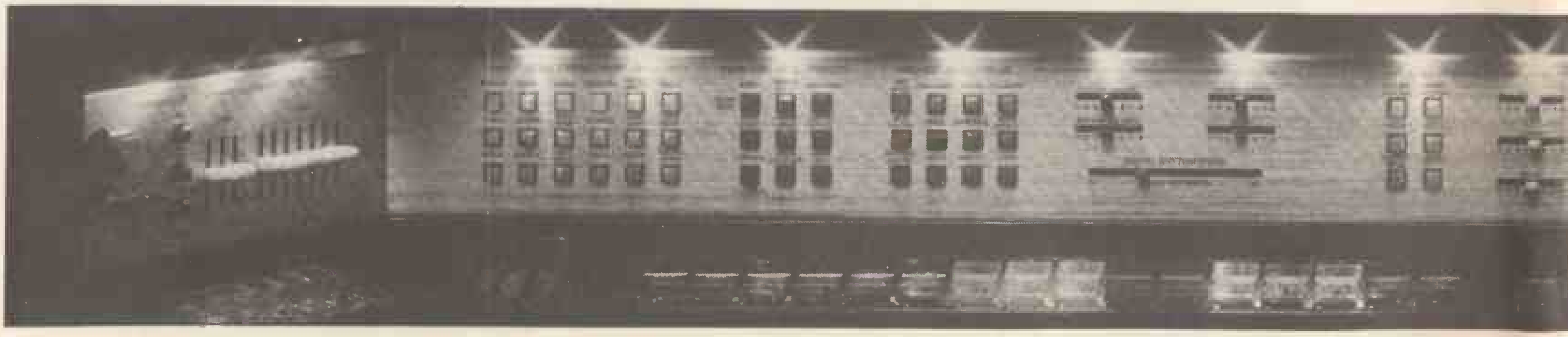
We switched on and immediately the organ jumped into a routine of flickering lights reminiscent of Star Trek's instrument panels! In fact the tabs, pedals and obviously the presets, which all have coloured LEDs under their buttons, are scanned one by one every 5 microseconds to show that the organ is operating properly and waiting for your command. The moment you select any button the effect is cancelled. The majority of the controls operate through a 'PIC' — Parallel Interface Controller which enables, for example, tabs to switch FETs and similarly gate all the other hardware that the performer uses to the organ microprocessor.

The control panel is illuminated by two side halogen spotlights that can be directed onto the controls or music rest at two itensities. There are tab lights, pedal and panel lights (high and low brightness) as well. Lowrey sliders, introduced about 2 years ago, are smaller than standard constructors sliders and felt as smooth as they should be and the small single touch 'latching' presets contain a special low current LED that can change colour on certain functions (from red to yellow or green) thus indicating a change of mode. This is especially useful on the Digital Stereo Rhythm to indicate end of intros.

A low impedance stereo headphone socket is provided, if you don't want to deafen your neighbours with the MX-1's 6 x 40 watt amplifier system. An interesting extra, that should be on all drum machines these days is a 3-digit LED readout of tempo for setting the rhythms which subsequently synchronise all the 'Orchestration Plus' accompaniments, 'Magic Genie' chords and 'Golden Harp' arpeggios. The control slider is not a 'pot' type but a multiple switch, so that the numbers indicated step from 54, 59, 64 in exponential fashion to 295, 321, 350 and 380 maximum tempo — no more guessing the correct speed from Rock to Waltz!



Back cover removed showing first layer of circuitry.



All controls are situated on the main front console and this includes external phono sockets in and out for stereo recording of the organ or playback of taped music. Another big advantage here is that the 'Leslie' effect (called Stereophaze Sound) for the organ tabs is very good indeed and is electronically-generated so that it will be present on the recorded signal. The organ speakers can be cancelled if desired and external speakers used instead and there is a 'Cancel' switch that will cut out all accompaniments immediately to give full manual control.

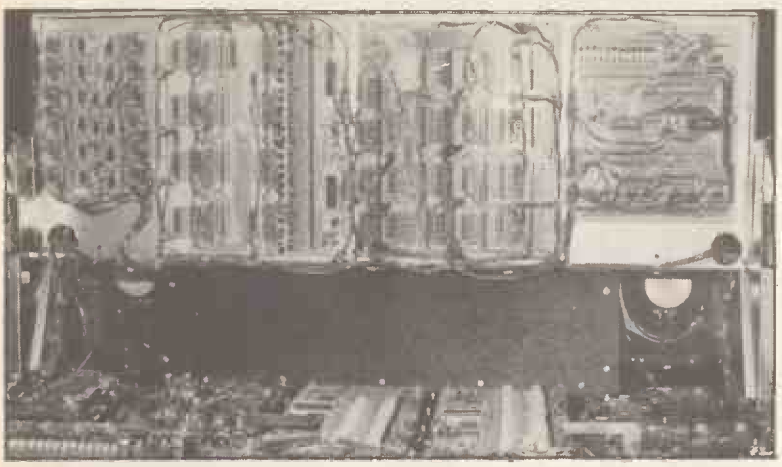
Circuitry

The power supply is quite substantial and provides a range of + and - voltages that draws a surprisingly small primary current of under 1 amp! The keyboards (both 49 note, upper C-C and lower F-F) are fully polyphonic, operating single contacts for diode keying and they are scanned from right to left every 5 microseconds by the Serial Interface Controller. You can even hold virtually all notes of the lower manual on 'Magic Key Memory' without the pitch drifting. Thus 49 upper, 49 lower and 18 pedal switches feed serial data to the Keyboard Encoder which sends its information to the upper manual flutes, Solo Symphonizer, Golden Harp, Orch. Percussion and AOC; lower manual flutes, Magic Memory and Magic Chord. It provides data that selects the fractional flute, on/off strike tone and Orchestral Symphonizer pitches. At this point too, the pedal and lower keyboard serial data goes to the CPU which produces Data and Address lines and Control Bus (WR, Reset) for the Orchestration Plus system. The Magic Chord, AOC and Golden Harp are also controlled via the Keyboard Encoder.

Various triggers, for the EGs, sustain control, strike tone for bells and vibe voices, snub lines (for initial control of piano and other percussive instruments) are initiated from keynotes played. Main tone generation is done by Top Octave Synthesisers (TOS) receiving a 4mHz oscillator and dividing down over the pitch range. Vibrato and Glide (a semitone slide up to the note) is obtained by modulating the oscillator, the latter effect is sometimes inserted automatically on Orchestration Plus, or it can be added manually from a foot button operated by the right toe as it moves the swell pedal. Certain sounds such as 'piano' will change the glide into a 'sustain' control. The selected pitches are sent to the main instrument tone generation boards which include Symphonic Strings, Vibes, Vibra Harp, Violin, Hawaiian Guitar as well as the Orchestration Plus and Solo Symphonizer. The Custom Symphonizer is really a synthesiser with the minimum preset and control slider functions for quick setting up.

It relies on a suitable sound source, taken from Orchestra (Polyphonic) or Solo (Monophonic) before it can produce percussive effects. Wow and rich stereo chorus can be added to get a big solo lead synth sound.


Second layer of circuitry revealed.


Note the two 6" x 9" chorus speakers and the sealed unit for the 10" bass speakers.

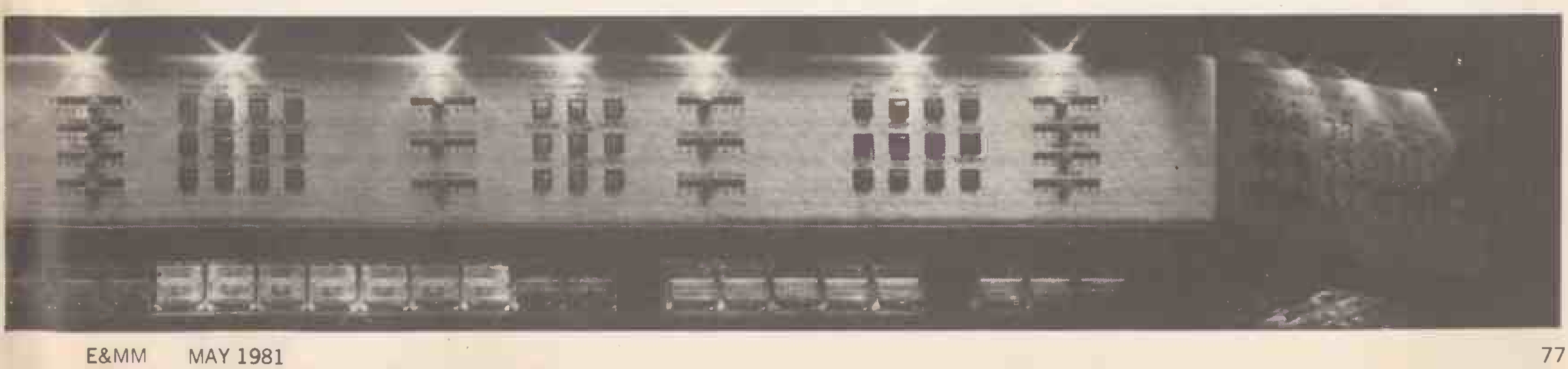
Many of the voices are derived from several tone formants that are a result of adding pulse waves and sawtooth waves which are then filtered to give instruments like oboe, trumpet, sax, bassoon, and jazz flute. Fractional filtering gives flute pitches of 16' 8' 5⅓' 4' 2⅔' 2' and 1' and low frequency sawtooth waves also control attack and decay on filters to give more realistic sounds. Tremolo can also be added to both Orchestral and Solo Symphonizer, which is really a BBD generated chorus effect giving pitch and volume variation after a slight delay. The result is a much more natural modulation on most instruments especially 'wind' types. It's nice to see a tuning control for each of these sections so that synthesiser style detuning can be done. Incidentally, instruments have their tonal qualities altered as you play each group of 7 notes up the keyboard, thus acting like a keyboard follower to brighten higher pitches.

The Solo Symphoniser plays on the highest note of the upper manual and has Piano, Clavecin, Rock Guitar, Sax, Oboe, Jazz Flute, Jazz Guitar, Clarinet, Bassoon, Trombone and Trumpet instruments. A solo keying on/off button ensures that note jumping does not take place — i.e. from releasing a single top note it will not jump to a lower pitched left-hand chord, which can be very irritating with both hands on the one manual. The large Solo generator chip gives 16' 8' 4' and 2' squarewave outputs and these go through their own Solo filter board containing analogue switched filters for multiple selection during the actual instrument envelopes. The Jazz Flute is a good example with a 4' initial envelope and noise 'breath' added to the 8' pitch. The noise generator is digitally produced from the Rhythm board.

The Rhythm system is operated from another PIC which keys 15V opamps, providing suitable triggers for each percussion effect. The main sounds are bongo, bass drum, cymbal, tom-tom, wood block, hi-drum, snare, low-drum, clave, and noise (for Jazz Flute treatment). With 'Autostart' on, the drum rhythm selected — there are 16 to choose from including two-tone metronome — will commence as soon as you play one or more notes on the lower manual and the percussion will continue until you release all these notes. It doesn't stop immediately but ends suitably on the first beat of the next bar (that is why there is a period when you can release the chord and move your left hand to play the upper manual or select other tabs, before it is necessary to return to the chord for continuous rhythm — very useful indeed). One of the most interesting developments here is that when a sound is selected on 'Orchestration Plus', the rhythm section will flash those selector buttons that provide the most appropriate rhythms for the sound, so 'Big Band' suggests a choice of Dixie, Country or Samba. Choose one of these and you then have the best combination for the music you are playing. You could, of course override the suggestions by selecting another rhythm — such as 3-beat 'Waltz' with a 4-beat 'Baroque' (Dave Brubeck would like this one!). The 3 beats of the waltz still have the same basic pulse as 4-beat, unlike other drum machines whose beats are divided over 48 parts, (i.e. 3 every 16, and 4 every 12).

The drum sounds themselves are extremely authentic and are produced in stereo with a push-button cymbal crash that is derived through its own LSI to give you multiple ringing effects exactly like a big cymbal decaying. There's an 'intro' button that gives a suitable fill-in before all the Orchestration Plus and Magic Genie accompaniments burst forth. You know when the fill-in is finished because the LED downbeat indicator changes colour from red to green, and a 'Rhythm Balance' control sets the L/R speaker outputs for real stereo percussion.

Needless to say, this is where both Braham and myself began to deviate from the circuitry functions towards the musical effects and special controls! So I will simply justify this by saying that we both had realised that the enormous complexity of this instrument can only be briefly discussed in this review — it's the central processing unit based on an 8085 microprocessor, with bi-directional Address/Data bus and control lines for operating an 8 x 1K RAM, SIC 1 Button scan, address latches, SIC 2 Keyswitch scan, that masterminds the MX-1. The push-button scanning is performed through the SIC by looking at Y select lines (a vertical row of



buttons) and then sending an X-scan to decode which of the horizontal buttons in the vertical group has been selected. The Orchestration Plus boards produce up to 6 different instruments including a bass line from the 'pedal keyer and filter' board for each button selected.

Controls and effects

There are a lot of features on the MX-1 that make it easy for the beginner to get a full accompaniment that is synchronised with the rhythm and other effects. On the other hand, they also increase the possibilities of multi-layer 'orchestral' performances for the more experienced musician.

The 'Magic Genie' chord system gives interesting homophonic accompaniment from Piano, Guitar and Banjo tabs, with auto bass derived from the LH chord played. A LH single note gives a major chord and this is changed to minor from the right toe foot switch on the pedal. This switch also adds Golden Harp when you want it and gives yet another effect for the competent player to master and enjoy. Its extra 'Magic Key Memory' feature is linked to the 'Magic Genie' and 'Orchestration Plus' to allow the player the temporary use of both hands on the upper keyboard to play full block chords.

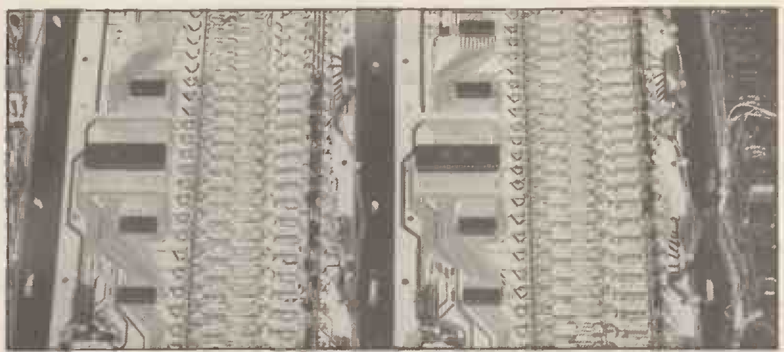
Orchestral percussion has a distinctive set of percussive instruments: Bells, Vibes, Vibraharp, Chimes (on top 30 notes), plus Accordion, Hawaiian Guitar and Violin. Also here are 4' and 2⅔' harmonics for adding to flute drawbars used on jazz/pop organ playing.

The Golden Harp is great fun to use and will give swirling arpeggios, always synchronised to the rhythm tempo, but selectable for fast, slow, up, down and 'virtuoso' (variations on up/down) arpeggios. It works on the Orchestral Percussion voices (and Orchestral Symphonizer as an option).

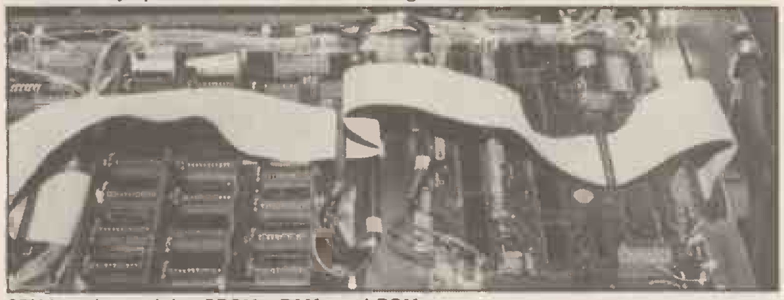
AOC (Automatic Organ Computer) is one of Lowrey's selling features on their organs and it gives full upper keyboard harmony from 1 finger of the right hand. The chord is formed from the lower manual chord being played. AOC 'Organ' provides chords for upper tabs and most of the Orch. Symphonizer voices and polyphonic Custom Symphonizer. In addition, AOC 'Open Harmony' produces a wide two-hand style chord that really does give a full ensemble sound to melodies and can easily convince the listener that a complete woodwind, string or brass section is playing.

The 'Stereophaze Sound' provides a particularly good stereo image for the player from carefully positioned speakers in the console. Here you have the traditional Leslie sound and more, all electronically produced so that recording the 'live' sound is easily done through the Stereo phono output sockets.

It's not a bad idea to use headphones to monitor recording if possible and it's also important to keep the swell pedal volume off maximum otherwise you'll start picking up the usual electronic organ background whistles and noise. In live performance the sound quality is excel-

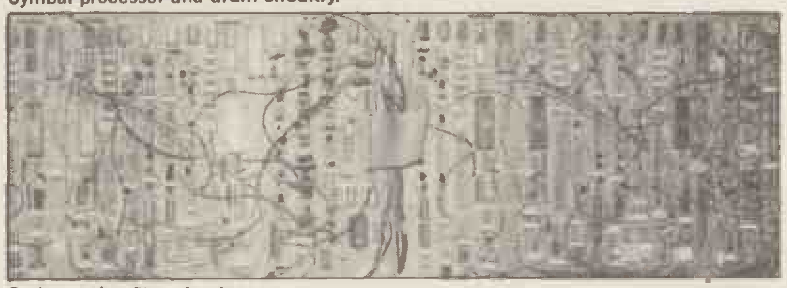


Orchestral Symphonizer Sound Decoder using PIC 7949.



CPU board containing PROMs, RAMs and ROMs.

Cymbal processor and drum circuitry.



Orchestration Plus circuitry.

lent — especially considering that the largest speaker is a 10", for the bass really thumps out if you want and the top is bright enough to do justice to all those high harmonics.

In all there are two 10" Bass speakers mounted in a central sealed enclosure (see photos), two 6" x 9" Chorus speakers at left and right ends of the console, one 8" main speaker and two 8" flute speakers.

'Vibra Trem Flutes' create the traditional 'chorus' fast rotor effect. Flute and Main Chorus tabs give an ensemble (from a very short pulsed delay treatment on one channel whilst the other side is straight). Chorus Celeste' is really the slow rotor 'chorale' effect. Vibrato, Tremolo (as described) and reverberation can be added to complete the concert hall sounds of the MX-1. There's even a Marimba repeat that gives alternate reiteration from two notes, and of course variable sustain.

Instrument Sections

Now we come to one of the most exciting aspects of this instrument, the vast range of sound combinations available — there's virtually nothing missing (except Harmonica!) and to complete it all comes the innovative 'Orchestration Plus' section.

There are Symphonic Strings on upper and lower chorus that have a realistic phased ensemble quality for d. bass, cello, viola and violin. 'Orchestral Symphonizer' gives Grand Piano, Brass Ensemble and specials such as Banjo, Electric Guitar, Post Horn and Mandolin. The Solo Symphonizer complements the latter section for lead-line playing that adds an authentic top-note solo to your right hand, from a reasonable 'reedy' Sax to 'breathy' Jazz Flute, and then you can add the Custom Symphonizer in mono or poly mode as well.

'Symphonic Bass' gives tremendous depth to your own pedal playing — after all, 'piano' on the Bass gives that rich orchestral film score feeling (such as on John Williams' original score for 'Star Wars'). There is Tuba and Bass Fiddle as well, with the 18 note pedal-board a great help for church organ music. And we mustn't forget the full tab selections on upper and lower manuals. These not only include a full flute tab set (except 1' mixtures), but have a custom flute tab that lets you set sliders in any combination just like drawbars. Full brass, clarinet, and a Vox Humana that almost sounds like voices complete the tabs.

Finally, we come to Orchestration Plus, described by Lowrey with a string of superlatives as 'the most advanced, innovative, imaginative, truly incredible musical feature ever to be introduced in an electronic organ'!

There is no doubt that this section provides the most exciting feature for this instrument. Its innovative design enables, for the first time from one instrument, a choice of twelve preprogrammed fully orchestrated accompaniments that are very realistic indeed. Despite the fact that every two or four bars, the selected 'orchestra' repeats its various counterpoints based on lower manual chords (any inversion), the variations of instruments and melodies are sufficient to avoid any feeling of monotony when played properly. With 'Chord-Logic' button on certain chords (in particular the flattened 7th) will make the CPU select a slightly different melodic line, and even give glide on appropriate instruments such as trombone. 'Basic Mode' will give a full set of instrument groups on all chord rhythms. Switch this effect off and you're back to separate sections 'doing their own thing'. 'Variation' ensures that you'll never get tired of the accompaniment! You can also have 'keyed style' so that the orchestra only plays for the duration of a left-hand chord. Needless to say, there are enough couplers and upper/lower select options to give plenty of variations to your registration.

It is at this point that the final say has to be left to the instrument itself! So on E&MM's Demo Cassette No. 2 I have provided examples of the Orchestration Plus section, from Big Band and Polka to Waltz and Baroque. Here I'm sure the provision of an aural complement to this review will be worthwhile, for the examples are done not by spending hours of practice to master the controls and effects in a virtuoso way, but by simply sitting at the organ and there and then assessing what the instrument can do without too much effort. Thus you have a more accurate idea of what the home musician can achieve after a very short time (provided he knows his chords and names of controls). Other features are highlighted on the cassette and along with this review should help you assess this unique instrument for yourself. You may need a good few 'strong arm' men to lift the superbly finished console — it weighs 357 lbs (162kg) (there's a matching bench too) and it measures 28¾" (731mm) from front to back. That's just less than many door frames — but I for one would be quite happy to remove my front door to get the MX-1 in my house!

Mike Beecher **E&MM**

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Hot Wiring your GUITAR

Adrian Legg

Coil tapping humbuckers

Coil taps are an extremely simple way of producing a fundamental character change in the tone of a guitar, both from the point of view of function and operation, and installation. The apparent extra treble is generally enhanced by the use of 1n0 capacitors on backed off volume controls, giving a breathy, edgy sound that goes some way towards a Telecaster's character, though other physical changes are necessary to help overcome the difference between the Tele's taut 25½ inch scale and the 24¾ inch scale found on most guitars fitted with humbuckers. But, physical stuff aside, coil taps are pretty much the bee's knees in simple modifications. Volume drop can be a nuisance, and where it is not possible to overcome this by using floor volume pedals or compressors, a partial tap can help.

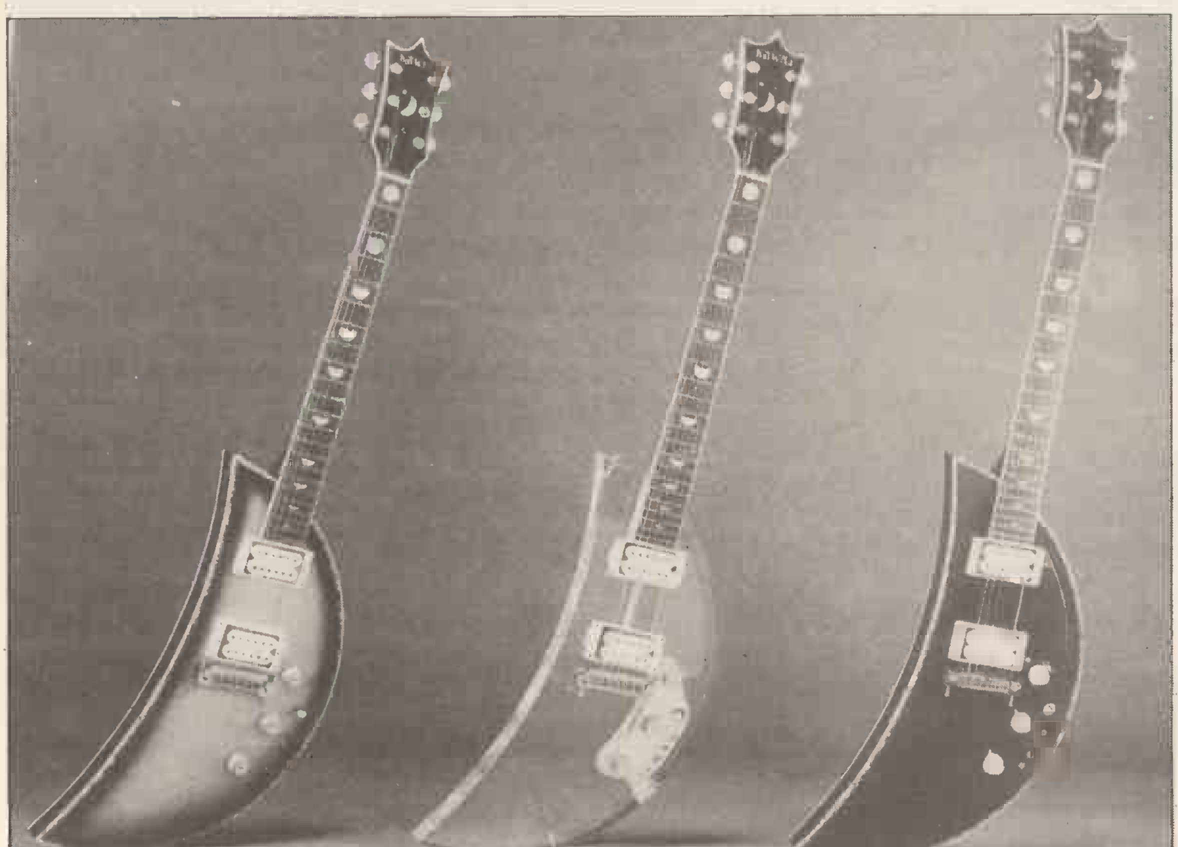
Turning one coil off altogether can be done by leaving it open circuit or without earth reference, or by earthing one of the pair out partially or completely. Earth-type taps are the simplest to add, as the extra wire does not require screening. The extra wire is added to the join between the coils as in Figure 1. Here, earthing the tap wire will cut out coil 2. Switching can be done by an on/off switch, or preferably for cosmetic reasons, by a mini-toggle SPDT (single pole, double throw). The mini-toggle switches are generally available with a ¼" shaft, and as the external appearance is similar with a variety of S/DPDT's, it will tie in with other modifications such as phase or series/parallel — of which more at a later stage. It is unwise to use a push button latching action switch, as you will have no visual check on mode, whereas with a mini-toggle, you can see which way the thing is set before you start.

To wire an on/off SPDT, run the tap wire to the centre terminal, and wire from one of the outer terminals to earth, as in Figure 2.

The alternative partial tap, which avoids a big volume drop, runs to earth via a capacitor, and this will take out the treble frequencies of coil 2, leaving the bass end of the pick-up humbucking, and allowing the treble frequencies of coil 1 to dominate the tone. This gives a weightier sound than a complete tap, and in my experience, requires a harmonically rich pick-up for best results — I would use it on a power pick-up rather than a vintage type. To wire it, simply replace the earth wire from terminal 3 with a capacitor. It is worth experimenting with different value capacitors to get the results most suited to you and your guitar. I use 33nF on my regular guitar; Lawrence recommend 20nF for their pick-ups, and I would suggest you experiment with capacitors between 10 and 50nF. Much will also depend on pick-up position, and capacitors are cheap enough anyway. Voltage rating is irrelevant except in that higher voltage units will be more robust and will be less susceptible to heat damage.

Capacitor value has another bearing on the sound in that the deeper down the frequency range that it cuts, the deeper will be the hum. That is, the pick-up will still be humbucking below the level that the capacitor removes to from one coil — the hum from a 10nF tap will be shallower than the hum from a 50nF tap, and complete tap will have all the hum that the humbucker usually cancels out.

I have found it useful on several custom guitars to be able to alternate between complete and partial tap, and this can be done by using an on/off/on SPDT as in Figure 3. The three switch positions give partial tap/humbucker/complete tap, and here, you may even find it useful to vary between different value partial taps rather than partial and complete. You could try, for example, a 10nF capacitor from terminal 1 to earth, and a 50nF from terminal 3 to earth. It has often been said that differences between capacitor values on tone controls are hard to hear, and it could be said that variance between two values on a partial tap are over fussy. However, I have found that seemingly minute changes in tone can make the difference between a satisfying gig and a gig that didn't quite cut it, and that's the best reason for experimenting. **E&MM**



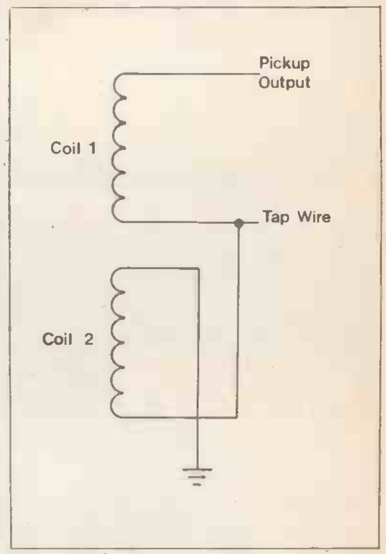


Figure 1

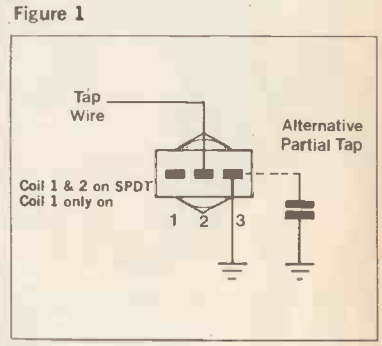


Figure 2

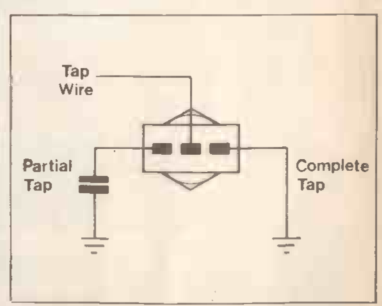


Figure 3

Organ Talk

Ken Lenton-Smith

TUNING

Whilst in the Services I played the piano in an Army dance band for a short period. Arriving at a Garrison Hall in India, we found the piano to be far from concert pitch. There was no alternative but to re-tune the instrument as quickly as possible, using a strip of bamboo between adjacent strings, a tuning lever and a great deal of patience. That experience taught me that piano tuning is very much the domain of an expert: at that time I little realised that pulling up tuning throughout can be very dangerous if the frame has hair cracks. Anyway, the tuning was completed in time for the concert and the piano passed muster!

Thank goodness that the modern electronic keyboard instrument only requires the adjustment of a single oscillator — or twelve tunings at the most — with the widely used divider system. Free phase generator systems, on the other hand, still require adjustment of each note generated and thus multiple tunings similar to the piano.

Standard

Despite the fact that electronic music facilities include glide, slalom and portamento, steady tones need accurate tuning. For this purpose a standard of pitch is necessary — an absolute reference to which all other notes can be related. Until the advent of broadcasting and recording there was no real standard. By international agreement, the pitch standard is that A above middle C is 440.00Hz (at 8' pitch). The BBC uses this frequency before the start of programme material as a tuning signal.

Although A = 440Hz is the ideal, other factors may have to be taken into account. For example, if an organ is to be played in duet with a piano which has deviated slightly from concert pitch, the organ can be easily brought into line. 'Sharp pitch' instruments used in military bands may be encountered occasionally so it will be necessary to re-tune to these if accompanying.

Having considered the international pitch standard, the question of intervals arises. Certain orchestral instruments are under total control of the player in this respect, such as the trombone and stringed instruments without frets. A certain amount of pitch bending is possible with brass and woodwind instruments but the intervals between notes are basically fixed by the position of wind holes and operation of valves. Excluding the synthesiser, keyboard instruments have fixed tonal intervals.

Intervals

Whilst it is a simple matter to tune octaves or perfect fifths by listening to the beats produced, musicians always had tuning problems until equal temperament tuning was adopted. The pure diatonic scale and its frequency ratios are shown in Table 1.

Due to the oddities of these frequency ratios, difficulties arise. For example, the first two notes in the key of C (C and D) have a different ratio from the first two notes in the key of D major (D and E), so transposition is impossible. For a while it was thought that making all the whole tone intervals equal would solve the problem, but cumulative errors arose when attempting to tune in perfect fifths.

	C	D	E	F	G	A	B	C
Ratio to lowest C	1:1	9:8	5:4	4:3	3:2	5:3	15:8	2:1
Ratio to note above		8:9	9:10	15:16	8:9	9:10	15:8	15:16

Table 1. Mean Tone Tuning

Divide by	Note	Frequency Produced	E.T. Frequency	Deviation in Hz.	I.C. Pin
239	C	8372.016	8372.016	-	8
253	B	7908.742	7902.131	+6.611	7
268	A#	7466.089	7458.619	+7.470	11
284	A	7045.464	7039.999	+5.465	12
301	G#	6647.548	6644.874	+2.674	6
319	G	6272.451	6271.926	+0.525	5
338	F#	5919.857	5919.909	-0.052	13
358	F	5589.139	5587.650	+1.489	14
379	E	5279.451	5274.040	+5.411	4
402	D#	4977.393	4978.031	-0.638	15
426	D	4696.976	4698.635	-1.659	16
451	C#	4436.612	4434.921	+1.691	3
	C		4186.008		

Table 2. AY-1-0212A supplied with 2.0009118MHz

Step	
1	Tune A to 440Hz by tuning fork or BBC signal.
2	Tune E below (with A) to 89 b.p.m.
3	Tune B above (with E) to 67 b.p.m.
4	Tune F# below (with B) to 100 b.p.m.
5	Tune C# below (with F#) to 75 b.p.m.
6	Tune G# above (with C#) to 56 b.p.m.
7	Tune D# below (with G#) to 84 b.p.m.
8	Tune A# above (with D#) to 63 b.p.m.
9	Tune F below (with A#) to 94 b.p.m.
10	Tune C below (with F) to 71 b.p.m.
11	Tune G above (with C) to 53 b.p.m.
12	Tune D below (with G) to 80 b.p.m.
13	Check that D to A has 60 b.p.m.

Table 3. Tuning the E.T. Scale by Audible Beats. Tune each interval to zero beat then *flatten* by the number of beats per minute indicated.

E.T. Tuning

Equal temperament tuning was adopted during the eighteenth century, where the frequency ratio between each semitone was made identical — based on the twelfth root of two. This method is a compromise and has been very successful but it does have the disadvantage that perfect intervals involve a slight beat because they are no longer perfect in the true sense!

When the T.O.S. (Top Octave Synthesiser) came to our rescue some years ago, its critics imagined it would not be sufficiently accurate to satisfy the ear of a trained musician: for tuning purposes, each semitone is divided into 100 cents — and a trained ear can detect errors of a few cents. The twelfth root of two is a complex number (1.0594631) for a digital divider system to cope with but the manufacturers have done their homework well.

To set the record straight, bearing in mind the problems the T.O.S. overcomes for amateur and professional builders alike, I have looked closely at a typical T.O.S., the AY-1-0212A from General Instrument Microelectronics. This device will accept an input frequency of 2.5MHz and so will produce 2' pitch without breaking back (the AY-1-0212 accepts up to 1.5MHz and so will only provide 4' pitch).

Table 2 shows the results obtained when supplying the AY-1-0212A with just over 2MHz to provide top C at 8372.016Hz.

Column one shows the divisors that are applied to the incoming oscillator signal, the next two columns the note of the scale and its frequency. For comparison, the precise E.T. figures are shown and are found by using the twelfth root of two as a constant divisor. The deviations are tiny indeed and in the worst case (A#) amount to one part in a thousand. In musical terms, this represents an error of less than 2 cents which a trained musician might be hard put to detect. With reverberation added to the instrument, this small deficiency would probably be covered.

The music industry must be thankful to GIM and other manufacturers of these devices for solving the problem of accurate tuning intervals. Additionally, the ability to re-tune the whole compass simultaneously is indeed a boon. Incidentally, I should mention that any constructor using TDA 1008 divider-keyers should use a TOS capable of top C = 16744Hz (such as AY-3-0214) if the full capabilities of the keyers are to be realised.

Alternatives

Some instruments still employ twelve master oscillators or an individual oscillator per note of the compass, in which case tuning is more complex. The middle octave of a well-tuned piano could be used to set the scale of a divider instrument, tuning each note until beats are eliminated. The various octaves of a free phase instrument can be tuned from these, again eliminating beats. The piano is intentionally mistuned progressively in each direction from the middle of the keyboard, so only its centre should be used as a tuning aid.

Alternatively, using a pocket calculator 440.00Hz can be multiplied or divided by 1.0594631 repetitively (using it as a constant) to give the E.T. semitone frequencies above and below the tuning standard. Having tabulated the figures, a frequency meter will indicate whether the oscillator is tuned correctly.

If neither a good piano nor frequency meter are to hand, tuning has to be tackled the hard way.

Tuning by introducing audible beats relies on the presence of harmonics, so I would suggest 8', 4' and 2' Diapason tabs are used simultaneously. The table shows A = 440Hz as the starting point with E tuned against it. Our E.T. calculations will show that E ought to be 329.6275Hz and its *fourth* harmonic therefore becomes 1318.51Hz. The *third* harmonic of A is 1320Hz, so the two harmonics will beat at 1.49Hz (or 89 beats per minute) when the fundamentals are correctly tuned to each other. The rest of the table is based on a similar calculation for each note.

Before embarking on the sequence of Table 3, allow the oscillators to settle down, then use a tuning fork or the BBC signal to set 440Hz to zero beat. When arriving at the last step, do not adjust A unless it has drifted from the standard. There should be 60 beats per minute between D and A and, if this is not the case, the process must be repeated and repeated . . . while trying to keep your temperament!

WORKING WITH VIDEO

Andrew Emmerson

This month we want to know if you're looking for trouble. Are you aware that every time you switch on your TV set or use your video recorder you are promoting its demise? Do you realise that by switching off your super new colour camera without first capping the lens with its proper plastic bung you may be shortening the life of its tube? Do you take risks by using cheap tapes? And so on... Have those silly articles in the weekend papers or those scientific looking adverts succeeded in making you think twice about even using your hard earned video equipment? Do you have a complex about misusing your video outfit?

Yes? Then don't! Honestly, to read some doom-laden articles, you would think that video was not at all a pleasurable activity. And some advertisements seem determined to get you worried about things you had never even realised were harmful previously. I want to dispel all these horror stories — as long as you follow the manufacturer's instructions and use the equipment in a normal manner, you should expect several years enjoyable and reliable service from your video gear. The reliability of modern consumer electronics products has grown considerably in the last five years, so much so that short of deliberate misuse it is almost impossible to blow up your expensive equipment. The Japanese started this when they figured that the only way to break into the European market was to make 100% reliable products: this way they could build up an unassailable reputation (and would not have to send back all the way to Japan for lots of expensive spares). Spurred on by this example, most European manufacturers are now achieving virtually identical reliability performance, and you, the consumer, gain the benefit.

As far as home video equipment is concerned, the items with the shortest probable life-time are the heads in video tape recorders. It is a fact of life that some things wear out faster than others — like tyres on a motor car. In the same way, video heads get abraded by the tape passing by them at high speed and there is nothing you can do to prevent this. Most manufacturers quote a minimum life of 100 hours for a set of heads but you can often exceed this figure by a factor of five. Replacing heads is not a do-it-yourself job by the way — although the commercial price for this job is between, say, £50 and £100 (depending on the type of machine and where you go), there is absolutely no way even a gifted amateur can escape this charge. Most of it is made up of the cost of the heads anyway, and fitting them needs the skills of a watchmaker as well as precision alignment gear and test tapes. So reconcile yourself to this expense at some time in the future if you have a video machine.

Hercules the bear found watching his favourite video programme!

How do you determined when your heads need replacing? Quite easily — when the picture you receive when playing back tapes is swamped by white flecks known familiarly as 'snow'. If you ignore the condition you will eventually have no picture at all, and it will also affect your ability to record programmes. Before you resign yourself to forking out for new heads do make some basic checks. If you see just as much snow when you are *recording* a programme or just watching TV this indicates a poor connection between the recorder and the TV set's aerial input or possibly the need to improve your aerial system. It could also mean that your TV set is not tuned exactly to the output of the VCR (try adjusting the fine tuning control on your TV set while watching a playback). If on replay you see a more or less static pattern of white or *black* speckles on the screen, try adjusting the tracking control on the video recorder — it might be a mistracking fault, particularly if it only occurs on tapes borrowed from other people. Actually, the tracking problem is largely a thing of the past now. The first Philips machines had a bit of a reputation for incompatibility between tapes recorded on one machine and another, but with the advent of VHS and Beta (and presumably more so for the new Philips system) this seldom gives any trouble.

We have now dealt with the most likely source of trouble and expenditure in your video system, which must mean that any further problems are likely to be slight. However, unless you happen to be an expert in electronics (or fancy yourself as one), there's little you can do to rectify any malfunction anyway. The traditional cure of thumping the equipment or employing a gas board screwdriver will have no curative effect and may even be injurious to your health or wealth. If you suspect a fault, do check first and see if you have forgotten to do something obvious; as a very last resort you could even consult the instruction manual! Failing this, it means taking the gear back to the place where it was bought or to a reliable service technician.

However, even if there's nothing one can usefully do, the devil will still find work for idle hands. People like to feel involved in the upkeep of their nice expensive equipment and this is where the anxiety mongers make their appearance. I mentioned them earlier; usually they are trying to sell you some gadget to prolong the equipment's life. Some of these devices are quite harmless or even a good idea such as, library cases, racks for tapes and perspex lids or fabric covers for keeping the dust out of VCRs. Less praiseworthy are some of the cleaning tools and fluids intended for cameras and tape machines. Some are useful, some are useless and some are positively harmful. Even if the product itself is good in skilled hands, its use by amateurs may be harmful, particularly if it encourages (or requires) them to disassemble equipment. The moral is that most of these accessories are gimmicks and expensive ones at that. (Ah, but you always have to pay for *quality*, Sir...) You may remember the grotty record care accessories that used to be on sale — most have disappeared now that hi-fi enthusiasts have become better informed. Manufacturers must presume videots have less sense (or more money to burn) because there is some real high class rubbish in the shops!

So let us get down to brass tacks. Most things intended for cameras are in fact quite useful. You can get lens brushes and tissues to (occasionally) clean the lens and possibly the faceplate of the tube. Do, however, avoid pointing the tube directly into strong light when you do this. You can cause nasty white burn marks on the tube, even if the camera is not switched on. It does not happen often, fortunately, but be warned. Beware of solvent cleaners — soapy water or isopropyl alcohol are all that I would use. Video-recorders are another kettle of fish. You can buy head-cleaning tapes (wet and dry), cotton buds, aerosols of compressed air and cleaning fluid, inspection mirrors and so on. All of these are acceptable if used in moderation and by people who know what they are doing. But excessive use of cleaning tapes can actually wear down the heads prematurely; cotton buds can leave fluff trapped in the mechanism; blowers can push dirt further inside; drenching with cleaning fluids can attack plastics and synthetic rubber pinch wheels. So my advice is save your money. Most tape recorder manufacturers do *not* recommend the use of cleaning tapes, and if you're worried, then once a year take your machine to the dealer you bought it from and ask his technician to check whether it needs cleaning. If it does, he will do it scientifically and will probably make little or no charge. You wouldn't attempt to take your watch to bits and squirt weird things into it, so why do the same to something costing a lot more?

If peace of mind as been restored, I look forward to meeting you again here next month. **E&MM**

Hobby Electronics '81
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London has more than its fair share of electronics shows, but we know that electronics enthusiasts are by no means limited to the capital. For that reason the first annual Hobby Electronics Show is to be held in Bristol — centre of the South-West.

What's to see there?

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TICKETS — at the door — **ADULT** : £1.00. **CHILD, STUDENT, OAP** : 50p.

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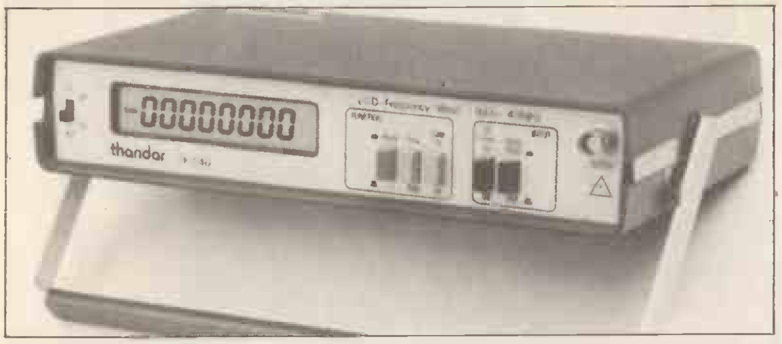
NEW PRODUCTS



L.C.D. FREQUENCY METER. TF040

Sinclair Electronics Ltd. announce the release of their new bench frequency meter. This battery operated unit has an 8-digit liquid crystal display (LCD) and covers the frequency range 10Hz to 40MHz, with a sensitivity of better than 40mV. The 0.5 in. display reads out direct in kHz with indicators for gate, overflow and low battery, and automatic positioning of the decimal point.

Typical battery life from 6 alkaline 'C' cells is claimed to be 80 hours, and the meter can also be powered from an optional AC adaptor.

Price of the TF040 is £110 + VAT. Further details may be obtained from Sinclair Electronics Ltd., London Road, St. Ives, Huntingdon, Cambs. Tel. (0480) 64646.

FUNCTION GENERATOR

A further addition to the Sinclair Thandar range of low cost professional bench test equipment is the TG100 function generator. This unit covers the range 1Hz to 100kHz, in 5 decade ranges with a calibrated vernier for fine adjustment and features D.C. offset control (+5V) and external sweep control.

In the sweep mode, the frequency range is extended downward to 0.01Hz and the maximum sweep range is 1000:1.

Output is a sine, square or triangular wave and is available at TTL level as well as 600Ω with two switch-selectable attenuator ranges with vernier control of each range.

For further details contact Sinclair Electronics Ltd., London Road, St. Ives, Huntingdon, Cambs. Tel. (0480) 64646.

DIY-HIFI

A new product from a new company — the 'CECILIA' DIY speaker.

For a fee of £2.50, DIY-HiFi will supply a construction guide package which includes full-size plans and step-by-step assembly instructions.

The drive unit in the speaker is the PIONEER TS107, which, although designed for use with in-car audio systems, boasts a frequency range of 50Hz to 20kHz and a power rating of 20 watts and thus is ideal for use in the 'bookshelf speaker' type of application.

DIY-HiFi quote a price of around £35 for a pair of speakers depending on materials and finish. The TS107 should be available from car radio centres and the construction package is available from:

DIY-HiFi, York House,
Swan Street,
West Malling, Kent.

JAPANESE BOOTS

Boots Audio have teamed up with AIWA to produce a Micro HiFi.

The system, consists of an amplifier with 20W RMS per channel output, a digital FM tuner, a dolby equipped cassette deck and 2-way full range loudspeakers.

The unit stands only 12 inches high and at present is available in walnut veneer only, but from May '81 it will be possible to order black, white or alternative wood veneer finishes.

The speakers are of British design and the unit is supplied pre-wired thus aiming for HiFi separates quality with the convenience of a music centre. The current price of the complete system is £397, and is available from the larger Boots branches.

VERTICAL SHARP

A new concept in music centres has been announced by Sharp. Designated the VZ3000, the unit is built around the first commercially available vertical turntable to allow both sides of a record to be played, without turning it over.

The turntable is a belt-driven type with two linear tracking arms, automatic size and speed detection, and can be set to play one side, both sides in sequence or continuously repeated.

In addition to the unique turntable, the unit also boasts a cassette deck which features the Sharp APSS, Dolby noise reduction and metal tape capability, as well as a LW/MW/FM stereo radio. The system output is 25 watt per channel and has a 2-way bass reflex loudspeaker system.

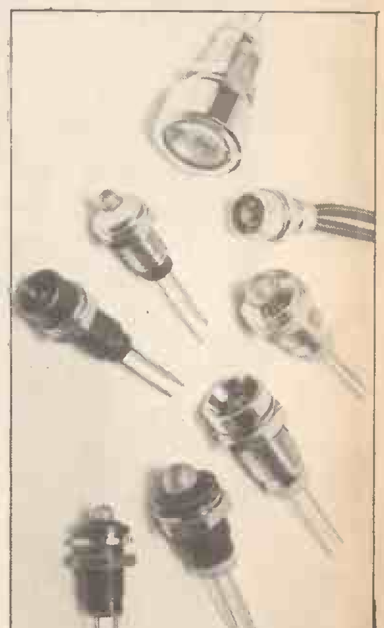
Due for release in the autumn, the expected retail price is around £325. Sharp Electronics (U.K.) Limited, Sharp House, Thorp Road, Newton Heath, Manchester, M10 9BE.

FLASHY LEDs

West Hyde are now marketing a range of LEDs from the German company, Mentor, which are available in two sizes 3mm and 5mm diameter, with the choice of four colours and concave or convex reflectors. The bodies finished in chrome or black.

Many variations to the standard range are available including water resistant types, units fitted with wire leads and assemblies with built-in series resistors. In addition to these more conventional devices, West Hyde also offer 'flashing' variants and even an integrated device which gives steady green or flashing red from the one unit.

West Hyde Developments Ltd., Unit 9, Park Street Industrial Estate, Aylesbury, Bucks HP20 1ET



EXPANDABLE POLYPHONIC SYNTHESISER

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(single voice)

Plug in extra Voices — Kit price £52 + VAT (£48 — + VAT if ordered with kit)

TRANSCENDENT POLYSYNTH

By brilliant design work and the use of high technology components the Polysynth brings to the reach of the home constructor a machine whose versatility and range of sounds is matched only by ready built equipment costing thousands of pounds. Designed by synthesiser expert Tim Orr and being featured in Electronics Today International, this latest addition to the famous Transcendent family is a 4 octave (transposable over 7½ octaves) polyphonic synthesiser with internally up to 4 voices making it possible to play simultaneously up to 4 notes. Whereas conventional synthesisers handle only one at a time.

The basic instrument is supplied with 1 voice and up to 3 more may be plugged in. A further 4 voices may be added by connecting to an expander unit, the metalwork and woodwork of which is designed for side by side matching with the main instrument. Each voice is a complete synthesiser in itself with 2 VCOs, 2 ADSRS, a VCA and a VCF (requiring only control voltages and a power supply, the voice boards are also suitable for modular systems). One of these voices is automatically allocated to a key as it is operated. There are separate tuning controls for each VCO of each voice. All other controls are common to all the voices for ease of control and to ensure consistency between the voices.

Although very advanced electronics the kit is mechanically very simple with minimal wiring, most of which is with ribbon cable connectors. All controls are PCB mounted and the voice boards fit with PCB mounted plugs and sockets. The kit includes fully finished metalwork, solid teak cabinet, professional quality components (resistors 2%, metal oxide or metal film of 0.5% and 0.1%), nuts, bolts, etc.

Kit also available as separate packs

Pack		Price
POLY 1	Pair of PCB's for multiplex cct. K.B. contacts	£9.50
POLY 2	IC's IC sockets, Rs, Cs, for multiplex cct.	£8.20
POLY 3	Superior quality keyboard	£32.25
POLY 4	Contacts and bus bars	£12.00
POLY 5	Double sided plated through PCB for digital control and pitch/gate generator cct.	£17.25
POLY 6	Rs, Cs, heat sink for fitting to Pack 5	£10.50
POLY 7	IC's IC sockets, diodes for fitting to Pack 5	£31.30
POLY 8	Double sided mother board (for plug-in voices)	£18.90
POLY 9	Rs, Cs, connectors for mother board	£14.10
POLY 10	IC's IC sockets, Trs, heat sinks for mother board	£13.10
POLY 11	PCB for master controls (left of section marked VOICES)	£18.80
POLY 12	IC's IC sockets, diodes, Trs, Rs, Cs for master control PCB	£9.30
POLY 13	Pots, Switches for master control board	£11.80
POLY 13	Pots, Switches for master control board	£11.80
POLY 14	PCB for VOICE controls	£6.80
POLY 15	Pots, switches, diodes, Cs for VOICE PCB	£4.80
POLY 16	PCB for plug in voice	£8.20
POLY 17	Rs, Cs, presets, connectors for one voice	£16.30
POLY 18	IC's, IC skts, diodes for one voice	£27.50
POLY 19	Transformer 0-120-240, 17-0-17, 0-7.7	£6.30
POLY 20	Pitch bend control	£3.90
POLY 21	Misc parts e.g. jack sockets, knobs, mains switch etc.	£13.00
POLY 22	Ribbon cable, ribbon cable connectors, mains cable	£8.45
POLY 23	Fully finished metalwork and fixing parts	£25.60
POLY 24	Solid teak cabinet	£25.80
POLY 25	Construction manual	£1.50
	Total cost for individually purchased packs for single voice instrument	£355.15
	Special kit for 4 voice expander kit including connectors	£295.00

ADSR IC CEM 3310 .... £4.00

VCO IC CEM 3340 .... £6.00

ICs and details of all packs in our FREE CATALOGUE

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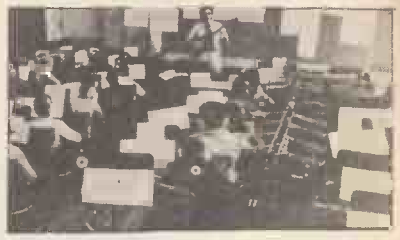
Electronics & Music Maker looks to the future by choosing projects that use up-to-date technology and features that inform its readers of the latest developments in electronics and electro-music.

Education in its broadest sense is therefore one of the key aspects of this magazine.

It is also exciting that it will be read by teachers and pupils alike through its wide circulation in this country and many subscriptions abroad.



EDUCATION

The Portable Music Lab

One of the most pleasant rewards of music teaching is to see individual pupils in a class group responding and learning in their own different ways. Many children who do not take to group class singing will nearly always have a go at playing an instrument. But all the pupils in a particular class have to be catered for and this at first seems as unsurmountable problem with large groups of 25 or more children. Nevertheless, once the teacher knows his individual pupils in a group and arranges activities on a rota system from week to week, the practical teaching of a group of six or more pupils can be done effectively even using such instruments as the synthesiser, electric piano or guitar.

I am not assuming that the music teacher knows a lot about electronics, although E&MM should provide plenty of information each month! So once electronic instruments are considered, the problem of operating and maintaining the electronics may put a lot of people off — apart from their lack of sufficient playing ability on the keyboard or guitar.

Synthesisers can be used in the classroom in a number of ways so I'll leave these for a later article and look at a system from America that should offer a ready-made solution to finding enough instruments to go round. Although the initial outlay may be considered high, the long-term benefits of using "real" electronic instruments make it worth the investment. Often area education authorities, rather than individual schools are willing to purchase a music system and allocate them on a temporary basis.

The 'portable music lab' system comes from an American company: Multivox/Sorkin Music Company Inc. They have two music labs — one for guitar and the other, which has only just become available in its up-dated form, for the electronic piano.

Mobile Piano Lab

This is a compact, modular solid state system on a fold-up, roll about table which may be expanded to accommodate a maximum of 18 students. Its design enables the whole unit to be moved around the room and locked away at the end of the day. The electronic pianos have a 61-note keyboard and slide controls for piano/harpsichord sounds plus vibrato and pitch adjustment. The control unit is housed in a free-standing case and puts the teacher in two-way communication with any pupil at the touch of a button. An additional button is provided for reaching all students simultaneously. The instructor's piano and microphone headset are connected directly to the control console. Facilities are also provided for the connection of a cassette tape player or other external source, for programmed learning cassettes, demonstrations, accompaniment, etc.

The system's big advantage is in its potential for providing individual instruction at the level required. In practice, it is advisable for the teacher to explain to the whole group what the Lab is all about and then select reasonably compatible groups of pupils for a general introduction lesson, before beginning to give personal attention to individuals who are perhaps not quite sure of how to proceed. One item that does not seem to be provided is a pupils step-by-step instruction book, so presumably the teacher would have to find a suitable course book.

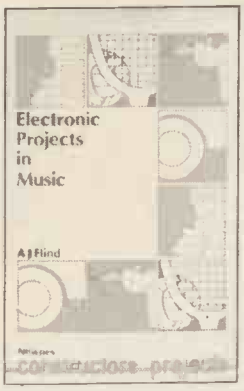
Guitar Lab

This is similar in concept to the piano lab with a music wagon containing 8 electric guitars, cables, leather straps and picks plus the individual headsets with boom microphone and teacher's control console.

Further information on the full range of Premier Labs can be obtained from Multivox/Sorkin Music Company Inc., 370 Motor Parkway, Hauppage, New York 11787 (Tel: (516) 231-7700). **E&MM**

BOOK REVIEWS

Electronic Projects in Music
by A. J. Flind
Published by Newnes Technical Books
Price £2.50



A book which seeks to explain the functioning of electronic circuitry, without one single calculation, must surely have a great deal to interest the novice and the non-mathematically minded.

'Electronic Projects in Music' is intended to be of practical value to any amateur interested in both the production and reproduction of electronic music. Chapter one sets the style of the book with a single-transistor, flat response amplifier, which is used to demonstrate how this basic building block of sound engineering functions. The author then proceeds progressively to more elaborate circuitry, including in his repertoire the operational amplifier.

A general overview of the history and workings of the op amp — one of the most important of the electronic engineer's tools — is given in the book's usual concise and simplistic terms.

Several novelty circuits have been included, the most intriguing of which must surely be the 'mini organ' in chapter eleven. This useful project features switchable vibrato and a half watt power amplifier. The most ingenius aspect of this miniature circuit is its keyboard, which uses a pre-calculated resistor network, leaving only one control necessary to tune the entire keyboard.

Mr. Flind has taken the standard text book style for beginners' projects and succeeded in presenting them in a commendably clear and approachable manner. Each project makes use of standard veroboard, and contains a circuit diagram, a schematic representation of the board layout from above and below, as well as a clear and informative photograph.

Attention is also directed towards the linking of the various effects into existing equipment.

I consider 'Electronic Projects in Music' a book to be recommended to anyone wishing to develop an active interest in the musical aspect of electronics without being bogged down by mathematical formulae.

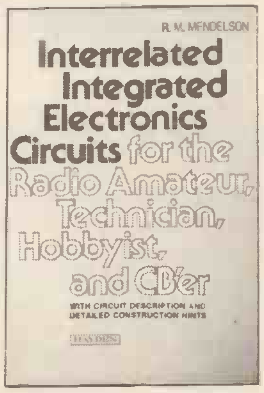
Ron Levy

Inter-related Integrated Electronics Circuits
by R. M. Mendelson
Published by Hayden Book Co. Inc.
Price £5.53

The full title of this book is 'Inter-related Integrated Electronics Circuits for the Radio Amateur, Technician, Hobbyist and CB'er.'

It should be noted that the book is American in origin, and that certain adaptions to the circuits portrayed within the text may be necessary, to interact successfully with British mains voltage and to make them safe for use in this country.

Each project concludes its text with a 1:1 printed circuit board artwork, complete with component overlay. If that does not put most British books to shame then the appendix might, for every artwork is repeated in bold type and can quite easily be cut out and removed from the book.



The layout of this publication bears a distinct resemblance to the familiar arrangement used in the many monthly periodicals that adorn the market. A circuit description, incorporating a photograph of the finished article and the circuit diagram, is followed by the parts list. Most of the components used throughout the book are readily available from the larger, and better known mail order companies in this country. When you have dug out and acquired all the necessary bits and pieces, you can then read on and thread your way through the script headed 'Construction.' It is here that the artwork and overlay appear together with many constructive hints to help prevent any disappointment when you reach that apex in electronic project building — the point of 'switch-on.' However great the enjoyment of construction, it is never the same, when the final result refuses to oblige in doing what it ought.

The author has chosen five areas from which to extract his designs. They are: power supplies, amplifiers, passive circuits, instruments and games. Some of the more noteworthy circuits include dual tracking voltage supply, SSB detector, Wheatstone bridge, frequency counter, dwell-tachometer, and digital roulette.

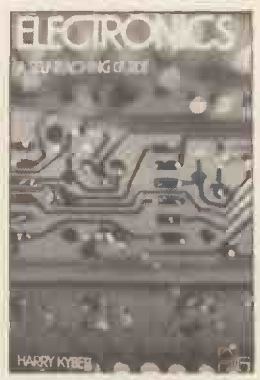
N.F.

Electronics — a self teaching guide
by Harry Kybett
Published by J. Wiley & Sons Inc.
Price £5.85

Harry Kybett's authority in writing a teach yourself electronics book, is the result of many years producing training programmes for the Sony Corporation, and his work for British television and Columbia Pictures. He is probably better known for his works on video tape recorders. He takes the stand that most other home study publications are over complicated by containing too much irrelevant and highly technical dogma.

The book does not follow the usual pattern of tackling the simpler passive components before venturing on to higher levels, instead it starts almost immediately with the diode and transistor, then goes on to devote more than half of the book to, AC theory, oscillators and amplifiers. Each chapter is remarkably reminiscent of those tests which one took at school, where you get asked a series of questions, each followed by its answer. At the end of the section you are greeted by another questionnaire, the intention of which is to measure your progress through the subject.

A prologue heads each chapter, guiding you in the direction of what is to come, and roundly informing the reader of the extent to which his knowledge will be increased. The book culminates in one massive 'final self-test.' After successfully completing this test your understanding of electronics is laid down in no uncertain terms, for the 'conclusion' states that you will be able to: 'Re-



cognise all the important electronic components; recognise several, simple circuits; do simple circuit calculations; analyse simple circuits, design simple circuits; build simple circuits in a lab and make them work.'

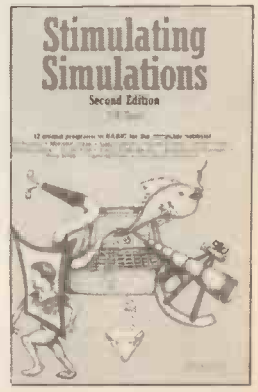
A disappointment of the book is the opening statement, 'This book assumes some knowledge of basic electricity... if not you should read Charles Ryan's 'Basic Electricity' (also a self teach guide...').

I would have thought that a really good book, covering the rudiments of any subject, would have started at the most logical point — the beginning.

N.F.

Stimulating Simulations
by C. W. Engel
Published by Hayden Book Co. Inc.
Price £3.95

This book is written one hundred per cent for the computer hobbyist. It can only be described as a fun book. It is a paperback and at £3.95 is very reasonable, considering that it is imported. The author has tried to steer clear of the many computer games based on mathematical theorems and has achieved a book full of recreational programming, all of which is designed to give a graphical representation of the real life situation or sequence of events it is simulating. His second breakaway from convention is to deliberately prevent the computer from doing all the 'thinking' and thereby force the user into developing strategies to achieve the objectives.



There are twelve programs featured in the book, a brief resumé of which follows:

Art Auction — Buying and selling works of art to make a huge profit, if possible.
Monster Chase — You are being chased by a monster. If you can preoccupy it for ten moves your life is spared.
Lost Treasure — Speaks for itself.
Gone fishing — Catch as big a haul as possible but distractions such as a storm and boat problems, in a shark ridden sea, spell danger.
Space Flight — Plot a course, keep to it and do not run out of fuel whilst delivering medical supplies to a distant planet.
Starship Alpha — As above but more interesting.
Forest fire — Your mission, should you choose to accept it, is to control, subdue and extinguish the fire.
Nautical Navigation — As title.
Business Management — You control a manufacturing company — maximize the profits.
Rare Birds — Identify as many rare birds as you can.
Diamond Thief — You're the detective, catch him.
The Devil's Dungeon — You must enter a bottomless, demon-filled cave and fight with monsters, poisonous gas and other horrors to obtain and escape with the gold.

Each program is well documented, has a good flowchart and a sample run. A thoroughly enjoyable book which gives days of fun at the keyboard and has the added advantage of educating the user in many elements of software design.

Nigel Fawcett

RECORD REVIEWS

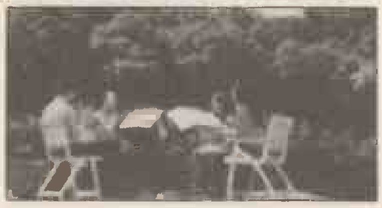
Sternklang (2 LPs)
(Park Music for five groups)
Karlheinz Stockhausen
Deutsche Grammophon 2707 123

Stockhausen calls Sternklang a work of sacred music, yet at the very heart of the composition is the relationship between the music and the classical star constellations, making this a more mystical exercise. 'Park Music for 5 Groups' was conceived in 1969/71 and first performed in the Berlin Tiergarten in June 1971. As 'spatial' music this recording suffers greatly from the Stereophonic medium; few of the 'subtle timbral changes' that Stockhausen desired are here. Other similarly conceived works by this composer benefit enormously from the use of space:

GRUPPEN — for 3 orchestras 1955/57
KONTAKTE — for Electronics, piano and percussion 1958/60
TELEMUSIK — 5 channel loudspeaker electronics 1966

Thus Sternklang would have been better served in Quadrophony.

The five groups of musicians play an assortment of wind and stringed instruments as well as synthesisers and also use the human voice to great



effect, reminiscent of Stockhausen's Stimmung of 1968 for voices and electronics. The five chord material for this rather lengthy piece suggests an accessibility uncommon in much music of the latter half of this century Fundamental notes and their related harmonic series are articulated in a variety of ways; the marriage of synthetic and acoustic sounds present a tantalizing sound-scape and the limited pitch material really does allow the listener to sink into Stockhausen's 'cosmic whole.'

The beautiful bell sounds that begin the work also bring it to a close, their tonality of 'F' seeming to motivate the related tonal-centres of 'Db' and 'Bb' that permeate the whole piece.

If this music is for 'concentrated listening in meditation' then I must confess that I was distracted by the insistent use of isorhythm, the interjections of a rather operatic soprano and the literal references to the star signs including one timely scream of 'Pollux.'

There are some lovely moments in smaller episodes of the piece, the trombone/voice cadenza for example represents a style very akin to Vinko Globokar and the movement in modern instrumental music to beat electronic music at its own game. Also very attractive is the use of chanted monotone, a device heard before in Stockhausen's investigation into Buddhism and related ceremony.

Among the five groups there is a British contingent of Peter Britton, Tim Souster, Robin Thompson, Roger Smalley and others; proof of our standing in the contemporary music world.

To sum up it would be wise to remember that this work was conceived for performance in a large space, to create a feeling of 'spiritual ceremony,' we therefore are left with a catalogue of musical events. That they are beautiful in themselves is remarkable and altogether due to Stockhausen's sympathetic ear.

Jeffery J. Wilson — E&MM

Sirius (2 LPs)
Karlheinz Stockhausen
Deutsche Grammophon 2707 122

'Sirius, the alpha star of Canis Major-8.7 light-years away... For the inhabitants of Sirius, music is the highest form of all vibrations.' We are asked to accept this state of affairs before embarking upon a musical star trek through the astrological constellations. This voyage, judging by the sleeve photographs, would seem to be as theatrical as Stockhausen's 'Harlequin' (1975) for solo clarinet. We are denied the theatrical experience and have to be content with the musical one.

Sirius is written for trumpet, soprano, bass clarinet, bass and electronic music. It falls into three sections: Presentation, Wheel and Annunciation. The Wheel is the only changeable part of the composition enabling four different versions to correspond with the seasons. Four main melodies are utilised in this section, deriving from an earlier work, 'Tierkreis' (1975/76); I can thoroughly recommend this charming and uncharacteristic Stockhausen monodic writing, recorded on this label (D.G.2530 913).

The eight-track tape electronic music section of this work was conceived in Cologne (July 1975/March 1977) and in the Presentation the composer makes use of realistic sounds, such as recordings of wind, water and fire. For the remainder the E.M.S. Synthesiser 100 is used very largely as an additional voice in the corporate ensemble.

Very crucial to this work as a whole is Stockhausen's conception of the analogous relationship between the natural sciences and electronic music. This concept of structural similarities between natural phenomenon and the composer's art in electronic music is not as technical nor as high powered as it sounds. Indeed, in Sirius we have a glimpse of Stockhausen's wit when the soprano Annette Meriweather complains about the early arrival of Libra heralding winter (must have been recorded in England!).

The very comprehensive sleeve notes, including the composer's own text and sample 'dope sheets,' make this an invaluable addition to any contemporary collection.

Jeffery J. Wilson

Karlheinz Stockhausen

Annette Meriweather — Soprano

Markus Stockhausen — Trumpet

Suzanne Stephens — Clarinet

Boris Carmelli — Basso profundo

EVENTS

Apr 14th-16th — LONDON COMPUTER FAIR, North London Polytechnic (opposite Holloway Road tube station).
Exhibits include Hobbyists, Club Stands, Work Shops, Seminars.

Apr 29th — MICRO SHOW, New Century Hall, Manchester.
Aimed at industry although the hobbyist would find it interesting.
Further information from Online Conferences Ltd., Argyle House, Joel Street, Northwood Hills, Middlesex.

May 8th-11th — INTERNATIONAL MUSIC FAIR, Poland.
For further information contact Management of the Poznan International Fair, Glogowska St 14, 60-734 Poznan.

May 10th-17th — AUDIO VISUAL & TELEVISION FAIR, National Exhibition Centre, Birmingham.
For the Entertainment Industry.

May 12th-14th — INTERNATIONAL MICRO ELECTRONICS EXHIBITION, Exhibition Centre, Bristol.
Aimed at industry and business.
Free tickets from Euro Fairs Ltd, 9 Park Place, Clifton, Bristol BS8 1JP.

May 22nd — THE EXPERIMENTAL MUSIC GROUP present a music theatre piece which deals with 'Exploitation' particularly in the field of advertising.
Venue, Royal College of Music, London. Tickets available on the night.

May 26th — ELECTRONIC MUSIC STUDIO.
Informal concert featuring work by Royal College of Music students.
Venue, Royal College of Music, London. Tickets available on the night.

June 27th-July 4th — KEYBOARD AND ELECTRONIC MUSIC FESTIVAL, to be held at the London Musicians' Collective, in conjunction with the October Gallery.
If you wish to participate, contribute or perform, please post tapes, videos, cassettes to: Ken Guntar, c/o October Gallery, 24 Old Gloucester St, Queen Square, London WC1.
Closing date 20th May 1981.

Don't forget the Franz Lambert concerts during April and May on the Wersi organs. Details on page 83.
We shall be pleased to publish news of forthcoming electronic and electro-music exhibitions, clubs — also special electronic music concerts.

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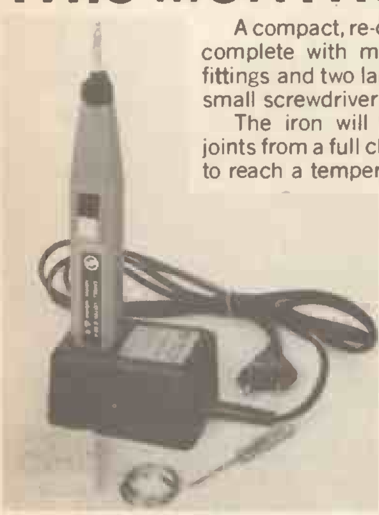

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MURPHY'S LORE
by STICHOS

Oh, 'tis 'Murphy this,' and 'Murphy that'
and 'Murphy jiggled me arm'
Are the piteous cries that rend the skies
when our projects come to harm.
'If it can go wrong — it shall go wrong'
is the rede that runs world-wide;
So all Snags obey, and — night or day —
their irritant faults provide.

Who is this Murphy? What is he, and
how was his Law made clear?
Is it true his Pop was a New York cop
who'd been born in Ballyneer?
Or did an emigré from Europe
feeling bitter and morose
Leave his life of strife for an Irish wife,
and change his name in Ballyclose?

Make sure you are sitting in comfort,
and the bottle's close to your hand,
As Truth is revealed that's been concealed
whilst Error ran rife in the land.
The heart of the matter's quite simple,
(though rumour's sure to persist),
Stripped of all myth we get to the pith —
that Murphy — doesn't — exist!

My! You've gone all puffy and purple;
sit down; sup up, and relax.
A hasty decision lacks in precision,
so let us consider the facts.
The existing Law's not disputed —
it's the existing Man we doubt;
Not a him-type him but an acronym
is what M.U.R.P.H.Y.'s all about.

Savants point to a deeper Law
while professionally deposing
That ev'ry Action incurs Re-action
which has equal force opposing
Any change in status quo; thus huge efforts
result in huge tantrums,
Whilst removing stress, and struggling less,
turns set-backs into phantoms.

Our so-called 'M.U.R.P.H.Y.'s Law,' as proper
sibling to a mightier sire,
Controls the effects of those defects
that are known to raise Man's ire.
Fully-named 'Make-Useless Reaction, —
Primarily Human Yearning'
It seeks to reverse, in manner perverse,
our efforts at every turning.

Wise men use Laws for advantage —
making allies out of opponents —
Thus I've not lost my wits in smashing to bits
this box of brand-new components;
For we cannot deny the Law must perform
impartially its duty,
So, *I'll* make each Snag; and, — later on — brag
that the *Murphy-made* rig is a beauty!

ADVERTISERS INDEX

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CORRIGENDA

The following errors and omissions have been noted in previous issues of E&MM and are brought to your attention:

MARCH ISSUE. Hi-Fi Sub-Bass Woofer
Page 32: TR8 is shown as a PNP transistor in the wiring diagram. It is in fact a NPN device.
APRIL ISSUE. Direct Inject Box
Page 29: 'R10 and R11' should read 'R9 and R10'
Matinee Organ
Page 37: C212 should read C208

The Editorial staff apologise for any inconvenience that may have been caused to our readers.

TECHNICAL WRITER

Additional staff are needed to join our editorial team to help us produce projects, features, news and reviews that make E&MM the No. 1 monthly for the electronics and music hobbyist.

We require immediately a TECHNICAL WRITER with experience in editing or writing projects and articles in the field of electronics.

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