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ELECTRONICS & MUSIC MAKER

April 1981

100 Pages for the Electronics and Music Hobbyist!

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16 The Avenue
Highams Park
London E4 9LD
Tel: 01-527 3376

Published by
Maplin Publications
282 London Road
Westcliff-on-Sea
Essex SS0 7JG
Tel: (0702) 338878

Distributed by
Cemas Limited
24 Bridge Street
St Ives
Huntingdon
Cambridgeshire PE17 4EG
Tel: (0480) 63942

Printed by
Eden Fisher (Southend) Limited

Typeset by
Quillset Typesetting

Subscriptions
Rates for 12 issues:
UK & Overseas Surface: £9.90
Europe: £11.64
Airmail: £25.20

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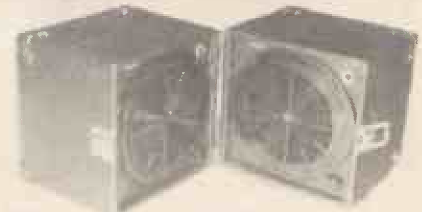

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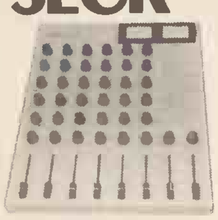

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ELECTRONICS & MUSIC MAKER

A tremendous response for E&MM from our readers!

In this time of recession, many people could rightly argue against the merits of launching a new magazine. Nevertheless, since September last year when the editorial and consultant staff were being appointed, one outstanding factor was evident. That everyone involved in E&MM's plans for the future was overwhelmingly enthusiastic about a magazine that brought together electronics and music, in a way that would appeal to a wide age range of hobbyists at all levels.

One development that was not envisaged was the receipt of a large number of subscriptions even before the first issue was available! We are already on international distribution with a lot of demand for E&MM copies from

by Mike Beecher, Editor
Electronics & Music Maker.

Australia and even as far away as Norway, Iceland, Poland, Finland and India.

I have personally been very excited about the response to our cassette as an aural complement to the magazine, for in my years of reviewing electronic instruments I found that a recording of an instrument's sounds always prompted a more objective response to its capabilities. The E&MM cassette is not like a commercial recording, but provides in the best stereo quality we can get a means of assessing for yourself what our electro-music projects sound like. It also helps us maintain our aim of updating our readers in electronic music developments as soon as they are available, and in the past it may have been impossible for many to ever hear the sounds of the most expensive instruments making music.

Schools and colleges should also benefit in the educational and informative presentation of E&MM and a special competition for hobbyists projects is planned. This will also allow musicians to perform their compositions on their own electronic instruments.

So many people today are eager to build projects for the home and now that music making in the home involves computers as well as electronic instruments we have an unique opportunity to promote 3 main areas of leisure interest for the future — electronics, computing and music.

Mike Beecher

Letters

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

Dear Sirs

Congratulations on a first class, First Issue. The presentation of each article was both clear and concise.

Keep up this standard and you are on a winner.

G. B. Bromage
Leicester

Dear Sir,

May I first congratulate you on the launch of your new magazine Electronics & Music Maker which fills a long felt need for people like myself who are electronic hobbyists with a strong interest in musical instruments.

Yours sincerely
A. W. Button
Corby

Dear Sir,

Congratulations on a super magazine!

Yours faithfully
R. J. Teasdale
Kings Langley

Dear Sir,

Thanks for a GREAT! new magazine.

Yours faithfully
L. A. Cowburn
Preston

Dear Editor,

Many congratulations on the first edition of your new magazine, I haven't been able to put it down. I am interested in the music articles but found all the other articles equally interesting, written in language anyone can understand. All the reviews were excellent, as were the news pages.

Best of all is the idea of having a cassette aural compliment to the magazine. I can't wait to receive my copy.

Thanks again for providing us with a magazine really worth the 65p, with the special offers included its great value.

Looking forward to the next issue. Keep up the good work.

Mr S. Byhurst
Caterham

Dear Mr Beecher,

May I first of all congratulate you on such a superb magazine. As a musician interested in electronic music it is like a dream come true to read a magazine such as yours. May I wish you all the success for the future.

Yours sincerely
Paul Miller
Craigavon

Dear Sirs

Let me congratulate you on the superb new magazine that brings my two main hobbies together under one cover.

I look forward to all subsequent issues of Electronics & Music Maker.

Thanking you in sleepless anticipation,

B. N. Bidgood
London

Dear Editor,

Browsing through the magazine racks in the newsagents I came across the first issue of E&MM. After a quick glance, I thought it justified the 65p.

Having now read it and being interested in electronics and electro-music I can only say this is a superb, well-balanced in content magazine.

The constructional projects are particularly good in all aspects, the technical writing being easy to understand.

Again many thanks, keep up the good work.

Yours sincerely
B. I. Hewlett
Evesham

Dear Editor,

This is certainly the type of publication I have been hoping and waiting for. I am impressed with it and feel it certainly fills a major gap in the field of electronics.

With all good wishes for the success of your new magazine.

Yours sincerely
E. Skelton, C.Eng.
Stockton-on-Tees

Dear Editor,

Having just received and glanced through the articles in the first issue of Electronics & Music Maker, we have decided to add this to the list of technical journals that we take.

May we wish you every success with your new venture.

The Sphereola Company Ltd
Rochester

Dear Sir,

I have just purchased your first edition of Electronics & Music Maker and am most impressed with it.

Yours faithfully
A. H. Moore
Tavistock

The Syntom DRUM SYNTHESISER

Join Warren Cann in the drum revolution with this unique touch sensitive instrument costing under £15

by
Clive Button

The Syntom is a very effective drum synthesiser that can produce a variety of fixed and falling pitch effects, triggered either by tapping the unit itself, or by striking an existing drum to which the device is attached.

Four potentiometers give control over different characteristics of the sound, the Volume control being used to switch off the internal battery as well as determining the level of the signal sent to the external amplifier. The Decay pot. governs the time taken for the sound to die away after each strike, from less than 1/10 sec. to several seconds, giving a wide range of envelopes. The frequency of the note is variable over the entire audio range by means of the Pitch control, and the Sweep control introduces a voltage causing the pitch to fall as the amplitude decreases. These controls, when used in combination with each other enable the most popular drum synthesiser effects heard on commercial recordings to be obtained.

Circuit

The Circuit is in three main parts: the envelope generator, the Voltage Controlled Oscillator (VCO), and the Voltage Controlled Amplifier (VCA). IC1 forms the first stage of the envelope generator, detecting the signal produced by the crystal earpiece when the unit or the drum to which it is fitted is struck. The trigger signal charges C1 via D1, and the capacitor is then discharged slowly by RV1 and R3. This envelope voltage is buffered by IC2c and sent to the VCA. It is also fed (via RV2 — the Sweep potentiometer) to IC2d, the VCO control voltage summing amplifier where it is mixed with a voltage from the Pitch control, RV3.

The VCO consists of an integrator formed around IC2a, and a Schmitt trigger (IC2b) driving TR1. When the integrator voltage reaches the upper threshold of IC2b, TR1 is turned on shorting the non-inverting input of the integrator to earth, causing it to act in inverting mode. Hence the output voltage falls until the lower threshold is reached, IC2b changes state, turning off TR1, and the output of IC2a starts to rise, as it is once more in non-inverting mode. The resultant triangle wave is fed to the VCA section, which consists of a CA3080 transconductance amplifier, IC3. The gain of this amplifier is controlled by the output of the envelope generator, such that as the envelope voltage decays,

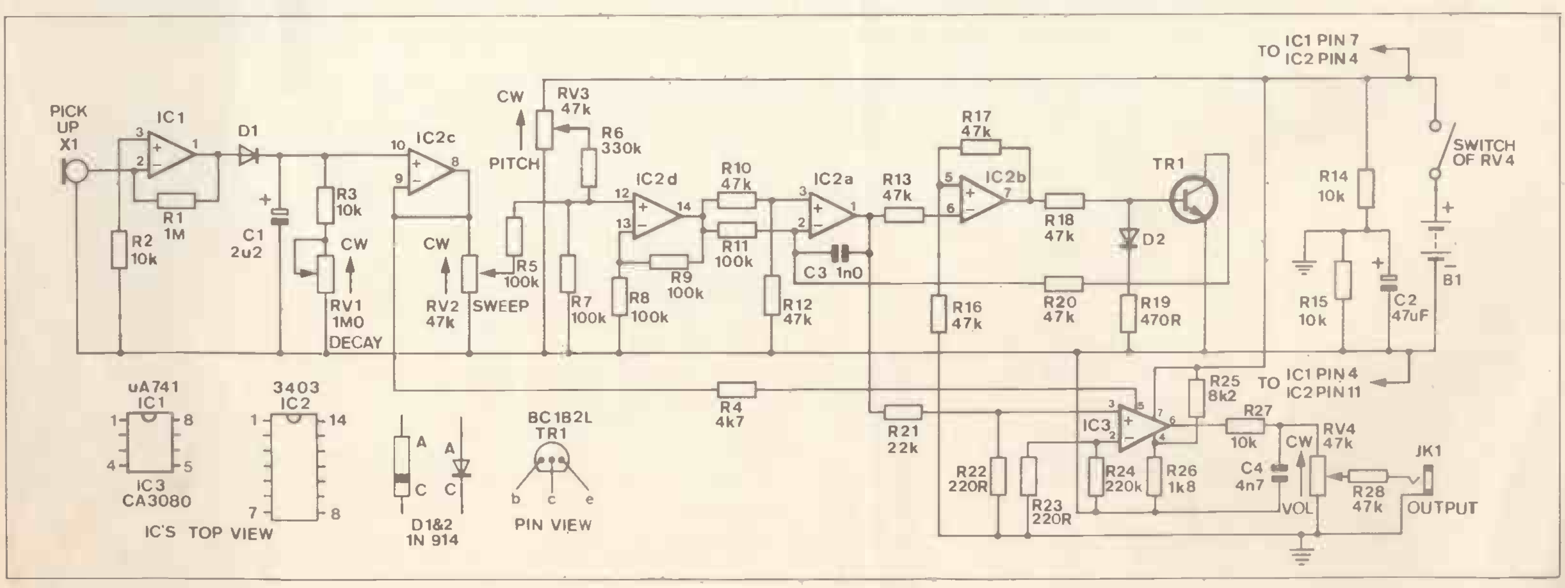


Figure 1. The circuit diagram of the Syntom.

the triangle wave is increasingly attenuated until it is reduced to a very low, inaudible level. The output of the CA3080 is fed to RV4, the Volume pot, and then on to the jack socket.

A dual supply is derived from the single 9V battery by a potential divider formed by R14 and R15, providing a 0V supply which is stabilised by C2.

Constructional Details

All resistors, capacitors and semiconductors except R28 are mounted on the printed circuit board in that order, taking care as always with the orientation of electrolytic capacitors, IC's, diodes, and the transistor. If the suggested case is used, veropins for connection of the pots, jack, battery and earpiece must be mounted from the component side since this side faces away from them and there is no room for the wires to pass around the edge of the board. Otherwise they fit from the track side, or can be left out altogether, the wires being soldered directly to the tracks.

The potentiometers are mounted on the front side (which is the side opposite the removable side if using the case suggested in the parts list), after their spindles have been sawn to a length suiting the knobs. The jack socket is best mounted on the back, where the lead to the external amplifier will be out of the way during use, but take care here since the board, battery and earpiece all fit near the back of the case. The connections to the off-board components can now be made, and the PCB fitted in the special slots on the inside of the case (with the track side facing towards the pots). Note that R28 is connected directly from the wiper of RV4 to the signal terminal of the jack socket.

For use with an existing drum, the Syntom is attached to the drum by a securing bolt and a bracket made from 25mm aluminium channel section which is fixed to the case by two bolts with washers. A simple hexagonal-head bolt could be used, but the handwheel bolt specified in the parts list is much easier to use, and lends a professional appearance to the finished unit. One side of the bracket must be drilled and threaded to accommodate the bolt, and it is a good idea to stick a small piece of rubber on the inner face of the opposite side to prevent scratching of the drum rim. The final constructional stage is to fit the knobs, connect the battery using a PP3 connector, and screw on the back of the case. A piece of foam glued to the inside of the back will hold the battery against the potentio-

PARTS LIST

Resistors — all 5% ⅓W carbon unless specified

R1	1M0		(M1M0)
R2,3,14, 15,27	10k	5 off	(M10K)
R4	4k7		(M4K7)
R5,7,8, 9,11	100k	5 off	(M100K)
R6	330k		(M330K)
R10,12, 13,16-18,20, 28	47k	8 off	(M47K)
R19	470R		(M470R)
R21	22k		(M22K)
R22,23	220R	2 off	(M220R)
R24	220k		(M220K)
R25	8k2		(M8K2)
R26	1k8		(M1K8)
RV1	1M0 log. pot.		(FW28F)
RV2,3	47k log. pot.	2 off	(FW24B)
RV4	47k log. pot. with switch		(FW65V)

Capacitors

C1	2u2 63V axial electrolytic		(FB15R)
C2	47u 10V axial electrolytic		(FB38R)
C3	1n0 Mylar Film		(WW15R)
C4	4n7 Mylar Film		(WW17T)

Semiconductors

IC1	uA741, 8-pin DIL		(QL22Y)
IC2	3403		(QH51F)
IC3	CA3080, 8-pin DIL		(YH58N)
TR1	BC182L		(QB55K)
D1,2	1N914	2 off	(QL71N)

Miscellaneous

X1	Crystal earpiece		(LB25C)
JK1	Mono-jack socket (open type)		(HF91Y)
	Case MB2		(LH21X)
	Handwheel bolt		(YL23A)
	M4 6mm bolts		(BF33L)
	Printed circuit board		(GA05F)
	PP3 connector		(HF28F)
B1	PP3 battery		
	Ribbon cable (10 way)	1m	(XR06G)
	1mm Veropins		(FL23A)
	Knobs	4 off	(YG40T)
	Blue knob cap		(QY01B)
	Green knob cap		(QY02C)
	Grey knob cap		(QY03D)
	Red knob cap		(QY04E)
	Front Panel		(BH60Q)

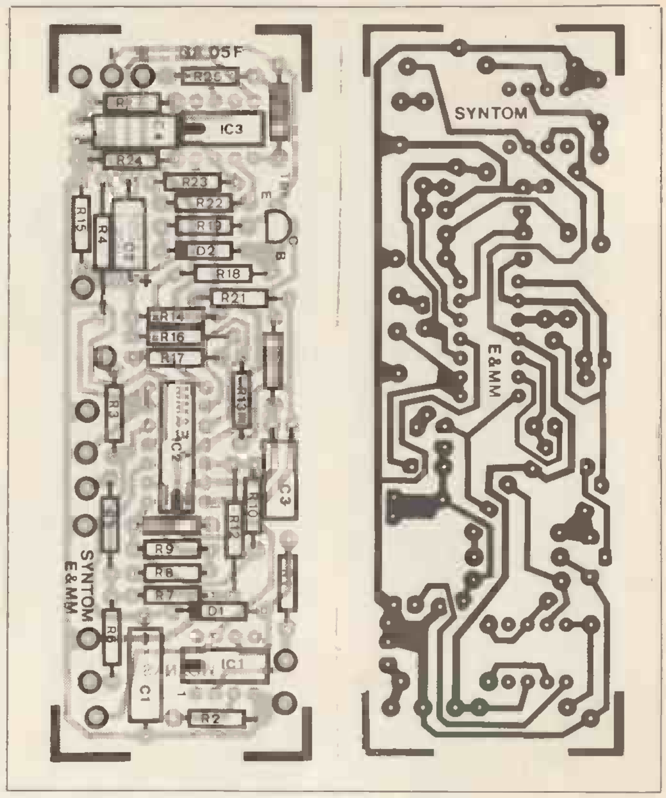


Figure 2. The Syntom PCB.

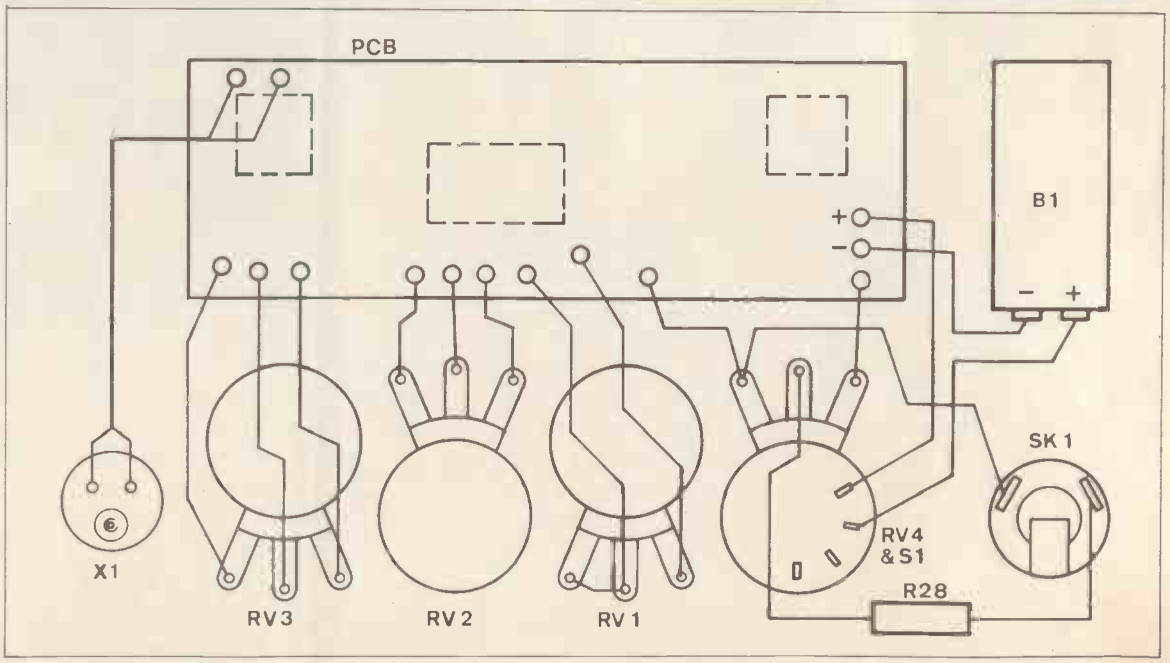
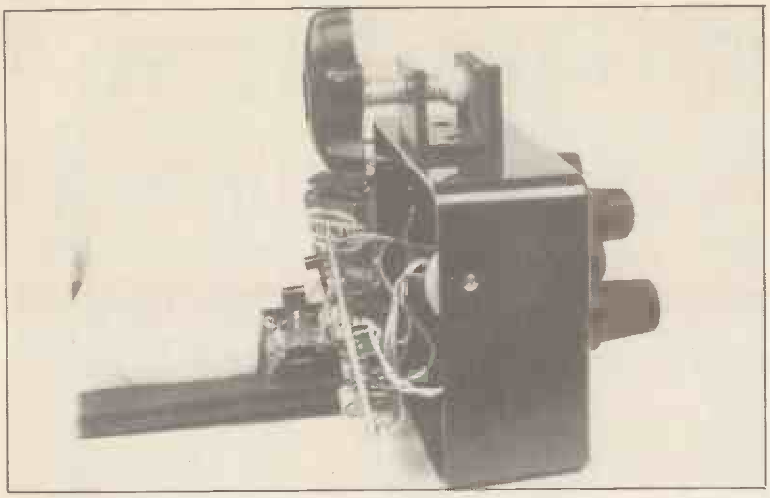


Figure 3. PCB wiring, with the board viewed from the track side.



meters and prevent rattling, which could cause unwanted triggering of the unit.

Testing & Use

Connect the drum synthesiser to an external amplifier, and with all controls at midway position, firmly tap the case. A medium duration falling pitch effect should be heard, and experimentation with the controls will soon reveal the whole range of sounds available. The sensitivity of the unit has been fixed to respond to a direct hit or a hit on the drum to which it is fixed but not to external sounds and vibrations, including those from other drums in the kit. When fixed to a drum, the Syntom can be set off by just hitting the drum rim with the stick, or caused to sound along with the drum if the skin is hit. Since the sound varies with stick impact, particularly interesting effects can be produced by, for example, using a sharply falling pitch with an envelope of similar length to the natural drum sound, and playing single hits and rolls of differing impact force on the drum skin.

Since the drum synthesiser is battery powered, it should be turned off when not in use to conserve power, though a single PP3 will still provide for up to 60 hours of continuous playing.

Read Warren Cann's comments in our Ultravox feature and listen to it on the E&MM cassette.

E&MM

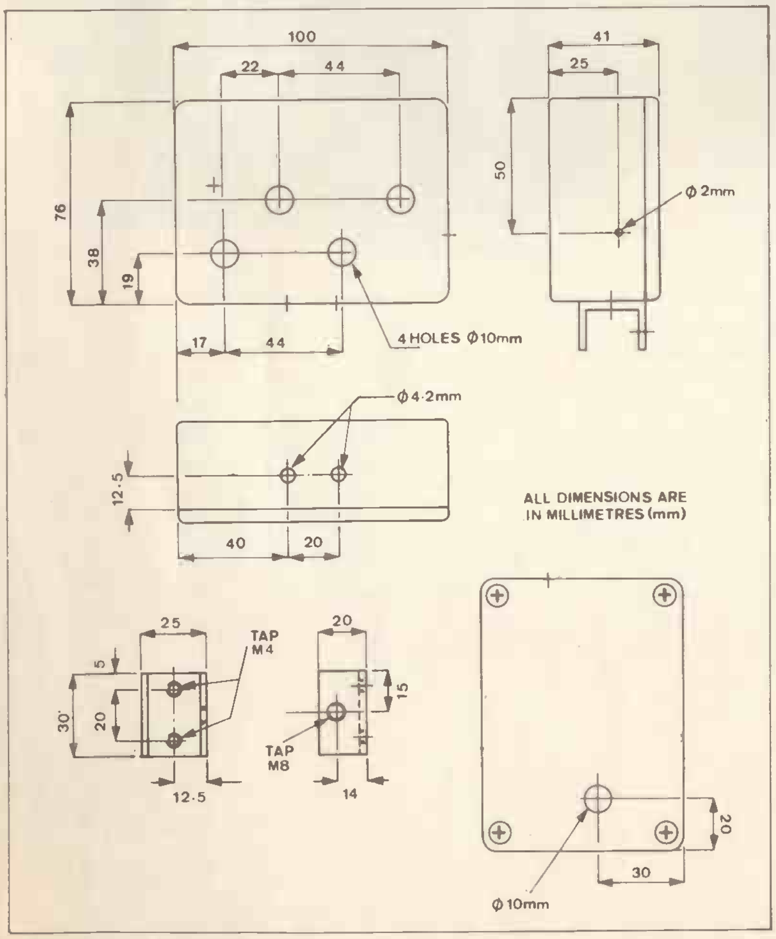


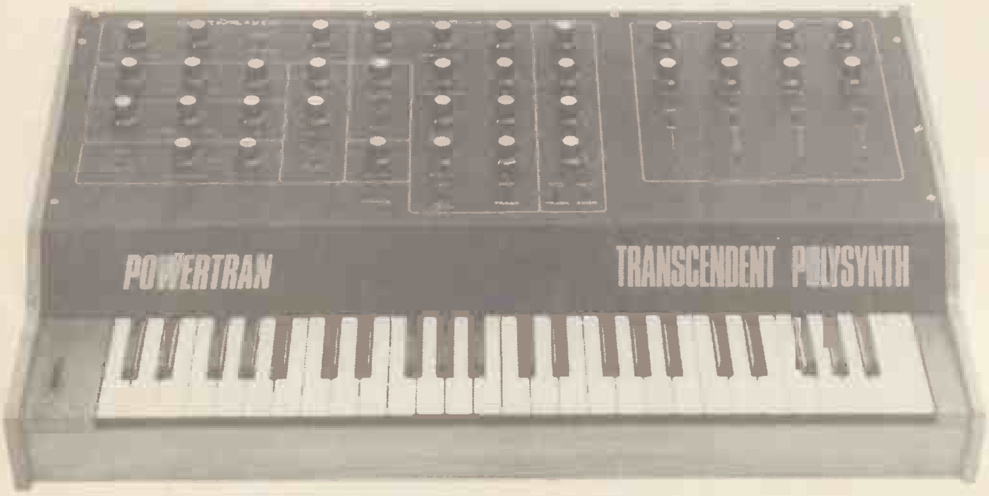
Figure 4. Case and bracket construction.

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.



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POLY 13	Pots, Switches for master control board	£11.80
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MANY MORE KITS ON PAGES 28 & 31

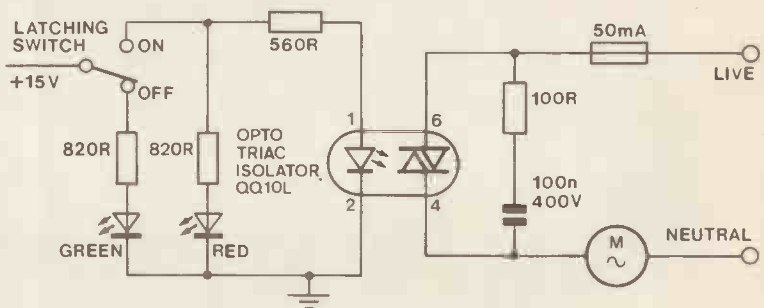
CIRCUIT MAKER

One of the nice features about a magazine such as this is the way readers can contribute, thus presenting their ideas to a large number of people. Each contribution may be a full feature or constructional article describing some piece of electronic, electro-musical equipment, or more probably, a short piece containing the circuit diagram and a short piece of explanatory text. It is thus our intention to set aside pages in each issue for 'Circuit Maker', a feature dedicated to short ideas, mostly sent in by readers.

Remote Disco Deck Switching

Nearly all disco decks have some form of deck switches on the front console. These are generally mounted away from the actual mixer to avoid hum, since they usually switch the mains supply to the motors directly. It is much more convenient to have the decks controlled from a switch adjacent to the relevant fader, thus allowing full control with one hand and this indicates that a remote switching unit is required. A small relay could be used, but apart from cost, a relay makes a mechanical contact and thus suffers from wear and electrical noise. The design idea presented here is for a very small solid state switching circuit using one of the fairly new opto-isolated triacs. This can be mounted close to the motor and can be controlled from a variety of switching circuits. A simple push to start and push again to stop system is employed here, with two LEDs to indicate the state of the deck. Obviously, the push switch can be replaced with a simple toggle.

The switch operates the LEDs on the panel, and also the LED in the opto-isolator. The opto-isolator triac will handle 100mA, and should be adequate for most deck motors (an SP25 takes about 25mA), but a 50mA fuse should be included in circuit. A small snubber network across the triac helps to kill any switching spikes, but these will be minimal anyway since the triac is continuously driven.

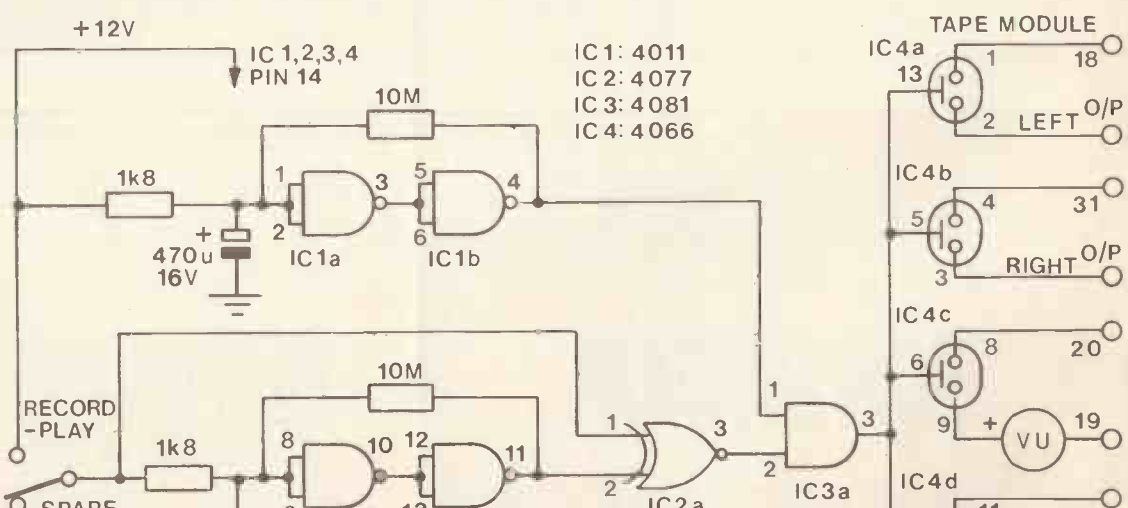


Maplin Cassette De-Thump

G. Durant, Brayton, N. Yorks

This circuit was designed to remove the irritating thump which occurs as the Maplin cassette deck is switched on, or when the record switch is operated. It is split into two main parts. The first part, a Schmitt trigger built around IC1 a & b, generates a delay at power up. This works by allowing the 470uF capacitor to charge via the resistor until the voltage is sufficient to trip the trigger, which then locks into the high state. The second part is similar, but operated from a spare set of contacts on the 'switch circuit board' record latchswitch. When the record button is pressed or released a two second delay occurs before the output of the trigger changes state. This delay is combined with the original switching signal by an EXclusive-NOR gate. Since an EX-NOR gate gives a low output when the two inputs differ a low output will be present on IC1d for two seconds every time the record switch is operated (either on or off). This record delay and the switch on delay are AND-ed to operate a 4066 quad bilateral switch, which only connects the outputs and the VU meters when the logic drive is high. The thump is thus blanked. The pin numbers on the circuit refer to the Maplin Hi-Fi tape module, but the circuit can be applied to any recorder where this problem exists.

A small reduction in the number of ICs may be obtained by using the more expensive 4093 quad NAND Schmitt trigger instead of the discrete gate versions used in this design.



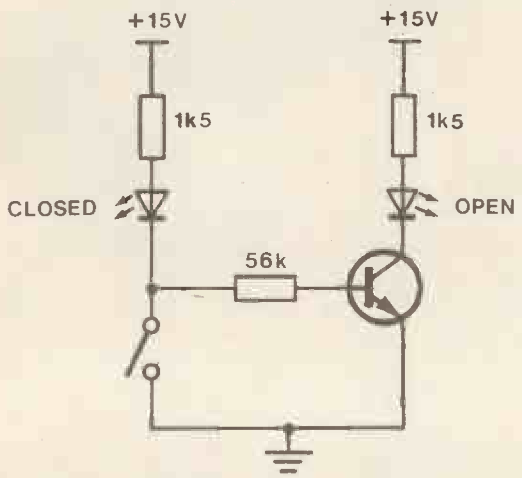
Headphone Sensitivity

Many cheap mono headphones, particularly those intended for communication use, are specified as high impedance types — typically described as two 250 ohm speakers in series to give a 500 ohm load. The sensitivity of such phones leaves much to be desired, the 500 ohm load implying that high drive voltages should be used to obtain a decent volume. In fact the phones tend to be quiet even when run with 25 volts RMS, the simple reason being that the actual speaker units are standard low impedance types with a series 470 ohm resistor. Naturally the resistor drops most of the applied voltage, and can be much reduced in value if required. The resistor is usually mounted behind the speaker to which the connection wire is attached. Obviously care should be taken to avoid overloading the speakers, and it would seem a good idea to leave at least 47 ohms in series.

Two LEDs: One Switch

Occasionally it is necessary to switch two LEDs in changeover fashion from a single pole switch, generally when the other pole is used for audio. This frequently occurs when designing with switched potentiometers.

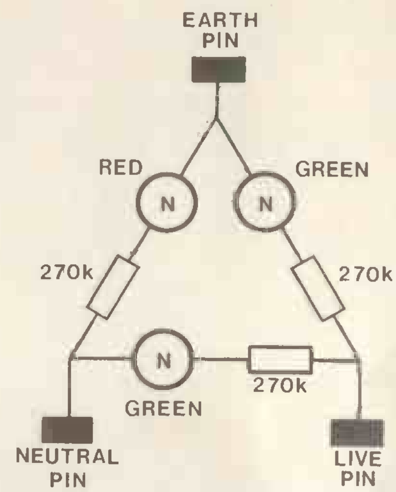
The circuit below uses two LEDs, one of which comes on when the switch is closed, the other when it is open. If the switch is closed the transistor is turned off, and a direct path to ground lights the first LED. When the switch is opened the first LED goes off, but still passes sufficient current to turn the transistor on, thus lighting the second LED.



Earth Fault Detector

It is a sad fact that many people, some of them musicians, are killed every year through faulty equipment. A common problem is faulty earthing, allowing the case to float live in the event of a second fault (live short to case) rather than blowing a fuse.

The status of the earth can be cheaply and easily monitored by the triangle of neons. Under normal circumstances only the two green neons will be lit, but the red one will light if the earth becomes open, or if the neutral-earth voltage becomes very high. It is a good idea to mount a set of neons on ALL equipment where metal panels are in continuous use (particularly guitar amps and disco decks), and make a habit of checking them. It is also well worth the trouble to mount a triangle in a 13 amp plug. Miniature neons (complete with internal resistor) are suitable for panel mounting, but the 13 amp plug will need the very small 'bead' neons, together with an external resistor.



True Amplifier Clip Indicator

Terry Barnaby, S. Glamorgan

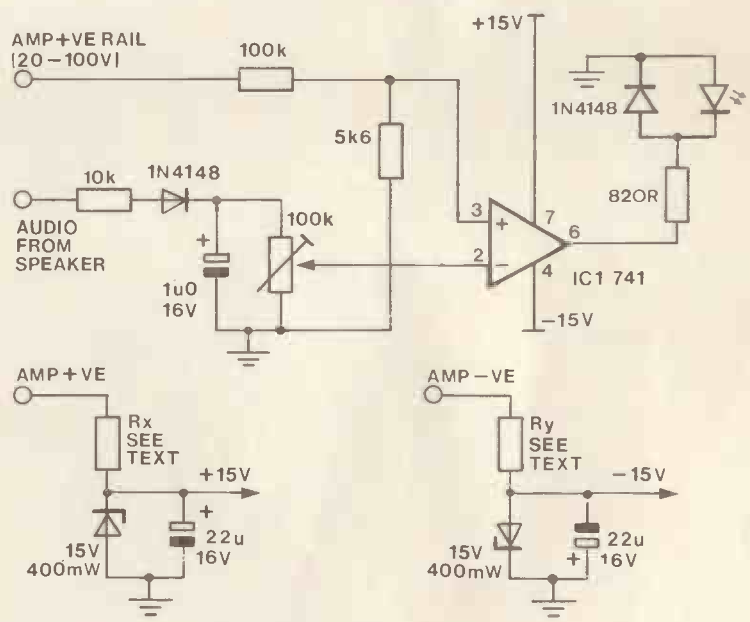
Some PA amplifiers use a common power supply for two or more channels, and as such the clipping level of one channel is dependent on the load on the other. For example, a bass guitar in one channel will cause considerable power supply droop, particularly if the supply is only just adequate. In view of this a clipping indicator which monitors the rail voltage with respect to the output is needed to indicate true clipping, and in this case lights a red LED if the output approaches the rail.

The indicator employs a 741 op-amp used as a comparator. The audio input is rectified and smoothed to give a voltage, equal to the peak level of the signal. A fairly fast attack time is needed to catch transient peaks. The rectification stage causes some voltage loss, allowing a wide range of amplifier powers to be used without circuit alterations. The peak level is fed to the inverting input of the 741, whereas the non-inverting input is connected to the rail of the amplifier via a potential divider. The output of the op-amp goes low when the audio peak level exceeds the rail derived voltage and thus lights the LED. A silicon diode is connected across the LED to protect it against reverse voltage greater than 3V. The circuit is calibrated by means of the 100k preset potentiometer which attenuates the signal to the comparator.

If a 15 volt supply is available (from a pre-amp) a separate supply is not required. Otherwise a simple zener based regulator using the main amp rails will suffice. The resistors R_x and R_y should be chosen to pass about 25mA using the formula:

$$R = \frac{\text{Rail volts} - 15}{\text{Current}}$$

Ensure that the power rating of the resistor is sufficient.



D-I-Y Printed Circuit Board Hints

Most printed circuit boards prepared in the home are drawn using the blue etch resist pens. These have fairly thick tips and drawing high density tracks (e.g. down the centre of an integrated circuit) can be very hard. To obtain such tracks it is much easier to block in the area of the tracks totally and then draw in the inter-track gaps by scraping off the etch resist with a sharp scribe. The gaps can thus be minimised, and the necessary density can usually be obtained. The copper in the gaps is then etched away as part of the normal process.

It is nearly impossible to remove a small area of etch resist after a mistake has been made. A cotton bud (Q-tip or similar) soaked in acetone softens the ink which is then drawn up by the cotton tip. The area of removal is limited only by the size of the cotton tip, and it is usually possible to trace one track.

Note the fairly well known fact that a large area thick tipped etch resist pen is made by Pentel and can be purchased at most drawing shops for about 40 pence. Do use a black one though, the other colours do not cover as well.

Finally, removing the etch resist after etching is most easily achieved with the aid of a standard paint stripper, such as Polystripper. This is faster than a rubbing block, and cheaper than solvent. Do take care to keep it off skin, and wash the board very carefully afterwards, preferably using a sponge to force water down any holes previously made.

SPECTRUM SYNTHESISER

Part 2 of this constructional series describes the keyboard controller

by Chris Jordan

Figure 2 shows the circuit diagram of the keyboard controller. Connections 1 and 2 are the bottom and top respectively of the keyboard divider chain. This is arranged in the feedback loop of IC3a, which drives a current of about 1.8mA through the divider chain. This generates 8.3V across each divider chain resistor, corresponding to a semitone, and 1V across each group of twelve, corresponding to an octave. R58 and R59 drop 1.7V so the range of key voltage is 1.7 (top C) to 5.7V (bottom C). R57 and RV3 determine the current, RV3 allowing it to be trimmed for exactly 1V/octave.

IC3b generates a signal that is used, after processing, to gate the envelope generators and key voltage sample - and - hold. With no keys depressed, the non-inverting input is held low by R60 and since the inverting input is at +0.83V (determined by R58 and R60) IC3b's output is at its negative extreme, almost -15V. When a key is depressed, the voltage at the inverting input rises to between 1.7 and 5.7V since the gate bus-bar is connected to the divider chain by the contact of the depressed key, and the output of IC3b goes high.

TR3 is an FET which acts as a voltage controlled switch in the sample-and-hold circuit around C11. It is normally held off by the negative output voltage of IC3b, via R62 and D14, but upon this going positive it is turned on and C11 charges to the voltage on the S/H bus-bar (connection point 3). Since the contact spring makes with this before the gate bus-bar, the new key voltage is always ready for sampling by the time the FET is turned on. IC5a is an FET input op-amp with a very low input bias current. This ensures that when the key is released and TR3 turns off the charge on C11 is retained with the minimum of droop. With the 50pA worst case input bias current of the buffer amplifier, it takes about 13 minutes for the pitch of the oscillators controlled by the keyboard to drop one semitone.

With the output of IC3b low, C10 is kept charged by D11, but when a key is depressed it is allowed to discharge through R65 and R66. It takes approximately 2mS for the voltage to reach the threshold of the schmitt NAND-gate IC6a, the output of which then goes low. Since D11 charges C10 very fast upon the comparator output going low, it must remain high for at least 2mS for the gate signal to be passed on to IC6b. This ensures that the effect of contact bounce upon key depression or release is eliminated and cannot cause false triggering of the envelope generators.

The external gate signal is inverted by TR4 and NAND-ed with the output of IC6a to give the key gate signal which is sent to the EG's.

If a new note is played on the keyboard before the previous one is released, a new CV is generated, but since the key gate signal remains high, the EG's will not restart their envelopes. This can be a problem when percussive envelopes are used, fast keyboard runs giving missed notes. The problem is eliminated by detecting a change in CV at the sample and hold output, and generating a key retrigger signal for the EG's. IC4a is a high-gain differentiator that produces a pulse for each change in the value of the CV. These pulses are rectified and squared up by the comparator IC4b, and lengthened by D16, R75, and C12 to a minimum of 5mS.

Contact bounce produces a very ragged CV change when a note is depressed while one is already down, and this in turn produces a multiple pulse at the output of IC4b. The circuit around IC6c generates a clean 500uS pulse from this signal — most important for external devices such as sequencers which count in response to triggers from the keyboard. When the charge on C12 reaches the threshold of IC6c, the output goes high and C14 charges via D18 and R85. After 500uS, C14 also reaches the required level, the output is forced low, and C14 begins to discharge slowly through R81. For 30mS after each pulse C14 inhibits IC6c so that no more pulses can occur at the output during this period.

Since the sample-and-hold voltage is updated before the key gate starts, a first key depression would cause an unwanted pulse on the key retrigger line. This is eliminated by D17, which holds the input of IC6d high until the gate is received.

The de-bounced gate signal from IC6a is inverted by TR5, which drives the 'key gate out' interface jack. D19 causes the gate out signal to go low in response to the key retrigger

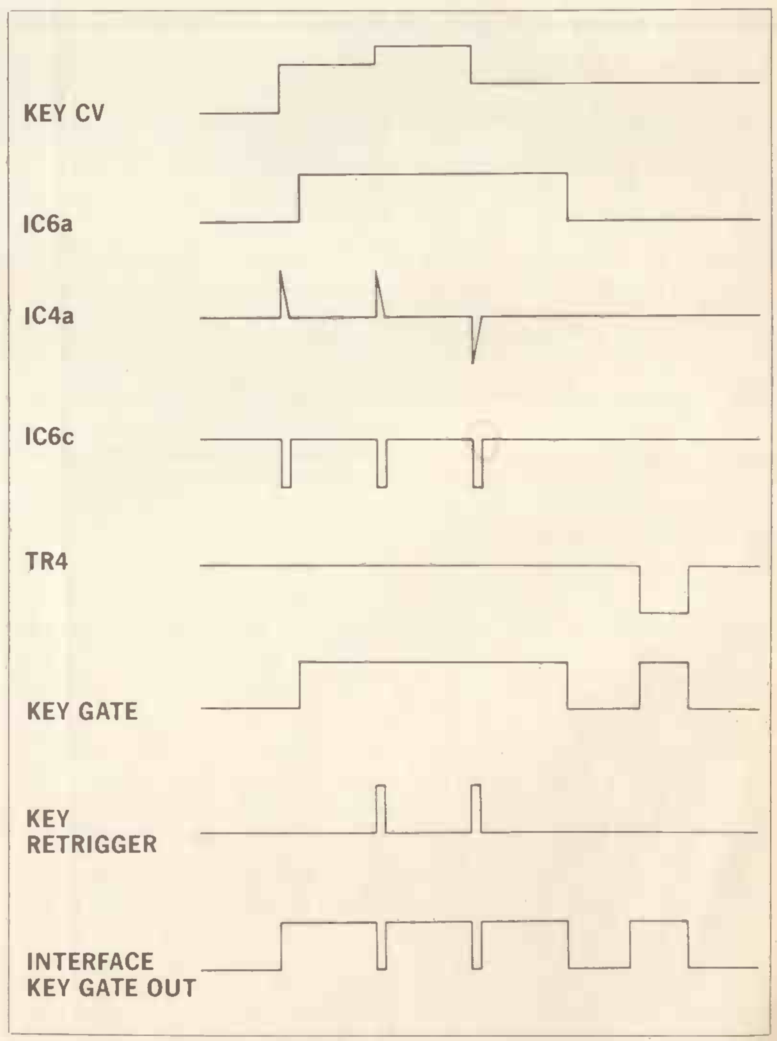


Figure 1. Keyboard controller signals.

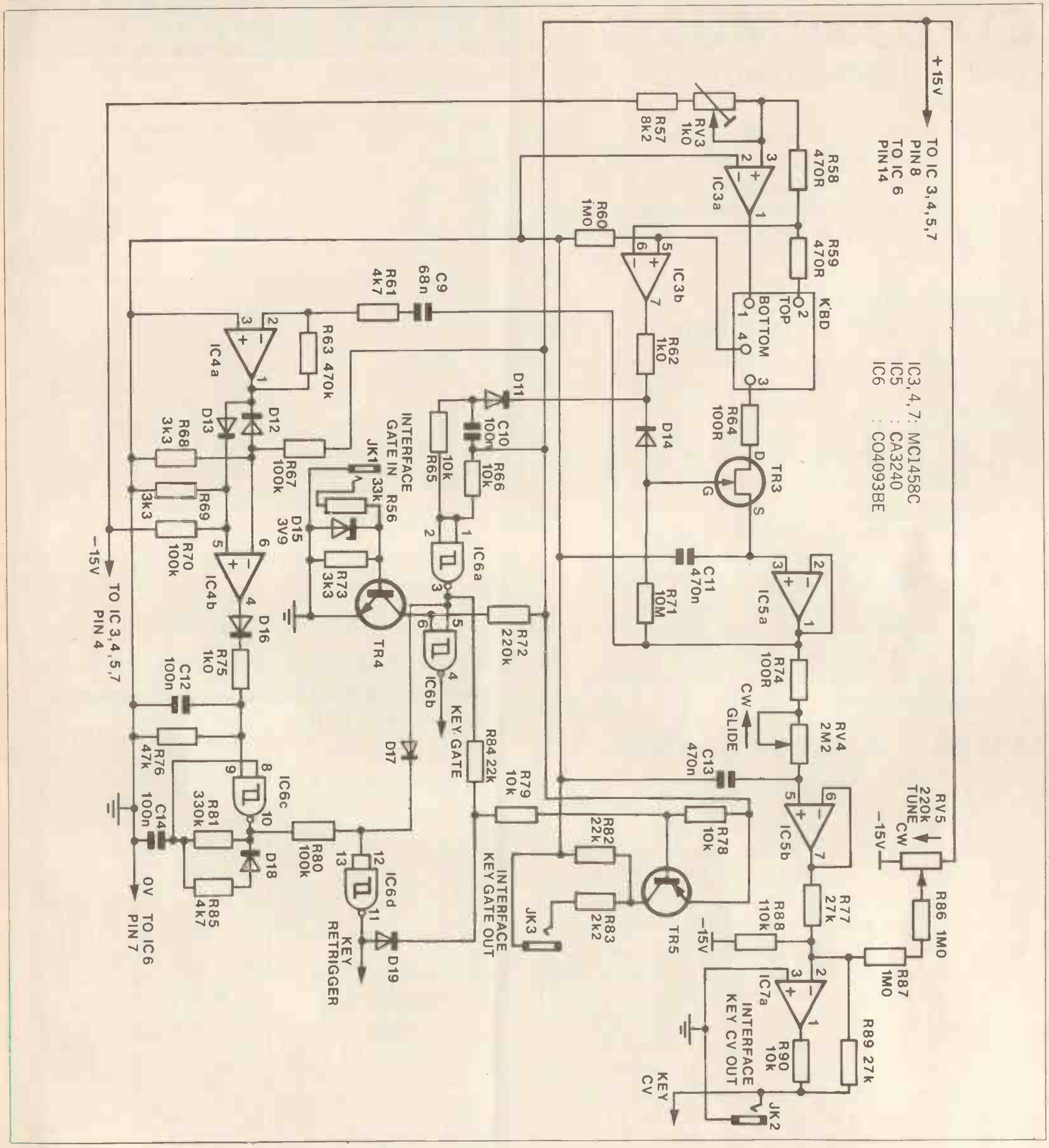


Figure 2. The circuit diagram of the Spectrum keyboard controller.

signal. TR5 is arranged to pull the output to +15V to generate the gate signal — this system allows gates from different sources to be connected together, providing an OR-function that gates the controlled device if any source signal is high.

The output of the sample-and-hold circuit (TR3, C11, IC5a) is passed to the glide circuit (R74, RV4, C13, IC5b) which produces sweeps between successive notes. The time taken for a new note voltage to be reached is controllable from almost instantaneous to five seconds for one octave by RV4. IC5b is a low input bias current op-amp, avoiding any voltage drop across RV4 that would cause a perceptable pitch error with maximum glide.

IC7a inverts the output of the glide circuit, and applies an offset so that the middle 'C' of the keyboard generates a key CV of 0V. This simplifies interfacing with additional equipment. The 'Tune' pot. (RV5) shifts the pitch up to ± 2 semitones. R90 limits the current supplied by IC7a but does not affect the voltage under normal conditions. This is required since the CV is momentarily shorted to earth when the other end of the patch lead from JK2, the 'key CV out' interface jack, is plugged into another piece of equipment.

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PART 2: Curtis Electro music Specialities

Charles Blakey, Digisound Limited

Having looked at the CEM 3340 Voltage Controlled Oscillator last month, let us now proceed to the VCF, VCA and EG.

CEM 3320 Voltage Controlled Filter (VCF)

Filters are used to modify the harmonic content of signals and in a synthesiser one requires a VCF which will track the VCO so that the harmonic content remains constant over the range of the keyboard. Thus if the VCO is set to a 1 volt/octave scale then the VCF must have the same scale and so we are back to the exponential generator.

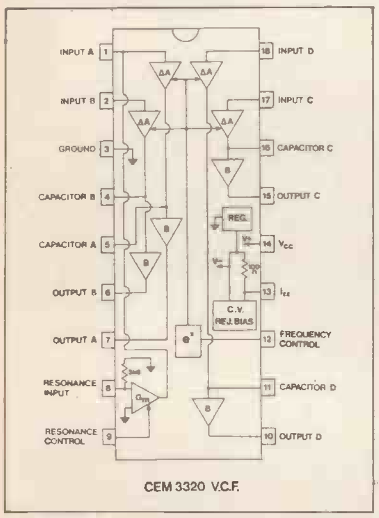

Figure 1.

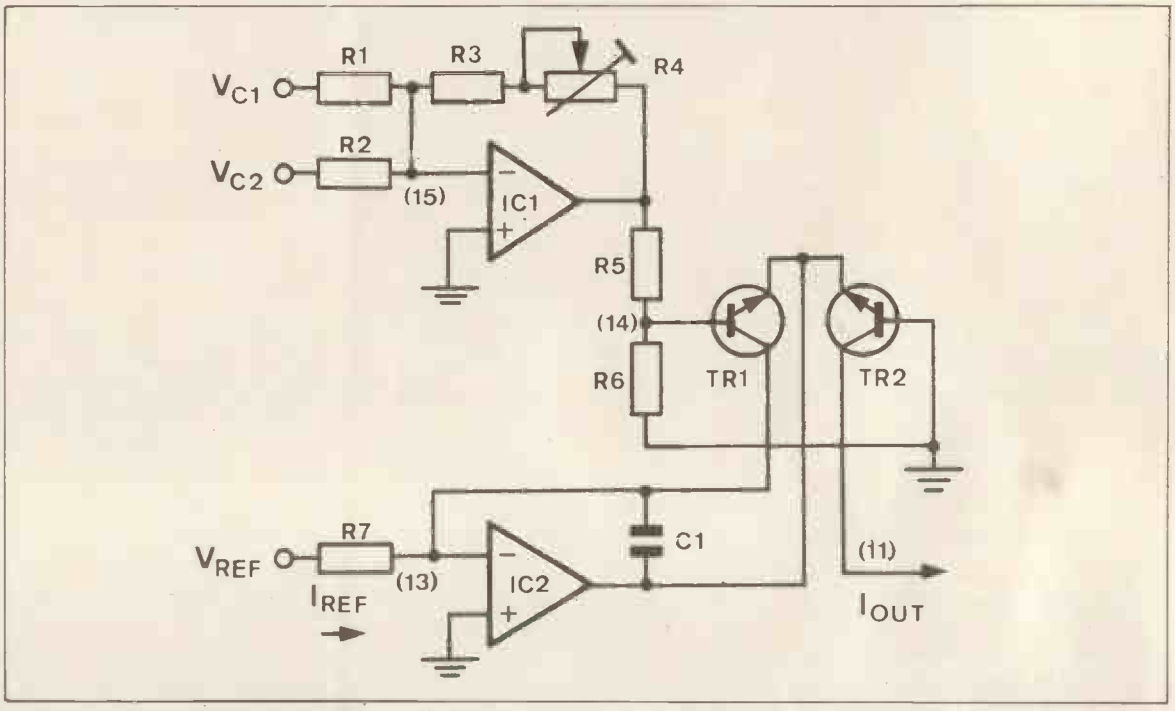

Figure 2. Typical exponential generator using discrete components.

The functional block diagram of the CEM 3320 is shown in Figure 1 and pin 12 is labelled the frequency control input to an internal exponential generator which in turn is connected to the four gain cells in the filter. This generator does not have IC1 and associated scaling components shown in Figure 2 (discussed last month). For a dedicated application one might get away with a simple 100k/1k8 resistor network which will produce a nominal 18mV/volt at the resistor junction which is connected to pin 12. The free end of the 1k8 resistor of course goes to ground and we must also provide some means of keeping the control range to the 100k resistor between -1V4 and +8V6, which is the best range of the exponential generator. Another snag with this simple approach is that an increasing positive voltage will decrease the cut-off frequency which is the opposite response to the VCO. The alternative approach is to add IC1, etc. of Figure 2 and suitable values are R1 = 100k, R3 = 91k, R4 = 20k, R5 = 56k and R6 = 1k0 with the junction of R5/R6 connected to pin 12. One may then add other input resistors for coarse control, initial frequency and so on, as discussed for the CEM 3340 VCO. While the gain cells of the CEM 3320 are temperature compensated there is still the temperature sensitive 1/T term for the exponential generator and this could be compensated, if considered necessary, by using a 3500ppm/°C temperature compensating resistor in place of R6.

The inputs to the four filter stages are at pins 1, 2, 17 and 18. Normally pin 1 will be made the first stage, for reasons that will be apparent later, but the other stages may be used in any order to suit PCB lay-out. Each filter stage consists of a variable gain cell followed by a high impedance buffer. Note that the buffer outputs are not short circuit protected and care should be exercised so as not to short them to ground or either supply. Because the gain cell is a current-in, current-out device instead of the usual voltage-in, current-out type the circuit configurations may appear unusual. To simplify matters the first two stages of 24dB/octave low pass and high pass filters are both illustrated in Figure 3. The first point to note is that the input to each variable gain cell (shown only for

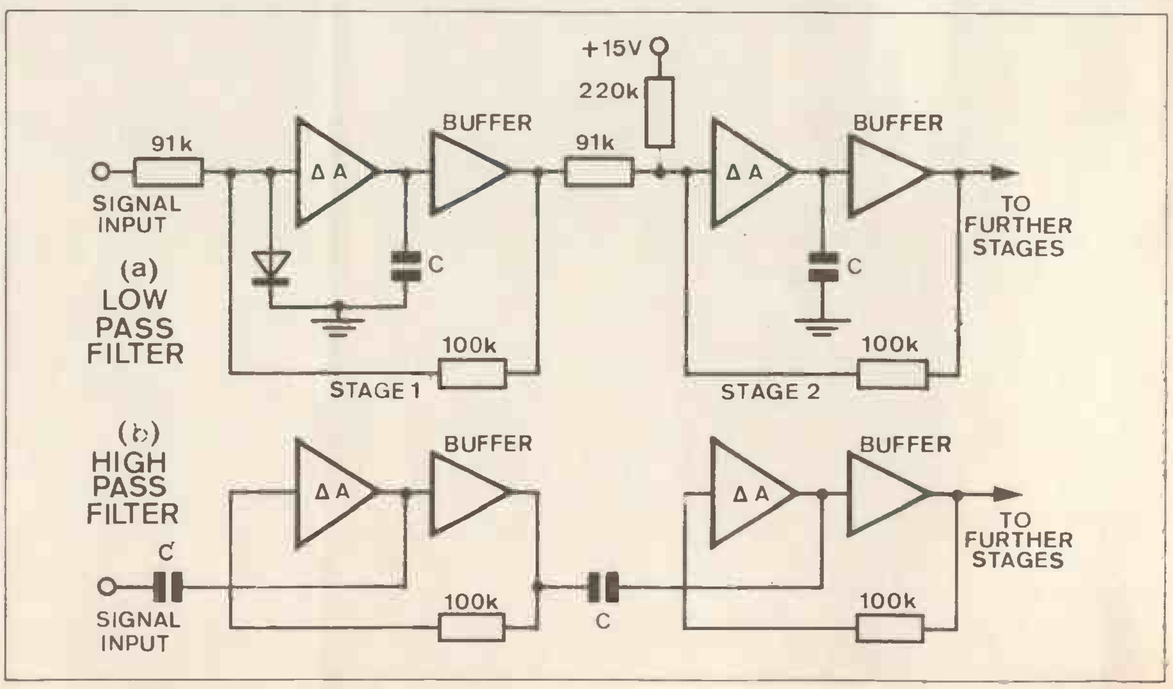

Figure 3. Filter configurations using the CEM 3320.

Stage 1 of the low pass filter) has a forward biased diode to ground and so provides a low impedance summing node of 0V65 above ground. The input current, derived from the input signal, may therefore be obtained with a resistor, or resistors, terminating at this node.

For normal operation each stage is set up with a feedback resistor from the buffer output to the input of the variable gain cell to establish a reference current. In the quiescent state (no signal input) the buffer output will adjust itself to maintain this reference current. For lowest voltage control feedthrough, that is breakthrough of any modulating waveform or 'plop' noises with rapid changes in DC control voltages, and for maximum output signal the quiescent output voltage of each buffer should be equal to 0.46 V_{cc} which for a +15V positive supply equals 6V9. The internal reference current is a nominal 63uA and thus the feedback resistor may be calculated from 6V9-0V65 (remember the diode!) divided by 63uA, which gives a nominal 100k. Referring to the low pass filter circuit, Stage 1 will normally have a zero DC quiescent voltage and therefore all of the input current, I_{in}, equal to I_{ref} will be provided by the 100k feedback resistor.

For Stage 2, as well as for Stages 3 and 4 not illustrated, I_{in} will be made up of 63uA from the feedback resistor plus 70uA from the quiescent voltage of 6V9 across the 91k coupling resistor between stages. We therefore have to sink this excess 70uA and this is done with the 220k bias resistor connected to the -15V supply. For the high pass configuration the input stage and subsequent stages are capacitor coupled, which blocks out the quiescent voltage of the buffer and therefore the required reference current is attained solely with the 100k feedback resistor for all stages.

Hopefully it will now be obvious that if the input signal contains a DC component then the low pass filter should be capacitor coupled at its input to avoid upsetting the desirable current conditions and raising the voltage at the buffer output. A band pass filter is not illustrated since this may be configured simply by using two stages of high pass followed by two stages of low pass, the latter being as Stage 2 of Figure 3a. A capacitor of 270pF will be satisfactory for these circuits.

The signal input should be a maximum consistent with avoiding clipping at output stages and normally 5V p-p will be acceptable with a +15V supply. The input/output structure of any filter is, however, up to the designer so as to suit a particular application. The input signals may be directly connected, as shown in Figure 3, although in this case the signal source should be of low impedance for the high pass filter. Similarly the output may simply have a capacitor in line to block the DC voltage from the buffer stage. An alternative approach is to use op amp inverters for both the input and output of the filter to provide the greatest flexibility in terms of impedance, signal levels and so on. In the latter case the residual DC voltage may be trimmed out using a preset connected from the negative supply and the summing input of the op amp.

The CEM 3320 has a traditional transconductance amplifier, similar in principle to the CA3080, whose output is internally connected to pin 1, which is the input stage of the first filter section. This may be used for voltage control of resonance (Q) by feedback of the output to pin 8 via a blocking capacitor and a resistor, the latter being about 50k for the filters outlined above. Voltage control is applied to pin 9 via a resistor whose value is selected according to the control voltage available and is such that oscillation does, or does not occur, according to preference, at maximum control voltage. If using a +15V supply for the control voltage try a 150k resistor to begin with. Remembering that the output of the transconductance amplifier is connected to the first stage, it may also be used as a VCA to control the amplitude of the signal input and in this mode it may be used to prevent clipping of large signals or perhaps even to introduce signal clipping to add colouration.

For negative supply voltages in excess of -4V, a current limiting resistor must be placed between the negative supply and pin 13 whose value is calculated from $(V_{EE}-2.7)/0.008$. For a -15V supply a 1k5 resistor is suitable. Some improvement in control voltage feedthrough may, however, be obtained by using a variable resistor in series with a fixed resistor and by switching back and forth between the extremes of control voltage while adjusting the trimmer to give the same DC voltage at the extremes. A value of 1k0 for the fixed resistor and 1k0 for the trimmer is a practical combination for a -15V supply.

CEM 3330 Dual Voltage Controlled Amplifier (VCA)

Figure 4 illustrates the functional block diagram of the CEM 3330 and some of the features previously discussed are evident. The variable gain cell is a current-in, current-out type and provision is made for both linear and exponential control of gain. Since there are two VCA's in the package we will often have to give two pin numbers during the discussion and the pin numbers for the second VCA are given in brackets. Linear inputs, pins 7(12), are accepted as currents, I_{CL}, and the on-chip log converter generates the logarithm of this current while exponential control inputs, V_{CE} at pins 6(14), are transmitted unchanged to the gain cell.

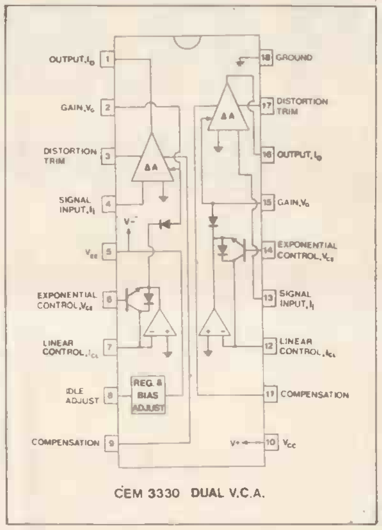

Figure 4.

Before discussing selection of component values there are a number of features of the CEM 3330 which should be noted. First, that both the signal inputs, pins 4(13), and the linear control inputs, pins 7(12), are summing nodes which allows any number of signal and linear control voltages to be mixed within the IC. Next that the current output should be converted to a voltage using an op amp configured as a current-to-voltage converter (Figure 5) and use Ohm's Law, $V = I \times R_F$, to calculate the voltage. The op amp should be a low noise high slew rate type such as LF351 or NE5534. Third, referring to Figure 4 one sees that pin 8 is labelled 'Idle Adjust' and one of the novel features of the CEM 3330 is the ability to alter the quiescent standby current of the signal carrying resistors and hence the operation of the gain cells between Class A (say, 100uA) and Class B (say, 1uA). The choice depends on the application and in general terms operating at high standby current will increase slew rate, increase available output current and decrease distortion but at the expense of increased noise and control voltage feedthrough. For typical VCA synthesiser application one would compromise and choose an operating point of about Class AB (about 7uA standby current) which would be achieved with a 6k8 resistor between pins 8 and 5.

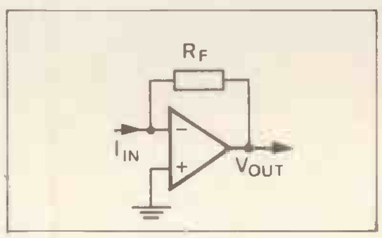

Figure 5. Current-to-voltage converter.

Lastly, for most VCA applications the main concern is achieving a wide dynamic range which for a properly configured CEM 3330 is a minimum of 100dB for linear control and 120dB for exponential control. This range must, of course, be consistent with retaining a high signal to noise ratio, low voltage control feedthrough and low distortion.

As a starting point, with minimum distortion in mind, the signal input resistor, R_I, and the signal output resistor, R_F, should be chosen to give input and output currents of 100uA which for a +10V signal requires 100k resistors. The upper current limits are dictated by the choice of standby current and reference to the data sheet for the Class AB chosen above shows a peak cell current (input plus output), C_P, of about ±600uA. In no case therefore should R_I or R_F be chosen to exceed $V_{max}/½C_P$ where V_{max} is the peak input or output voltage. Another restraint is that the sum of the signal voltages should not exceed ±10V. Now if we look at the equation for the total voltage gain of the CEM 3330 we have:

$$A_V = \frac{R_F}{R_I} \cdot \frac{I_{CL}}{I_{REF}} \cdot e^{-(V_{CE}/V_T)}$$

where I_{CL} is the linear input current into pin 7(12), I_{REF} a reference current into pin 2(15), V_{CE} the exponential control voltage to pin 6(14), and V_T which is our old temperature dependent friend and can be taken as 26mV.

Now if we did not require exponential control then pins 6(14) would be grounded and we would only have to juggle with I_{CL} and I_{REF} having already fixed R_I and R_F. For most synthesiser VCA applications we do, however, require this control for the reason stated in Part 1's introduction and two features of this exponential control input should be kept in mind. First it will be the lowest control voltage which results in maximum gain and secondly, as is the case with other IC's already described, the control voltage will have to be attenuated. As regards the latter we are no longer restricted to an 18mV change at pin 6(14) for each one volt change at the input resistor and it may be scaled to suit, for example, 27mV/volt using a 36k/1k0 divider (the 1k0 being grounded and the resistor junction at pin 6(14)). I_{CL} can be as high as 300uA but is best restricted to 100uA if linear scale accuracy is essential and I_{REF} should be set in the range of 50uA to 200uA.

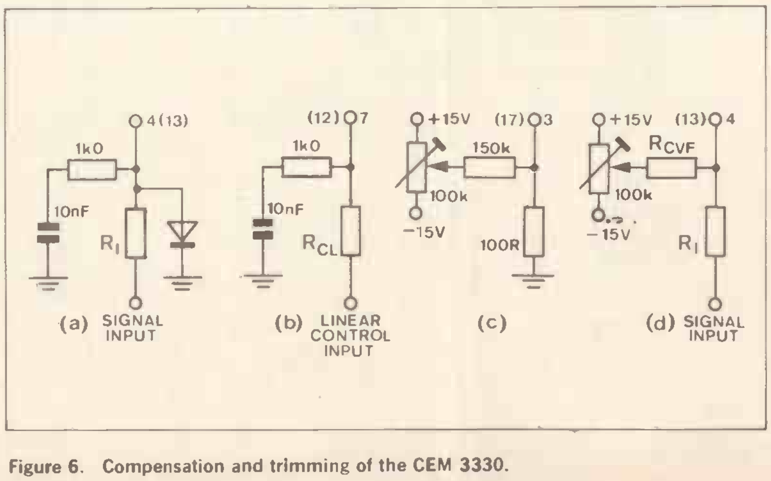

Figure 6. Compensation and trimming of the CEM 3330.

A practical example follows. Suppose I_{REF} is set to 100uA, the signal input is 10Vp-p and we have 0 to +10V control voltages for both the linear and exponential control inputs. A suitable starting point for a VCA would then be: 150k resistor connected between pin 2(15) and the +15V supply to establish the 100uA reference current; a 100k resistor, R_I, to pins 4(13); a 36k/1k0 divider to pin 6(14) to provide 27mV/volt; a 100k resistor to pin 7(12) to develop a maximum of 100uA for I_{CL}; and an output resistor, R_F, of 51k. It is now relatively simple to find your own starting conditions by substitution, for example, if the signal input is 5V p-p then R_I is halved to 51k.

Compensation components for the CEM 3330 are necessary and it may also be desirable, depending on application or the compromises made in design to achieve certain objectives, to provide trimmers to improve distortion and control voltage feedthrough. A summary of these is shown in Figure 6. 6a illustrates compensation for the signal input and the diode (IN4148, etc) is to prevent latch-up. With these component values then pins 9(11) must also have 150pF capacitors to ground. Figure 6b shows the compensation components for the linear control inputs. 6c is an arrangement for allowing distortion to be trimmed to a minimum while 6d allows reduction of control voltage feedthrough. Note that for 6d the compensation components shown in 6a must also be added and that the resistor, R_{CVF}, is calculated from $15V/I_{idle}$ which for the 7uA example above gives a value of 2M1 and so 1M8 would be satisfactory.

One major benefit of the simultaneous linear and exponential controls provided is that it is possible to configure each VCA for exponential response and then incorporate linear amplitude modulation (tremolo). It will also be apparent that a negative voltage into the linear control input will gate the VCA off. Do not gate the VCA off by applying a negative voltage to the gain pins 2(15).

Finally, if the negative supply is greater than -7V5 then a current limiting resistor should be placed between the negative supply line and pin 5. This is selected by $(V_{EE}\ -7.2)/I_{EE}$ and in this case I_{EE} depends on the idle current to pin 8, being: 10mA for idle currents less than 10uA; 12mA when the idle current is between 10uA and 50uA; and 14mA for idle currents in the range 50uA to 200uA. For the 7uA idle current example and a negative supply of -15V then the calculated resistor value is 780R and thus a 750R resistor will be suitable.

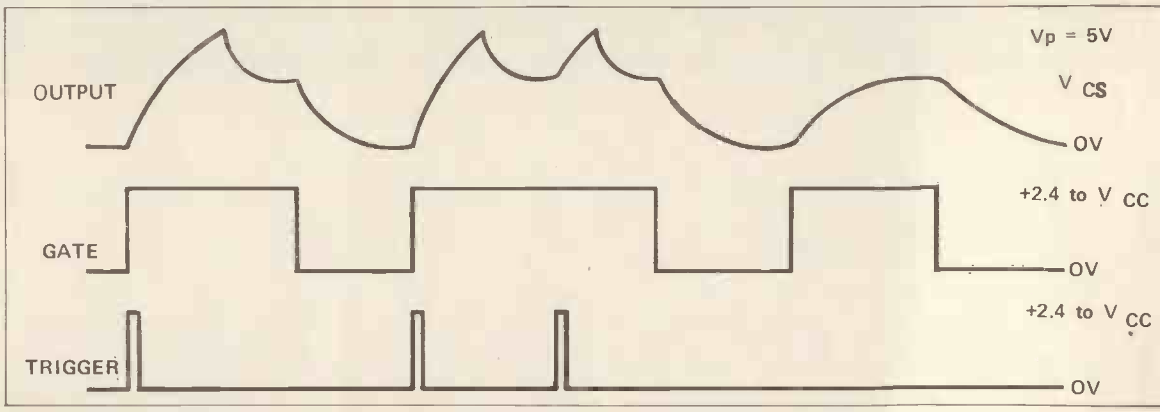

Figure 7. Envelope responses to gate and trigger pulses.

CEM 3310 Voltage Controlled Envelope Generator

First let us clarify some terminology. As most readers will know, when one of the keys of a synthesiser is pressed there are usually two output voltages generated. One is the control voltage associated with a particular key and primarily used to control the VCO and VCF and this voltage will (or should) remain constant until a different key is played. The second is a constant voltage change, for example, a step change from 0 to +15V, or from -7V to +7V and so on, and this change is used to initiate the cycle of an envelope generator. This voltage remains at its changed level for the duration the key is held down and determines the sustain period, that is, on releasing the key an ADSR envelope generator will go into its release (R) phase. In many articles this voltage is referred to as a 'TRIGGER' but when discussing purpose designed integrated circuits it is always referred as the 'GATE' voltage.

For the CEM 3310 envelope generator we need two control voltages, namely, the GATE voltage as already defined and a TRIGGER voltage. Normally if only a gate voltage is present at the appropriate input then an AD (attack-decay) envelope will be generated whereas if simultaneous

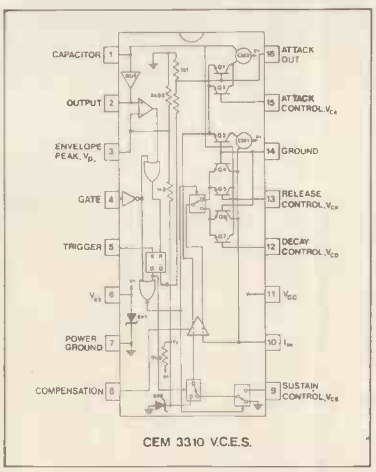

Figure 8.

gate and trigger pulses are received then an ADSR (attack-decay-sustain-release) envelope will be produced. Similarly if a second trigger pulse is received while the gate voltage is still present then the generator will recommence the attack cycle and thus allow complex envelopes to be produced. The different envelopes in relation to the status of the gate and trigger pulses is illustrated in Figure 7. Note that while the CEM 3310 may be configured to give the AD envelope with a gate pulse it is somewhat complicated and beyond the scope of this article.

The block diagram for the CEM 3310 is shown in Figure 8. If only a gate voltage is available then the trigger may be derived from it. Typically the gate voltage goes to pin 4 which has a 10k pull-down resistor to ground and also via a 3n3 capacitor to the trigger input at pin 5. These allow any ground referenced gate pulses up to +18V (V_{cc} = +15V).

The RC time constants for attack, decay and release are a function of R_xC_x times the exponential multiplier EXP $(-V_c/V_T)$, where R_x is a resistor taken from the output (pin 2) to I_{in} at pin 10, C_x is the timing capacitor connected from pin 1 to ground, and V_c is the control voltage. A convenient value for C_x is 33nF and R_x may then be set over a wide range to suit the control voltages. In practice, however, it is desirable to keep R_x low, although above 24k, so as to minimise control voltage feedthrough and other errors. A suitable value for R_x is 27k with the 33nF capacitor. The tracking between different CEM 3310's is typically ±15% and therefore if more accurate tracking between a number of devices is required one can use a fixed resistor plus a trimmer for R_x to compensate for differences between devices.

The control scale sensitivity of the CEM 3310 is 60mV/decade (18mV/octave) and so for a four decade range of, say, 2 milliseconds to 20 seconds, one only requires a -240mV voltage excursion at the A, D and R pins which are numbers 15, 12 and 13 respectively. The impedance at these pins should be kept low to maintain the best accuracy and thus 27k/470R resistive dividers with the junctions at their respective inputs and the other end of the 470R resistor grounded will give slightly more than the four decade control range when the input control voltage is varied from 0 to -15V. The higher the negative voltage the longer the time. For the sustain level control a voltage of 0 to +5V at pin 9 will vary the sustain level from 0 to 100%. Again the sustain voltage may be obtained using a resistive divider connected to the positive supply line via a potentiometer. The control inputs to the CEM 3310 are NPN transistors which allows a single attenuator to drive the same parameter on several devices configured in a multiple chip system, for example, a polyphonic synthesiser. The output voltage of the CEM 3310 is nominally 0 to +5V and the impedance of the driven load should be no lower than 20k. If necessary the output may be buffered using an appropriate FET op-amp. A compensation capacitor of 22nF should be tied to ground from pin 8 in all cases.

Two other features of the CEM 3310 may be useful for some applications. First that pin 16 outputs a voltage of between -0V4 to -1V2 only during the attack phase and this may be used to generate a logic signal to indicate the attack phase. Secondly, if the sustain voltage were to exceed the maximum attack voltage of the CEM 3310 then at the end of the attack curve the output voltage will ramp up to the sustain voltage. This feature can be taken care of by trimming the maximum sustain voltage so that it equals the maximum peak attack voltage but another technique is to use the envelope peak output available from pin 3. For the latter a precision rectifier must be connected which will then automatically limit the sustain voltage.

Details are shown on the relevant data sheet and it should be realised that many op amps have protective diodes at their inputs and so cannot be used in the precision rectifier mode.

As usual we have to place a current limiting resistor between pin 6 and the negative supply if the latter exceeds a certain value, which for the CEM 3310 is -7V5. This resistor is calculated from $(V_{EE}-7.2)/0.010$ and for a -15V supply gives a calculated value of 780R and a practical value of 750R. While the other CEM devices described will operate with positive voltages down to +9V (+10V for the CEM 3340) the specified limit for the CEM 3310 is +12V5. Thus to simplify power supply design +15V is a good choice for a full complement of CEM devices although +15V, the -15V for external op amps, and a -5V supply has many merits.

This concludes the review of just four of the specialised integrated circuits available for electro-music applications. If at first reading you find it a bit difficult to follow then don't despair since their internal circuitry is probably far more complicated than the overall circuit in which they are used. On the other hand if some readers find it too simple then data sheets are available but it should be stressed that these are for the relatively experienced designer. One thing is certain, such devices will play an increasingly important role in synthesiser and related designs.

REFERENCES: Data sheets for CEM 3310, CEM 3320, CEM 3330/3335 and CEM 3340/3345 prepared by Curtis Electromusic Specialties.

E&MM

WORKSHOP POWER SUPPLY UNIT

by Ben Willcocks

After the sad demise of my first power supply unit, I searched in vain for a design that in my opinion overcame shortcomings that most power supplies suffer from. The search proved fruitless and I ended up designing my own unit, which has overcome those problems, and at a reasonable cost. Now, for an outlay of approximately forty five pounds, one can build a sophisticated and virtually foolproof variable power supply unit for general workshop use.

The features considered necessary to be included were as follows:

1. A maximum voltage of at least 25 volts at a current of up to 2.5 amps to make the unit versatile.
2. The full voltage should be available, properly regulated, at the maximum output current.
3. The voltage and current limit controls should operate down to virtually zero.
4. The unit should have adequate heatsinking and should be protected against excessive heatsink temperatures.
5. The voltage/limiting current should remain stable with temperature changes.
6. The unit should not be prone to oscillation.
7. An indication of current limit mode should be provided.
8. Wiring should be kept to a minimum.

The first two criteria were met by the use of a high rating transformer and smoothing capacitors. The third criterion proved more difficult since many dedicated I.C's will not operate below about 3 volts, nor will they provide reliable current limiting over the range required. To overcome these problems, the use of op-amps was adopted. The voltage and limiting current are referenced solely to the 78M12 regulator which generate the +12V for the majority of the unit's control circuits. Thermal drift is therefore determined by the thermal stability of the 12V regulator and is negligible. Wiring has been kept to a minimum by mounting the majority of the front panel controls and associated components on a PCB.

The resulting unit is compact and easy to build despite its complexity, yet difficult to damage by misuse.

Circuit Description

Figure 1 shows a simplified block diagram of the PSU and Figure 2 shows the overall circuit diagram. The 35V from the bridge rectifier and smoothing components (D1-4, C1-4) is fed directly to the output stage (TR1, 3 R14-16) which is an effective high gain series regulator. It is also fed to the regulator ICI but has to be pre-regulated by TR2, 4, D7, and R13 since the maximum input voltage for 78 series regulators is 30V. The pre-regulation improves the overall regulation of the unit as it reduces the error at the 78M12 output, due to voltage fluctuation, with load of the nominal 35V supply. This voltage dropped to about 27V at full output current on the prototype. The regulator provides the +12V supply for the control circuits of the PSU.

Voltage control is achieved by IC4 and associated components. The IC acts as a comparator, comparing the output voltage (divided by R17, R18) with the voltage set by the voltage control pot, RV6. IC4 drives TR6 which in turn drives the output stage. TR5, D8, R11 provide a 5V reference for TR6. This is necessary because most op-amp outputs cannot swing below about +2V, which would be more than enough to switch on TR6 if it was referenced to 0V. With a 5V reference, TR6 base voltage has to exceed 5.4V before the output stage is biased on at all.

Current limiting is controlled by IC5. The PSU has effectively two 0V rails, which will be referred to as "0V pre" and "0V post" for description purposes. "0V post" is the 0V rail on the D7 side of R1, the sensing resistor. "0V pre" is the 0V line prior to R1. "0V post" becomes slightly more positive than "0V pre" when the unit is on load, due to the voltage drop across R1. IC5 compares the "0V post" with a reference set by the current limit control RV7.

When the "0V post" rail becomes more positive than the reference voltage, the PSU goes into the current limit mode. In this state, the output of IC5 goes low, reducing the voltage at the base of TR6. This action stabilises at the limit current setting chosen.

Thermal protection is provided by IC2. This compares the voltage set by the shutdown threshold preset, RV1, with the voltage derived from a potential divider consisting of R27, R10. When increasing temperature causes the resistance of the thermistor to decrease, the potential rises above that set by RV1, and the output of IC2 goes low, switching off the output stage by reducing the base voltage of TR6, in the same way as the current limit IC. R3 introduces a certain amount of hysteresis and prevents continual switching of the thermal limit system.

The sole function of IC3 is to sense when current limiting is operative. The current limit IC drives the base of TR6 via R7; by sensing the voltage across R7, sensing of current limiting can be achieved. The original design had the current limiting LED directly in the IC5-TR6 circuit but it was found to be impractical to use sufficient currents to achieve full brightness. Also, a current was sinked by the current limit IC before a current limit situation had been reached, which resulted in a vague, premature indication by the LED. With an extra IC to control the LED, indication is definite and full LED brightness can be obtained.

CA3130T's are specified for the voltage and current limit control circuits because it is required to have a comparator action operating down to 0V, which these IC's can achieve. The capacitors between pins 1 & 8 of the CA3130T's provide frequency compensation, i.e. they reduce the gain at high frequencies and so prevent the unit from becoming the latest thing in high output oscillators. If oscillation becomes a problem with your unit, try increasing the values of C6/C7, or C8/C9, depending on whether the unit oscillates in the set voltage or current limit mode. The prototype did not suffer these problems.

FS1 is connected in series with the transformer secondary, protecting the transformer in the vent of rectifier/output transistor failure. FS3 is the mains input fuse.

Some confusion could be caused over the switching arrangements around SW1. The

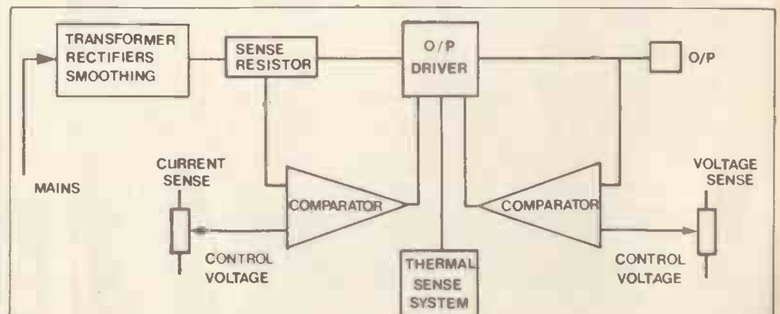

Figure 1. Block diagram of PSU.

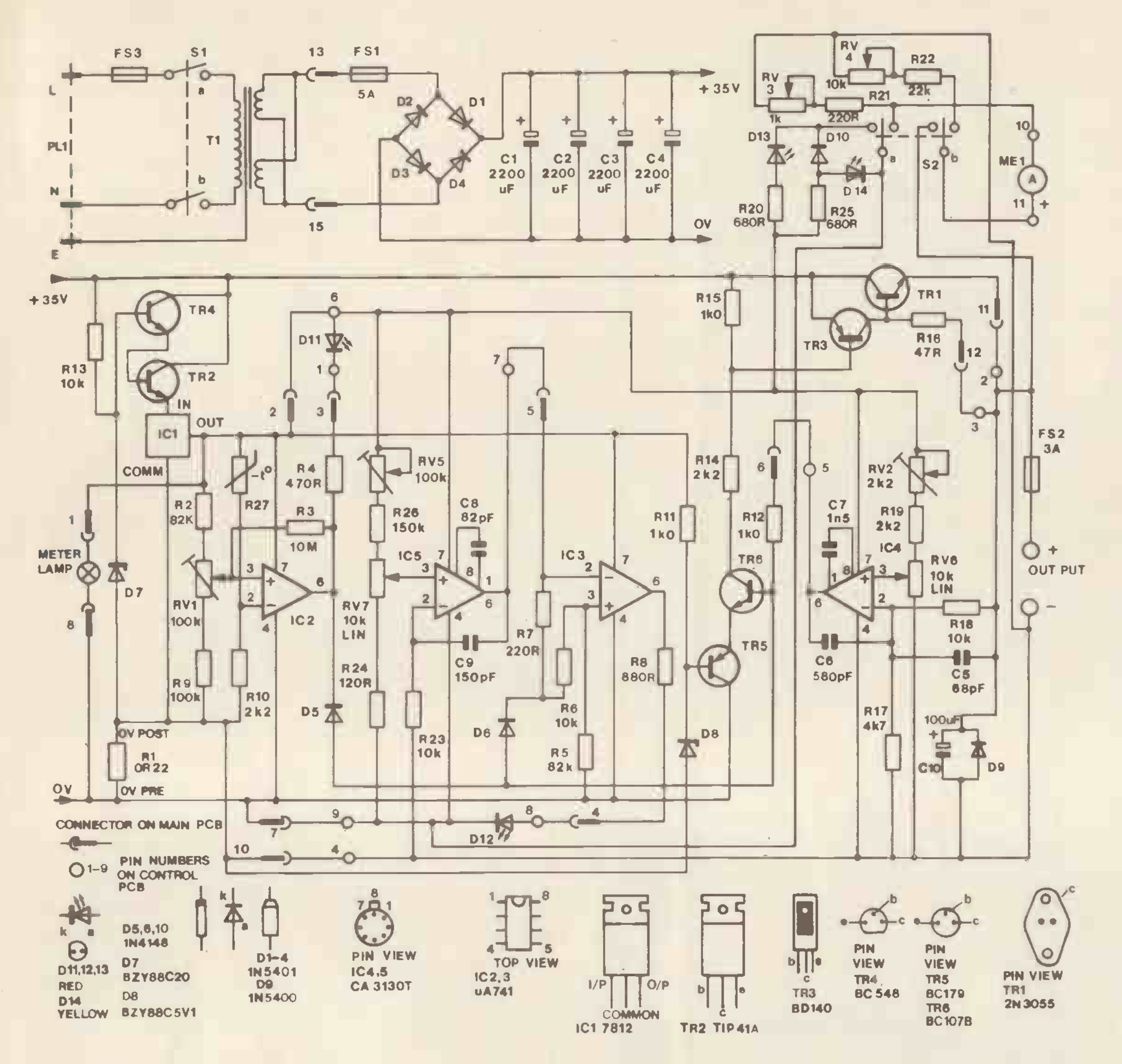

Figure 2. PSU circuit diagram.

rather unorthodox arrangement is the only way of controlling all of the functions with a two-pole switch. Consider the switch in the "volts" mode. The yellow LED (D14) which is normally operated via R25, is off because its anode is held low by the switch via D10. The +ve end of the meter is taken to the output voltage and the -ve end is taken to '0V post', to avoid inaccuracies due to any voltage drop across R1, via R21/RV3. Thus the meter is in effect an ammeter with a multiplier (RV4). Now consider the switch in the "amps" mode. The anode of D14 is no longer held low, so the LED lights. The cathode of the red LED (D13) is no longer earthed, so it is extinguished. The -ve end of the meter is taken to "0V pre." The +ve end of the meter is taken to "0V post" via R21-RV3. Thus the meter is in effect an ammeter with a shunt (R1). R24 is included to provide a slight bias to the current limit control, since without it, the current limiting will operate when no current is being drawn at the output. Using the specified value of R24, a minimum current limit of about 20mA occurs, which is convenient for testing LED's etc.

Construction

Printed circuit boards are used since they reduce the construction to a reasonably straightforward task. Details of the two boards are shown in figures 3 and 4. Figures 5 and 6 show wiring

PARTS LIST

Resistors — all 5% ⅓W carbon unless specified

R1	0R22 3W W/W		(W0R22)
R2,5	82k	2 off	(M82K)
R3	10M		(M10M)
R4	470R		(M470R)
R6,13,18,23	10k	4 off	(M10K)
R7,21	220R	2 off	(M220R)
R8,20,25	680R	3 off	(M680R)
R9	100k		(M100K)
R10,14,19	2k2	3 off	(M2K2)
R11,12,15	1k0	3 off	(M1K0)
R16	47R		(M47R)
R17	4k7		(M4K7)
R22	22k		(M22K)
R24	120R		(M120R)
R26	150k		(M150K)
R27	Thermistor KR152CW		(FX87U)
RV1,5	100k Hor. sub-min. preset	2 off	(WR61R)
RV2	2k2 Hor. sub-min. preset		(WR56L)
RV3	1k Hor. sub-min. preset		(WR55K)
RV4	10k Hor. sub-min. preset		(WR58N)
RV6,7	10k pot. lin.	2 off	(FW02C)

Capacitors

C1,2,3,4	2,200uF 40V axial elect	4 off	(FB91Y)
C5	68pF ceramic		(WX54J)
C6	560pF ceramic		(WX65V)
C7	1500pF ceramic		(WX70M)
C8	82pF ceramic		(WX55K)
C9	150pF ceramic		(WX58N)
C10	100uF 25V, PC elect.		(FF11M)

Semiconductors

D1,2,3,4	1N5401	4 off	(QL82D)
D5,6,10	1N4148	3 off	(QL80B)
D7	Zener diode, 20V, 400mW		(QH21X)
D8	Zener diode, 5.1V, 400mW		(QH07H)
D9	1N5400		(QL81C)
D11,12,13	0.2in. LED, red	3 off	(WL27E)
D14	0.2in. LED, yellow		(WL30H)
TR1	2N3055		(BL45Y)
TR2	TIP41A		(QL17T)
TR3	BD140		(QF08J)
TR4	BC548		(QB73Q)
TR5	BC179		(QB54J)
TR6	BC107B		(QB31J)
ICl	uA78M12UC		(QL29G)
IC2,3	uA741C, 8-Pin DIL	2 off	(QL22Y)
IC4,5	CA3130T	2 off	(QH28F)

Miscellaneous

FS1	Quick blow fuse, 5A, 20mm		(WR07H)
FS2	Quick blow fuse, 3A, 20mm		(WR06G)
FS3	Anti-surge fuse, 1A, 20mm		(WR19V)
S1	Sub-min toggle type E		(FH04E)
S2	DP rocket neon		(YR69A)
ME1	2in. Panel meter, 1mA fsd		(RW94C)
T1	I.L.P. Toroidal transformer (0-25v, 0-25v, 1.6A Sec.)		I.L.P. Code WSP 1*
	Case Centurion EX1-H		(XQ11M)
	Heatsink 2E	2 off	(HQ70M)
	Meter illuminating kit		(RX55K)
	Mounting kit, TO3		(WR24B)
	Mounting kit, TO126		(WR26D)
	Mounting kit, (P) PLAS	2 off	(WR23A)
	Chassis fuseholder 20mm		(RX49D)
	Fuse clip	4 off	(WH49D)
	Push-on receptacles		(HF10L)
	Push-on receptacle covers		(HF12N)
	Low cost knob	2 off	(YG40T)
	Knobcap, red		(QY04E)
	Knobcap, yellow		(QY06G)
	Cliplite, red	3 off	(YH56L)
	Cliplite, yellow		(YH57M)
	Wafercon plug 12-way		(HL08J)
	Wafercon plug 3-way		(HL04E)
	Wafercon socket 12-way		(HL13P)
	Wafercon socket 3-way		(HL09K)
	Wafercon terminal	13 off	(HL14Q)
	6BA ½in. Bolts		(BF06G)
	6BA ½in. C/S screws		(BF12N)
	4BA ½in. Bolt		(BF03D)
	8BA ½in. C/S screws		(LR00A)
	6BA Nuts		(BF18U)
	8BA Nuts		(BF19V)
	4BA ½in. threaded spacers		(LR71N)
	Systoflex, 1mm, red		(BH03D)
	Systoflex, 4mm red	1m	(BH15R)
	Heavy duty wire, brown	1m	(XR34M)
	Heavy duty wire, blue	1m	(XR33L)
	Heavy duty wire, white	1m	(XR37S)
	Connection wire		(BL07H)
	Spirawrap 6mm	1m	(BL58N)
	Spirawrap 3mm	1m	(BL57M)
	Cabinet feet	4 off	(FW19V)
	6BA Shakeproof		(BF26D)
	Printed circuit board, main		(GA20W)
	Printed circuit board, control		(GA21X)
	Heatsink bracket		
	Thermpath, small		(HQ00A)
	6BA tag		(BF29G)
	Line Eurosocket		(HL16S)
	Mains cable, 6A, 3-core	2m	(XR04E)
	Chassis Europlug		(HL15R)

*The I.L.P. 32016 transformer (code WSP1) Price £8.00 incl. VAT and P&P is available from:

I.L.P. Transformers,
Freepost T2, Graham Bell House,
Roper Close, Canterbury CT2 7EP.
Tel: (0702) 54778

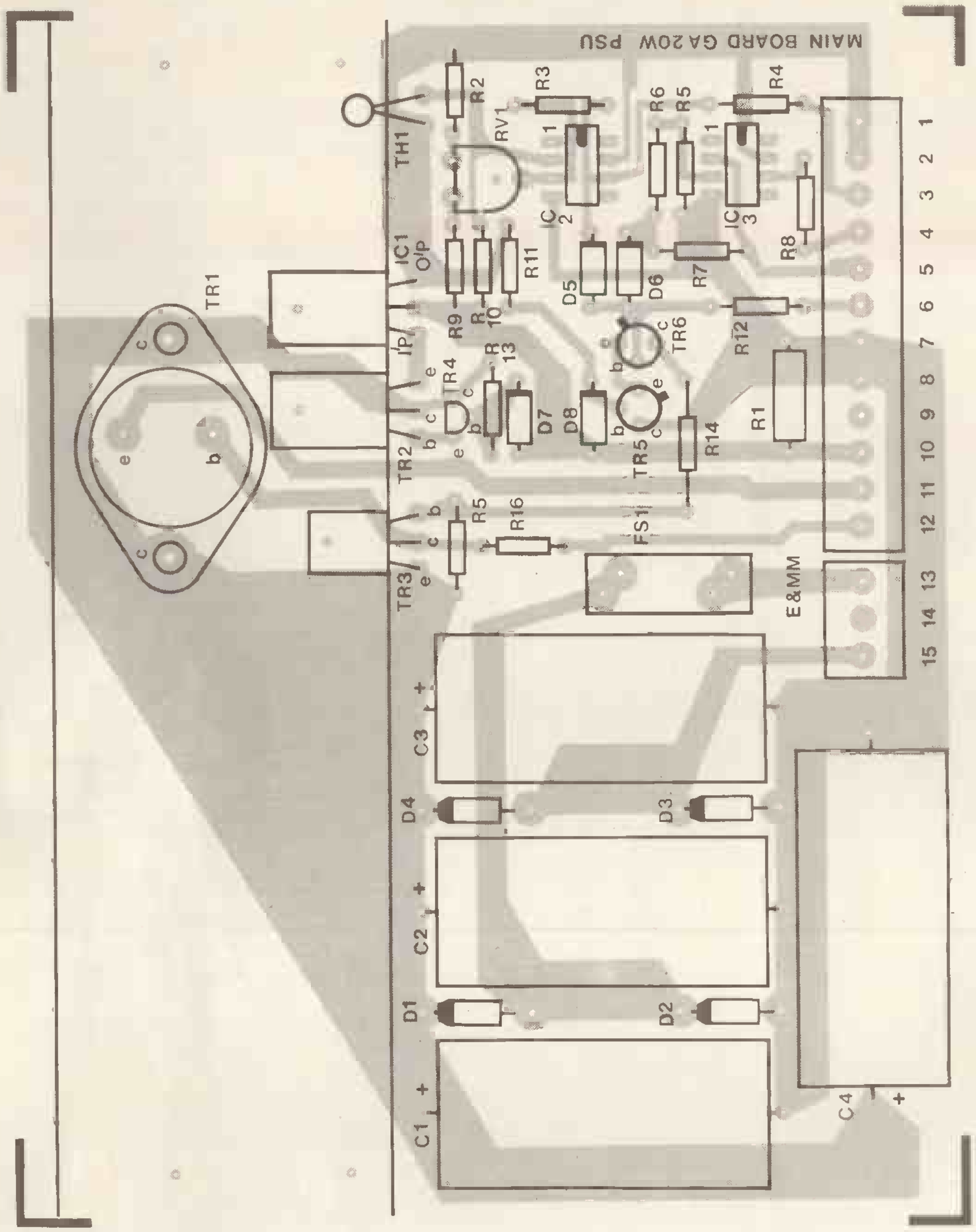

Figure 3. Main printed circuit board.

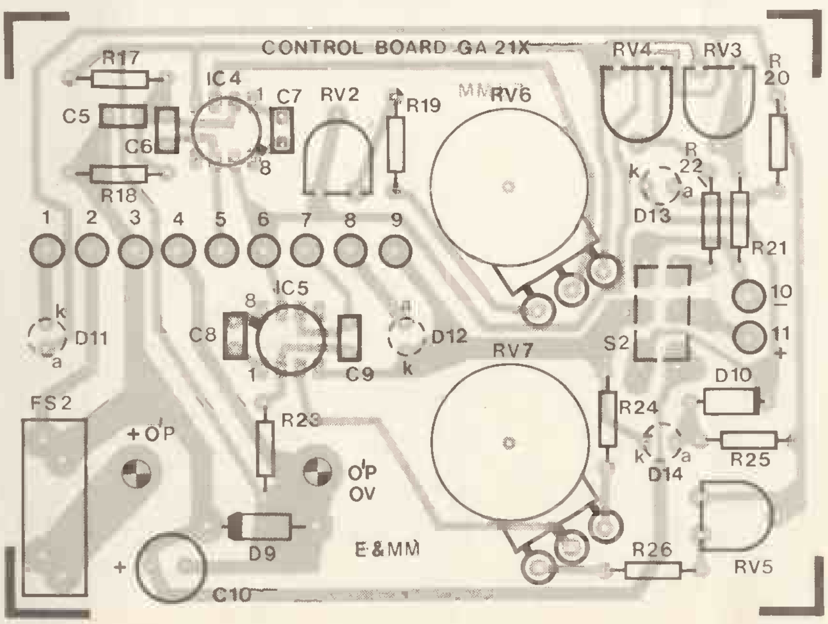

Figure 4. Control printed circuit board.

and heatsink fixing details respectively.

Start by assembling the main PCB. First mount all resistors. Note R1 is a 3W wirewound type. It dissipates a fair amount of heat and it is advisable to leave a gap of about ⅛in. between it and the PCB to aid dissipation. Next, mount RV1, D5, D8, IC2, IC3, TR4, TR6 and D14. Then attach the heatsink bracket to the PCB with 4 x 6BA, ½in. bolts. Preferably use shakeproof washers as well. Now mount ICI, TR1 as shown in the diagram, noting that the plastic bushes supplied in the TO-3 insulating kit are not used, the bolts provide the connection to the PCB.

Slide a suitable length of systoflex over the fixing bolts to ensure that the bolt is insulated from the heatsink.

It now remains to fit the two wafercon plugs, the fuse clips and C1-4. These have been left until last to avoid obstruction of the board during assembly.

You now have a complete and (hopefully) operational PCB. Next, assemble the control PCB.

Again, begin by mounting the resistors, followed by C6,-9, RV2,-5, D9, D10. Now fit the sockets for IC4, IC5 and the fuse clips. Mount the toggle switch on the copper side of the PCB. Now, insert (but do not solder), the LED's, again from the copper side, taking care to observe correct polarity. Take the front panel and fit the two terminal posts to it (black on the left, red on the right). Also insert the four cliplites (LED clips). The yellow cliplite should be fitted below the toggle switch. Tighten the nuts holding the terminal posts securely and fit the 4BA ½in. spacers to them. Now offer the PCB up to the front panel securing it in place by means of the nut on the toggle switch and two screws through the PCB into the threaded spacers. The LED's on the PCB should now be manoeuvered into the cliplites. A small amount of twisting of the cliplites aids insertion of the LED's. Use a small soldering iron to temporarily solder the LED's into place; final soldering can be achieved with the board removed from the front panel again. It is only necessary to fix the LED positions so that the spacing of the PCB is correct. Remove the board from the front panel, fix and solder RV6, RV7 and mount C10. Now make the wiring connections to the PCB holes numbered 1 to 9 on the main PCB. Fit two wires to holes 10 & 11 but keep them separate from the rest of the wires, which should be cut to a length of approximately 8 inches and grouped using 6mm spirawrap.

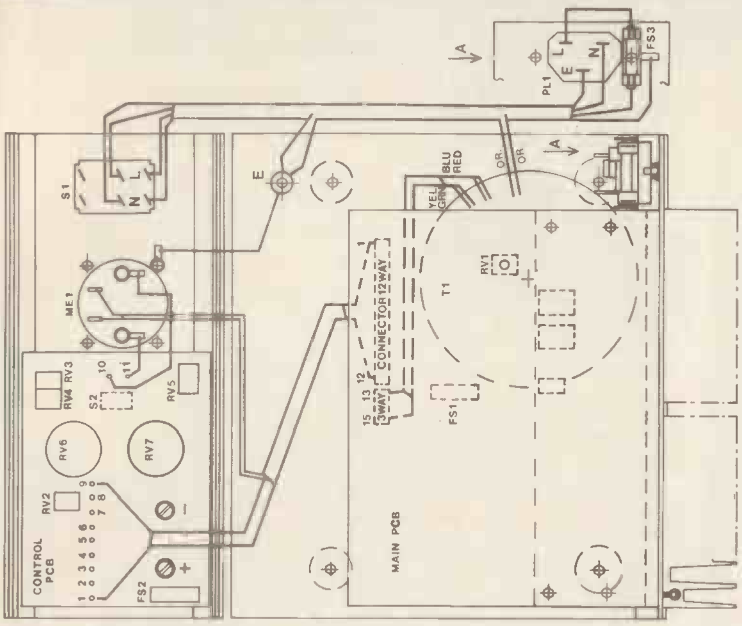

Figure 5. PSU wiring details.

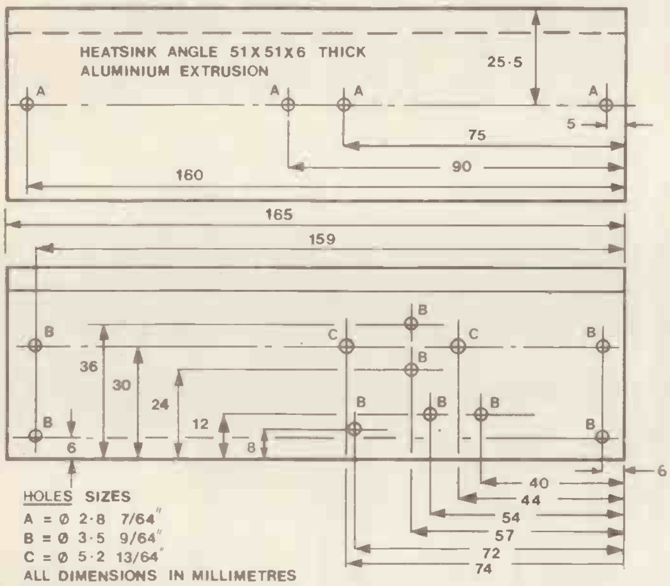

Figure 6. Heatsink fixing details.

TABLE 1. PSU WIRING CHART

FROM	TO	WIRE TYPE	FUNCTION
*A1	Meter Illumination	702	Meter Illumination
A2	B6	702	+12V
A3	B1	702	Thermal Shutdown LED
A4	B8	702	Current Limit LED
A5	B7	702	Current Drive
A6	B5	702	Voltage Drive
A7	B9	702	"0V PRE"
A8	Meter Illumination	702	Meter Illumination
A10	B4	3202	"0V POST"
A11	B2	3202	OUTPUT +V
A12	B3	702	O/P Return
B10	Meter -Ve	702	Metering
*B11	Meter +Ve	702	Metering
A13	Trans. Secondary	Trans. lead	AC Supply IN
A15	Trans. Secondary	Trans. lead	AC Supply IN
Europlug Earth	Earth Tag	3202	Earth
Rear Panel	Earth Tag	3202	Earth
Front Panel	Earth Tag	3202	Earth
Europlug Pin L	Fuse Holder	3202	AC Live (L)
Fuse Holder	DP SW L	3202	AC Live
Europlug Pin N	DP SW N	3202	AC Neutral (N)
DPSW OUT S	Trans. Primary	Trans. lead	
AC in Earth lead	Earth Tag on rubber foot	3202	Main Unit Earth

NOTES 1 *A refers to main PCB, *B refers to control PCB.
2 WIRE TYPE refers to cable type, e.g. 702 means cable comprising 7 strands of 0.2mm diameter wire (commercial 3 amp. cable)

Fit the 12-way wafercon socket to the end of this wiring loom, connecting it as shown in Figure 5 and Table 1. The two wires from pins 1 & 8 of the wafercon socket provide the 12V supply for the meter illumination. The wires to holes 10 & 11 of the main PCB are the meter coil connections.

If the 3-pin wafercon socket is now fitted to the transformer secondary wires, and the mains connected temporarily to the primary, a check of the PCB's can be crried out. Plug the transformer to the main board. Switch on and check that pin 1 of the 12-way wafercon plug is +12V with respect to pin 10, and that the voltage at the input terminal of IC1 is approximately +20V. If the results of these checks are satisfactory, you are unlikely to have any faults serious enough to damage the other PCB, so plug it in and test the unit with a voltmeter across the output to ensure correct operation. If all is well, switch off and proceed with the rest of the construction.

Fit the four rubber feet and mount the transformer to the base panel of the case. Fit the Europlug to the rear panel with two 6BA ½in. countersunk head screws, and a 6BA tag, to provide rear panel earthing.

Fit the meter to the front panel and snap the mains DP rocker switch into place. Fix a 6BA tag under one of the meter fixing screws to provide front panel earthing. Terminate the front and rear earthing wires with 6BA tags and secure them to one of the foot fixing screws, *using a second nut* to ensure a secure contact. Also attach a tag to this screw, and wire it to the earth terminal of the Europlug.

Take the heatsink bracket of the PCB and smear the rear face thinly with thermpath. Apply the bracket to the rear panel, and insert the 8BA mounting screws, putting the nuts on the ends. These nuts should have two opposite sides filed slightly, so they fit the heatsink mounting plots. Smear thermpath thinly onto the rear faces of the heatsinks; then slide the heatsinks onto the nuts,

and tighten the screws firmly.

Wire the meter movement to the wires from the control PCB. Pin 10 should be connected to the -ve terminal, pin 11 to the +ve terminal. Wire the meter illumination terminals (the small ones) to the two wires from the 12-way wafercon socket.

Finally, attach the control PCB to the front panel again, assemble the case, make up the mains lead, and check the unit for correct operation.

Setting Up

Assuming you now have a functioning power supply, it only remains to set up the maximum output voltage, maximum current limit, thermal shutdown temperature, and meter calibration control circuits.

See Figure 4 for RV2 and RV5 locations. RV1 is located on the main printed circuit board. To avoid confusion, it is recommended that you adopt the following setting-up procedure.

1. Connect a voltmeter across the PSU output. Rotate RV2 fully counter-clockwise. Set the voltage control (RV6) fully clockwise and adjust RV2 until the voltmeter indicates 25V.

2. Leaving the voltage control at maximum, but with the current limit control (RV7) and the preset, RV5, fully counter-clockwise, connect an ammeter with a fsd of at least 2.5A across the PSU output. Set RV7 to maximum, and adjust RV5 until a reading of 2.5A is obtained on the external ammeter.

3. Disconnect the external meters, set the monitor switch to VOLTS, set the voltage control to maximum, and adjust RV4 until the internal meter reads 25V.

4. Set the monitor switch to AMPS, short the output terminals, set the current limit control to maximum and adjust RV3 until the internal meter indicates 2.5A.

5. Keep the output shorted, and the voltage and current limit controls set to maximum (fully up). Rotate RV1 clockwise until the thermal shutdown lamp lights. Keep backing off the control in small steps, waiting in each case for the temperature to "catch up." When the heatsink temperature is approximately 80 degrees centigrade, or if a thermometer is not available, when the temperature feels to be as high as is advisable, rotate RV5 clockwise until thermal shutdown occurs. With the specified resistor values and thermistor, 80 degrees centigrade is the limit temperature when RV1 is set fully counter-clockwise. Setting up is now complete. **E&MM**


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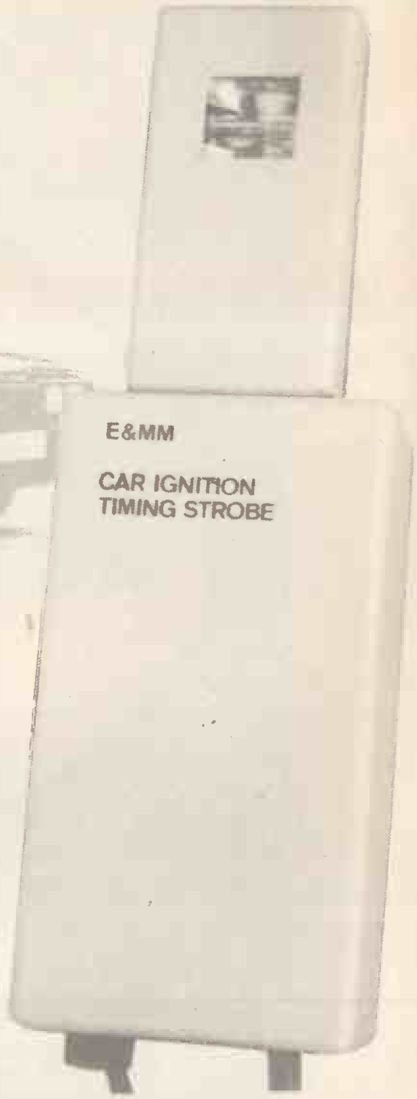
CAR IGNITION TIMING STROBE

by Michael Maurice



An ideal unit for improving your car's engine performance

In order to gain the maximum efficiency, economy and performance from a petrol engine, the ignition must be set to fire at a certain point in the firing sequence; this is normally just before the piston reaches the top of the compression stroke (known as top dead centre). A few degrees out and the fuel consumption and performance will suffer with possible damage to the engine. An engine in which the ignition is retarded will suffer from lack of power and possibly overheat, while an engine in which ignition is advanced will give off a metallic knocking sound (PINKING). There will also be undue strain put on the pistons and crankshaft bearings, which could eventually lead to expensive engine damage.

One way of setting the ignition timing is to rotate the engine either by hand or on the starter, until the timing marks on the crankshaft pulley or the engine flywheel line up with the corresponding marks on the engine; then rotate the distributor body until the points just open. This is not an accurate method, although useful for initially setting the timing. A more accurate setting can be obtained using the unit described.

The unit has three leads — two connect to the battery and one to the spark plug which is to be used for setting the timing. The strobe emits a flash of light when the spark plug fires and this is used as a basis on which to check and set the timing. Commercial units are available which perform the same function, but they either work off the mains or utilise a neon lamp whose light output is sometimes insufficient. Commercial units which utilise a Xenon strobe tend to be expensive.

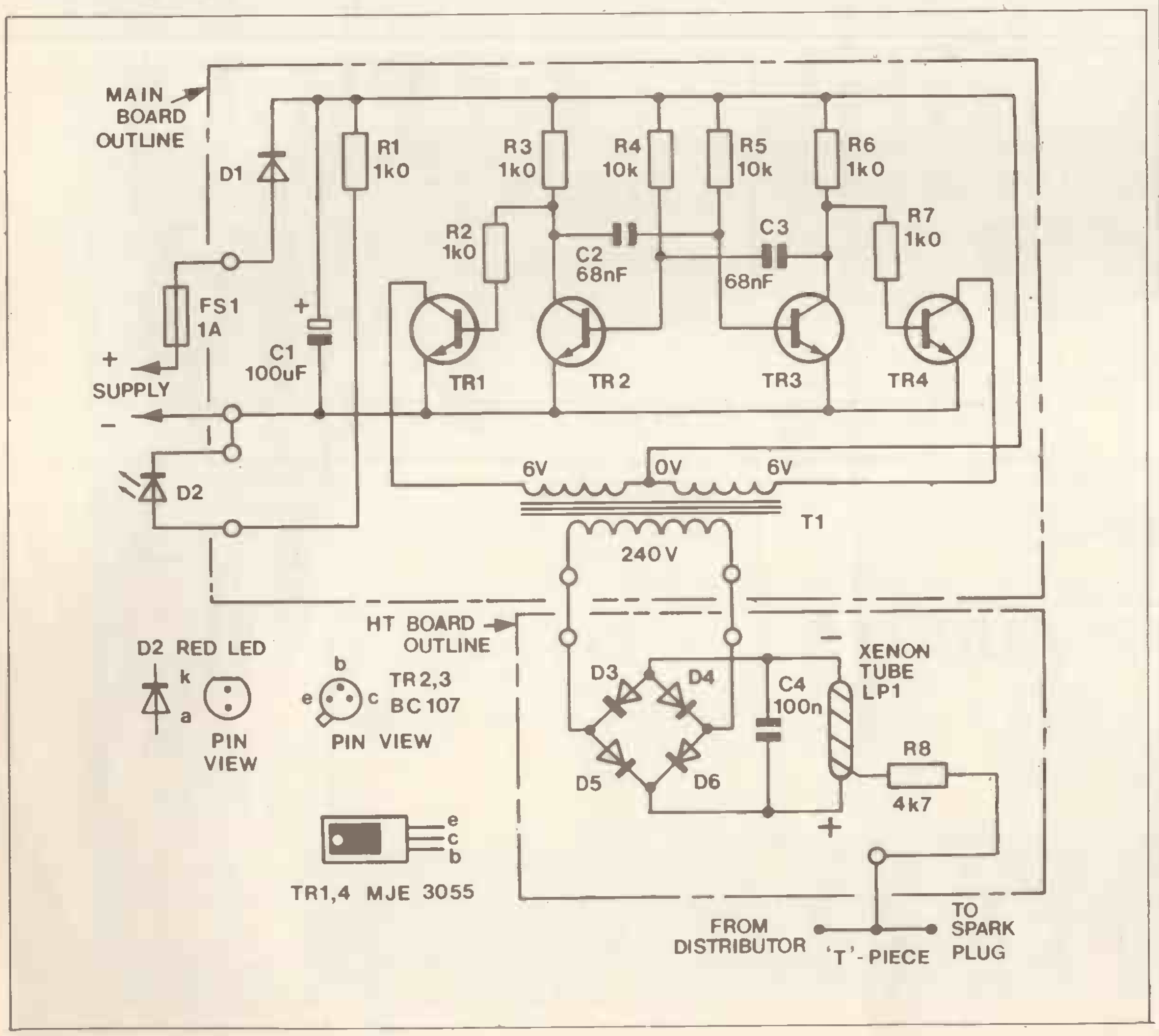


Figure 1. Circuit diagram of the timing strobe.

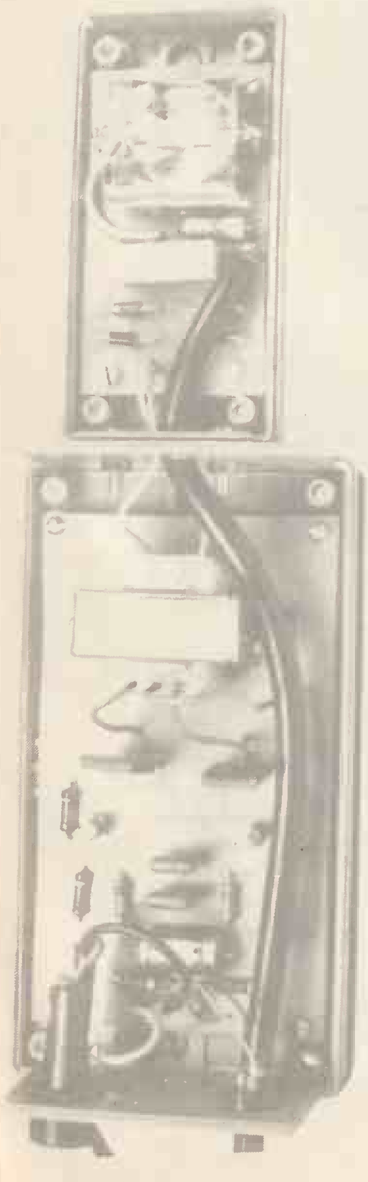
Circuit

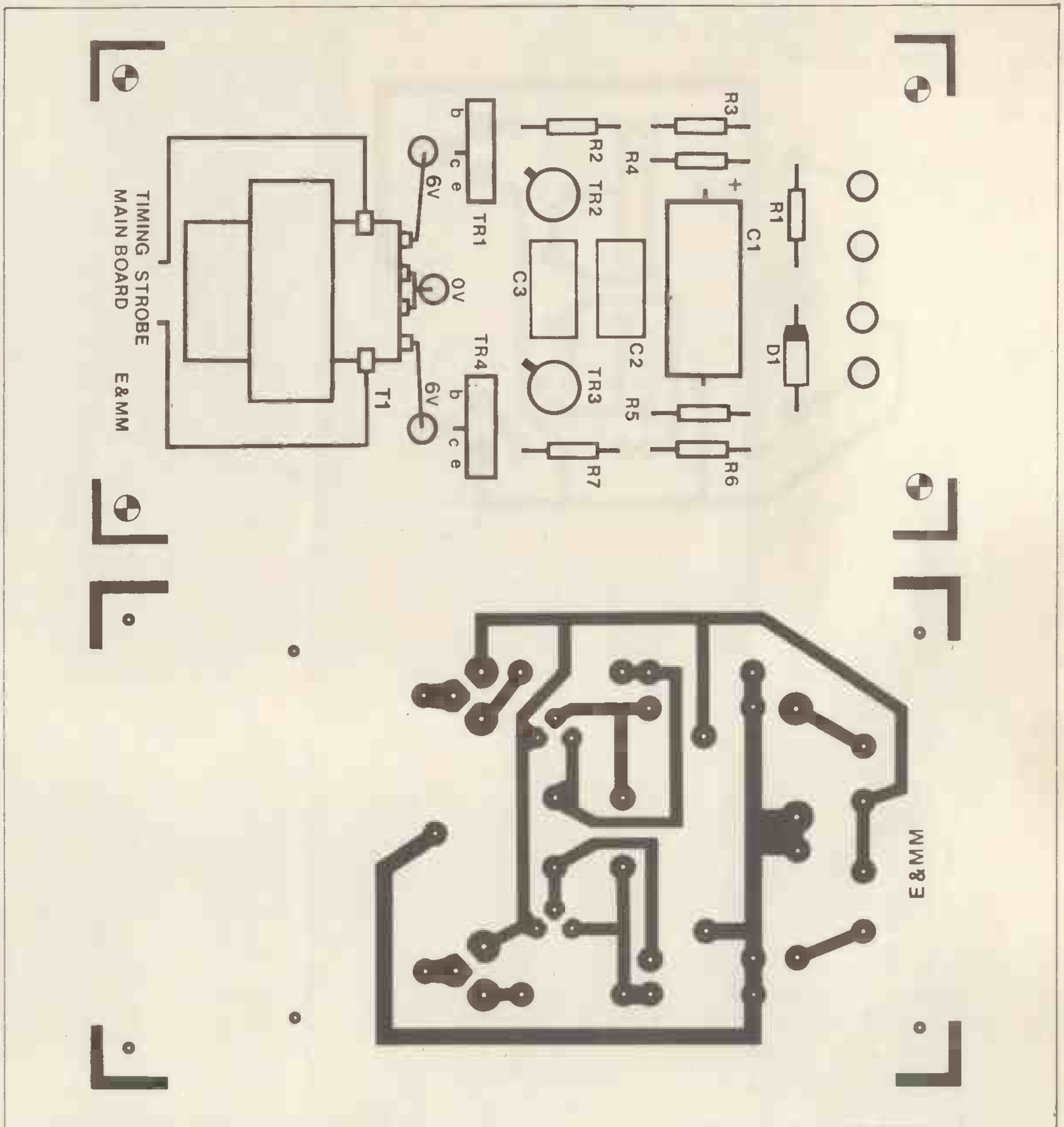
The unit described is a Xenon tube strobe which runs off the car's 12 volt battery. Figure 1 shows the complete circuit diagram.

The heart of the circuit is an inverter, this is designed to step up the 12 volts DC from the car battery to approximately 400-500 volts. TR2, TR3, R3, R4, R5, R6, C2 and C3 form a simple multivibrator oscillating at approximately 800Hz. The waveform at the junction of TR2, R3, R2, C2, is 180° out of phase with that at the junction of TR3, R6, R7, C3. TR1 and TR4 are power transistors used in common emitter configuration. The outputs are fed through a 6-0-6V miniature mains transformer wired in reverse. The output from the 240 volt winding is rectified by D3-D6, smoothed by C4, and fed to the Xenon tube. The Xenon tube fires on receiving the spark plug pulse. D1 is used to protect against accidental reverse connection of the supply. D2 is an LED and indicates correct connection to the battery. R8 is used so that in the event of arcing of the HT supply to some other component, the HT to the engine is not interrupted as this would cause the engine to severely misfire and run unevenly.

Construction

The Ignition Timing Strobe is built into two veroboxes bolted together. Each verobox has its own PCB. The first box, the bigger of the two, is where the cables enter the unit. The PCB holds the oscillator, power stage and transformer; the second PCB in the smaller box holds the bridge rectifier, the smoothing capacitor, R8, and the Xenon tube. The Xenon tube is mounted within the remains of a flashcube, this is to help in reflecting the light. You are strongly advised to follow the constructional details, in particular using the plastic boxes; the use of metal cases may lead to arcing to the case and electric shocks may occur. Begin by building up the PCB's as shown in Figure 2.





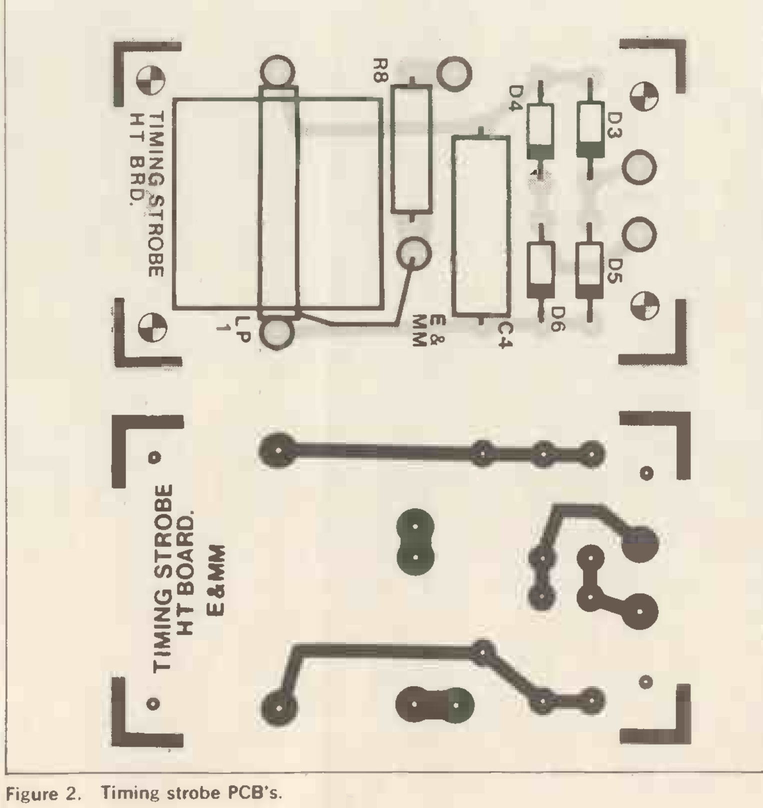


Figure 2. Timing strobe PCB's.

To mount the Xenon tube cut open a used flashcube and cut away one of the four sections of the reflective plastic after removing it from the flashcube base. Cut a hole through the top of the reflective section (where the top of the bulb would have been) to fit the tube. With the bulb removed, mix up some filler as in the manufacturer's instructions. Car body filler was used in the prototype to mount the reflective section securely on the PCB. Allow the filler to dry before proceeding to build up the board. The Xenon tube is mounted as shown in Figure 3; use an insulated wire on the trigger lead and remember to observe polarity.

Cut or drill the holes for the cables, LED, fuseholder and PCB's, and those for bolting the boxes together. Observe the fact that the mounting holes for the

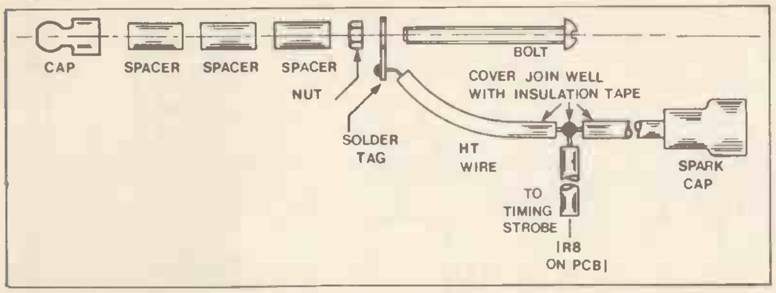
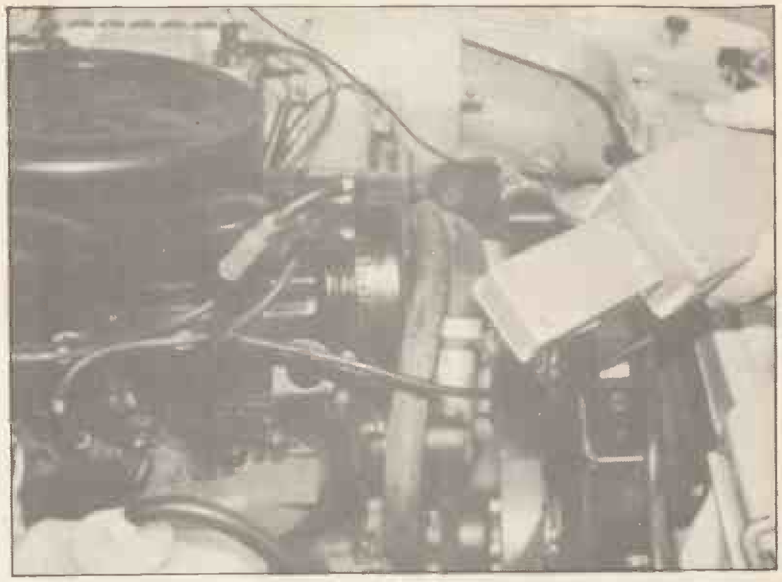


Figure 4. 'T'-piece construction.



PCB are spaced at different distances at each end of the box in both boxes and cut the holes in the end faces accordingly. Now bolt the two boxes together using ½ in. 4 BA bolts and nuts. Assemble the fuse holder and LED to the large case and then mount the PCB's in the boxes. Wire the unit as in Figure 2. If it is desired, the two units can be left separated; just extend the cable from the transformer. You will find it more convenient, however, to build the project up in one unit.

The next constructional step is to build the take-off point for the spark plug. This is essentially a 'T' piece of HT wire with one end made up of spacers, a 1½ in. screw and the cap of a spare spark plug. The other end is fixed on to a spark plug cap and the third end goes to the unit. Solder the wires at the T-junction and cover with insulation tape. One layer is not enough — if necessary use a whole reel. During operation there is 20,000 volts at this point. The assembly diagram is shown in Figure 4.

The final part of construction is to cut the hole in the top of the smaller box for the strobe. When cut cover with a piece of clear acetate or plastic.

Using the unit

Setting the ignition timing on most cars is quite straightforward, but the details vary from one make and model of a car to another. Referring to the manufacturer's handbook, locate the following:—

1. The cylinder plug which is used to determine the timing setting.
2. The appropriate ignition timing marks.
3. The adjustment on the distributor.

Before setting the timing it is recommended to take the distributor cap off the distributor and with a set of feeler gauges check the gap in the points as in the manufacturer's specification. If the points have not been changed for some while then it is always wise to replace them, cost approximately £1. Replace the cap of the distributor in the correct position and see that it is held down tight.

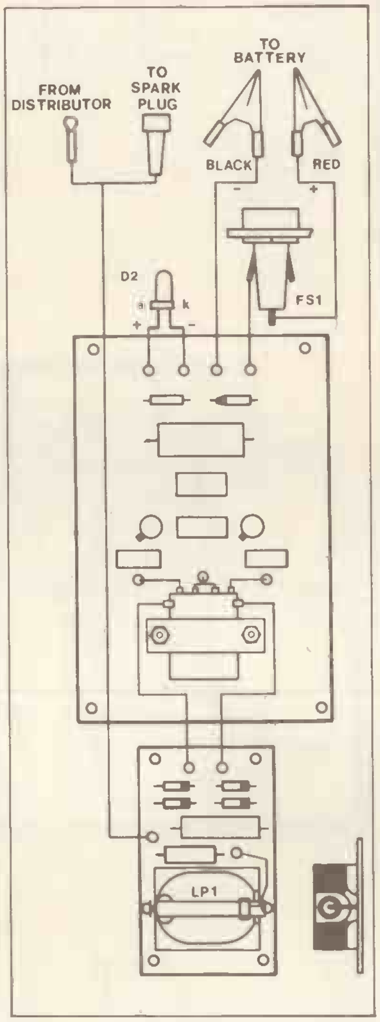


Figure 3. Timing strobe wiring diagram.

With the engine stopped and ignition off, remove the appropriate HT lead from the spark plug and connect the timing strobes HT lead in its place. Connect the unit to the battery. If all is well, the red LED will come on. A faint whistling noise may be heard from the unit.

Following the manufacturer's instruction start the engine and run it at the recommended speed. Also on some cars it may be necessary to remove the vacuum advance pipe, again this information should be given in the handbook.

Flashes of light should be given out by the strobe, if the engine is running at high revs, the light will appear to be continuous. Shine the light at the timing marks, which should appear to be aligned. Again the timing marks and their location will vary from car to car. On some cars there is a steel ball in the flywheel and this should line up with a recess in the timing aperture. If the timing marks are aligned, the timing is correct and no further adjustment is necessary. If, however, they are not aligned, slacken the nut on the distributor and turn the distributor in the required position until the timing marks are aligned. Switch off the engine, remove the HT leads and replace the HT lead from the distributor on to the spark plug. Disconnect the strobe supply from the battery. Do not remove these leads while the engine is running or you may receive an electric shock.

CAUTION:

The fan may appear to be stationary or revolving slowly when viewed in the light from the timing strobe — this, however, is not the case and injury may result if you put your hand in the vicinity of the fan or fan belt whilst the engine is running.

PARTS LIST

Resistors — all 5% ½W carbon

R1,2,3,6,7	1k0	5 off	(S1K0)
R4,5	10k	2 off	(S10K)
R8	4k7		(S4K7)

Capacitors

C1	100uF 40V axial elect.		(FB50E)
C2,3	68nF polyester	2 off	(BX75S)
C4	100nF 600V mixed dielectric		(BX67X)

Semiconductors

TR1,4	MJE3055	2 off	(QH56L)
TR2,3	BC107	2 off	(QB31J)
D1	IN5400		(QL81C)
D2	0.2in. LED, red		(WL27E)
D3-6	IN4007	4 off	(QL79L)
LP1	Xenon tube		(YQ62S)

Miscellaneous

	Verobox 102	(LH01B)
	Verobox 106	(LL03D)
T1	Transformer 240v Prim., 0-6, 0-6v Sec. 6VA	(WB06G)
	Panel fuse holder, 1¼in.	(RX97F)
FS1	Fuse, 1A, 1¼in.	(WR11M)
	0.2in. LED clip	(YY40T)
	4BA ½in. Bolts	(BF03D)
	4BA 1½in. Bolts	(LR52G)
	6BA ¼in. Bolt	(BF05F)
	4BA Nuts	(BF17T)
	4BA Solder tags	(BF28F)
	4BA ½in. spacers	(FW32K)
	Mains cable. 3A, 2-core	(XR47B)
	HT Wire	*
	Used flashcube	
	Spark plug cap	*
	Alligator clip, red	(HF24B)
	Alligator clip, black	(HF23A)
	Main PCB	(GA22Y)
	HT PCB	(GA23A)

**Obtainable from most motorist's shops*

TRANSCENDENT 2000 SINGLE BOARD SYNTHESISER

Designed by consultant Tim Orr (formerly synthesiser designer for EMS Ltd.) and featured as a constructional article in ETI, this live performance synthesiser is a 3 octave instrument transposable 2 octaves up or down giving sweep control, a noise generator and an ADSR envelope shaper. There is also a slow oscillator, a new pitch detector, ADSR repeat, sample and hold, and special circuitry with precision components to ensure tuning stability amongst its many features.
The kit includes fully finished metalwork, fully assembled solid teak cabinet, filter sweep pedal, professional quality components (all resistors either 2% metal oxide or ½% metal film), and it really is complete — right down to the last nut and bolt and last piece of wire! There is even a 13A plug in the kit — you need buy absolutely no more parts before plugging in and making great music! Virtually all the components are on the one professional quality fibreglass PCB printed with component locations. All the controls mount directly on the main board, all connections to the board are made with connector plugs and construction is so simple it can be built in a few evenings by almost anyone capable of neat soldering! When finished you will possess a synthesiser comparable in performance and quality with ready-built units selling for many times the price.
Comprehensive handbook supplied with all complete kits! This fully describes construction and tells you how to set up your synthesiser with nothing more elaborate than a multi-meter and a pair of ears!

COMPLETE KIT ONLY £168.50 + VAT!

Cabinet size 24.6" x 15.7" x 4.8" (rear) 3.4" (front)

1024 NOTE SEQUENCER/COMPOSER — see our advert on Page 56

ETI VOCODER

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Panel size 19.0" x 5.25". Depth 12.2"

Featured as a construction article in Electronics Today International this design enables a vocoder of great versatility and high intelligibility to be built for an amazingly low price. 14 channels are used to achieve its high intelligibility, each channel having its own level control. There are two input amplifiers, one for speech either from microphone or a high level source e.g. mixer or cassette deck and one for external excitation (the substitution signal) from either high or low level sources. Each amplifier has its own level control and a rather special type of tone control giving varying degrees of bass boost with treble cut or treble boost with bass cut. The level of the speech and excitation signals are monitored by LED PPM meters with 10 lights — 7 green and 3 red which indicate the level at 3dB steps. There are three internal sources of excitation — a noise generator and two pulse generators of variable frequency and pulse width. Any of the internal sources and the external source can be mixed together. There is a voiced/unvoiced detector which substitutes noise for the excitation signal at the points in speech where the vocal chord derived sounds of the speaker are substituted for by the unvoiced sounds of sibilants, etc. There is a slew rate control which smooths out the changes in spectral balance and amplitude enabling a change of the speech into singing or chanting and other special effects. A foot switch is provided to permit a complete freeze in spectral balance and amplitude whenever required. An LED on this indicates when the freeze is in operation.
An output mixer allows mixing of the speech, external excitation and vocoder output. The majority of the components fit into the large analysis/synthesis board with the rest on 8 much smaller boards with the controls and sockets mounted on them for ease of construction. Connectors are used for the small amount of wiring between the boards.
The kit includes fully finished metalwork, professional quality components (all resistors 2% metal oxide), nuts, bolts, etc. — even a 13A plug!

TRANSCENDENT DPX MULTI VOICE SYNTHESISER

Another superb design by synthesiser expert Tim Orr published in Electronics Today International

COMPLETE KIT ONLY £299 + VAT!

Cabinet size 36.3" x 15.0" x 5.0" (rear) 3.3" (front)

The Transcendent DPX is a really versatile 5 octave keyboard instrument. These are two audio outputs which can be used simultaneously. On the first there is a beautiful harpsichord or reed sound — fully polyphonic, i.e. you can play chords with as many notes as you like. On the second output there is a wide range of different voices, still fully polyphonic. It can be a straightforward piano as a honky tonk piano or even a mixture of the two! Alternatively you can play strings over the whole range of the keyboard or brass over the whole range of the keyboard or should you prefer — strings on the top of the keyboard and brass as the lower end (the keyboard is electronically split after the first two octaves) or vice-versa or even a combination of strings and brass sounds simultaneously. And on all voices you can switch in circuitry to make the keyboard touch sensitive! The harder you press down a key the louder it sounds — just like an acoustic piano. The digitally controlled multiplexed system makes practical touch sensitivity with the complex dynamics law necessary for a high degree of realism. There is a master volume and tone control, a separate control for the brass sounds and also a vibrato circuit with variable depth control together with a variable delay control so that the vibrator comes in only after waiting a short time after the note is struck for even more realistic string sounds.
To add interest to the sounds and make them more natural there is a chorus/ensemble unit which is a complex phasing system using CCD (charge coupled device) analogue delay lines. The overall effect of this is similar to that of several acoustic instruments playing the same piece of music. The ensemble circuitry can be switched in with either strong or mid effects. As the system is based on digital circuitry digital data can be easily taken to and from a computer (for storing and playing back accompaniments with or without pitch or key change, computer composing, etc., etc.).
Although the DPX is an advanced design using a very large amount of circuitry, much of it very sophisticated, the kit is mechanically extremely simple with excellent access to all the circuit boards which interconnect with multiway connectors, just four of which are removed to separate the keyboard circuitry and the panel circuitry from the main circuitry in the cabinet.
The kit includes fully finished metalwork, solid teak cabinet, professional quality components (all resistors 2% metal oxide), nuts, bolts, etc., even a 13A plug!

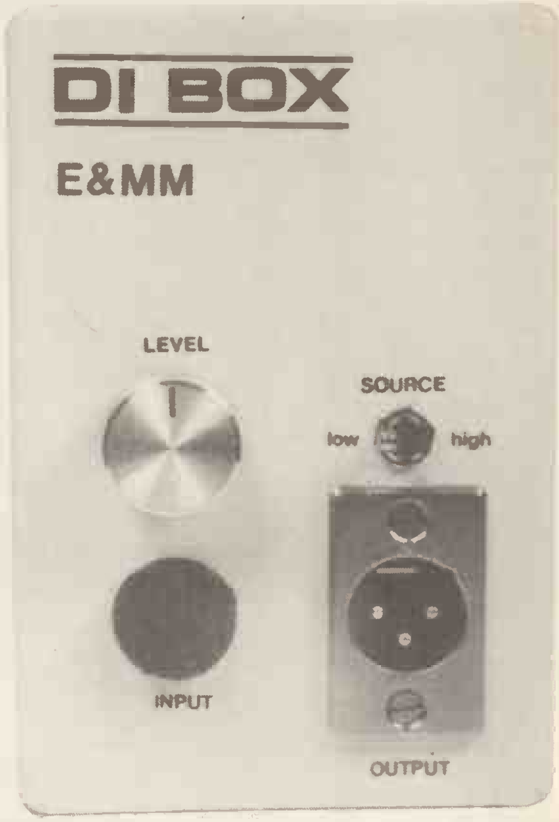
POWERTRAN

MANY MORE KITS ON PAGE 31 — MORE KITS AND ORDERING INFORMATION ON PAGE 7

All projects on this page can be purchased as separate packs, e.g. PCBs, components sets, hardware sets, etc. See our free catalogue for full details and prices.

DIRECT INJECT BOX

by Chris Lare



The Direct Inject Box (D.I. Box) allows the signal from an amplified instrument to be fed directly into a balanced line mixing desk, and as such is invaluable on stage, and in the home or professional recording studio avoiding many of the disadvantages of using a microphone. It is much cheaper to build the D.I. Box than to buy a good microphone, and it eliminates acoustic feedback and 'spill-over' of other sounds into the instrument channel.

The Circuit

The D.I. Box takes its input from the instrument amplifier and converts it to a balanced line output at microphone level. Figure 1 shows the circuit employed. The input signal is fed via a switchable attenuator to the 47k potentiometer. This means that the box has an input impedance of about 47k when used as a low level (line) input and over 700k in the speaker level mode. As shown the input is dc coupled and if a dc offset appears on the input the potentiometer will be noisy as it is moved. If this occurs a 470nF polyster capacitor should be connected in series with the input.

Two J-FET op-amps, chosen mainly for their very low power consumption, form the phase and antiphase generator. The first op-amp inverts the signal and divides its level by 4, whereas the second op-amp merely re-inverts the output from the first. The two outputs are thus of the same level but exactly out of phase and can be used directly. A 100R resistor is included in each output as a protection against short circuits, and a capacitor is obviously required to block the dc level. The op-amps are biased to half rail by R10 and R11 which hold the non inverting inputs at 4.5 volts and R3 which provides a dc offset for the input signal. Diodes D1 and D2 protect the op-amp in the event of severe overload, and play no part in the normal operation of the circuit.

A single 9 volt battery is used to power the circuit. This is switched in the usual way by using a stereo jack socket on the input.

Construction

A printed circuit board holds all the resistors, capacitors and semiconductors except R1 and RV1. Mount and solder the components and Veropins on the PCB, with IC1 left to last. Bolt the PCB to the lid of the box and the connectors, pot, and switch to the base. If a box other than the one recommended is used, check that it is deep enough to take the chassis Cannon plug. Solder R1 and the battery connector in position, and wire up the connections to the PCB using screened cable.

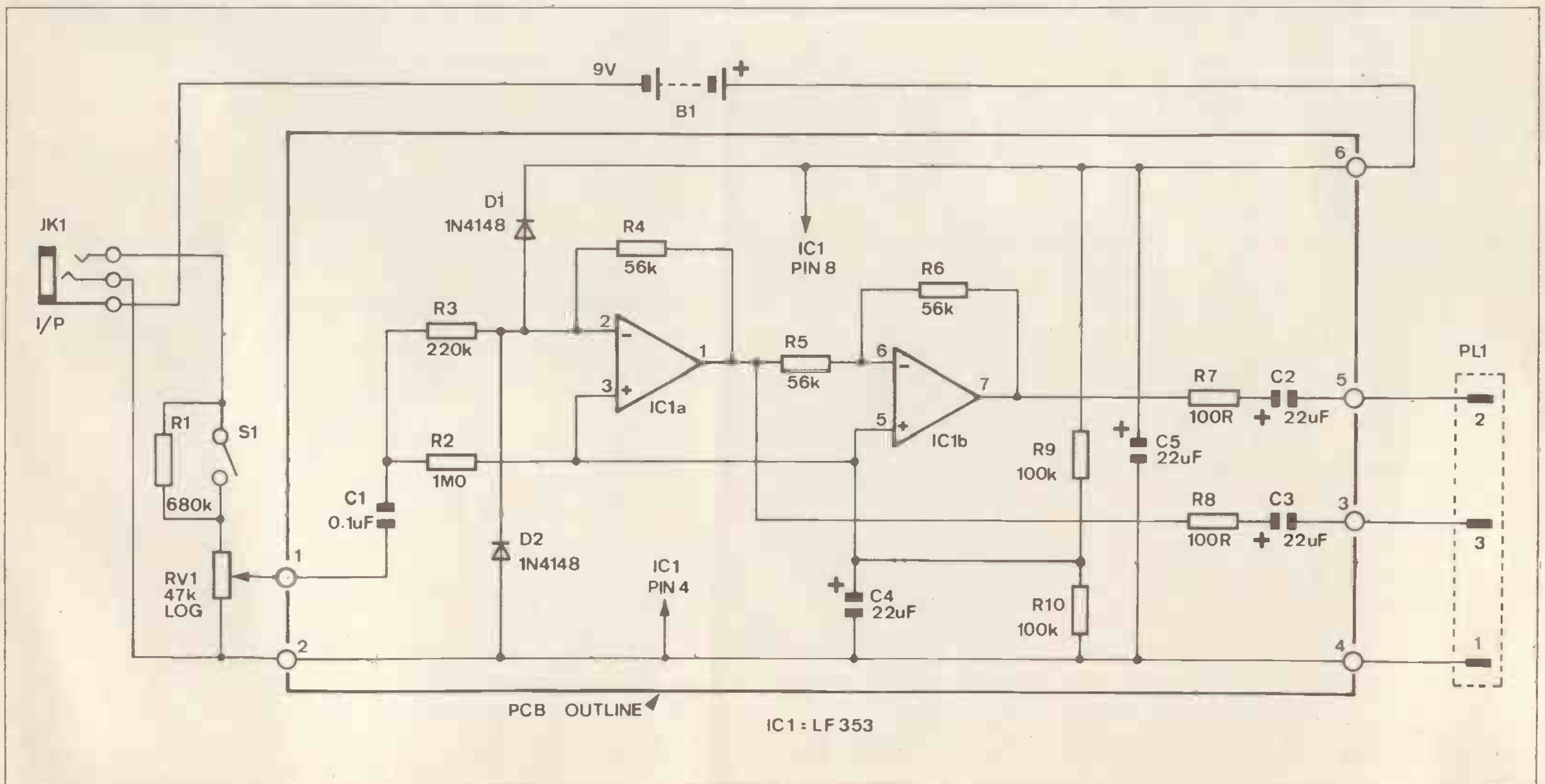


Figure 1. Circuit Diagram of the D.I. Box.

The prototype used a small piece of polystyrene foam glued to the lid above the battery position to hold the battery in place. Finishing consisted of lettering and varnishing the front, and sticking four rubber feet on the bottom.

Operation

Use a jack-to-jack to connect the D.I. Box to the extension speaker socket on the amplifier or speaker cabinet, or the amplifier slave out jack, remembering to set the high/low switch accordingly. If an additional speaker output jack is not available, a jack-to-two-jack splitter lead can be used to connect the D.I. Box input in parallel with the speaker cabinet. RV1 should be adjusted for a convenient signal level to the desk.

Unlike direct injection of the instrument output or pre-amplified signal, the D.I. Box passes the full sound of the amplified instrument, including the effects of tone controls, signal processors, and amplifier distortion (the latter is often an important part of guitar sound) from the speaker outputs to the mixing desk for recording or amplification by the group P.A. Alternatively, the unit can be connected to the 'Slave Out' or 'Link' jack socket of the amplifier avoiding the distortion of the output stage. This is particularly useful for amplifiers which are also used as sub-mixers e.g. with keyboards, since output stage distortion is especially noticeable on a mix of different signals.

It is important to note that the D.I. Box design that follows is intended for mixers with balanced line inputs. If the mixer in question does not have such inputs it is debatable if the D.I. Box is worth using; a simple wire connection being the easiest. If hum problems do occur, or particularly long connections are required, better results will be obtained with the E&MM Line Driver/Receiver presented in last month's issue. The Balanced Line System, although designed for microphone use, will handle signal levels of up to 400mV without any trouble.

Obviously some instruments cannot be D.I.'ed — the most notable example being an organ with a Leslie cabinet. The D.I. is also a matter for personal opinion, indeed many claim that the sound produced is too dry. Additionally, problems will occur if tonal adjustments are made before the D.I. connection to compensate for a poor speaker cabinet. It is, however, a much under-rated technique, offering several advantages — cheaply. E&MM

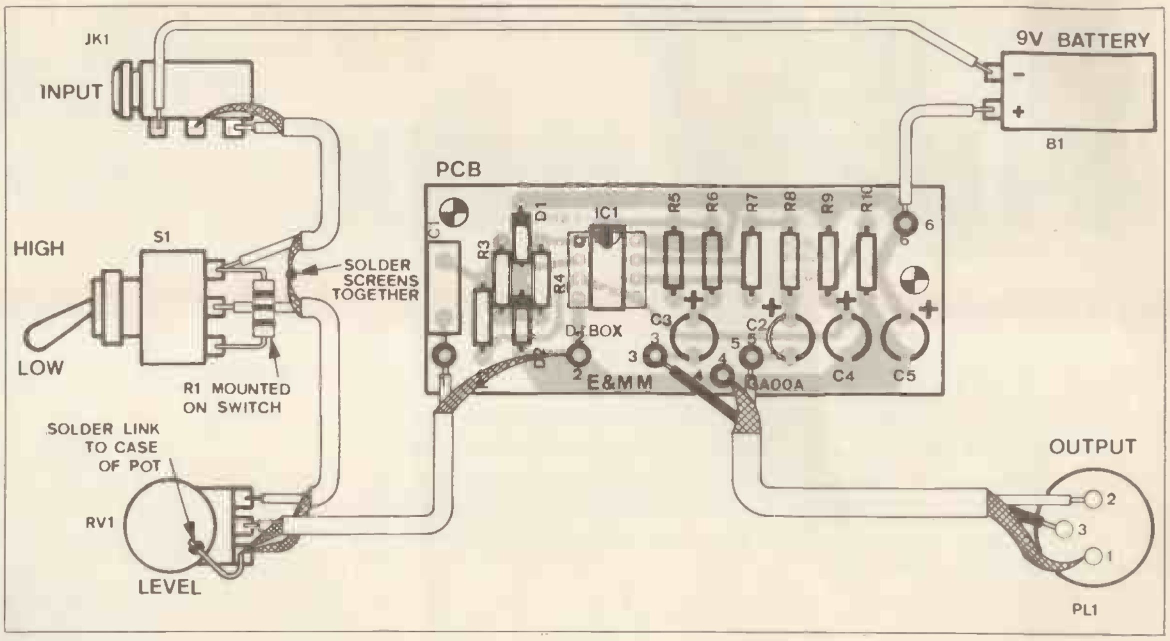


Figure 2. Internal Wiring of the D.I. Box.

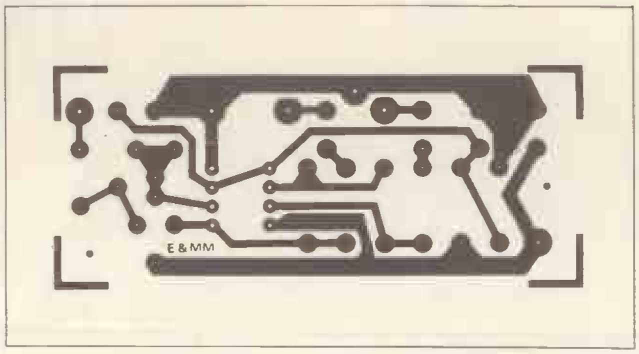


Figure 3. The D.I. Box PCB.

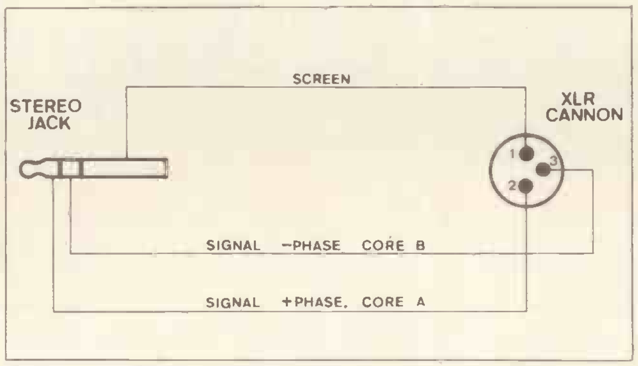
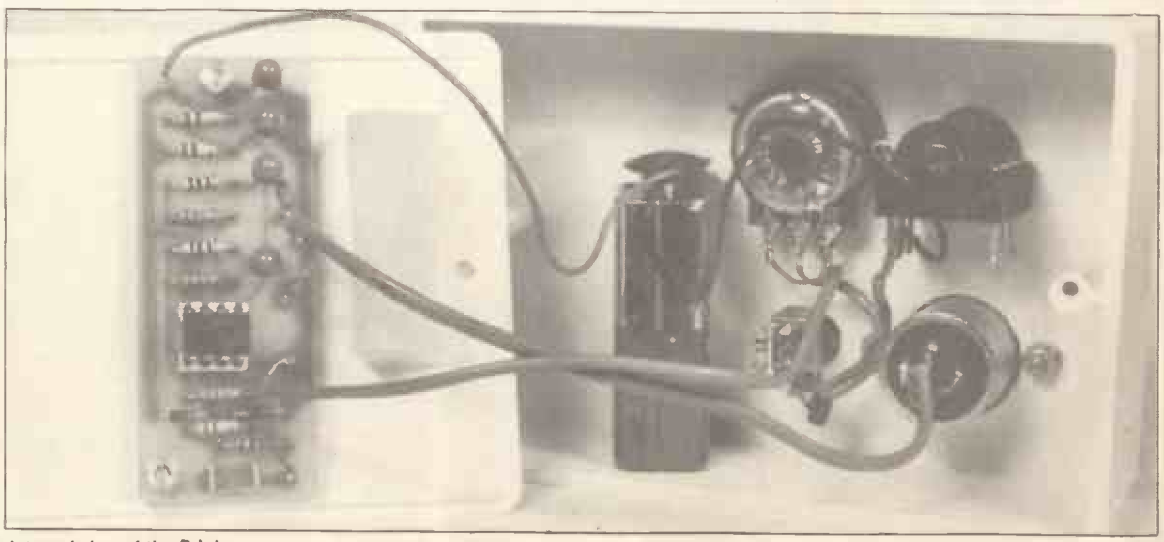


Figure 4. XLR Cannon-to-jack lead connections.

PARTS LIST

Resistors — all 5%⅓W carbon unless specified

R1	680k		(M680K)
R2	1M0		(M1M0)
R3	220k		(M220K)
R4,5,6	56k	3 off	(M56K)
R7,8	100R	2 off	(M100R)
R9,10	100k	2 off	(M100K)
RV1	47k log. pot.		(FW24B)
Capacitors			
C1	100n carbonate		(WW41U)
C2,3,4,5	22u 16V tantalum	4 off	(WW72P)
Semiconductors			
IC1	LF353		(WQ31J)
D1,2	1N4148	2 off	(QL80B)
Miscellaneous			
PL1	XLR chassis plug, 3-pin		(BW92A)
S1	Sub-min toggle 'A'		(FH00A)
JK1	Jack socket, stereo		(HF92A)
B1	PP3 battery		
	Printed circuit board		(GA00A)
	Case PB1 (or alternative)		(LF01B)
	Veropins, 1mm		(FL24B)
	PP3 connector		(HF28F)
	Knob R52 (or alternative)		(HB29G)
	Twin screened cable	1m	(XR21X)

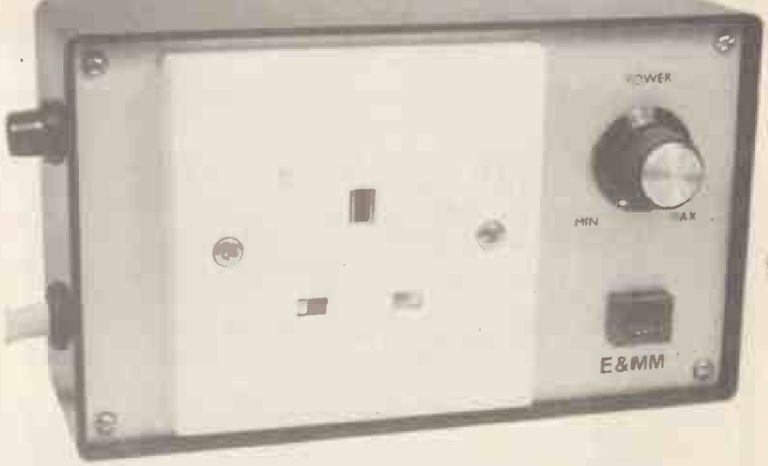


Internal view of the D.I. box.

POWER CONTROLLER

by R. A. Penfold

- Dual Purpose
- Smooth Action Lighting Control
- Useful for Electric Drills and Soldering Irons
- Neon Indicator



This versatile power controller is suitable for use as a lamp dimmer with a standard or table lamp, and can also be used as a drill speed controller. It can handle loads of up to 720 watts, and this is more than sufficient for any normal domestic lamp or electric drill. The controller is easy and convenient to use since there is a mains outlet on top of the unit and the controlled equipment is merely plugged into this.

It is possible to use other items of equipment with the unit, and it could be used as a soldering iron temperature controller for example. It is quite common for soldering irons to have a short bit life due to an excessive operating temperature, and this can be corrected by slightly reducing the power fed to the iron. This gives a bit temperature that is still adequate for efficient soldering, and substantially fewer replacement bits are needed.

An unusual feature of the unit is the precise control it provides at low output power levels. When an ordinary power controller is advanced from zero it tends to give no output until the power control has been advanced some way, and then suddenly operates normally. This controller has additional circuitry which eliminates this effect.

Fluorescent lamps require a special type of dimmer circuit incidentally, and cannot be used with normal power controllers such as the one described here.

Operating Principle

A power controller can simply consist of a high power variable resistor (rheostat) connected in series with the supply, but this results in a lot of wasted power in the resistor which is converted into unwanted heat. A more efficient method is to use a switching circuit where the power fed to the load is controlled by pulsing it full on for a certain proportion of the time.

This method is illustrated by the output waveforms of Figure 2. The waveform shown in Figure 2a is that obtained with the controller set for maximum power. Here power is applied to the load almost at the beginning of each mains half cycle, and is maintained practically until the end of each half cycle. While there is obviously a small loss of power because the very beginning of each mains half cycle has been cut off, this loss is far too small to be of practical significance.

In order to reduce power the mains is not switched through to the load until later in each half cycle. In the waveform of Figure 2b only the second half of each mains pulse is applied to the load, thus giving half power. In the waveform of Figure 2c only the final part of each half cycle is present at the output, giving practically zero output power.

The Circuit

The circuit diagram of the controller is shown in Figure 1 and the circuit is basically a conventional triac-diac type.

The triac (CSR2) is connected in series with the supply to the output, and this device will normally be switched off. It can be made to conduct between the MT1 and MT2 terminals by applying a brief trigger current of around 30mA to the gate terminal, and it will continue to conduct until the end of the mains half cycle when the current through the device falls to zero, and it switches off. CSR1 is a diac connected in the gate circuit of the triac. A diac has similar characteristics to a triac, but it has no gate terminal, and triggers automatically if it is subjected to a potential of more than about 32 volts.

With RV1 set for minimum resistance C2 will charge rapidly via R3 at the beginning of each half cycle, and the voltage across C2 will be virtually equal to the mains voltage. When the charge voltage on C2 reaches the trigger potential of the diac the latter 'fires' and discharges C2 into the triac's gate. This triggers the triac very early in each half cycle, giving virtually full power at the output. Once triggered, the triac short circuits R3, RV1, and C2 so that C2 remains uncharged until the end of the half cycle, and is ready to start from the beginning at the start of the subsequent one.

If RV1 is set for a higher resistance this increases the lag between the charge on C2 and the mains voltage so that the circuit triggers later in each half cycle and gives reduced output power. The circuit will not trigger at all with RV1 at maximum resistance, and it is therefore possible to vary the output power from zero to maximum by means of RV1.

If the resistance of RV1 is such that the diac does not trigger, there is a residual charge left on C2 at the end of the mains half cycle. C2 is subjected to a charge of opposite polarity on the next half cycle, and the residual charge on C2 obviously counteracts the new charge to some extent. It is this that would give poor control when RV1 is advanced from zero power, with RV1 needing to give a fairly low resistance in order to overcome the reverse charge on C2 and charge the latter to the trigger voltage of the diac. Once this happens, C2 is uncharged at the end of each half cycle, and the unit functions normally.

In this circuit the problem is overcome by the inclusion of R2, D1, and D2. On half cycles where the MT2 terminal of CSR2 is

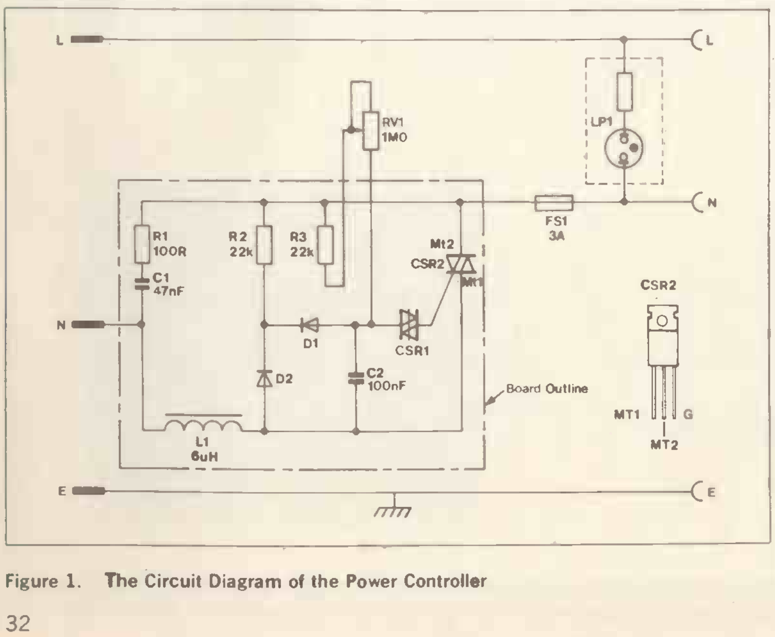


Figure 1. The Circuit Diagram of the Power Controller

negative of its MT1 terminal the additional components have no real effect. A small current will flow through R2 and D2, but this is not sufficient to have any significant affect. About 0.6 volts is produced at the junction of R2, D1, and D2, and the charge on C2 reverse biases D1 so that this has no effect either.

When the supply is of the opposite polarity D2 is reverse biased, and so is D1 initially since the voltage on C2 lags behind the mains voltage. The situation is different towards the end of the half cycle when the mains voltage drops towards zero. C2 then rapidly discharges through D1 and R2 so that the unwanted residual charge is lost. The circuit therefore functions normally on the subsequent half cycle, and the diac will trigger if RV1 has a suitable setting.

Circuits of this type inevitably generate some radio frequency interference due to the rapid rise in the output voltage when the triac triggers. R1, C1, and L1 are included to minimise this interference.

LP1 is a neon indicator lamp with integral resistor which varies in brightness according to the power level fed to the load, and is useful when the unit is used with something like a soldering iron which gives no obvious or immediate indication of the power level it is receiving. Fuse FS1 protects the unit if the output is loaded excessively.

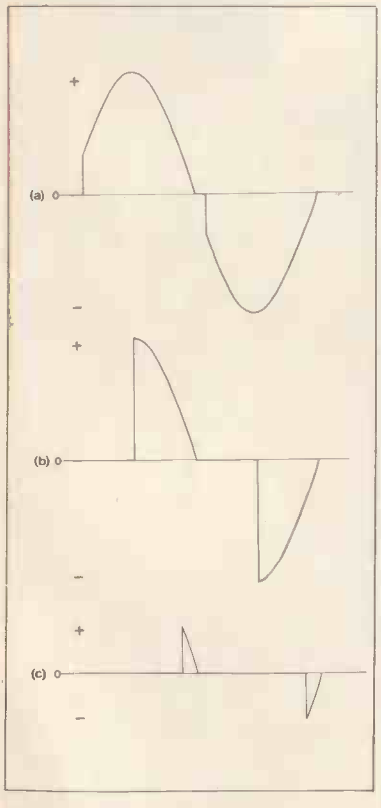


Figure 2. Output Waveforms:
(a) at maximum power
(b) at half power
(c) at virtually minimum power

PARTS LIST

Resistors — all ½W 5% unless specified

R1	100R		(S100R)
R2	22k 3W W/W min.		(W22K)
R3	22k		(S22K)
RV1	1M0 lin. pot.		(FW08J)

Capacitors

C1	47n polyester		(BX74R)
C2	100n carbonate		(WW41U)

Semiconductors

CSR1	ST2 Diac		(QL08J)
CSR2	SC146D Triac		(QL05F)
D1,2	1N4004	2 off	(QL76H)

Miscellaneous

L1	6uH 3 Amp suppression choke		(HW06G)
	3 AMP 20mm quick-blow fuse		(WR06G)
	Plastic case with aluminium panel		(WY02C)
	Printed circuit board		(GA25C)
	Square panel neon (red)		(RX81C)
	Unswitched mains socket		(HL68Y)
	Knob M2		(RW89W)
	20mm panel fuseholder		(RX96E)
	Mains cable, 6A, 2m		(XR04E)
	Vaned heatsink, plastic power		(FL58N)

Construction

A suitable case for the unit is the Metal Panel Box (type M4005) which has outside dimensions of 161 x 96 x 59mm, but any case of about the same size should be satisfactory. RV1 and LP1 are mounted on the right hand side of the top panel, with the mains outlet on the left. A large cutout is required for the outlet, and this can be made by drilling a string of very closely spaced holes around the inside of the perimeter of the cutout. A miniature round file can then be used to join the holes and complete the cutout. The outlet is bolted in place using M4 fixings. The right hand side of the case is drilled to take the mains input lead and the fuseholder.

All the other components are fitted onto a small printed circuit which is detailed in Figure 3. This diagram also shows the other wiring of the unit. The printed circuit is completed in the normal way, and is bolted to the base panel of the case, beneath RV1 once it has been wired to the rest of the unit. Note that the triac must be fitted with a small finned heatsink or the unit will only be able to safely handle loads of up to about 300 watts.

In the interest of safety it is essential that the metal front panel is earthed, and the connection is made by the earth connector and one of the mounting bolts of the mains outlet. The case must be a type that bolts together, and should not be one that could simply be unclipped to reveal mains wiring. RV1 should be a type having a plastic spindle and it should be fitted with a plastic control knob. Do not touch any of the wiring while the unit is plugged into the mains supply.

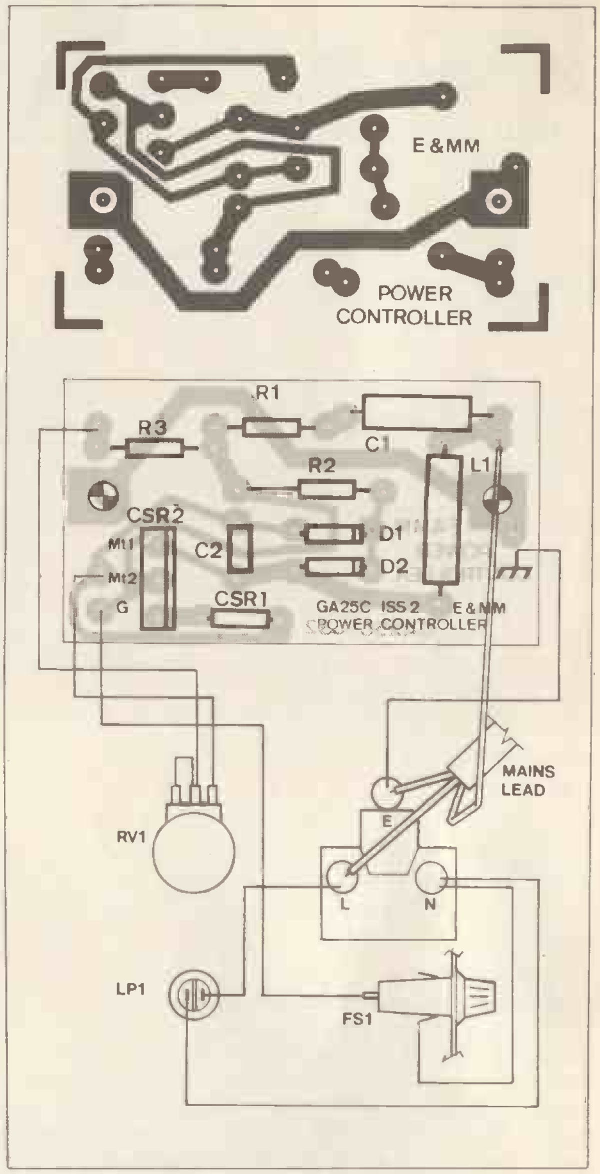
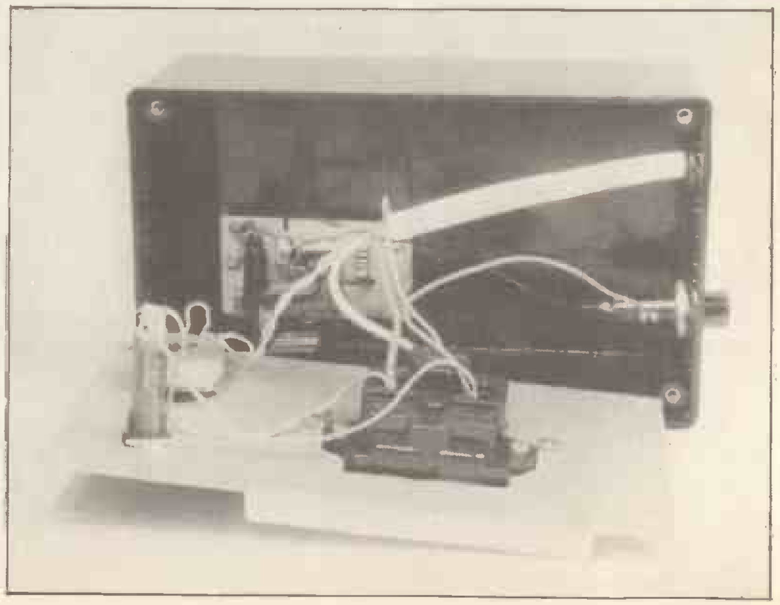


Figure 3. The Power Controller Printed Circuit Board

If the unit is working correctly LP1 will light up at full brightness when the unit is connected to the mains supply (due to the current it receives via R3 and D2), and it will vary in brightness in sympathy with the setting of RV1 when a load is connected to the unit. It may be found that due to component tolerances zero power is achieved some way before RV1 is fully backed-off. If necessary, this can be remedied by adding a 2.7 megohm ⅓ watt resistor in parallel with RV1.

E&MM



THE MATINÉE ORGAN

A complete electronic organ to build at low cost

PART 2: Construction of the keyboards and of all the upper manual circuits described

To successfully make the Matinée organ you do not need any knowledge of electronics, though you will undoubtedly learn some as you go along. The only vital requirement is the ability to be able to solder correctly and neatly. Good soldering is a skill that is learnt by practice and it is most important that you learn this skill before starting this project.

How to solder

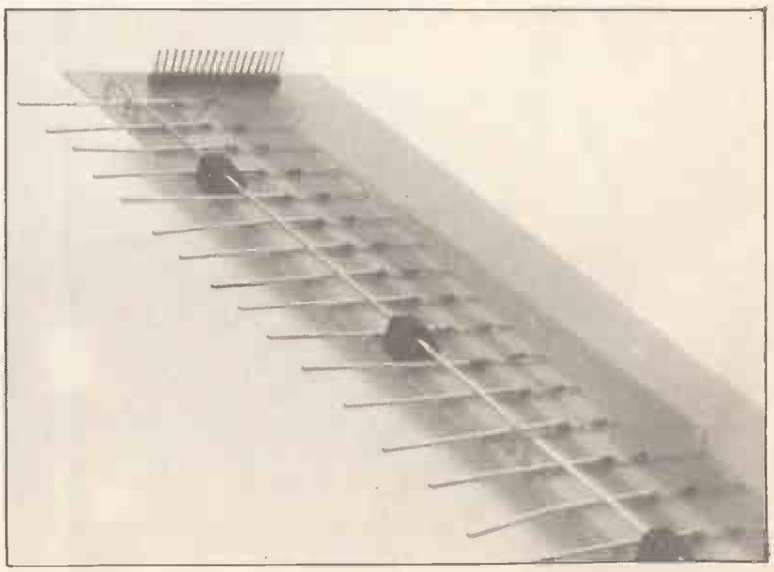
The main point to remember is that both parts of the joint to be made must be at the *same* high temperature. The solder will flow evenly and make a good electrical and mechanical joint only if both parts are at an equal high temperature. In this organ almost all the solder joints to be made are between a component wire and a printed circuit track, so in this case both the wire and the track must be at the same high temperature before the solder is applied. Before attempting this project practise soldering using a piece of Veroboard and some resistors or scrap components.

The first thing you'll need is a good soldering iron. There are plenty to choose from such as the Antex X25 or Litesold LC18 which both have a fairly high wattage to help the heat flow quickly into the joint so that the heat need be applied for only a short time. When the iron is hot apply some solder to the flattened working area at the end of the bit and wipe it with a piece of cardboard or damp cloth so that the solder forms a thin film on the bit. Always use a good quality solder such as Ersin multicore. A standard 60% tin, 40% lead alloy solder with cores of non-corrosive flux will be found the easiest to use.

If the wires of the component to be fitted are parallel to one another on the same side of the component (radial) they should fit directly into the PCB without bending, but if the leads come out of opposite sides of the component (axial) they should first be bent at right angles close to the body of the component. Push the leads through the PCB from the non-coppered side and splay out the ends of the leads a little on the coppered side so that the component does not fall out when the board is turned over and so that the wire touches the edge of the copper track.

Now melt a little more solder on to the tip of the soldering iron and put the tip so that it contacts both the copper track and the component wire. It is the molten solder on the tip of the iron that allows the heat to flow quickly from the iron into both parts of the joint. If the iron has the right amount of solder on it and is positioned correctly, the two parts to be joined will reach the solder's melting temperature in about half a second. Now apply the solder to the point at which the copper track, component wire and soldering iron are all touching one another. The solder will melt immediately and flow around all the parts that are at or over the melting point temperature. It should be possible to take the iron away within one and a half seconds of first touching the iron to the joint. Make sure that the lead and PCB do not move after the soldering iron is removed until the solder is completely hard. This should happen within five to ten seconds. If one of the components moves during this cooling period the joint may be seriously weakened.

The hard cold solder on a properly made joint will have a smooth shiny appearance, and if



Completed keyboard PCB, showing bus-bars, spacer blocks and contact springs in position.

the component is cut off and the wire from the joint pulled as hard as possible the wire should not pull out of the joint. It should be possible to pull the copper track up off the Veroboard by pulling on the wire. In a properly made joint the solder will bond the wire to the copper track very strongly indeed. It is also important to use the right amount of solder, both on the iron and on the joint. Too little solder on the iron will result in poor heat transfer to the joint, too much and you will suffer from the solder forming strings as the iron is removed, causing splashes and bridges to other tracks. Too little solder applied to the joint will give the joints a half-finished appearance: a good bond where the soldering iron was, and no solder at all on the other side of the joint. Too much solder applied to the joint will cause bridging when adjacent points are soldered.

Now, with all this in mind, make and test solder joints over and over again on a piece of Veroboard until you are making good solid joints every time. Remember it is much, much more difficult to correct a poorly made joint without damaging something, than it is to make the joint properly in the first place. Anyone can learn to solder properly, it just takes practice.

Keyboard Construction

When you are quite sure that you have mastered the art of soldering you are ready to start the construction of the Matinée. The first parts to be put together are the two keyboards. They are supplied already fixed into a frame so you do not have to worry about getting them set at the right height and offset with respect to one another; the manufacturers have done this for you. Another advantage with the frame is that each keyboard can be hinged up individually on the frame to make construction and servicing really easy.

There are two identical printed circuit boards; one for each manual. Forty-nine diodes, one for each key, are mounted on each PCB. Place the diodes in the positions marked on the PCB taking the wires through the holes, but do not cut off any of the leads yet. Long white lines are marked close to one edge of the PCB and this is the bus-bar edge. The bodies of the diodes should be positioned close to this edge of the PCB and not centrally between the holes for the diode's leads.

One end of each diode has a ring printed around it. This end is the cathode and corresponds to the thickened end in the drawing on the PCB. All the diodes must be placed the right way round, that is with the cathode farthest from the bus-bar edge of the PCB. Now take the wire from the other end of the diode (the anode) and push it back up through the next nearest hole on the PCB as shown in Figure 3. Make sure there is at least 1cm now sticking up above the PCB. Now solder all the cathodes and cut off the excess wire. Pull the lead from the anode fairly tight so that the loop under the PCB is as small as possible and then cut each wire so that it protrudes above the surface by about 1cm.

Take one of the contact springs and place it on one of the diode wires. Slide the wire in from the belled out end of the spring. Bend the wire and spring forward a little, towards the bus-bar side of the PCB and solder the wire to the spring. Place the iron on the bell of the spring for two or three seconds then touch the iron to the diode wire as well and apply the solder at the same time. The solder should run up the wire and fill the bell in the spring. Repeat this for all forty-nine diodes on both boards then bend them all forwards across the bus-bar lines

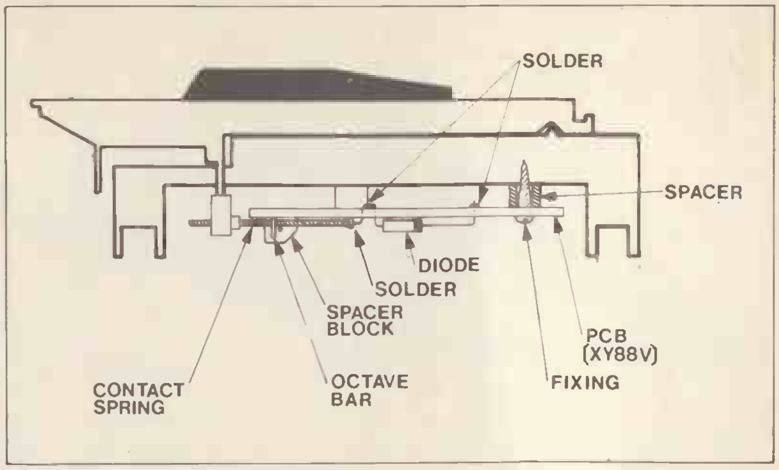


Figure 3. Assembly of Keyboard PCB.

on the PCB so that they lay flat on the PCB. Finally solder the loops on the coppered side of the PCB on each of the diodes.

Nine bus-bars are required, each about 18cm long. On eight of them slide two bus-bar support blocks. The bars should pass through the hole farthest from the mounting lug on the block. Now bend the bars as shown in Figure 4. Push the ends of the bars into the PCB at the same time pushing the lug on the bus-bar support blocks through the hole drilled out for them on the PCB. Melt over the ends of the lugs with a hot clean soldering iron, then clean the iron and solder the bus-bars ends to the PCB. Cut the ninth bus-bar to make the contact loop required for the forty-ninth note on each keyboard and bend it as shown in Figure 4 and solder to the PCB, keeping it at the same height from the PCB as the others. Note that the springs should all now be under the bus-bars.

There are two seventeen-way PCB-mounting plugs and one must be soldered to each PCB. The PCB destined to be fitted under the upper manual should have its plug fitted in the position marked 'solo' on the PCB and the PCB to be fitted under the lower manual should have its plug fitted in the position marked 'accompaniment' on the PCB. Make sure that you fit the plug the right way round so that the locking lugs are on the same side as the lugs printed on the PCB. This will ensure that when the ready-made connecting cable is plugged in, it can only be the right way round. The other end of this cable will be plugged onto the main PCB. We shall describe construction of the main PCB in Part 3.

Press fit the five spacers to each keyboard PCB and mount the PCB under the appropriate keyboard using self-tappers (No. 4 x ½in.) through the spacers into the pre-drilled holes in the plastic frame of the keyboard. Carefully take the loose end of each spring and push it through the hole in each plunger under the keys. Finally check that when the keys are at rest none of the springs are touching the bus-bars and that each contact spring touches the bus-bar as each key is pressed. This completes the construction of the keyboards.

Keyboard Operation

The seventeen wires to the keyboard are connected in a 5 x 12 matrix. All five C's on the

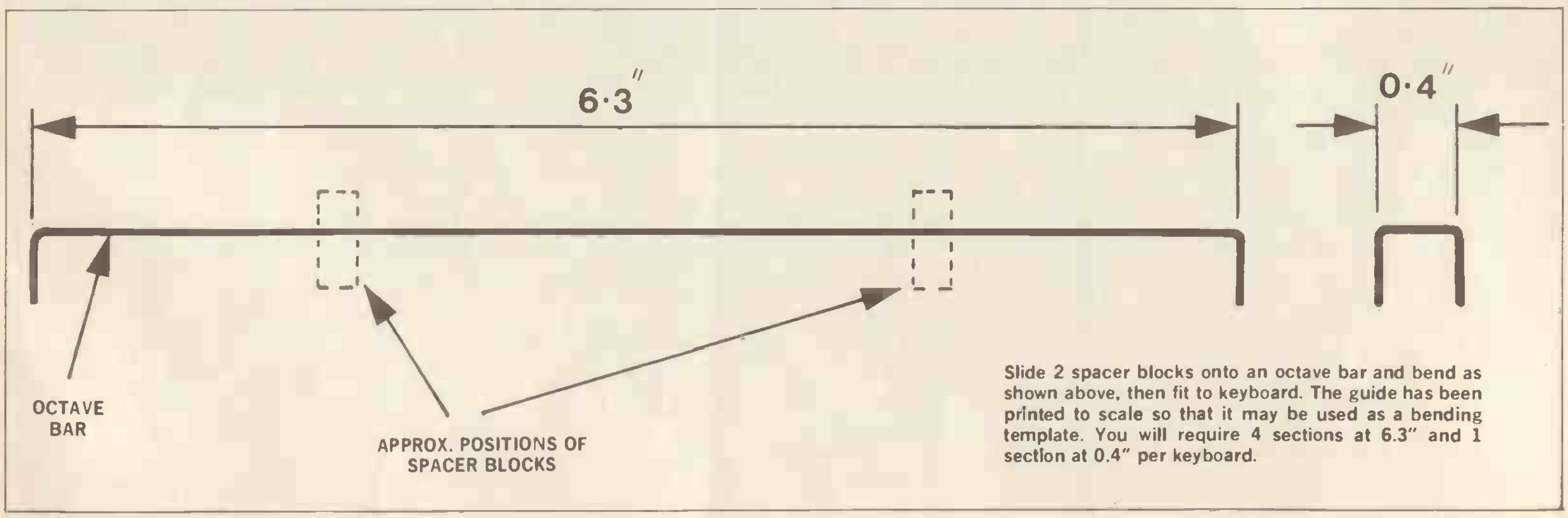
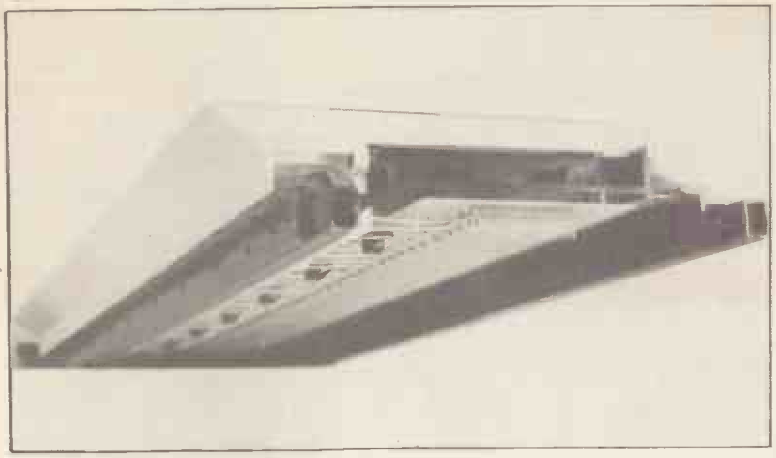


Figure 4. Template for Octave Bars.



Picture 2. Keyboard PCB fixed to keyboard using keyboard spacers. Note the end of the frame has been removed to show detail clearly.

Table 3. M108 Pin Functions

1.	-6V	20.	+6V
2.	Power-on reset	21.	B
3.	8th/7th	22.	A#
4.	4 foot/5th	23.	A
5.	8 foot/3rd	24.	G#
6.	16 foot/root	25.	G
7.	Bass output	26.	F#
8.	ROM A	27.	F
9.	ROM B	28.	E
10.	ROM C	29.	D#
11.	NPA (pitch present in accompaniment outputs)	30.	D
12.	$\overline{\text{TDB}}$ (trigger decay bass)	31.	C#
13.	$\overline{\text{TDS}}$ (trigger decay solo)	32.	C
14.	$\overline{\text{KPA}}$ (key pressed accompaniment)	33.	Octave bar 6
15.	KPS (key pressed solo)	34.	Octave bar 5
16.	16 foot	35.	Octave bar 4
17.	8 foot	36.	Octave bar 3
18.	4 foot	37.	Octave bar 2
19.	+6V	38.	Octave bar 1
		39.	Master frequency input
		40.	Matrix scanning frequency input

keyboard are linked together, all four D's are connected together and so on for the twelve notes. Each of the five separate bus-bars are connected with the other twelve wires to the M108 matrix inputs. Thus the M108 detects which keys are pressed because each key makes a unique connection between one of the twelve key wires and one of the five octave wires. However, if two C's for example were pressed simultaneously the two octave bars involved would be shorted together and if any other key in these two octaves were played the M108 would not be able to tell which of the two octaves the key was in. Therefore a diode is connected in series with each key contact so that the octave bars cannot be shorted together. In addition the inputs to the M108 for the octave bars require pull-up resistors and these are found on the main circuit board.

The M108 is capable of being switched to operate in one of two modes called the 'single' mode and the 'split' mode. In order to produce a fairly sophisticated instrument, in the Matinée both keyboards have their own M108 although the IC was designed originally as a single-chip organ. In the Matinée, on the lower manual it performs its dual function, but on the upper manual, which we shall look at first, it is locked permanently into the 'single' mode.

The M108 sends a signal to the twelve key lines in turn (pins 21 to 32) and looks on the five octave lines (pins 33 to 37) to see if any of the signals are returned. If one or more keys are played on the keyboard then a signal on that key line will be detected on the appropriate octave line and the internal keyboard decoder will allow the appropriate set of three frequencies to be switched to the three octave related outputs (pins 4, 5 and 6 for the lowest octave and pins 16, 17 and 18 for any other note).

The matrix scanning frequency is set by the frequency connected to pin 40 on the IC whilst the output frequencies are determined by the frequency connected to pin 39 on the IC. In the Matinée these pins are connected together and the same master frequency used for both. This is divided down to provide the output frequencies and the chip can generate 85 different notes (all at once as well if you could stand the noise!). When any key is pressed three output frequencies appear, one on pin 6 or 16, one on pin 5 or 17 exactly one octave higher and one on pin 4 or 18 exactly one octave higher than that.

Since the octave bar input to pin 33 on the M108 only ever has top C (from matrix output pin 32) connected to it, eight of the other eleven possibilities (pins 21 to 31) are used to allow various options. The options on pins 24, 27, 28, 30 and 31 are inoperative if the IC is permanently locked in the 'single' mode as is the case with the upper manual, and pins 21 to 23 have no function when linked to pin 33. Each of the eight possibilities has one function when not connected and another function when linked. There must be a diode in the link as they work in the same way as the key contacts.

On the upper manual pin 25 is not connected and this enables an anti-bounce circuit that stops noise and switching transients from the key contacts triggering the IC for a few milliseconds after any key is pressed. Pin 26 is not connected and this locks the IC into the 'single' mode. Finally pin 29 is connected via D143 to pin 33. This connection switches a sustain function on. If it were not connected then after playing, when the last key was released, the frequency outputs from the M108 would cease immediately. Since we are generating our own decay envelopes, we require the frequency outputs from the M108 to remain on. If this pin is connected, the frequency outputs

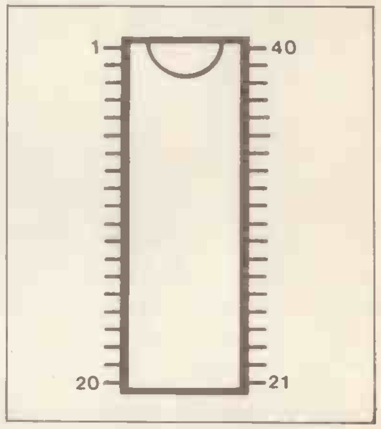
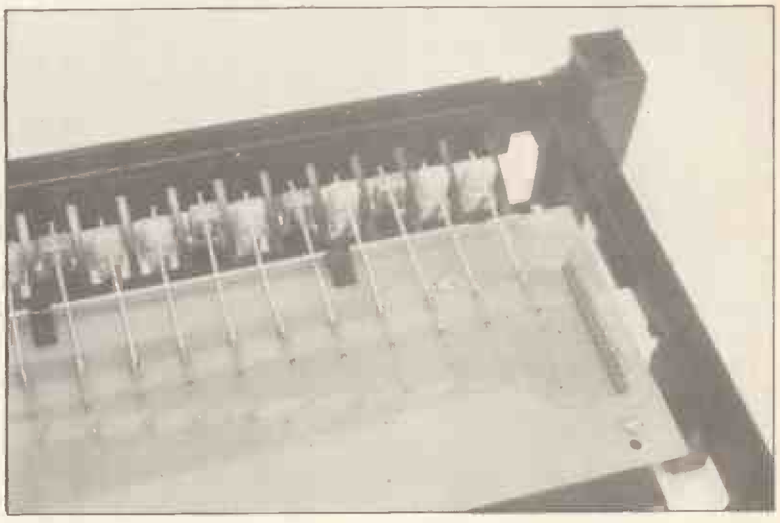


Figure 6. M108 (viewed from above).



Keyboard PCB in position showing contact springs in key plungers.

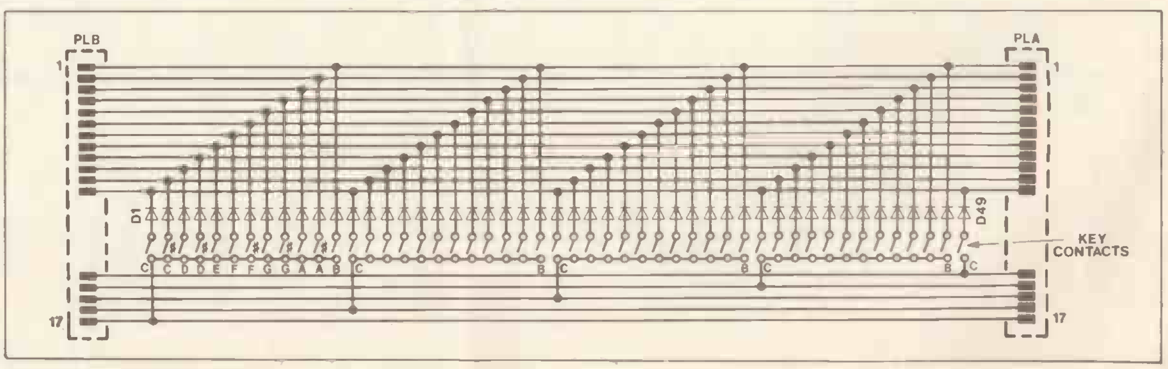


Figure 5. Keyboard Circuit.

KEYBOARD PARTS LIST

Semiconductors			
D1-49	1N4148	98 off	(QL80B)
Miscellaneous			
PLA, PLB	Minicon latch plug, 17-Way	2 off	(BH61R)
	Spacer Block	16 off	(BH62S)
	Keyboard Spacer	10 off	(BH63T)
	Palladium Bar	9 off	(XB04E)
	Contact Spring	98 off	(QY07H)
	Twin Keyboard & Frame	1 off	(XY92A)
	Self-Tapper No. 4 x ½in.	10 off	(BF66W)
	Contact printed circuit board	2 off	(XY88V)

present just prior to all keys being released, remain on until a new key or keys are pressed.

Most of the remainder of the functions of the M108 (on pins 3, 7, 8, 9, 10, 11, 12 and 14) are concerned with the 'split' mode of operation and will be described when we look at the lower manual in Part 4. This leaves six pins. Pin 1 is connected to -6V and pin 20 is connected to +6V. Pin 19 is used by the manufacturer during testing, but in use it has no function and must be linked to pin 20.

Pin 15 provides a continuous low (-6V) DC level all the time any key or keys are played and a continuous high (+6V) DC level when no keys are played. This signal is called KPS (key pressed solo). Pin 13 (TDS) provides a trigger pulse whenever a key is pressed, but this facility is not used in the Matinée. Finally pin 2 is used to reset the logic in the IC when power is first applied. A short positive going pulse is required here and it is provided by C212 and R379.

Organ Voice Circuits

The two 4 foot outputs are

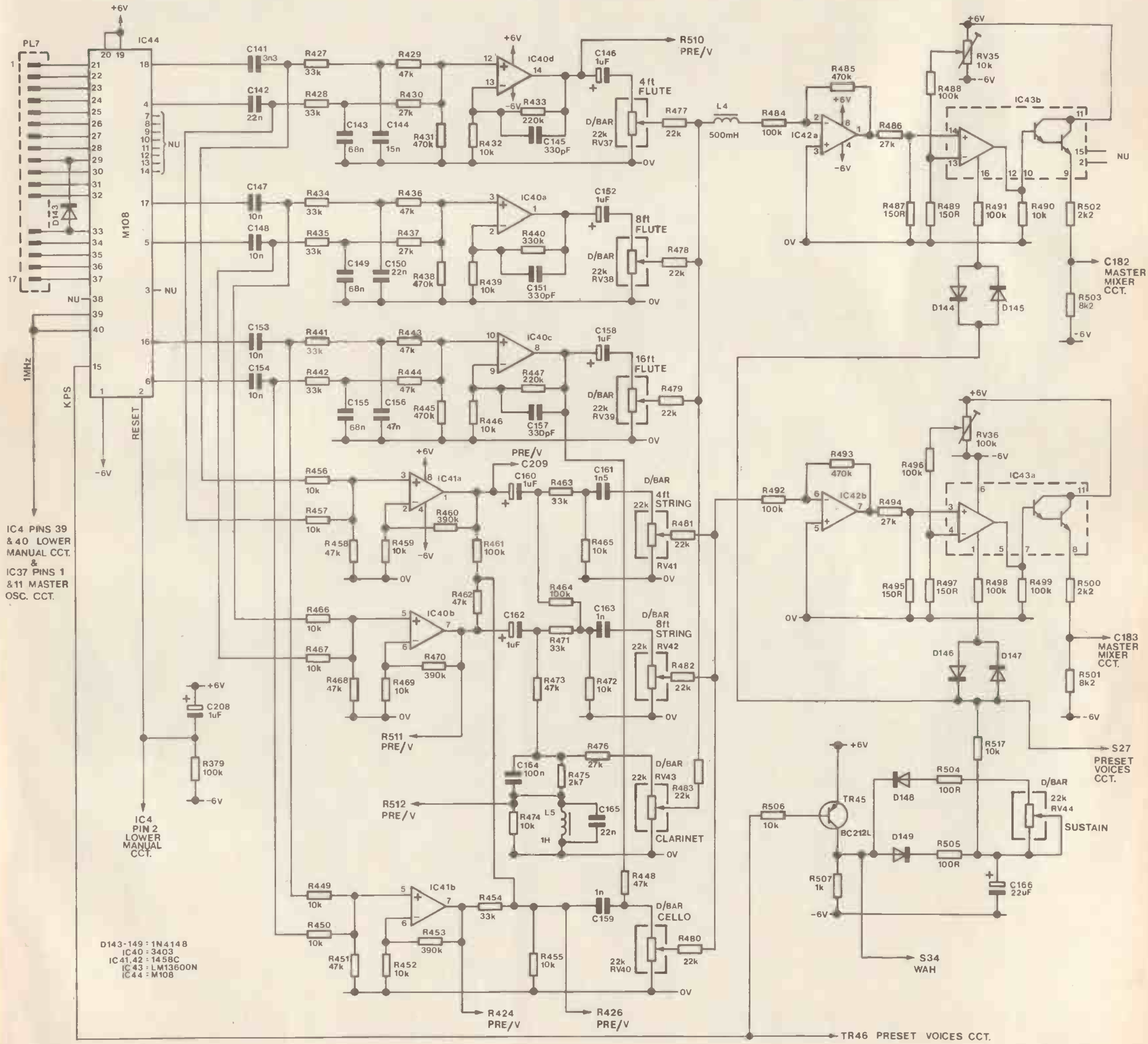


Figure 7. Upper Manual Circuit.

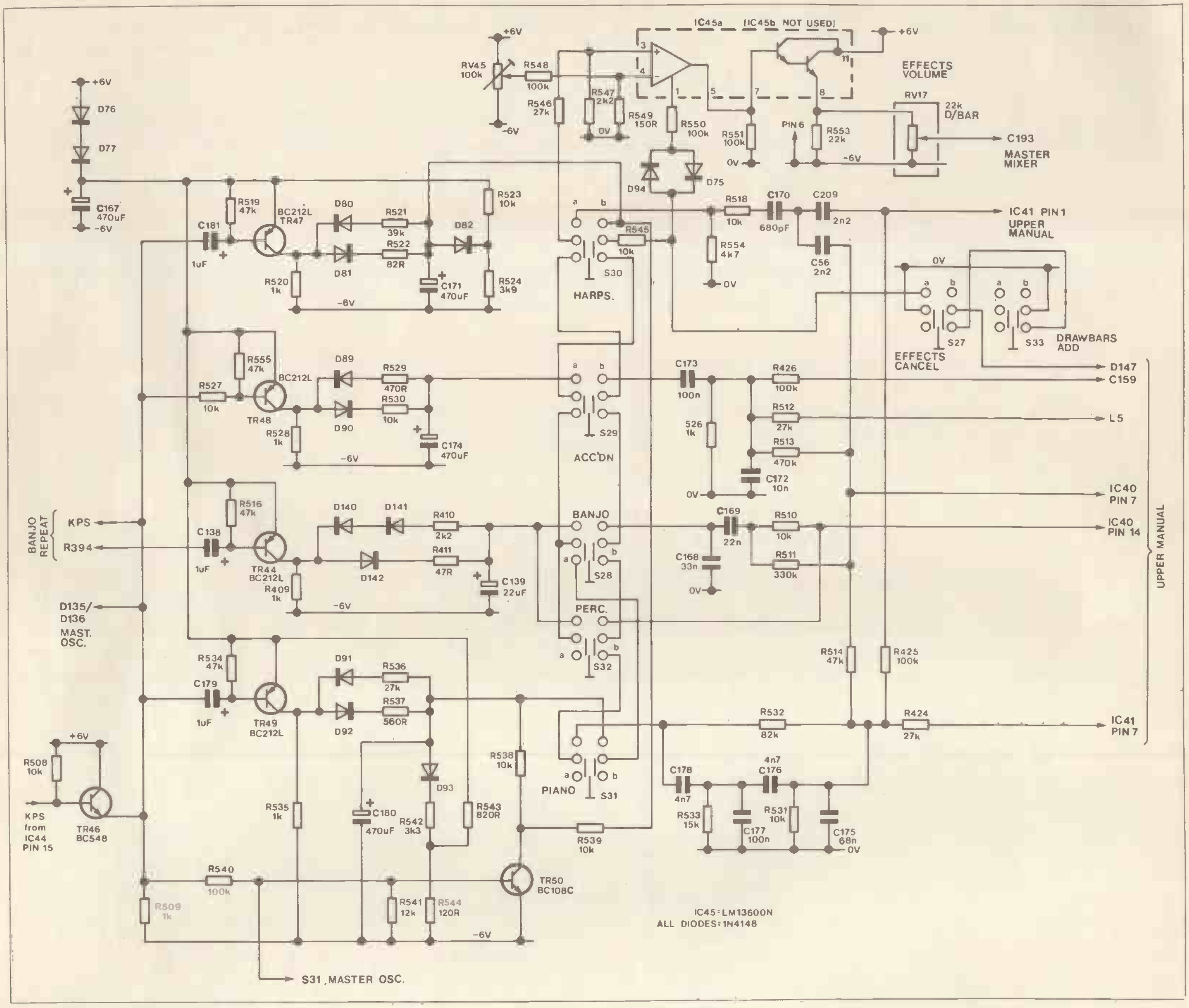


Figure 8. Preset Voices Circuit.

UPPER MANUAL CIRCUIT PARTS LIST

Resistors — all 5% ½W carbon unless specified

R379,461,464,484,488, 491,492,496,498,499	100k	10 off	(M100K)
R427,428,434,435,441, 442,454,463,471	33k	9 off	(M33K)
R429,436,443,444,448, 451,458,462,468,473	47k	10 off	(M47K)
R430,437,476,486,494	27k	5 off	(M27K)
R431,438,445,485,493	470k	5 off	(M470K)
R432,439,446,449,450, 452,455-457,459, 465-467,469,472, 474,490,506,517	10k	19 off	(M10K)
R433,447	220k	2 off	(M220K)
R440	330k		(M330K)
R453,460,470	390k	3 off	(M390K)
R475	2k7		(M2K7)
R477 to 483	22k	7 off	(M22K)
R487,489,495,497	150R	4 off	(M150R)
R500,502	2k2	2 off	(M2K2)
R501,503	8k2	2 off	(M8K2)
R504,505	100R	2 off	(M100R)
R507	1k		(M1K)
RV35	Hor S-min preset 10k		(WR58N)
RV36	Hor S-min preset 100k		(WR61R)
RV37-43	Drawbar, white, 22k lin.	7 off	(BR42V)
RV44	Drawbar, blue, 22k lin.		(BR98G)

Capacitors			
C141	3n3 polycarbonate		(WW25C)
C142,150,165	22nF polycarbonate	3 off	(WW33L)
C143, 149,155	68nF polycarbonate	3 off	(WW39N)
C144	15nF polycarbonate		(WW31J)
C145,151,157	330pF ceramic	3 off	(WX62S)
C146,152,158,160, 162,208	1uF 63V axial elect.	6 off	(FB12N)
C147,148,153,154	10nF polycarbonate	4 off	(WW29G)
C156	47nF polycarbonate		(WW37S)
C159,163	1nF polycarbonate	2 off	(WW22Y)
C161	1n5 polycarbonate		(WW23A)
C164	100nF polycarbonate		(WW41U)
C166	22uF 10V axial elect		(FB29G)
Semiconductors			
D143 to 149	1N4148	7 off	(QL80B)
TR45	BC212L		(QB60Q)
IC40	3403		(QH51F)
IC41,42	1458C	2 off	(QH46A)
IC43	LM13600		(YH64U)
IC44	M108		(YY90X)
Miscellaneous			
L4	500mH 40R choke		(HX24B)
L5	1H 55R choke		(HX25C)
PL7	Minicon plug 17-way		(BH64U)
	40-pin DIL socket		(HQ38R)
	Veropin 2145	4 off	(FL24B)

All parts will be available as a complete kit from Maplin Electronic Supplies Ltd., in mid April when Part 3 is published.

PRESET VOICES CIRCUIT PARTS LIST

Resistors — all 5% ¼W carbon unless specified

R409,509,520,526,528,535	1k	6 off	(M1K)
R410,547	2k2	2 off	(M2K2)
R411	47R		(M47R)
R424,512,536,546	27k	4 off	(M27K)
R425,426,540,548,550,551	100k	6 off	(M100K)
R508,510,518,523,527,530,531, 538,539,545	10k	10 off	(M10K)
R511	330k		(M330K)
R513	470k		(M470K)
R514,516,519,534,555	47k	5 off	(M47K)
R521	39k		(M39K)
R522	82R		(M82R)
R524	3k9		(M3K9)
R529	470R		(M470R)
R532	82k		(M82K)
R533	15k		(M15K)
R537	560R		(M560R)
R541	12k		(M12K)
R542	3k3		(M3K3)
R543	820R		(M820R)
R544	120R		(M120R)
R549	150R		(M150R)
R553	22k		(M22K)
R554	4k7		(M4K7)
RV17	Drawbar, green, 22k lin.		(BR99H)
RV45	Hor S-min preset 100k		(WR61R)
Capacitors			
C56,209	2n2 polycarbonate	2 off	(WW24B)
C138,179,181	1uF 35V tantalum	3 off	(WW60Q)
C139	22uF 10V axial elect.		(FB29G)
C167,171,174,180	470uF 16V axial elect.	4 off	(FB72P)
C168	33nF polycarbonate		(WW35Q)
C169	22nF polycarbonate		(WW33L)
C170	680pF ceramic		(WX66W)
C172	10nF polycarbonate		(WW29G)
C173,177	100nF polycarbonate	2 off	(WW41U)
C175	68nF polyester		(BX75S)
C176,178	4n7 ceramic		(WX76H)
Semiconductors			
D75-77,80-82,89-94,140-142	1N4148	15 off	(QL80B)
TR44,47-49	BC212L	4 off	(QB60Q)
TR46	BC548		(QB73Q)
TR50	BC108C		(QB32K)
IC45	LM13600		(YH64U)
Miscellaneous			
S27-30,32,33	Latchswitch 2-pole	6 off	(FH67X)

connected to each of the voicing filters. On the flute filter the lower octave output passes through a different part of the filter from the rest of the keyboard in order to maintain the quality of the flute sound, but on the other voices the two outputs are simply mixed together and fed through the one filter. The same applies to the 8 foot and 16 foot pairs of outputs. At the inputs to the filters the square wave from the M108 is present, though of course this will be a complex waveform if more than one key is pressed. The square waves are perfectly symmetrical about 0V referenced by 1k resistors.

The flute filters convert the square waves to sine waves which are very much like the waves produced by a real flute. The string filters, after the original square waves have first been amplified by an op-amp, produce short pulses that are rich in harmonics, like the waves produced by a bowed string. The characteristic clarinet sound is produced by a resonant circuit in the clarinet filter. Finally, the cello sound is produced by mixing and filtering the 16 foot output from the M108 with the outputs of the op-amps in the 4 foot and 8 foot strings before filtering.

The output of each filter is connected to its drawbar which acts as a volume control. The sliders of the flutes and clarinet are resistively mixed, pass through L4 for final voice improvement and then go to IC42a; the flute mixer. The sliders of the strings and cello are resistively mixed and go to IC42b; the string mixer. The output of IC42a goes to IC43b whilst the output of IC42b goes to IC43a. IC43 is a dual transconductance op-amp connected here to operate as two independent voltage controlled amplifiers.

The percussion is simply a 4 foot flute voice and the banjo envelope (TR44) is used again as it produces a very fast attack and decay to produce a 'plink'.

The harpsichord voice is obtained by mixing and filtering 4 foot string and 8 foot string. The envelope (TR47) has a fast attack and a very fast initial decay, but when the voltage on the capacitor C171 falls below the point at which D82 conducts (set by R523 and R524) the decay continues at a much slower rate under the control of the normal discharge path R521 and D80. If KPS returns high due to all the keys being released during the normal discharge time, a very fast decay is initiated via R539 when TR50 turns on as described in the piano below.

The piano voice is obtained by mixing and filtering 4 foot string, 8 foot string and cello. The envelope (TR49) has a fast attack and like the harpsichord has an initial fast decay until D93 ceases to conduct (at the point set by R543 and R544), then the decay continues via the normal discharge path R536 and D91. If KPS returns high due to all the keys being released during the normal discharge time, a very fast decay is initiated via R538, due to TR50 turning on when KPS went high. The action of TR50 is inhibited by the 'loud pedal' (S36) — this is the glide switch except when the piano stop is pressed — such that the note sustains for a long time when the switch is operated whether the keys are released or not.

The harpsichord, banjo, piano and percussion voices are capacitively coupled to KPS so that only the negative transitions on KPS are detected and the continuous level on KPS does not override the envelope. On all other stops including accordion, KPS is DC coupled and the note sounds continuously as long as the key is pressed.

A negative voltage occurs on pin 15 (KPS) of the M108 when any key or keys are pressed, and TR46, an emitter follower prevents loading of the KPS signal. However, one output is taken directly from KPS and applied to TR45. When KPS goes negative, TR45 switches on and C166 charges via D19 and R505. The value of R505 sets the attack time and the voltage across C166 is the control voltage applied to the control inputs of the two upper manual voltage controlled amplifiers (VCA). When the last key is released TR45 ceases to conduct and C166 discharges via the sustain drawbar RV44, and R504, D148 and R507 which shuts the VCA down slowly depending on the setting of RV44.

Preset Voice Circuits

When any preset voice switch is selected, the output from the envelope shaper is inhibited by connecting an earth to the control voltage line. But if the 'drawbar add' switch is operated, the earth is removed and the organ voices sound again.

The five preset voices (piano, harpsichord, accordion, banjo and percussion) have their own voltage controlled amplifier and each voice has its own individual envelope shaper to control the VCA. The voicing of the preset stops is achieved by simply mixing and further filtering the basic string and flute voices already described.

The envelope shaper with each preset voice is triggered by the KPS signal from the same emitter follower as the other voices and operates in the same way as the flutes and strings envelope shaper. However, there are slight variations in each one to produce the characteristic attack and decay of the instrument concerned.

The accordion voice is achieved by mixing and filtering cello, clarinet and 8 foot string. The envelope (TR48) is designed to give a very slow attack and a fast decay. The slow attack results from having a high value charging resistor: R530.

The banjo voice is produced by mixing and filtering 4 foot flute and 8 foot string and the envelope (TR44) gives a very fast attack. The decay characteristic, however, has two stages; an initial decay that is very fast and a later decay that is much slower. Because there are two series diodes in the discharge path, when the charge on C139 falls to the voltage at which the diodes cease to conduct (about 1.5V for two series diodes), the discharge is considerably slowed giving a final low-level ring to the voice.

The outputs of each of the five preset voices are taken through double-pole double-throw (DPDT) latch switches. One pole switches the tone to the signal input of the effects VCA (IC45a) and one pole switches the output of the envelope shaper to the control input of the effects VCA. The switches are interlocked so that only one preset voice can sound at any one time.

In part 3 we shall describe the remainder of the electronic construction: making the main PCB and making the power unit. We shall also look at the interwiring and describe how the power unit and the pedalboard works. **E&MM**

Completed upper manual.

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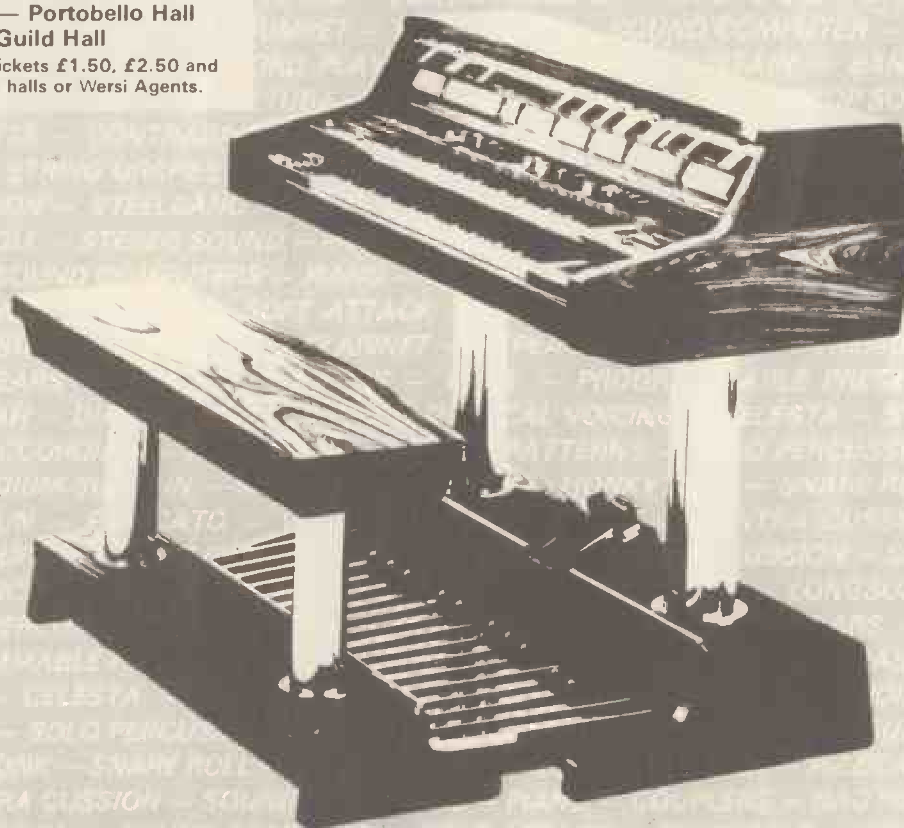

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WERSI AND AURA SOUNDS — THE WINNING COMBINATION

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 subsequent 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.

Part 2

So far we have considered some basic theory relating to voltage, current, and resistance. We will now see how this can be put to use in a practical project — a high resistance voltmeter. First though, we will examine just what this piece of test equipment does.

Voltmeters

In an ordinary voltmeter circuit the test voltage is applied direct to a meter circuit employing a moving coil meter. This device makes use of the fact that a magnetic field is produced around a conductor while it is passing a current, and the strength of the field is, up to a point, proportional to the level of current flow. This magnetic force is used to drive a pointer, and the deflection of the pointer is proportional to the current flow. A scale calibrated in terms of current flow is marked behind the arc covered by the tip of the pointer.

Of course, the current flowing through the meter depends on the applied voltage, and the meter could be calibrated in terms of voltage if required. Furthermore, the voltage needed to give full scale deflection (f.s.d.) of the meter can be increased if necessary by adding a resistor in series with the meter. For instance, a 1mA meter could be given a full scale value of 10 volts by the addition of a series resistor to give a total circuit resistance of 10k, (R = V/C = 10/0.001 = 10,000 ohms or 10k), as we can see by applying Ohm's Law. In fact a 1mA meter needs a total circuit resistance of 1k per full scale volt, and it is common for test meters to be quoted as a so many ohms per volt type (20k/V is typical). The significance of this figure will become apparent shortly.

This simple form of voltmeter works very well much of the time, but it can sometimes give misleadingly low readings. This is due to the meter affecting the circuit under test. Consider the example shown in Figure 1; there is a potential of 4.5 volts at the junction of R1 and R2. However, when the voltmeter circuit is connected across R2 it "shunts" this resistor as it is connected in parallel with R2. From the parallel resistor theory we know that this effectively reduces R2 to 50k, and as a result the voltage at the junction of R1 and R2 drops to 3 volts. This is the reading obtained on the meter, and it is erroneous in that this voltage is only present while the meter is connected to the circuit!

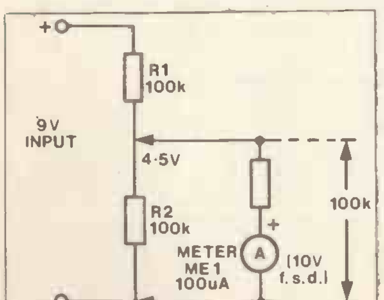
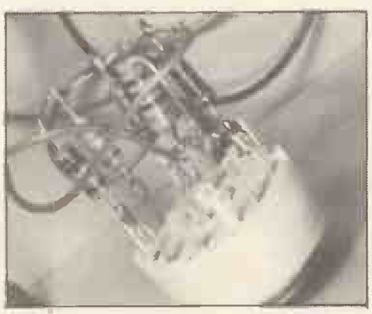


Figure 1. A circuit which demonstrates the loading effect of a voltmeter.


Range switch: location of range resistors.

In order to minimise this loading of the circuit under test the meter circuit should have the highest possible resistance. Thus a 20k/V meter circuit is better in this respect than say a 1k/V type. It is difficult to make rugged and accurate moving coil meters having an f.s.d. value of less than about 50uA, which limits the maximum sensitivity to about 20k/V (which is the sensitivity of most good quality test meters). A higher sensitivity can be achieved by adding a current amplifier ahead of the voltmeter circuit so as to boost the resistance through the circuit. This type of voltmeter is known as a high resistance voltmeter, and circuits of this type usually have an input resistance of about 10 or 11 megohms.

General view of voltmeter.

Making a Voltmeter

The instrument described here has an input resistance of 10M and has five measuring ranges of 1, 5, 10, 50, and 100 volts f.s.d. This gives a sensitivity of 100k/V on the 100 volt range to some 10M/V on the 1 volt range. In practice this should always be sufficient to ensure accurate readings.

Figure 2 is the complete circuit diagram of the instrument. This includes three components which have not been discussed so far, and these will be considered briefly before we proceed further.

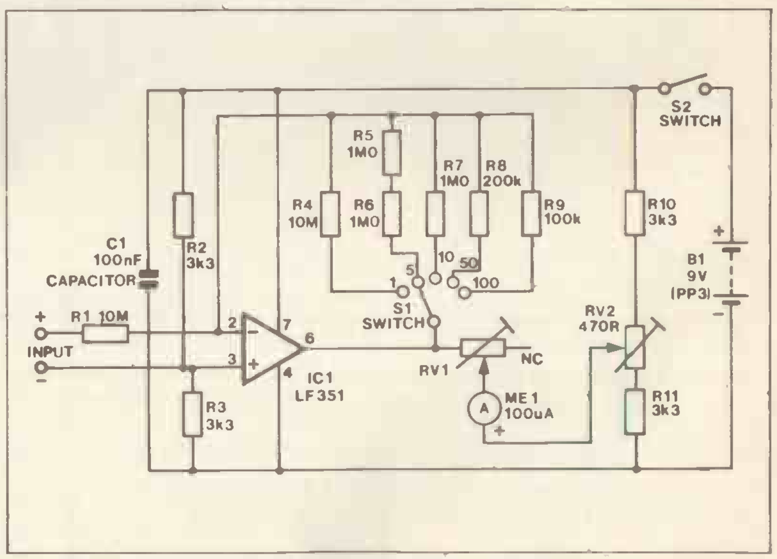


Figure 2. The circuit diagram of the High Resistance Voltmeter.

The most simple of these components is switch S2 which is an ordinary on/off switch. This is shown in the "off" position (as is the convention), and in this state it provides an almost infinite resistance between its two terminals. Therefore no significant power flows from battery B1 to the main circuitry. When in the "on" position the switch has virtually zero resistance between its two terminals, and the battery is connected straight through to the main circuit.

S1 is a little more complicated, and this is a five position rotary switch. This is used to select the desired measuring range, and the central (pole) terminal of the switch can be connected to just one of the arc of five contacts. If it is switched to the "1V" range R4 is connected into circuit, and R5 to R9 are effectively cut out of the circuit. When it is set to the 5 volt range the series combination of R5 and R6 are switched into circuit, while R4 plus R7 to R9 are disconnected, and so on. Incidentally, two 1M resistors connected in series are used on the 5 volt range because a resistor having the required value of 2M is not readily available.

Component IC1 is an integrated circuit, operational amplifier, and is quite a complex device. However, its action in this circuit is quite simple, and this device need not be considered in great detail here. This device merely adjusts the voltage at its output (pin 6) to a level that maintains the same voltage at its inverting input (pin 2) as appears at its non-inverting input (pin 3). The necessary "feedback" to achieve this is provided through S1 and whichever of the range resistors is selected.

Capacitor C1 is the third type of component we have not yet covered, and this is needed to prevent the circuit from becoming unstable. It is a supply decoupling capacitor, and this will be covered in detail in the next article which is devoted to capacitance.

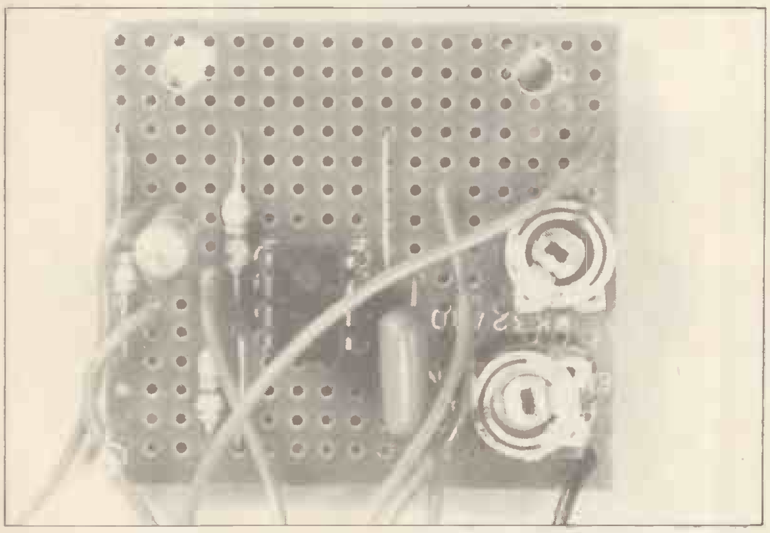
Circuit Operation

If we first consider the circuit switched to the 1V range and with no input signal applied, R2 and R3 form a simple potential divider which bias the non-inverting input of IC1 to half the supply voltage. In order to bring the inverting input of IC1 to this potential it is merely necessary for the output to also assume half the supply potential. In fact the output must assume a fractionally higher voltage as some current does flow from the output of IC1 and into the inverting input. However, IC1 is a special device that requires an extremely small input current indeed, and so despite the high value of R4, the voltage drop through this component is far too small to be of significance.

R10, RV2 and R11 form another voltage divider across the supply lines, and in practice RV2 is adjusted for a wiper voltage that exactly matches that present at the output of IC1. RV1 and ME1 form a simple voltmeter circuit, and RV1 is adjusted for a full scale sensitivity of 1 volt. Of course, under quiescent conditions the meter circuit is connected between two points at equal potentials (this is a form of bridge circuit) and it registers zero voltage.

If we consider the unit switched to the 1 volt range and a potential of 1 volt connected to the input with the correct polarity, this input signal obviously tries to take the inverting input positive of the non-inverting input (R2 and R3 effectively clamping the latter at half the supply voltage). The output swings negative by an amount that maintains the inverting input at its original level by a potential divider action across R1 and R4. Since these two components have the same value, the output goes negative by an amount equal to the input voltage, or 1 volt in this case. This gives the required full scale deflection of ME1. Lower input voltages give correspondingly lower output voltages and meter readings. Due to the high value of R1 only a very small current is drawn from the circuit under test (0.1uA maximum on the 1 volt range).

The circuit operates in the same basic fashion on the other ranges, but the resistance switched in by S1 is lower so that for a given input voltage a smaller output voltage swing is sufficient to maintain the voltage at IC's inverting input. The values of R5 to R9 are chosen to give additional full scale values of 5, 10, 50, and 100 volts. These range resistors are all close tolerance types so that there are only small discrepancies between the various ranges.



Veroboard: component assembly.

Construction

A number of the components are fitted onto a 0.1in. pitch Veroboard which measures 15 copper strips by 17 holes. Veroboard is not sold in this particular size, and so the panel must be cut from a larger piece using a hacksaw. Figure 3 gives details of the wiring of the unit. There are five breaks to be made in the copper strips and there is a special "spot face cutter" tool for doing this. A simple alternative is to use a hand held twist drill about 3.5 to 4.5mm. in diameter. The two mounting holes can be 3.3mm. in diameter, and these will then accept either M3 or 6BA fixings.

The components are fitted one by one onto the top side of the board and then soldered to the copper strips on the underside after trimming the leadout wires using wire clippers where necessary. Note that there are also two link wires to be fitted onto the board.

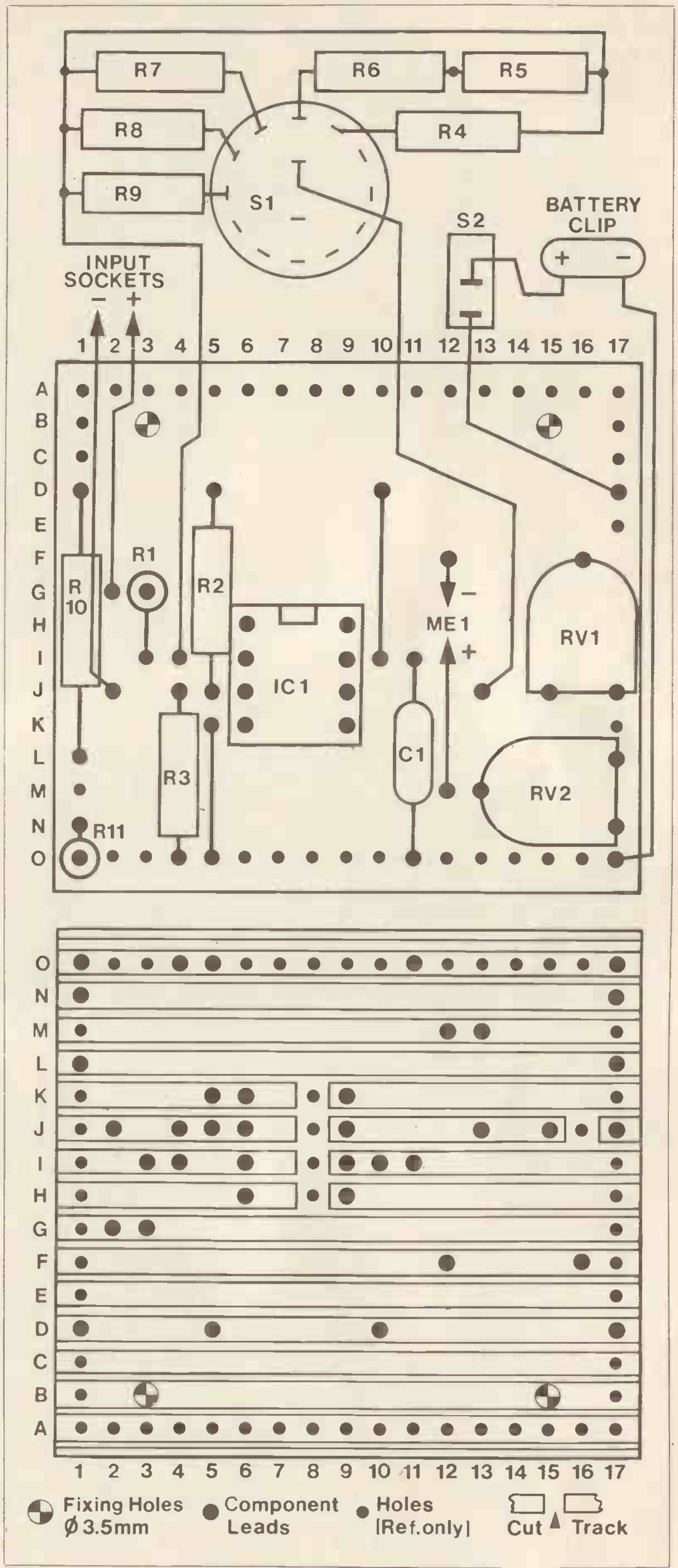
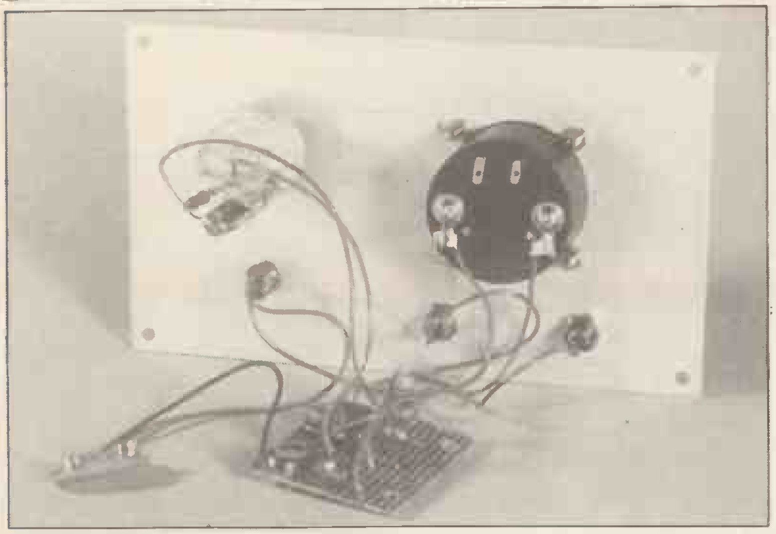


Figure 3. Constructional details of the High Resistance Voltmeter.

The prototype is fitted into a sloping front (Console) case type M1005, with the meter, controls, and input sockets mounted on the top panel. This is all quite straightforward except for the meter which requires a large (38mm. diameter) main mounting hole. This can be cut using a fretsaw, coping saw, miniature round file, or by drilling a ring of small closely spaced holes and then punching out the part of the panel within the ring. A large, half round file can then be used to tidy up the cutout. The positions of the four smaller mounting holes can be located using the meter as a sort of template.



Unit wiring details.

PARTS LIST

Resistors — all 5% ½W unless specified

R1,4	10M		(S10M)
R2,3,10,11	3k3	4 off	(S3K3)
R5,6,7	1M0 ½W 2%	3 off	(X1M0)
R8	200k ½W 2%		(X200K)
R9	100k ½W 2%		(X100K)
RV1	10k S-min. horizontal preset		(WR58N)
RV2	470R S-min. horizontal preset		(WR54J)
Capacitors			
C1	100nF polyester		(BX76H)
Semiconductors			
IC1	LF351 op-amp (8-pin DIL)		(WQ30H)
Meter			
ME1	100uA fsd panel meter		(RW92A)
Switches			
S1	6-way 2-pole rotary		(FF74R)
S2	SPST Sub-miniature toggle		(FH00A)
Miscellaneous			
	ABS console M1005		(LH63T)
	Veroboard 0.1 in. matrix 17 holes × 15 strips		(FL07H)
	Knob K7B		(YX02C)
B1	PP3 battery		
	PP3 connector		(HF28F)
	Wander socket, red		(HF59P)
	Wander socket, black		(HF56L)
	Wander plug, red		(HF53H)
	Wander plug, black		(HF50E)
	Probe clips, pair		(HF21X)
	Connecting wire		(BL07H)

R4 to R9 are mounted direct onto the tags of S1, and both the ends of the leadout wires and the tags of S1 should be generously tinned with solder before fitting the resistors into place. There should then be no difficulty in producing strong joints. The soldering iron should only be applied to the leadouts of the resistors for a second or two at a time so that the resistors do not become overheated and lose their accuracy. Then the battery clip is wired in and the seven insulated connecting wires are added. Finally, the component board is mounted on the rear panel of the case.

Adjustment

As with any newly constructed project, check all the wiring very carefully before switching on. In this case it is also necessary to check that the meter is mechanically zeroed so adjust the screw on the front of the meter if necessary. Also, adjust RV1 and RV2 fully clockwise. When the unit is switched on there should be a small forward deflection of the meter (switch off at once and recheck the wiring if there is not), and the meter is zeroed by adjusting RV2.

One way of giving RV1 the correct setting is to take a 9 volt battery and measure its precise voltage using a multimeter. Switch S1 to the 10 volt position and connect the battery to the input of the unit with the correct polarity. RV1 is then adjusted for the appropriate reading on the meter. If a multimeter is not available, use a fresh 9 volt battery, which will have an actual voltage of almost exactly 9.5 volts, and adjust RV1 accordingly.

The meter can be given an additional 0 to 5 scale using rub-on transfers, but the meter movement is very delicate and great care must be taken when the front cover of the meter is unclipped. It is by no means essential to add this scale since it is quite easy to convert meter readings to their corresponding voltages on the 5 and 50 volt ranges. E&MM

BI-PAK NEW EXTENDED 1981 RANGE

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	15
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
BCO	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
BF176	36
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
BFR42	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
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TIP41C	48
TIP42A	44
TIP42B	46
TIP42C	48
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TIP3055	50
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TIS91	22
TIS92	22
UT46	20
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ZTX303	16

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ZTX550	25
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2N1893	40
2N2147	75
2N2148	70
2N2192	38
2N2193	38
2N2194	38
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2N2219	28
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2N2220	20
2N2221	20

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2N2906	18
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2N2907A	22
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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
2S321	57
2S322	43
2S322A	43
2S323	57
2S324	71
2S325	71
2S326	71
2S327	71
40326	40
40360	46
40361	46
40362	46
40406	55
40407	45
40408	80

DIODES

AA119	08
AA120	08
AA129	09
AAY30	09
AAZ13	15
AAZ17	15
BA100	10
BA102	20

BA144	09
BA148	15
BA154	12
BA155	14
BA156	14
BA173	15
BA248	16
BB104	30

BAX13	07
BAX16	08
BY100	22
BY101	22
BY105	22
BY114	22
BY124	22
BY126	11

BY127	12
BY128	16
BY130	17
BY133	21
BY156	08
BY164	51
BY176	75
BY206	30

BY210/600	09
BYZ10	45
BYZ11	45
BYZ12	40
BYZ13	40
BYZ16	41
BYZ17	36

BYZ18	36
BYZ19	36
OA5	60
OA10	35
OA47	08
OA70	08
OA79	10
OA81	10

OA85	10
OA90	07
OA91	07
OA95	07
OA182	13
OA200	08
OA202	08
SD10	06

SD19	06
IN34	07
IN34A	35
IN60	06
IN914	04
IN916	05
IN4148	04
IS44	05

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BI-PAK

74 LS SERIES TTL

7400	14	7450	15	74136	65
7401	12	7451	15	74141	60
7402	12	7452	15	74144	2.50
7403	12	7453	15	74145	80
7404	13	7454	15	74150	1.00
7405	13	7460	15	74151	65
7406	28	7470	32	74153	65
7407	28	7472	28	74154	1.00
7408	20	7473	32	74155	70
7409	20	7474	30	74156	70
7410	13	7475	44	74157	70
7411	20	7476	35	74160	90
7412	22	7480	48	74161	90
7413	30	7481	95	74162	90
7414	50	7482	70	74163	90
7416	28	7483	68	74164	1.00
7417	28	7484	95	74165	1.00
7420	14	7485	95	74166	1.00
7421	32	7486	28	74167	2.30
7422	24	7489	1.95	74174	90
7423	28	7490	36	74175	80
7425	28	7491	75	74176	85
7426	30	7492	50	74177	85
7427	28	7493	36	74180	90
7428	34	7494	75	74181	2.30
7430	14	7495	65	74182	85
7432	28	7496	65	74184	1.35
7433	36	74100	1.10	74190	1.00
7437	30	74104	50	74191	1.00
7438	30	74105	50	74192	95
7440	15	74107	32	74193	1.00
7441	60	74110	46	74194	90
7442	60	74111	60	74195	90
7443	1.00	74118	95	74196	95
7444	1.00	74119	1.20	74197	85
7445	90	74121	36	74198	1.45
7446	90	74122	46	74199	1.45
7447	65	74123	60	74279	95
7448	65	74124	60		

LINEAR I.C.'s

CA270BE	95	MC1304	1.90
CA280Q	95	MC1310P	1.45
CA3011	98	MC1312	1.70
CA3014	1.75	MC1350	1.20
CA3018	65	MC1352	1.40
CA3020	1.75	MC1469	2.70
CA3028	80	MC1496	90
CA3035	2.30	NE555	20
CA3036	1.00	NE556	55
CA3042	1.60	NE561	3.80
CA3043	1.85	NE562	4.00
CA3046	70	NE565	1.20
CA3052	1.60	NE566	1.50
CA3054	1.10	NE567	1.70
CA3075	1.50	72702	46
CA3080	65	UA703C	25
CA3081	1.50	UA709C	25
CA3085	95	72709	46
CA3089	2.00	709P	35
CA3090	3.60	UA710C	40
CA3123E	1.50	72710	30
CA3130E	90	UA711C	32
CA3140E	48	72711	32
LF351N	55	UA723C	45
LF353N	88	72723	45
LF356N	90	UA741C	24
LH0042CH	2.25	72741	24
LM301A	25	741P	17
LM334	1.60	UA747C	60
LM308	75	72747	60
LM309K	1.25	UA748	35
LM317H	2.50	748P	35
LM318H	1.95	SN76013N	1.60
LM320/5v	95	SN76023N	1.65
LM320/12v	95	SN76110	1.50
LM320/15v	95	SN76115AN	1.90
LM320/24v	95	SN76660N	90
LM324N	48	TAA550B	35
LM337T	1.35	TAA621	2.00
LM339N	65	TAA661B	1.50
LM348N	90	TAD100	1.30
LM380	85	TBA120B	70
LM381	1.45	TBA540	1.40
LM382N	1.20	TBA641A	2.20
LM384	1.45	TBA800	85
LM1458	42	TBA810S	95
LM3900	58	TBA820	70
LM3909N	70	TBA920Q	2.50
LM3911N	1.20	TCA270S	1.40
LM3914N	2.20	ZN414	90
LM3915N	2.20	ZTK33B	15

COMPUTER I.C.'s

2114L-3	2.40	2516/2716-5v	4.90
2708	3.50	4116	2.25

74 SERIES TTL

74LS00	13	74LS109	70	74LS243	1.60
74LS01	13	74LS112	38	74LS244	1.50
74LS02	15	74LS113	68	74LS245	2.20
74LS03	15	74LS114	38	74LS247	1.20
74LS04	15	74LS122	68	74LS248	1.20
74LS05	22	74LS123	60	74LS249	1.20
74LS08	21	74LS124	1.60	74LS251	1.20
74LS09	21	74LS125	45	74LS253	90
74LS10	20	74LS126	45	74LS257	90
74LS11	22	74LS132	60	74LS258	1.10
74LS12	26	74LS136	50	74LS260	85
74LS13	34	74LS138	60	74LS259	1.50
74LS14	50	74LS139	68	74LS261	4.00
74LS15	34	74LS145	1.15	74LS266	72
74LS20	18	74LS147	2.00	74LS273	1.65
74LS21	26	74LS148	1.60	74LS275	3.50
74LS22	32	74LS151	70	74LS279	85
74LS26	38	74LS153	68	74LS280	2.40
74LS27	35	74LS155	65	74LS283	85
74LS28	35	74LS156	80	74LS290	90
74LS30	18	74LS157	60	74LS293	1.00
74LS32	22	74LS158	60	74LS295	1.90
74LS33	34	74LS160	85	74LS298	1.50
74LS37	28	74LS161	75	74LS299	3.50
74LS38	28	74LS162	1.00	74LS323	3.50
74LS40	25	74LS163	90	74LS324	1.90
74LS42	55	74LS164	90	74LS325	3.00
74LS47	72	74LS165	1.20	74LS326	3.20
74LS48	80	74LS166	1.70	74LS327	3.10
74LS49	90	74LS168	1.80	74LS348	1.80
74LS51	24	74LS169	1.80	74LS352	1.50
74LS54	28	74LS170	2.50	74LS353	1.50
74LS55	28	74LS173	95	74LS365	45
74LS63	1.40	74LS174	95	74LS366	55
74LS73	30	74LS175	95	74LS367	62
74LS74	30	74LS181	2.70	74LS368	80
74LS75	38	74LS183	2.80	74LS373	1.45
74LS76	42	74LS190	95	74LS374	1.45
74LS78	46	74LS191	95	74LS375	1.10
74LS83	68	74LS192	95	74LS378	1.20
74LS85	75	74LS193	95	74LS386	75
74LS86	38	74LS194	95	74LS393	1.10
74LS90	38	74LS195	85	74LS395	2.00
74LS91	1.10	74LS196	1.00	74LS398	2.70
74LS92	68	74LS197	85	74LS399	2.00
74LS93	58	74LS221	1.00	74LS390	1.40
74LS95	95	74LS240	1.60	74LS670	2.50
74LS96	1.10	74LS241	1.60		
74LS107	40	74LS242	1.60		

CMOS

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

VOLTAGE REGULATORS

MVR7805	58	78L18	28	LM320/5V	95
MVR7812	58	78L24	28	LM320/12V	95
MVR7815	58	79L05	55		
MVR7818	58	79L12	55	LM320/15V	95
MVR7824	58	79L15	55		
MVR7905	63	79L18	55	LM320/24V	95
MVR7912	63	79L24	55		
MVR7915	63	LM304H	1.60	LM337T	1.35
MVR7918	63	LM308	1.75	MC1469	2.70
MVR7924	63	LM309K	1.25	UA723C	45
78L05	28	LM317H	2.50	72723	45
78L12	28	UA79MGHC	2.50		
78L15	28				

CASSETTES

301	Low Cost C60	0.36
302	Low Cost C90	0.45
303	Low Cost C120	0.65
304	30 Min Letter Tape	0.38
305	Empty Library Case	0.12

SILICON RECTIFIERS

200mA	
IS920 50v	06
IS921 100v	07
IS922 150v	08
IS923 200v	09
IS924 300v	10
1 Amp	
IN4001 50v	04½
IN4002 100v	05
IN4003 200v	06
IN4004 400v	06
IN4005 600v	07
IN4006 800v	07
IN4007 1000v	08
1.5 Amp	
IS015 50v	09
IS020 100v	10
IS021 200v	11
IS023 400v	13
IS025 600v	14
IS027 800v	16
IS029 1000v	20
IS031 1200v	25
3 Amp	
IN5400 50v	11
IN5401 100v	12
IN5402 200v	14
IN5403 300v	15
IN5404 400v	16
IN5405 500v	17
IN5406 600v	18
IN5407 800v	28
IN5408 1000v	25
6 Amp	
BYX38-300	45
BYX38-600	60
BYX38-300R	45
BYX38-600R	60
10 Amp	
IS10/50 50v	30
IS10/100 100v	35
IS10/200 200v	40
IS10/400 400v	50
IS10/600 600v	60
IS10/800 800v	70
IS10/100 1000v	85
IS10/1200 1200v	95
30 Amp	
IS30/50 50v	56
IS30/100 100v	69
IS30/200 200v	93
IS30/400 400v	1.25
IS30/600 600v	1.76
IS30/800 800v	1.94
IS30/1000 1000v	2.31
IS30/1200 1200v	2.88
70 Amp	
IS70/50 50v	75
IS70/100 100v	84
IS70/200 200v	1.20
IS70/400 400v	1.75
IS70/600 600v	2.25
IS70/800 800v	2.50
IS70/1000 1000v	3.00

BRIDGE RECTIFIERS

1 Amp RMS	
BR1/50v	20
BR1/100v	22
BR1/200v	25
BR1/400v	29
2 Amp RMS	
BR2/50v	35
BR2/100v	40
BR2/200v	44
BR2/400v	50
BR2/1000v	65
6 Amp RMS	
BR6/50v	75
BR6/100v	80
BR6/200v	88
BR6/400v	95
10 Amp RMS	
BR10/50v	1.40
BR10/100v	1.50
BR10/200v	1.60
BR10/400v	1.90
25 Amp RMS	
BR25/50v	1.85
BR25/100v	1.95
BR25/200v	2.05
BR25/400v	2.90
BY164	51

TRIACS & DIACS

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

ZENER DIODES

400mW (BZY88) Voltages available:— 1.3v, 2.2v, 2.7v, 3.3v, 3.9v, 4.3v, 4.7v, 5.1v, 5.6v, 6.2v, 6.8v, 7.5v, 8.2v, 9.1v, 10v, 11v, 12v, 13v, 15v, 16v, 18v, 20v, 22v, 24v, 27v, 30v, 33v, 39v.
O/NO: Z4/Voltage 8p

1.3W
Voltages available:— 1.3v, 2.2v, 2.7v, 3.3v, 3.9v, 4.3v, 4.7v, 5.1v, 5.6v, 6.2v, 6.8v, 7.5v, 8.2v, 9.1v, 10v, 11v, 12v, 13v, 15v, 16v, 18v, 20v, 22v, 24v, 27v, 30v, 33v, 43v, 47v, 51v, 68v, 72v, 75v, 82v, 91v, 100v.
O/NO: Z13/Voltage 15p

10W Stud Type
Voltages available:— 1.3v, 2.2v, 2.7v, 3.3v, 3.9v, 4.3v, 4.7v, 5.1v, 5.6v, 6.2v, 6.8v, 7.5v, 8.2v, 9.1v, 10v, 11v, 12v, 13v, 15v, 16v, 18v, 20v, 22v, 24v, 27v, 30v, 33v, 43v, 47v, 51v, 68v, 72v, 75v, 82v, 91v, 100v.
O/NO: Z10/Voltage 35p

INSTRUMENT CASES

155	8" x 5¼" x 2"	1.70
156	11" x 6" x 3"	2.63
157	6" x 4¾" x 1¾"	1.64
158	9" x 5¼" x 2½"	2.20

THYRISTORS

600mA — TO18 CASE	
THY600/10v	15
THY600/20v	16
THY600/30v	20
THY600/50v	22
THY600/100v	25
THY600/200v	38
THY600/400v	44
800mA — TO92 CASE	
THY800/10v	16
THY800/20v	17
THY800/30v	22
THY800/50v	24
THY800/100v	28
THY800/200v	32
1 Amp — TO39 CASE	
THY1A/50v	34
THY1A/100v	38
THY1A/200v	42
THY1A/400v	50
THY1A/600v	65
THY1A/800v	78
BT101/500R	80
BT102/500R	80
BT106	1.25
BT107	93
BT108	98
2N3228	70
3 Amp — TO66	
THY3A/50v	35
THY3A/100v	37
THY3A/200v	40
THY3A/400v	50
THY3A/600v	60
THY3A/800v	75
5 Amp — TO64	
THY5A/50v	36
THY5A/100v	45
THY5A/200v	50
THY5A/400v	57
THY5A/600v	60
THY5A/800v	75
5 Amp — TO66	
THY5A/50v	36
THY5A/100v	45
THY5A/200v	50
THY5A/400v	57
THY5A/600v	60
THY5A/800v	75
2N3525	77
BTX30/50L	40
BTX30/400L	70
BT116	1.50
C106D	38
BTY79/400R	95
5 Amp — TO220 PLASTIC	
THY5A/50vP	35
THY5A/100vP	45
THY5A/200vP	47
THY5A/400vP	50
THY5A/600vP	60
THY5A/800vP	70
10 Amp — TO48	
THY10A/50v	45
THY10A/100v	50
THY10A/200v	55
THY10A/400v	60
THY10A/600v	80
THY10A/800v	1.10
16 Amp — TO48	
THY16A/50v	65
THY16A/100v	80
THY16A/200v	90
THY16A/400v	1.20
THY16A/600v	1.50
THY16A/800v	2.00
30 Amp — TO49	
THY30A/50v	1.30
THY30A/100v	1.50
THY30A/200v	2.95
THY30A/400v	4.00
THY30A/600v	4.20

KNOBS

1101	Black/Silver Knob	0.28
1102	Large Calibrated Knob	0.30
1103	Alli PA 100 Knob	0.46
1104	Heavy Brushed Alli Knob 15mm	0.32
1105	Heavy Brushed Alli Knob 22mm	0.40
1106	Heavy Brushed Alli Knob 28mm	0.52
1107	Matt Black Knob 17mm	0.40
1108	Matt Black Knob 24mm	0.46
1109	Matt Black Knob 28mm	0.56
1110	All Metal Serated Edge Knob 15mm	0.34
1111	All Metal Serated Edge Knob 24mm	0.48
1112	All Metal Serated Edge Knob 30mm	0.60
1113	Black Plastic Metal Skirt	0.24
1114	Black Pointer Knob	0.22
1115	Black/Chrome Instrument Knob 22mm	0.32
1116	Alli Push Button Knob 11mm	0.14
1117	Black Plastic Slider Knob	0.12
1118	Chrome Slider Knob	0.14
1119	Chrome/Black Slider Knob	0.22

MICROPHONES etc

1325	Crystal Desk Mike	3.30
1326	Cassette Mike 2.4mm + 3.5mm Plugs	1.46
1327	Dynamic Cassette Mike	1.86
1328	Dual Imp Dynamic Mike	10.50
1329	Dual Imp Condenser Mike	13.20
1330	Plastic Mike Holder	0.66
1331	Windshield Medium (Pair)	1.38
1332	Windshield Large (Pair)	1.92
1333	Gooseneck 320mm (Chrome)	2.60
1334	Gooseneck 515mm (Chrome)	3.50
1335	Mike Floor Stand	10.70
1336	Cassette Deck Mike 5K ohm	5.30
1337	Mike Boom Arm	8.80
1338	Crystal Mike Insert	0.52
1339	Two-Station Intercom	6.60
1340	Mobile or CB Mike 600 ohms	5.98
1341	Mobile or CB Mike 250 ohms	6.00

AERIALS

105	Adjustable Aerial Gutter Mount	3.00
106	C.B. Mobile Antenna	9.50
107	FM Indoor Ribbon Aerial	0.50
108	4 Section Car Aerial (Stainless)	2.16
109	4 Section Car Aerial (Chrome)	1.80
110	8 Section 1200mm Telescopic Aerial	2.00
111	8 Section 750mm Telescopic Aerial	2.60
112	5 Section 570mm Telescopic Aerial	2.64
113	Roof Mounting Aerial (Car)	3.80

AUDIO LEADS

114	5 pin — 3.5mm 3 & 5 connected	0.65
115	5 pin — 3.5mm 1 & 4 connected	0.65
116	Car Aerial Ext Lead	1.00
117	Mains Cassette Lead	0.48
119	2 x 2 pin Plug in In Line Stereo Jack Socket	0.74
120	Universal Car Adaptor Plug	0.52
123	20ft Coiled Guitar Lead	1.50
125	5 pin to 5 pin DIN	0.65
126	5 pin to DIN to open ends	0.65
127	5 pin to DIN to 4 Phono Plugs	1.00
128	5 pin Plug to 5 pin socket	0.75
129	5 pin to 5 pin Plug (Mirror image)	0.72
130	2 pin Plug to 2 pin Line Socket 5 mtrs	0.55
132	2 pin Plug to 2 pin Line Socket 10 mtrs	0.85
133	5 pin Plug to 2 Phono Plug	0.65
136	Headphone ext lead 7 mtrs	1.50

A.B.S. PLASTIC BOXES

141	4" x 1" x 2"	1.08
142	4.4" x 1.22" x 2.44"	1.24
143	4.75" x 1.56" x 2.56"	1.30
144	6.00" x 2.00" x 3.15"	1.50
145	7.5" x 2.38" x 4.33"	2.64
146	2.8" x 4.37" x 1.63"	1.40
147	3.78" x 6.33" x 2.06"	1.92
148	5.63" x 4.14" x 2.19"	2.14
149	5.63" x 6.7" x 2.19"	2.62
150	6.65" x 4.98" x 2.76"	3.84
151	9.57" x 7.36" x 4.06"	5.82

TOOLS CROC CLIPS etc

2001	Insulated croc clips (Red)	0.06
2002	Insulated croc clips (Black)	0.06
2003	1½ insulated croc clips (Red)	0.07
2004	1½ insulated croc clips (Black)	0.07
2005	30 Amp croc clips 100mm per pair	0.74
2006	Test Leads	0.55
2007	Test Lead Kit	1.70
2008	4mm Test Lead Set	1.36
2009	4mm Test Prods Set	0.52
2010	Pincer Action Prod Set	1.40
2011	Cutters	5.50
2012	Pliers	5.20
2013	Croc clip test set	1.00
2014	Resistance sub box	3.30
2015	IC Extraction Tool	0.64
2016	Neon Mains Tester/Screwdriver	0.52

ALUM BOXES

159	5¼" x 2¼" x 1½"	0.83
160	4" x 4" x 1½"	0.83
161	4" x 2¼" x 1½"	0.83
162	5¼" x 4" x 1½"	0.93
163	4" x 2½" x 2"	0.83
164	3" x 2" x 1"	0.57
165	7" x 5" x 2½"	1.30
166	8" x 6" x 3"	1.68
167	6" x 4" x 2"	1.12
168	Sloping Box — Large	6.97
169	Sloping Box — Small	4.63

VERO CASES

152	23/16" x 2" x 1" Black	0.47
153	23/16" x 2" x 1" White	0.47
154	Vero plastic case box	4.82

CABLE

		per metre
390	Light Mic Cable	0.10
391	Twin Mic Cable	0.15
392	Fig. 8 Stereo Cable	0.12
393	4 Way SCR Cable	0.35
394	4 Way Ind. Screened Cable	0.18
395	Heavy Mic Cable	0.25
396	3 Amp 3 Core Mains Cable	0.16
397	Twin Oval Mains	0.10
398	Fig. 8 Speaker Cable	0.07
399	Low Loss Coax. 750 ohms	0.20
400	Uniradio 76-50 ohms coax.	0.30

ELECTROLYTIC CAPACITORS

430	470uF 50v	0.30
431	1000uF 25v	0.40
432	1000uF 63v	1.00
433	1000uF 100v	1.25
435	2200uF 25v	0.70
436	2200uF 40v	1.20
437	2200uF 100v	2.00
438	3300uF 100v	2.40
439	4700uF 25v	0.90
440	4700uF 63v	2.30

CAPS, CHOKES, TRIMMERS

327	Jackson Coupling	0.74
328	Jackson Slow Motion Drive	1.38
329	Jackson 300PF Dilecon	2.64
330	Jackson 500PF Dilecon	3.10
331	Jackson 01-365PF	2.86
332	Jackson 02-365PF Dual	4.34
333	Jackson 804 10PF	2.62
334	Jackson 804 25PF	2.88
335	Jackson 804 50PF	2.88
336	Jackson 804 100PF	3.42
337	Trimmer Cap 40PF	0.20
338	Trimmer Cap 250PF	0.25
339	Trimmer Cap 450PF	0.30
340	Trimmer Cap 750PF	0.34
357	Repanco CH1 2.5MH	0.44
358	Repanco CH2 5.0MH	0.50
359	Repanco CH3 7.5MH	0.50
360	Repanco CH4 10.0MH	0.56
361	Repanco CH5 1.5MH	0.44
362	Repanco CH6 5UH	0.38
363	Repanco DRX1 Coil	0.60
364	Repanco DRR2 Coil	1.00

ENAM. COPPER WIRE

		2oz
365	40 swg	1.00
366	38 swg	0.88
367	36 swg	0.90
368	34 swg	0.82
369	32 swg	0.80
370	30 swg	0.80
371	28 swg	0.76
372	26 swg	0.74
373	24 swg	0.66
374	22 swg	0.62
375	20 swg	0.60
376	18 swg	0.60
377	16 swg	0.52
378	14 swg	0.52

TINNED COPPER WIRE

		4oz
379	24 swg	0.94
380	22 swg	0.83
381	20 swg	0.86
382	18 swg	0.90
383	16 swg	0.78

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

ETCHANT AND PENS

1610	Dalo Etch Resist Pen	0.90
1611	Ferric Chloride ½lb pack	0.95
1612	Pentel Etch Resist Pen	0.65

SATISFACTION OR YOUR MONEY BACK

III

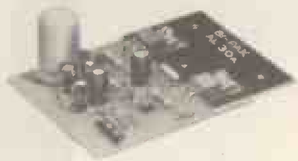
BI-PAK

CHOOSE FROM OVER
20 TOP QUALITY
MODULES

BI-PAK Audio Modules are famous for their variety, quality of design and ruggedness. For over 10 years BI-PAK have been suppliers to manufacturers of high quality audio equipment throughout the world — to date, well over 100,000 modules have been sold — this is why discerning amateur enthusiasts insist on using BI-PAK modules in their equipment. They know that every item is designed and tested to do the job for which it is intended before it leaves the factory. Whatever you are building, there is a kit or module in the BI-PAK range to suit your every need from 5 watts to 125 watts to 125 watts, from amplifiers to equalisers AND if you cannot see what you require in this advertisement, just write or phone us — we are waiting to help you!

AL20A-30A

AUDIO AMPLIFIER MODULES



AL80

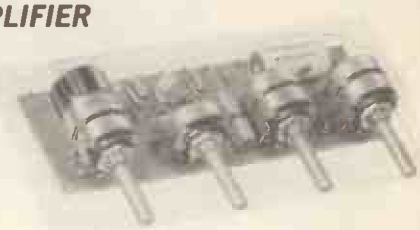
AUDIO AMPLIFIER MODULE
35 Watts RMS

AL60

AUDIO AMPLIFIER MODULE
25 Watts RMS

PA12

STEREO PRE-AMPLIFIER

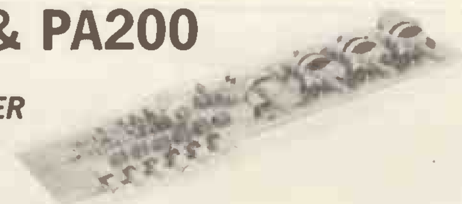


AL120

AUDIO AMPLIFIER
50W R.M.S.
With integral heat sink and short-circuit protection

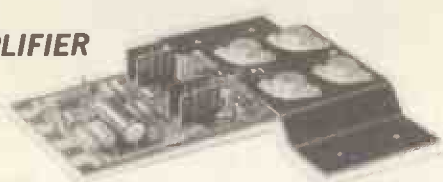
PA100 & PA200

STEREO PRE-AMPLIFIER



AL250

POWER AMPLIFIER



GE100 M

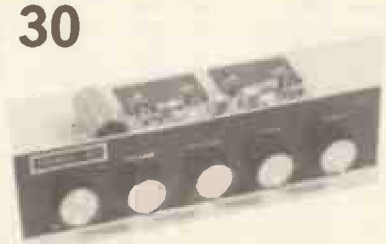
10 CHANNEL
MONOGRAPHI

LATEST ADDITION:
MM100 suitable for disco mixer
MM100G suitable for guitar pre-amp mixer

£12.43 each

Stereo 30

COMPLETE AUDIO CHASSIS



LARGEST SELECTION
LOWEST PRICES

AMPLIFIERS

AL20. 5 watt Audio Amplifier Module 22-32v supply £3.57
AL30A. 7-10 watt Audio Amplifier Module 22-32v supply £4.16
AL60. 15-25 watt Audio Amplifier Module 30-50v supply £5.15
AL80. 35 watt Audio Amplifier Module 40-60v supply £8.07
AL120 50 watt Audio Amplifier Module 50-70v supply £13.14
AL250. 125 watt Audio Amplifier Module 50-80v supply £19.60

STEREO PRE-AMPLIFIERS

PA12. Supply voltage 22-32v input sensitivity 300mv. Suit: AL10/AL20/AL30 .... £8.55
PA100 Supply voltage 24-36v inputs. Tape Tuner Mag P.U. Suit AL60/AL80 .... £17.65
PA200. Supply voltage 35-50v inputs. Tape Tuner Mag P.U. Suit AL80/AL120/AL250 £18.24

IV

BI-KITS

STA5. 5 watts per channel Stereo Amplifier Kit consisting of 2 x AL20 amplifiers, 1 x PA12 pre-amplifier, 1 x PS12 power supply, 1 x 2036 transformer and necessary wiring diagram £19.52

STA10. 10 watts per channel Stereo Amplifier Kit consisting of 2 x AL30 amplifiers, 1 x PA12 pre-amplifier, 1 x PS12 power supply, 1 x 2036 transformer and necessary wiring diagrams £20.63

STA15. 15 watts per channel Stereo Amplifier Kit consisting of: 2 x AL60 amplifiers, 1 x PA100 pre-amplifier, 1 x SPM80 power supply, 1 x 2034 transformer, 2 x coupling capacitors for 8 ohms 470mfd 30v and necessary wiring diagram £36.76

BI-KITS

STA25. 25 watts per channel Stereo Amplifier Kit consisting of: 2 x AL60 amplifiers, 1 x PA100 pre-amplifier, 1 x SPM 120/45 power supply, 1 x 2040 transformer coupling capacitors for 8 ohms 470mfd 45v. 1 x reservoir capacitor 2200mfd 100v and necessary wiring diagram £40.50

STA35. 35 watts per channel Stereo Amplifier Kit consisting of: 2 x AL80 amplifiers, 1 x PA100 pre-amplifier, 1 x 2035 transformer, 2 x coupling capacitors 470mfd at 50v for 8 ohms, 1 x reservoir capacitor 2200mfd 100v and necessary wiring diagram . £45.76

BI-KITS

STA50. 50 watts per channel Stereo Amplifier Kit consisting of: 2 x AL120 amplifiers, 1 x PA200 pre-amplifier, 1 x 2041 transformer, 2 x coupling capacitors 1000mfd 63v, 1 x reservoir capacitor 3300mfd 100v and necessary wiring diagram £59.89

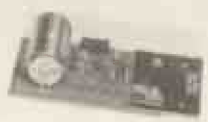
STA100. 100 watts per channel Stereo Amplifier Kit consisting of: 2 x AL250 amplifiers, 1 x PA200 pre-amplifier, 2 x SPM120/65 power supplies, 2 x 2041 transformers, 2 x coupling capacitors 1000mfd 100v and necessary wiring diagram £84.68

PS12
POWER SUPPLY MODULE

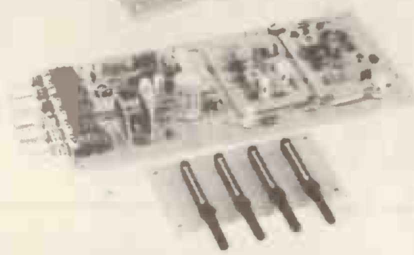
MPA30
MAGNETIC CARTRIDGE PRE-AMPLIFIER

BP124
SIREN ALARM MODULE

SPM80
STABILISED POWER SUPPLY



S450
STEREO FM TUNER Fitted with phase lock-loop



SPM120
STABILISED POWER SUPPLY

Mk II
C EQUALISER

Transformers are not included with power supplies
SPM120 Range also require reservoir and output capacitors

MONO PRE-AMPLIFIERS

MM100. Supply voltage 40-65v inputs: Tape, Mag P.U. Microphone Max output 500mv £12.43

MM100G. Supply voltage 40-65v inputs: 2 Guitars, Microphones Max output 500mv £12.43

POWER SUPPLIES

PS12. 24v Supply. Suit: 2 x AL10, 2 x AL20. 2 x AL30 & PA 12/S. 450 .... £1.65

SPM80. 33v Stabilised supply. Suit: 2 x AL60, PA 100 to 15 watts £4.84

SPM 120/45. 45v Stabilised supply. Suit: 2 x AL60. PA 100 to 25 watts £6.38

SPM120/55. 55v Stabilised supply. Suit: 2 x AL80. PA200 .... £6.38

SPM120/65. 65v Stabilised supply. Suit: 2 x AL120, PA200, 1 x AL250 .... £6.38

SG30. 15-0-15 Stabilised power supply for 2 x GE100MK11 .... £3.80

MISCELLANEOUS

MPA30. Stereo Magnetic Cartridge Pre-Amplifier — input 3.5mv Output 100mv £3.27

S.450. Stereo FM Tuner Supply Voltage 20-30v — Varicap tuned £25.56

STEREO 30. Complete 7 watt per channel Stereo Amplifier Board — includes amps, pre-amp, power supply, front panel knobs etc. — requires 2039 Transformer £21.09

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. 1.5amp 0-45v-55v. Suit: SPM120/45, SPM120/55v £6.45

2041. 2 amp 0-55v-65v. Suit: SPM120/55 SPM120/65v £8.46

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, 320 x 235 x 81mm £7.00

140. Teak Cabinet. Suit: STA15, 425 x 290 x 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 15 Amplifier) £19.95

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

VPS30
REGULATED VARIABLE STABILISED POWER SUPPLY

KIT £20 + VAT

Stabilised Power Supply Kit
Variable from 2-30 volts and 0-2 Amps
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 — 470ohm wirewound potentiometer
1 — 4K7 ohm wirewound potentiometer

Wiring Diagram Included

Access and Barclaycard accepted — just telephone our Orderline — Ware (STD 0920) 3182
All prices exclude VAT, add 50p postage per order. Terms: CWO, cheques, Postal Orders payable to Bi-Pak

Send to: Dept. EMM2 PO BOX 6, Ware, Herts.

V

BI-PAK

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

EARPIECES AND BUZZERS

500	Solid State Buzzer 4-25v	£0.75
501	Crystal Earpiece	£0.42
502	8 ohm Earpiece 2.5mm Plug	£0.18
503	8 ohm Earpiece 3.5mm Plug	£0.18
505	200 ohm Earpiece 3.5mm Plug	£0.44

MAINS PLUGS & SOCKETS

1618	13 Amp Rubber Plug	0.52
1619	13 Amp Plastic Plug	0.46
1620	13 Amp Free Socket	0.50
1621	13 Amp 2 way Free Socket	1.50
1622	13 Amp 4 way Free Socket	4.20
2019	2 Amp Terminal Block 12 way	0.24
2020	5 Amp Terminal Block 12 way	0.24

SOLDERING EQUIPMENT

1925	12 volt soldering iron MLX	5.46
1927	Multicore solder 22 swg tube	1.00
1928	Multicore solder 22 swg reel	3.50
1929	Multicore solder 18 swg reel	3.50
1930	Desolder braid	0.75
1931	X25 Soldering Iron	4.20
1932	X25 ⅛" replacement Bit	0.50
1933	X25 3/16" replacement Bit	0.50
1934	X25 3/32" replacement Bit	0.50
1935	X25 Replacement Element	1.80
1936	Desolder Pump	5.56
1937	Desolder Pump Nozzles	0.64
1938	SK1 Soldering Kit	7.00
1939	ST3 Iron Stand	1.60
1940	Horizontal IC Desoldering Bit	1.95
1941	Vertical IC Desoldering Bit	1.95
1942	Antex Heat Shunt	0.15
1943	CCN240 Soldering Iron	4.20
1944	CCN240 3/32" Replacement Bit	0.50
1945	CCN240 ⅛" Replacement Bit	0.50
1946	CCN240 3/16" Replacement Bit	0.50
1947	CCN240 Replacement Element	1.90
1948	C240 Soldering Iron	4.20
1949	C240 3/32" Replacement Bit	0.50
1950	C240 ⅛" Replacement Bit	0.50
1951	C240 3/16" Replacement Bit	0.50
1952	C240 Replacement Element	1.70
1953	G Soldering Iron	4.20
1954	Model G 3/32" Replacement Bit	0.50
1955	Model G ⅛" Replacement Bit	0.50
1956	Model G 3/16" Replacement Bit	0.50
1957	Model G Replacement Element	1.90

METERS

1305	2" Meter 2 Amps	2.88
1307	2" Meter 50UA	2.88
1308	2" Meter 100UA	2.88
1309	2" Meter 500UA	2.88
1310	2" Meter 1MA	2.88
1311	2" Meter 50 volts	2.88
1312	SWR and FS Meter	9.50
1313	SWR and Power Meter	11.90
1315	Test Meter 20,000 OPV	24.75
1316	Multi Tester RE185M	40.00
1317	Double VU Meter	3.25
1319	100-0-100 UA Meter 45mm	1.90
1320	Min Level Meter 23mm	0.95
1321	VU Meter 40mm	1.96
1322	Test Meter 1000PV	6.50
1323	Test Meter 20,000 OPV	11.40
1324	Test Meter 50,000 OPV	19.75

VI

SWITCHES

1958	Min SPST Toggle Switch	0.70
1959	Min SPDT Toggle Switch	0.75
1960	Min DPDT Toggle Switch	0.80
1961	Min DPDT Centre Off Switch	0.95
1962	Push Button SPST	0.90
1963	Push Button SPDT	0.95
1964	Push Button DPDT	0.98
1965	1P 12W Rotary Switch	0.60
1966	2P 6W Rotary Switch	0.60
1967	3P 4W Rotary Switch	0.60
1968	4P 3W Rotary Switch	0.60
1973	Min DPDT Slide Switch	0.15
1974	Std Slide Switch	0.16
1975	SPST Toggle Switch	0.33
1976	DPDT Toggle Switch	0.46
1977	Rotary On-Off Switch	0.56
1978	Push to Make Switch	0.15
1979	Push to Break Switch	0.19
1981	SPST Rocker Switch (Black)	0.32
1982	SPST Rocker Switch (White)	0.32
1983	SPST Rocker Switch (Blue)	0.32
1984	SPST Rocker Switch (Yellow)	0.32
1985	SPST Rocker Switch (Luminous)	0.32
1986	Sub min SPST Toggle Switch	0.54
1987	Sub min SPDT Toggle Switch	0.58
1988	Sub min DPDT Toggle Switch	0.62
1989	Keyboard 24 way	1.50
1990	Keyboard 40 way	1.60
1991	Keyboard Switch	0.20
1992	Push to Make Switch (metal body)	0.32

MIN PRESETS 9p EACH

1801	100 ohm	Horizontal
1802	220 ohm	Horizontal
1803	470 ohm	Horizontal
1804	1K	Horizontal
1805	2K2	Horizontal
1806	4K7	Horizontal
1807	10K	Horizontal
1808	22K	Horizontal
1809	47K	Horizontal
1810	100K	Horizontal
1811	220K	Horizontal
1812	470K	Horizontal
1813	1M	Horizontal
1814	2M2	Horizontal
1815	4M7	Horizontal
1816	100 ohm	Vertical
1817	220 ohm	Vertical
1818	470 ohm	Vertical
1819	1K	Vertical
1820	2K2	Vertical
1821	4K7	Vertical
1822	10K	Vertical
1823	22K	Vertical
1824	47K	Vertical
1825	100K	Vertical
1826	220K	Vertical
1827	470K	Vertical
1828	1M	Vertical
1829	2M2	Vertical
1830	4M7	Vertical

TRANSFORMERS

2021	6-0-6v 100mA	0.90
2022	9-0-9v 75mA	0.90
2023	12-0-12v 100mA	1.15
2024	0-6v 0-6v 280mA	1.60
2025	0-12v 0-12v 150mA	1.60
2026	6-0-6v 1 Amp	2.40
2027	9-0-9v 1 Amp	2.00
2028	12-0-12v 1 Amp	2.50
2029	15-0-15v 1 Amp	2.75
2030		
2031	Multi tap ½ Amp	3.40
2032	Multi tap 1 Amp	4.80
2033	Multi tap 2 Amp	6.40
2034	0-35v 1.7 Amp	4.90
2035	0-55v 2 Amp	6.65
2036	0-17v 750mA	2.85
2037	Min audio output	0.25
2038	Min audio driver	0.36
2039	0-20v 1 Amp	3.50
2040	0-45-55v 1.5 Amps	6.45
2041	0-55-65v 1 Amps	8.46
2042	0-25v 2 Amps	4.50
2043	15-0-15 150mA	2.40

2017	Pick-up for Acoustic Guitar	5.50
2018	Telephone Pick-up Coil	0.66
170	Quick Test Block 'Keynector'	6.50
1617	T03 Transistor Socket	

Mains Fuses 13A Plug Type

643	1A	0.12
644	2A	0.12
645	3A	0.12
646	5A	0.12
647	13A	0.12

SEMICONDUCTOR HARDWARE

867	T0220	0.20
868	T03	0.20
869	S055 Insulating kits in packs of 5	0.20
870	T066	0.20
871	T064	0.20
872	T048	0.20
873	T03 Single Heat Sink	0.26
874	T03 Double Heat Sink	1.35
875	Double Sided Heat Sink	2.65
876	T05/39 Heat Sink	0.15
877	T018 Heat Sink	0.15
878	T01 Heat Sink	0.10
879	T0220 Heat Sink	0.15
880	T066 Transistor Cover	0.14
881	T03 Transistor Cover	0.14

BATTERY HOLDERS

200	Batt Holder 2 x HP7 short	0.18
201	Batt Holder 4 x HP7 short	0.19
202	Batt Holder 6 x HP7 short	0.20
203	Batt Holder 4 x HP7 long	0.19
204	PP3 Battery Clips	0.07
205	PP9 Battery Clips	0.12
206	Batt Holder 4 x HP11 long	0.25
207	Batt Holder 4 x HP11 short	0.25
208	Batt Holder 4 x HP2 long	0.30

POTS

1831	1K	Lin Single Pots	29
1832	2K2	Lin Single Pots	29
1833	4K7	Lin Single Pots	29
1834	10K	Lin Single Pots	29
1835	22K	Lin Single Pots	29
1836	47K	Lin Single Pots	29
1837	100K	Lin Single Pots	29
1838	220K	Lin Single Pots	29
1839	470K	Lin Single Pots	29
1840	1M	Lin Single Pots	29
1841	2M2	Lin Single Pots	29
1842	4K7	Log Single Pots	29
1843	10K	Log Single Pots	29
1844	22K	Log Single Pots	29
1845	47K	Log Single Pots	29
1846	100K	Log Single Pots	29
1847	220K	Log Single Pots	29
1848	470K	Log Single Pots	29
1849	1M	Log Single Pots	29
1850	2M2	Log Single Pots	29
1851	4K7	Lin Dual Pots	88
1852	10K	Lin Dual Pots	88
1853	22K	Lin Dual Pots	88
1854	47K	Lin Dual Pots	88
1855	100K	Lin Dual Pots	88
1856	220K	Lin Dual Pots	88
1857	470K	Lin Dual Pots	88
1858	1M	Lin Dual Pots	88
1859	2M2	Lin Dual Pots	88
1860	4K7	Log Dual Pots	88
1861	10K	Log Dual Pots	88
1862	22K	Log Dual Pots	88
1863	47K	Log Dual Pots	88
1864	100K	Log Dual Pots	88
1865	220K	Log Dual Pots	88
1866	470K	Log Dual Pots	88
1867	1M	Log Dual Pots	88
1868	2M2	Log Dual Pots	88
1869			
1870	4K7	Lin switched pots	68
1871	10K	Lin switched pots	68
1872	22K	Lin switched pots	68
1873	47K	Lin switched pots	68
1874	100K	Lin switched pots	68
1875	220K	Lin switched pots	68
1876	470K	Lin switched pots	68
1877	1M	Lin switched pots	68
1878	2M2	Lin switched pots	68
1879	4K7	Log switched pots	68
1880	10K	Log switched pots	68
1881	22K	Log switched pots	68
1882	47K	Log switched pots	68
1883	100K	Log switched pots	68
1884	220K	Log switched pots	68
1885	470K	Log switched pots	68
1886	1M	Log switched pots	68
1887	2M2	Log switched pots	68
1888	100K	Log-Anti Log Dual Pot	68
1889	5K	Log pot 16mm switched	36
1890	5K	Log pot 17mm switched	48
1891	10 ohm wire wound pots		85
1892	22 ohm wire wound pots		85
1893	47 ohm wire wound pots		85
1894	100 ohm wire wound pots		85
1895	220 ohm wire wound pots		85
1896	470 ohm wire wound pots		85
1897	1K ohm wire wound pots		85
1898	2K ohm wire wound pots		85
1899	4K7 ohm wire wound pots		85

BABANI BOOKS

BP160 Coil Design and Construction Manual £1.2
BP202 Handbook of Integrated Circuits (IC's) Equivalents & Substitutes £1.45
BP205 First Book of Hi-Fi Loudspeaker Enclosures £0.95
BP207 Practical Electronic Science Projects £0.75
BP208 Practical Stereo and Quadrophony Handbook £0.75
BP211 First Book of Diode Characteristics Equivalents and Substitutes £1.25
BP213 Electronic Circuits for Model Railways £1.00
BP214 Audio Enthusiasts Handbook £0.85
BP218 Build Your Own Electronic Experimenters Laboratory £0.85
BP219 Solid State Novelty Projects £0.85
BP220 Build Your Own Solid State Hi-Fi and Audio Accessories £0.85
BP221 28 Tested Transistor Projects £1.25
BP222 Solid State Short Wave Receivers for Beginners £1.25
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BP41 Linear IC Equivalents and Pin Connections £2.75
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BP47 Mobile Discotheque Handbook £1.35
BP48 Electronic Projects for Beginners £1.35
BP49 Popular Electronic Projects £1.45
BP50 IC LM3900 Projects £1.35
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BP52 Long Distance Television Reception (TV-DX) for the Enthusiast £1.95
BP53 Practical Electronic Calculations and Formulae £2.25
BP54 Your Electronic Calculator and Your Money £1.35
BP55 Radio Stations Guide £1.75
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BP59 Second Book of CMOS IC Projects £1.50
BP60 Practical Construction of Pre-amps, Tone Controls, Filters & Attn. £1.45
BP61 Beginners Guide to Digital Techniques £0.95
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BP63 Elements of Electronics—Book 2 £2.25
BP64 Elements of Electronics—Book 3 £2.25
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BP68 Choosing and Using Your Hi-Fi £1.65
BP69 Electronic Games £1.70
BP70 Transistor Radio Fault-Finding Chart £0.50
BP71 Electronic Household Projects £1.75
BP72 A Microprocessor Primer £1.75
BP73 Remote Control Projects £1.95
BP74 Electronic Music Projects £1.75
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BP77 Elements of Electronics—Book 4 £2.95
BP78 Practical Computer Experiments £1.75
BP79 Radio Control for Beginners £1.75
BP80 Popular Electronic Circuits—Book 1 £1.95

PLUGS AND SOCKETS

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1626 2mm Plug BLACK £0.16
1628 2mm Socket RED £0.16
1629 2mm Socket BLACK £0.16
1634 4mm Plug BLACK £0.16
1637 4mm Plug RED £0.16
1640 4mm Socket BLACK £0.16
1643 4mm Socket RED £0.16
1652 2 Pin DIN Chassis Socket £0.08
1654 5 Pin 180° DIN Chassis Socket £0.12
1655 5 Pin 240° DIN Chassis Socket £0.12
1656 2.5mm Chassis Socket £0.10
1657 3.5mm Chassis Socket £0.10
1658 Metal Std. Jack Chassis Socket (Mono) £0.18
1959 Metal Std. Jack Chassis Socket (Stereo) £0.24
1660 Single Phono Socket £0.09
1661 Double Phono Socket £0.12
1662 Coax Surface Socket £0.22
1663 Coax Flush Socket £0.22
1664 Plastic Std. Jack Socket (Mono) £0.20
1665 Plastic Std. Jack Socket (Stereo) for headphones £0.32
1666 Car Aerial Chassis Socket £0.18
1667 AC Chassis Socket £0.16
1668 4-Way Phono Chassis Socket £0.22
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1670 AC switched non rev. Socket £0.32
1672 2 Pin DIN Line Socket £0.10
1674 5 Pin 180° DIN Line Socket £0.17
1675 5 Pin 240° DIN Line Socket £0.20
1676 2.5mm Plastic Line Socket £0.12
1677 3.5mm Plastic Line Socket £0.12
1678 Std. Jack Plastic Line Socket (Mono) £0.17
1679 Std. Jack Metal Line Socket (Mono) £0.30
1680 Std. Jack Plastic Line Socket (Stereo) £0.22
1681 Std. Jack Metal Line Socket (Stereo) £0.38
1682 Phono Lin Line Metal Socket £0.16
1684 Coax Line Socket £0.34
1685 Coax Back-Back Socket £0.14
1686 AC Line Socket (2 pin USA Type) £0.18
1687 Phono In Line Plastic Socket £0.12
1688 Phono Back-Back Socket £0.20
1689 2 Pin DIN Plug £0.10
1692 5 Pin 180° DIN Plug £0.14
1693 5 Pin 240° DIN Plug £0.14
1696 2.5mm Plug (Metal) £0.15
1697 3.5mm Plug (Plastic) £0.12
1698 3.5mm Plug (Metal) £0.16
1699 Std. Plastic Jack Plug (Mono) £0.16
1700 Std. Metal Jack Plug (Mono) £0.30
1701 Std. Metal Jack Plug (Stereo) £0.35
1702 Plastic Phono Plug £0.11
1703 Car Aerial Plug £0.24
1704 Coax TV Plug £0.22
1705 Right Angle Jack Plug (Mono) £0.20
1706 2.5mm Plastic Plug £0.12
1707 Std. Plastic Jack Plug (Stereo) £0.22
1708 Metal Phono Plug £0.14
1709 2.1mm DC Plug £0.12
1710 2.5mm DN Plug £0.12
1711 AC Plug (2 pin USA Type) £0.16
1712 AM Aerial Plug £0.17
1713 Cassette AC Input Plug £0.15
1714 FM Aerial Plug £0.13
1715 PL 259 Plug £0.40
1716 SO239 Socket 4-hole fixing £0.38
1717 SO239 Socket single-hole fixing £0.40
1718 PL258 Double Ended Female Coupler £0.40
1719 NC555 Reducer for PL259 (Small) £0.16
1720 NC556 Reducer for PL259 (Large) £0.16
1721 M359 Right Angle Coupler PL259 SO239 £0.75
1722 M358 T Connector Female-Male-Female £0.85
1723 NC563 Inline Coupler PL259 x 2 £0.60
1724 BNC15 50 obm Standard Plug £0.64
1725 BNC1502 Chassis Mounting Socket £0.75
1726 BNC1503 Chassis Mounting Socket single-hole fixing £0.70
1727 BNC1520 BNC Male to SO239 Female £0.85
1728 BNC1521 BNC Female to PL259 Male £0.85
1729 Junction Box on in two out £0.80
1730 Low Loss Splitter £1.00

GOOD QUALITY STEREO HEADPHONES

Double padded headband, Circular vented padded earpieces, Black and aluminium finish Impedance 8 ohms, Frequence response 20-19,000 HZ, Weight 350gms £8.25

SUPERIOR QUALITY STEREO HEADPHONES

Wide black padded headband with padded matt aluminium earcups. Impedance 8 ohms, Frequency response 15-25,000 HZ. Weight 290gms £15.85

COMPONENT PAKS

C26 300 Pre-formed Carbon Resistors, mixed, ¼-½w £1.00
C27 50 2-10 watt Wire Wound Resistors, mixed £1.00
C28 300 approx Resistors, mixed values (count by weight) £1.00
C29 200 approx Capacitors, mixed values and types (count by weight) £1.00
C30 60 Precision Resistors 1-5% to 1 £1.00
C31 100 approx ⅛ watt min. Resistors, mixed values £1.00
C32 6 pieces Ferrite Rods £1.00
C33 60 meters Single strand wire, assorted colours £1.00
C34 15 Reed Switches, glass type £1.00
C35 5 Micro Switches, assorted types including min. £1.00
C36 6 Assorted Audio Jack Sockets and Plugs £1.00
C37 100 Disc Ceramic Caps, mixed values £1.00
C38 20 Assorted Pots £1.00
C39 40 C280 type Capacitors, metal foil £1.00
C40 60 Electrolytics, assorted £1.00
C41 50 Assorted Polyester/Polystyrene £1.00
C42 60 Low voltage Electrolytics, mixed values up to 10v £1.00
C43 15 Assorted Slider Pots £1.00
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C45 1 Pack assorted Hardware, nuts/bolts, etc. £1.00
C46 10 Assorted Switches, slide/rocker/mains £1.00
C47 3 Relays 24v coil £1.00
C48 20 Assorted Knobs, push, screw and slider types £1.00
C49 20 Assorted Tag Strips and Panels £1.00
C50 4 Wave Change Switches, rotary £1.00
C51 1 Pack of assorted PVC Sleeving and Markers £1.00
C52 100 ½ watt Resistors, mixed values £1.00
C53 35 Presets, assorted type and values £1.00
C54 40 Meters, stranded wire, assorted colours £1.00
C55 10 Assorted DIN/sockets/Coax/speakers/phone £1.00
C56 10 Assorted Plugs, DIN/Coax/speakers/etc. £1.00
C57 10 meters assorted Cable. Mains/speaker/Coax/microphone £1.00
C58 100 sq. in. Clopper-clad board, single-sided paper £1.00
C59 75 sq. in. Copper-clad Fibreglass Board £1.00
C60 15 assorted IC Sockets, 8, 14, 16 pin £1.00

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2201 2.5" x 5" .1 copper £0.76
2202 3.5" x 3.75" .1 copper £0.66
2203 2.5" x 17" .1 copper £2.28
2204 3.75" x 5" .1 copper £0.86
2205 3.75" x 3.75" .1 copper £0.76
2206 3.75" x 17" .1 copper £2.96
2207 4.75" x 17.9" .1 copper £3.90
2208 2.5" x 1" 5 in pack £0.92
2209 3.75" x 17" .1 Plain £1.92
2210 3.75" x 2.5" .1 Plain £0.48
2211 5.0" x 3.75" .1 Plain £0.72
2212 Vero Pins Double-sided .040mm .1" (in 100's) £0.52
2213 Vero Pins Single-sided .040mm .1" (in 100's) £0.52
2214 DIP Breadboard £3.26
2215 Vero Cutter £1.06
2216 Insertion Tool .1 £1.46
2217 PCB Transfers £1.46
2217 PCB Transfers
2218 12 volt mini drill £7.00
2219 Right Angle Bracket 1¾" x ⅝" £0.07
2220 Right Angle Bracket ⅝" x ⅝" £0.06

BUDGET STEREO HEADPHONES

Black with padded earcups: Impedance 8 ohms. Frequency response 30-18,000 HZ. Weight 300gms £4.20

BREADBOARD

2195 EXP325 £1.84
2196 EXP350 £3.62
2197 EXP650 £4.14
2198 EXP300 £6.61
2199 EXP4B £2.65
2200 EXP600 £7.25

BI-PAK
THE PROFESSIONAL APPROACH

VII

THE BI-PAK OPTO SHOW

LEDs

1501	£0.10	TIL209 Red LED .125"
1502	£0.16	TIL211 Green LED .125"
1503	£0.16	TIL213 Yellow LED .125"
1504	£0.10	FLV117 Red LED .2"
1505	£0.16	FLV310 Green LED .2"
1506	£0.16	FLV410 Yellow LED .2"
1507	£0.80	2nd Grand LED pack, 10 assorted
1522	£0.12	MIL32 Clear Illuminating Red LED .125"
1532	£0.12	FLV111 Clear Illuminating Red LED .2"
1524	£0.05	CQX21 Red Flashing LED
1525	£0.75	CQX95 Two Colour LED

OPTO-ISOLATORS

1515	£0.55	Opto-Isolator IL74 Single
1516	£1.16	Opto-Isolator ILD74 Dual
1517	£2.10	Opto-Isolator ILQ74 Quad

7 SEGMENT LED DISPLAYS

1508	£0.30	BDL307 7 segment LED display .3"
1509	£1.80	BDL527 Dual 7 segment LED display .5"
1510	£0.98	BDL707 7 segment LED display .3"
1511	£1.75	BLD747 7 segment LED display .6"
1512	£1.90	BDL727 Dual 7 segment LED display .5"

MISCELLANEOUS

1514	£0.60	ORP12 Light Dependent Resistor
1518	£0.60	Photo Transistor P20 NPN
1519	£0.26	Photo Darlington MEL11 NPN
1520	£0.40	Photo Transistor OCP71 PNP
1526	£0.38	FPE100 Infra Red Emitter
1527	£0.38	CQY89 Infra Red LED

BEGINNERS PAK

No. 1 — 100 TRANSISTORS

A pack of well known transistors, as used in many popular projects. A must for beginners (and very useful to experienced constructors too).

10	BC107/8	TO18	Metal	NPN
10	BC237	TO92	Plastic	NPN
5	BC177/8	TO18	Metal	PNP
5	BC251	TO92	Plastic	PNP
10	BFY51-BC141	TO39	Metal	NPN
5	BC160	TO39	Metal	PNP
5	2N3055	TO3	Metal	NPN
2	BD312/MJ2955	TO3	Metal	PNP
5	TIP29-31	TO220	Plastic	NPN
2	TIP30-32	TO220	Plastic	PNP
10	OC71-76	Germanium		PNP
5	AC128-188	Germanium Metal		PNP
5	AC127-187-188	Germanium Metal		NPN
5	OC44-45	Germanium		PNP
5	TIS43-UT46	Unijunction Plastic		
5	2N3819	F.E.T.		
2	MEL11	Photo Transistor Plastic		
2	BD131	TO126	Plastic	NPN
2	BD132	TO126	Plastic	PNP

100 TOTAL

ALL devices — brand new and full spec. as per device coding. Data and lead out details included in Pak.
Normal Retail Value £23.00
Our Special Offer Price £15.00

BEGINNERS PAK

No. 2 — 100 RECTIFIERS, SCR's TRIACS, DIODES

20	IN4001-IN4007	1 Amp Silicon Rectifier
20	IN5401-IN5407	3 Amp Silicon Rectifier
20	IN4148	Fast Switch Diodes, Silicon
10	OA200 BAX13-13	General Purpose Diode, Silicon
4	C106D	Thyristor 400v, TO202 Case
2	10 Amp Triacs 400v	TO220 Case, Isolated Tab
2	4 Amp Triacs 400v	TO220 Case, Non-Isolated Tab
10	Assorted 3 Amp	Thyristors 50-600 volts, TO64-TO66 Case
5	Assorted 1 Amp	Thyristors 50-600 volts, TO39 Case
6	OA31-91	General Purpose Germanium Diodes

100 TOTAL

All devices brand new and full spec. Data and lead out details included.
Normal Retail Value £17.00
Our Special Offer Price £11.00

UNTESTED SEMICONDUCTOR PAKS

U1	150 germ Gold Bonded Diodes OA47		£1.00
U2	150 germ Point Contact Diodes OA81		£1.00
U3	150 Silicon G.P. 200mA Diodes OA200		£1.00
U4	150 Silicon Fast Switch Diodes IN4148		£1.00
U5	25 Stud type Silicon Rectifiers up to 10A		£1.00
U6	10 SCR's 5 Amp, TO66		£1.00
U7	40 Sil Trans NPN, TO18 Case	BC107/8/9	£1.00
U8	40 Sil Trans PNP, TO18 Case	BC177/8/9	£1.00
U9	40 Sil Trans NPN, TO18 Case	2N706/8	£1.00
U10	40 Sil Trans NPN, TO5/39	2N697/2N1711	£1.00
U11	40 Sil Trans PNP, TO5/39	2N2905/1132	£1.00
U12	30 Sil Trans NPN, TO39	BFY51-BC141	£1.00
U13	30 Sil Trans PNP, TO39	BC160-161, etc.	£1.00
U14	10 Sil Trans NPN, TO3	2N3055	£1.00
U15	10 Sil Trans NPN, TO220	TIP29-31-33	£1.00
U16	10 Sil Trans PNP, TO220	TIP30-32-34	£1.00
U17	30 Sil Trans NPN, TO39	High Volts BF258/115	£1.00
U18	40 Sil Trans, TO92	BC237/8	£1.00
U19	40 Sil Trans, TO92	BC251	£1.00
U20	40 Sil Trans NPN, TO92	BC183-4	£1.00
U21	40 Sil Trans PNP, TO92	BC257 BC212L	£1.00

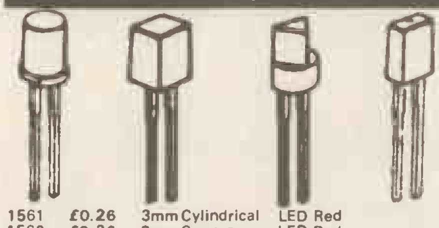
Code No's mentioned above are given as a guide to the type of device in the Pak. The devices themselves are normally unmarked.

ELECTROLYTIC PAKS

A range of Paks each containing 25 first quality, mixed value miniature electrolytics.

EC1	Values from .47mFD-10mFD	£1.00
EC2	Values from 10mFD-100mFD	£1.00
EC3	Values from 100mFD-1000mFD	£1.00

NEW SHAPE LEDs



1561	£0.26	3mm Cylindrical	LED Red
1562	£0.26	3mm Square	LED Red
1563	£0.26	3mm Triangular	LED Red
1564	£0.26	5mm Rectangular	LED Red
1565	£0.26	5mm Cylindrical	LED Red
1566	£0.26	5mm Square	LED Red
1567	£0.26	5mm Triangular	LED Red
1568	£0.26	3mm Cylindrical	LED Green
1569	£0.28	3mm Square	LED Green
1570	£0.28	3mm Triangular	LED Green
1571	£0.28	5mm Rectangular	LED Green
1572	£0.28	5mm Cylindrical	LED Green
1573	£0.28	5mm Square	LED Green
1574	£0.28	5mm Triangular	LED Green
1575	£0.28	3mm Cylindrical	LED Yellow
1576	£0.28	3mm Square	LED Yellow
1577	£0.28	3mm Triangular	LED Yellow
1578	£0.28	5mm Rectangular	LED Yellow
1579	£0.28	5mm Cylindrical	LED Yellow
1580	£0.28	5mm Square	LED Yellow
1581	£0.28	5mm Triangular	LED Yellow

CERAMIC PAKS

Containing a range of first quality miniature ceramic capacitors.

MC1 40 miniature ceramic capacitors: 5 of each value: 22pf, 27pf, 33pf, 39pf, 47pf, 56pf, 68pf, 82pf £1.00

MC2 40 miniature ceramic capacitors: 5 of each value: 100pf, 120pf, 150pf, 180pf, 220pf, 270pf, 330pf, 390pf £1.00

MC3 40 miniature ceramic capacitors: 5 of each value: 470pf, 560pf, 680pf, 820pf, 1000pf, 1500pf, 2200pf, 3300pf £1.00

MC4 35 miniature ceramic capacitors: 5 or each value: 4700pf, 6800pf, .01uf, 0.15uf, .022uf, .033uf, .047uf £1.00

SPEAKERS AND CROSSOVERS

1901	Dome Tweeter 3½", 8 ohms, 50w	£3.20
1902	Dome Tweeter 3", 8 ohms, 20w	£2.60
1903	Flared Horn Tweeter, 8 ohms, 30w	£3.80
1904	2-way Crossover, 15w, 8 ohms	£1.24
1905	2-way Crossover, 40w, 8 ohms	£2.70
1906	3-way Crossover, 60w, 8 ohms	£3.50
1907	Piezo Tweeter	£5.20
1914	70mm 80 ohm Speaker	£1.20
1915	70mm 8 ohm Speaker	£0.95
1916	56mm 8 ohm Speaker	£0.65
1917	2½" 8 ohm Speaker	£0.75
1918	2½" 64 ohm Speaker	£0.82
1919	5½" Whoofer, 4 ohms, 10w	£3.90
1920	5½" Whoofer, 8 ohms, 10w	£3.90
1921	5¼" Dual Cone, wide tange, 8 ohms	£5.80
1922	8" Dual Cone, long throw, 8 ohms, 15w	£4.84
1923	8" Whoofer, dual 4 + 8 ohms rubber edge, 20w	£7.80

DIL SOCKETS

1601	8 Pin	£0.09	1605	20 Pin	£0.20
1602	14 Pin	£0.11	1606	22 Pin	£0.24
1603	16 Pin	£0.12	1607	24 Pin	£0.28
1604	18 Pin	£0.18	1608	28 Pin	£0.32
			1609	40 Pin	£0.36

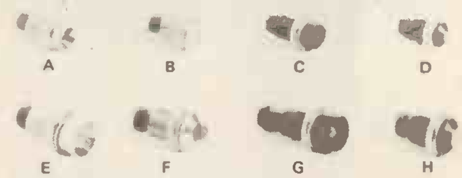
LATE ADDITIONS

HIGH CURRENT AMPS AND SWITCHES

		VCEO	VCBO	I.C. Max.
BFT32	£0.60	60	80	3A
BFT33	£0.62	80	100	3A
BFT34	£0.65	100	120	3A
BFT37	£0.95	100	120	3A

RPY76A Infra Red Detector £0.65

LED CLIPS AND HOUSINGS



1548	£0.15	LED Plastic Clips .125"	
1549	£0.18	LED Plastic Clips .2"	
1550	£0.26	LED Housing (nickel plated) .125"	A
1551	£0.22	LED Housing (nickel plated) .125"	B
1552	£0.37	LED Housing (matt black) .125"	C
1553	£0.31	LED Housing (matt black) .125"	D
1554	£0.34	LED Housing (nickel plated) .2"	E
1555	£0.28	LED Housing (nickel plated) .2"	F
1556	£0.44	LED Housing (matt black) .2"	G
1557	£0.36	LED Housing (matt black) .2"	H

BULBS AND NEONS

1534	£0.24	LES Bulb 6v 0.36w
1535	£0.24	LES Bulb 6.5v 1w
1536	£0.24	LES Bulb 14v 0.75w
1538	£0.24	MES Bulb, Round, 6v .04A
1539	£0.20	MES Bulb, Round, 6.5v .15A
1540	£0.20	MES Bulb, Round, 6.5v .3A
1541	£0.20	MES Bulb, Round, 12.0v .1A
1542	£0.20	MES Bulb, Round, 12.0v 2.2w
1543	£0.34	Neon Rec, Round, 240v
1544	£0.34	Neon Red, Rectangular, 240v
1545	£0.34	Neon Orange, Rectangular, 240v
1546	£0.34	Neon Green, Rectangular, 240v
1547	£0.18	MES Batten Holder

CARBON FILM RESISTOR PAKS

These Paks contain a range of Carbon Film Resistors, assorted into the following groups:

R1	80 Mixed ¼w	100 ohms-820 ohms	£1.00
R2	80 Mixed ¼w	1K ohms-8.2K ohms	£1.00
R3	80 Mixed ¼w	10K ohms-82K ohms	£1.00
R4	80 Mixed ¼w	100K ohms-1M	£1.00
R5	60 Mixed ½w	100 ohms-820 ohms	£1.00
R6	60 Mixed ½w	1K ohms-8.2K ohms	£1.00
R7	60 Mixed ½w	10K ohms-82K ohms	£1.00
R8	60 Mixed ½w	100K ohms-1M	£1.00

TANTALUM BEAD CAPACITORS

401	0.1uF	16v	£0.11	414	47.0uF	16v	£0.55
402	0.22uF	16v	£0.11	415	100.0uF	10v	£0.55
403	0.33uF	16v	£0.11	416	.1uF	35v	£0.12
404	0.47uF	16v	£0.11	417	.22uF	35v	£0.12
405	0.68uF	16v	£0.11	418	.33uF	35v	£0.12
406	1.0uF	16v	£0.11	419	.47uF	35v	£0.12
407	2.2uF	16v	£0.12	420	.68uF	35v	£0.12
408	3.3uF	16v	£0.13	421	1.0uF	35v	£0.12
409	4.7uF	16v	£0.14	422	2.2uF	35v	£0.13
410	6.8uF	16v	£0.15	423	3.3uF	35v	£0.15
411	10.0uF	16v	£0.16	424	4.7uF	35v	£0.18
412	22.0uF	16v	£0.28	425	6.8uF	35v	£0.30
413	33.0uF	16v	£0.50	426	10.0uF	35v	£0.38

FAIRCHILD/DARLINGTONS

TYPE	Pol	VCEO	VCBO	I.C.	HFE	CASE	£ p
2N6052	PNP	—100v	—100v	12A	750-18K	TO3	1.50
2N6282	NPN	60v	60v	20A	750-18K	TO3	1.25
MJ3000	NPN	60v	60v	10A	1KMN	TO3	1.00
SE9300	NPN	60v	60v	10A	1000	TO220	0.90
SE9031	NPN	80v	80v	10A	1000	TO220	0.95
SE9304	NPN	80v	80v	10A	1000	TO3	0.95
SE9305	NPN	100v	100v	10A	1000	TO3	1.00
SE9401	PNP	—80v	—80v	10A	1000	TO220	1.10
TIP115	PNP	—60v	—60v	2A	1K	TO220	0.40
TIP117	PNP	—100v	—100v	2A	1K	TO220	0.50
TIP120	NPN	60v	60v	5A	1K	TO220	0.60
TIP121	NPN	80v	80v	5A	1K	TO220	0.65
TIP122	NPN	100v	100v	5A	1K	TO220	0.08
TIP126	PNP	—80v	—80v	5A	1K	TO220	0.70
TIP127	PNP	—100v	—100v	5A	1K	TO220	0.72

POWER SUPPLIES

137	AC-DC Adaptor 6, 7½, 9 & 12 volts	£3.50
138	DC-DC Adaptor 6, 75, 9 volts	£2.70

CABINETS

139	Teak 30 Case	£7.00
140	Teak 60 Case	£9.50

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USING MICROPROCESSORS

Peter Kershaw BSc.

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.

More about Microprocessors

In Part 1 we saw that a microprocessor requires external memory which holds programs and data, and interfaces for communication with the "outside world". If, as in Figure 1, Part 1, we have a separate output for each device attached, the number of outputs from the processor may need to be very high. Furthermore, for increased speed the data is sent in parallel along 8 data lines. Thus a whole byte appears on the 8 inputs/outputs simultaneously. If 8 separate connections were required for each interface, the processor would require a vast number of pins.

To simplify matters therefore, a *bus* structure is adopted, as shown in Figure 2. The data bus is bidirectional (i.e. data may travel to or from the processor). Notice the notation used to denote the width of the bus. Similar bus structures are adopted for addresses and control signals. Whilst any number of devices may read the data bus simultaneously, it is essential that only one device tries to place data on the bus at one time. If two devices try to pull a bus line in opposite directions, at best the result will be indeterminate; at worst the devices will be damaged. The data outputs must therefore be capable of being electrically disconnected from the bus. Such outputs are generally known as 'tri-state' as they may be in one of three states — high (1), low (0) or disconnected (off).

The management of the data bus is controlled from the microprocessor. If, for example, it is required to read a memory location in a ROM the procedure below is followed (also see Figure 3):

Step 1
The control signals are organised such that all device outputs are disconnected from the bus.

Step 2
The address of the ROM location to be read is placed on the address bus. The most significant address bits are decoded externally to the processor to select the device required; the last significant bits select the exact location within the device.

Step 3
The control bus signals tell the ROM when to place its data on the data bus.

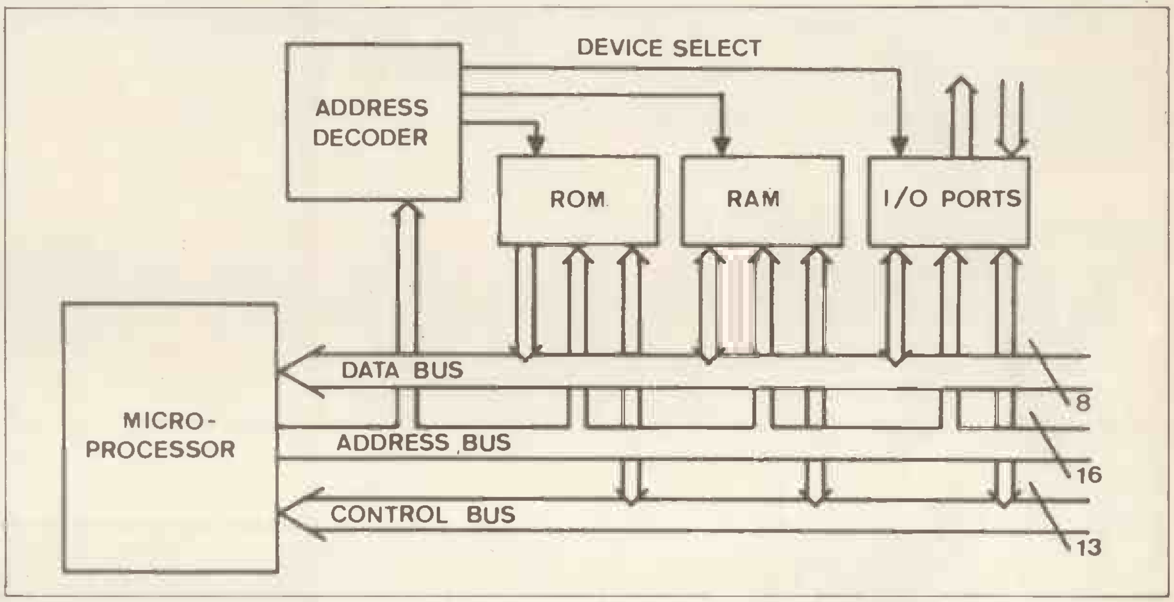

Figure 2. A Microprocessor Bus Structure.

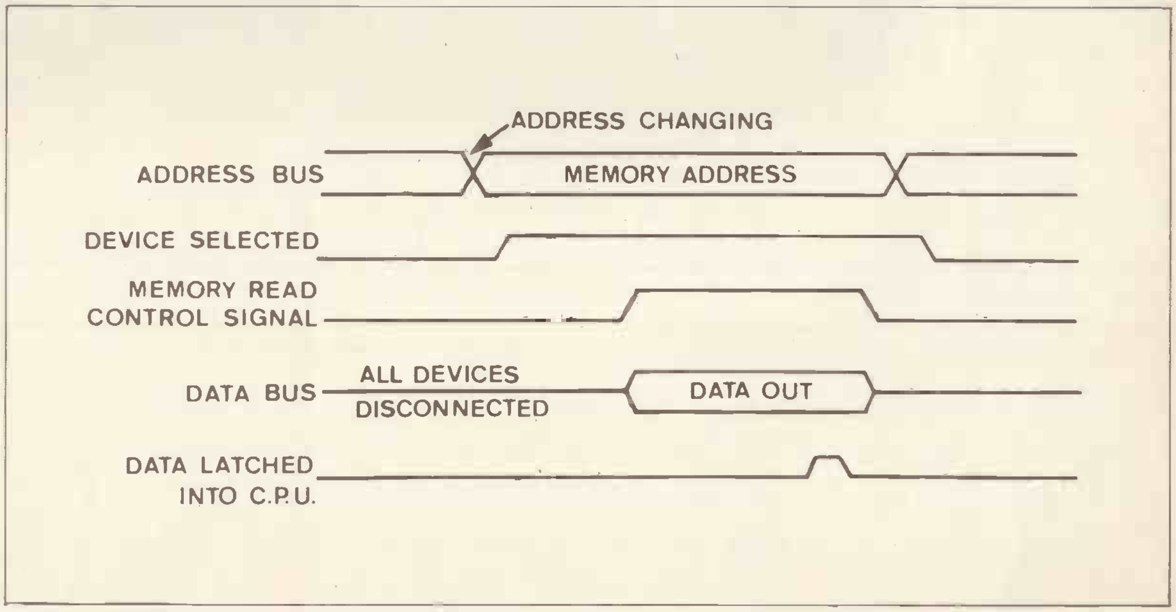

Figure 3. Timing diagram of a Memory Read Operation

Step 4
After a delay in order to let the voltage levels on the bus settle, the microprocessor assumes that the data is now valid and reads the data bus.

Step 5
The control bus signals are removed and the ROM disconnects its outputs from the data bus.

Similar procedures are used to write to memory and to communicate with other peripheral devices. This will be shown in more detail in a later article.

A Real Microprocessor

The internal structure of the Z80 microprocessor is shown in Figure 4. This is a fairly popular 8-bit processor made by Zilog and Mostek. As mentioned earlier, there are many different microprocessors available and they differ in many respects. However, the basic ideas are always the same and if you understand the Z80 you should have little trouble in adapting to other processors.

The main parts of the CPU are:
1. REGISTERS — These are memory locations which are internal to the processor and may therefore be accessed much more quickly than external memory. They are used as the source and destination of data and as 'pointers' to memory locations. They are not addressed as external memory but are implied as part of an instruction. The registers are analysed in more detail below.
2. ARITHMETIC AND LOGICAL UNIT (ALU) — This performs the 8-bit arithmetic and logical operations required in the execution of programs, such as ADD, SUBTRACT, logical AND, COMPARE, etc. The source of the data ('operands') may be registers or external memory.
3. INSTRUCTION DECODE AND CONTROL — When an instruction is read in from memory, it is placed in the instruction register and decoded. The control section then provides the control signals for the registers, ALU and external devices to perform the required function.

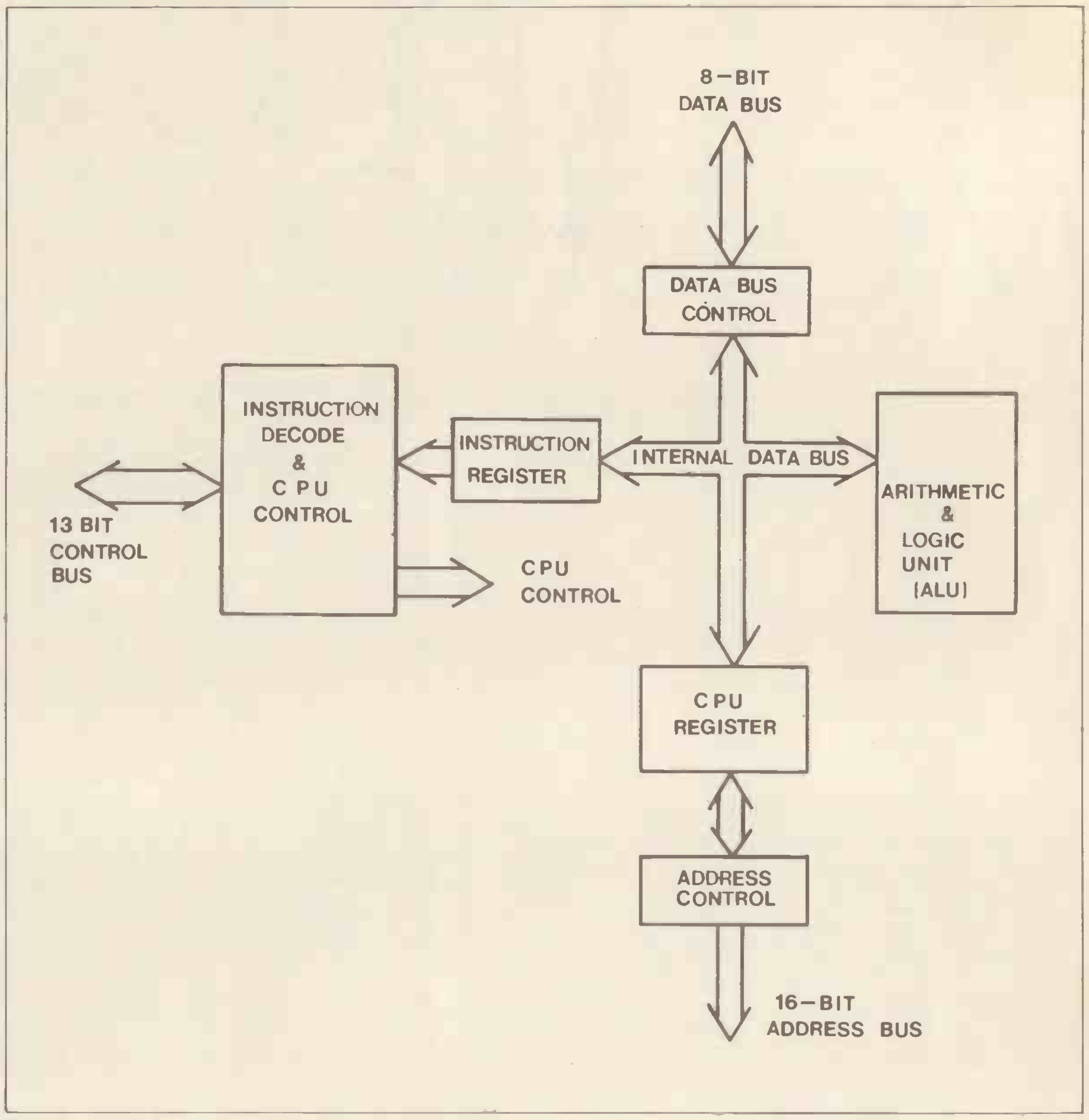

Figure 4. Internal Structure of the Z80 Central Processing Unit (CPU).

The Z80 Registers

The set of Z80 registers accessible to the programmer is shown in Table 2. The 8-bit general-purpose registers are duplicated in an alternate register set. For now, however, we will consider only the main register set.

Accumulator, A — This holds the results of 8-bit arithmetic or logical operations.

Flags, F — Each bit of the flag register indicates some characteristic of the result of the preceding operation. For example, if the result of an operation is zero, the zero bit of the flag will be set. The complete flag register is as follows:

bit 7	6	5	4	3	2	1	0
S	Z		H		P/V	N	C

Bit 0 — Carry Flag (C) — Indicates a carry from the most significant bit after an addition, or a borrow from a subtraction.

Bit 1 — Add/Subtract Flag (N) — Set or reset after an addition or subtraction. Used for decimal arithmetic.

Bit 2 — Parity/Overflow Flag (P/V) — After an arithmetic operation, indicates a 2's-complement overflow. After a logical operation, indicates the parity of the result (whether the number of 1's in the bit pattern is odd or even).

Bit 4 — Half carry Flag (H) — Indicates a carry or borrow from the lower half-byte to the upper. Used for decimal arithmetic.

Bit 6 — Zero Flag (Z) — Set if the result of an operation is zero.

Bit 7 — Sign Flag (S) — Set if the most significant bit (MSB) of a result is 1.

Bits 3 and 5 of the Flag Register are unused. Most Z80 instructions affect some of the flag bits. The flags are used for arithmetic operations (e.g. Add with Carry) and to change the order of program execution (e.g. Jump if Negative).

General purpose registers — The 8-bit registers B, C, D, E, H and L may be used as separate registers for data manipulation. They may also be used as 16-bit registers BC, DE and HL. In particular, HL is used as a 16-bit address pointer. For example, the accumulator may be loaded with the data from the memory location pointed to by HL. Also, BC is often used as a counter.

Program counter, PC — This points to the next instructions to be executed in memory. The program counter is automatically incremented whilst an instruction is being read. If a program jump occurs, the program counter is overwritten with the new instruction address.

Stack pointer, SP — This points to a special area of memory used for temporary storage of data and addresses. The stack facilitates the use of subroutines and modular programming. This will be discussed in detail when it is first used.

Index registers, IX & IY — These two independent 16-bit registers may be loaded with base addresses for indexed addressing. An extra byte appended to indexed instructions gives a displacement from this address. It would therefore be possible, for example, to load the accumulator from the address in register IX plus 25. The displacement is in 2's-complement form so it may be positive or negative. Indexed addressing is particularly useful for manipulation of tables of data.

Memory refresh register (R) — This 7-bit register is almost never used by the programmer, but makes the use of dynamic memories much easier than with most other processors. We will look at this in more detail when we examine some hardware implementations.

The two complementary sets of general purpose registers may be exchanged by a single instruction and together with register I this facilitates very fast response to an external event. This is interrupt response, which will be discussed in a later article.

Next month, we will further extend the discussion of binary data and look at some Z80 instructions. **E&MM**

MAIN REGISTER SET		ALTERNATE REGISTER SET
Accumulator, A Flags, F		Accumulator, A' Flags, F'
B C	General purpose 8/16 bit registers	B' C'
D E		D' E'
H L	Address pointer	H' L'

SPECIAL PURPOSE REGISTERS	
Program Counter, PC Stack Pointer, SP Index Register, IX Index Register, IY	16-bit address pointers
Interrupt Vector, I	8-bit
Memory Refresh, R	7-bit

Table 2. The Z80 CPU Internal Registers

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200 WATT MODEL £14.95 plus £1.15 p&p

SPECIFICATIONS

Max Output power	125 watt RMS
Operating voltage (DC)	50-80 Max.
Loads	4-16 ohms
Frequency response measured at 100 watts	25Hz-20KHz
Sensitivity for 100 watts	400mV @ 47K
Typical T.H.D. @ 50 watts 4 ohms load	0.1%
Dimensions	205 x 90 and 190 x 36 mm

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Suitable LS coupling electrolytic for 200W model	£1.25	plus 25p p&p.
Suitable Mains Power Supply Unit for 125W model	£7.50	plus £3.15 p&p.
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MULLARD LP1183 STEREO PREAMP

FREE! Original listed price over £5.00. Suitable for ceramic and auxiliary inputs, when you purchase 2 power module kits.

PRACTICAL ELECTRONICS CAR RADIO KIT (Constructors pack 7)

2 WAVE BAND MW LW
* Easy to build * 5 push button tuning
* Modern styling design * All new unused components
* 6 watt output * Ready etched & punched P.C.B.
* Incorporates suppression circuits * Now with tape input socket

All the electronic components to build the radio, you supply only the wire and solder as featured in the Practical Electronics March issue. Features: Pre-set tuning with five push button options, black illuminated tuning scale, with matching rotary control knobs, one, combining on/off volume and tone-control, the other for manual tuning, each set on wood simulated fascia.
The P.E. Traveller has a 6 watts output, neg ground and incorporates an integrated circuit output stage, a Mullard IF module LP1181 ceramic filter type, pre-aligned and assembled and a Bird pre-aligned push button tuning unit. The radio fits easily in or under dashboards.
Complete with instructions **£10.50** plus £2.00 p&p

CONSTRUCTORS PACK 7A

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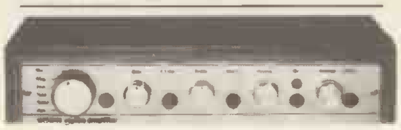

10+10 WATT STEREO AMPLIFIER KIT

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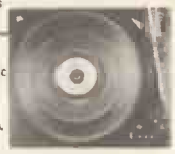
* Featuring latest SGS/ATES TDA 2006 10 watt output I.C.'s with in-built thermal and short circuit protection.
* Mullard Stereo Preamplifier module.
* Attractive black vinyl finish cabinet. Size 9" x 8¾" x 3¾" approx.
* Converts to a 20 watt Disco amplifier.

To complete you just supply connecting wire and solder. Features include din input sockets for ceramic cartridge, microphone, tape or tuner. Outputs—tape, speakers and headphones. By the press of a button it transforms into a 20 watt mono disc amplifier with twin deck mixing. The kit incorporates a Mullard LP1183 pre-amp module, plus power amplifier assembly kit and mains power supply. Also featured 4 slider level controls, rotary bass and treble controls and 6 push button switches. Silver finish fascia panel with matching knobs and contrasting ready made black vinyl finish cabinet and ready made metal work. For further information instructions are available price 50p. Free with kit.

SPECIFICATIONS

Suitable for 4 to 8 ohms speakers

Frequency responce	40Hz — 20KHz
Input Sensitivity	P.U. 150mV Aux. 200mV Mic. 1.5mV
Tone controls	Bass ± 12db @ 60Hz Treble ± 12db @ 10KHz
Distortion	·1% typically @ 4 watts
Mains supply	220-250 volts 50Hz



BSR chassis record deck with manual set down and return, complete with stereo ceramic cartridge. £8.50 plus £3.15 p&p when purchased with amplifier.
Available separately £10.50 plus £3.16 p&p.

8" SPEAKER KIT 2 8" approx. twin cone domestic use speakers. £4.75 per stereo pair plus £1.70 p&p when purchased with amplifier. Available separately £6.75 plus £1.70 p&p.

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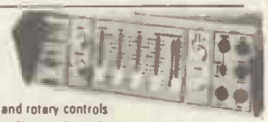
STEREO DISCO PREAMPLIFIER

matching above modules, suitable for twin deck mixing with P.F.L. output and Mic/Tape input.
Ready built, ready to play with circuit diagram and application notes to suit our power module kits. **£21.95** plus £1.72 p&p

100 WATT MONO DISCO AMPLIFIER



Brushed aluminium fascia and rotary controls
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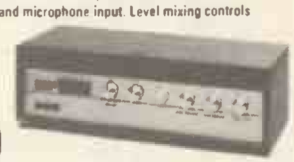
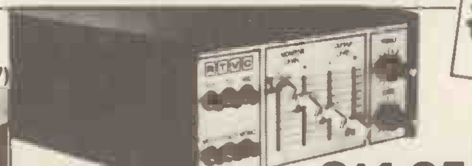


£30.60 plus £3.68 p&p



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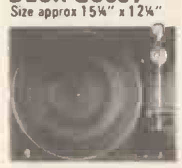

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PROGRAMMING MICROCOMPUTERS

by Keith Manison, T.Eng. (CEI) AFSERT
Electronics Engineer, Faculty of Natural Sciences, University of the West Indies

The repertoire of tasks attributed to computers seems to be virtually endless. Apart from the purely numerical tasks that were performed by the first generation machines, computers soon showed capabilities in fields as diverse as code breaking, data storage and analysis, control of specially modified machinery, etc. However, the sheer physical size of the early generation machines limited the applications for which they could be used.

The low cost and high volume production of processor elements as single components enables computing power superior to that of the early IBM giants to be available in miniature form. This has opened up a wide range of new applications. Microprocessors are now found in devices as common as a television game or as devastating as a cruise missile. It could well be the same processor being used in both.

So, granting that the microcomputer probably has the ability to accomplish the particular task that we have in mind for it, the question still remains, 'How do I get it to do what I want it to do?' The simple answer is that 'You program it'. However, even though the answer is simple, producing the program may not be.

What is a Program?

First, the term 'program' must be defined. A program is a sequence of simple instructions which, when followed, will complete a more complex task. Let us consider an example in human terms. A person driving a car from one location to another can be considered as executing a complex task. A program to accomplish this task could consist of a set of simple directions stating which turnings to take.

SINGLE ROUTE PROGRAM

```
START
FIRST LEFT
FIRST RIGHT
THIRD RIGHT
SECOND LEFT
....
....
....
SECOND RIGHT
FIRST LEFT
STOP
```

By starting from the correct location and following the list of directions the driver will eventually reach his destination. Each program step is very simple to understand and carry out. The actual journey may be very long and complex.

A computer program is very similar in concept to the above example. Simple logical and arithmetic steps are performed in sequence to accomplish a task that may be as extensive as computing the payroll of a large firm or calculating the course of a plane on a trans-Atlantic flight. However, as well as following the list of instructions, the microcomputer also has the ability to test current conditions or the results from previous operations. It can then skip instructions or execute a different set of instructions depending upon the outcome of the test. To return to our analogy of the car driver. There may be two routes to the required location, one is direct but becomes congested during peak periods. The other is longer but subject to fewer traffic delays in the rush hour. Therefore, the list of directions could have a 'conditional branch' built in. When the driver had progressed so far he would have to make a choice based on a test of current road conditions. For example, the branch instruction may be, 'If the traffic is very heavy, turn left and continue. If the traffic is light, drive straight on and follow the second set of directions'.

The Algorithm

To write successful and efficient programs, an ordered and systematic approach is required. Firstly, an algorithm must be developed. This is a series of procedural steps for the solution of a specific problem, a generalized procedure for accomplishing the type of task in hand. To continue with the car driving example: the list of instructions presented above is only good for a journey between two fixed locations, say, from home to the town centre. But if we want to drive from our office to the pub, an entirely new program will have to be written, even though the type of task, driving a car, is identical.

However, we can write an algorithm, a general purpose set of instructions, and present it with data to drive between any two given locations. In this case, the data would be a list of street names to be travelled. The algorithm would then be a set of instructions directing the driver to look at each turning he passes, see if it matches with a street name on his data list, and if it does, to turn on to it.

UNIVERSAL PROGRAM

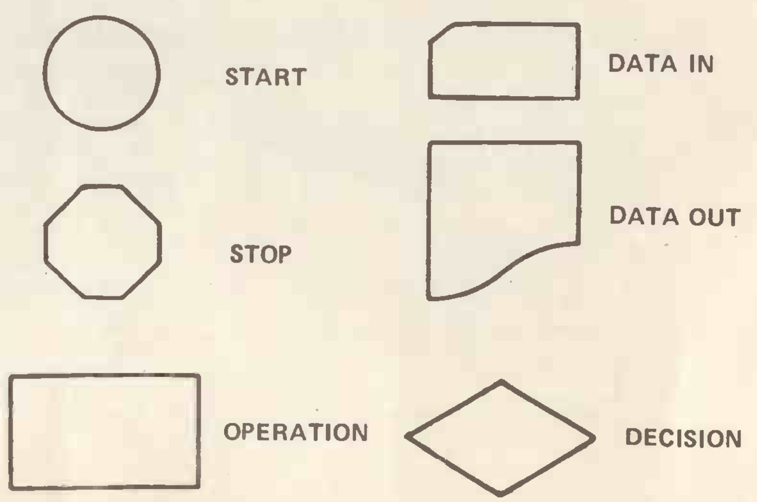
```
Label    Instruction
         START
FETCH    GET NAME FROM LIST
COMP     COMPARE WITH ROAD NAME
         IF NOT EQUAL JUMP TO COMP
         TURN ON TO ROAD
         CHECK FOR MORE ROAD NAMES
         IF MORE JUMP TO FETCH
         STOP
```

With this algorithm, any journey can be executed with the same program or list of instructions. All that is required is for the correct data to be presented to the program or algorithm.

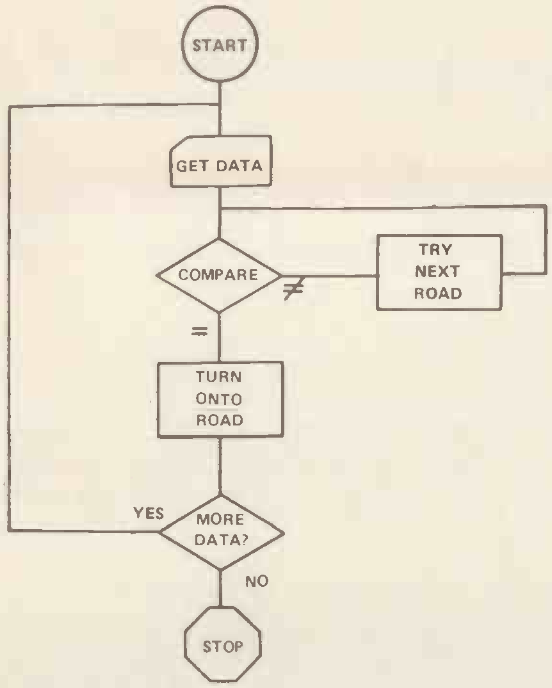
Flow Charts

It is essential to be able to write down the procedural steps required, the algorithm, in a form that is easily understood and that will reveal the logical flow of operations. For a very simple problem it may be that a written description of each step is adequate. However, increasingly complex tasks have many branches and loops. It soon becomes impossible to follow the sequence of operations and mistakes are easily made. Some errors (called 'bugs' in the programmers vocabulary) would be difficult to detect. Such a bug could be a loop or a supplementary set of instructions re-entering the main program at an incorrect place, or perhaps not re-entering at all!

Therefore an instantly comprehensible diagramatic form of presentation is required, and the Flow Chart is used for this. Each step is described and enclosed in a box, the shape of which indicates the nature of the operation.



Each step or box is joined to its logical successor by arrowed lines which quickly illustrate the flow of operations and reveal loops, branches and any discontinuities that may have originally been overlooked. A flow chart for the car driving algorithm would appear as follows:



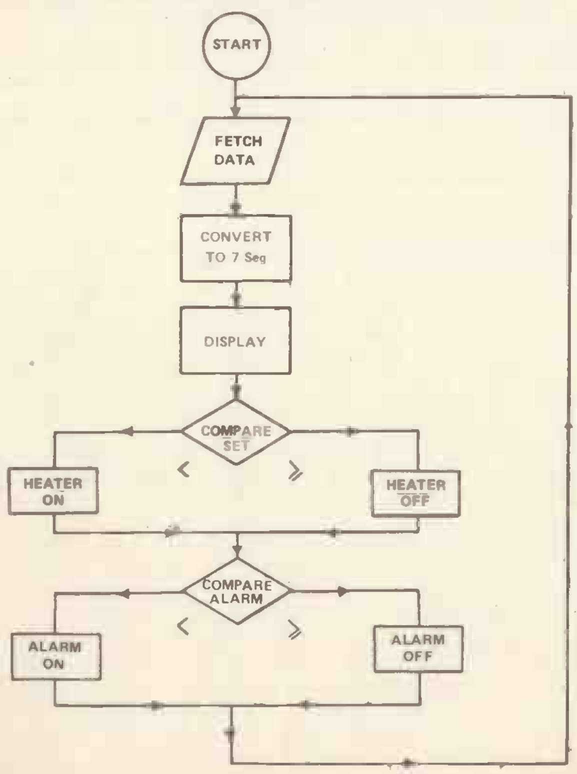
Once the algorithm has been generated, documented in the form of a flow chart, logically checked for errors and corrected it can then be assumed that any computer, human or electronic, capable of carrying out the steps specified, will be able to reach the desired solution in time.

The algorithm and its attendant flow chart are the prerequisites of successful programming and are discarded at the programmer's peril. True it may appear quicker to jump right on to the machine and enter instructions, but the time taken to debug (correct) the illogical mess produced would have been better spent in these first vital stages of formally presenting the solution to the task in hand.

First we must define our solutions to the problem by means of a flow chart and then the program may be developed from it. In descriptive terms, our algorithms would be:

Fetch the BCD temperature data, convert it to seven segment code and output it. Compare the BCD with the temperature set point and if lower, turn on the heater, if equal or higher, turn off the heater. Compare the BCD data with the alarm set point and if higher, sound the alarm. Loop to fetch new BCD data.

The above algorithm depicted as a flow chart would appear as:



1. Brake until speed is 20 mph;
2. Change into second gear;
3. Brake until speed is 10 mph;
4. Turn steering wheel to the left;
5. Straighten steering wheel;
6. Accelerate to 20 mph;
7. Change into third gear;
8. Accelerate to 30 mph;
9. Change into top gear.

Here we have nine machine instructions to carry out our single high level instruction 'turn left'. The conversion from high level to machine level is carried out automatically by a set of instructions or procedural steps resident in the driver's head. In other words, the driver is already programmed to drive the car. The high level program provides directions which are interpreted by the driver and used to control hand and foot movements at the machine level.

Therefore, at the bottom of the scale of programming languages we have 'Machine Code' which corresponds to the 'accelerator', 'brake' instructions of our car. This is the series of binary bit patterns which are recognised by the microprocessor as instructions or information.

Each microprocessor has its own unique 'instruction set' or repertoire of fundamental operations that it uses to manipulate it's registers and associated memory. Each instruction, and there are usually between 100-200 in an average microprocessor instruction set, is identified by a binary code or bit pattern. Each bit pattern can be expressed as a number to base 16, 10, or 8. The preferred bases are usually 16 and 8 as the conversion becomes particularly easy.

For example, a section of a program may in fact look like:

10001101
01100000
00111101
11100100
01101010
10110101

It can be seen that it is not easy to quickly identify the binary patterns, therefore mistakes are not easily detected and it is very tedious to write. However, an 8-bit binary number can be represented easily by either a two digit hexadecimal number (base 16) or a 3 digit octal number (base 8).

HEX		OCTAL		
1000	1101	10	001	101
8	D	2	1	5

Rewriting the above section of program in either of the two bases would yield:

HEX	OCTAL
8D	215
60	140
3D	075
E4	344
6A	152
B5	365

This is somewhat easier to write and check as fewer digits are involved and the appearances is not quite so eye boggling.

The problem with machine code is that only the microcomputer can instantaneously recall the meaning of a particular number. Hence the need for some kind of aide-memoir for the human programmer. This is the 'Assembly Language' or 'Assembly Code' in which each instruction is allocated an easy to remember mnemonic. For example, in one microprocessor the machine code to clear the accumulator is 01001111, or 4F in hexadecimal. The assembler code, however, is CLRA which is easily recognizable as CLeaR Accumulator. So now the programmer can write a program using a psuedo English code which is much easier to remember than a string of numbers, and which indicate the function being carried out.

Below can be seen a small integer multiplication routine showing the comparison between binary and hex machine codes and assembly mnemonics. It is written for the MOTOROLA M6800 microprocessor.

Label	Binary	Hex	Interpretation
START	11010110	D6	LDAB MULP
	00101000	28	
	10010110	96	LDAA MULT
	00101001	29	
CALC	00110111	37	PUSH B
	10000101	85	BIT A 01
	00000001	01	
	00100111	27	BEQ NEXT
	00000100	04	
	11011011	DB	ADDB STOSUM
	00110000	30	
	11010111	D7	STAB STOSUM
	00110000	30	
NEXT	00110011	33	PULB
	01011000	58	ASLB
	01000100	44	LSRA
	01001101	4D	TSTA
	00100110	26	BNE CALC
	11110001	F1	

The problem is that the computer can still only understand the numbers. Two courses are open for the programmer. One is to go through a code book and convert from the assembly mnemonics to machine code. Of course, that would cancel many of the advantages of writing in assembly language. The other course is to have the computer itself do the conversion. This requires that a program be written which will cause the microcomputer to accept the assembly code and convert it into machine language. This type of program is called an Assembler, and is a basic requirement for anyone who plans to write complex programs at the machine level. A good Assembler does more than just convert from mnemonics to machine code. It will load the assembled program in memory, make copies of the assembly language program (called the source code) and the machine language program (called the object code) on whatever storage medium you have, such as magnetic tape or disk. The Assembler will allow you to label memory locations with English type words, and it will also alert you to any errors you may have made. In conjunction with another program, called an Editor, those mistakes can easily be corrected.

However, even though communication with the computer is made easier by the use of Assembly Language and an Assembler program, we are still programming at the very basic machine instruction level. To be able to program at a higher level more than an Assembler is required.

When asking the machine to do some arithmetic for example, it would be nice to be able to write program instructions which look like the arithmetic function we wish to perform. For example, if we need to calculate the area of a circle, the program statement could be:

Let A = 3.14159 * R * R

The asterisk (*) is used to replace the more familiar (×) for multiplication. This is done to avoid the confusion which could arise when multiplying by ×.

We are now programming in a high level language because the instructions are written much as we would write or state them in English. To set the computer to understand the statement and recognize it as a series of instructions to be executed requires yet another program. This program has to examine each line or statement of the high level program and interpret it into machine executable code which is then carried out. Not surprisingly, a program which does this is called an Interpreter.

Interpreters have their limitations. Human communications via an interpreter takes time. You speak, the interpreter translates, you wait for the other person to speak and then the interpreter re-translates to you. So, too, with the interpreter program. Each line or statement of high level program is translated and then executed before the next line is looked at. Even if it is to be executed repeatedly, it has to be translated into machine code each time. Therefore, the program will run much slower. The advantage, of course, is that two-way dialogue is possible with each party responding to the other. So for languages that feature interaction between man and machine, the interpreter program is often used. One such high level language is BASIC or 'Beginners All-Purpose Symbolic Instruction Code' which was developed at Dartmouth College, U.S.A. in the early 1960's. One of the objectives was to produce a language that would be easy to learn and use but would still be powerful enough to solve small and medium scale problems in a wide range of applications.

At present, BASIC is the most popular high level language for use on microcomputer systems. Many books and tutorial programs are available for those that wish to learn BASIC, so little more will be said about it here. However, an example of a BASIC program is shown below. The users input is shown underlined.

BASIC Program

```
LIST                              (RETURN)
10  INPUT R
20  LET A = R*R*3.14
30  PRINT 'AREA EQUALS', A
40  STOP
READY
RUN                               (RETURN)
? 2                               (RETURN)
AREA EQUALS 12.56
STOP AT LINE 40
READY
RUN                               (RETURN)
? 3.5                             (RETURN)
AREA EQUALS 38.48
STOP AT LINE 40
READY
```

The obvious way to overcome the speed problem of the Interpreter is to convert the whole high level program into machine code at one time and then execute the machine language program. Machine language programs generated this way are more efficient than interpreter produced code, and once the machine language has been produced, it can be stored and run repeatedly with no further time required for conversion either before or during its execution. The program which performs this conversion from high level to machine code, is called a compiler. Languages, such as FORTRAN, are compiler based.

FORTRAN, developed in 1950 by IBM, stands for Formula Translation and has undergone many improvements and modifications since its inception. An example of a FORTRAN Program is shown here:

FORTRAN Program

```
C     THIS PROGRAM CALCULATES THE AREA OF 5 CIRCLES
C     GIVEN THEIR RESPECTIVE RADII
      DIMENSION R(5), A(5)
      READ (1,5) R
      DO 4N = 1,5
      A(N) = 3.14 * (R (N) ** 2)
      WRITE (3,10) N,A(N)
   4  CONTINUE
   5  FORMAT (5F 4.2)
  10  FORMAT (1H, I1, 4X, F3.2)
      STOP
      END
      DATA
```

These high level languages make any detailed knowledge of the computer organization unnecessary for the programmer. Once the language has been learnt, programs may be written and run on any machine which has the requisite compiler or interpreter. These advantages plus that of being able to program at a high concept level make high level programming languages extremely popular and indeed vital for many applications. So why bother with the seemingly more cumbersome and, certainly, more difficult to use assembly and machine codes?

The answer to this depends upon the application. Most high level languages are designed around a given set of applications. For example, FORTRAN is a scientifically biased language and is used mainly for Science and Engineering. ALGOL (Algorithmic Language) is a direct competitor with FORTRAN. COBOL (COmmon Business Orientated Language) is business orientated and works most efficiently with that type of problem. PILOT is designed for text handling and Computer Aided Instruction. LISP is excellent for handling strings of data and arrays.

However, none of the high level languages easily lend themselves to applications such as process control or real time analysis of signals, for example. This is where the assembly language comes into its own. Another problem with high level languages on small systems is the amount of memory occupied by the interpreter or compiler alone. Memory is still one of the most significant costs in computer systems. To have an interpreter taking up 8K of memory (i.e. 8,000 locations) to run programs that only occupy 2K could mean that the cost of the machine is 3010 higher than if assembly language programs only were used. Also, the machine code produced by an interpreter is not as efficient as that produced by a good programmer. Assembly language programs, therefore, will often run faster and this gives them the advantage in closed loop control applications. On the other hand, assembly language or machine code is machine dependent, i.e. it will only run on the computer for which it written. Its instruction set comprises the complete list of basic functions capable of being performed by the machine. There are no limitations as to the type of application that may be approached, as long as the machine has the capability, e.g. speed and memory capacity.

So while many high level languages can be, and are, used with microcomputers, the majority of specialized application use the assembly code. Indeed it is vital for anyone planning to use microprocessors to be familiar with this type of programming as in reality, it is the only way to set the thing to work. Even if a high level language is to be used, many machine code routines are often required for specialized tasks.

Assembly Language Programming

So far we have shown that a program is built up from a series of simple instructions. These instructions are carried out sequentially to complete a larger task. We also saw how these instructions could be written at various levels, or in different programming languages. Now let us look closely at ASSEMBLY LANGUAGE programming, the language used at the processor level.

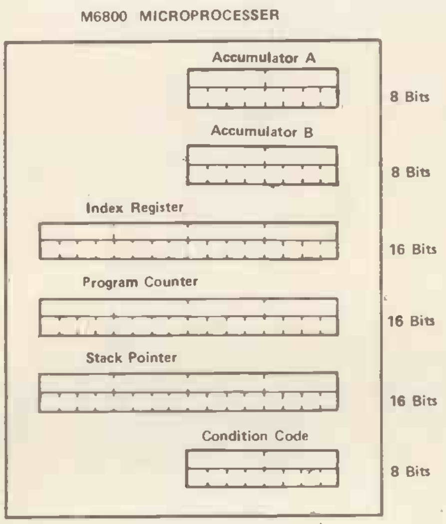
Unlike the high level languages, there is no single programming language called ASSEMBLY, as there is BASIC or FORTRAN. Rather, for each microprocessor on the market, there is a list of the simple logic and arithmetic functions which it can perform. This is often called the 'Instruction Set' and, as the name implies, is the complete set of instructions which the processor can recognize and execute.

The implication of this, of course, is that an assembly language program written for the Z80 will not run on a M6800. For the most part this is true. The exceptions to this occur when one microprocessor has a similar architecture to another and the instruction reflects this similarity. Examples of this are the Z80 and 8080, and the M6809 and M6800, where, in both cases the latter's instruction set is a subset of the former's. Even in such cases the similarity is often only at the assembly language level. Down at the machine code level the binary numbers that the microprocessor recognizes are probably different. An example of this is the 'No Operation' instruction in the M6800 and M6809, which in assembly code is NOP for both processors. However, this will assemble to 00 (in HEX) for the M6800, and 12 (in HEX) for the M6809.

Therefore, to program in assembly language it is vital to know each instruction available for the processor being used. However, that is only half of the story. As well as the instruction set, the logical organisation of the computer system must also be known. To print a character, for example, it is necessary to send it's code to the printer. So, you must know which output port the printer is attached to before you can start writing the output routine. Therefore, to program in assembly language two essential basics are required:

1. A program model of the microcomputer system;
2. The instruction set of the microcomputer, i.e. the intrinsic functions which it can perform.

One of the easiest microprocessors to understand and program is the Motorola M6800. The programming model is simple — two accumulators, an index register, program counter and stack pointer.



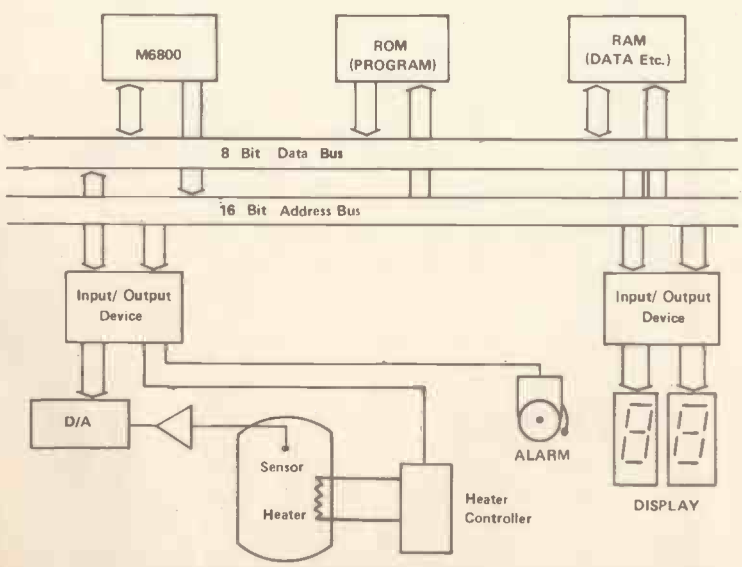
The M6800 has 72 executable instructions in the source or assembly language, some of which require two or three bytes of machine code. Although that seems to be a large number of instructions to remember, they can be grouped under general headings such as LOAD instructions, STORE instructions, BRANCH instructions and so on. So, it soon becomes easy to remember instructions at the assembly language level. The programming model is of great assistance as it shows what is available for use by the instruction.

In a familiarization article, such as this, it is clearly impossible to describe in any detail the workings of all the instructions. Even to mention all of them would just cause confusion. However, to illustrate programming techniques at the assembly language level, we shall develop a program to accomplish a closed loop control system and explain the instructions we encounter on the way. It will be seen that every operation has to be thought out in terms of basic steps.

Programming Exercise

The Problem To control the temperature of an immersion heater, display the current temperature and raise an alarm condition if the temperature exceeds a safety value.

The Solution To achieve a solution with a microcomputer system, it will first be necessary to interface or couple the computer to the process.

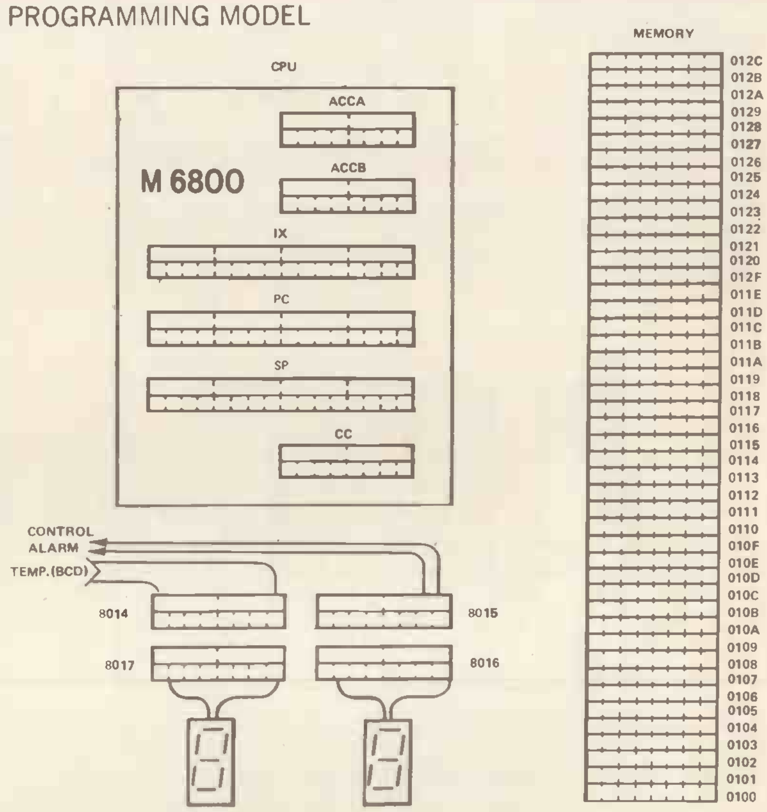


For this problem let us assume the following: Temperature data from the process is presented to the computer as two binary coded decimal digits on 8 data lines. Therefore, the temperature data in, can be from 0 degrees C to 99 degrees C. The control output is a simple ON/OFF signal to an immersion heater element. The display to the operator is in the form of a two-digit seven segment display. There is also a signal out to operate the alarm.

The system model can be shown as below and it can be seen that it is a bus-oriented system.

However, before we can begin to write a program, it is necessary to develop a programming model. This will incorporate the programming model of the microprocessor and include the memory and I/O's (input/output interface). Such a model would appear as shown:

PROGRAMMING MODEL

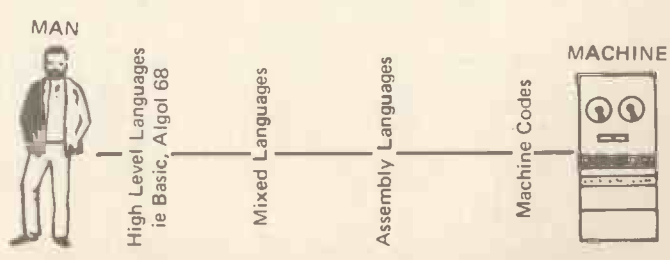


Once we have decided what generalized set of instructions our microcomputer must follow, we have to present it with those instructions in a format that it will understand. This brings us to the subject of Programming Languages.

Programming Languages

Basically, any digital computer from the biggest IBM to the smallest micro, responds only to two state voltage patterns called HI and LO or 'one' and 'zero'. Every instruction has to be presented to the processor in this format. However, humans do not think in terms of digital 'ones' and 'zeros'. Therefore, interpretation is necessary for two-way communications between man and the microcomputer. There has to be some give and take on both sides. The computer can only go part way towards understanding English; therefore, we have to go the rest of the way. The method by which this is achieved is to use an intermediate language understandable to both man and machine.

Of course, man, as the designer of the digital computer, can and does understand what has been called 'Machine Language', that is the patterns of ones and zeros which the computer recognizes. As the computer becomes more complex, it is possible to program it to 'understand' a more human type language. Thus, we have a hierarchy of languages based on the criteria of understandability from the human standpoint. Programming languages closer to the human language are called 'high level' and that of the computer is called a 'low level' language or just 'machine language'. This puts the computer in its place!



We can stick to the car driving analogy to illustrate the concept of programming at different language levels. The instructions so far have been of a high level in concept. The car, like a computer, can only respond to a fixed instruction set, which in reality would be the drivers control movements. There are no controls on a car which correspond to our 'turn left', 'turn right' instructions. True, the steering wheel will move the front wheels but the car will only turn a corner if it is already moving. To make the car take a corner several 'machine level' instructions are required. So the high level instruction 'turn left' in reality needs a more complete set of instructions like this.

From the above flow chart, we can start to develop a program utilizing the resources available to us in the programming model and the instruction set of the M6800 Microprocessor. Each step of the flow chart may require several steps of program or even a complete subroutine, but by working through step by step, mistakes are kept to a minimum.

The first step is to fetch the temperature data from the I/O port. The instruction would be:

LDAA 8014 — Load Accumulator A with data from 8014.

The second step is more difficult to code. It requires splitting the 8-bit code in the A Accumulator into 2, 4-bit BCD parts, converting each part and outputting the correct 7-segment code to the display I/O ports. First, we must save the combined BCD data for later comparisons. That can be done by the instruction:

TAB — copy A Accumulator into B Accumulator.

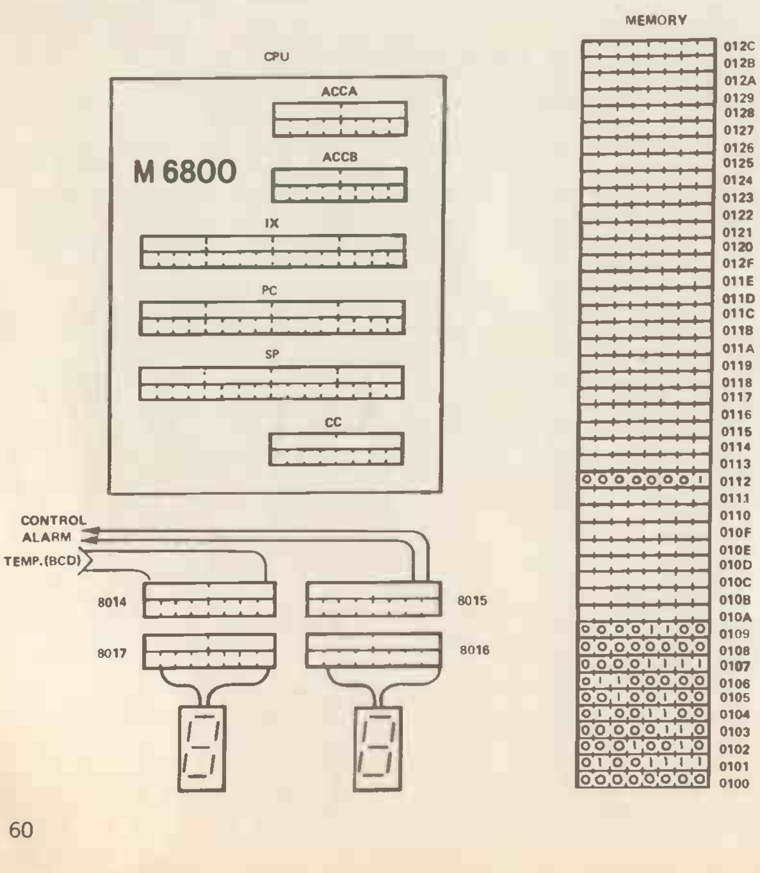
The best way to convert from BCD to seven-segment code is to use a look-up table as shown below. The BCD number is then used to address the memory location containing the required 7-segment code.

TRUTH TABLE												OUTPUT WORD (HEX)
BCD CODE				SEVEN-SEGMENT CODE							DISPLAY	
d	c	b	a	A'	B'	C'	D'	E'	F'	G'		
0	0	0	0	0	0	0	0	0	0	1		01
0	0	0	1	1	0	0	1	1	1	1		4F
0	0	1	0	0	0	1	0	0	1	0		12
0	0	1	1	0	0	0	0	1	1	0		06
0	1	0	0	1	0	0	1	1	0	0		4C
0	1	0	1	0	1	0	0	1	0	0		24
0	1	1	0	1	1	0	0	0	0	0		60
0	1	1	1	0	0	0	1	1	1	1		0F
1	0	0	0	0	0	0	0	0	0	0		00
1	0	0	1	0	0	0	1	1	0	0		0C

This look-up table can be loaded into the bottom of our available memory and a base pointer loaded at location 0112. The memory would now be as shown in the second programming model that follows.

SECOND PROGRAM MODEL

PROGRAMMING MODEL



The list of instructions to convert the BCD data would first clear the four most significant bits in the accumulator to zero and store the contents of the accumulator in 0113. The index register is then loaded with the data in 0112 and 0113 (it is 16-bits long, remember) and then the A accumulator is loaded with contents of the memory location whose address is now in the index register. This will be the correct seven-segment code for the LSD (Least Significant Digit) of the temperature and so it can be output to I/O port 8016. You may have to go over this sequence a couple of times to see exactly what is happening. It is important to understand this 'look-up' method of data conversion as it is used in many programs. The use of the Index register to access data is also a common procedure.

Now, the second digit has to be converted in a similar manner. The contents of the A accumulator are restored from accumulator B and shifted to the right, 4 places to position the second BCD code ready for conversion. This shifting loses the 4 least significant bits, that is, the code we have already converted. The same conversion process will have to be carried out for this second BCD digit. To save writing the same set of instructions again, the conversion instructions can be written as a subroutine which is called by the main program.

The complete instruction sequence would then be:

```
ANDA  #OF   —  Mask left 4 bits
BRS   CON   —  Branch to subroutine CON
STAA  8016  —  Store Accumulator A in I/O 8016
TBA         —  Copy B Accumulator into A Accumulator
LSRA
LSRA
LSRA        —  Shift right 4 places
LSRA
BRS   CON   —  Branch to subroutine con
STAA  8017  —  Store Accumulator A in I/O port 8017
```

Where subroutine CON is:

```
STAA  0113  —  Store Accumulator A in memory
               location 0112
LDX   0112  —  Load index register from memory
               location 0112 & 0113
LDAA  0,X   —  Load Accumulator A from memory addressed
               by X Register
RTS         —  Return to main program
```

It will be noticed that we have also accomplished the fourth function of our flow chart, that is, outputting the temperature. Therefore, we can now progress to the comparisons. To do this, it is required that the set points for temperature and alarm be placed in memory. Let's assume the temperature set point is in 0110 and alarm in 0111. The compare and branch set of instructions is then:

```
CMPB  0110   —  Compare B Accumulator with contents of 0110;
BHI   ATEST  —  If higher branch to alarm test;
LDAA  #01    —  Load Accumulator with 01;
STAA  8015   —  Store A Accumulator in I/O port 8015;
BRA   INPUT  —  Branch to fetch next data.
```

Again, we have also accomplished the task of turning the heater on for a low temperature reading by storing 01 in the control I/O port.

A similar set of instructions is used to compare the temperature against the alarm set point.

```
ATEST  CLR   8015   —  Set I/O port 8015 to all zeros;
       CMPB  0111   —  Compare B Accumulator with contents
                       of 0111;
       BHI   ALARM  —  If higher branch to turn on alarm;
       BRA   INPUT  —  Branch to fetch next data;
ALARM  LDAA  #02    —  Load A Accumulator with 02
       STAA  8015   —  Store Accumulator in I/O port 8015.
```

The complete program is shown below.

```
PROGRAM NAME:  CONDIS                    SUBROUTINE:  OUT

INPUT   LDAA   8014          CON         STAA   0113
        TAB                              LDX    0112
        ANDA   #OF                       LDAA   X,00
        BRS    CON                       RTS
        STAA   8016
        TBA
        LSRA
        LSRA
        LSRA
        LSRA
        BRS    CON
        STAA   8017
        CMPB   0110
        BHI    ATEST
        LDAA   #01
        STAA   8015
        BRA    INPUT
ATEST   CLR    8015
        CMPB   0111
```

```
        BHI     ALARM
        BRA     INPUT
ALARM   LDAA    #02
        STAA    8015
        BRA     INPUT
```

It can be seen from this simple example how very elementary program steps can be put together to accomplish a complex task. The program just developed would occupy 62 bytes of memory and execute in approximately 75 m/sec. That means more than 10,000 temperature measurements would be made each second. For most purposes, once a second is probably adequate, so the rest of the time could be spent checking on other areas and controlling added functions.

Many points have been omitted in this simple example. Questions that may come to mind now are: How do you get the Set Points into memory? Or How is the program loaded? etc. Each of these tasks can be thought out, written as an algorithm and then converted to assembly code. Then the computer can be made to load its own program, or accept different temperature values for the system. The only thing to do is to write more program.

Conclusion

It is hoped that this brief article on programming microcomputers will have allayed any fears that programming is some sort of black art known only to those interested in its secrets. True, good and efficient programming is a skill, but like any other skill, it is sharpened with practice and use. If the basic steps are followed, that is, systematically thinking through a problem, developing an algorithm to solve it, presenting the algorithm as a flow chart and then using the flow chart as a basis for coding a program, few mistakes will be made and successful programs will be the result.

Many questions have been left unanswered. It is impossible to unravel all the mysteries and wonders encountered when programming microcomputers. However, the purpose has been to show that it is not above the average enthusiast's ability. The only way to learn programming is to do it at the machine level to become familiar with the intrinsic functions and capabilities of the processor being used, and with a high level language for those business and engineering problems that have to be solved. There is no reason why we should not be adding our own special applications to the growing list of tasks performed by the microcomputer. E&MM

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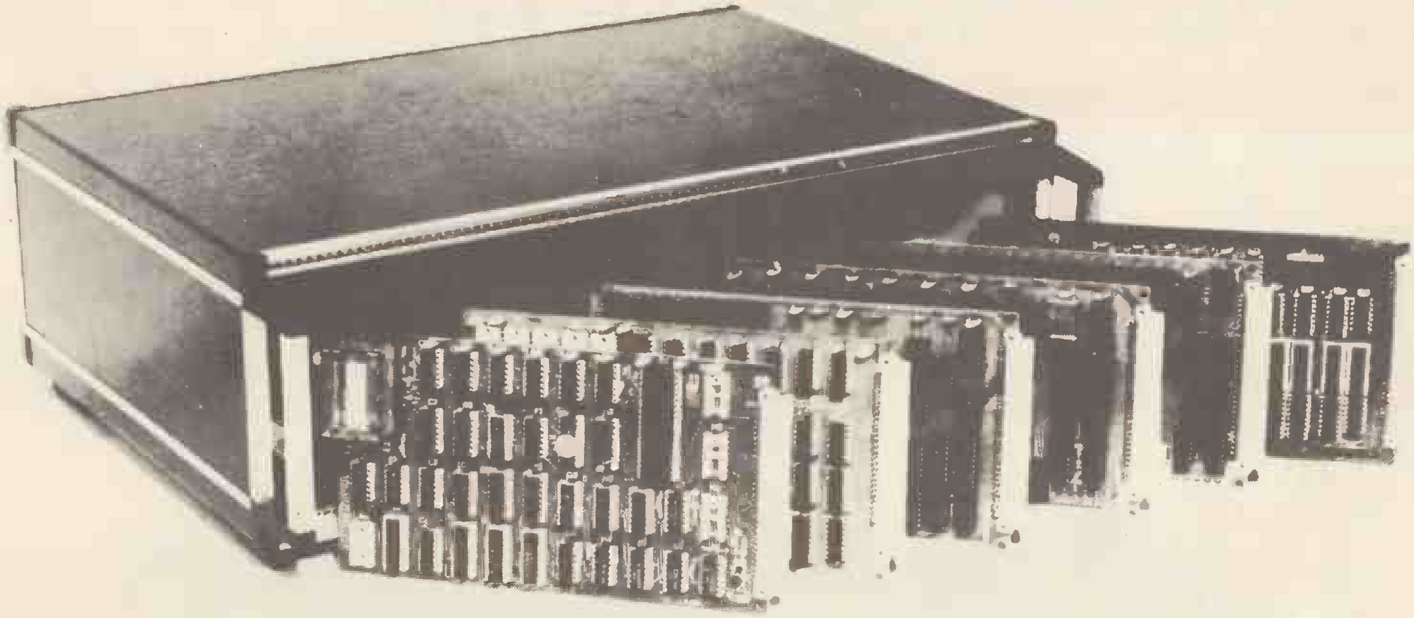

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BASICALLY BASIC

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.

Graham Hall

Last month we looked at how a flow diagram could be used to represent information in a clear concise way. This month we shall use a flow diagram to show diagrammatically the steps that must be followed in order to solve a problem.

Variables

A variable can be thought of as a 'pigeon-hole' in which a numerical value can be stored. In more technical terms it is a location in the computer's storage area. The number stored in this location can be manipulated during the operation of a program. A computer program will often need to use more than one variable so variables are each given a unique name. In BASIC the name of a variable may be any single letter of the alphabet (A to Z) or a single letter immediately followed by one digit (and one digit only!), e.g.:
A, A1, B1, B2, Z, P3
are all permissible names for variables. Some examples of names which are NOT allowed are as follows:
FRED, AA, AB, 27, A66, A.2.
Soon we will introduce a statement from the BASIC language (the 'LET' statement) which will define a variable by giving it a unique name, and assign to this variable a particular numerical value.

Now let us consider a simple problem which uses three variables and can be solved by devising an algorithm which can be translated into a computer program written in BASIC.

Example problem:

Calculate the average of the counting numbers from 1 to 10 inclusive.

To find the average of a group of numbers we first add them together to give their sum. This sum is then divided by however many figures were added together. e.g. To find the average of the three numbers 2, 5 and 8.
First find the sum: Sum = 2 + 5 + 8 = 15
There are three numbers so we must divide the sum by three to give the average:
Average = 15 ÷ 3 = 5.

The Algorithm

By carefully thinking about the problem and using what we have learnt about variables, you should be able to devise an algorithm to solve the problem. (Devising an algorithm to solve a problem means finding a method of giving a complete, correct solution in a certain number of well defined steps.)

We will need three variables: one to store the value of the sum, one to store the value of the 'count' and one to store the final result of dividing the sum by the total count to give the average. (Note: the 'count' will tell us how many numbers have been added together). We will name the variables as follows:—
C — Count (Counting variable)
S — Summing variable
A — Answer variable

Initially S must be given its first value and is set to 0. Similarly C must be set to 1. Now we increase C in steps of one at a time. Every time C is increased by 1 the new value of C is added on to the number stored in S. The result replaces the previous value of S. In other words, S will store the *sum* of all the values which C has taken up to the point when you stop changing C, (i.e. 1 + 2 + 3 . . . + 10). When the value of C reaches 10 (and S will then be the sum of the numbers 1 to 10), S is divided by C. The result of this is the answer to the problem and can be stored in variable A.

In the above algorithm a number of commonly encountered techniques have been introduced. Throughout this series we will introduce new computing terms and definitions in a shaded box.

As can be seen above, when an algorithm is actually written down it appears unnecessarily complicated. It can be made much easier to follow by representing it with a flow diagram. As you become more familiar with the technique of representing information by a flow diagram you will find them an extremely useful tool for program development.

Figure 1 shows a flow diagram which represents the algorithm to calculate the average of the counting numbers from 1 to 10. There are a couple of new features which need to be explained. First, if you carefully study the flow diagram you will see that the diamond box contains a question. A decision is made at this point and the appropriate exit taken

INITIALISATION —	The process of giving to a variable its first value (e.g. in the above algorithm S is initialised to 0 and C is initialised to 1).
INCREMENTATION —	The process of increasing the value of a variable by a fixed amount (e.g. in the above algorithm variable C is repeatedly incremented by 1).

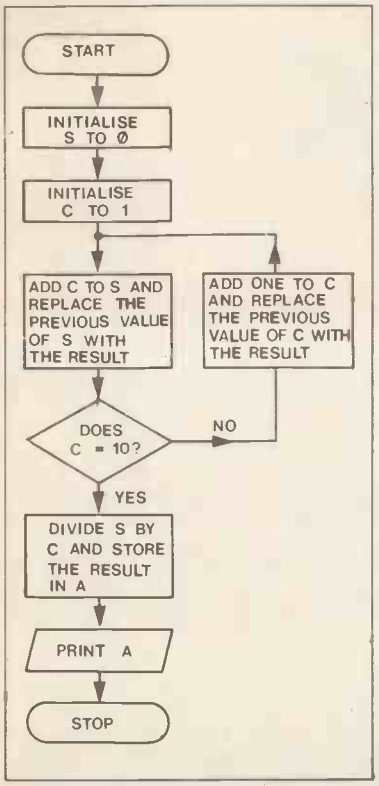


Figure 1. Flow diagram for averaging the counting numbers from 1 to 10 inclusive.

from the diamond. If the answer to the question 'does C = 10?' is 'NO' the path followed is backwards so that C is incremented by 1 and then added to S. The question is then asked again. This is called a 'loop'. The loop is finished when the answer to the question 'does C = 10' is 'YES'. A downward path is then taken to finish the calculation.

LOOP/LOOPING — to perform a set of one of several instructions (statements) repeatedly is called looping. On a flow diagram this will be represented by a loop.

There is a statement from the BASIC language (the 'FOR' statement) which allows loops to be written in a BASIC program.

Writing a BASIC program

Now we have devised an algorithm to give a solution to the problem the next step is to translate the algorithm into a short BASIC program so that a computer can be used to give us the answer. However, before the program can be written we need to explain, and know how to use, some of the statements which appear in the BASIC language.

The LET Statement

Every programming language (with a few special exceptions) has a way of declaring and assigning values to variables which are to be used in a program. In BASIC the simplest way of defining a variable is to use the LET statement.

As we saw earlier a variable can be any single alphabetic character so a variable called 'S' can be defined *and* initialised to 0 by the BASIC statement:

```
10 LET S = 0
```

A couple of things to note here. First, the '=' symbol used in this context means 'to be replaced by the value of'. Secondly, the LET statement is preceded by a number, in this case '10'. Every BASIC program statement has to be preceded by a unique line number. It is conventional to use intervals of 10 for the numbers of adjacent lines in a program. This is because any modification in the program must also have unique line numbers — the in-between numbers can be used for that purpose. The line numbers do not have to be typed in order — the computer will follow numerical order when the program is executed.

Now we can write a three line BASIC program:

```
10  LET  S=0
20  PRINT  S
30  END
```

We have introduced another two BASIC statements in this program. Line 20 is a PRINT statement which is used to output results from the computer in an easily understandable form. Later in this series we will examine the use of the PRINT statement more closely.

The highest numbered line in a BASIC program is always the END statement (although the END statement is optional in some computer systems).

If you have a personal computer system with a BASIC interpreter or compiler try typing in the above program. On proper instruction (which depends on the computer you are using) the computer will execute the program and then stop. The result will be a 0 displayed on the terminal you are using. It is impossible to describe how to make each different computer execute a BASIC program because there are so many different versions, each with their own peculiarities. You should be able to find out how to execute a BASIC program by reading the user guide of the computer which you are using.

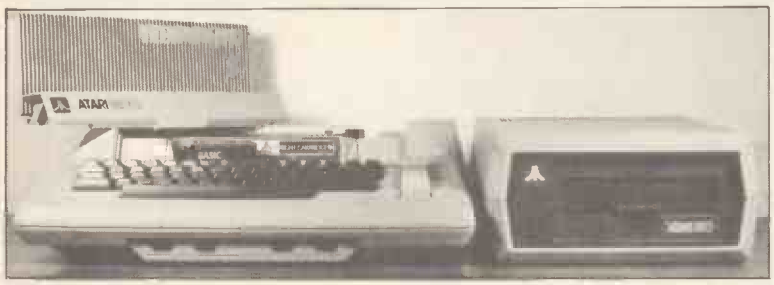
Next month we shall finish describing the LET statement and continue to explain some more simple BASIC statements.

If you are fortunate enough to have a personal computer system then type in the following program and see what results it gives. If you have not, try to think out the problem in your head:

```
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
```

If you are familiar with BASIC try converting the algorithm we devised this month into a BASIC program. (HINT: some of the statements of the above program, together with some other statements, one of which will be an 'IF' statement, could be used).

COMPUTING NEWS



ATARI IN APRIL

It's nearly here, Ingersoll, the importer and distributor of this machine say they should be available in 'late April'. It now seems that the Atari 400 will be provided with 16K of user RAM and will retail at around £395 including VAT, the 800 will sell at £695 inc. VAT. At this time prices for disc drives, printers and other peripherals are not available and as yet no firm dealership arrangements have been set up.

News from America is that after a slow start the machines are now beginning to take off, most sales going to enthusiasts and also to the consumer market. It seems that the average American citizen is getting fed up with just games and is taking up the option offered by Atari of superb games combined with real computing power and it will be interesting to see how the British public reacts to this machine as it could be the first move towards 'man in the street' computing.

Visicalc, currently available for the Apple and Pet microcomputer systems, has now been re-written for Atari's 800 system.

VIC

Reports are coming in that VIC from Commodore is now available in Japan, information so far says that it has plug-in memory and cartridge facilities interface for joysticks, games, riddles and the like, is expandable to 32K, has RS-232 capability, and special function keys, some of which are programmable. It displays 22 characters on 23 lines, and has graphics resolution of 176 by 184.

No price as yet but it looks very promising. We will keep you posted.

TAKE OVER

The official distributors of Apple microcomputers in this country, Microsense Computers, have sold out to Apple Computers of California, thus becoming a subsidiary of this ever-expanding company. Microsense first took over the Apple dealership in mid-1979 and has been largely responsible for the growing popularity of the machine.

Whilst on the subject of Apple, it's nice to see a manufacturing base being developed on our doorstep in Cork, Ireland, where machines for the European market will be produced along with its many add-ons.

European sales are also strengthened with a distribution and marketing centre being set up in Holland — it seems that from little pips mighty Apple trees grow!

GRAPHICS TABLET

A new peripheral in the form of a high resolution graphics tablet has been developed for UK Apple users. Its best attribute is its cost at only £149 plus VAT and it must be high on any Apple owners shopping list.

To use the device, you place your drawing underneath an acetate sheet, then trace the details using a drawing arm; the outline is followed and reproduced on a VDU. Commands available with the softwave provided include P - Point cursor, which moves the cursor and displays the X, Y coordinates. S - Scale of drawing, gives control over size in both X and Y axes. The M - command enables you to create and store shape tables of items that you wish to draw repeatedly, i.e. architectural symbols, component conventions etc. The Z - command can be used for shading areas in colour (or is it color!) of which there are 106 choices.

Other facilities offered include adding text to your graphics in five sizes, four directions and in any colour.

Further details from Micro Management, Ipswich, Suffolk.

Micromusic

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

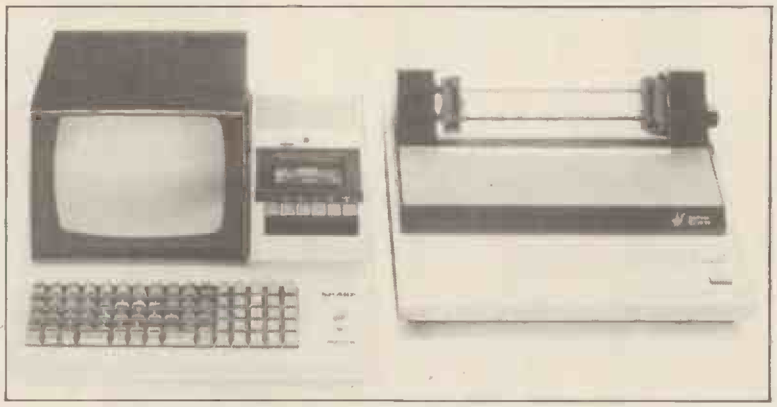
Programming Music on the Sharp MZ-80K

Graham Knight

The last issue of E&MM detailed the special dialect of BASIC used on the Sharp MZ-80K microcomputer which allows the user to program music. Ten different note and rest durations can be programmed and the computer will play music over a three octave range at any one of seven tempos. Users are soon able to write musical programs transcribing sheet music to a computer program — an early attempt will look something like the listing for the tune "Two Lovely Black Eyes" (program 1).

It will be seen that the Sharp BASIC is quite clever and that the notes can be sharpened by prefixing with a # symbol. Suffixes are also used and these are numbers which define the note and rest durations between a demi-semi quaver (0) and a semi-breve (9). After a few hours' experimentation with the music lines it will become apparent that even this relatively short program can be simplified. When a series of notes have the same duration the numbered suffix need only be added to the first note. Each succeeding note will repeat the first duration until a new suffix is added. Thus the program for the tune "Two Lovely Black Eyes" becomes even easier (program 2).

With a little practice it soon becomes easy to remember the BASIC notation and programs like the Bach Musette (program 3) can be written quickly. Line 300 sets the tempo for the whole piece and the music in lines 310-340 is played only once. The music in lines 360-430 is played twice and this double play is defined in line 350. The ability of the computer to return and play the same music over again is a most useful facility and it is used in the next example tune — the



Frank Mills composition "Music Box Dancer" (program 4). Here the music plays three times and increases in tempo each time. Line 44 defines the tempo as variable T which is set to vary between 4 and 6 in line 43. The net result of these two lines is that the program runs playing the music in lines 45-56 at a slow tempo then returns to the start and plays it again at a medium tempo before again returning to the beginning and playing the tune for the last time at a fast tempo. Without this return and tempo stepping facility the program would be three times as long and the tempo would have to be defined on three separate lines.

Last month I showed how to POKE machine code routines from BASIC to give a large variety of sound effects and it should be noted that the Sharp BASIC only covers three octaves. Using machine code it is possible to program notes from as high as 4kHz to as low as 40Hz. Spectacular cosmic sounds can be programmed in this way and POKEing machine code notes from BASIC will be detailed in next month's edition. It is fairly easy to see that a machine code program can be written which will allow some of the keys on the MZ-80K to be defined as certain notes. It is possible to write a routine to define the keys CDEFGA and B so that they respond by playing a scale. A keyboard scan routine checks if a key is pressed and the appropriate note is then played for as long as the note is depressed. However, the keyboard on the Sharp is laid out in QWERTY typewriter style and this is obviously not the best type of keyboard for a musician. Victor Kusin has taken one of our machine code routines and rewritten it to run from BASIC using data statements. The program defines the keys in two of the rows as per the conventional piano layout and the program illustrates this on the screen. As keys are depressed the appropriate notes are played and the Sharp BASIC notation is displayed. This enables musicians who play by ear to play on the Sharp keyboard and then see the tune in Sharp BASIC notation on the screen. It is then a simple matter to note the lines of program and to incorporate them in later programming.

This program is particularly popular with children and is used a great deal in various school music departments. With a little ingenuity and some programming experience it will soon become apparent that the Sharp music facilities are very important. The music greatly enhances the games — Space Invaders without sound would be unthinkable — and is very useful as an error indicator in business or computer assisted learning programs. It is very easy to program a friendly pip if you have made a correct entry and it is just as simple to program a low note to indicate the operator is trying to enter wrong information.

The "Computer Piano" program makes use of the special POKEs which are only used for music — the next issue of "Electronics and Music Maker" will examine memory locations 4514 and 4513 in greater detail and describe the use of strings in music programming. **E&MM**

```
1 PRINT"TWO LOVELY BLACK EYES"
2 TEMPO 6
3 MUSIC"R8#F8E5D5E5D8D5R5R5¯D8";
4 MUSIC"B5G5B5A8A5R5R5¯D5B5¯D5";
5 MUSIC"¯#C5A5¯#C5B5G5B5A8#F8E5D5"
6 MUSIC"E5D8D5R5
```

Program 1

```
1 PRINT"TWO LOVELY BLACK EYES"
2 TEMPO 6
3 MUSIC"#F8E5DED8D5R7¯D8"
4 MUSIC"B5GBA8A5R7¯D5B¯D"
5 MUSIC"¯#C5A¯#CBGBA8#FE5D"
6 MUSIC"ED8D5"
```

Program 2

```
270 PRINT"▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒Musette"
280 PRINT"▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▬▬▬▬▬▬▬▬▬▬"
290 PRINT"▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒J.S.Bach.(1685-1750)."
300 TEMPO4
310 MUSIC"¯A5¯G1¯#F1¯E1¯D1¯A5¯G1¯#F1¯E1¯D1"
320 MUSIC"#F1G1A3G3#F3E3A3#F3D3"
330 MUSIC"¯A5¯G1¯#F1¯E1¯D1¯A5¯G1¯#F1¯E1¯D1"
340 MUSIC"#F1G1A3G3#F3E3A3D5"
350 FORX=1TO2
360 MUSIC"¯#C1¯D1¯E3¯#C1¯D1¯E3¯A3¯E2R0¯E5
370 MUSIC"¯A3¯E3¯A3¯E3¯D1¯#C1B1A1B3E3
380 MUSIC"¯E3¯#D3E3¯D5¯#C3¯A3¯#G3
390 MUSIC"¯E3¯#D3E3¯D5¯#C3¯A3¯#G3¯E1¯#D1¯#C1¯#D1¯E1¯#D1¯#C1¯#D
400 MUSIC"¯E3#G3A3¯D3¯#C1¯D1¯E3A3D3#C1D1E3_A5"
410 MUSIC"¯A5¯G1¯#F1¯E1¯D1¯A5¯G1¯#F1¯E1¯D1
420 MUSIC"#F1G1A3G3#F3E3A3#F3D3¯A5¯G1¯#F1¯E1¯D1"
430 MUSIC"#F1G1A3G3#F3E3A3D6"
440 NEXTX
```

Program 3

```
42 PRINT"MUSIC BOX DANCER
43 FOR T=4 TO 6 STEP 1
44 TEMPO T
45 MUSIC " ¯C2R0¯C2G¯C¯ E¯C¯E¯G¯C¯#B"
46 MUSIC "¯B¯A¯G6R1"
47 MUSIC"¯G2¯F¯DBGB¯D¯F¯E¯C¯A¯G¯G¯G"
48 MUSIC"R1"
49 MUSIC " ¯C2R0¯C2G¯C¯ E¯C¯E¯G¯C¯#B"
50 MUSIC "¯B¯A¯G6R1"
51 MUSIC"¯G2¯F¯DBGB¯DB¯CG¯E¯C¯C¯CR"
52 MUSIC"¯#B¯A¯F¯CA¯C¯F¯A¯G¯C¯A¯G¯G"
53 MUSIC"R¯G¯F¯DBGB¯D¯F¯E¯C¯A¯G¯G
54 MUSIC"RR"
55 MUSIC"¯#B¯A¯F¯CA¯C¯F¯A¯G¯C¯A¯G¯G"
56 MUSIC"RRR¯G¯F¯DBGB¯DB¯CG¯E¯C¯C¯CRR"
57 NEXT T
58 RETURN
```

Program 4

```
18 REM ▒▒▒   COMPUTER PIANO            0 REM  ▒▒▒   VIC KUSIN  JULY 1980
19 DIMC(255),F(255),P$(255):LIMIT24552
20 DATA205,27,0,50,240,95,201,0
21 DATA 117,3,245,¯B,115,4,49,¯#A,212,4,113,¯A,218,4,180,¯#G
22 DATA 215,4,252,¯G,236,5,72,¯#F,226,5,152,¯F,227,5,237,¯E
23 DATA229,6,71,¯#D,251,6,167,¯D,61,7,12,¯#C,59,7,119,¯C,76,7,234,B
24 DATA79,8,98,#A,75,8,226,A,73,9,104,#G,74,9,248,G,85,10,144,#F
25 DATA72,11,48,F,71,11,218,E,84,12,142,#D,70,13,78,D,82,14,24,#C
26 DATA68,14,238,C,83,15,212,_B,87,16,196,_#A,65,17,196,_A,81,18,208,_#G
27 FORA=24553TO24560:READB:POKEA,B:NEXT
28 FORA=1TO28:READK,C(K),F(K),P$(K):NEXT
29 PRINT"▒                  COMPUTER PIANO
30 PRINT"▒ The keys in the QWERTY and ASDFGH rows
31 PRINT" are your piano keyboard as shown below
32 PRINT" Use CR and DEL keys to separate lines.
33 PRINT"▒    ▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒
34 FORJ=1TO3
35 PRINT"    ■ ■ | ■ ■ | ■ ■ ■ | ■ ■ | ■ ■ ■ |":NEXT
36 FORJ=1TO3
37 PRINT"    | | | | | | | | | | | | | | | |":NEXT
38 PRINT"    ─────────────────────────────▒
39 USR(24553):A=PEEK(24560)
40 IFA=0THENX=A:USR(71):GOTO39
41 POKE4514,C(A):POKE4513,F(A):USR(68)
42 IFX=ATHEN39
43 IFA=102THENPRINT" ":PRINT"▒▒▒";
44 IFA=96THENPRINT"▒ ▒";
45 PRINTP$(A);:X=A:GOTO39
```

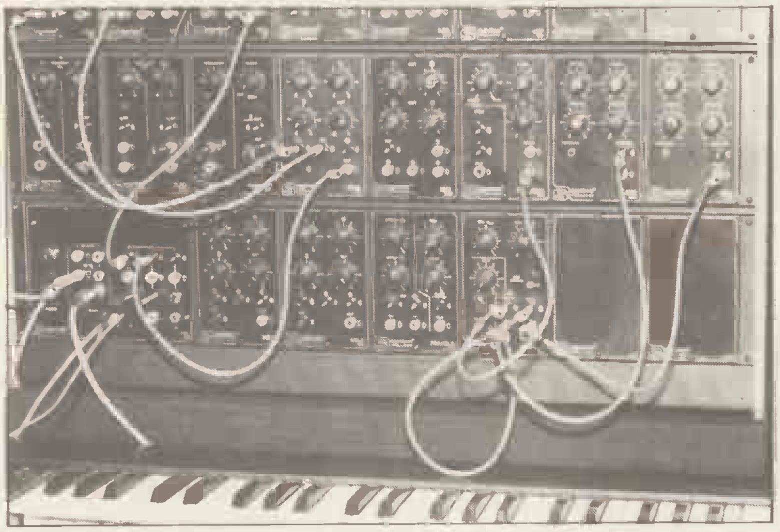
Program 5

Guide to Electronic Music Techniques

Vince S. Hill

Last month we took a look at understanding the synthesiser and the way in which sound is produced. The next technique involved in Electronic Music is to understand the modules of the synthesiser, being able to know exactly what sound you are trying to obtain and what modules are used to create various sound effects.

The terminology used on synthesisers today does vary from manufacturer to manufacturer, from old design synths to new and from analogue to digital. I shall try to explain all.



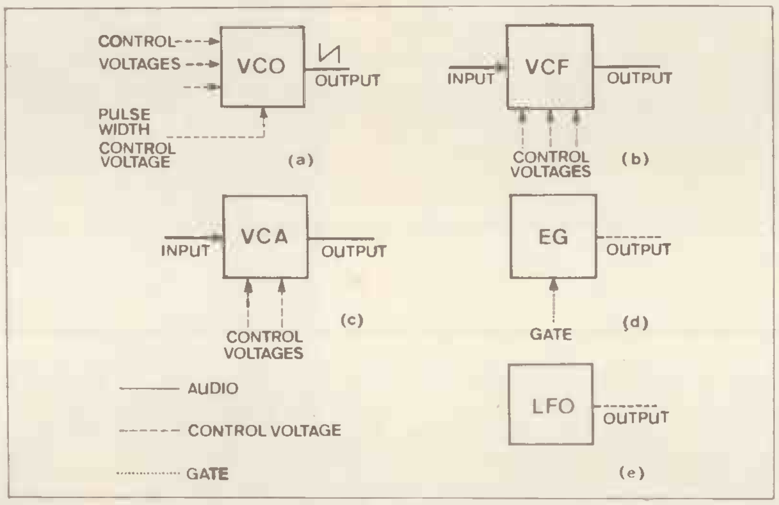


Figure 1. Graphic notation of synthesiser modules discussed.

Voltage Controlled Oscillator (VCO)

The VCO or Signal Generator (SG) commonly found on most music synthesisers consists of a exponential amplifier, a resettable integrator, and waveshaping circuitry. 'Voltage Controlled Oscillator' means an oscillator whose operating frequency or pitch can be controlled by an external control voltage.

As seen previously the VCO is responsible for the pitch and the basic timbre. On most VCO modules you will find a waveform selector that selects tone colours (sine, triangle, sawtooth, square and pulsewave). If within the waveform selector there is a facility of Pulse Width Modulation (PWM) then there will be a control which adjusts the intensity of PWM (ie. the amount of variation in the pulse width from a square wave to a narrow pulse wave). Some synthesisers also combine a square wave and pulse wave together with a separate control voltage adjusting the pulse width. The VCO will also contain an octave selector which in most cases is marked in 'feet', akin to the footages of an organ.

The graphic notation of a VCO is shown in Figure 1(a).

Voltage Controlled Filter (VCF)

The VCF module receives an audio signal from the VCO and also accepts CV signals from other modules. The Voltage Controlled Filter is a filter whose cut-off frequency can be controlled by an external control voltage. The filter processes the waveform from the VCOs and Noise Generator. If on your synthesiser there is only one filter, in most cases it will be Low-Pass, ie. the harmonic elements of the waveform which are higher than the cut-off will be removed, producing a rounder tone. Remember a filter takes away harmonics. The VCF module will contain a cut-off frequency (Fc) control, and usually a 'resonance' control which emphasises harmonics at the cut-off point. On some synthesisers there is a 'keyboard follower' control which adjusts the Fc over the scale of the keyboard, preserving the same timbre for different pitches.

There are various types of filters available as you go further into sound synthesis. A Band-Pass filter allows one frequency band to pass, a Band Reject Filter or Notch stops a particular band passing. High-Pass filters allow high frequencies through and cut out low frequences. Low-Pass filters cut out high frequencies and allow low frequencies to pervade. This can be shown in graphic notation (see Figure 1(b)).

Voltage Controlled Amplifier (VCA)

The VCA determines the volume of signal passing through it in accordance with the total control voltage from the envelope generator (EG) and from any external controller connected. A Voltage Controlled Amplifier is an amplifier whose gain can be controlled by an external control voltage. The VCA module might contain a gain control which allows any signal passing through the other modules to reach the output of the synthesiser, the other control will be a selector switch which tells the VCA which type of envelope is controlling it. On some synthesisers you will find extra facilities, including a VCA CV 'Intensity' which adjusts the VCA's input sensitivity to the control signal being used and an 'Initial Level' Control which allows the sound through when the EG is 'off'.

Envelope Generator (EG)

The envelope shaper consists of a combination of VCA and EG. The VCA varies the volume of the sound in accordance with the envelope signal. The envelope signal is initiated by a gate signal whenever a key is depressed. As in the VCF there are different forms that the envelope can take. The most typical are ADSR and AR. A = Attack, D = Decay, S = Sustain, R = Release. This may seem complicated but if we remember what we said regarding sound and its change in volume over time you will obtain a clearer picture.

In an ADSR envelope module you will find four controls. The attack time adjusts the rate of rise of the envelope to the peak value. The decay time controls the time for the volume to fall from its peak to its sustain level. The sustain level adjusts the level at which the volume will be sustained from the end of the decay time until the end of the gate signal (when the key is released) and the release time will denote how long the sound will take to fade away after the end of the gate signal. If your synthesiser has a hold switch or control this will extend the trigger signal by a variable specified amount of time.

When you find a synthesiser with more than one EG, the second will most probably be an AR or AD envelope. This envelope is used mainly for VCF control.

Understand the effects you are trying to obtain when using two EGs: the ADSR will shape your sound and AR will then control what happens within that sound by introducing another modifier.

Low Frequency Oscillator (LFO)

The LFO module allows a control voltage in the shape of a waveform to effect and change the characteristics of the audio signal. It is basically an oscillator which is designed to generate a cyclic voltage signal at subaudio frequencies. The oscillator can normally produce many waveshapes that can be used specifically for modulation purposes. On most synthesisers the LFO section is situated near or with the particular module that will be affected. The LFO module will contain a waveform selector and a frequency control. Whether you will be modulating the VCO, VCF or amplitude these controls will be the basic system, there will also be a control which allows the intensity of the effect to be altered. Modulation of the VCO will allow vibrato, trills and siren type effects and when modulating the VCF you will obtain cut-off frequency modulation (FcM), for growling sounds.

There are synthesisers on the market which include an additional VCA: this is usually controlled by the LFO but will have a specific control of the intensity of amplitude modulation. The extra VCA is a very useful addition to the synthesiser, allowing effects from tremolo through to ring modulation.

If your synthesiser has two or more LFO's then the capability is greatly enhanced. In some cases the LFO can be directed through to the filters allowing timbre modulation of the audio signal independent of other modulations.

There are of course many more modifiers in a synthesiser. In synthesising any sound you use two types of voltage. An audio signal voltage is the first type which provides the fundamental base for the sound that you will hear. Whether it be a square wave or sine wave, the audio signal is the raw material. And secondly, when creating synthesised sounds you will be using control voltages. Control voltages are not heard although you will hear their effect on the audio signal, eg. vibrato, trills etc.

Most synthesisers work in the same way to produce sounds. To delve further into electronic music and sound synthesis you must be aware of what your synthesiser is capable of, and this is a technique in itself. **E&MM**

ULTRAVOX

Warren Cann talks about the electronics and the music techniques he uses as their drummer

'Most musicians are going to need at some point a lot more background in Electronics because it's the way instruments in this day and age are going'....

'There's a real kind of revolution happening in the drumming world,' says Warren, 'that was taking place in the 50's with bass guitar and electric guitar and in the 70's with keyboards. Hollow logs covered with animal skins aren't all that far removed from drum kits and they've been taken almost as far as they can go — there's been quite a few developments made in recent years, with different heads and funnel shaped designs for projecting sound out to an audience. But refinements are becoming increasingly smaller so, for example, you're not going to get much better cymbals than Zildjian make now.'

Warren Cann is undoubtedly a special kind of electro-musician and this has contributed a great deal to the commercial sound that has brought Ultravox such great success in this country recently.

Warren is 27 and comes from Vancouver, Canada. His parents are English and emigrated there before he was born. He is entirely self-taught as a musician. His fascination for the electronic side of percussion came from his study of electronics for four years.

Drums and Electronics

Warren's percussion equipment is built up around a simple but effective old Ludwig acoustic kit that he acquired in 1968, although its finish has only been on general sale last year. It's a four drum kit because he thinks that big drum kits are a 'load of waffle.' 'It's a challenge, if you can play on that you can play on anything!'

To his left when seated at the kit there is a rack of electronic equipment. Starting from bottom up this contains: A Yamaha Stereo Power Amp (P2100) and an RSD 12 into 2 mixer which has sufficient EQ over 3 bands plus foldback and echo sends. Usually 9 channels are enough for mixing all the drum electronics, and there are 2 Yamaha PA columns (S0410H) to the left and right behind Warren for monitoring, each containing 4 x 10's and top horn, which in practice are used upside down because the top horns are so efficient.

There is a considerably modified Roland TR77, which Warren has used for a long time. Snare Drum, Hi-Hat and Bass Drum are available on separate outputs and the Snare Drum voicing is pot controlled to alter its noise content. Bass Drum attack can also be varied by damping the oscillation and the circuitry has been modified to give a stronger initial peak. A 'thud' control changes the Bass Drum oscillation pitch.

Above the TR77 is the Roland CR78 drum unit. Both these machines have had fine tuning controls added — the original pots as supplied were too coarse. They are never run at the same time because of the problems in synchronising the two together. A very small tempo change in Warren's drumming can quite drastically alter the feel and temperament of a song; 'the psychological aspects of tempo when you're working with drum machines, either playing along with them using acoustic drums like I do on some songs, or just using drum machines entirely on their own, is interesting because it used to be that everyone would tell me the tempo was too fast. But often this was because we were tired, that's all. The 'fine tune' can be used to make adjustments without the rest of the group being aware of any change occuring.

'In Vienna the first section speeds up, then there's a ritardando in the middle section, and then it goes back to a different tempo. So we don't let the machines dictate to us and in a song where the tempo would be the same throughout, I occasionally 'tweak' the tempo up a little bit.'

An interesting extra for the CR78 is a 'decay' adjustment for the Bass Drum. Normally it sounds okay at low volume levels — playing at 10 or 15 thousand watts you don't get 'thunk' you get 'boing!' The snare drum can also become horrendously loud.

In Ultravox's music the electronic drum complements the acoustic drum so well that the listener might often find it hard to discern one from the other (try listening to "Mr. X" before looking at the music and see if you can tell the difference). A further example is in 'Astradyne,' where the metallic cymbal sound comes from the CR78's 'metallic beat.'

It is often quite difficult in performance to maintain a correct tempo. A responsive audience can increase the excitement of a piece and upset correct perception of a steady pulse, so that the music sounds too slow. To help get over this, Warren has an LED 3-digit readout of the tempo set (measuring frequency period) that has been designed by his engineer and is mounted in a general effects box next to the CR78. This also contains an Electro-Harmonix distortion unit which can be used to boost or totally distort sounds. Below this there's various MXR devices: a phaser 100, three noise gates and a flanger. The latter has had its standard on/off switch replaced with a 'press to make' switch so that Warren can flange a specific beat during a rhythm.

Above these effects is a Roland DC30 Echo and a Dave Simmonds 'Clap-Trap.' Electronic clap boxes are not much used by American groups (even though Electro-Harmonix in America also do a good one). Warren uses it in all 3 modes and has a trigger footswitch for it situated just next to the hi-hat, so that his left toe stays on the hi-hat plate while his heel swivels on to the Clap-Trap switch. One of its main uses is to give that multi-overdubbed hand clap heard on so many R&B and Soul records on the 'off' beats. Actual audience clapping can only be achieved to some extent by triggering it from an LFO. Its sound is improved by using it through a chorus box and it can also be triggered by the drum-synth trigger or from a pick-up on the snare drum.

Having recently travelled all over America with this set-up, dust and humid conditions become quite a problem although this would be accentuated if sliders and knobs were left in the same settings and Warren in fact uses the controls frequently as he plays. Some drum machines effects are rarely used, e.g. on the CR78, he does not like the 'fill-ins,' preferring the A/B alternating rhythms every 2,4,8,12,16 bars and the 'break' setting that gives a silence bar at the end of these bar groups. He also uses the 'Write' pad of the CR78 in 'play' mode without actually 'storing' it in the memory.

'Incidentally,' says Warren, 'I'd found that the drum machine track or click track that was first put down as a guide to recording other instrument overdubs sometimes required changing — and this was impossible. This was also true if I wanted to overdub another drum machine track.' So Warren suggested a possible design to overcome this to his engineer. Although he does not have time to do this himself, he majored in electronics as a student and so has a good understanding of what can be or can't be done without actually knowing how to wire up the finished product.

And Warren is sure that a lot more musicians are going to need at some point a lot more background in electronics because it's the way instruments in this day and age are going.

'I'm not knocking acoustic instruments, there are going to be separate instruments — just as there are grand pianos and electric pianos. It *is* a great help if you know what's available — new technology helps you get more from your music and if you can build the electronics yourself or know what to suggest to someone who can build equipment for you, then you have a big advantage.'

Coming back to the click track problem, the unit used by Warren to help with this is named the 'Trigger Recorder Sequencer.' Basically the unit can put down a click track on specific beats out of a maximum 16, and on separate tracks if necessary where it may become part of the final sound mix, with different EQ's and treatments. Then afterwards portions or all of it can be erased and new material added. Always in sync too, Warren claims, despite mains fluctuation and problems of linking old material to new tracks! A line of toggle switches selects the click pulses to trigger the drum machines, clap trap or even keyboard synthesisers used by Chris. The biggest advantage it provides is to allow numerous drum and additional sequencer tracks to be built up in synchronisation with everything. It was used on Vienna which was made very quickly, with the basic recording taking 2 weeks and the mixing about 10 days over in Germany. 'Vienna' and 'Western Promise' both needed extra treatment with the unit. While touring in America Ultravox did some recording at Criterion Studios in Miami, where the Bee Gees, Eagles and other notable groups record and the engineer there was totally impressed with the sophisticated drum electronics pointing out that very few U.S. bands were using these techniques with percussion.

The whole set up is modular so that Warren can frequently update his equipment and several units have been housed in clear perspex, which although fragile looks good. Numerous LED's provide control status signals while others simply enhance the visual effect. At the rear of the rack most signals and power lines are fed via cannon connectors. All of Ultravox's keyboard and drum frames are metal with castors to facilitate transport.

Writing and performing the music

Ultravox are unusual in that they don't have one central writer — all four of the group compose the material.

When performing, Warren has to carefully monitor the bass part played by Chris because a lot of the time he plays synthesiser instead of guitar and his sequencer pulses have to fit exactly with the drums. Headphones are not used by the group for stage monitoring on a gig and in Warren's case he has tried various amplification set-ups, from small on-stage monitor wedges to huge 500 watt side-fills. He's found a big PA side-fill will be loud and powerful but it colours the sound too much.

'The answer for me because I'm using electronic drum machines' comments Warren, 'is plenty of quite small speakers — 2 x 15's and a folded horn isn't the answer. Headphones give a totally different sensation — it's a lot more complex because you've got to start mixing everyone in.' So the two Yamaha PA columns are the best situation given the space limitations of the drum platform and the locations that the group performs at, which in the States can be from the huge Santa Monica Civic at Los Angeles to a small club at Tulsa, Oklahoma.

Other Drum Parts

Warren uses two 'Synare 3' drums which have a good filter sound and are ideal if you're on a tight budget. They're right next to the hi-hat because it's easier to get off the hi-hat and on to the Synare drums. They add definite electronic sounds to the percussion in contrast with the acoustic kit.

Over by the Ludwig tom-tom drum are two very narrow Premier drums that have the same kind of effect as the Synare 3 electronic drums. These were early versions of Dave Simmons drum synthesisers that utilised real drum heads and small drum rims, with tuning lugs and wood shells, but actually having no acoustic sound. The rubber pad used on the Synare 3 is also ideal as the 'skin' for electronic drums and gives sufficient bounce for the sticks. When Warren is playing a ride cymbal pattern on the floor tom-tom, it's very easy for him to lift his stick a couple of inches and catch the Synares for interjecting accents. Placing of these extra electronic drums is important as is the position of microphones over the drum kit. He deplores the drum kit set-up that has a forest of chrome stands for mikes as well as cymbals, which can cause trouble from vibrations rotating a mike off-position and requires someone to come on stage during a number to put it right.

All Warren's drums are miked up with individual mikes used for snare drum (top and underneath), hi-hat, rack-tom, bass drum, and floor-tom. A 'Dead-ringer' (circular band of highly adhesive foam) is used between the drum rim and the skin to deaden the sound. Next to the hi-hat footplate is, on the one side, the clap-trap switch already mentioned and a start/stop switch for the TR77 on the other side. This is essential for Warren, as the touch-plate of the TR77 may not always trigger (or sometimes double triggers) when playing in hot humid conditions. Hum can be a problem with all the electronics — and the MXR gates help overcome this.

The Simmons SDS3 drum synthesiser control box is located to the right of the mixer and PA mikes can go directly through it as well, thus eliminating having to put pick-ups all over the acoustic drums, yet still giving the choice of electronic treatment of the whole kit if desired. Sometimes recorded material is put through the SDS3 and triggered from the drum pads.

The Syntom

'I think the Syntom is an excellent way of getting your feet wet when you know nothing about electronics, you're a drummer and you want to start familiarising yourself with what can happen. It's very simple to use — and at its price it's excellent,' states Warren enthusiastically. 'I found that if you have just one Syntom, you can do some pretty marvellous things with your bass drum, because if you have difficulty getting a real solid heavy sound, then by attaching it to the hoop and adjusting the sensitivity you'll make a big improvement. In order to fit it on the bass drum I removed the piece of rubber from the mounting clip. The Syntom increases the drum's scope and gives special effects for some songs. I don't like to use it too much for the typical high sounds that swoop down in pitch, because they've been done to death recently on disco records — just like a lot of records had wha-wha and fuzz tones for a time. So the high pitched effects from the Syntom are fine once in a while but its main purpose for the serious musician — and it can be used by any member of the band, attached to a convenient place or simple held in one hand and hit with a finger of the other hand — is for providing new electronic sounds to your music.

Warren likes it on the snare drum rim: 'By playing with a little bit of "decay" and "sweep" and adjusting your "pitch" you can definitely expand the effects from your snare, either by using it all the time fairly subtly or by suddenly whacking up your sweep control or decay. Of course, the controls inter-relate with each other, you can't adjust the sweep without affecting the pitch — it takes a little bit of experimenting with, especially if you're not conditioned to turning knobs whilst drumming.'

Warren found that he did not have any feed back problems at all and is currently using it with his kit. 'By the way, if a drummer thinks, "Well great, I'd like to have one of these very much," the chances are he's going to have to borrow a spare amp from someone in the band. And don't forget that when you use the Syntom or any other type of electronic percussion you hit, you're probably only hearing a fraction of the quality the unit can put out because most people won't have a sophisticated enough amplification set-up to actually get it!'

'If you have one on the snare drum then it really is a good idea to add a second Syntom to the tom-tom to balance up the drum output.'

The Future

'The player activated type of percussion — the Syntom, the Synares, the Syndrums, the Simmons equipment: All that type of thing is initially the easiest sort of gear for a drummer

Warren plays on his set-up for our cassette.

The electronics from the rear.

to make the leap into electronics with, because it's something that he hits and plays like a drum. He does have the controls and modifiers to contend with but it's going to become a lot more popular and it's going to be integrated a lot more into bands in general.'

It's usually the synthesiser player on stage who has quite a lot of setting up to do, but Warren is the same and rarely has a spare second — often making adjustments during the music. A different approach to playing exists for him — he has to be totally alert the whole time during a 1¼ hour show with only a couple of minutes relaxation.

Warren adjusts the controls of the Syntom.

Warren comments further: 'Personally, and some people might not agree with me, I think the real future of electronic percussion isn't so much in player programmable percussion. I think that drum machines that enable you to pre-program an assortment of beats will definitely be the ones that open things up — that's really what a drummer does in the first place! In his mind he might have (not considering jazz and other esoteric types of music) as many as a dozen Rock and Roll rhythms upon which to base his playing and maybe it will be possible to do all of this in advance of a performance, with drum machines programmed with these possibilities. Then instead of just using the acoustic kit you would also consider the use of your own original creative electronic drum programs!'

In Ultravox's latest album 'Vienna' (which is on special offer this month), the group made a decision on this particular album to under-play the use of electronics. 'The only thing to expect from Ultravox is change,' says Warren emphatically, 'that's why "Vienna" surprised a lot of people who thought we'd become more esoteric, and it should make the album enjoyable for a much wider audience.'

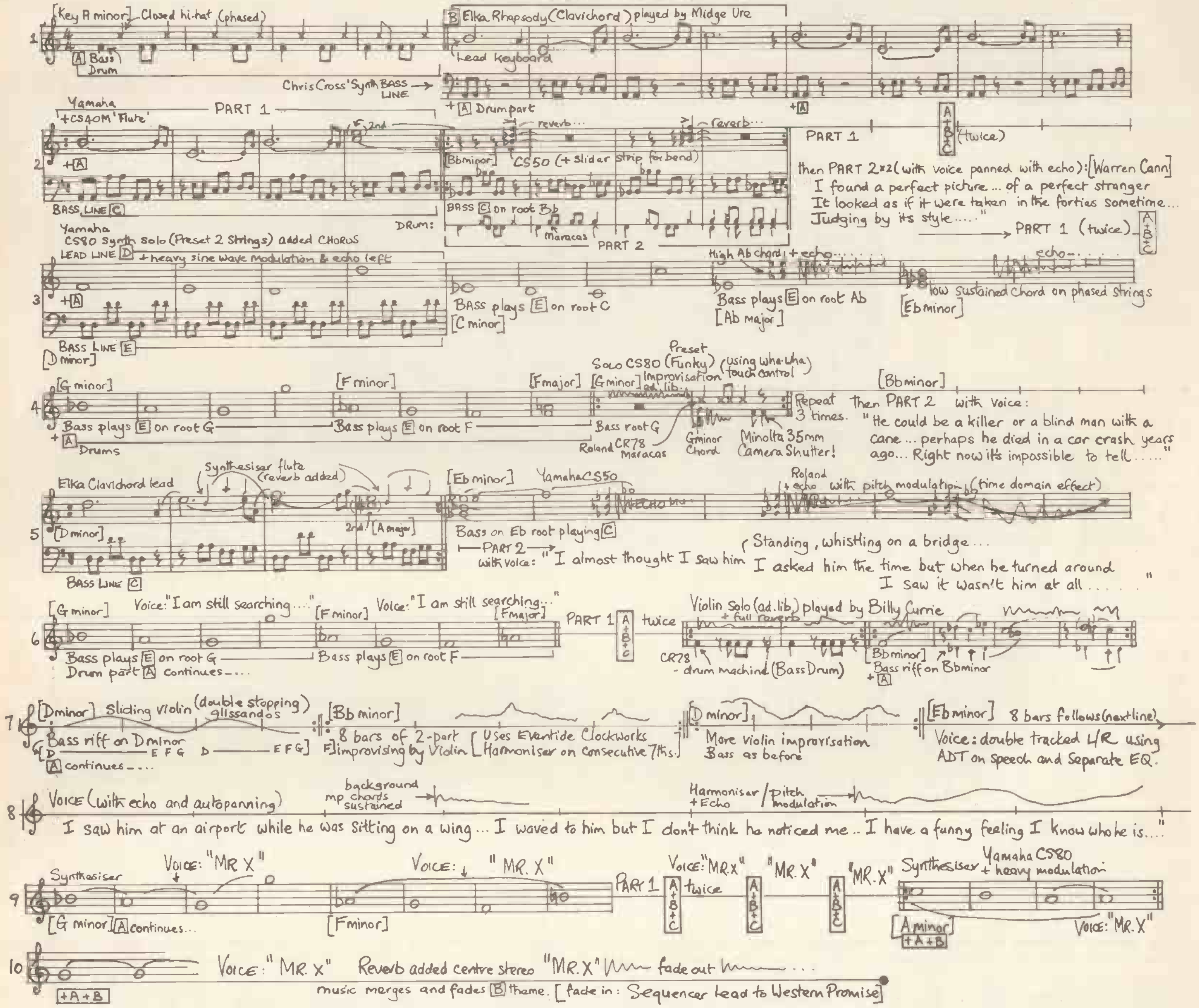
Warren finished by adding: 'The next album is going to be different again. One of our trade marks is our duality — total opposites being blended together and we're going to try for something that's a lot more 'off the wall' but at the same time is still easy to listen to and fun to dance to — a lot more electronics will be evident too!'

Mike Beecher **E&MM**

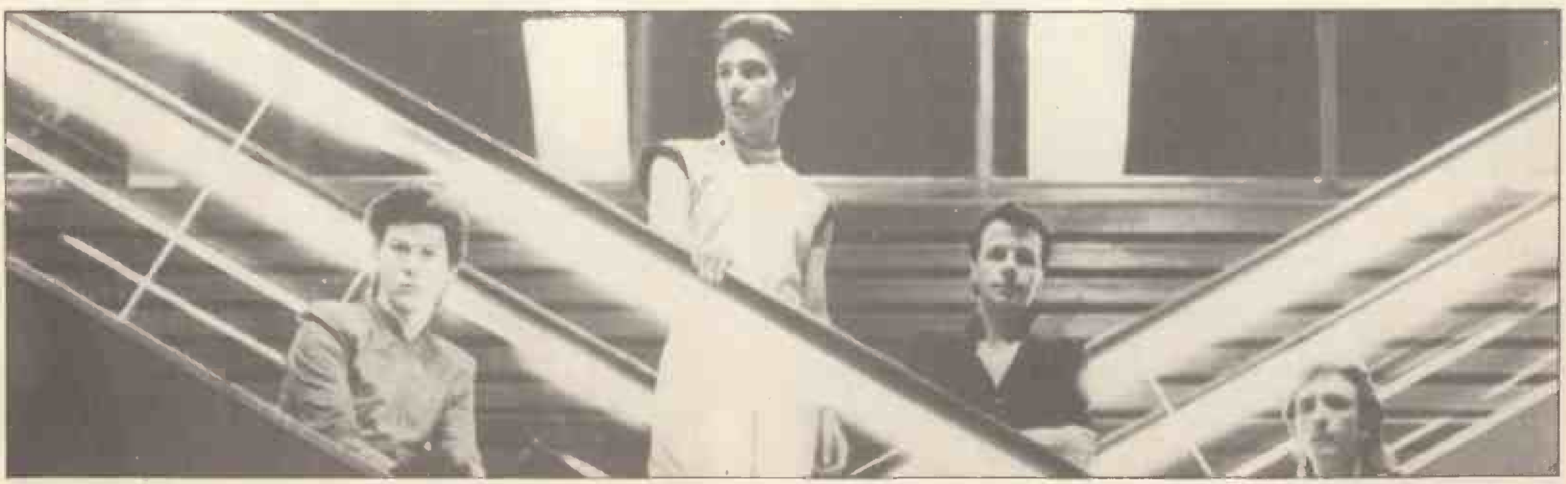
Midge Ure - Lead keyboards
Chris Cross - Synthesiser Bass
Billy Currie - Violin & keyboards
Warren Cann - Percussion

'MR. X'

from Ultravox
"Vienna" album

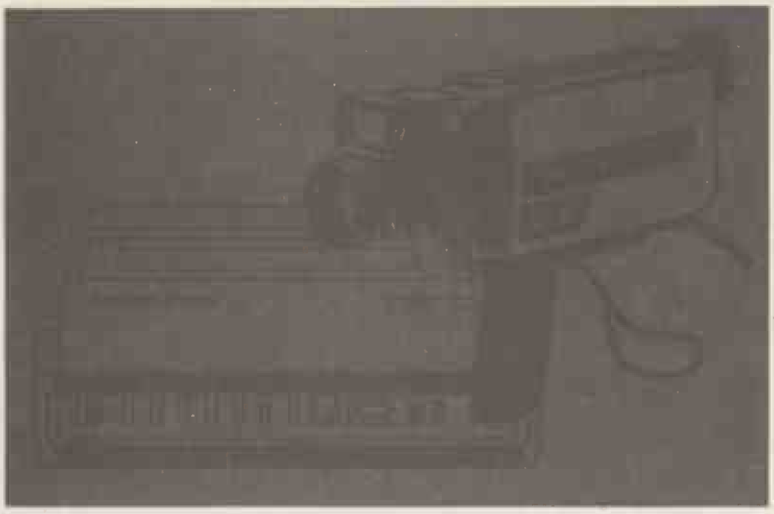


Electro-Musical analysis by Mike Beecher. Island Music-Copyright Control.



WORKING WITH VIDEO

Andrew Emmerson



Hello again, and welcome back to our continuing examination of what's going on in video and how it affects you, minus the hype and drivel you get in the video comics. In fact, one of the aims of this column is to take an 'alternative' look at video and give you some insights you probably won't read elsewhere. Unlike some of the 'straight' video magazines, we can truthfully claim to be totally unbiased in our approach and in our reporting. We don't rely on block advertising bookings from prime video manufacturers and we can say what we think about equipment without fear or favour. That's enough of the sermon, let's get down to business.

One of the questions asked most frequently is whether the time is yet right to get into video and if so, which make or system to get. After all you are probably talking about spending £400 or £500 if you intend to buy your machine, and you don't want to make any mistake when you spend that sort of money. So where do you go for this sort of advice? Your High Street photo/hi-fi store? The discount warehouse just outside town? Or that rather upmarket video and hi-fi 'studio' twenty miles away that advertises in all the magazines? Chances are, if you go and ask in each place you'll get a different answer in each. And will any of the answers be right? Will they accord with the idea you had already got from seeing the advertisements on TV? Bewildering isn't it?!

In theory, any shop which claims to be a specialist in this sort of thing ought to be a good source of friendly advice, but I sometimes wonder. It never fails to amaze me how some of the most video-orientated stores, even in London's Tottenham Court Road, can demonstrate such badly adjusted TV sets. Ghosty pictures, over-saturated colours, noisy signals, well you may know what I mean . . . I wouldn't buy a set in a shop where they clearly couldn't be bothered (or don't even know how) to put on a decent display. And when they demonstrate video recorders on one of these poorly adjusted receivers it's no wonder you'll see some pretty misleading results. I suppose it's fair game to display recordings on a 13" Trinitron (any picture looks sharper and brighter on a small screen) but when you hear salesmen say one manufacturer's VHS machine gives much clearer pictures than a rival VHS machine it makes you wonder, as they say. Many salesmen are on commission (it keeps them on their toes) and it stands to reason that they'll try and sell you a more expensive machine if they sense a big credit card burning in your pocket. Fortunately not all shops are like this!

But what's the real truth? How do the various makes and systems compare? What follows now is an honest and unbiased opinion. It's only an opinion and I respect the fact that you are entitled to your own opinion, even if, say, you are in fact mistaken. Straightaway I will repeat something I said before — on the video marketplace now there are no 'cowboy' makes. If you buy any current production home video system you cannot really go wrong. You may spend too much or miss out on some features you could have had for the same price on another model, but you won't buy rubbish. Shops cannot afford to sell rogue makes: they don't want customers coming back to the shop making a scene and demanding £500 back nor in fact do they want to see the machine back for an expensive service job until at least a month after the free maintenance guarantee has run out. In terms of quality, then, no manufacturer stands out as a rogue nor, for that matter, as spotless. I repeat, there is no rubbish on the market. Mind you, some manufacturers, e.g. Philips, get top marks for supporting their products with a good spares backup for a long time after they are obsolete, and some of the Japanese manufacturers have acquired a nasty reputation for spare parts which are either pricey or totally unavailable for months. Do, however, avoid buying cheap obsolete or professional systems which appear to be a bargain.

So your choice is down to the machine's styling, features and price, and also its 'format'. The first three of these I leave to your judgement, but you may need a bit of guidance on the format or system, which is quite important really. There are three formats or types of machine currently in production. All of them use tape which is ½" wide but the way in which they record picture and sound signals on the tape differs fundamentally, so that a tape recorded in one format will not play back on a machine belonging to another format group. This is what they mean by compatibility — whereas any audio cassette you buy will play in your home cassette recorder, whatever its make, there is not the same sort of interchangeability with video cassettes. No format is the exclusive province of a single manufacturer: the manufacturers line up into opposing camps depending on which format they have signed up with, and the originators of each format are delighted to admit new members to their 'club', knowing that they could never achieve total market saturation alone.

These three formats are VHS, Beta and Video 2000. VHS or Video Home System can, through its penetration of the rental market, claim 70% of the British home video market and no. 1 in the world status. These figures do rather speak for themselves. For instance, blank and recorded tapes are plentiful and competitively priced, and if you want to swap tapes with people at work you had better go for VHS as the chances are that this is the one they have got. Picture quality ranges from acceptable to pretty good but never as good as broadcast TV. If you look closely at the screen of a TV set replaying a VHS tape you will see a noticeable fuzziness or lack of very fine detail and the picture is covered with countless tiny specks of random colours known technically as colour noise. From normal viewing distances you won't notice these defects and the pictures are subjectively very good. You can record up to four hours on a single tape with VHS now.

VHS was developed by JVC and is supported by many manufacturers. Not among them is Sony, since Sony originated the main rival system. This is called Beta. Technically Beta and VHS share many similarities, so you would expect results to be more or less equal. They are, although the best VHS pictures I have seen had a slight edge on the best Beta results. Tape costs are comparable and you can record up to 3¼ hours on one tape. The number of manufacturers making Beta format recorders is smaller and thus you will have less choice, though no shortage of features. Prices are very competitive.

VHS and the Beta format both originated in Japan; the third is the European alternative. It was developed jointly by Philips and Grundig to keep a segment of the European market for European suppliers. Some people say it has arrived too late to do this, but it does stand a very good chance of success in continental Europe, where they tend to be more European-minded, if not the UK. Unlike both of the systems mentioned previously it uses a tape cassette which you can flip over when you come to the end and the total recording time per tape is up to eight hours. No wonder they call it the Video Compact Cassette or VCC. For all the technical wizardry built into their machines (and there's a lot of very clever stuff in them) they are not cheap and they don't have some of the features the Japanese manufacturers offer. And what's more, the picture is no better.

Given the foregoing I can see no reason for buying anything other than VHS — it has the widest choice of machines and prerecorded tapes, and its overwhelming popularity means they won't ditch the format overnight. If you're a bit short of the ready cash you may point out that Sanyo make their basic Beta machine quite a bit cheaper than any VHS. This is true . . . but if you want video on a budget why not try the radical alternative? Do what everyone warns you against, go out and deliberately buy a secondhand machine of an obsolete format! In point of fact this can make a lot of sense as long as you don't spend much money on the experience. And experience is what you'll be buying. For £100 or £150 you can have a lot of fun and learn a lot about video. You may well get a whole load of tapes thrown in with the machine, after all, if the owner is changing system he will no longer need the old tapes. You'll probably keep the machine for about nine months and then resell it for not much less than you paid for it. In the process you will have learned what you can get out of video and you will definitely know which new machine to go for. So avoid the temptation to buy the first new machine you see and . . . buy secondhand, folks!

Where do you find secondhand machines you can trust? The best source is trade-ins from dealers. No, you don't see them in the shop windows, and they won't even offer you one unless you ask because they have no wish to lose the chance of selling a new machine. But if you explain you're starting on a budget you will probably get quite a good machine, with three months' guarantee to boot, which is better than nothing and indicates a certain degree of confidence. If a few phone calls to local dealers do not work you could take a look in the local paper or in "Exchange and Mart", but you cannot get a meaningful guarantee from a private seller and you might just be paying for the privilege of taking over someone else's troubles. Whatever you do, refuse to pay more than £150. The machine you will end up with will be either a Philips 1500 or 1700. Both models are obsolete now but were good machines in their day. The picture quality on them is better than any current production model and the few complaints of tape breaking levelled at these old machines are almost entirely due to user error. Putting a cold tape in a warm machine is a guarantee for disaster! The biggest snag is the tape cost (try and get secondhand tapes) and the 1500 had a maximum record time of 65 minutes, so it's no good for feature films.

These old (only a few years) machines can be an ideal way of getting into video painlessly and on a budget. Think on it if you are not quite sure what you really want out of video. In future articles we'll discuss some of the more creative things you can do with a video recorder. See you next time!

E&MM

Organ Talk

Ken Lenton-Smith

THE LESLIE SPEAKER

Although the principle of using the Doppler Effect by means of a rotating baffle next to a speaker was Don Leslie's original idea, it has been copied by a number of manufacturers. Imitation is a very good form of flattery, of course, but perhaps speaker systems working on this principle should be referred to as 'Doppler Speakers' as they may not necessarily be genuine Leslie products.

The constructor may be assured of one fact — that making a doppler speaker from scratch is not easy. The professional product may be thought to be fairly expensive, but there is considerable technical know-how required to make such a speaker mechanically silent enough to be useful. The rotor and/or horn unit impart sound modulation at about 7Hz and thus must rotate at some 450 revs per minute. The motors employed have to be powerful enough to get the mechanism moving at full speed in a fairly short time and so vibration, mechanical hum and wind noise are factors that have to be considered in the design. Four or more motors are not unusual and these are resiliently mounted in large rubber grommets and the rotor and horn bearings also have forms of rubber suspension.

The addition of a Doppler Speaker enhances the sound of most electronic keyboard instruments. Indeed, once it has been fitted to an organ, that instrument loses its aural identity — which might even be an advantage! The rather special sound the Doppler Speaker imparts makes it difficult to tell which make of instrument is being played: without it, the expert would be able to identify many makes of organ, especially with their own electronic vibrato in operation.

There are many ways in which vibrato (and tremolo) can be applied to sounds electronically. Perhaps one of the best methods devised was the scanner-phase vibrato used in Hammond tone-wheel organs (now defunct), where the audio signal was passed down a relay line which was scanned back and forth to produce phase shift vibrato that was near perfect. Even so, you will note, Hammond also provided means for fitting a Leslie speaker: this would seem to underline my comment on sound enhancement!

Vibrato

The string player 'wobbles' his finger on the stopped point, making the string fractionally longer and shorter cyclicly. In electronic terms, this is frequency modulation and is usually achieved by injecting a low frequency sine wave into the master oscillator of the generator system. In practice, a set of stable generators that will stay in tune does not like to be modulated and in certain cases it can be difficult to obtain sufficient modulation. Occasionally one hears electronic vibrato which is noticeably lopsided — where the frequency swing is not equal either side of centre. Even when electronic perfection has been achieved, the result is often only mildly interesting.

Tremolo

Also called Tremulant, this is amplitude modulation of the audio signal. Arranging this effect is fairly simple compared with vibrato, as an opto-isolator (or its equivalent) and a square wave oscillator will serve admirably. Tremulant is often used in serious music, rather than vibrato, and again is only of mild interest.

Doppler Speakers

In my view, what makes Leslie speakers and their imitators more interesting is that these combine both vibrato and tremolo by the nature of their operation.

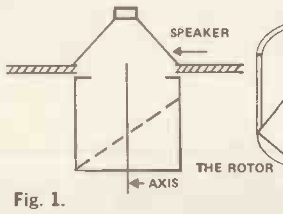


Fig. 1.

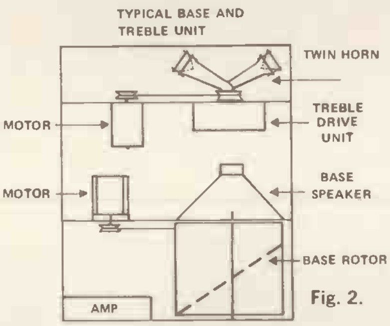


Fig. 2.

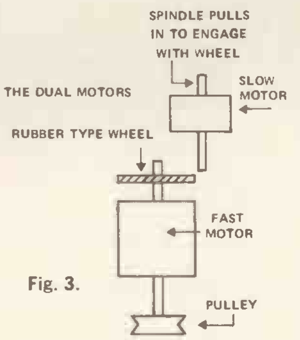


Fig. 3.

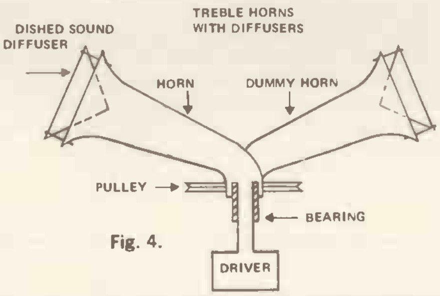


Fig. 4.

The Doppler Effect is caused when a sound source is moving relative to the listener. The pitch of a police car's siren falls as it passes the listener because the frequency is travelling at the speed of sound plus the speed of the car as it approaches and at the speed of sound less the car's speed as it recedes. So the eardrum receives more pulses per second on approach than after the car has passed.

The same effect can be obtained by mounting a speaker on a large rotating baffle board and at least one manufacturer has used this method in the past for obtaining chorale. This proved to be both large and cumbersome and Don Leslie circumvented these problems by using a stationary speaker and rotor next to it, as shown in Figure 1.

Small Leslie units employ a polystyrene foam rotor, which is light enough for a relatively small motor to drive it. If built into a small organ, the unit is turned on its side compared with cabinet models, the sound emerging through slots at the side of the console. The drive from the synchronous motor is by means of pulleys and a cotton covered belt.

Larger Leslie units have heavier wooden rotors which reflect more sound than the polystyrene types. The belt drive system is similar except that a more powerful motor has to be employed. The wooden rotor is shrouded in cloth for aerodynamic reasons and thus produces less wind noise. Figure 2 shows the typical arrangement.

The speaker over the rotor may be up to 15" in diameter and is mounted either in a form of infinite baffle or with acoustic wadding behind it in the console. In either case, the sound is directed into the rotor with its opening constantly approaching and receding from the listener, so giving frequency modulation. In addition, the volume of sound alters as the rotor's aperture passes, so amplitude modulation occurs.

Some cabinet models also employ treble horn units. In this case, a crossover network feeds the lower frequencies to the rotor speaker and the higher ones to a treble driver unit. Above the driver is a pair of horns, one being a dummy for balance only, driven by separate motors, pulleys and belt.

The treble horn unit makes a great difference to the doppler speaker sound: the bass rotor alone works reasonably well but is not sufficient on its own. I would strongly recommend purchasing a treble horn unit if the doppler speaker system is at present limited to bass rotor only. This can be built into a box to sit on top of the existing cabinet.

It is usual to have two motors so that the rotor/horns can be driven at 'fast' (about 7.5Hz) or 'chorale' (about 0.5Hz) speeds according to the switching. A combination of a straight speaker signal and sound from the doppler speaker on 'chorale' gives a very full and pleasant sound to any sort of music. It takes that hard electronic edge off the instrument and, because of the slow meandering of sound, adds a cathedral-like effect to the instrument. The Leslie motors are shown in Figure 3.

Practical Aspects

It is not a good idea to feed reverberated signals through the doppler speaker as these sound rather unpleasant. If possible, a separate speaker should handle reverberation which in itself will probably give some chorale effect with the slowly turning rotor or horns.

I have already underlined the importance of the treble horn unit to give the true 'Leslie' sound. The horns should be fitted with sound diffusers, for without them the effect will tend more towards tremolo than vibrato. These are simply small 'dishes' placed about one inch from the mouth of the horn which allow the sound to be heard after the mouth of the horn has passed. If these are absent, for any reason, they can be added without too much trouble. Figure 4 shows the horns and diffusers.

The diffusers can be made by cutting out a disc of card about ¼" greater in diameter than the horn mouth. Mark out and remove a 30 degree slice and join the card with tape to make a shallow cone. Treat this card with a releasing agent and build up about half a dozen layers of fibreglass tissue on it with polyester resin. When the resin has hardened thoroughly peel off the card and trim the diffuser's edges. Drill at 3 points (120 degrees apart) and fit 1" from mouth of horns with thin dowel and Araldite.

Unless the reader happens to be a mechanical expert, it is probably best to buy complete doppler speaker units, preferably both bass and treble. As mentioned earlier, it might appear to be fairly simple to make everything from scratch, but mechanical noise will undoubtedly prove to be a major problem.

Switching, both for speakers and rotor/horn speeds should be available at the keyboard. This should allow the choice of main speaker, doppler speaker or both, whilst a further two-position switch is provided for fast and slow speeds.

The only disadvantage with doppler systems is that they are acoustic, which means that their effect is lost when using headphones for practice purposes or when making direct recordings. Those who demand these facilities plus good electronic vibrato will have to settle for bucket brigade systems. E&MM

Advanced Music Synthesis

Chris Jordan

In the 1950's Karlheinz Stockhausen generated new, complex timbres by splicing small sections of tape containing sine waves recorded at different frequencies into a single loop, and replaying it at high speed, while Pierre Schaeffer used the sounds of natural instruments and transformed them by separating out different portions of their envelopes, again by tape splicing. Hence the old concept of synthesis was born, recognising two distinct approaches: additive synthesis, where separate elements are assembled to give a complex result; and subtractive synthesis, where components of the original are removed, yielding new elements. When applied to timbre generation using electronics, additive synthesis becomes the mixing of separate tones at different frequencies to generate sounds with new overtone series, and more specifically, adding sine waves to build up a timbre harmonic by harmonic. Subtractive synthesis becomes filtering of waveforms, generating new timbres by eliminating unwanted harmonics, and processes that generate new components from an input signal correspond to the early techniques of Intermodulation, whereby the timbre, amplitude or pitch of one sound transforms similar properties of another.

Clearly in many ways this concept is out-of-date in the context of the modern analogue synthesiser. For example, the commonest modern application of multiple oscillators controlled as a group with their outputs mixed is to produce rich sounds by tuning them in unisons and/or octaves, rather than successive harmonic intervals for the synthesis of new harmonic structures. In 'classical' additive synthesis, the oscillators must either be very stable or have some method of locking their frequencies together, since where one harmonic is made up of components from more than one oscillator, a slightly changing phase difference will destroy the integrity of the resultant harmonic series. Sine waves or other low harmonic content waveforms were used, giving independent control over the amplitude of each harmonic, and also minimising the effect of frequency drifts. By contrast, the modern unisons-and-octaves technique relies upon beating between oscillators for the richness, and without a high harmonic content the sweeping cancellations that are the most useful effect of beats would not be heard.

Additive synthesis for timbre generation was practical in the early classical electronic music studios where the only pieces of equipment built specifically for music synthesis were custom mixers, modulators etc. Like some of the theory, most items were borrowed from radio: banks of sinewave oscillators (not voltage-controllable) provided the best method of synthesising arbitrary timbres. Pulse generators and octave filter banks gave an alternative but something like a rampwave oscillator was considered a luxury, the commonest substitute being a sine wave oscillator driving one or more valve amps to overload. Nowadays, synthesisers use multiple oscillators to create new timbres by various kinds of modulation, for example frequency and amplitude modulation for non-harmonic tones and waveform shape modulation, including sync. and self-modulation, for harmonic tones. Hence it is possible to design a small, low-cost synthesiser which is more powerful than a complete classical electronic music synthesis system, while larger synthesisers can incorporate features to take full advantage of the voltage-controllability of the oscillators and other modules. These two approaches to timbre generation, classical using parallel organisation and contemporary using series organization, are illustrated in Figure 1. For the purposes of this comparison, doubling up of tones to thicken the sound is not considered a basic part of timbre generation since it does not fundamentally affect the partials of the sound and is usually achieved by simple duplication of the oscillator part of the patch. Nevertheless, like reverb and echo it is still an important factor in determining overall tone quality.

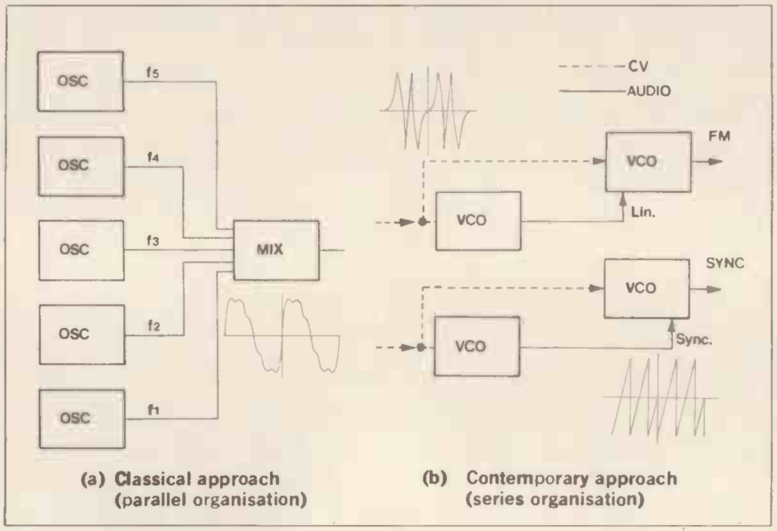


Figure 1. Timbre Synthesis.

Returning to the concept of synthesis and the need for an update to include integrated electronic systems, I propose that the various tone-forming techniques of synthesis, both analogue and digital, be divided into four groups, according to their effects on the time domain (waveform) and frequency domain (spectrum) representations of the signal. These four groups are:

1. Frequency domain additions.
All that produce new components not necessarily harmonically related to those of the original eg. frequency and amplitude modulation, frequency shifting.

2. Time domain transformations.
All that introduce new harmonically related components or alter the amplitudes of existing ones by non-linear processing of the original eg. waveform shape, clipping.

3. Frequency domain transformations.
All that alter the amplitude of existing components according to their frequencies, eg. filters.

4. Time domain additions.
All that reintroduce the original signal after a time delay eg. reverb, echo.

Where one device can perform in different ways depending upon the input, it falls into more than one group. For example rectification can be used for waveform shape modulation, as it is on many analogue synthesisers where a variable triangle-to-ramp waveform is available; or for amplitude modulation where one of the signals is a square or pulse wave. Chorusing can be considered a member of Group 3, since phase cancellation alters the strength of harmonics, or Group 4, because a distinct separate image may be heard.

The techniques of Group 2 are best described as waveform shape modulation — the shape of the waveform is controlled directly, and independently of the frequency. This latter point is a useful property of this type of timbre generation and makes it different from filtration (Group 4) where the effect is purely based on frequency so that a given waveform gives different results at different frequencies when processed by a fixed filter. Another important difference is that shape modulation has a more general effect on the harmonics of the waveform. Unlike a simple filter which has a single cutoff or centre frequency which relates directly to the frequencies of the harmonics affected, altering the shape of a waveform effects the strengths of many harmonics simultaneously. This means that it cannot be used to specifically control certain bands of harmonics, and the nearest it comes to a filter's functionality in these terms is with synchronisation, which can increase the energy near the natural frequency of the slave oscillator. This makes shape modulation no less powerful: filters cannot produce many of the shape modulation effects, for example gradual introduction of even harmonics in a square wave, but are still invaluable. (In fact seemingly ultimate digital synthesis systems which allow each harmonic its own key-gated ADSR for amplitude are unable to produce the sound of a low-pass filter sweeping the spectrum, since this requires sequential control of each harmonic.) Hence waveform shape modulation and filtering are excellent complementary timbre-forming techniques, and together provide easy and versatile static and dynamic control of the timbres of harmonic sounds.

Pulse Waves and Pulse Width Modulation (PWM)

The commonest type of waveform shape modulation (WSM) is pulse width modulation, which potentially provides any pulse width between 0 and 100%. Since a pulse wave with a width greater than 50% is merely the corresponding wave with a width less than 50% but inverted, the range from infinitesimally thin (delta wave) to equal mark/space ratio (square wave) contains all the different timbres. However, in the same way that a mix two unison ramp waves of the same sense sounds very different from that with one inverted, the effect of inverting a pulse wave can be important when it is heard with other waveforms. Also its control properties are different, and the effect of sweeping a pulse width through 50% could not be easily duplicated if only one half of the range was available, so it is useful to have access to the complete

0-100% range. The spectra of a square wave and two different pulse waves are shown in Figure 2. Note that the pulse wave spectra show periodic dips — these occur where the harmonic number is a multiple of n, where n is 100/width (%). In the case of the square wave they occur at every second harmonic, eliminating all the even ones. The odd-looking sharpness of these dips is a result of the fact that alternate inter-dip groups of components are of opposite phase relative to the fundamental, hence the envelope of a pulse wave's spectrum can be thought of as a decaying sine wave where below-the-axis components have reversed phase. This makes the difference between a square wave and a triangle wave, which also has odd harmonics only, more than just a matter of harmonic strength since the square waves components alternate in phase, and this has a more important effect when considering waveform shape modulation by linear self-modulation in frequency domain terms.

The complex nature of pulse wave spectra makes PWM unique among common WSM techniques, none of the others having nulls at related harmonics. This has little consequence whem PWM is used as a source of different static timbres where the most important feature is the increasing amplitude of harmonics, odd and even, in relationship to that of the fundamental, as the width is made more extreme. But when the pulse width is varied dynamically the nulls sweep the frequency spectrum, giving a marked phasing effect that is virtually impossible to obtain by other means not incorporating time delays. It is hence very useful in creating multiple oscillator sounds with just one, and is the basis of most chorus features on preset monophonic synthesisers. In fact periodic shallow PWM at about 5Hz is the easiest and sometimes the only way of getting a sustained tone that is pleasing to the ear on many cheap commercial single VCO instruments.

The reason why PWM with a low frequency oscillator waveform sounds like phasing is that it very nearly *is* phasing, of a sort, since mixing a rising rampwave and a falling rampwave of the same pitch and amplitudes produces a pulse wave since the slopes cancel and the resets produce respective rising and falling edges. As the phase relationship changes due to a slight pitch difference, the pulse width becomes more extreme until perfect cancellation occurs, then the advancing phase produces a thin pulse of the opposite sense. This process is illustrated in Figure 3.

So, the dips in a pulse wave's spectrum correspond to cancellations of harmonics of two rampwaves with the particular phase difference required for that pulse width.

The major reason why sweeping doesn't sound exactly like phasing is because of the way it is used — the reversal of the modulating waveform before 0 to 100% is reached gives it away as not being the real thing. It is used like this because a cutoff of the sound at each extreme is often undesirable, and anyway difficult to

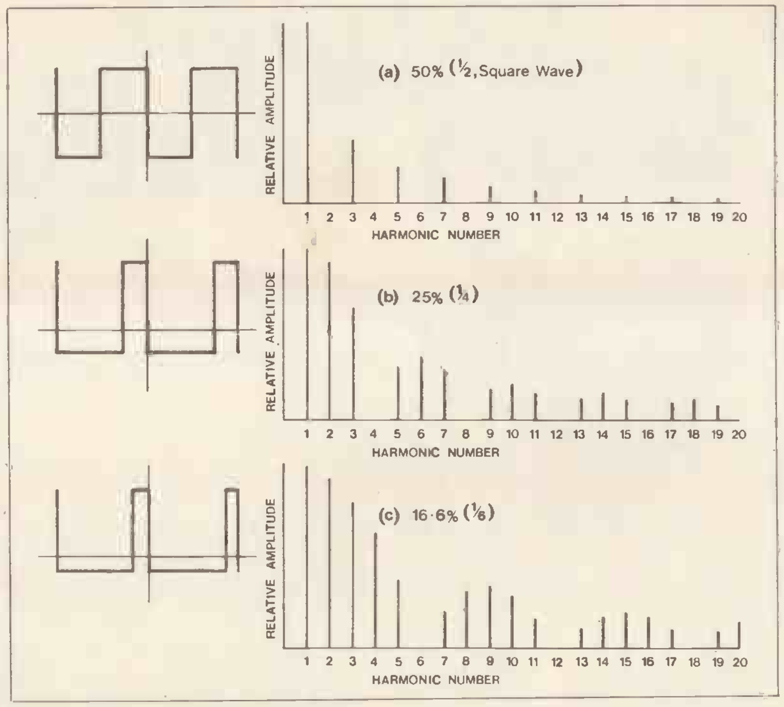


Figure 2. Pulse Waves.

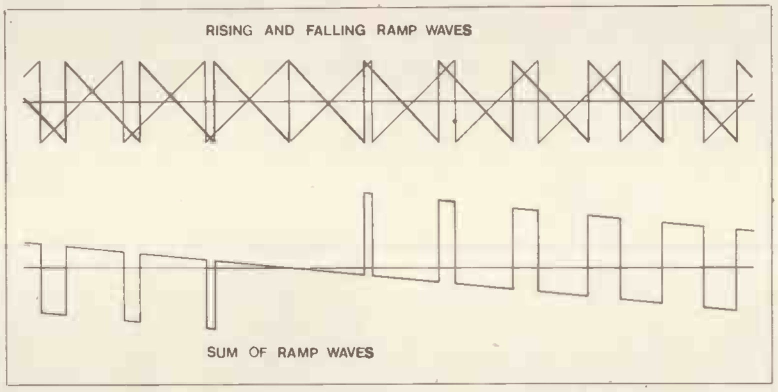


Figure 3. Phasing of ramp waves.

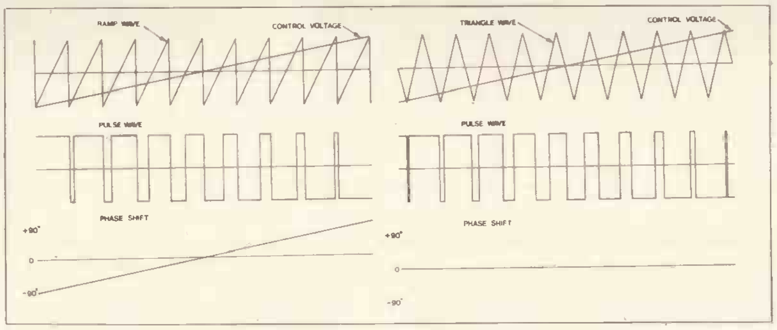


Figure 4. Pulse wave generation.

arrange precisely. What is really required is the sound of two identical signals with a changing delay, without one inverted. Since a pulse wave is the difference we only have to add twice as much of one of the imaginary original ramps to get a more realistic phasing effect.

The resultant waveform is indistinguishable from a mix of two rampwave oscillators, and remember so far we have only used one oscillator, with PWM.

In just about all analogue synthesisers, the variable width pulse wave is derived from another waveform using a comparator, a device which has two inputs, and an output which is at one of two values depending upon which of the inputs is most positive at any instant. A ramp or triangle wave is compared with a control voltage, and a pulse wave is generated with a width according to the proportion of time the waveform spends above the value of the control voltage. Hence by sweeping the control voltage to the comparator, which will usually be the sum of a voltage

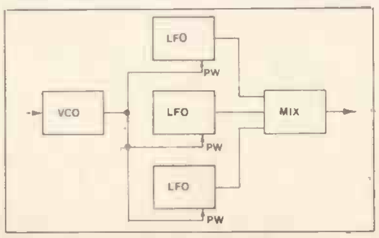


Figure 5. Multiple PWM patch.

from the pulse width control and an external CV, between the limits of the waveform, the width can be varied between 0 and 100%. This is shown in Figure 4. Note that the limits of the resultant pulse waves are independent of their widths, so for values other than 50% there is a DC offset equal in magnitude but opposite in sign to the control voltage (assuming that the input waveform has no offset). The pulse waves in Figure 2 are shown with no offset and since the ramp waves of Figure 3 are symmetrical about 0V, the resultant waveform has no offset, so the peak levels slope up or down, to be returned to zero when the pulse wave 'turns over'. Offset that varies with shape is a feature of most kinds of waveform shape modulation, and can cause problems when the output is used as a CV, e.g. for FM.

As Figure 4 shows, there are important differences between triangle- and ramp-derived pulse waves. One edge of a ramp-derived pulse will coincide with the reset of the ramp, so there is a phase difference which is proportional to pulse width. This is most obvious when the PW is modulated by an LFO signal, since the phase modulation can become great enough to be perceived as vibrato (the frequency shift equals the differential of the phase shift). Since no phase error occurs if a triangle wave is used as the basis of the pulse wave, this is more suitable for chorus effects, where a sine wave of around 5Hz is used to modulate the pulse width over a small range. Considering the pulse wave as the sum of two ramps again, ramp-derived PWM gives vibrato to one of the ramps only, whereas triangle-derived PWM modulates the frequencies by the same amount but in opposite phase, retaining a constant 'average pitch'. The vibrato effect of the former is very obvious with a fast LFO and large depth, rendering the tone unusable for melodic playing, and since the frequency shift is constant with changing pitch it is more noticeable at low frequencies, where even a envelope sweep of width can cause an audible 'wow'.

LFO's that are equipped with PWM are particularly useful for audio since apart from the sense (inverted or non-inverted) of the output, the comparator is symmetrical in its response to the waveform and CV. Hence we can just as easily modulate an LFO by a ramp or triangle wave from a VCO to generate a pulse wave with swept width, appearing at the LFO output. Using more than one LFO in this way gives pulse waves with independently varying widths, producing some beautiful multiple chorus/phase sounds, depending on the LFO rates. Unlike more conventional techniques, this requires only one VCO. Also, the basic waveform is accessible, so the rampwave could be mixed in as previously described. However, a triangle wave gives best results since all components are then of independent phase, whereas in the case of the ramp, the resultant pulse waves have simultaneous falling edges and therefore degenerate components. A basic patch demonstrating multiple PWM is shown in Figure 5.

Hot Wiring your GUITAR

Adrian Legg

Last month we considered the basic electronics of a single pickup guitar, with various equivalent ways of connecting the tone pot. and capacitor. Two-pickup guitars follow the same plan, with the circuitry duplicated up to the jack socket, where a pickup selector switch connects one or both of the volume pot. wipers to the single output jack. This arrangement is shown in Figure 1.

When the pickup selector switch is in either the up (neck pickup) or down (bridge pickup) position, the appropriate volume control wiper is connected directly to the live of the jack socket and the other is left isolated. When the switch is in the centre position, the two wipers and the jack socket live are connected together and if neither volume control is at zero, a mix of the two pickup signals is fed to the socket. The 'mixing' of the two signals is very crude and if either control is at zero there will be no output regardless of the setting of the other, since the jack socket live is grounded. This can be an advantage since it allows the output signal to be shut off completely by turning either volume control to zero but is undesirable if you want to be able to turn off one pickup without changing the selector switch, gradually. For example, Figure 2 shows how to rewire the volume controls for independent operation.

To avoid one control shutting off the signal from the other, the input (left-hand tag viewed from the back with the tags facing you) and wiper (centre tag) connections should be reversed for each pot. The circuit now appears as in Figure 2, with the tone and pickup part of the circuit remaining the same. Now at maximum volume setting the pickup is still connected directly to the selector switch (with the full track resistance to earth), but at the minimum setting the pickup is earthed and the track resistance lies between the earth and the selector switch, so the other signal is not shorted to ground. It is impossible to damage either pickup by shorting its ends together, and this occurs anyway with an unmodified two-pickup circuit when one volume is at 10 and the other at 0.

If the modification is done on just one volume pot. the other can be used as a 'master', shutting the signal off when at zero, with the ability to bring in the other pickup signal independently.

At this point, I will just explain about two different types of pot. available, for those beginners who don't know already. These are logarithmic ('audio') and linear, which are manufactured to give differently tapered responses. A linear pot. gives a constant change in signal amplitude (when used as a volume control) as the control is turned. But the ear hears this as a non-linear change in volume. Audio pots. have a response that gives subjectively linear control of volume, and consequently are more useful as volume controls. Fitting a linear pot. instead of an audio pot. will give a large increase in volume over the first third with little else happening for the rest of the travel. Note that the two ends of an audio pot's track are not equivalent and reversing the track connections will give an even more extreme response, in addition to changing the direction of control.

Another modification I want to deal with is probably the simplest, cheapest, and in my opinion, the most effective of any. Leo Fender used it on the Telecaster and it is a major reason why that guitar sounds the way it does. It was also used by Travis Bean on humbuckers on the Standard and Artist models.

Quite simply, it is a 1nF capacitor across the 'in' and 'out' tags of the volume pot. As the volume is decreased slightly, treble frequencies bypass the resistance and proportionately increase the amount of treble in the sound. The increase is particularly noticeable with single coil pick-ups or tapped humbuckers, less obvious as an increase with straight humbuckers. Most guitars on the market now use audio pots, and the effect of the capacitor is most noticeable on these. A linear pot gives a barely noticeable effect as there is in my experience, less treble loss in the first place. Cheaper audio pots will give an immediate effect at a volume setting around nine, as the treble loss tends to occur very suddenly just under full volume. While linear pots give less treble loss, they can be less effective than audio immediately in front of a pre-amp. I've found that in that situation, I got virtually no change in level until I got down to around two, when the sound packed up altogether. Fitting audio pots cured the problem. So, although the 1nF capacitor bypass evolved primarily as a crude means of combating treble loss, these days it is very useful as a definite effect. Simple fitting should be as in Figure 3 but it is possible that you will find this a help in some circumstances, and a hindrance in others. For example, the softening effect of winding down an audio pot on a front pick-up can help in getting a warmer, jazzier sound without actually cutting treble on the usual passive tone pot, which can sometimes be difficult to set accurately, quickly. In this case, the answer is to make the capacitor switchable. An interesting side effect of using the capacitor is that passive tone controls will sound more effective, as, at lower volume settings, there is more treble left for them to cut than on an unmodified guitar, where the top end has already been rolled off by the volume pot. **E&MM**

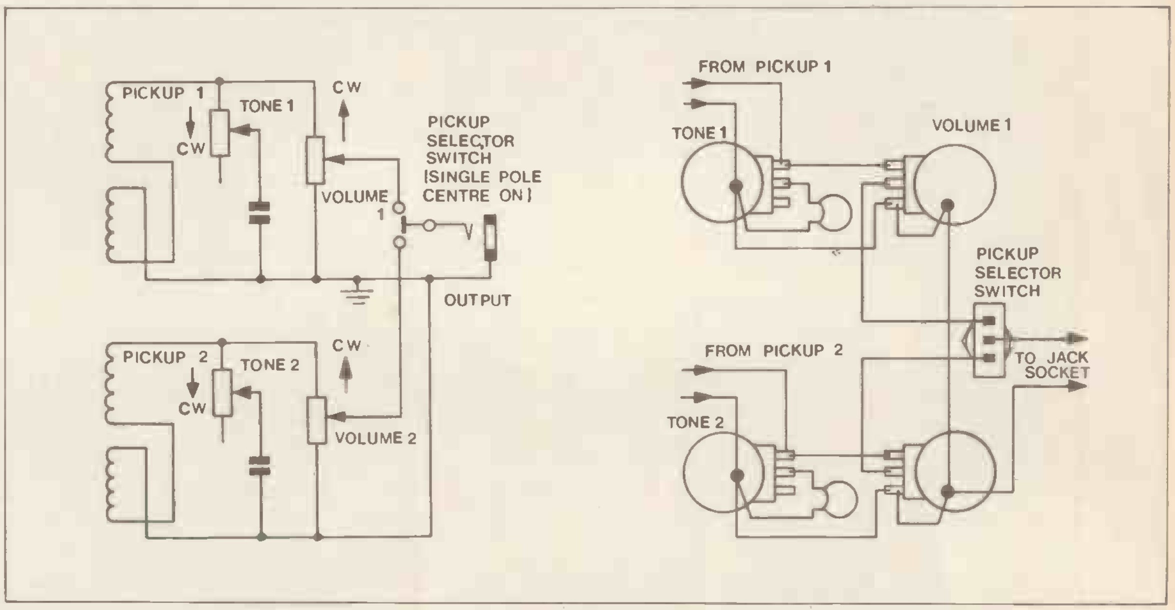


Figure 1. Electronics of a two-pickup guitar.

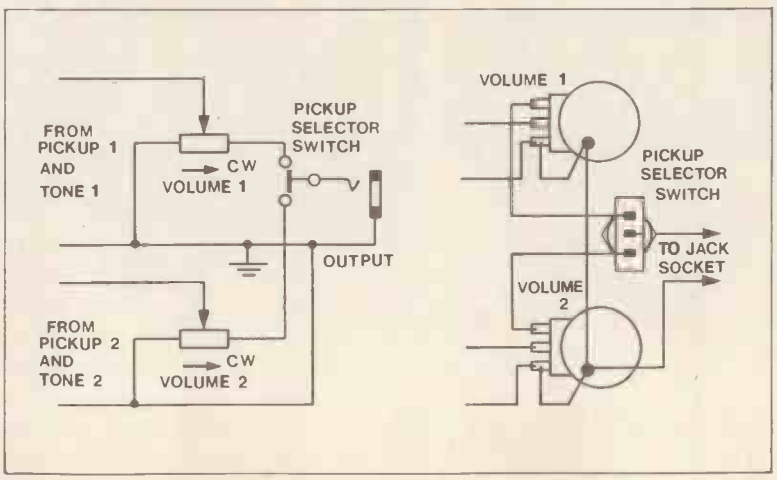


Figure 2. Modified volume control circuit.

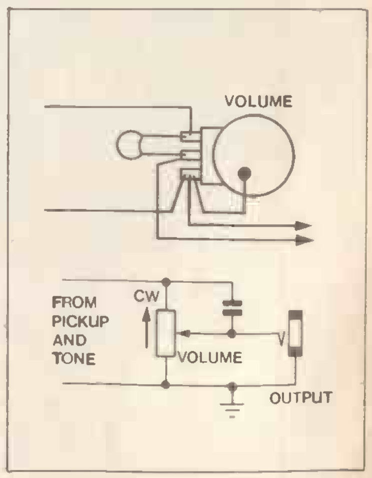


Figure 3. Capacitor fitted for treble boost.

INSTRUMENT REVIEW

Each month we review the latest Electro-Music Equipment —from synthesisers to sound reproduction and effects!
E&MM's special in-depth reviews look at what's new in the world of commercial music — a vital updating for both electronics designers and musicians.

PAIA 8700 Computer/Controller

PAIA are a small company in Oklahoma City, USA, producing a wide range of music synthesis equipment, and the 8700 Computer/Controller represents the main product that really distinguishes them from other synthesiser manufacturers. The guiding force behind PAIA is John Simonton and it is his design philosophy that makes PAIA so interesting.

Basically, this is to make available a comprehensive range of synthesiser modules with all the necessary interfacing hardware for the minimum possible price, and to provide computer control over all voltage-controllable functions. A complete system (the 4700/J) in kit form, consisting of 3 VCOs, 2 ADSRs, 2 VCFs, 2 VCAs, control oscillator/noise source, various interface units, a digitally-encoded keyboard and the computer/controller, sells in the USA for around $800. This system is capable of various modes of polyphonic operation (though obviously the number of voices is limited to the number of available VCOs) and, to a certain extent, offers multi-track capability, the 'recorded' music then being dumped onto tape.

The individual modules range in price from $35 for a kit VCO to $26 for an ADSR and display a no-frills attitude to design. The modules show considerable design ingenuity, but I do feel that more modern circuits based on, say, Curtis Electromusic Specialties chips could perhaps improve some performance parameters and certainly offer additional facilities. For some reason apparent to only themselves, PAIA have opted for linear response modules (like Yamaha) rather than the linearly-controlled exponential modules common to ARP, Moog and Oberheim. So, real problems arise if one starts interfacing PAIA modules with the linearly-controlled systems common in this country. Linear to exponential converters are one expensive solution, but a preferable alternative is to use the interesting part of the system, the 8700 computer/controller, with one's own favourite linearly-controlled modules.

Computer/Controller Functions

The block diagram set out below should illustrate how the Computer/Controller is interfaced between a keyboard and synthesiser modules (Figure 1). The 6503 CPU (same software compatability as the standard 6502 but with fewer address lines) is used as what might be described as a 'fairly dedicated' processor (less dedicated than those in some washing machines, more dedicated than the average home computer), i.e., solely for making music rather than indulging in pan-galactic fantasies or working out how much you'll be putting into the Chancellor's pocket!

Pitch information is derived from an encoder that scans a 7 x 7 matrixed keyboard for depressed keys. The beauty of this type of encoder, in comparison to the customary 'brute-force' diode encoder, is that polyphonic information is also encoded.

Program entry is accomplished by loading from tape, operating a touch-triggered keypad, or by accessing a PROM. The cassette interface provides visual (LED and display) and auditory (bleep tone) indication of successful loading and dumping, and unusually also offers the facility of motion control. Software for the cassette interface is derived from firmware, a PROM located on the main 8700 board. This format appears gratifyingly tolerant of speed variations and/or distortion, and caused no problems other than those derived from user error. The keypad didn't get quite such high marks, however, for though a 'bleep' provides feedback of data entry, the passive action of a capacitively-operated touch switch makes for easy mistakes when entering a long program, or when aiming a finger at a crucial control function during the middle of a bit of demonic keyboard work. On the plus side, though, this type of keypad doesn't wear out, and, as with PAIA's Programmable Drum Set, there's no doubt that you do digitally adapt to it.

Moving to the other side of the CPU, the data output, PAIA protocols use 6 bits of an 8-bit word to specify an analogue parameter (control voltage) while the other 2 bits are flags (flag 1 is used as a 'trigger', and flag 2 as a general-purpose control bit which the Quad Addressable Sample-and-Hold recognises as a glide control bit).

One digital to analogue conversion later, the newly-generated control voltage is applied to another peripheral, the QuASH (Quad Addressable Sample and Hold), which via some address lines from the CPU turns one CV (Figure 2) into multiple control parameters for multiple VCOs, VCFs, or whatever (Figure 3). The other half of the 4052 multiplexes Flag 1 giving us four triggers as well as the four CVs from each QuASH. With two QuASH's we have a system reminiscent of the Roland MC8 Micro Composer (which offers microprocessor control of eight analogue voices), but at a fraction of the cost. However, to get the maximum benefit of all this, we do need a couple of VCOs (to give a 'fat' sound) for each voice, not to mention sundry ADSRs, VCFs and VCAs.

Undoubtedly the answer to this alarming escalation of expense is to

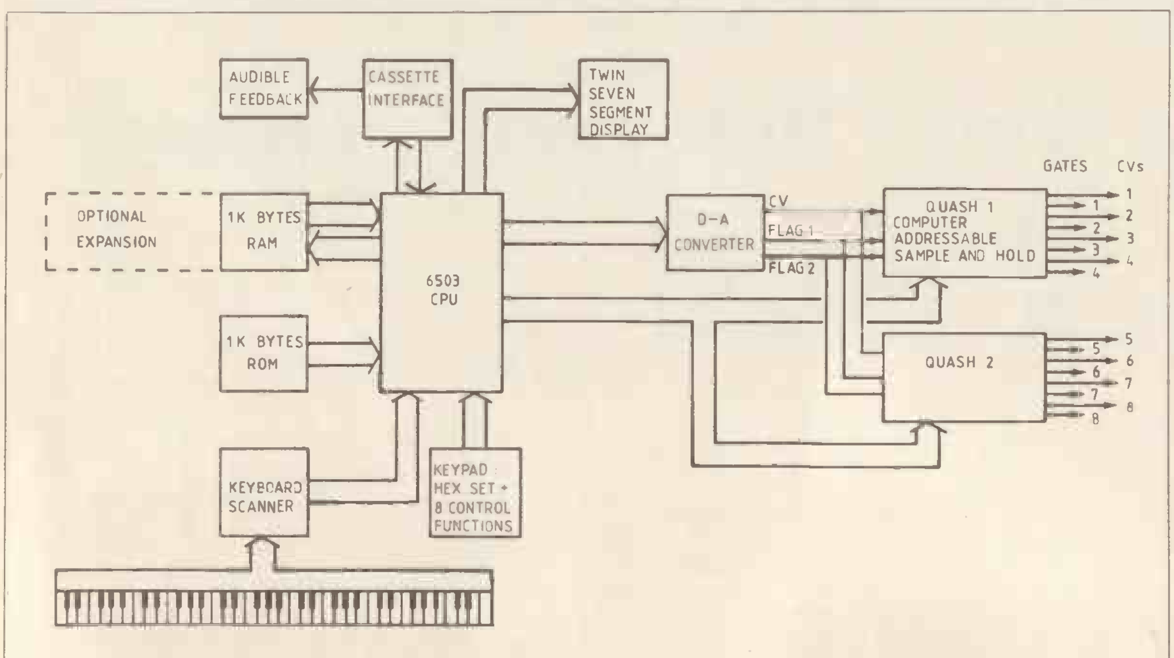


Figure 1. Block diagram of the PAIA 8700 Computer/Controller.

interface the 8700 directly with a bank of digital VCOs. In theory, digital VCOs should make VCFs and VCAs redundant since a waveform's harmonic structure and overall amplitude can be controlled in real time. As practice is inclined to be eons away from initial theory, General Instruments' AY-3-8910 may be a sensible interim step towards a super-amazing waveform generator.

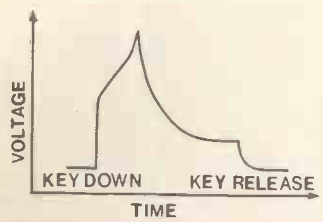
Software Options

Meanwhile, and returning to things nearer home, i.e., standard analogue synthesiser modules, it's time to look at PAIA's software options for the 8700. Over the three years since the 8700 was introduced, PAIA have produced a variety of software ranging from the sublime to the less than amazing. Table 1 gives the current options with PAIA's selling points and my 'test comments'.

To construct a program, PAIA start by running a LOOK sub-routine which, by scanning the keyboard, generates KTABLE, a list of notes held down. Another sub-routine, NOTEOUT, takes care of note output by reading the sequential entries from NTABLE, a list of notes to be outputted, and causing the D/A converter to turn key data into CVs which are assigned to the first, second, third or fourth S/H sections of the QuASH.

In between KTABLE and NTABLE comes a middle program which determines the actual personality of the program. Two straightforward possibilities for a middle program are shown in Figure 4.

Let's examine two of the software options to see what it is about the middle program that makes the 8700 more than just a pretty face. Firstly, MUS-1.0: this consists of POLY 1.0, a polyphonic allocation algorithm that assigns up to 16 depressed notes to respective channels of QuASH; INIT, an initialization routine that serves to set variables and buffer areas; and TRGN, a routine that serves as a software transient generator, a cunning substitute for the old analogue ADSR. TRGN responds to a note that has just been triggered by producing an ADSR voltage transient that is assigned to even number QuASH channels, whilst pitch setting voltages (CVs) are assigned to odd number QuASH channels. The value of this software transient generator is more apparent if we examine an ADSR transient like the following:



This sort of transient starts out as a non-percussive kind of swell with a percussive 'kick' added at the last instant before the transition to the Decay and Sustain cycles. It's also possible to defeat portions of the ADSR cycle by, for instance, going from the middle of the Attack period to the Release state without including the intermediate Decay and Sustain cycles. This exciting type of flexibility just isn't feasible with traditional ADSR's and gives you that characteristic super-sharp digital sound much in favour with rock producers.

The second program I'm particularly enthusiastic about is SEGUE 1.0. PAIA's aim is to introduce an entire family of sequencer software, ranging from a humble monophonic program to an ultra-sophisticated system capable of complex multi-tracking. At present, only SEGUE 1.0, the 'universal monotonic sequencer', is available, although the 4-channel version, POLY SEGUE, is in the proverbial pipeline.

SEGUE 1.0 seems to stand way above the rest of the monophonic digital sequencer crowd. The Electronic Dream Plant 'Spider' and Roland's CSQ100 have a reasonable note capacity (126 and 168 notes, respectively), but the options available for adjusting sequences (or, as some would say, for 'musicalizing' a sequencer), either in terms of note length or key, are nowhere near as good as with SEGUE 1.0. In the case of the 'Spider', transpositions can be effected during playback of a sequence by touching pads marked '2nd', '3rd', '4th' or '5th', which transposes the sequence downwards accordingly. This is adequate in some situations, but for instance to transpose by a 7th, it's necessary to touch the '5th' and '2nd' pads together, and this doesn't exactly make for easy operation! It's interesting to note that this is exactly the same principle as that used in EMS's Synthi DK1 keyboard, and that's almost ten years old.

With SEGUE 1.0, once a line has been played into the memory, the sequence can be transposed by depressing any note on the keyboard and, if necessary, this information can be entered into the memory as a separate transposition sequence. What's more, the entire note and transposition sequences can be dumped onto tape and recalled ad lib. With 1K RAM, the sequence length isn't exactly limitless, and, if the POLY SEGUE program were available, you'd be lucky to squash a 4-part jingle into the available memory space.

You can hear some music using this system on the E&MM demonstration cassette No. 1.

If PAIA could amalgmate a polyphonic version of SEGUE 1.0 with a routine offering software transient generators, expand memory space so that multitracking is really feasible, and add digital waveform generators, then they'd definitely be on to a winning system!

Dr. David Ellis **E&MM**

PROGRAM	FEATURES	COMMENTS
MUS-1.0	16-voice polyphonic synth with software transient generators.	An excellent allocation program and the software transient generators are a real plus.
POLY SPLIT	Splits the keyboard into two polyphonic synths with up to 8 voices each.	An extension of MUS-1.0, but, as only 4 voices were available at the time of testing, its potential was only partially realized. Even so, it was very useful for separating a bass line from upper parts.
SEGUE 1.0	A general purpose monotonic sequencer.	Very flexible, both in studio and on stage; lacks back-space editing but does provide click-track sync, real-time and event scoring, as well as a variety of manual and automatic transposition options.
POLY SEGUÉ	A 4-voice sequencer.	Not yet available.
ORGASMATRONIC GLIDE	A fast programming sequencer that plays keys held down (up to 8) in sequence up or down.	Whilst this program might get some Americans hot under the collar, it's a rather hackneyed effect, useful for getting those ultra-fast arpeggios and nice scrunchy clusters.
PINK TUNES	Composes 4-part harmonies.	Instant pentatonic Nirvana! Actually, it's a lot more adaptable than that as the program chooses notes from an updatable 16-note stack entered by the operator.
PINK FREUD	Composes 4-part canons.	Round and round and round . . .
SHAZAM	Multiple keyboard split and chorusing.	Isn't that useful unless you have multiple synth modules, but chorusing feature is nice.
ECHO	Like tape echo, but can be with different voices.	Very useful and an effect that's pretty difficult to produce any other way.

Table 1. Software options.

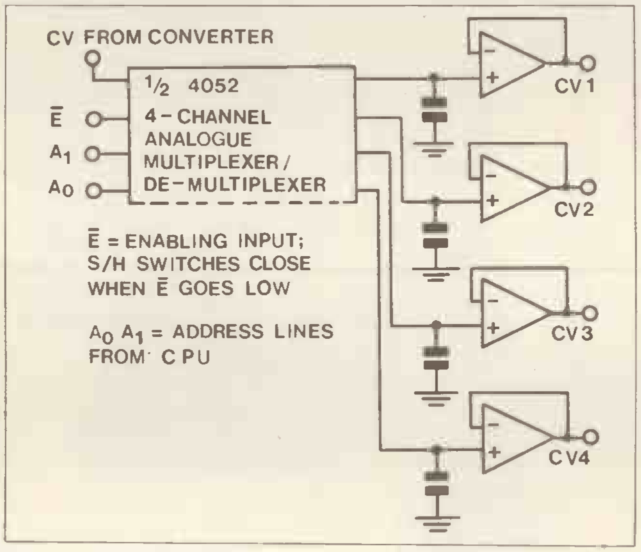


Figure 3. The basic QuASH.

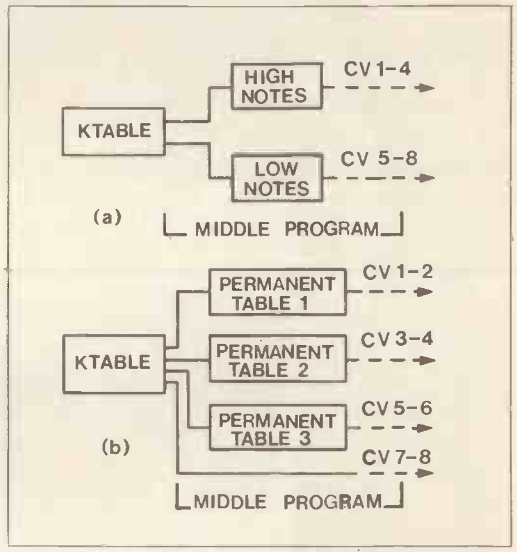


Figure 4. Two keyboard programs: (a) Split keyboard (b) Multi-tracking.

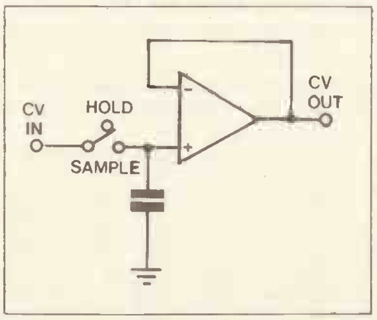


Figure 2. Simple sample-and-hold circuit.

HI-FI

Jeff Macaulay

Some interesting things have come my way this month including the new Rega R100 cartridge and some super cut records.

First the super cuts. A word of explanation is required here for those who have yet to come in contact with these products.

A 'super cut' is a Hi-Fi version of a record that is already on release. The difference is that the super cut is half speed mastered and generally of the same standard of quality as the master tape.

In addition they are normally cut on so-called 'super vinyl' which is harder and a lot quieter than the normal material. The full dynamics and frequency range of the master tape is maintained throughout the production process.

This is where the half speed cutting comes in. If the master lacquer is cut at half the normal speed, four times the energy can be put onto the disc during transients.

So much for the technicalities — how do they sound? The simple answer is terrific! On a good system one becomes aware that the source material that is normally encountered is lousy. For example, the surface noise is lower than the noise generated by the amplifier so that the quite passages are really quiet.

A most illuminating experience is to compare the normal cut with the super cut version. When this is done the former invariably sounds as if it were recorded in a dynamic vice! The differences in intensity between the loud and soft passages seem, in comparison, very small.

Lovers of rock music, like myself, will be gratified to learn that more of our type of music is being issued in this format. In particular lovers of Supertramp and Pink Floyd read on. First, some comment on three Supertramp albums released by A&M records (A&M of course are Supertramp's normal record label): 'Crime of the Century', 'Even in the Quietest Moments' and 'Breakfast in America'.

Chronologically 'Even in the Quietest Moments' was the first of this trio to be released. The original recording dates from 1977. Artistically though I personally rate this as the least worthy. The standard of musicianship is superb but the compositions lack the panache of the other two albums.

Two of the best tracks are 'Fools Overture' and the title track. If you love the normal recording though you'll go overboard for the supercut. Crime of the Century is an exceptional album, even by super cut standards. Not only is the recording superb, but almost every track is musically satisfying. In particular the drum kit in 'School' is the most accurate I've ever heard on any recording, direct cuts included. The sheer power of the instrumental has to be experienced to be believed.

The last of this trio, 'Breakfast in America', is the band's last but one offering and offers the same high technical standards. The track that stands out, in the musical sense on this album is 'Child of Vision'. The piano solo on this track is exceptional.

If you only can afford or obtain one of these albums then 'Crime of the Century' is the one to choose.

Rega Planar II Record Deck.

Supercut Records.

Ortofon VMS20E II.

Mobile Fidelity is a name that is rapidly becoming synonomous with super cut records and provides another interesting recording — the legendary 'Dark Side of the Moon', Pink Floyd album. This rock classic, in supercut, is now being imported into this country. At £12.50 though I must admit that my initial impression on listening to it was one of disappointment.

Compared to the Supertramp albums the differences between the normal and supercut versions was not so evident. After a few plays though the difference became clearer. Vocals on the supercut were more easily understood and the subtle nuances in the instrumentals were more apparent. Bass on 'Any Colour You Like' is definitely cut at a higher level and is felt more than heard.

All in all it is difficult to fault the album in a technical sense, although £12.50 is a lot of money. On a value for money basis the Supertramp albums are a better deal.

Rega R100 Cartridge

The testing of pickup cartridges is fraught with hidden difficulties. Apart from the inevitable slight differences in sound that occur due to the turntable employed there is always the chance that the sample reviewed is not representative of the stock item.

Although the measured parameters of a cartridge are interesting and occasionally revealing these do not indicate what it sounds like.

In order to write a sensible review of a product there must be some yardstick against which it is to be measured. This yardstick furthermore must be readily available. It's nonsense to compare all cartridges against a £500 Koetso, which 99.9% of readers will never hear. Similarly comparison against a G800 is equally useless.

For this reason, in future cartridge reviews the chosen reference is the VMS20E II mounted in a Rega arm. The reasoning behind this choice is simply that the cartridge is both a good performer and representative of what is actually used. The Rega arm is a high quality design that is capable of taking almost all of the cartridges currently available. It is used on the Rega planar turntable which is one of the best and is often mated with the Linn.

Having defined the reference we can get down to the nitty gritty and present a review. A new cartridge that recently appeared is the Rega R100. This moving magnet design was apparently designed completely on subjective factors. The story goes that Rega sent back the samples that the cartridge manufacturer provided, with notes suggesting improvements until a suitable sound was forthcoming. The cartridge is supplied without the usual data on compliance and output voltage.

Setting the cartridge up in the arm presented no problems. The optimum tracking force is 1.5gm and this was indeed found to be the best for tracking loud complex passages or direct cuts and digital discs.

First impressions of the sound were mixed. There was no lack of detail but compared to the reference the sound was very dry. There was, however, one area in which the cartridge really excelled and that was in presenting the stereo image. Compared to the Ortofon the sound had real depth.

Where the recording technique permitted, it was possible to determine the precise position of the instruments in space. A considerable achievement for a £37 cartridge. It should be noted, however, that obtaining this information requires that the speakers are mounted away from the walls to prevent diffraction effects.

The bass region was also better defined than on the 20E. Bass guitar notes had more of a plucked sound and bass drum sounded more natural.

The midrange was detailed and neutral but subtly different to the midrange presented by the reference. The high frequency notes lacked the sheen of the Ortofon but were equally detailed. Violins for example sounded more harsh, especially on close miked material.

All in all a cartridge that lacks the immediate attack of the Ortofon but which, on closer acquaintance performs considerably better on most counts. Prospective buyers are recommended to listen to both the Ortofon and R100, if possible, before buying. I feel that for most people the choice between the two will depend on their temperament.

Finally this month a few words on record deck support. Most people are aware that it is not a good idea to place a record deck where it is possible to pick up direct or airborne vibrations from the speakers. In extreme cases it is possible for the whole system to 'burst into oscillation'.

The problem is that the record deck and speakers couple mechanical energy to each other. The result is that the sound becomes coloured. One sure way to avoid the direct transmission of this energy is to mount the deck on a solid base. A marble slab from an undertaker's is ideal! Airborne energy can be reduced by playing records with the perspex lid down. **E&MM**

America

Ian Waugh

To those of you who have been working very hard since last month and find yourselves with $69,200.00 stashed under the mattress, I shall explain how you can rid yourself of this burden in one fell swoop. Place in a brown paper bag and leave under the third bench from the right in Central Park. Alternatively, you could invest in the AUDITY polyphonic synthesiser system from E-mu Systems. This is available with up to 16 computer-controlled voice cards (more to special order) and as the central computer has independent control over each voice, different sounds can be simultaneously assigned to different channels. The sounds are stored on floppy discs and can be edited without loss of the original sound. It boasts a 16 channel digital memory sequencer which allows the storage of up to 6,000 notes of multi-track composition. The system works on a 1 volt/octave control system and the user can assign different controllers to the various channels so 16 musicians could play the AUDITY at the same time. An extensive range of special-function software is available to extend its capabilities even further.

Electro-Harmonix have now available a new percussive instrument controller called the CLOCKWORKS CONTROLLER.

This instrument is capable of generating rich and complex rhythms with many variations. It is used to control several different Electro-Harmonix electronic drums and effects with variable electronic pulses from its five independent outputs. These controllable pulses from the 'Clockworks' trigger the various drum modules in the same manner as drum sticks do when they strike the pads.

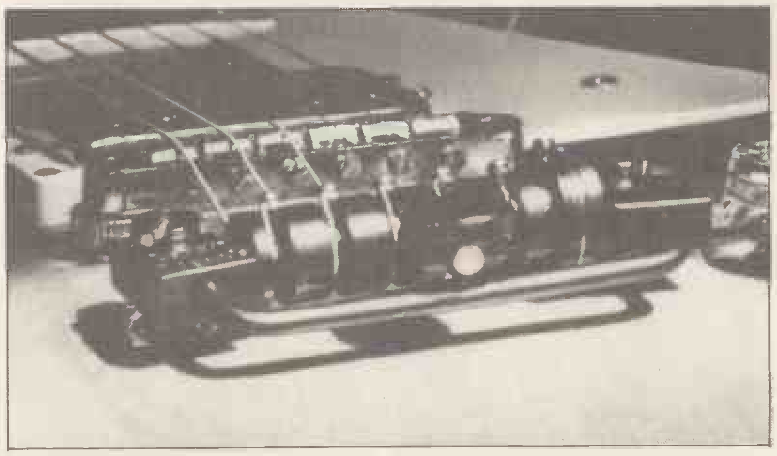
The pulses from the Clockworks can vary automatically, or the player can manipulate its ten slide controls to synthesise rhythmic patterns in real time.

Modulations from the 'Super Space Drum', bursts of pink noise from the 'Crash Pad', handclapping mixtures from the 'Clap Track' can be mixed with note sequences to produce creative exciting effects.

Also their Ambitron, available in America for some time now, is heading for England. This takes a single mono output and splits and 'broadens' it to a stereo image. It will probably be selling for around £79.

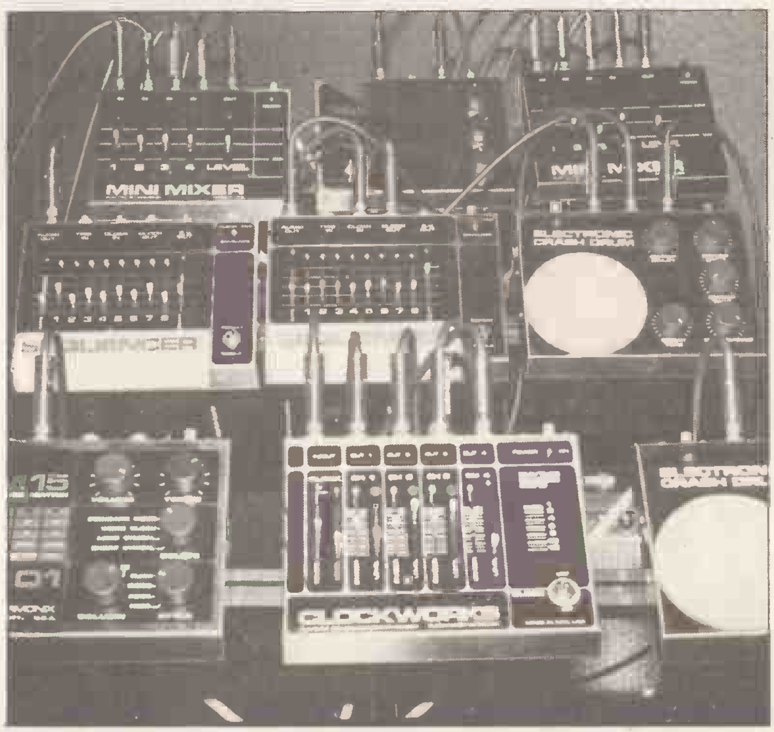
An interesting device from Lenny Pogan Productions is the Pitchfinder which replaces the 'stop' tailpiece on certain guitars. It enables you to retune all six strings simultaneously over a range of 100 cents (one semitone). Aimed at guitarists who play along with records and radio, it could be useful.

Ampersand have developed a Link system which can be added to Sequential Circuits' Prophet 5. It allows for separate control and gating of the Prophet's 5 voices. The Link consists of ¼ inch jacks for each of the



Lenny Pogan Pitchfinder.

Multivox Big Jam Effects.



Electro-Harmonix Clockworks Controller set-up.

voices' gate and control voltage inputs and outputs. Unison gate and control voltage inputs and outputs are also available and five switches select the voices to be controlled by the Link. The system will interface with the Roland Microcomposer and similar units. Guitar synthesisers and other instruments using a 1 volt/octave control system can also be used. Price is $990.00 installed by Ampersand.

The XL-210 Master Room reverb system from Micmix Audio is a self-contained 3½ inch rack mounted unit containing two independent stereo channels that are switchable to mono. The unit can be fed by either balanced or unbalanced lines and the unbalanced outputs will drive a 600 ohm load. Both channels include active equalization and chamber isolation techniques that enable the unit to be used near loudspeakers without feedback. The unit has been designed for road use and operates on 120 or 240 volts. Cost is $950.00.

Multivox have a new series of 10 effect units called Big Jam. They incorporate FET switching and LED operation indicators. All are battery-powered and have battery-check switches but an AC adapter is also available. The units comprise a graphic equaliser, an envelope-controlled filter, a compressor, a distortion unit, an octave follower, two phasers (one being a dual phaser), an analogue echo and two flangers (one is a flanger/overdriver combination).

Loft Modular Devices introduce a Series 450 Delay Line/Flanger capable of producing doppler, choral and delay effects. The unit is rack mountable and AC powered. Delays available are from 4 to 160 milliseconds for echos and 5 to 20 milliseconds for flanging. LEDs show operating mode and signal level and external control of the unit is possible by control voltage inputs and outputs. Total harmonic distortion over a range of 20Hz to 20kHz is reckoned to be 0.5%. Output noise is quoted as -78dB.

If you are one of those musicians who cannot keep their hands still and are continually playing scales up and down table-tops, over your jam sandwiches and up and down your legs — or your girlfriend's — (I hope you wipe your hands first), then Sports Health have just the answer (assuming you want to kick the habit). It comes in the form of a hand-developing putty, a rubbery/silicone material designed for twisting, pulling, stretching, punching and other grisly operations. It is intended to develop manual strength and dexterity and thus be an aid to musicians' digits. The putty is a blue colour and comes in a silver-coloured case shaped like a fist. An illustrated exercise booklet is included and the whole costs $6.50. I seem to recall seeing some 'heavies' kneading something similar as they lounged languidly in seedy doorways. You know, this could be dangerous — in the wrong hands. (Sorry!)

Companies and manufacturers mentioned:

E-mu Systems Inc., 417 Broadway, Santa Cruz, CA 95060.

Electro Harmonix, 27 West 23rd Street, New York, NY 10010.

Lenny Pogan Productions, Inc., Cathedral Station, Box 353A, New York, NY 10025.

Ampersand, 9548 E. Zayante Road, Felton, CA 95018;

Micmix Audio Products, 2995 Ladybird Ln., Dallas, TX 75220.

Multivox, 370 Motor Parkway, Hauppauge, NY 11787.

Loft Modular Devices, 91 Elm Street, Manchester, CT 06060.

Sports Health Products, 527 West Windsor Road, Glendale, CA 91204.

E&MM

RECORD REVIEWS

Telekon
by Gary Numan
ATCO SD 32-103

Gary Numan's latest LP (a Beggars Banquet recording) is a mediocre collection of ten tracks each immediately identifiable as a Gary Numan product.

Musically the album lacks imagination — hardly any use is made of dynamics except to fade out at the end of a track. The synthesised percussion guarantees a constant tempo and the main theme is invariably played on a synthesiser with screaming frequency modulated oscillators and swishing phasing. Technically the album deserves a little more merit. It contains some interesting sounds synthesised by several types of synthesisers (Polymoog, Minimoog, A.R.P. Pro-Soloist and Prophet 5) and also strings and piano.

Gary Numan's voice penetrates through the complex waveforms but to help decipher his unique pronunciation the lyrics are printed on the inner sleeve of the album. I will leave the interpretation of the lyrics to Gary Numan fans since, like the song titles, their meanings to me are ambiguous.

A Gary Numan fanatic will not be disappointed with this record but if you are just extending your record collection to include electronic music, I would advise you listen to a copy of this album before you considered buying it.
Graham Hall.

Possible Musics
Jon Hassell/Brian Eno
Polydor EGED 7

Over the past centuries, since music has evolved from pure emotion through to purist appreciation there has always been various slots for music to be in i.e. Classical, Jazz, avant-garde etc., etc. When a composer has fused several ideas or forms together it can still be labelled as a type, however listening to Possible Musics is an experience in itself, there is no tag.

Possible Musics exudes emotion, from the sensual down to the depressive state.

The instruments used are mainly trumpet, bass, congas and electronic treatments with subtle synthesiser usage and the range of sound is quite astounding because the electronic processing adds a new dimension to basic instrumentation in such a way that you cannot discern between reality and dimension.

Hassell's use of a trumpet with harmonizer works very well, allowing what most composers want to do with electronics, to add textures and control previously unknown.

Possible Musics is a total concept, a combination of ethnic and traditional stretching to the most diverse and cunning usage of electronics. I would recommend to anyone who is composing or recording live electronic music to broaden their horizons by listening to Possible Musics.
Vince S. Hill.

Flash Gordon
by Queen
EMI EMC 3351

Here we have it: on a single LP a remixed and abridged version of the soundtrack of Flash Gordon, the remake that masterfully combines spoof with tribute to the original 1930's 'Flash Gordon Conquers the Universe', on which its plot (if one can call it such) is loosely based.

The story has been given a 1980's presentation, including a typical American Boy ('Just a man, with a man's courage') and Girl ('Look, water is leaking from her eyes!'), and the features of the now very dated original which have been retained, including Professor Zarkov's minimalist rocket 'capsule' with a fire button and a decelerator pedal as the only controls, give the film a very tongue-in-cheek quality which demands that it be taken less than seriously for maximum enjoyment.

Unfortunately the same must be said of Queen's soundtrack music which, with a few exceptions, is particularly uninspiring, especially on record without the film to back it up. This seems often to be so with the latest wave of films having pretensions to Science Fiction (witness the Black Hole and Star Trek — The Movie), but since so much noise has been made about the band's involvement, we could have expected some music of more original value. The Queen multitracked vocal sound that first got their LP's noticed (have another listen to the grand opera section of Bohemian Rhapsody) and drew accusations of Sweet-plagiarism at the time is little in evidence except for in the opening track 'Flash's Theme', released as a single. Brian May's much sought after 'muffled fuzz' guitar sound is also largely lacking. In fact most of the music is incidental, a mixture of simplistic synthesiser playing (probably Oberheim homogenous poly's) and orchestral arrangements.

On their early albums the band expressed their childish contempt of synthesisers in general with the appendage to the credits 'and nobody played synthesisers' (to which Larry Fast responded 'and nobody played guitars' on the sleeve of his 'Electronic Realisations for Rock Orchestra') but now it appears we have a policy U-turn, perhaps an attempt by the band to drag themselves up-to-date. EMI's publicity blurb for 'Flash Gordon' reveals that though all members of the band use synthesisers on the LP, they only started playing them last June. Presumably this is for the benefit of those who have not yet heard the music; after seeing the film and listening to the record it certainly comes as no surprise to me. Most playing consists of phase and cycling filter type sounds used as atmospheric mood-setters, accompaniment, or occasionally lead. Laser fire and other effects sounds abound, the former based on intense pitch modulations at around 10Hz and extreme envelope sweeps, in fact just what one would expect from an inexperienced and unimaginative player who starts with everything turned up and then 'mucks about' until he finds something he likes.

The possibilities offered for experimentation in a score for a film such as this are vast, so perhaps Queen have found the medium that suits their approach to synthesis — certainly it will give them a chance to get the practice they need in order to catch up with everyone else.

The album sleeve lists no less than eighteen separately titled tracks, though the boundaries are often obscure and the total playing time is only about 35 minutes. The best of these are undoubtedly 'Flash's Theme', though its multiple reprises soon become tiring, 'Vultan's Theme', and 'Football Fight'. The latter is rocky instrumental featuring guitar and synthesisers, and is punctuated by repeated 'klonk' sounds, which will no doubt get many of you who have not seen the film wondering. However, I think this is definitely an LP for fans of the film rather than Queen fans, containing carefully chosen sections of the film script that appear between and over the music. These keep the storyline going so that the listener knows what is going on in the scene that uses each piece of music, and include hilarious snippets such as '... unpredicted solar eclipse no cause for alarm ...' (Newscaster), 'Forget it, Ming. Dale's with me!' (Flash), and the much reported 'Flash, Flash, I love you, but we only have fourteen hours to save the Earth!' (Dale). They turn what would have been a pretty boring 'music-from-the-film' LP into a REAL soundtrack album, which is an excellent memento of the film and of course, great fun!
Chris Jordan.

BOOK REVIEWS

Introduction to Computer Music
by Wayne Bateman
Published by J. Wiley & Sons
Price £15.20

At last, a book that gives an accurate and readable introduction to the subject of computers in music. Unlike many books with that word in their titles, this really is an introduction, dealing with all relevant aspects of computer science and musical acoustics.

The preface says that it is primarily intended for the musician, and although no prior knowledge of computer science or electronics is required, the book is involved enough to interest the more technically-minded reader. The sections on musical acoustics in particular are superb and better than those in most electronic music books. The discussion of frequency domain analysis is particularly excellent, and deals with the meaning of the analyses of non-periodic signals such as isolated instruments tones; a subject which is difficult for musicians and engineers alike to grasp and one which regrettably I have never seen covered in a book of this type before.

A non-technical introduction to the operation of a computer preceeds discussion of programming, including algorithms, flow charts, and high and low-level languages. This is then applied to simple methods of tone-generation by computer, complex tone synthesis, and the organisation of the hardware and software components of a computer music synthesis system to allow communication with the composer/programmer in the most useful terms without sacrificing versatility. The increasingly important field of computer processing of natural sounds is given an up-to-date treatment, and the simulation and reproduction of natural sounds is covered separately from original synthesis. The book ends with a chapter on computer composition of music, and a thought-provoking discussion of the meaning of machine and human creativity, a particularly tricky subject to write upon.

The book is illustrated throughout with excellent diagrams, mostly computer-drawn, the accuracy of which is very important for explanations of waveform analyses etc. There's not a semicircular 'sine' wave, or 'square' wave with rounded corners, all too common in less authoritative electronic music books, to be found anywhere here.

Introduction to Computer Music should appeal to all musically minded engineers and technically minded musicians who want to find out about the musical applications of computers. It could even be useful to analogue synthesists who require more advanced information on tone-forming techniques than available from electronic music books.
Chris Jordan.

Electronic Music Projects
by R. A. Penfold
Published by B. Babani Ltd
Price £1.75

Mr Penfold's name is already familiar to many constructors and in this book he presents twenty-three original music related projects aimed at the hobbyist who already has some experience of building electronic circuits. They are presented in the categories Guitar Effects Units, General Effects Units, Sound Generator Projects, and Accessories, and though most are fairly basic they include a reverb unit, guitar practice amplifier and 3 channel sound-to-light unit.

The function and circuit operation of each project is explained with reference to large, clear circuit diagrams and sometimes graphs and other diagrams. The designs cover a wide range with some appearing as complete units and others as modules for use with other circuitry. The latter is particularly the case with the sound generators — the tone and noise sources could be used with some of the modulating and effects circuits to form a simple experimental electronic music system for the beginner.

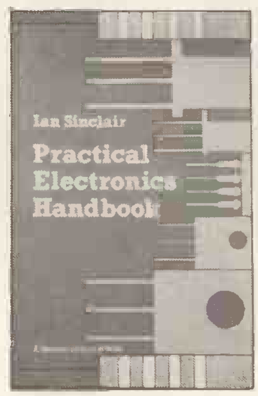
The function of the major components in the circuits are explained well, and since various different design techniques are used, all projects should prove instructive to the reader who only intends to build a few. For example, in the designs which involve electronic control of gain such as the Sustain Unit, Amplitude Modulator and Voice Operated Fader, alternative approaches using a discrete opto-coupler, an FET, and a voltage controlled attenuator IC are used with the properties of each device explained.

There is a good balance between discrete and IC circuits with the commonest types of IC, including op-lamps, power amps, timers, and logic well represented. All components used are easily obtainable and all but one project are powered by 9V batteries.

Board layouts and constructional details are not given, except for short notes for the few projects where the layout is likely to affect operation. Hence the book is not suitable for the total beginner, but includes more projects than would otherwise be possible for those hobbyists who can work out the construction for themselves.
Chris Jordan.

Practical Electronics Handbook
by Ian Sinclair
Published by Newnes Technical Books
Price £4.05

Ever wished you had a book which contained all the necessary information to design your own projects, to your own specification, without having to refer to a daunting pile of literature, concerned only with their own specific type of component?



Books like that are rare and authors capable of producing such a book, with less than two-hundred pages of essential information, are normally only found on Betelguese. It does not come as a surprise then, that the book I have just read was written by Ian Sinclair, for nowadays his name, in modern electronics is synonymous with Shockley or Voltaire.

Briefly, the contents are divided into the following sections: Passive components, Active discreet components, Discreet component circuits, Linear ICs, and Digital ICs.

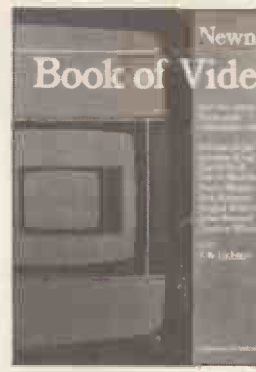
A nice bonus is the addition of pin out details for TTL and CMOS ICs appended to the chapter on digital ICs.

If you have ever had difficulty in understanding the part that a passive component plays within a circuit, or have been unsure of the results expected, when its value is changed, then this is the book for your — however with all the equations it contains you had better keep it on the work bench, preferably somewhere near your calculator.

The book's best quality, is that having once explained the theory, you are given the opportunity to try your own practical working models, with the circuit examples shown, and hence, draw your own conclusions.

As a final point, I should mention, that this book is not aimed at the absolute beginner, it is more for the enthusiast who has become fed up with simply building projects, without really understanding how they work.
Nigel Fawcett.

Newnes Book of Video
Edited by K. G. Jackson
Published by Newnes Technical Books
Price £5.95



The Newnes Book of Video, is a compilation of manuscripts, submitted by various experts in their field.

The book does not really leave one with the feeling of greater knowledge, or insight into the subject. It tends more to confirm what was already suspected, only slightly improving one's foreknowledge.

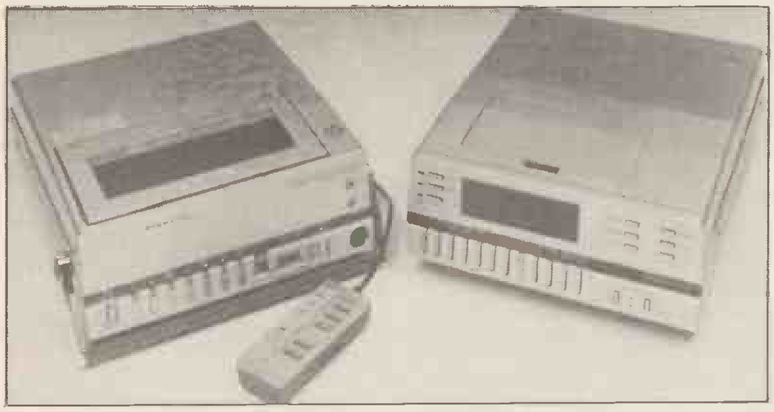
Each section of the book covers a different sphere in the science of video-technics. Unfortunately, the layout is not dissimilar to a spaceship, relaying information about a subject, that only orbits around the topic in question, never actually landing, to take a closer look. This technique, is the same as that used in the correlation of encyclopaedia's, that is; each entry stating the minimum of facts required to purvey a fair picture of the article described. This approach is fine for those who know nothing of the subject, but is not for those whose appetite has already been whetted, and are not satisfied with the basic facts.

An interesting little deviation, from standard, technical journal layout, is the friendly opening to each section, by introducing the particular contributor on a personal note, with a photograph, and a few words about his technical background.

Do not get me wrong. The book is well written and easy to read, it is just that I did not find it absorbing, due to lack of fresh data.
Nigel Fawcett.

NEW PRODUCTS

HITACHI VIDEO RECORDER



New from Hitachi comes a redesigned portable VHS video recorder. Styled in the current inscrutable satin look, the system comprises lightweight recorder, tuner/timer, power adaptor and a new 'low cost' camera. The new line is known as the 7000 series and combines the desirable freedom of a lightweight portable recorder with all the user features previously found only on the big domestic machines, such as full remote control, still frame and slow motion.

A colleague was so impressed that he bought one before we even had a review sample — it does all it claims and even provides clean 'crash' edits. Highly recommended — the total suggested price is over £1,000 but we suggest you check around the discount stores.

Also new from Hitachi are the VT-8000 and VT-8500 mains video recorders. The VT-8500 is the more sophisticated unit featuring visual search, pre-programming and cordless remote-control for 12 functions. Other interesting facilities include speed control, picture sharpness adjustment, automatic tape indexing in rewind or fast-forward, and auto channel lock during recording.

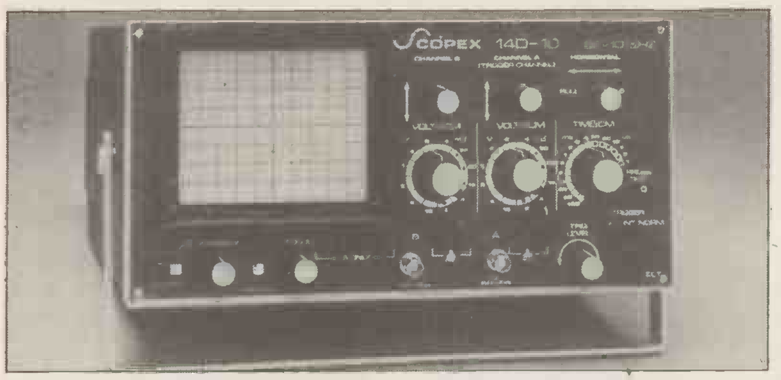
ANTENNA TRAINER

A new product from Feedback Instruments for the educational field is a system designated the ASD512 Antenna Systems Demonstrator.

Designed to introduce students to the basic concepts of most types of antenna in common use, the ASD512 consists of an R.F. Generator unit which has variable output power and an R.F. Wattmeter which can be switched to display power output from the generator and also power reflected by the antenna.

It has a collection of nickel plated brass tubes with which the various antenna types are built up and a number of connections with integral bulbs such that bulbs are connected in series with the antenna elements and give a clear visual indication of the current standing wave on the elements. The system also includes two hand-held detectors. One is a current and voltage 'field' probe giving a linear LED display and the other is a receiving dipole which is used to show the field strength of the radiated signal at various polarisations (both detectors being powered by Ni-Cad batteries which are re-charged from the generator unit).

Feedback Instruments Ltd, Park Rd, Crowborough, Sussex TN6 2QR.



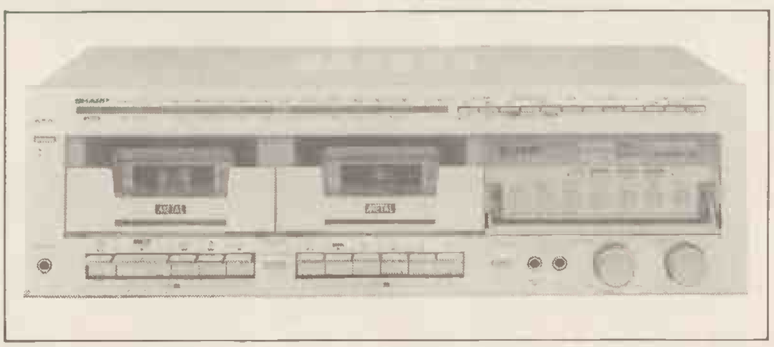
DUAL BEAM OSCILLOSCOPE

A new low cost oscilloscope has been introduced by Scopex Instruments. Designated the 14D-10, this dual-beam instrument has a 14cm rectangular tube (10 x 8cm display graticule) a verticle sensitivity on both channels of 2mV/cm to 10V/cm in 12 steps and a timebase which ranges from 100ms/cm to 1us/cm with a x5 expansion option to give 200 ns/cm.

Bandwidth is claimed to be DC to 10MHz (-3dB) and the trigger control has been modified from the standard Scopex range such that positive and negative edge triggering is achieved by a polarity selection switch rather than adjustment of a pot.

Add and invert facilities are provided, as is push-button X-Y (ideal for Lissajou figures and logic analysis). The power supply is of the switched mode type, thus reducing weight and increasing reliability. Price for the 14D-10 is £230 + VAT.

Scopex Instruments Ltd,
Pixmore Industrial Estate,
Pixmore Avenue, Letchworth,
Herts SG 6 1JJ.



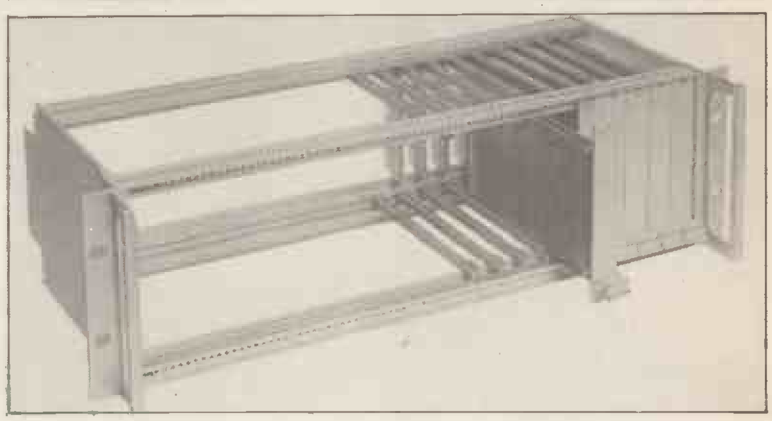
SYSTEM 700

Ideal for the electro-music enthusiast is the Sharp System 700.

The heart of the system is the SC-700X stereo receiver/double cassette deck. The SC-700X has two cassette mechanisms, both with Dolby, one with Sharp's unique APSS and both with 'one-touch start'. The receiver section covers AM medium wave (510-1620kHz) and FM (87.6-108MHz) with an output power of 25W RMS into 4 ohms at 0.5% THD with both channels driven.

A bonus is the ability to use metal tapes with both cassette mechanisms. Editing, dubbing and mic-mix recording are all made simple by comprehensive controls.

The finishing touches to the System 700 are a belt-drive turntable and a rack to house the cassiever and turntable. Sharp Electronics (U.K.) Ltd., Thorp Road, Newton Heath, Manchester M10 9BE.



CARD FRAMES AND CUTTERS

West Hyde Developments Limited has introduced a range of high quality, low cost 19" card-frames.

Their Swiss-made frames are available in two depths, 210mm or 270mm with heights of 133.35mm (5¼") and 266.7mm (10½") as standard or 400mm (15¾") to special order.

The frames are suitable for three connector types, Mil-C-21097, DIN 41612 and DIN 41617. Prices start from £18.23 + VAT for one-off with the usual generous discount for quantity orders.

Also from West Hyde, two new hand reamers with integral Tommy-bars. The smaller of the two covers the range from 3.2mm to 12.7mm and the larger manages anything between 9.7mm and 25.4mm. Both card frames and reamers are available from: West Hyde Developments Ltd., Unit 9, Part Street Industrial Estate, Aylesbury, Bucks HP20 1ET. Tel: Aylesbury (0296) 20441/5.

MUSIC MAKER EQUIPMENT SCENE

Frankfurt Music Fair is widely known as one of the most prestigious music fairs, and manufacturers and distributors from all over the world filled three halls of the huge exhibition centre from February 7th to 11th to show their latest musical equipment.

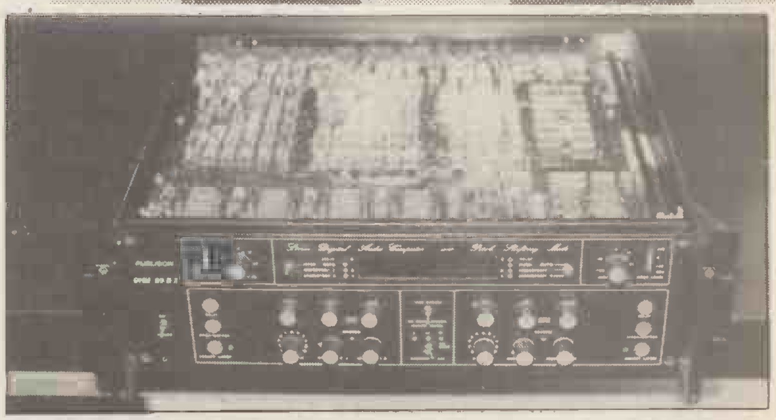
This year's fair was certainly one of the biggest with over 600 exhibitors, including more than 90 UK companies. A visit to all the stands can take a couple of days and if all the demos are attended and instruments tried, then a lot more time is needed.

On the electro-music side, new synthesisers and organs have benefited from computer technology at both ends of the price scale with rhythm boxes improving as well. Disco gear now appears in rack-mounted control boxes that give further variations of strobe, sequence, ropelight and laser effects, plus touch plates to 'play' lights. Sound mixers were orientated towards the home studio and effects boxes at last have electronic switching. Electronic drums are here to stay and electric guitars in two-tone colours, different body shapes and active tone controls are now available.

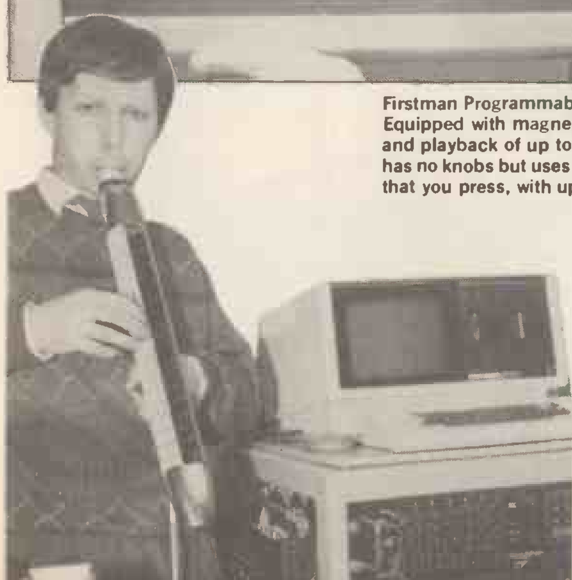
Here are just a few photos of the electronic instruments from the exciting stand displays. We'll be taking a closer look at some of these in forthcoming issues.

The new Yamaha Grand 'Synthesiser' GS-1 has 8 factory preset sounds for both left and right halves of the keyboard and an incredible touch response — listen to our cassette!

Firstman Programmable Synthesiser FS-10C. Equipped with magnetic cards for recording and playback of up to 8 channels. It also has no knobs but uses printed panel switches that you press, with up/down digital control.



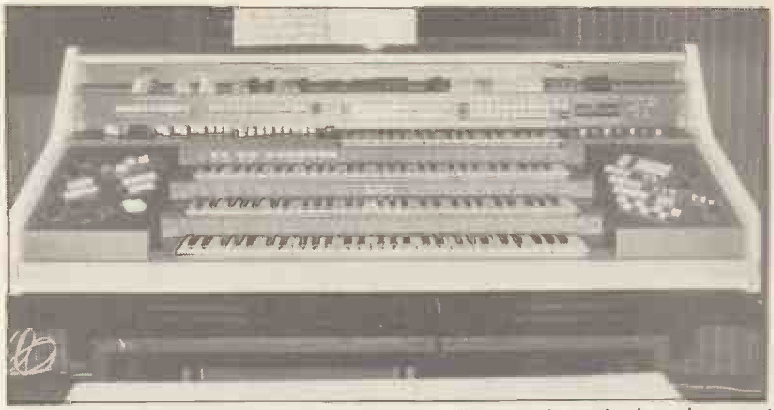
The D.H.M. 89B2 is a stereo audio computer which allows dual digital delay, pitch shifting, automatic arpeggio, reversed sound. It can repeat a memorised sound indefinitely. Electronics hold a 16-bit A/D converter with 95dB dynamic range and 210k bits memory.



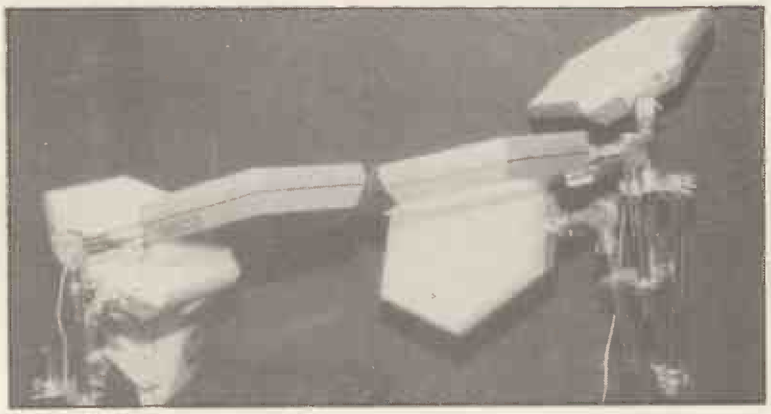
The 'Variophon' has an electronic keyboard that reproduces the sound of acoustic wind instruments. Played through a recorder type mouthpiece for dynamic and tone modulation through breath control, and with plug-in modules for individual brass and woodwind instruments.

The 'Treble' upright piano actually has a complete synthesiser sounding from its keys as well as a drum rhythm box for accompaniment.

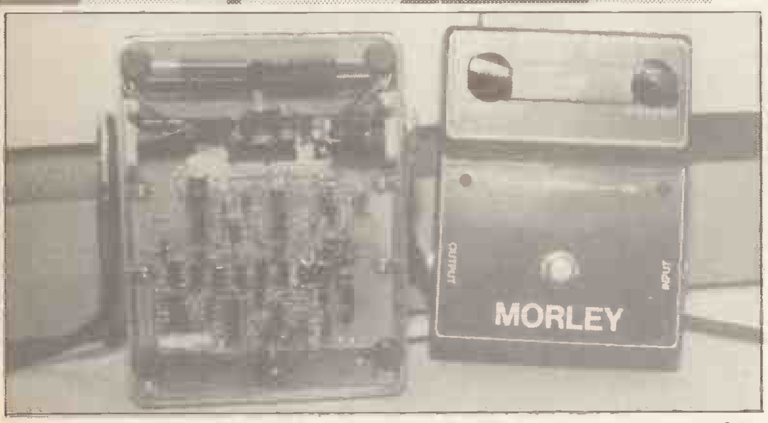
MUSIK MESSE FRANKFURT



Three 61-note manuals, a 25-note pedal board, a 37-note solo synthesiser plus a vast rhythm accompaniment section. Chorus 'ah', 'uh' voices, saxophone, chimes, sitar, thunder and bird affects, clap, siren, timpani, etc., etc! — the Kawai T-30.



Here's the latest electronic drum kit from Dave Simmons called the SDSV. Each drum has 1 preset and 3 programmable memories stored in a 19" rack. Bass drum, snare, tom tom and hi-hat are now available, with cymbals, cowbells and special effects to follow.



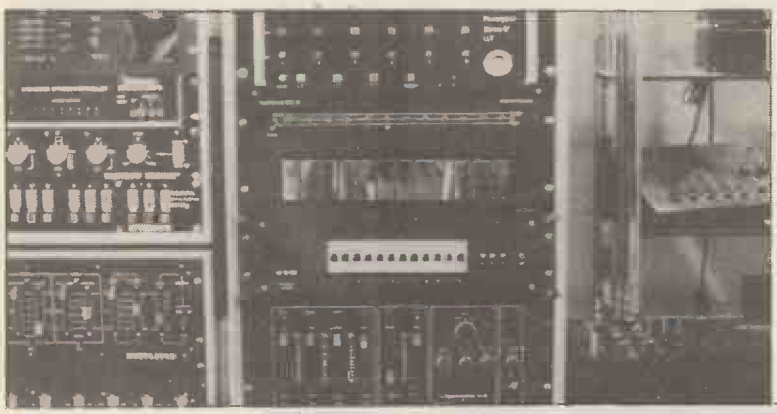
The Morley De-Luxe Phaser is the newest effects unit from this American company. Other effects available are Super Distortion, Compressor, De-Luxe Flanger and Noise Gate/ Line Driver.

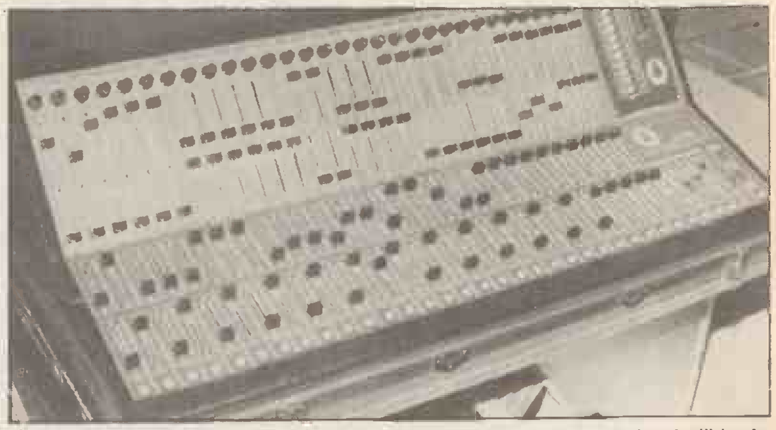
Wersi's Galaxis organ W4SKT Is their top of the range instrument that you can build. An Industry Profile on this German company will appear soon.

An 8-Voice Polyphonic Synthesiser from Korg called the Trident. Up to 16 different polysynth tone colour program settings can be memorised with additional piano sounds also available. It also features a brass/synth section, string ensemble, keyboard split and flanger.

The 'Kaleidophon' has 4 dynamic and pitch sensitive 'strings' which are electronically tuned and adjustable for left hand guitar, bass, violin and other string instrument playing, whilst the right hand controls many extra effects.

Here's part of Amptown distributors range of rack mounting lighting controllers — notice the chrome touch plates for 'playing' lights. This company from Hamburg, Germany has a vast range of effects controllers including 'Fog' generators, pulsars, rainbow strobe and chasers.





Not a sound mixer but a light controller! It comes from Artick in Italy. It has facilities for multi-scene dimming, flashing and cassette storage of memory positions.

MUSIK MESSE FRANKFURT

Next month's Industry Profile looks at the development of UK's new synthesiser factory, the Electronic Dream Plant. Their latest instrument, the Wasp DeLuxe has a proper keyboard to replace the earlier Wasp's touch sensitive version.

E&MM

PORTABLE RADIO CASE

Size. 11 x 8 x 3¼ ins approx. Made from ply wood, pleasingly covered. Suitable for any normal radio circuit. Has studs for mounting 5" speaker and the front is drilled to take a tuning condenser in the centre and normal controls either side. £2.30 + £1.50 post.

LAST MONTH'S SNIP – STILL AVAILABLE

And it still carries a free gift of a desoldering pump, which we are currently selling at £6.35p. The snip is perhaps the most useful breakdown parcel we have ever offered. It is a parcel of 50 nearly all different computer panels containing parts which must have cost at least £500. On these boards you will find over 300 IC's. Over 300 diodes, over 200 transistors and several thousand other parts, resistors, condensers, multi-turn pots, rectifiers, SCR, etc. etc. If you act promptly, you can have this parcel for only £8.50, which when you deduct the value of the desoldering pump, works out to just a little over 4p per panel. Surely this is a bargain you should not miss! When ordering please add £2.50 post and £1.27 VAT.

MAINS MOTORS

Precision made as used in record players, blow heaters, etc. Speed usually 1,400. All have ample spindle length for coupling fan blade, pulley, etc. Power depends on stack size. 5/8" stack £2.00; ¾" stack £2.50; 7/8" stack £3.00; 1" stack £3.50; 1½" stack £4.50. Add 25% to motor cost to cover postage, and then add 15% VAT.

YOUR LAST CHANCE FOR THIS BARGAIN

100 twist drills, regular tool shop price over £50, yours for only £11.50. With these you will be able to drill metal, wood, plastic, etc. from the tiniest holes in P.C.B. right up to about ¼". Don't miss this snip – send your order today.

MAGNETIC LATCH

Low voltage (4 - 8 volt AC/DC operation). Only £1.50 each.

PUNCHED TAPE EQUIPMENT

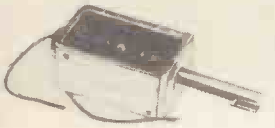
For controlling machine tools, etc, motorised 8 bit punch with matching tape reader. Ex-computers, believed ingood working order, any not so would be exchanded. £17.50/pair. Post £3.00.

STEREO HEADPHONES

Japanese made so very good quality. 8 ohm impedance, padded, terminating with standard ¼" jack plug. £2.99 Post 60p.

BRIDGE RECIFIER

1 amp 400v 30p each. 10 for £2.50. 100 for £20.00

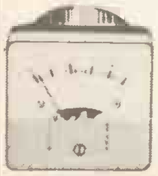


SOLENOID WITH PLUNGER

Mains operated £1.99
10 – 12 volts DC operated £1.50.

MOTORISED DISCO SWITCH

With 10 amp changeover switches. Multi-adjustable switches all rated at 10 amps, this would provide a magnificent display. For mains operated 8 switch model £6.25, 10 switch model £6.75, 12 switch model £7.25.

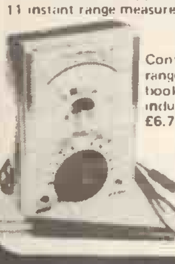


PANEL METERS

Japanese made, full vision front, size 2¼" x 2¼". 0 - 100 uA £2.85. Similar but size 2" x 1¾" 100 uA, scaled Vu. Ditto, but scaled 0 - 100. (note: front covers easily removable if you want to rescale these £2.30 each) Ditto but size 1¼" x 1¼", scaled Vu, sensitivity 100 uA, £1.50.

MINI-MULTI TESTER

Deluxe pocket size precision moving coil instrument, jewelled bearings – 2000 o.p.v. mirrored scale. 11 instant range measures: DC volts 10, 50, 250, 1000. AC volts 10, 50, 250, 1000. DC amps 0 – 100 mA. Continuity and resistance 0 - 1 meg ohms in two ranges. Complete with test prods and instruction book showing how to measure capacity and inductance as well. Unbelievable value at only £6.75 + 50p post and insurance.



FREE Amps range kit to enble you to read DC current from 0 - 10 amps, directly on the 0 - 10 scale. It's free if you purchase quickly, but of you already own a Mini-Tester and would like one, send £2.50.

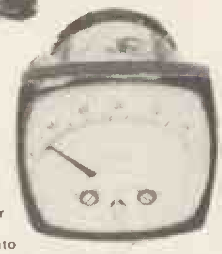
SUPER HI-FI SPEAKER CABINETS

Made for an expensive Hi-Fi outfit – will suit any decor. Resonance free cut-outs for 8" woofer and 4" tweeter. The front material is carved Dacron, which is thick and does not need to be stuck in and the completed unit is most pleasing. Colour black. Supplied in pairs, price £6.90 per pair (this is probably less than the original cost of one cabinet) carriage £3.50 the pair.

LOUDSPEAKERS

8" woofer and 4" tweeter, 4 ohms 35 watts power rating £6.90 per pair. Ditto but 8 ohms, £11.50 per pair. Post £2.00.

ELECTRONIC VOLT-METER/ SENSITIVE RELAY

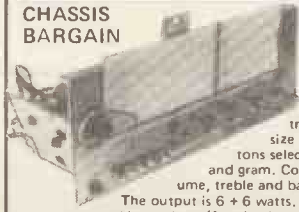


Consists of a 4½" square drop through panel volt meter, 0 - 10 fed. Built into the front of the meter are two screw adjusters which move two pointers, up and down the scale, to set a minimum and maximum. A unique "under" and "over" circuit inside the meter operates one of two reed relays to bring an 'under' or 'over' circuit into action. The scale plate is detachable via two screws to be calibrated to your own individual requirements. The 10 transistor 'under' and 'over' circuit is completely separate from the meter movement so does not have to be connected to use this as a standard 0 - 1 meter. Many uses including level controls, light controls, auto battery chargers, alarm units, etc. Manufacturers list price of over £120 each. An unbelievable snip at £9.95 (less than the value of the meter alone.)

THIS MONTH'S SNIP

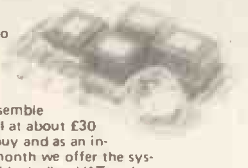
Vu METER Approximately 1 5/8" square, sensitivity 0 - 500 uA suitable for use also as a recording level meter, power output indicator or many similar applications. Full vision front cover easily removable if you wish to alter the scale. Special snip price £1, or 10 for £9. post & VAT paid.

CHASSIS BARGAIN



3 wave band radio with stereo amplifier. Made for incorporation in a high-class radiogram, this has a quality of output which can only be described as superb. It truly hi-fi. The chassis size is approx. 14". Push buttons select long, medium, short and gram. Controls are balance, volume, treble and bass. Mains power supply. The output is 6 + 6 watts. Brand new and in perfect working order, offered at less than value of stereo amp alone, namely £6.90. Post £2.50.

MULLARD UNILEX



A mains operated 4 + 4 stereo system. Rated one of the finest performers in the stereo field this would make a wonderful gift for almost anyone. In easy to assemble modular form this should sell at about £30 – but due to a special bulk buy and as an incentive for you to buy this month we offer the system complete at only £16.75 including VAT and post. FREE GIFT – buy this month and you will receive a pair of Goodman's eliptical 8"x 5" speakers to match this amplifier.

VENNER TIME SWITCH

Mains operated with 20 amp switch, one on and one off per 24 hrs. repeats daily automatically correcting for the lengthening or shortening day. An expensive time switch but you can have it for only £2.95. These are new but without case, but we can supply plastic cases (base and cover) £1.75 or metal case with window £2.95. Also available is adaptor kit to convert this into a normal 24hr. time switch but with the added advantage of up to 12 on/offs per 24hrs. This makes an ideal controller for the immersion heater. Price of adaptor kit is £2.30.

DELAY SWITCH

Mains operated – delay can be accurately set with pointers knob for periods of up to 2½hrs. 2 contacts suitable to switch 10 amps – second contact opens a few minutes after 1st contact. £1.95.

LEVEL METER

Size approximately ¾" square, scaled signal and power but cover easily removable for rescaling. Sensitivity 200 uA. 75p.

ADVANCE ADVERTISING BARGAINS LIST!

Our FREE monthly list gives details of bargains arriving or just arrived – often bargains which sell out before our advertisement can appear – it's an interesting list and it's free – just send S.A.E. Below are a few of the Bargains still available.

TRANSMITTER SURVEILLANCE
Tiny, easily hidden but which will enable conversation to be picked up with FM radio. Can be made in a matchbox – all electronic parts and circuit. £2.30.

RADIO MIKE
Ideal for discos and garden parties, allows complete freedom of movement. Play through FM radio or tuner amp. £6.90 comp. kit.

SAFE BLOCK
Mains quick connector will save you valuable time. Features include quick spring connectors, heavy plastic case and auto on and off switch. Complete kit. £1.95.

LIGHT CHASER
Gives a brilliant display – a psychedelic light show for discos, parties and pop groups. These have three modes of flashing, two chase patterns and a strobe effect. Total output power 750 watts per channel. Comlete kit. Price £16. Ready made up £4 extra.

FISH BITE INDICATOR
Enables anglers to set up several lines then sit down and read a book. As soon as one has a bite the loudspeaker emits a shrill note. Kit. Price £4.90.

6 WAVEBAND SHORTWAVE RADIO KIT
Bandspread covering 13.5 to 32 metres. Based on circuit which appeared in a recent issue of Radio Constructor. Complete kit includes case materials, six transistors, and diodes, condensers, resistors, inductors, switches, etc. Nothing else to buy if you have an amplifier to connect it to or a pair of high resistance headphones. Price £11.95.

SHORT WAVE CRYSTAL RADIO
All the parts to make up the beginner's model. Price £2.30. Crystal earpiece 65p. High resistance headphones (gives best results) £3.75. Kit includes chassis and front but not case.

RADIO STETHOSCOPE
Easy to fault find – start at the arial and work towards the speaker – when signal stops you have found the fault. Complete kit £4.95.

INTERRUPTED BEAM
This kit enables you to make a switch that will trigger when a steady beam of infra-red or ordinary light is broken. Main components – relay, photo transistor, resistors and caps etc. Circuit diagram, but no case. Price £2.30

OUR CAR STARTER AND CHARGER KIT has no doubt saved many motorists from embarrassment in an emergency you can start car off mains or bring your battery up to full charge in a couple of hours. The kit comprises: 250w mains transformer, two 10 amp bridge rectifiers, start/charge switch and full instructions. You can assemble this in the evening, box it up or leave it on the shelf in the garage, whichever suits you best. Price £11.50 + £2.50 post.

GPO HIGH GAIN AMP/SIGNAL TRACER. In case measuring only 5½in x 3½in x 1¾in is an extremely high gain (70dB) solid state amplifier designed for use as a signal tracer on GPO cables, etc. With a radio it functions very well as a signal tracer. By connecting a simple coil to the input socket a useful mains cable tracer can be made. Runs on standard 4½v battery and has input, output sockets and on-off volume control, mounted flush on the top. Many other uses include general purpose amp, cueing amp, etc. An absolute bargain at only £1.85. Suitable 80ohm earpiece 69p.

3 CHANNEL SOUND TO LIGHT KIT
Complete kit of parts for a three-channel sound to light unit controlling over 2,000 watts of lighting. Use this at home if you wish, but it is more than rugged enough for Disco work. The unit is housed in an attractive two-tone metal case and has controls for each channel, and a master on/off. The audio input and output are by ¼" sockets and three panel mounting fuse holders provide thyristor protection. A four-pin plug and socket facilitate ease of connecting lamps. Price £14.95, complete kit and case.

8 POWERFUL BATTERY MOTORS
For models, Meccanos, drills, remote control planes, boats etc. £2.50.

WATERPROOF HEATING WIRE
60 ohms per yard, this is a heating element wound on a fibre glass coil and then covered with p.v.c. Dozens of uses – around water pipes, under grow boxes in gloves and socks. 23p per metre.

COMPONENT BOARD Ref. W0998
This is a modern fibreglass board which contains a multitude of very useful parts, most important of which are: 35 assorted diodes and rectifiers including 4 3amp 400v types (made up in a bridge) 8 transistors type BC 107 and 2 type BFY 51 electrolytic condensers. SCR ref 2N 5062, 25 0uf 100v DC and 100uf 25v DC and over 100 other parts including variable, fixed and wire wound resistors, electrolytic and other condensers. A real snip at £1.15.

FRUIT MACHINE HEART. 4 wheels with all fruits, motorised and with solenoids for stopping the wheels with a little ingenuity you can defy your friends getting the "jackpot". £9.95. + £4 carriage.

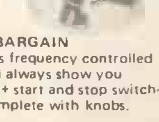
DESOLDERING PUMP
Ideal for removing components from computer boards as well as for service work generally. Price £6.35.

4-CORE FLEX CABLE
White pvc for telephone extensions, disco lights, etc. 10 metres £2, 100 metres £15. Other multicore cable in stock.

MUGGER DETERRENT
A high-note bleeper, push latching switch, plastic case and battery connector. Will scare away any villain and bring help. £2.50 complete kit.

HUMIDITY SWITCH
American made by Honeywell. The action of this device depends upon the dampness causing a membrane to stretch and trigger a sensitive microswitch. Very sensitive breathing on it for instance will switch it on. Micro 3 amp at 250V a.c. Only £1.15.

EXTRACTOR FANS – Mains Voltage
Ex-Computer, made by Woods of Colchester, ideal also as blower; central heating systems, fume extraction etc. Easy fixing through panel, very powerful 2,500 rpm but quiet running. Choice of 2 sizes, 5" £5.50. 6" £6.50. post £1 per fan.



TIME SWITCH BARGAIN
Large clear mains frequency controlled clock, which will always show you the correct time + start and stop switches with dials. Complete with knobs. £2.50.

J. BULL (Electrical) Ltd.

(DEPT. EMM2), 34-36 AMERICA LANE, HAYWARDS HEATH, SUSSEX, RH16 3QU.

J. BULL (Electrical) Ltd – Established 25 years. MAIL ORDER TERMS: Cash with order – please add 60p to all orders under £10, to offset packing, etc. ACCESS & BARCLAYCARD WELCOMED. Our shop is open to callers. BULK ENQUIRIES INVITED. Telephone: Haywards Heath (0444) 54563.

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.

Since the acceptance of calculators in education for the teaching of mathematics, who would have guessed that the follow-up to this would be a calculator that plays music!

The calculator functions are still there and yet, packed into Casio's latest product, the VL-Tone, is a complete 29-note synthesiser that records and plays back. The range of the keyboard is, in fact, almost 5 octaves and there is a built-in speaker for adequate classroom playback level. A special numerical display shows pitch including sharps and programming information. Melody can be recorded one 'key' at a time or done all in one go. On playback, new tempos can be set and there's a choice of sounds: Piano, Fantasy, Violin, Flute, Guitar, and ADSR. To complete the music melodies are 10 preset 'drum' rhythms. It's great fun to use and is ideal for plenty of creative music making in the music lesson.

Finally, I must mention how impressed I was at Frankfurt with Frank Chastenier's playing (see photo). His performance on the flagship of the Hammond organs, the new Elegante, was remarkable and at the age of 14, he undoubtedly inspired a lot of musicians.

E&MM

EDUCATION

Can we program a computer to be clever?

Very often we hear people say something like, 'a computer is just a dumb slave'. Perhaps what they are really trying to say is that computers are dependent upon human beings to program them. Is it possible to program a computer to be clever, then?

If we are going to use a computer to help us solve problems we must first think about the ways in which we might program a computer to reach solutions. Perhaps the 'dumbest' way might be to say, 'look at all the possibilities and then find the best.'

What would happen if we tried this approach with the game of chess? It has been estimated that the theoretical maximum of the number of possible chess games is approximately 10^{15790}. Even if we considered all games that lasted forty moves we will still have as many as 10^{120} — both values are literally astronomical! It would be impossible for a computer to consider all possibilities. So we must find methods that might *discover* a solution other than through 'dumbly' looking at all possibilities. Part of the idea of discovery is *learning*. There is not much point of discovering something if we cannot learn from it; we will want to be able to program a computer to discover things and learn from those discoveries.

Let us look for example at how we might program a computer to discover a path through a maze. Figure 1 shows a simple maze. How can we represent this for the computer? We shall pick out the number of paths and draw them in the form of a *tree graph* (Figure 2). The tree graph may be represented as in Table 1. We have numbered the points in the graph where paths join, and in the Table a '1' shows that the points are joined and an '0' means that they are not. Table 1 may now be fed into a computer with the use of a two-dimensional array or matrix.

Now, this is how we might find a path through a maze:

Step 1: Enter maze until we come across a junction where paths part. Take all paths in clockwise order.

Step 2: Is there a path from this junction to look at that we have not looked at yet? If answer is YES, go to Step 3; if answer is NO, go back along path to the previous point, then start Step 2 again.

Step 3: Does this path bring us directly to the EXIT? If YES, then STOP; if NO then go to Step 2.

Work through this method with the maze in Figure 1. Let us now adapt this method so that it may be used with the data in Table 1, and this we shall do by the flow-chart in Figure 3.

From the flow-chart a computer program can be written — although we shall find that the flow-chart does not give all the answers! For example, how do we know that we have or have not been along a particular path? Will this method work for any maze? How can we program a computer to remember the paths it has taken? — and so on.

Steve Leverett.

		END OF PATH								
JUNCTION NUMBERS		1	2	3	4	5	6	7	8	9
	1	0	1	1	1	0	0	0	0	0
	2	1	0	0	0	0	0	0	0	0
BEGINNING	3	1	0	0	0	1	1	0	0	0
OF	4	1	0	0	0	0	0	0	0	0
PATH	5	0	0	1	0	0	0	0	0	0
	6	0	0	1	0	0	0	1	1	0
	7	0	0	0	0	0	1	0	0	0
	8	0	0	0	0	0	1	0	0	1
	9	0	0	0	0	0	0	0	1	0

Table 1. Path table from tree graph.

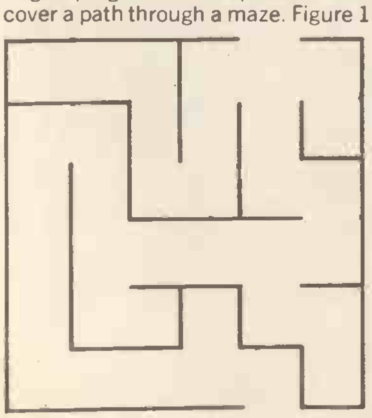


Figure 1. A simple maze.

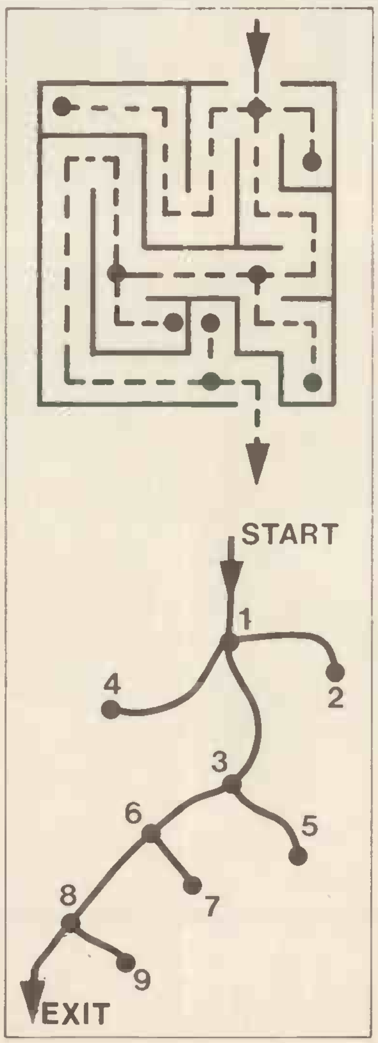


Figure 2. Tree graph representation.

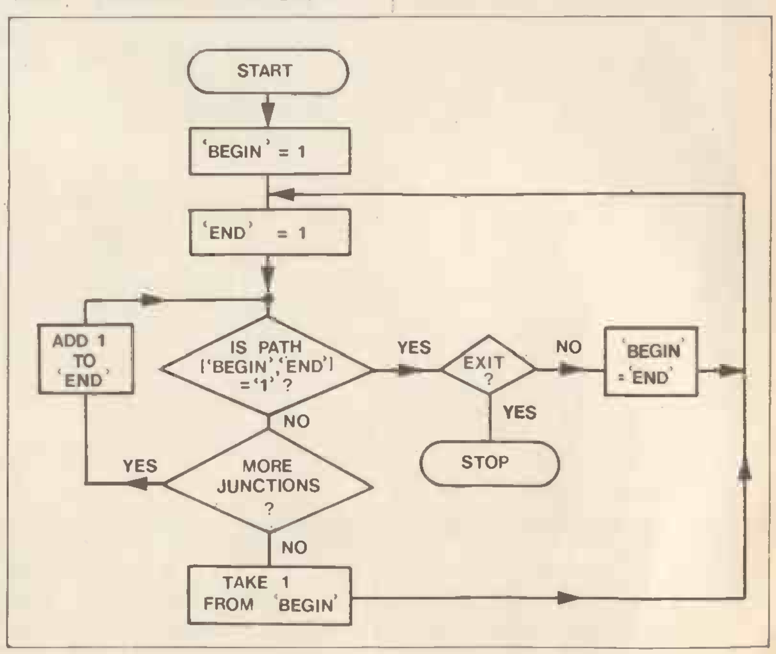


Figure 3. Flow Chart for maze solving.

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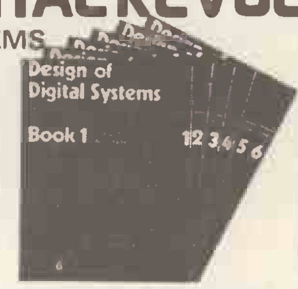

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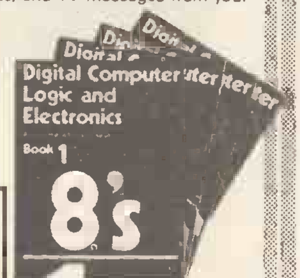

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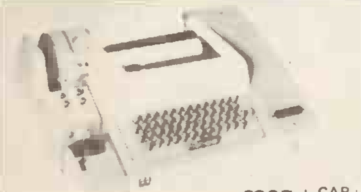

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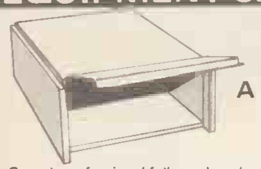

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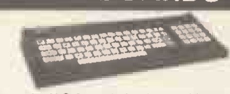

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Electronics & Music Maker was officially launched on the 10th February with a reception held at the British Film and TV Academy, Piccadilly, London.

The magazine was given an enthusiastic send-off by Dr Magnus Pyke, with a lively 'off-the-cuff' speech to an audience with representatives from Press and broadcasting and the electronics and electro-music industries.

Dr Pyke has always believed that the new developments of science that have taken place are of enormous interest and part of our lives. That's why he was interested and excited when he heard about E&MM.

He remembers, way back in the 1920's, making an instrument of the new technology of that time — the Crystal Set!

Now we've got all this new technology, he thinks this is so exciting and that people *want* to learn and find it pleasurable to do so.

He also pointed out that Elizabethan England to the present day has always been a musical land — in modern times the Beatles established a new style in music, which could not have been done without electronics.

He feels that E&MM will appeal to what some people say are two cultures of people — the dry technological scientists like him, and on the other side, you have the humane people — the musical people — who want to sing and make music. Now E&MM is joining them together — and this is very important because in a sense you

have pleasure, and you have leisure which is going to be a great thing! If musicians know a sound that they want, then they in turn want to learn about the electronics to get it. And this continues with the learning of mathematics for working with the electronics.

E&MM in a way will be increasing the enlightenment of the current generation and so will not only be providing information for readers of all ages who want to know but also educating the teachers.

So people in education should also benefit from the magazine and, said Dr Pyke, 'it should contribute to the enrichment of the life of the community and I hope that thereby it will also contribute to the enrichment of E&MM's authors and editorial staff for bringing it out.' **E&MM**

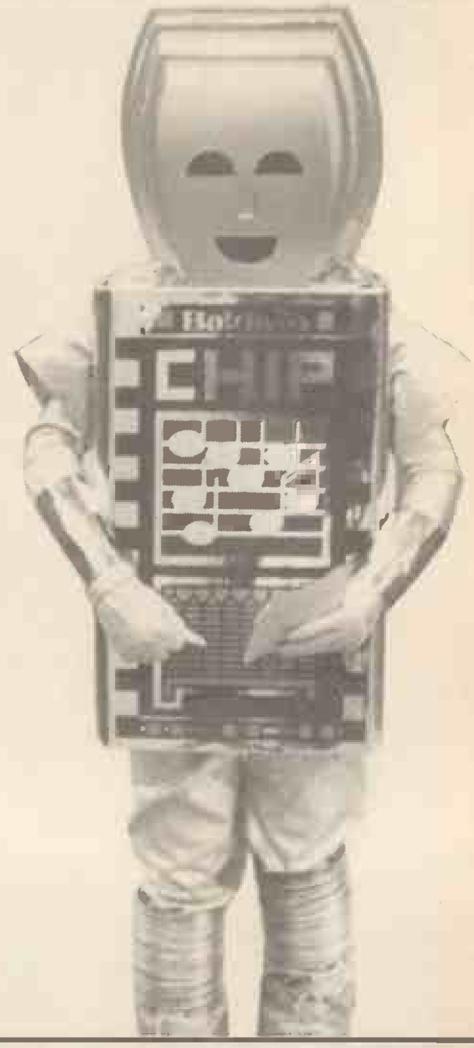
EVENTS

Mar 12th-16th	'HOME VIDEO SHOW', Cunard International Hotel, London.
Mar 17th-19th	COMPUTERMARKET, Albany Hotel, Glasgow. Aimed at senior management, executives and directors of organisations using or considering the use of computers.
Mar 23rd-27th	COMPUTER EXHIBITION, DATAKRAFT, Malmo.
Mar 24th-26th	COMPUTERMARKET, New Centry Hotel, Manchester.
Mar 24th-27th	INTERNATIONAL COMPUTING EXHIBITION, 'COMPUTEX', Dublin.
Mar 31st	ELECTRONIC TEST & MEASURING INST. EXHIBITION, Wythenshaw, Forum, Manchester.
Mar 31st	COMPUTERMARKET, Albany Hotel, Birmingham.
Apr 3rd-5th	HOBBY & LEISURE, Dornbirn, Austria.
Apr 7th-9th	COMPUTERMARKET, West Centre Hotel, London.
Apr 7th-10th	AUDIO VISUAL EXHIBITION, Wembley Conference Centre, London.
Apr 7th-11th	INTERNATIONAL EXHIBITION OF ELECTRONIC COMPONENTS, Paris.
Apr 8th-15th	AUDIO VISUAL COMMUNICATION EXHIBITION, Jaarbeursplein, Mediavisie, Holland.
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.

We shall be pleased to publish news of forthcoming electronic and electro-music exhibitions, clubs — also special electronic music concerts.

NEXT MONTH — May Issue

on sale at your newsagent from April 12th



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Each month, Electronics & Music Maker will be giving special offers to its readers that represent a substantial saving on normal retail prices. Items will be selected that are useful in our specialist area — electro-music.

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