THE No1 MONTHLY FOR THE ELECTRONICS & MUSIC HOBBYIST

ELECTRONICS & MUSIC MAKER

PROJECTS, FEATURES, NEWS & REVIEWS IN ELECTRONICS & ELECTRO~MUSIC

SEPTEMBER 1981
65p

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ELECTRONICS & MUSIC MAKER

September 1981 **The No 1 Monthly for the Electro-Musician!**

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CONTENTS

20 POWER AMPS 19 FUNCTIONAL MODULES DAWN

POWER UP TO 480 WATTS RMS SINGLE CHANNEL

Which amplifier?

I.L.P. Amplifiers now come in three basic types, each of which is available with or without heatsink. Having decided the system you want – home hi-fi (models HY30, 60 or 120 for example), super quality hi-fi with extra versatility (MOS120, MOS200) or Disco/PA/Guitar (HD120, HD200 or HD400) you will then decide whether amplifiers housed within their own heatsinks or plate amplifiers for bolting to a metal chassis will suit. With choice such as this and a brilliant new range of I.L.P. functional modules to choose from you now have the chance to build the finest audio system ever offered to the constructor.

AMPLIFIER WITH HEAT SINK

BIPOLAR Standard, with heatsinks / Without heatsinks

MODEL NUMBER	OUTPUT POWER Watts rms	DISTORTION T.H.D. Typ at 1kHz	DISTORTION I.M.D. 60HZ/7kHz 4:1	SUPPLY VOLTAGE TYP/MAX	SIZE mm	WT gms	PRICE	VAT	MODEL NUMBER	SIZE in mm	WT gms	PRICE	VAT
HY30	15w/4-8Ω	0.015%	<0.006%	±18±20	76x68x40	240	£7.29	£1.09					
HY60	30w/4-8Ω	0.015%	<0.006%	±25±30	76x68x40	240	£8.33	£1.25					
HY120	60w/4-8Ω	0.01%	<0.006%	±35±40	120x78x40	410	£17.48	£2.62	HY120P	120x26x40	215	£15.50	£2.33
HY200	120w/4-8Ω	0.01%	<0.006%	±45±50	120x78x50	515	£21.21	£3.18	HY200P	120x26x40	215	£18.46	£2.77
HY400	240w/4Ω	0.01%	<0.006%	±45±50	120x78x100	1025	£31.83	£4.77	HY400P	120x26x70	375	£28.33	£4.25

Protection: Load line, momentary short circuit (typically 10 sec) *Slew rate:* 15V/μs *Rise time:* 5μs
S/N ratio: 100db *Frequency response (–3dB):* 15Hz – 50kHz
Input sensitivity: 500mV rms *Input impedance:* 100kΩ *Damping factor:* (8Ω/100Hz)>400

HEAVY DUTY with heatsinks / Without heatsinks

MODEL NUMBER	OUTPUT POWER Watts rms	T.H.D.	I.M.D.	SUPPLY VOLTAGE	SIZE mm	WT gms	PRICE	VAT	MODEL NUMBER	SIZE in mm	WT gms	PRICE	VAT
HD120	60w/4-8Ω	0.01%	<0.006%	±35±40	120x78x50	515	£22.48	£3.37	HD120P	120x26x50	265	£19.84	£2.98
HD200	120w/4-8Ω	0.01%	<0.006%	±45±50	120x78x60	620	£27.38	£4.11	HD200P	120x26x50	265	£23.63	£3.54
HD400	240w/4Ω	0.01%	<0.006%	±45±50	120x78x100	1025	£38.63	£5.79	HD400P	120x26x70	375	£34.28	£5.14

Protection: load line, PERMANENT SHORT CIRCUIT (ideal for disco/group use should evidence of short circuit not be immediately apparent).
The Heavy Duty range can claim additional output power devices and complementary protection circuitry with performance specs. as for standard types.

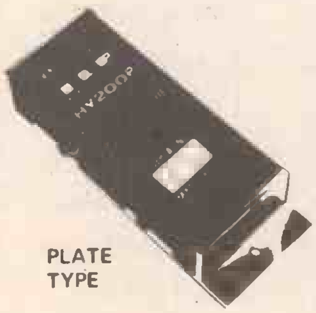

PLATE TYPE

MOSFET Ultra-Fi, with heatsinks / Without heatsinks

MODEL NUMBER	OUTPUT POWER Watts rms	T.H.D.	I.M.D.	SUPPLY VOLTAGE	SIZE mm	WT gms	PRICE	VAT	MODEL NUMBER	SIZE in mm	WT gms	PRICE	VAT
MOS120	60w/4-8Ω	<0.005%	<0.006%	±45±50	120x78x40	420	£25.88	£3.88	MOS120P	120x26x40	215	£23.32	£3.50
MOS200	120w/4-8Ω	<0.005%	<0.006%	±55±60	120x78x80	850	£33.46	£5.02	MOS200P	120x26x80	420	£28.53	£4.28
MOS400	240w/4Ω	<0.005%	<0.006%	±55±60	120x78x100	1025	£45.39	£6.81	MOS400P	120x26x100	525	£38.91	£5.84

Protection: Able to cope with complex loads, without the need for very special protection circuitry (fuses will suffice).
Ultra-fi specifications:
Slew rate: 20V/μs *Rise time:* 3μs *S/N ratio:* 100db *Frequency response (–3dB):* 15Hz – 100kHz
Input sensitivity: 500mV rms *Input impedance:* 100kΩ *Damping factor:* (8Ω/100Hz)>400

PSU

POWER SUPPLY UNITS

MODEL NO.	FOR USE WITH	PRICE	VAT
PSU30	± 15V combinations of HY6/66 series to a maximum of 100mA or *one* HY67	£4.50	£0.68
	The following will also drive the HY6/66 series except HY67 which requires the PSU30.		
PSU36	1 or 2 HY30	£8.10	£1.22
PSU50	1 or 2 HY60	£10.94	£1.64
PSU60	1 x HY120/HY120P/HD120/HD120P	£13.04	£1.96
PSU65	1 x MOS120/1 x MOS120P	£13.32	£2.00
PSU70	1 or 2 HY120/HY120P/HD120/HD120P	£15.92	£2.39
PSU75	1 or 2 MOS120/MOS120P	£16.20	£2.43
PSU90	1 x HY200/HY200P/HD200/HD200P	£16.20	£2.43
PSU95	1 x MOS200/MOS200P	£16.32	£2.45
PSU180	2 x HY200/HY200P/HD200/HD200P or 1 x HY400/1 x HY400P/HD400/HD400P	£21.34	£3.20
PSU185	1 or 2 MOS200/MOS200P/1 x MOS400/1 x MOS400P	£21.46	£3.22

All models except PSU30 and PSU36 incorporate our own toroidal transformers.

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Which modules?

In launching eighteen different units all within amazingly compact cases to help make complete audio systems using I.L.P. power amplifiers, we bring the most exciting, the most versatile modular assembly scheme ever for constructors of all ages and experience. Study the list – see how these modules will combine to almost any audio project you fancy – and remember *all I.L.P. modules are compatible with each other*, they connect easily: Modules HY6 to HY13 measure 45 x 20 x 40mm. HY66 to HY77 measure 90 x 20 x 40mm. They are so reliable that all I.L.P. modules carry a 5 year no quibble guarantee.

MODEL NO.	MODULE	DESCRIPTION/FACILITIES	CURRENT REQUIRED	PRICE	VAT
HY6	MONO PRE AMP	Mic/Mag. Cartridge/Tuner/Tape/ Aux + Volume/Bass/Treble	10mA	£6.44	£0.97
HY7	MONO MIXER	To mix eight signals into one	10mA	£5.15	£0.77
HY8	STEREO MIXER	Two channels, each mixing five signals into one	10mA	£6.25	£0.94
HY9	STEREO PRE AMP	Two channels mag. Cartridge/ Mic + Volume	10mA	£6.70	£1.01
HY11	MONO MIXER	To mix five signals into one + Bass/Treble controls	10mA	£7.05	£1.06
*HY12	MONO PRE AMP	To mix two signals into one + Bass/Mid-range/Treble	10mA	£6.70	£1.01
*HY13	MONO VU METER	Programmable gain/LED overload driver	10mA	£5.95	£0.89
HY66	STEREO PRE AMP	Mic/Mag. Cartridge/Tape/Tuner/Aux + Volume/Bass/Treble/Balance	20mA	£12.19	£1.83
HY67	STEREO HEADPHONE	Will drive headphones in the range of 4Ω – 2KΩ	80mA	£12.35	£1.85
HY68	STEREO MIXER	Two channels, each mixing ten signals into one	20mA	£7.95	£1.19
HY69	MONO PRE AMP	Two input channels of mag. Cartridge/ Mic + Mixing/Volume/Treble/Bass	20mA	£10.45	£1.57
HY71	DUAL STEREO PRE AMP	Four channels of mag. Cartridge/Mic + Volume	20mA	£10.75	£1.61
*HY72	VOICE OPERATED STEREO FADER	Depth/Delay	20mA	£13.10	£1.97
*HY73	GUITAR PRE AMP	Two Guitar (Bass/Lead) and Mic + separate Volume/Bass/Treble + Mix	20mA	£12.25	£1.84
†HY74	STEREO MIXER	Two channels, each mixing five signals into one + Treble/Bass	20mA	£11.45	£1.72
†HY75	STEREO PRE AMP	Two channels, each mixing two signals into one + Bass/Mid-range/Treble	20mA	£10.75	£1.61
†HY76	STEREO SWITCH MATRIX	Two channels, each switching one of four signals into one	20mA	*To be announced*	
†HY77	STEREO VU METER DRIVER	Programmable gain/LED overload driver	20mA	£9.25	£1.39

* Ready August – may be ordered now
† Ready September – may be ordered now

All the above modules operate from ± 15V minimum to ± 30V maximum higher voltages being accommodated by use of dropper resistors. HY67 can only be used with the PSU 30 power supply unit.

The modules are encapsulated and include latest design high quality clip-on edge connectors.

For easy mounting we recommend
B6 Mounting board for modules HY6 – HY13
78p + 12p. V.A.T.
B66 Mounting board for HY66 – HY77
99p + 13p. V.A.T.

All I.L.P. modules include full connection data.

I.L.P. Products are of British Design and Manufacture.

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£539

£579 including mike and cans

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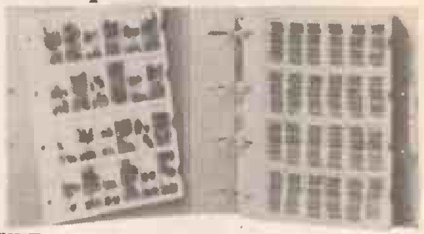

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RacKit **£19.55** Mounts three Accessit units to standard 19in rack

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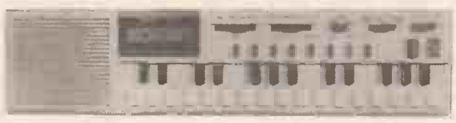

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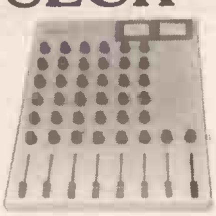
SECK £108.33

Professional Mixer in Kit Form



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A six input stereo mixer featuring wide range gain, treble, bass, echo, foldback and pan on each channel. For compact PA, keyboards, stage monitoring or recording, the ultra slim design is at home anywhere.

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60p

"The Multitrack Primer" from TEAC is a practical guide to setting up a home studio with many tips on wiring, acoustics, mike placement etc. The book is packed with superb illustrations. The best guide around by far.

£3.50

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ELECTRONICS & MUSIC MAKER

Can You Make Music Without Electronics?

by Mike Beecher, Editor
Electronics & Music Maker.

As a classically trained musician, it may be surprising that I even ask this question. I would be the last person to want to stop playing my acoustic piano, but as a composer using electronics, I have reached a turning point in my approach to making music. The two traditional methods of writing are either done with your instrument helping you along or by translating musical ideas straight onto manuscript. Plenty of acceptable modern music comes from experimentation although I am very often drawn towards traditional form. But now I am concerned with many other factors that lead me through several tasks to make my final piece.

First, the sounds have to be constructed and here I might spend several days linking devices with treatments that give the expected result. Sometimes, a different sound will emerge that takes me in another direction. More and more along the chain of composition in electronic music I am 'playing with dials', interfacing and even constructing to overcome limitations of existing equipment. Limitations in playing – in polyphonic playing due to the inability to cope with many parts at the same time or in monophonic, due to poor accuracy on fast notes – can all be overcome using dedicated micro/instrument storage and sequencing. Programming can set me back a week for just one small 'event'.

The more instruments and processing equipment I have, the more I must be able to select the right devices from the start. Then at last, I reach my actual composing stage (usually planned earlier) and afterwards spend considerable time evaluating tracks as to their quality and accuracy. The final mix down to stereo or quad marks the end of the piece, although it will be some time before I feel it is acceptable.

And so my piano is neglected, the instruments need maintaining and updating and further projects are planned for making new sounds and treatments. Listening to a wide range of music is vital in between times as a stimulus for new ideas. Discussing with other musicians problems and methods of composition is also an essential part of creating music.

E&MM can help in many ways to fill gaps in your knowledge of electronics, and provide information on musical events and performance that is essential for the modern musician. Like a good composer, it thrives on suggestions and feedback from its readers.

In choosing the spheres of electronics, computing and music as our specialist subjects, the magazine embraces the areas that are motivating a huge consumer industry into action and it is only the indiscriminate few who will reject or miss the opportunities for the future.

Mike Beecher

Readers Letters

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

Dear Sir,
I intend to build the E&MM Synwave but note that it must be triggered by a pulse of +7 to +15V. I wish to trigger it from a Roland DR55 which outputs a pulse of +4V, 10ms. What changes are required to the limiter section to permit this?
Secondly, I wish to add the trigger input of July '81 (page 40) to the Syntom. Figure 3 agrees with Figure 1 if the dotted lead means the Veropin or thick wire but paragraph 8 describes this as connecting to JK1. Which is correct?
I agree with I Calleja of Malta and hope you will manage a circuit for a Colour Negative Analyser.

J. E. Day
Herts

An input voltage of at least 7 volts is needed in order to trigger the 'Synwave' properly and there is no simple way of altering the circuit to trigger from only 4 volts. It would be necessary to have a non-inverting amplifier between the Roland and the 'Synwave' in order to obtain satisfactory results.

Dear Sirs,
Owners of the ZX 81 quickly realise it's severe shortage of useable RAM. The obvious way out is to purchase the optional 16k RAM pack, but at £50, it may be more both in price and capacity than many wish to stretch to, at least until the bug has bitten!
A very useful extension can be made, with little effort which more than doubles the useable RAM.
The Hitachi HM 6116 2k x 8 Static RAM is pin compatible with the 4118 1k x 8 RAM fitted, and by shopping about may be obtained for less than £15 and prices are falling.
To convert:
Remove IC 4 (the 4118 RAM). Remove link L1 at the side of IC 4 and fit link L 2, carefully plug in the new HM 6116 observing the precautions necessary with CMOS. Some owners may have two 2114 1k x 4 RAMs fitted. If so remove them both (but not the sockets).
Carefully solder in two rows of twelve Soldconn pins or a Texas 24 pin dil socket, with the centre spacing bars removed over IC 4A socket (check it is fitted correctly in the 24 pin IC 4 position, not over the 28 pin markings).
Fit link L2 and install the HM 6116.
Refit PCB in case and test. Use the test programme in chapter 23 of the ZX 81 manual and see the difference.
For purchasers of ready made ZX 81's the case is held together with five small screws (posidrive head), three of which are located under the sponge feet, and the PCB is held in by two similar screws. Refit all screws in their original positions i.e. two short in board, two short in front holes of case and three long in rear holes.

T. J. Cartwright
Leicester

None of the staff at Sinclair Research Ltd have actually tried the HM6116, but apparently the Mk4802, its Mostek equivalent, works fine. Note that the board is laid out for the 28-pin 4816 also; conversion procedure is the same but using a 28 pin socket of course.
Soldercon pins are definitely not a good idea: they can short out against other tracks on the top of the board, especially those which pass between the RAM pins.
Generally speaking, adding static RAM is easy provided you don't load the buses too much. Theoretically, D6 requires an access time no worse than 390ns (which is why 2 different grades of 2114 are used) – in practice, RAMs are specified at 70°C and get faster at room temperature: so 450ns parts are usually quite acceptable.

PeterMaydew

Dear Sir,
I have just received the April and May issues of E&MM. Thank you very much for fast and efficient service.
Now, I have a difficulty regarding one of the little ideas featured in 'Circuit Maker' in the June issue, i.e. the 'Dashboard Light Dimmer' on page 40. I have constructed this gadget as shown and fitted it in my car. The dimmer works well in that it dims the lights as it should. The only thing that is wrong with it is that the lights are dimmer than they were originally, when the dimmer is on 'bright', with the result that the lights are not bright enough when used when it is still twilight. I have tried changing the resistor values but to no avail. I would appreciate it if you would advise me as to what could be wrong. Thank you.

P Scerri
Malta

There are two possible sources for the type of problem you describe. First, it is possible that the output voltage of the 555 is not reaching +12 volts, in which case the output voltage will fall to the 555 high output minus about 600mV. The cure here is to increase the drive available to the transistor by strapping a 100R resistor between pin 3 and +12 volts. Such a resistor will increase the output voltage, which can tend to fall on load.
The other possibility is that the timing capacitor is taking longer to discharge than it should, presumably due to limitations within the 555 itself resulting in the discharge transistor not being driven hard enough. A quick and easy cure might be to reduce the timing capacitor to 0.1uF to reduce the current loading on this transistor.
The prototype has been in use without any trouble, although it should be noted that the lights will never be quite as bright because the simple nature of the circuit means that there is some voltage loss across the output transistor and the mark space ration never reaches 100% mark. Nevertheless, the actual dimming resulting from the factors is very small indeed.

Chris Lare

Dear Sir,
Thank you for such a superb magazine; as a student of electronics and working with rock groups, your magazine has become a bible for me and I'm sure many others in my situation.
Could I humbly suggest you consider including a sound mixer (for recording and P.A.) in your future projects.

Harold Barber
London W14

We are hoping to publish a mixer project in the near future.

Dear Sir,
First of all I must thank you for a most comprehensive magazine and I must say that the demonstration cassettes were the best thing that your magazine has done. Thank you again.
I have been following the 'Matinee Organ' project since it started in the first issue, and I am at present thinking about purchasing the kit myself. Though it would be a good idea if there was a DIN socket on the organ, (at the rear of course), so that you could record your music and replay it at a different time. This idea could then be carried on a bit, so you could connect the organ to a external speaker system.
Well thank you again for the magazine.

Peter Taylor
South Wirral

PARTYLITE

A 3-Channel sound-to-light modulator

by Clive Button

★ **No connection to your sound system required**

★ **Automatic level adjustment**

★ **3-channel operation**

★ **Operates from any sound level**

PARTS COST GUIDE £6 assembled board

The idea of a three-channel sound-to-light modulator is obviously not a new one, there being a multitude of units of this type already available, ranging from professional products to the types available at supermarkets for domestic use. Nevertheless, the Partylite is a worthy addition to the range because of its simplicity. It is fully automatic–no knobs to re-adjust every time the level or tonal content of your music alters. The Partylite also has its own built-in microphone eliminating the need for an audio connecting lead, making a completely free-standing unit and also avoiding the possibility of damage to your hi-fi or power amp. The Partylite employs zero voltage triggering of the thyristors. Consequently no interference is generated to produce

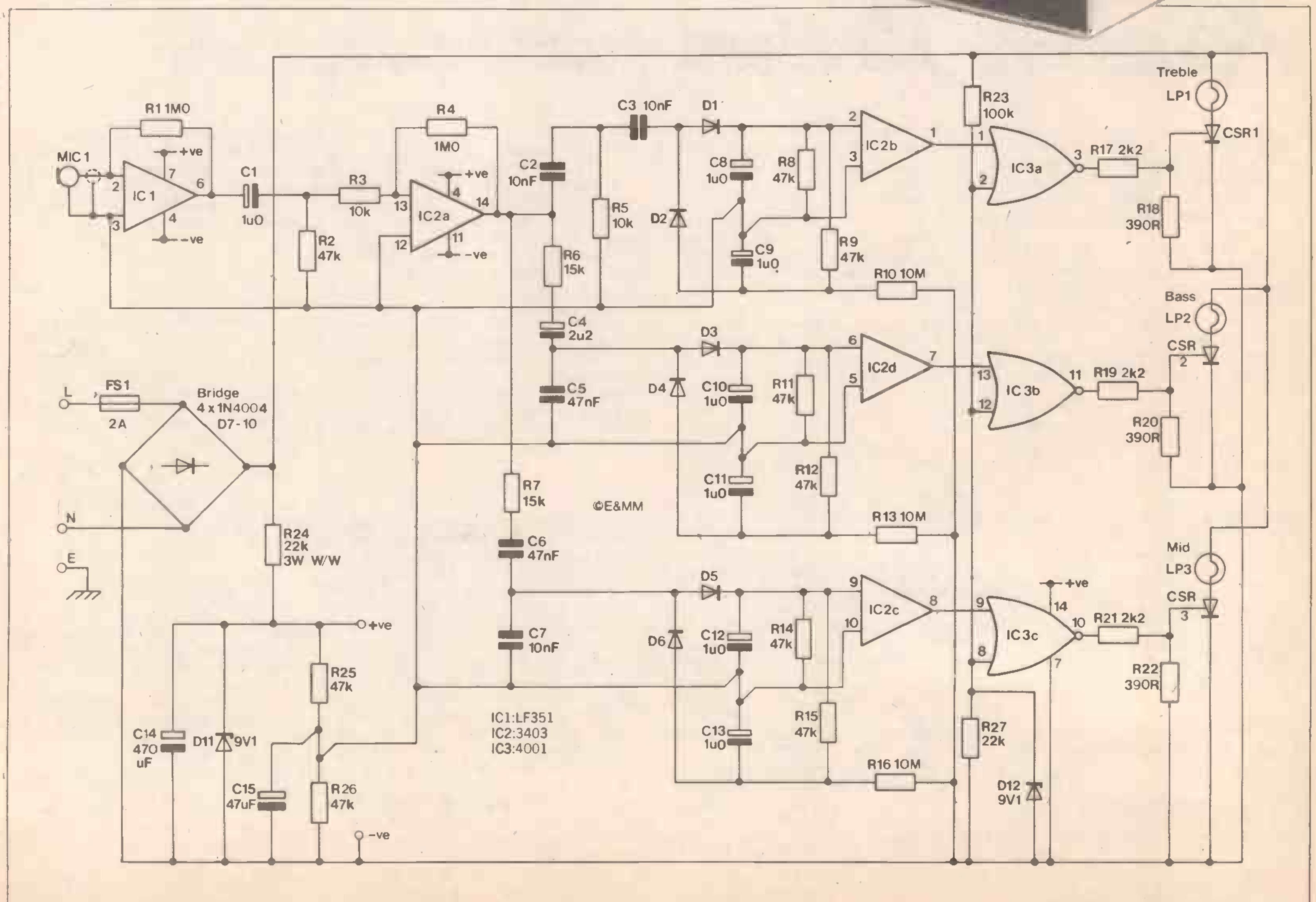


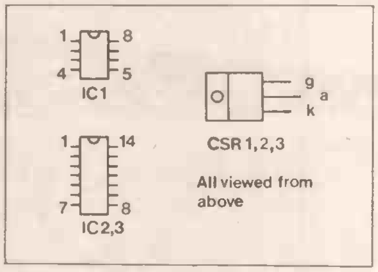
Figure 1. Partylite circuit diagram.

those annoying clicks through the speakers, so common with cheaper sound-to-light units. It will work effectively on all three channels with music at normal domestic listening levels or in a disco environment with say 100W pumping out. This is achieved by having independent, automatic level control circuits for treble, middle and bass frequencies.

Circuit Description

The circuit diagram of the Partylite is shown in Figure 1. IC1 acts as the input amplifier for the crystal mic; this signal is then fed to IC2a which provides amplification to a level sufficient to feed into the three filter networks. C2, C3 and R5 pass treble frequencies; R6, C4 and C5 pass bass frequencies, and R7, C6 and C7 pass mid-band frequencies. The outputs of these filters feed individual diode pump/comparator/automatic level control circuits (ALC). We only need to look at one of these in detail because all three are identical in operation. Consider the circuit around IC2b, the treble ALC. Its input comes from C3 with D1 passing the positive-going parts of the waveform and 'pumping-up' capacitor C8 with a positive charge. This level change is fed to the inverting input of the comparator IC2b and every time the level exceeds the non-inverting input, the comparator output will change state from positive to negative. Across C8, however, is a 47k resistor leaking its charge away, giving only short term level changes in response to the treble input. Working against this positive charge is D2, passing the negative part of the waveform and pumping up C9 in a negative direction but with no resistor across it, thus giving a slow response to the treble input. This negative charge is summed with the positive charge on C8 via resistor R9 giving ALC action as follows. If the input level increases (i.e. the music loudness increases), C8 will charge to a higher positive voltage, C9 will also charge, but negatively, consequently they will cancel each other out and the fast response of C8 to the input peaks will be the only signal to flip over the comparator output. This ensures that no matter what the level of the music is or what its tonal content may be, all three channels will always function and never stay permanently on or off. As C8 also has a delay time constant, even the fastest of treble spikes will give a finite 'on' time for the comparator not just an instant flip over, eliminating the annoying flicker associated with many sound-to-light units.

The 10M resistor R10 ensures that all lamps are properly extinguished when no signal input is present by providing a small negative bias to the comparator input. IC3 provides zero voltage triggering making sure no interference is generated by the circuit (another common fault of cheap units). IC3 is a quad NOR gate of which three gates are used. Looking again at the treble channel IC3a has two inputs both of which must be at logical '0' for it to give an output. One input is fed from



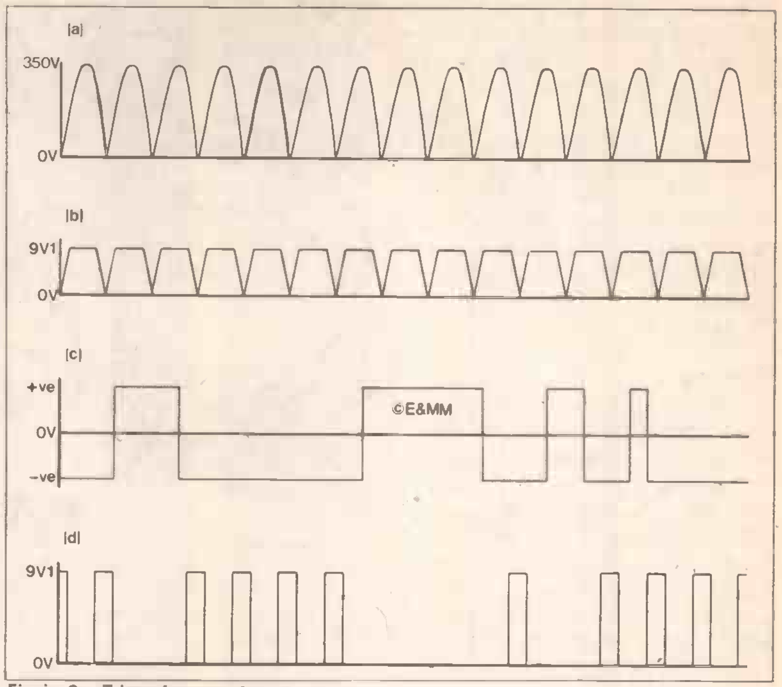


Figure 2. Triggering waveforms.

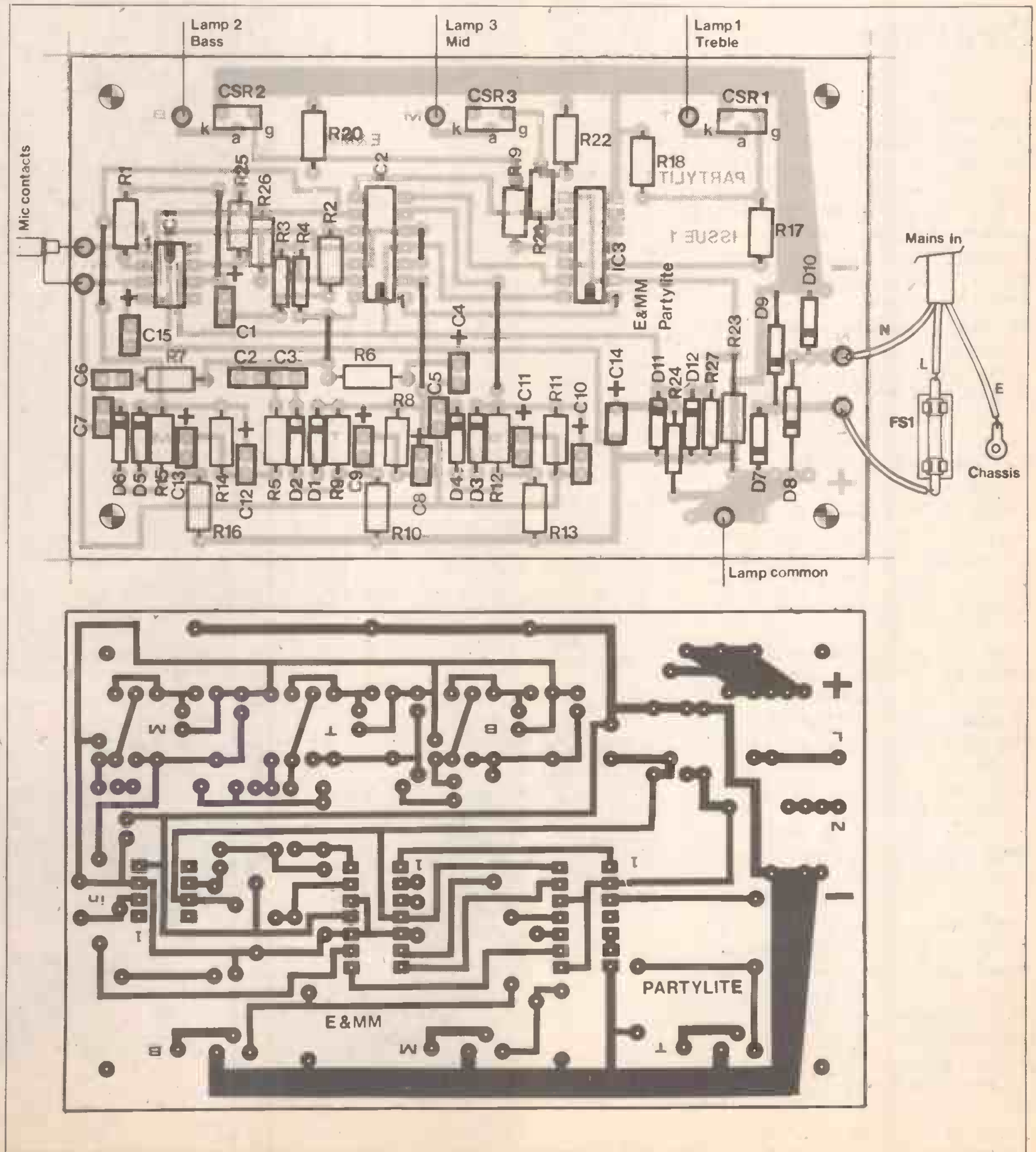


Figure 3. PCB track and legend details.

the comparator that goes to 'O' on detecting treble pulses; the other input is fed directly from the bridge rectifier with 100Hz positive pulses; these are suitably attenuated and limited to 9.1V to suit the inputs (see Figure 2). Thus an output can only be obtained when the mains voltage is zero, which happens at a rate of 100Hz, providing suitable gate pulses for switching the thyristors.

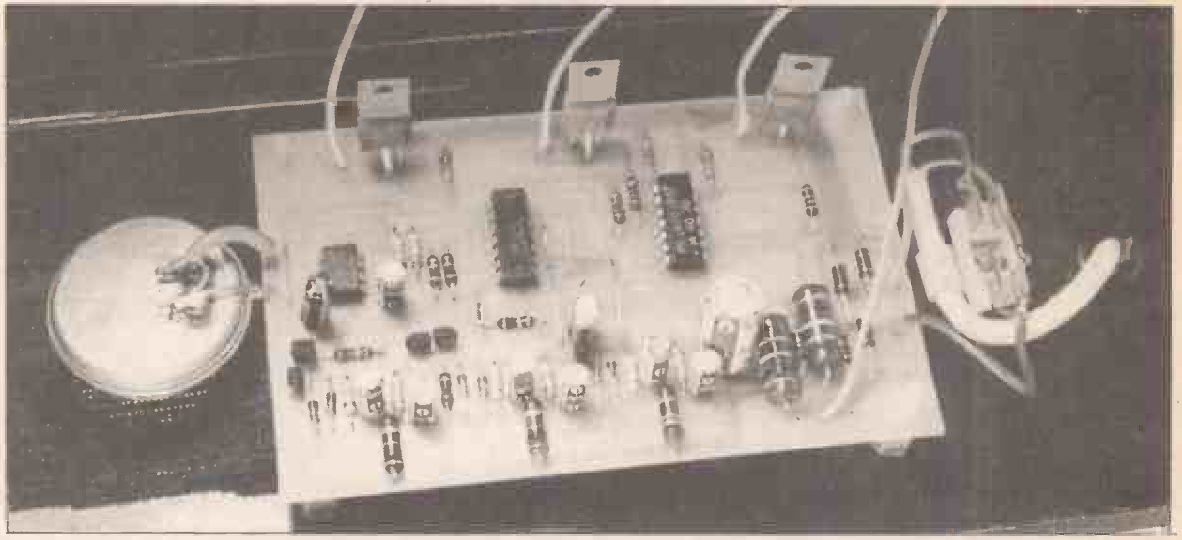
Warning:
The entire circuit is at live mains potential so be sure that it is properly mounted and avoid tampering with it when the unit is plugged into the mains supply. This includes the crystal mic which must be of the metal body type for input screening purposes and MUST be mounted to the PCB and not the unit case. The case must also be securely earthed.

Construction

The unit can be built either as a complete set-up containing modulator and lights as shown in the photographs, or as a separate modulator having output sockets to which the lights can be connected. In either situation the maximum power handling with the circuit as shown is 150W per channel. This limitation is imposed by the rating of the diodes in the bridge circuit and can easily be up-graded to 500W per channel by using 1N5004 diodes instead of 1N4004's and increasing the mains fuse to 6A.

Pay special attention to the warning given at the end of the circuit description and when wiring up the lamps/lamp outlets avoid running leads too close to the microphone end of the PCB as pick-up from these may be enough to operate the bass channel.

Mount all components and wire links to the PCB leaving the ICs until last (handle the 4001 carefully as it is a CMOS device). Mount the PCB on plastic mounts to keep it well isolated from surrounding casework etc. If necessary, insulate it from close proximity metal by covering the metal with insulating material. Fit a fuse external to the board in the live side of the mains input; this fuse should have a maximum rating of 2.5A for the circuit shown. Mount the microphone by twisting a length of heavy gauge tinned copper wire around its circumference, point solder it in position at, say, three points, and use this as the connection to the non-inverting input of IC1, thus providing a rigid mounting for the microphone.



Fully assembled PCB.

The microphone must be mounted to the PCB and not to any casework, for the unit to operate successfully. Use a short length of screened lead to connect the microphone input to the circuit board; the sensitivity of the unit is sufficient to cause premature turn-on if a plain lead is used.

Testing

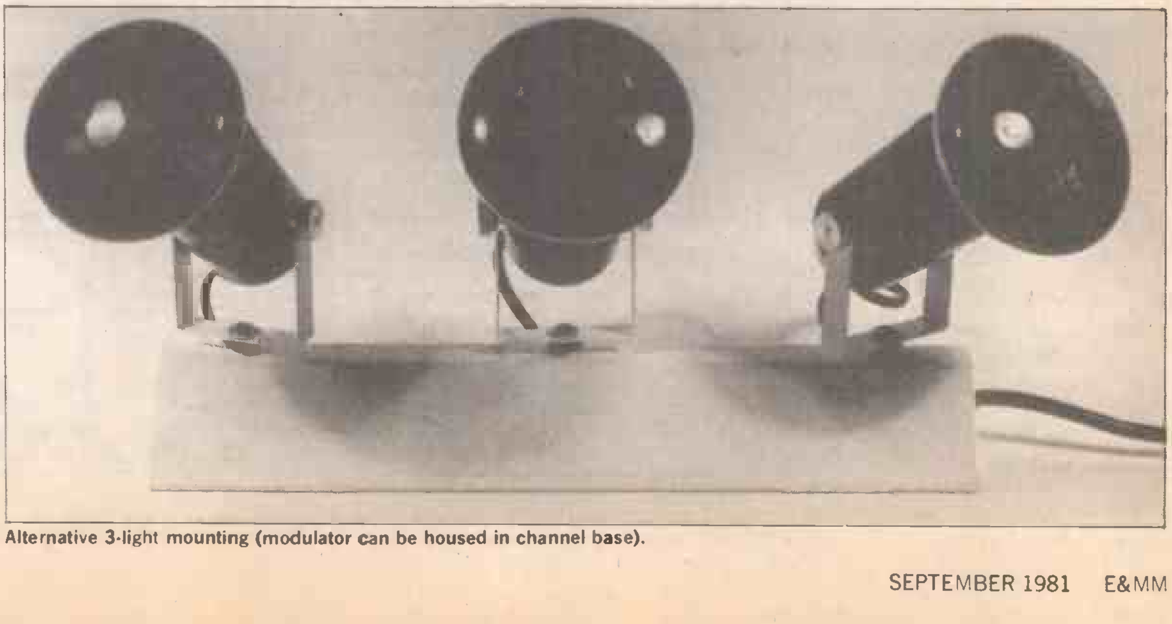
After the unit has been completed and the lamps connected, check that there is no continuity between the board and the case. The unit can then be plugged into the mains for testing. Should it not function correctly, disconnect the unit from the supply before making any checks. If the bass channel lamp stays on it is probably due to pick-up either from lamp outputs or main leads; re-route these and try again. If the unit is not sensitive enough the 10k resistor from the output of the first op-amp to the input of the second may be reduced in value or alternatively, a 10k pre-set may be fitted in its place to allow adjustment of the sensitivity. *(Use an insulated screwdriver for adjusting this pre-set if it is fitted).*

E&MM

PARTYLITE PARTS LIST

Resistors - all ¼W, 5% carbon unless specified			
R1,4	1M	2 off	(M1M)
R2,8,9,11,12,14, 15,25,26	47k	9 off	(M47K)
R3,5	10k	2 off	(M10K)
R6,7	15k	2 off	(M15K)
R10,13,16	10M, 10%	3 off	(M10M)
R17,19,21	2k2	3 off	(M2K2)
R18,20,22	390R	3 off	(M390R)
R23	100k, ½W, 5% carbon		(S100K)
R24	22k, 3W, wire wound Min		(W22K)
R27	22k		(M22K)
Capacitors			
C1,8,9,10,11,12,13	1u, 100V PC electrolytic	7 off	(FF01B)
C2,3,7	10n minidisc ceramic	3 off	(YR73Q)
C4	2u2, 63V PC electrolytic		(FF02C)
C5,6	47n minidisc ceramic	2 off	(YR74R)
C14	470u, 16V PC electrolytic		(FF15R)
C15	47u, 25V PC electrolytic		(FF08J)
Semiconductors			
IC1	LF351		(WQ30H)
IC2	3403		(QH51F)
IC3	CD4001		(QX01B)
D1-6	1N4148	6 off	(QL80B)
D7-10	1N4004	4 off	(QL76H)
D11,12	BZY88C9V1	2 off	(QH13P)
CSR1-3	C106D	3 off	(QH30H)
Miscellaneous			
	Case }*		
	Light fittings }*		
	Lamps		
	Mains cable		
	Mains plug		
	PCB mounting pillars		
	Fuse holder		
	Fuse, 2 Amp		
	Crystal mic		(HY33L)
	PCB		(GA42V)
	DIL socket, 14 pin	2 off	(BL18U)
	DIL socket, 8 pin		(BL17T)

*A suitable case with light fittings is Maplin part number XY00A



Alternative 3-light mounting (modulator can be housed in channel base).

TAPE-SLIDE SYNC

★ Synchronise your slide show and sound track
★ Compact low cost unit
★ Suitable for mono or stereo systems
★ Easy to operate

by Brian Milthorp

PARTS COST GUIDE £11.50

This useful Tape-slide synchroniser can be utilised in a number of ways with either stereo or mono tape recorders to give automatic slide changing. Units of this type have two basic sections; a tone generator which records 'bleeps' on to the tape and a tone detector which activates a relay and operates the slide change mechanism of the projector when it detects each 'key' during playback. The Tape-slide synchroniser can be used in a number of ways as follows:

1. With a mono recorder as a programmable slide timer. Here the tape is only fed with the 'bleeps' and there is no music or commentary on the recording.
2. With a mono recorder, the music, commentary, and bleeps being recorded on to the tape. This gives a recorded accompaniment and automatic slide changes, but the 'bleeps' are audible when they occur during playback.
3. With a stereo recorder, a mono accompaniment being recorded on to the left-hand channel, and the 'bleeps' being recorded on to the right-hand channel.
4. With a stereo recorder, accompaniment being recorded on to the left-hand channel, accompaniment and 'bleeps' being recorded on to the right-hand channel. This gives a full stereo accompaniment, but the 'bleeps' will be audible.

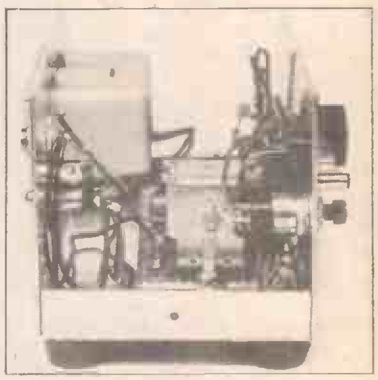
A LED indicator lights whenever triggering occurs and manual operation is possible at all times. The synchroniser is powered by an internal 9 volt battery.

Circuit Description

The circuit is built around a 556 timer IC (dual version of the popular 555 device); one circuit being used to generate the tone bursts, the other acting as the relay driver. The circuit diagram of the synchroniser is shown in Figure 1.

S2 is the record/playback selector and when the unit is in the playback mode S2a contacts are made such that the input from the right-hand tape channel is then fed via SK1 (pin 2) to the sensitivity control RV1. C1 is a DC blocking capacitor and R2, R3 provide positive bias to the base of TR1. This bias is not quite sufficient to bring TR1 into conduction. Positive input half-cycles from the tone bursts on the tape track to the base of TR1 cause it to conduct and charge C2 via D1, taking pins 6 and 2 of IC1 to a low voltage. This results in the output at pin 5 going high and activating the relay and LED indicator D3. The projector is then operated via a pair of normally open relay contacts, RL1/1, which close and extend an earth to the projector unit, via JK1.

When the input tone ceases R4 quickly discharges C2 and the



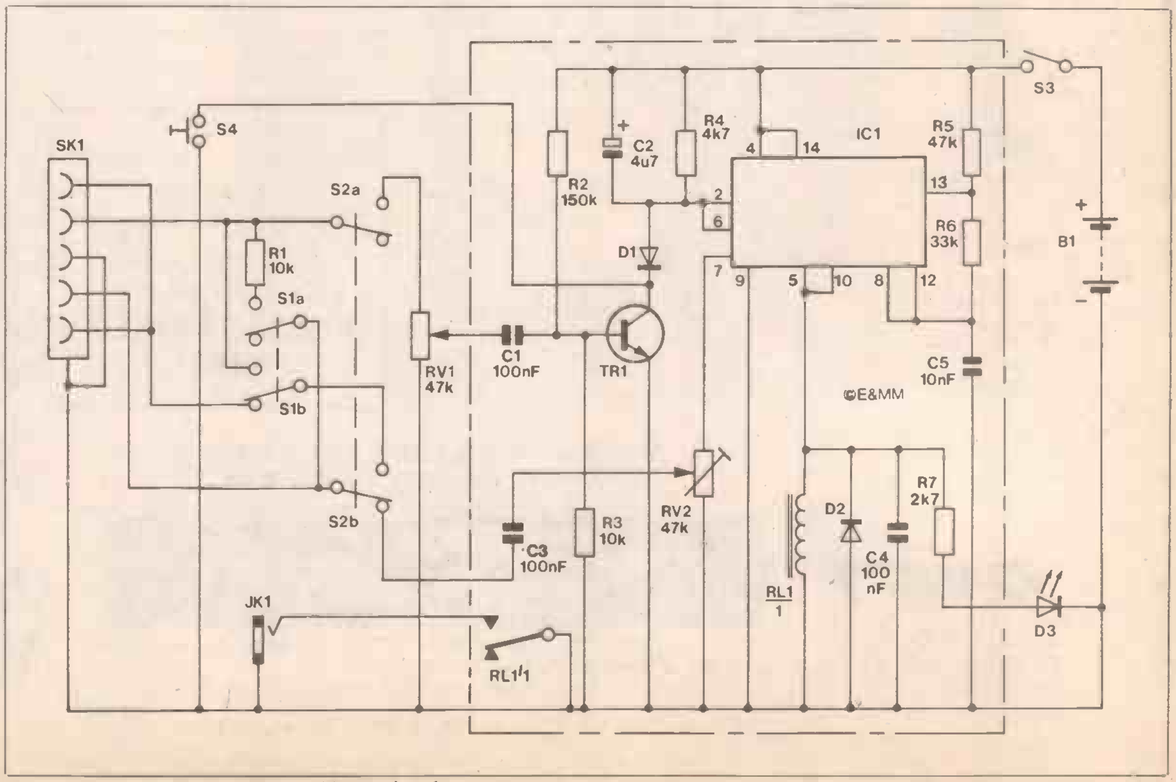


Figure 1. Circuit diagram of tape-slide synchroniser.

circuit reverts to its original state with the relay and D3 switched off.

The second section of IC1 forms the tone generator and the values of R5, R6 and C5 give an operating frequency of approximately 1kHZ. RV2 is the preset output level control and C3 couples the output signal to the pin 4 of SK1 when S2 is in the record mode. The 'bleeps' are obtained by operating S4. This takes pins 6 and 2 of IC1 low so that the output at pin 5 goes high, operating the relay and D3. In addition to giving the relay and operating the projector, pin 10 of IC1 is taken high so that the tone generator (which was previously disabled) functions in the normal way and generates the tone burst.

The left-hand channel signal is coupled straight through the unit.

In the mono mode the right-hand input is coupled through the unit via R1 and the tones are mixed into the output. The left-hand channel is unused.

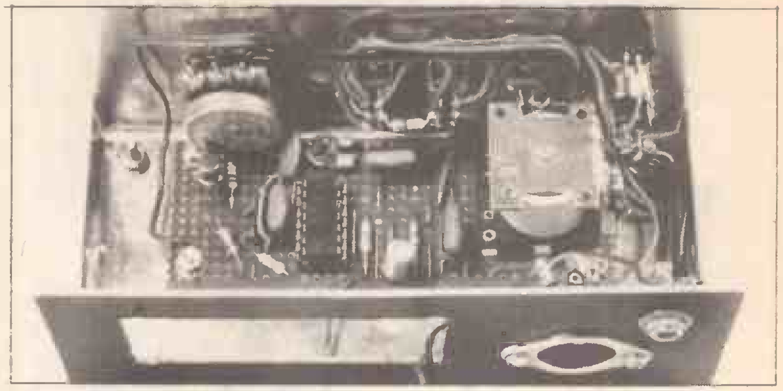
Construction

The unit can be constructed at an economic cost and made very compact. Most of the components including the relay are mounted on a piece of copper-clad Veroboard (cut to size 13 strips by 38 holes) which is bolted to the base of the case through spacers. Figure 2 shows the layout of the component panel.

Virtually any case having dimensions of about 130 x 75 x 60mm or more should accommodate all the components without difficulty. SK1 and JK1 are fitted on the rear of the case on the right-hand side (as viewed from the rear). The battery compartment is fitted on the other side of the rear panel and fits into a rectangular hole which has to be drilled out and filed smooth. S4 is mounted on the left-hand side of the front panel with the LED fitted above it. RV1 is mounted on the opposite side of the front panel with the three toggle switches grouped around the centre of the panel. These switches require M2 fixings.

Recording

Arrange the DIN connections so that the music or commentary if used, is entering the appropriate channel or channels. If the unit is to be used with 'bleeps' and music on the right-hand channel set S1 to 'stereo'. For other modes set S1 to mono. S2 is switched to 'record' of course. The output from SK1 connects to the input of the tape recorder, and S4 is then held down while RV2 is adjusted for a VU meter reading of about 0dB on the recorder. Then connect the slide projector's remote control socket to JK1 and begin recording. Press S4 for about one second or so where slide changes are required, in the same way as using the normal slide change button. The slide projector will change slides at the same time as the 'bleeps' are recorded. When recording 'bleeps' and an accompaniment on to the same channel, make sure that the music or commentary is not too loud or it may trigger the unit on playback.



Internal view from rear.

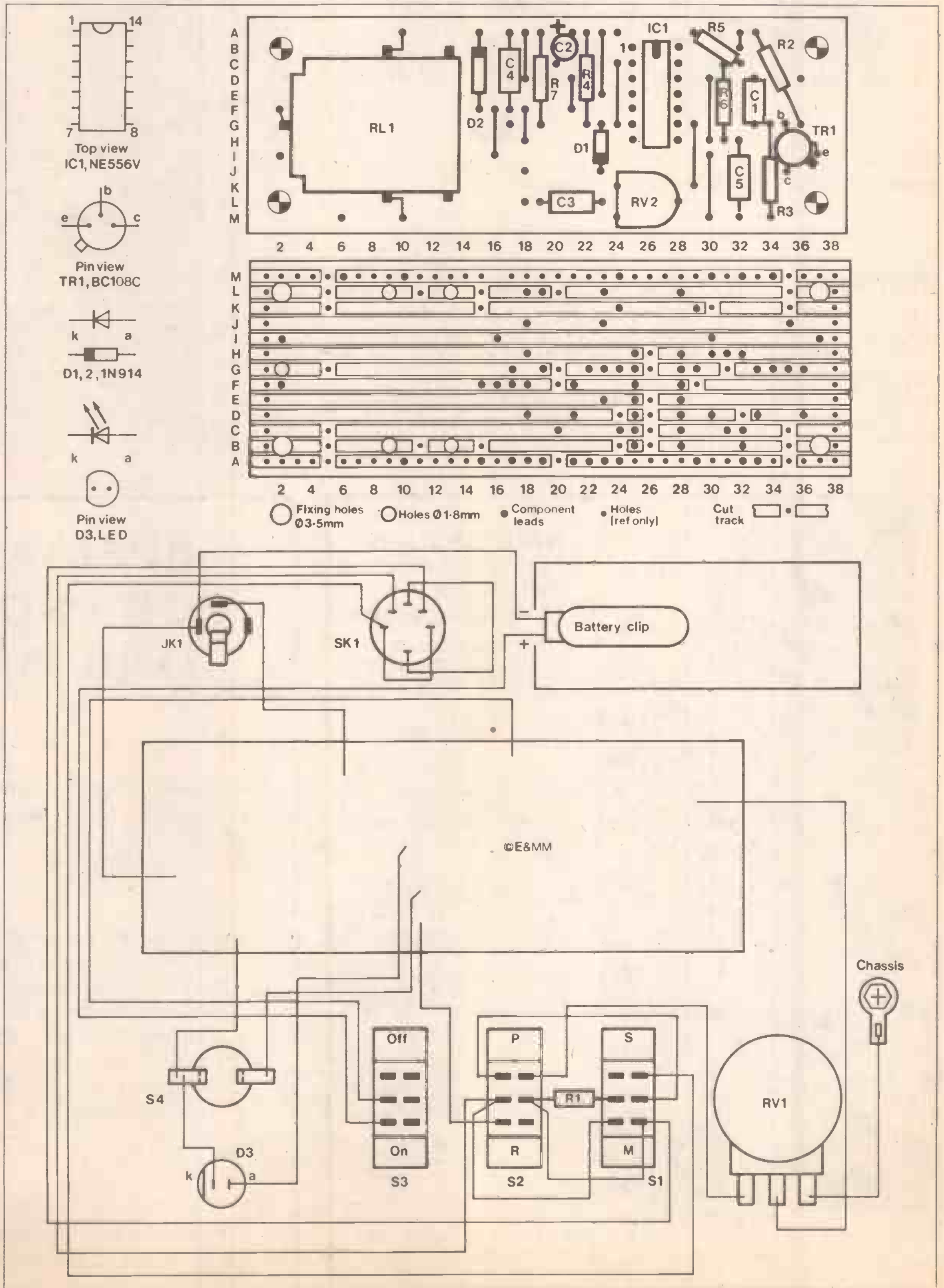
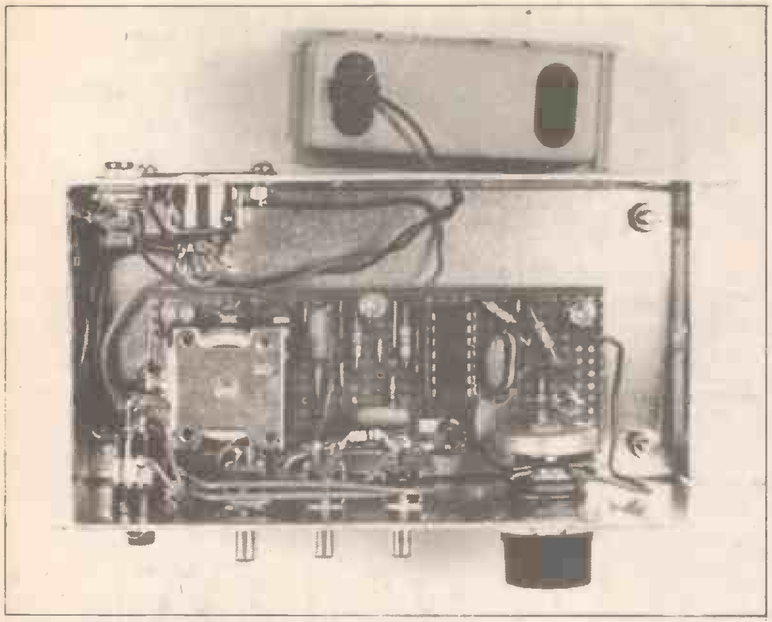


Figure 2. Veroboard and unit wiring details.



Interior view of unit with the battery compartment lifted out.

Playback

This time play the output from the recorder into the input socket to the synchroniser and take the output from the synchroniser to the input of the amplifier. JK1 of the synchroniser connects to the remote control socket of the projector, as before. Set S2 to playback, play the tape, and when a pulse occurs adjust the sensitivity control so that the relay just operates reliably. This reduces the risk of mis-triggering, particularly if the right-hand channel is carrying music or commentary in addition to the 'bleeps'. E&MM

TAPE-SLIDE SYNC PARTS LIST

Resistors - all 5% ⅓W carbon unless specified			
R1,3	10k	2 off	(M10K)
R2	150k		(M150K)
R4	4k7		(M4K7)
R5	47k		(M47K)
R6	33k		(M33K)
R7	2k7		(M2K7)
RV1	47k pot. lin.		(FW04E)
RV2	47k hor. preset		(WR60Q)
Capacitors			
C1,3,4	100nF polyester	3 off	(BX76H)
C2	4u7 63V PC electrolytic		(FF03D)
C5	0.01uF ceramic		(BX00A)
Semiconductors			
TR1	BC108C		(QB32K)
IC1	NE556V		(QH67X)
D1,2	1N914	2 off	(QL71N)
D3	LED orange		(WL29G)
Miscellaneous			
S1,2,3	Switch miniature slide	3 off	(FF79L)
S4	Switch push-button		(YR67X)
SK1	5-pin din socket		(HH34M)
JK1	3.5mm jack socket		(HF82D)
RL1	5A SPDT relay		(FX23A)
	IC holder 14-pin		(BL18U)
	Veroboard		(FL07H)
	Bolt 6BA ½in.	1 pkt	(BF06G)
	Bolt 6BA 1in.	1 pkt	(BF07H)
	Bolt M2 6mm	1 pkt	(BF41U)
	Spacers 6BA ¼in.	1 pkt	(FW34M)
	Nuts 6BA	2 pkts	(BF18U)
	Solder tags 6BA	1 pkt	(BF29G)
	Case TP1		(LH43W)
	9V battery holder		(XX33L)
	Scaled knob		(RX11M)
	LED clip		(YY40T)
	Rubber feet	1 pkt	(FW19V)

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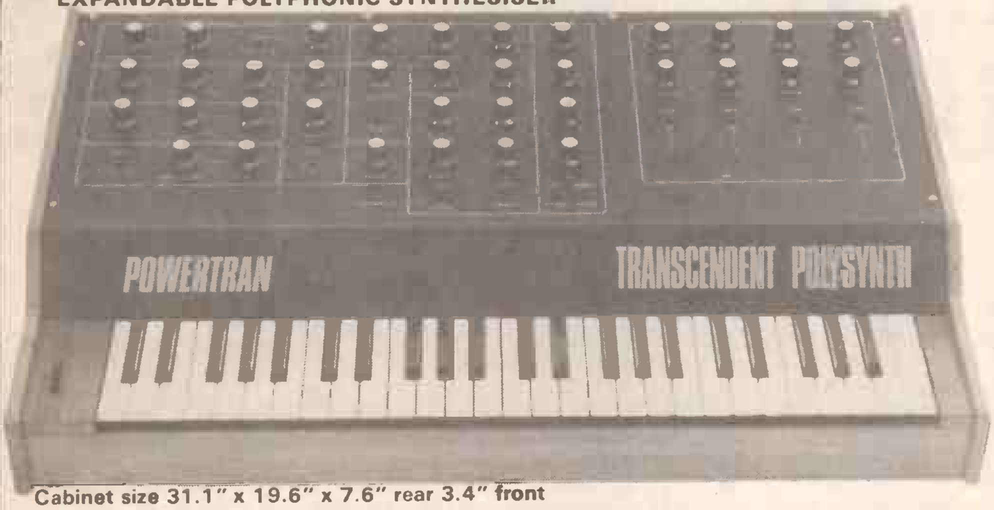

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The basic instrument is supplied with 1 voice and up to 3 more may be plugged in. A further 4 voices may be added by connecting to an expander unit, the metalwork and woodwork of which is designed for side by side matching with the main instrument. 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 using 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 22	Ribbon cable, ribbon cable connectors, mains cable	£8.45
POLY 23	Fully finished metalwork and fixing parts	£25.60
POLY 24	Solid teak cabinet	£25.80
POLY 25	Construction manual	£1.50
Total cost for individually purchased packs for single voice instrument		£355.15
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POLY 3	Superior quality keyboard	£32.25
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POLY 6	Rs, Cs, heat sink for fitting to Pack 5	£10.50
POLY 7	IC's IC sockets, diodes for fitting to Pack 5	£31.30
POLY 8	Double sided mother board (for plug-in voices)	£18.90
POLY 9	Rs, Cs, connectors for mother board	£14.10
POLY 10	IC's IC sockets, Trs, heat sinks for mother board	£13.10
POLY 11	PCB for master controls (left of section marked VOICES)	£18.80
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POLY 13	Pots, Switches for master control board	£11.80
POLY 13	Pots, Switches for master control board	£11.80
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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.
Each part of the series is accompanied by a simple constructional project which demonstrates 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.

Synpac Battery Eliminator

Alternating Current (AC)

So far we have only considered voltages and currents that are of fixed polarity and constant amplitude (or change in amplitude relatively slowly). Signals of this type are known as 'direct currents' or DC if the accepted abbreviation is used. There is another and equally important type of signal known as an 'alternating current' or just AC in its abbreviated form. An alternating current starts at zero and increases to its peak positive value, after which it then falls back to zero again. It then increases in amplitude again, but with the opposite polarity to the first part of the signal. As before, it climbs to a peak value and then falls back to zero again. One transition from zero to peak amplitude and back to zero again is a 'half cycle', and two half cycles of opposite polarity together give one complete 'cycle'.

An alternating signal can be represented graphically, as shown in Figure 1(a). Here the horizontal axis represents time and the vertical axis is representative of voltage. Alternatively, if the signal is fed to a resistive load the vertical axis could represent the current flowing through the load since the voltage and current would be proportional to one another. The waveshape shown in Figure 1(a) is known as a 'sinewave' and is important in that it is comprised of just one 'frequency'. Frequency is simply defined as the number of cycles in a given length of time and the basic unit of frequency is the 'Hertz'. One Hertz is equal to one cycle each second. A signal having (say) 300 cycles in a one second period has a frequency of 300 Hertz, or 300Hz in its abbreviated form.

In electronics it is quite normal to encounter quite high frequencies, and in order to avoid the use of excessively high numbers it is normal to use the following prefixes to the word Hertz:

kilo (kHz), equal to 1000 Hertz
Mega (MHz), equal to 1000000 Hertz
Giga (GHz), equal to 1000000000 Hertz

Thus a signal having 200000 cycles per one second period could be said to have a frequency of 200000 Hertz, but would normally be said to have a frequency of 200 kHz.

As stated earlier, a sinewave has just one frequency component, but any other waveshape will actually contain at least two frequencies, and could comprise any number of frequencies. When dealing with other waveforms it is quite normal simply to state the fundamental frequency of the signal and ignore the fact that other frequencies are present, but it is nevertheless important to bear in mind that these other frequencies are present as it can sometimes be of considerable practical importance.

Power Supplies

We have all used AC signals as the ordinary UK mains supply is just one of many common examples of AC signals. The amplitude of AC signals can be expressed in several ways and the figure of 240 volts normally quoted for the UK mains supply is 240 volts RMS (Root Mean Square). In simple terms, an AC power, voltage, or current figure given in RMS is an equivalent quantity to the same figure given as a DC quantity. For example, if 18 volts RMS are applied to a resistor, the power dissipated in the resistor and the heat generated within it will be the same as if 18 volts DC were to be applied to the resistor.

AC quantities are sometimes given in terms of peak value, or peak-to-peak value. The peak value is simply what it says: the highest value achieved during one cycle. For a sinewave signal this is more than the RMS value; about 1.414 times larger in fact. The peak-to-peak value is simply the peak positive value added to the peak negative value. For a sinewave signal this is obviously double the peak value and 2.828 times the RMS value.

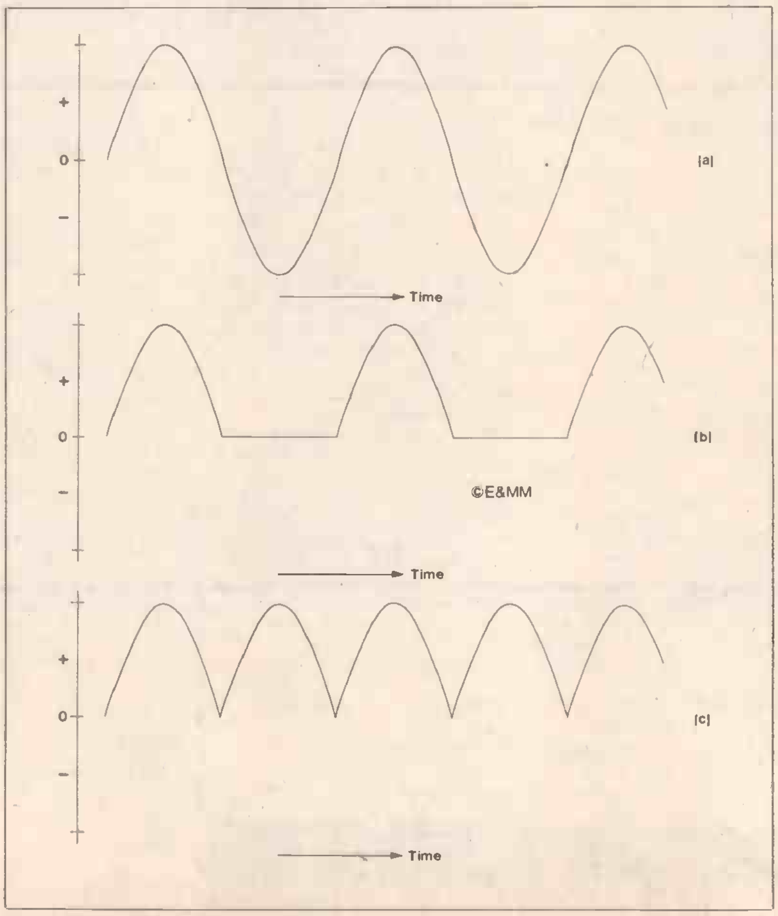

Figure 1. (a) Sine wave.
(b) Half-wave rectification of a sine wave.
(c) Full-wave rectification of a sine wave.

It is often necessary to change an AC signal to a DC one, and a simple example of this would be if it was necessary to power low voltage DC equipment from the AC mains supply. The first step in converting the high voltage AC input to a low voltage DC output is to reduce the input voltage to the required level. This could be done using a potential divider circuit but there are two drawbacks to this method. Firstly, the potential divider circuit would waste a great deal of power. For example, if we required an output voltage of 24 volts from a 240 volt AC input, there would be 216 volts across the dropper resistor and 24 volts across the output. The current flowing through the dropper resistor would be the same as that flowing at the output, and the power developed across the dropper resistor and across the output would be proportional to the voltages across these. Thus just 10% of the input power would appear at the output with the other 90% being wasted in the dropper resistor as heat. Lower output voltages would give even lower efficiency. The second drawback is that a potential divider circuit would give no isolation from the mains supply, and anyone touching the wiring at the output of the dropper circuit would be in danger of receiving a severe electric shock.

A much better way of obtaining the reduction in voltage is to use a component called a 'transformer'. This consists of two coils in close proximity to one another, and relies on the fact that if an AC signal is applied to a coil of wire (or even just a straight piece of wire) a varying magnetic field is produced around the coil (or piece of wire). If a coil is placed within a varying magnetic field, an AC signal is induced into the coil. Thus, by placing two coils close together and feeding an AC signal into one, an AC output signal can be taken from the other.

What makes a transformer so useful is that by having more turns on the

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TRANSCENDENT 2000 SINGLE BOARD SYNTHESISER

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

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 ca t 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!

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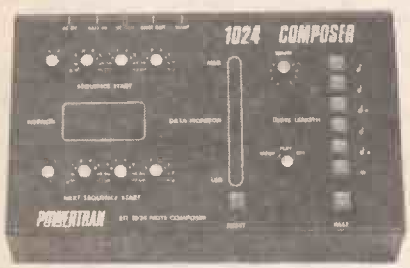
TRANSCENDENT DPX
MULTI VOICE SYNTHESISER

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

COMPLETE KIT ONLY £299 + VAT

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 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 and 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 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.

1024 COMPOSER



Programmed from a synthesiser, our latest design to be featured in Electronics Today International, the 1024 COMPOSER controls the synth. with a sequence of up to 1024 notes or a large number of shorter sequences e.g. 64 of 16 notes all with programmable note length. In addition a rest or series of rests can be entered. It is mains powered but an automatically trickle charged Nickel Cadmium battery, supplying the memory preserves the program after switch off.

The kit includes fully finished metalwork, fibreglass PCB, controls, wire etc. — complete down to the last nut and bolt!

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BLACK HOLE CHORALIZER

De Luxe version (dual delay line system) also available for £59.80 + VAT

Cabinet size 10.0" x 8.5" x 2.5" (rear) 1.8" (front)

The BLACK HOLE designed by Tim Orr, is a powerful new musical effects device for processing both natural and electronic instruments, offering genuine VIBRATO (pitch modulation) and a CHORUS mode which gives a "spacey" feel to the sound achieved by delaying the input signal and mixing it back with the original. Notches (HOLES), introduced in the frequency response, move up and down as the time delay is modulated by the chorus sweep generator. An optional double chorus mode allows exciting antiphase effects to be added. The device is floor standing with foot switch controls, LED effect selection indicators, has variable sensitivity, has high signal/noise ratio obtained by an audio compander and is mains powered — no batteries to change! Like all our kits everything is provided including a highly superior, rugged steel, beautifully finished enclosure.

COMPLETE KIT ONLY £49.80 + VAT!
(single delay line system)

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input coil than on the output coil it is possible to obtain a step-down in voltage. By having more turns on the output coil than on the input winding it is possible to have a voltage step-up through the component. The input winding is called the 'primary' and the output winding is called the 'secondary'.

In a theoretically perfect transformer the step-up or step-down ratio of the transformer is equal to the number of primary turns divided by the number of secondary turns. Therefore, in order to step-down the 240 volt mains supply to a level of 24 volts there would need to be ten times as many turns on the primary as on the secondary in order to give the required ten to one input to output ratio. Also in a theoretically perfect transformer there are no losses and if (say) 24 volts at 1 ampere is taken from the secondary, 240 volts at 100 milliamps would be needed at the input to the primary. In other words the input power matches the power

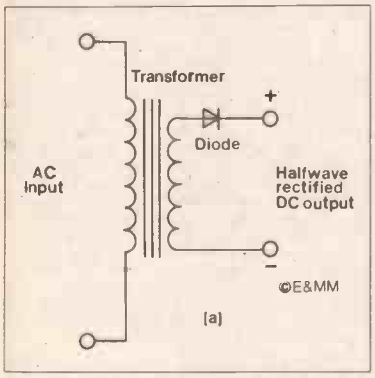
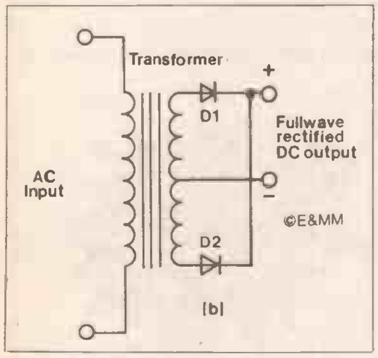
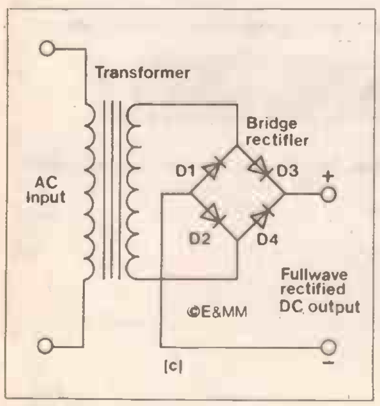


Figure 2. (a) Half-wave rectifier circuit.



(b) Push-pull rectifier circuit.



(c) Bridge rectifier circuit.

taken from the secondary, and both are 24 watts in our example above.

In a practical transformer there are substantial losses despite steps being taken to give high efficiency, such as the windings having a special laminated core. However, even if losses of around 40% occur through a transformer, this is likely to be far less than would be obtained using a potential divider circuit. The reduction in output voltage produced by the losses is simply overcome by increasing the number of secondary turns in order to restore the secondary voltage to the required figure.

As there is no direct connection between the primary and secondary windings of a transformer, when used in a mains power supply the transformer used to give the voltage step-down also isolates the output from the potentially dangerous mains, supply.

Rectification

Having obtained a low voltage AC signal it is now necessary to convert this to a DC signal. The most simple wave of achieving this is shown in Figure 2(a), and this simply consists of passing the output signal through a rectifier. When the transformer applies a positive-going signal to the diode it conducts and the signal passes through to the output. When the transformer supplies a negative going signal to the diode it does not conduct and blocks the signal from the transformer. This gives an output waveform of the type shown in Figure 1(b). Obviously this does not give a constant output voltage suitable for powering equipment such as musical effects units and transistor radios, and there is actually no output at all for about 50% of the time! As we shall see shortly, it is not difficult to 'smooth' out these fluctuations in the output voltage.

This type of rectification is known as half-wave rectification because only half of the input waveform appears at the output. It has two main drawbacks which result in it being little used in practical circuits. The main one is that since half of each output half-cycle from the mains transformer is unused, rather inefficient use of the transformer results. The second drawback is simply that the fairly long time between signal peaks makes the signal comparatively difficult to smooth to a reasonably steady DC output.

Much better efficiency and easier smoothing can be achieved using a full-wave rectifier circuit. Circuits of this type give an output waveform of the type shown in Figure 1(c), and here the part of the input waveform that was simply removed in the half-wave circuit has been inverted so that it is of the required polarity and partially fills the gaps between signal peaks.

There are two common types of full-wave rectifiers and Figure 2(b) shows one of these. This is the push-pull type which requires just two rectifiers, and needs a mains transformer having a centre tapped secondary winding. When the upper secondary connection is positive relative to the centre tap, the lower connection will be negative relative to the tapping point. On opposite half cycles when the upper secondary connection becomes negative, the lower one becomes positive in relation to the centre tapping.

When the upper connection is

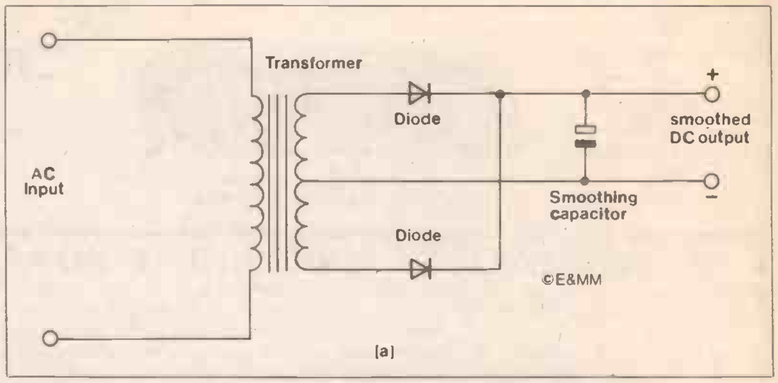
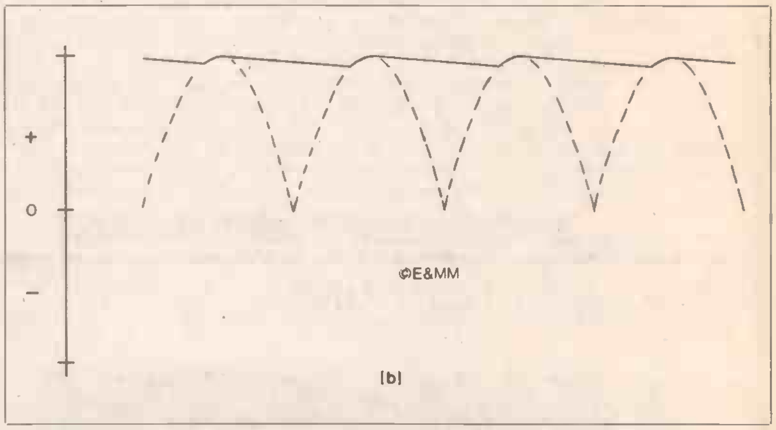


Figure 3. (a) A circuit giving full-wave rectification and smoothing.



(b) Output waveform of a full-wave smoothed power supply.

positive-going, D1 conducts and supplies a signal at the output. D2, on the other hand, blocks the negative-going signal from the lower secondary connection of the transformer. On the opposite set of half cycles D2 conducts and supplies a positive signal to the output, while D1 blocks the negative signal that it receives. Thus D1 and D2 alternately supply an output half cycle and give full-wave rectification.

The other type of full-wave rectifier needs only a single non-tapped secondary winding, but uses four rectifiers. The latter are connected in a bridge circuit and this will not be considered in detail here as this type of circuit has been covered in a previous part of this series (Starting Point Part 4, E&MM June 1981).

Smoothing

Smoothing of the raw output of a rectifier circuit can be achieved simply by adding a capacitor across the output, as shown in Figure 3(a). The capacitor charges up during signal peaks when one or other of the diodes becomes forward biased. At other parts of the output waveform of the rectifier circuit, the voltage across the capacitor is greater than the output voltage of the transformer and the diodes are reverse biased. The capacitor therefore has to discharge into the load connected across the output of the supply during the gaps between signal peaks, to maintain a reasonably steady output voltage.

In order to do this the capacitor needs to have quite a high value unless only a very low output current is drawn. In practice this means that an electrolytic component must be used. However large the smoothing capacitor is made in value, if an output current is drawn from the unit there will be some drop in output voltage between output peaks from the rectifier circuit. This gives an output waveform of the type shown in Figure 3(b) (the broken line represents the output waveform of the rectifier circuit with no smoothing used).

If a fairly high output current is needed together with a very well smoothed supply, the value of the smoothing capacitor becomes impractically high. There are ways of overcoming this and the most common these days is to use a voltage regulator to give additional smoothing, with a smoothing capacitor of only fairly modest value being used. There can be quite a high level of 'ripple' on the input to the regulator, but provided the input voltage does not fall to a level which is too low for the regulator to maintain its output voltage, a virtually ripple-free output will be obtained. The only problem with this system is that the transformer must give a slightly higher output voltage than would otherwise be required, in order to compensate for the voltage drop through the voltage regulator circuit. However, this is only a minor drawback and using a regulator to provide electronic smoothing is preferable to using a very high value smoothing capacitor.

Note that the smoothing capacitor charges to the peak output potential of the transformer, less any voltage drop through the regulator circuit. It does not charge to the RMS output voltage, which is the figure normally quoted in transformer specifications. It is also worth noting that in any of the rectifier circuits shown here the polarity of the output signal can be altered simply by reversing the polarity of the rectifier or rectifiers employed in the circuit.

Monolithic Regulators

We covered simple voltage regulators using discrete components in the previous part of Starting Point. Modern circuits often use integrated circuit regulators which enable highly efficient stabilisation to be achieved using very few components. The simplest type of IC regulator is the three terminal type which is primarily intended for use in fixed output voltage supplies, and is available with various output voltages.

This regulator is used in the manner shown in Figure 4(a), and as can be seen, requires only two discrete components. These are both decoupling capacitors which are needed to ensure that the regulator IC does not become unstable and in practice these should be connected physically close to the regulator device.

One problem with three terminal regulators is simply that there may not be a type available which has the output voltage you require. In such instances one solution to the problem is to use a four terminal IC regulator as this enables the output voltage to be set at virtually any desired level.

Figure 4(b) shows the way in which a four terminal regulator is used and this is very similar to using a three terminal device. The only difference is that the four terminal type has its additional leadout connected to the output of the circuit via a potential divider (R1 and R2). By a feedback action, the regulator is actually stabilising the additional terminal (the control or cont. terminal) at a certain potential, rather than stabilising the output at one particular voltage. The control input is often stabilised at 5 volts, although some devices use a different voltage. If we assume a figure of 5 volts is used and the control terminal is connected direct to the output, obviously the output will be stabilised at 5 volts. If the potential divider is introduced into the circuit there is obviously a voltage drop from the output to the control terminal, and the output will stabilise at somewhat more than 5 volts in order to maintain 5 volts at the control terminal. If we take a simple example, making the two arms of the potential divider the same value would give half the output voltage at the control terminal, and the output would stabilise at 10 volts in order to give 5 volts at the control input. The output voltage is equal to R1 plus R2, divided by R2, and multiplied by 5 (or whatever voltage is needed at the control terminal).

Incidentally, both three and four terminal regulators incorporate current limiting circuitry which protects them against damage due to short circuits across the output.

The Synpac Battery Eliminator

This month's project is a battery eliminator which gives a well smoothed and regulated output of nominally 9 volts and can supply currents of up to 500mA. It is primarily intended to be used with musical effects units and it has four output sockets so that up to four units can be powered from the eliminator. However, it can be used to power any 9 volt equipment that does not consume more than 500mA, and can power any number of units provided the total current drain does not exceed 500mA.

The circuit diagram of the Battery Eliminator is shown in Figure 5. T1 is the isolation and step-down transformer and the mains supply is coupled to its primary winding via on/off switch S1. LP1 is a neon on/off indicator and is a type having a built-in series resistor for 240 volt mains use (do not use a type which does not have this resistor). There are two identical 6 volt secondary windings on T1, which are wired in series to effectively produce a single 12 volt winding. Note that the 0 volt terminal of one winding must connect to the 6 volt terminal of the other (not 0 volt to

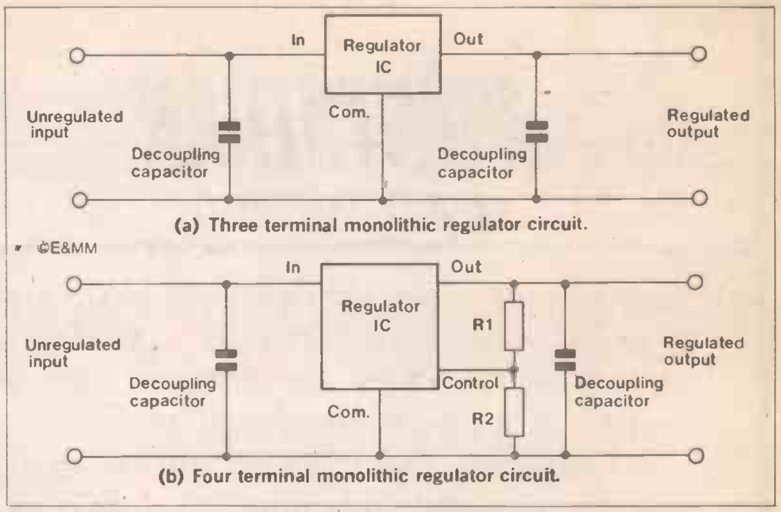


Figure 4.

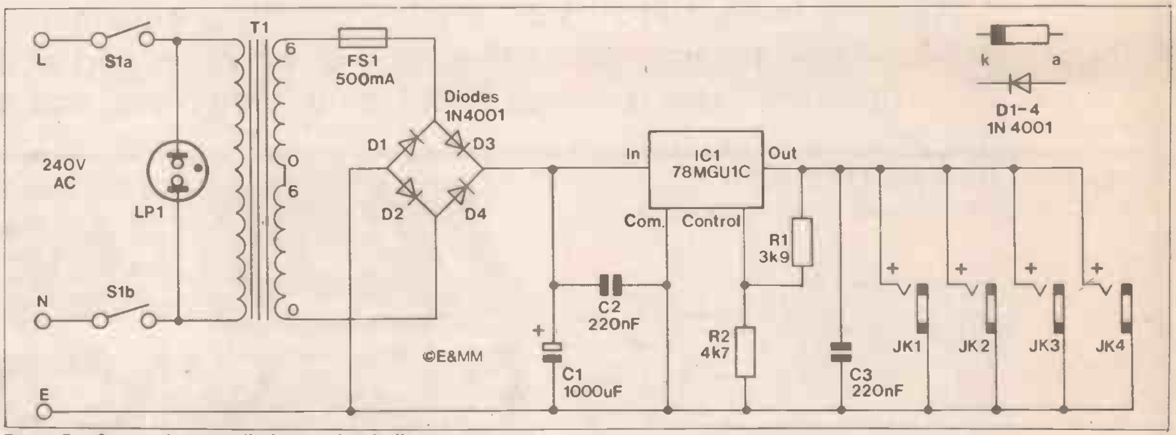


Figure 5. Synpac battery eliminator circuit diagram.

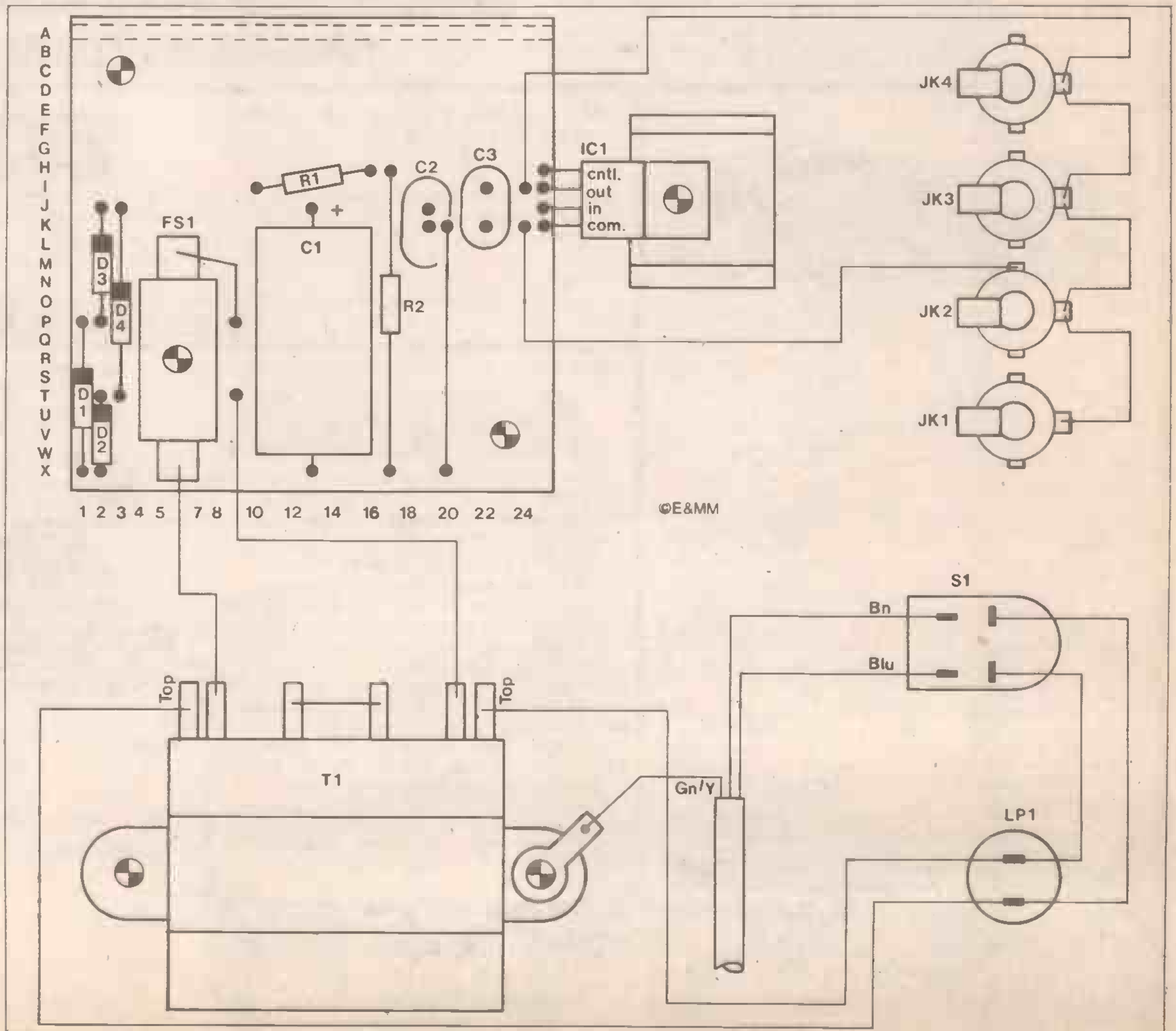


Figure 6. Component layout and wiring diagram for Synpac battery eliminator.

0 volt or 6 volt to 6 volt), otherwise the output from one secondary will cancel out the signal from the other winding and there will be no output whatever!

The output of T1 is coupled to a bridge rectifier by way of fuse FS1. As the circuit has output current limiting, FS1 is included as a protection against faults in the circuit rather than output overloads. C1 is the smoothing capacitor.

The regulator circuitry uses exactly the same configuration as the one shown in Figure 4(b) and described earlier. The specified regulator is a type which stabilises with 5 volts at the control terminal, and R1 and R2 therefore give a nominal output potential of fractionally over 9 volts (which is comparable to a slightly used 9 volt battery). R1 and R2 are precision (1%) components so that the output voltage is set with good accuracy. The output sockets are simply wired in parallel across the output of the unit, and as few or as many sockets as desired can be used here.

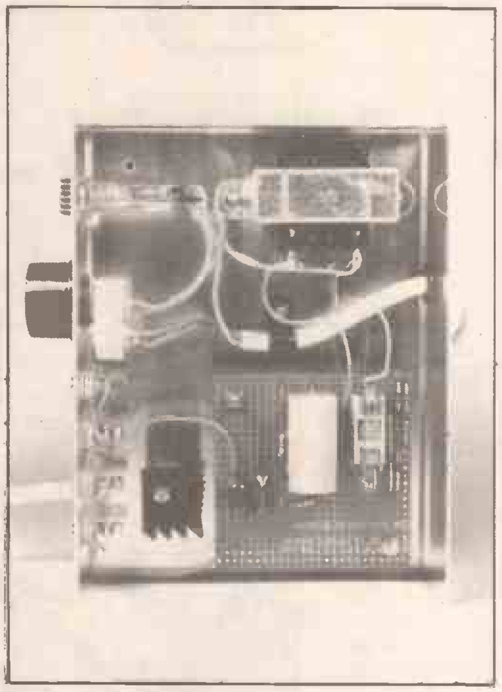
Construction

An instrument case having approximate outside dimensions of 114 x 152 x 44mm. makes a good housing for the Battery Eliminator, but it is not essential to use a case of this type. For reasons of safety though, the case should be a metal type and earthed to the mains earth lead. It should also be a type having a screw-on lid, rather than one having a lid which simply clips in place.

Reference to the photographs shows the general layout of the unit. A solder tag is fitted on one of the mounting bolts of T1 in order to provide a chassis connection point for the mains earth lead.

Figure 6 shows the component layout of the Veroboard panel and the wiring of the unit. The board has 24 holes by 25 holes and there are no breaks in the copper strips. IC1 is fitted with a small finned heatsink which is simply bolted on to the heat-tab of the component. FS1 is fitted in a chassis mounting fuseholder which in actual fact is bolted on to the component panel. When the board and all the point-to-point wiring has been completed, mount the board on the base panel of the case using ½in. spacers to keep the underside of the board well clear of the metal case.

Thoroughly check all the wiring, especially the mains wiring, and fit the lid of the case in position before connecting the unit to the mains and testing it. If possible, check that the output voltage is correct before connecting the unit to any equipment and be careful to connect the output of the unit with the correct polarity (the tip of the plug is positive and the barrel is negative). **E&MM**



Synpac Internal layout.

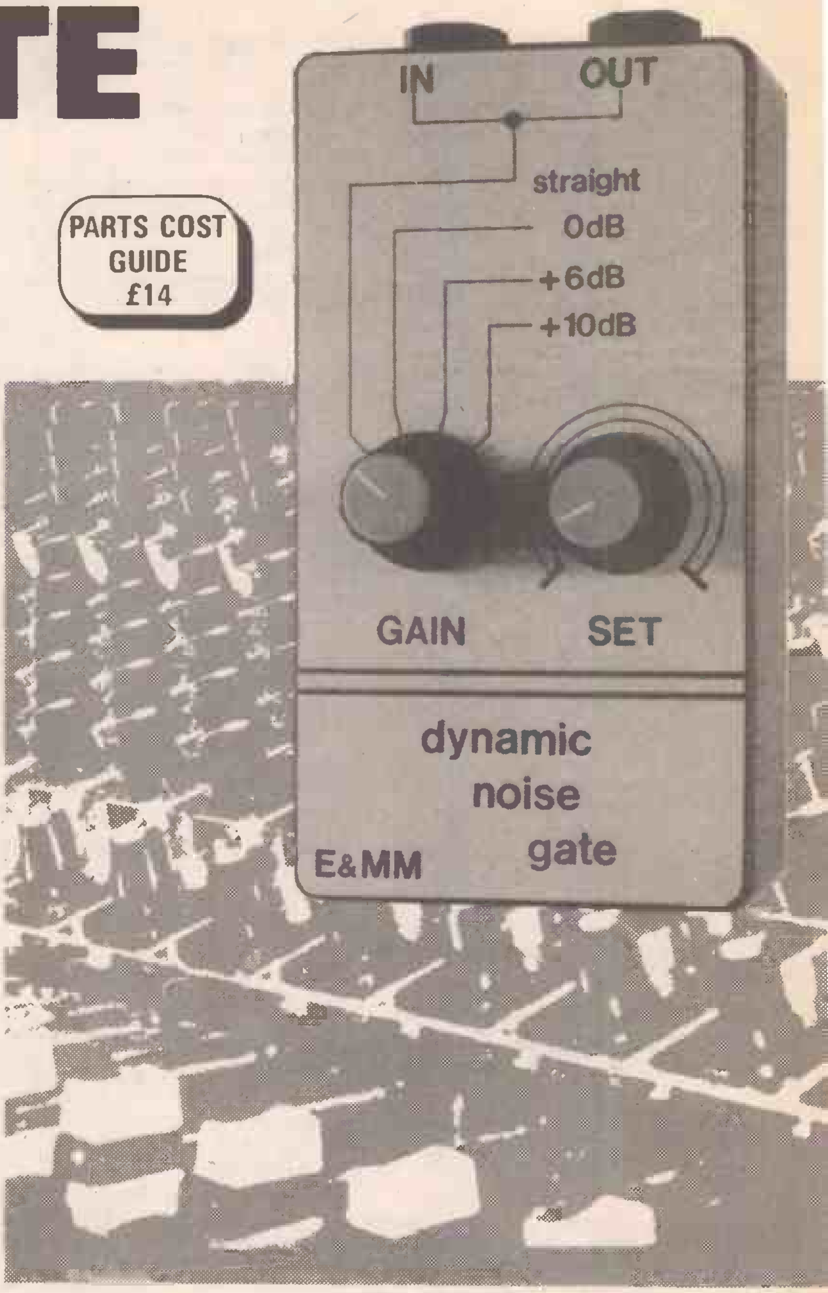
SYNPAC PARTS LIST

Resistors - ½W 1% carbon			
R1	3k9		(T3K9)
R2	4k7		(T4K7)
Capacitors			
C1	1000uF 25V electrolytic		(FB83E)
C2,3	220nF Mylar	2 off	(WW83E)
Semiconductors			
IC1	uA78MGU1C		(WQ78K)
D1,2,3,4	1N4001	4 off	(QL73Q)
Miscellaneous			
FS1	500mA 20mm. quick blow		(WR02C)
LP1	Green Mains Panel Neon		(RX98G)
S1	Rotary Mains Switch		(FH57M)
T1	Mains transformer having two 6 volt 500mA secondary windings		(WB06G)
JK1,2,3,4	Jacksocket 3.5mm	4 off	(HF82D)
	Case		(LH44X)
	Veroboard		(FL07H)
	Mains cable		(XR02C)
	Mains plug		(RW67X)
	Wire		(BL02C)
	Cabinet Feet		(FW19V)
	Control knob		(YX02C)
	Grommet		(FW59P)
	Fuseholder 20mm chassis mounting		(RX49D)
	Heatsink		(FL58N)
	Bolts 6BA 1in.		(BF07H)
	Nuts 6BA		(BF18U)
	Spacers 6BA ½in.		(FW35Q)

NOISE GATE

by Dave Roffey

PARTS COST GUIDE £14



- ★ Provides automatic shutdown of unwanted noise during 'pause' conditions
- ★ Compander technique eliminates 'signal snapping'
- ★ User adjustable characteristics for high or low level network insertion
- ★ Allows the use of otherwise 'too noisy to use' effects units
- ★ Can effectively cancel crosstalk in multi-microphone set-ups
- ★ Can be used in multi-instrument layouts for instant unit shutdown on changeovers
- ★ Will eliminate 'beehiving' in older type 'spaghetti' wired organs
- ★ No circuit trimming required or tight specification devices used
- ★ Can be used in its own right as an effect to create soft attack bowing characteristic
- ★ Uses only two low cost and readily available ICs
- ★ Self contained, jack-in-jack-out unit allows instant in-line connection

In these modern times of multi-device usage, noise or cross-talk can often become such a nuisance that desired sounds often have to be forfeited. Although this unit can do nothing for the possibly distracting noises emanating from audiences, producers etc., it can considerably reduce, or even eliminate, pause noise from devices in which it is otherwise impossible to improve on signal to noise ratios.

Several types of noise gate are available for this kind of noise elimination - 'snap-off' units - programmable types - externally controlled units - low level expansion devices etc. In order that the unit may have as wide a range of applications as possible, the low level expansion or dynamic gate has been selected. This type tends to be less critical in set-up

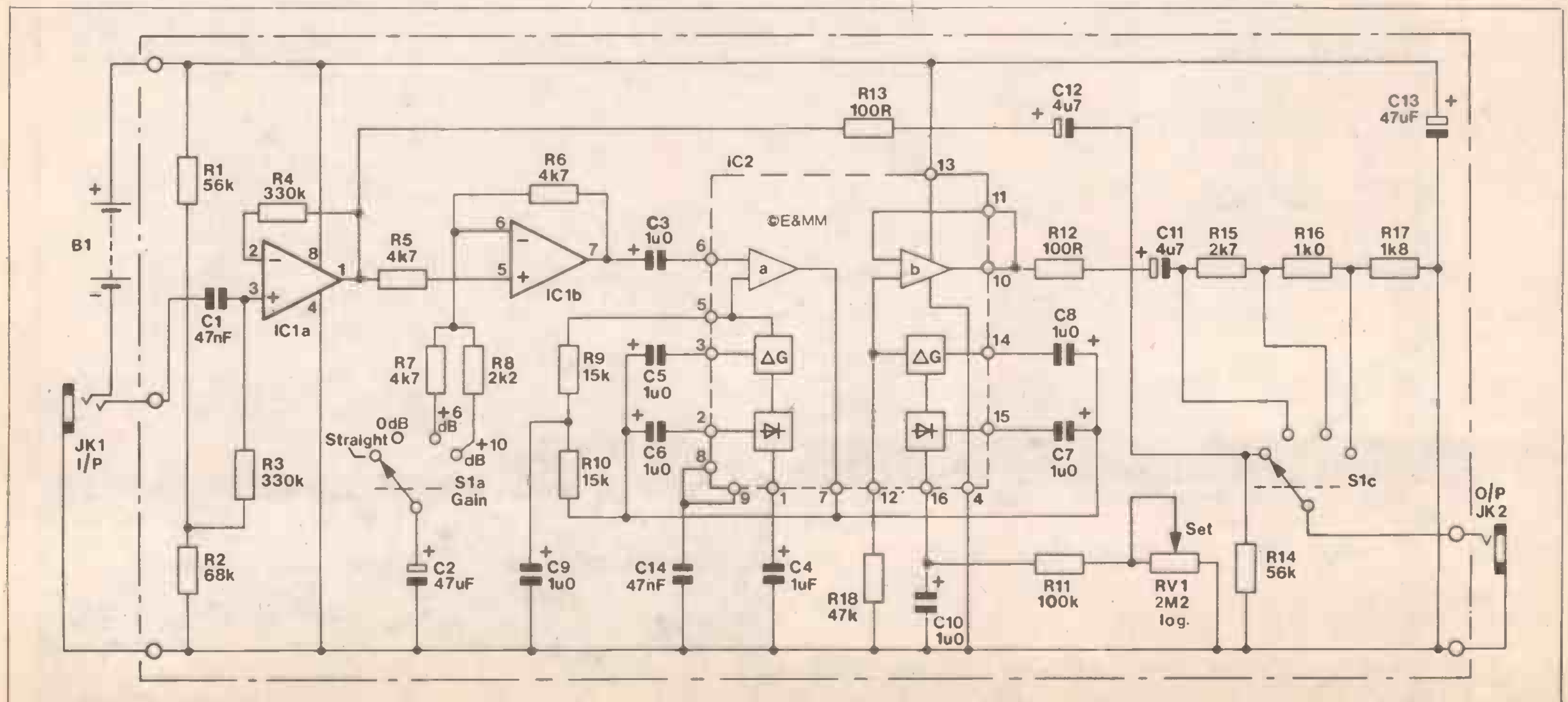


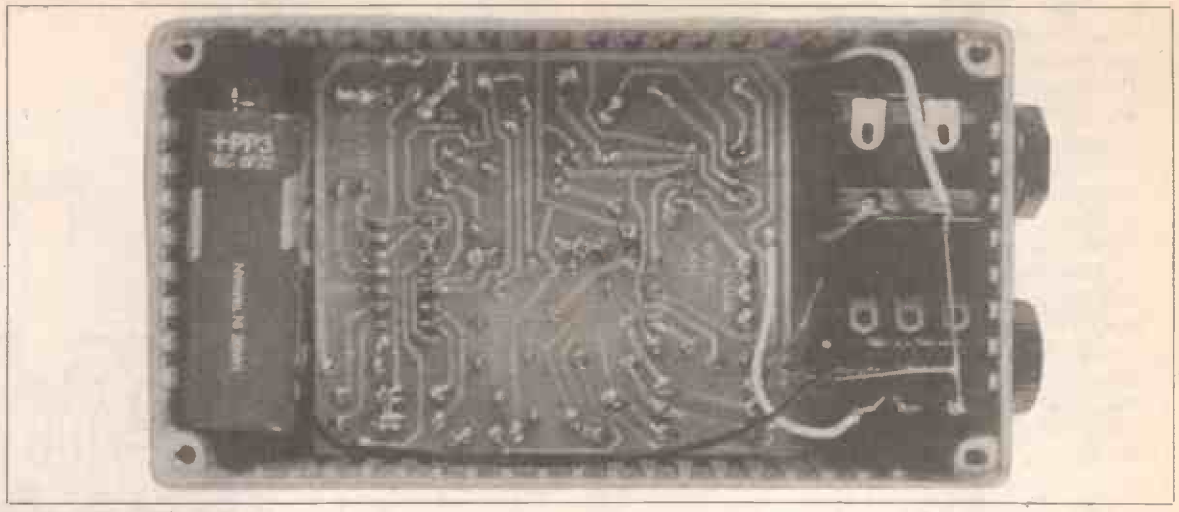
Figure 1. Circuit diagram for noise gate.

and general use, giving a more musically acceptable sound entrance and exit than the 'sudden shutdown' units.

Having a wide range of user adjustable characteristics, it should find many a useful working place with, for example, guitar / organ / keyboards / mic levels to mixer desk/P.A./recording levels. Not only can it be used for its main purpose, that of closing down noise or unwanted signals below a selected level, but as an effect in its own right, creating soft attack, bowing type characteristics.

Noise gates have been in use for considerably longer than most people would imagine. In fact, the first application of these devices was in the 1930's, when they were used to reduce unwanted crackles and pops from soundtrack film that had become dusty or scratched.

The most popular use for the dynamic noise gate is that of removing undesirable noise dur-



Internal view of noise gate.

ing pauses in live or recorded performance. To achieve this, the threshold would normally be set just under the required signal level.

The unit is easily constructed and does not require any 'setting up'. As a self contained unit, it can be used in different applications at will, although being very compact it may be just as easily panel mounted for 'one-off' noise conditioning.

Circuit

Block Format

1. Jacking input connects the -ve battery line to the common earth line by the use of a stereo socket. (A mono jack will short ring and earth contacts on the socket to effect power up).
2. A high input impedance stage is used to prevent input device loading. The output of this stage serves also as the straight driving unit for pre-post comparisons.
3. A switched gain stage provides adjustable sensitivity and allows flexible device usage.
4. The first stage of the dynamic noise gate's active circuitry consists of a fixed 2:1 compression network.
5. The second stage of this active circuitry consists of a 1:2 expansion network with a simple resistive control element (potentiometer) for adjustable low level mistracking. This action is responsible for the total characteristics of the unit.
6. A passive attenuator is switched in conjunction with (3) such that an overall 1:1 input/output level is maintained. Included in the switch position is a straight-through route which allows comparison tests.

For those interested in such details, phase inversion between input and output does not occur.

Internal parts removed from case.

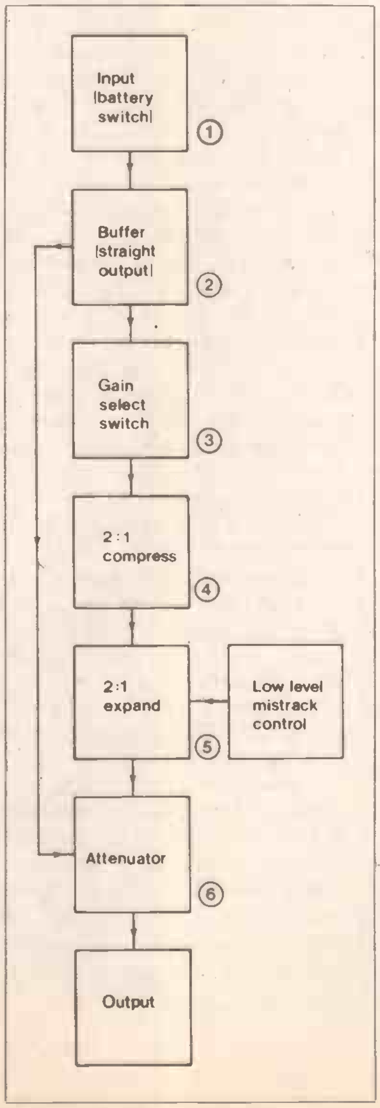


Figure 2. Noise gate block diagram.

Electronic Circuitry

Signals enter the +ve input of IC1a via the decoupling capacitor C1. IC1a is biased by R1 and R2 via R3 (R3 sets the input impedance level plus R1/R2). The voltage set by R1 and R2 ensures that outputs from IC1a and b will, at maximum levels, be evenly clipped. (At lower than normal V_{cc} levels maximum +ve excursions will be greater than available -ve excursions due to internal circuitry). R4, connected in the negative feedback line, equalises input biasing (R3=R4) for minimum output offset in IC1a.

IC1b is used in the non-inverting mode and has gain levels of 0dB, +6dB and +10dB, selectable via S1a, which introduces feedback reducing resistors R7 and R8.

Entry to the Compander section is now effected via C3, with compression achieved through IC2a and expansion by IC2b. All components in this section have been selected for the best overall performance in terms of frequency, speed of operation and distortion when bearing its 'musical' application in mind.

In the expansion section, RV1 is the resistive control element and operates by giving an increasingly false representation of lower level. Rectified signal voltages appear on C10, as RV1 resistance is decreased, causing an overall increase in attenuation rate.

This increasing attenuation characteristic creates low level expansion and is used to reduce the dynamic range of any signal within its domain with consequent drop in noise level. At higher signal levels RV1 becomes less effective in its role and allows a return towards original signal dynamics.

Returning to normality, S1c selects the resistors R15-R17 that are required to achieve an overall device gain of unity. S1a in conjunction with S1c also selects the output of IC1a, enabling pre and post 'gate' comparisons to be made.

Construction

The construction details relate to a cased unit, for panel mounting all that is necessary is to 'fly-lead' the input, output and RV1 wiring. Circuit board fixing is effected by the rotary switch on which the board is mounted. PCB assembly should begin with the two link wires.

Resistors, capacitors and ICs may now be fitted. Double-check polarised capacitor and IC orientation. Pins, or tinned copper wire should be soldered on to the board to hold RV1 in position, remembering that since RV1 is mounted above the board, components beneath it should lay flush to the board.

Solder the battery connector with the positive lead connected to the correct point on the board, and the negative lead to the centre tag of the stereo socket.

Fit the rotary switch next. This switch is normally obtained with solder type eyelet tags which need simple modifications for PCB fitting. Cut these eyelets off, as close to the solder hole as possible, then using snips, taper the ends to assist in aligning and fitting to the board. If the use of fixed pointer, push-on knobs is envisaged, remember to position the switch correctly bearing in mind the shaft 'flat' orientation.

Using tinned copper wire, earth, input and output leads can be connected to the board (using sleeving on the leads or slightly bending the wiring to avoid board shorts). After making sure all components have been fitted correctly, a few quick checks with a meter will verify correct basic operation. Switch to 100mA DC current range and connect the negative lead to battery and positive lead to earth. By touching the battery on to the connector a reading will be registered. A quick 'blip' and a reading under 10mA shows all is well. Voltage checks on outputs of ICs will confirm this - pins 1 and 7 on IC2 should be approximately 5V and pins 7 and 12 of IC2 about 3.6V. (These voltages are related to internal references that remain constant, and therefore allow for battery voltage reduction.)

All that remains now is to mount the unit in a suitable case. The metal case suggested in the parts list is ideal since it is small, easily workable, and provides good screening. Two appropriate holes in both the top and the side are all that are needed so that the whole assembly can just be fitted straight into the main case body and secured with the switch and jack sockets. An earth wire soldered to the edge of RV1 will ensure case earthing. If a plastic case is used, use adhesive backed metal foil tape (as used in pipe cladding) or glue household metal foil for internal screening.

Operation and Application

To obtain maximum usage of the unit, its functional characteristics should be fully understood. This can be achieved mainly by studying the response curves. The 1:1 gain slope reference allows visualisation of the deviation from normal input/output characteristics. The curve closest to the 1:1 gain slope shows input/output of the device when set in any gain position with RV1 set for minimum effect (clockwise). Note that just below -60dBm input levels, the output deviates more rapidly towards -85dBm. This is the operating region of the unit and any signal or noise below -60dBm will be attenuated, reducing its effective level. Any signal above -60dBm will have virtually normal dynamic range. Studying the curves of maximum effect characteristics shows that the noise gate can expand signals from even -15dBm down and completely shut down below -38dBm. (This setting will shut off most extraneous noises.)

Since the compander section uses rectified signal levels in its operation, speed of recognition of these levels becomes a compromise between several factors, one of which is the loading of the circuitry by RV1. It should, therefore, be remembered that the unit will take a finite time to attack and decay and that these times bear a direct relationship to the threshold level (that level selected at which deviation from normal characteristics occurs), and change in amplitude of the input signal. For example, with the noise gate set at 0dB gain with input levels gated from infinity to 0dBm, attack times will vary from typically 2ms to 0ms for minimum to maximum threshold

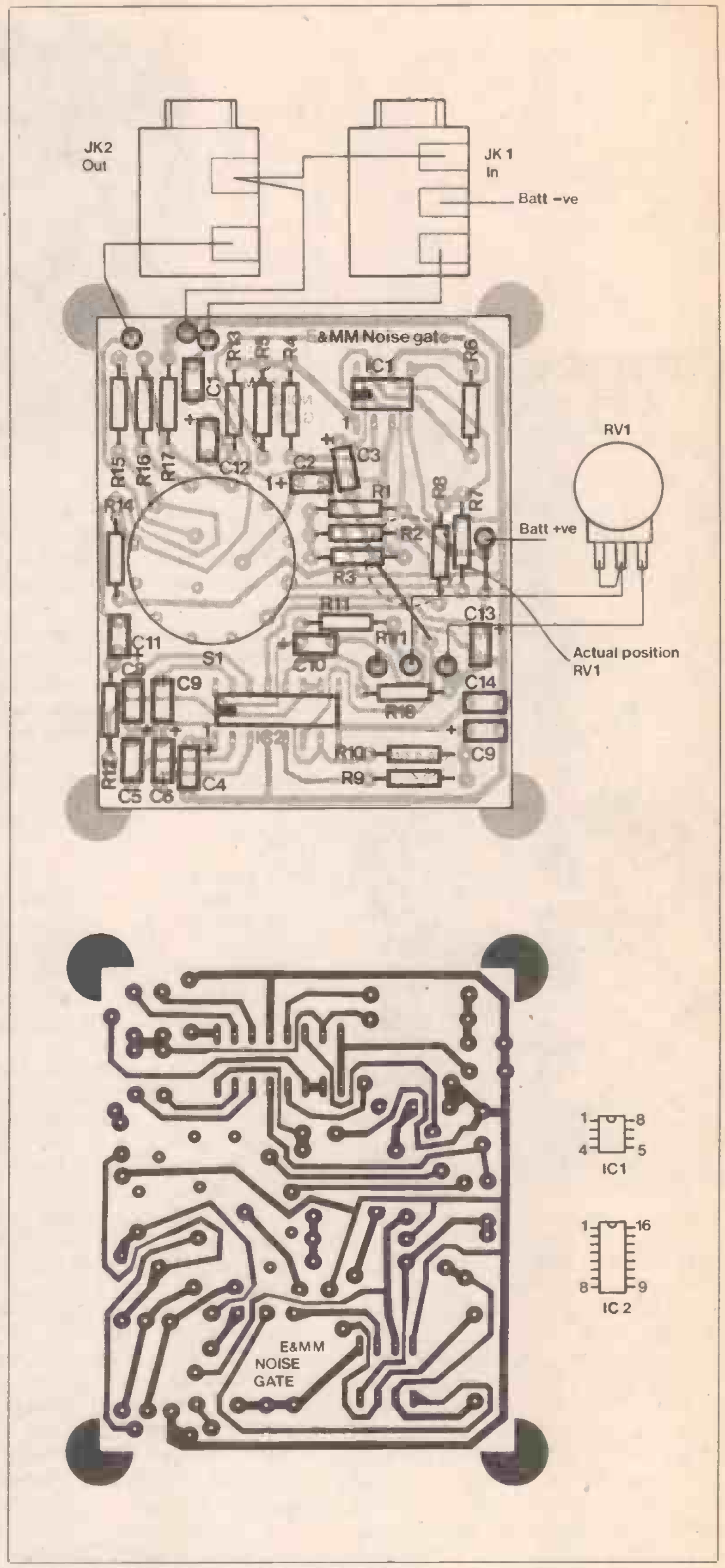


Figure 3. PCB track, legend and wiring details.

settings.

Before continuing with typical applications, it should be remembered that this unit is designed for 'pause' noise reduction, and has no magic ingredient for reducing any noise present in actual signals (see E&MM May 1981 for a noise reduction project).

Wherever noise exists, in-line connection of the noise gate should discriminate and further separate it from the required signal. Probably the lowest levels encountered will be from microphones and low output guitars (low Z mics will have to be transformed or the unit modified to suit). In the case of microphones, crosstalk (pick-up from sources other than that intended)

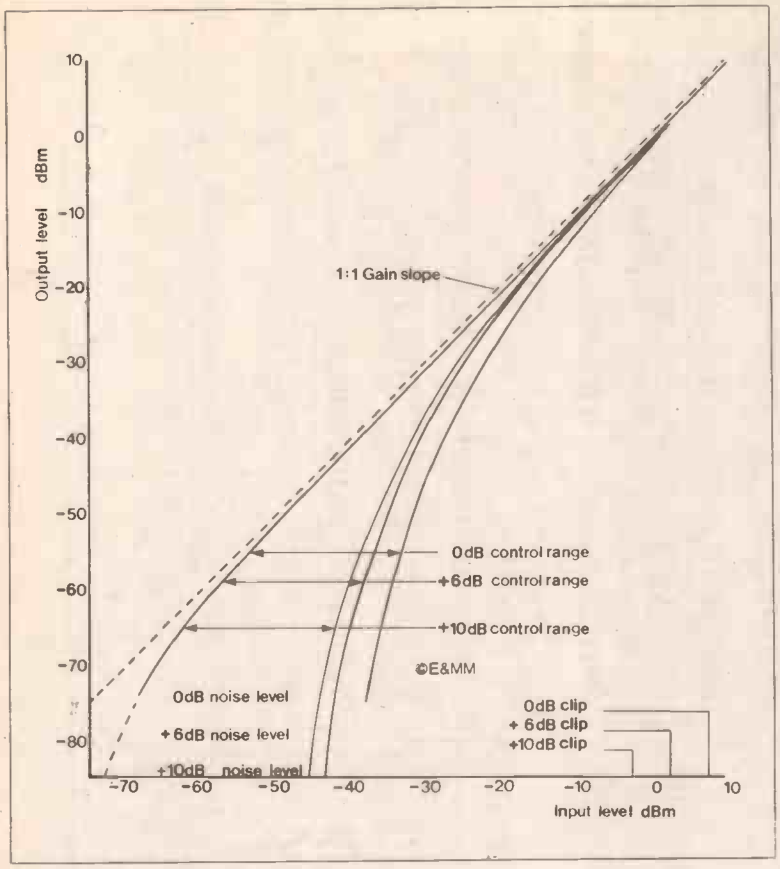
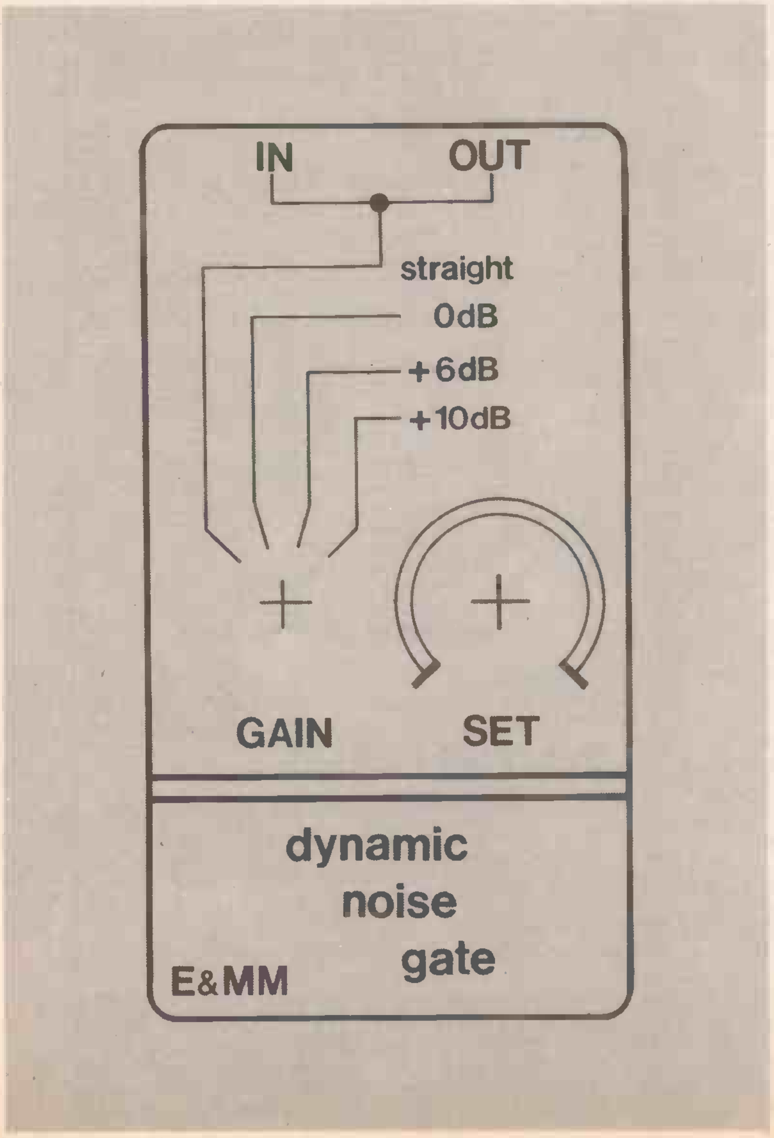


Figure 4. Response curves for noise gate.



NOISE GATE PARTS LIST

Resistors - all 5% ⅓W carbon unless specified			
R1,14	56k	2 off	(M56K)
R2	68k		(M68K)
R3,4	330k	2 off	(M330K)
R5,6,7	4k7	3 off	(M4K7)
R8	2k2		(M2K2)
R9,10	15k	2 off	(M15K)
R11	100k		(M100K)
R12,13	100R	2 off	(M100R)
R15	2k7		(M2K7)
R16	1k0		(M1K)
R17	1k8		(M1K8)
R18	47k		(M47K)
Capacitors			
C1,14	47nF min. ceramic	2 off	(YY10L)
C2,13	47uF 16V PC electrolytic	2 off	(YY37S)
C3-10	1uF 35V tantalum	8 off	(WW60Q)
C11,12	4u7 25V PC electrolytic	2 off	(YY33L)
Semiconductors			
IC1	MC1458		(QH46A)
IC2	NE571		(YY87U)
Miscellaneous			
S1	Switch 3-pole 4-way rotary		(FH44X)
RV1	2M2 log. pot.		(FW29G)
JK1	Stereo jack socket		(HF92A)
JK2	Mono jack socket		(HF90X)
	Battery connector		(HF28F)
	Case - M5004		(LH71N)
	Knobs, low cost collet	2 off	(YG40T)
	Cap, low cost, grey	2 off	(QY03D)
	PCB		(GA43W)

will be the problem to cure. The +10dBm setting will allow maximum dynamic range with fast attack to be achieved when dealing with low level crosstalk (drum kit miking, awkward placement instrument miking, outside recording in windy conditions excluded).

Guitarists working in cramped conditions may encounter induced hum from closely situated amps, especially via single coil pick-ups. This often embarrassing situation can be alleviated by using the noise gate between guitar and amp., adjusting the threshold control for the best overall effect. Another interesting use of the noise gate is for changing the attack characteristics of an instrument. If the threshold level is taken to extremes, soft attack bowing type sounds can be created.

Similar treatment can be applied to special effects units (Echo, Chorus, Phasing, Distortion etc.), by using the noise gate between the last unit and its main amplification. The +6dB mode will be the norm in this application, since typical peak levels may introduce clipping.

Multi-instrument set-ups can often make the background noise unacceptable, considering that all units probably remain set at the required output level when only one or two instruments are actually being used at any time. Fitting individual noise gates to the noticeably 'noisy' instruments will automatically shut off their outputs when not in use.

Extreme levels of noise, or higher input levels, can be coped with in the 0dB mode, making this setting suitable for most line and mixer desk levels.

In the studio, the noise gate is often used with drum kit multi-miking, where as many as 14 microphones may be allocated to the kit in an isolation booth. A rather woolly sounding bass drum can be tightened up effectively by using a fast attack setting (further improved by coupling with a slow attacking limiter) that recovers some of the basic square wave response. It's even worth trying this method using an LFO signal source to create a synthesised drum sound.

'Dynamic reversal' effects can be obtained using the gate followed by a fast attack limiter. With slow recovery times the signal applied is thus strongly over-limited and during the limiter's slow recovery is gradually attenuated by the gate on a slow release setting. The resulting effect sounds like a 'backward' snare drum, tom-tom or cymbal.

It is also possible to reduce fixed delay times of instruments or reverberation treatments by suitable setting of the noise gate control parameters. One further application useful as a treatment in electronic music, is the 'keyed' or programmable gate where an external control voltage switches the signal being processed (used by Irmin Schmidt on his 'Last Train to Eternity' featured last month). But that's another project . . .

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by Chris Lare

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Nowadays it is usual for a rock band to perform on stage with a high power sound system termed the 'PA'. This is the second part of a two part article and describes designs for an active crossover and a balanced line driver to be used in conjunction with the limiter and peak program meter detailed in the first part. These designs can, however, be installed in existing equipment allowing a fairly cheap upgrade. For those people wishing to build the complete Signal Processor a suitable power supply and constructional details are also given.

Active Crossover

When the scheme of an active crossover is first compared with a passive system the only gain seems to be cost, since more power amplifiers are required. Figure 8 shows the layout of a passive and an active crossover system. Such an active system is said to be 'tri-amped'.

The passive crossover will be a combination of inductors and capacitors which is very hard to design and not very efficient. The reasons for using an active system are summarised as:

(a) Overload of a sound system occurs initially in the bass region. This overload generates high order harmonics which are audible in a full range speaker, but not in a bass speaker since it cannot reproduce the high frequencies properly. As a result quite large amounts of overload may pass unheard. In any case, any small amounts of harmonics that do escape will be masked by the treble reproduced by a different drive unit.

(b) Any passive crossover and speaker network must be designed to remove impedance dips which could cause the amplifiers' protection circuits to operate. Attempts to do this will result in even lower efficiency. An active crossover avoids this since its input and output are defined and, furthermore, the damping of the speaker at low frequencies is much improved because it is connected directly to the amplifier.

(c) The crossover can be de-

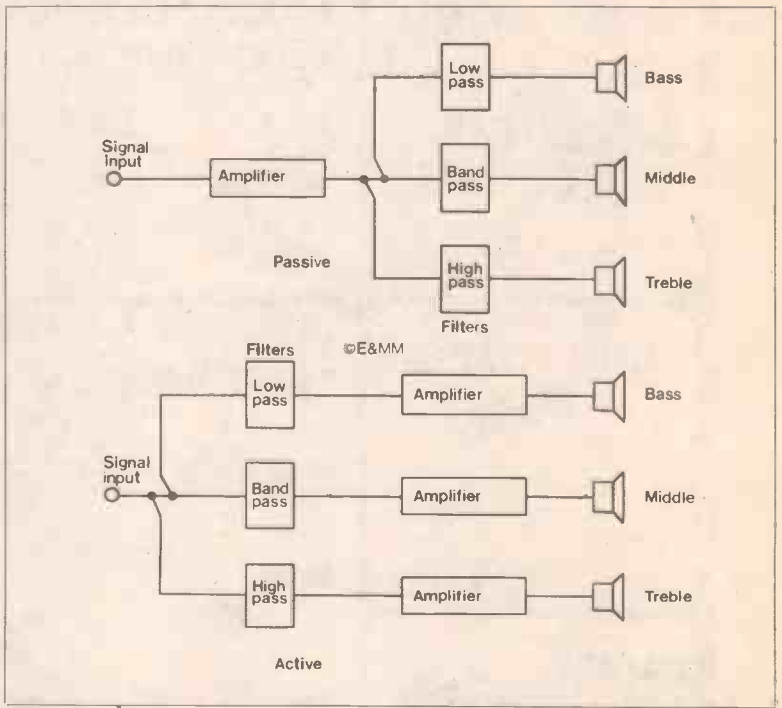


Figure 8. Active/Passive crossovers.

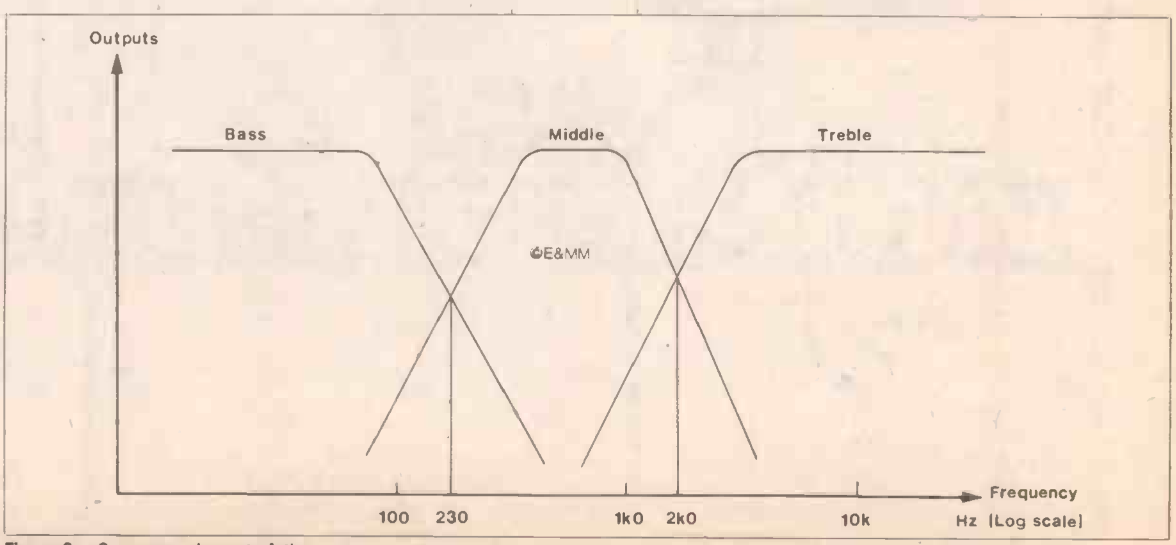


Figure 9. Crossover characteristics.

signed with steeper slopes if required. The crossover points may be changed at will, in this case by altering 8 resistors, the values of which are easily calculated. No precision inductors or bulky non-polarised capacitors are required either.

(d) A tri-amped system offers some degree of protection in event of failure. Simple signal repatching to feed full range into a bass bin may not sound too good, but it is a lot better than nothing. On this point note that a radial horn must never be fed with frequencies below its specified crossover point.

(e) In general, a tri-amped (or even 4-or 5-amped) system will sound louder than the equivalent power into a passive system. This is mainly because the system can be turned up without overload being audible and to some extent because no energy is wasted in a passive crossover element.

Crossover frequencies and roll off

The prototype was designed to crossover at 230Hz and 2kHz, these being suitable bands for most bass, mid and horn treble drivers. The design originally specified 250Hz for the bass crossover, but this was altered to suit component values with no obvious effect. It is possible to use more than 3 bands, although three is most common. Placing a crossover point in the middle of the mid-range should be avoided because experiments have shown that problems do occur due to phase anomalies which are particularly noticeable at these frequencies.

A further bone of contention centres around the optimum roll-off of such a crossover. This design employs filters of 24 dB/octave. Some schools of thought state that the sudden phase change of such a filter is undesirable and a shallower roll-off is better. This may well be true in a domestic installation, but in a PA other factors (alignment of speakers, shape of room) will cause more effect and so it seems desirable to keep the crossover within the smallest frequency band. The characteristics of the prototype crossovers are shown in Figure 9.

Filter design

Since a crossover consists of filter modules, it is necessary to examine such a module. It is not the purpose of this text to give a full description of the operation of filters; such work is covered elsewhere. The basic module used is a second order, equal component value (ECV), Sallen & Key filter. Figure 10 shows the circuits of such filters. Note that the high pass is simply a transposition of the low pass, a property of distinct use in crossover design since the mid-range filter can be derived by transposing the bass and treble filters; the values required being the same.

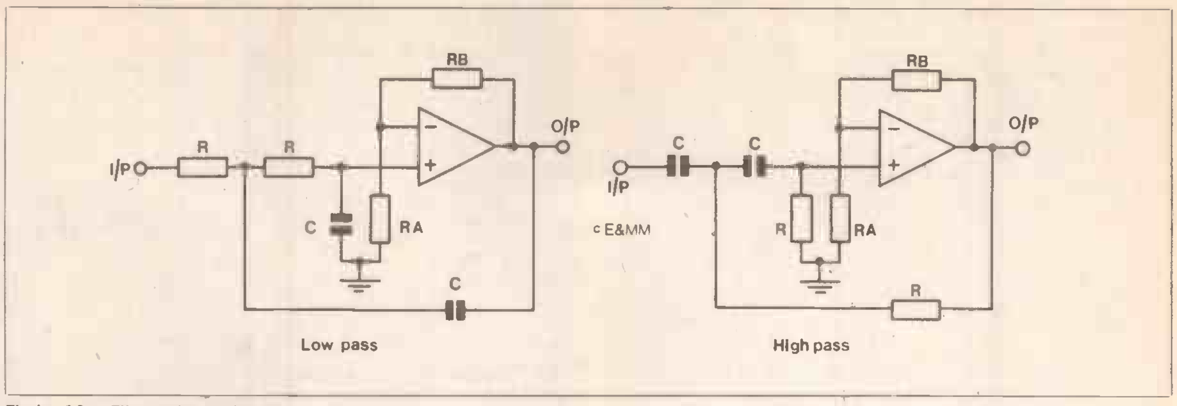


Figure 10. Filter schematics.

The break frequency of such filters, f_b, is given by $1/(2\pi fCR)$, and the Q factor by $1/(3\text{-}K)$, where K is the loop gain determined by $(RA+RB)/RA$. In all audio filtering a Butterworth filter should be used since this offers a flat top response and a reasonable actual roll-off. A Butterworth filter is characterised by setting the value of Q to 0.7, or slightly less. Using this figure the suitable crossover points may be chosen. In the prototype, frequencies of 230Hz and 2kHz were arrived at after due consideration of resistor availability and tolerance. A more precise crossover can obviously be made if desired.

The second-order section offers a 12 dB/octave roll-off and so two sections were cascaded to give the desired 24 dB/octave. Figure 11 shows the block diagram of the crossover. Note that the mid-range filter is simply a cascaded low pass and high pass with values corresponding to the transposition of the other edge of the crossover.

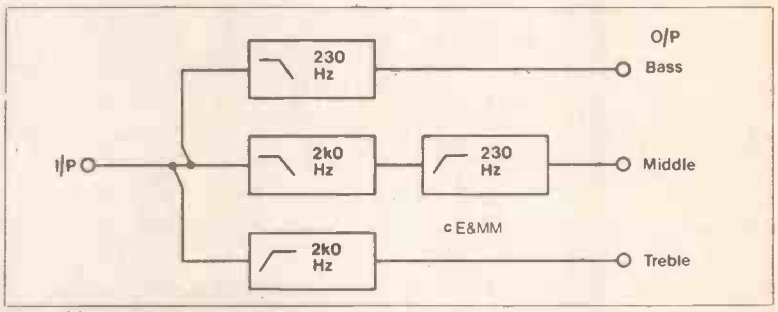
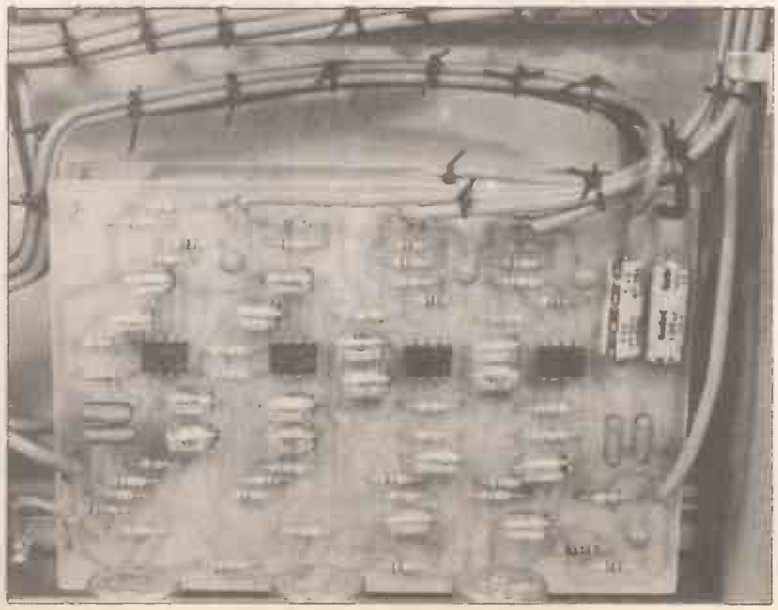


Figure 11. Crossover Block diagram.

The complete circuit can be seen in Figure 12. Each filter section is fronted by a level control which will normally be turned fully up in use and has been provided to facilitate setting up of the PA. A series resistor is included with each potentiometer, which is required to counteract the gain of the filter section. Each filter section is based around LF353 operational amplifiers, chosen again for their low noise and high input impedance. The components used are critical if very precise results are to be obtained, but this is generally unnecessary. Normal 5% resistors were used in the prototype, but the specified capacitors should be used. The output of each filter is fed through a 100R resistor and a 22 uF tantalum capacitor before being made available as the output. The PA slave output is also included with the crossover and this employs an identical output section to the filter elements. R131 allows the mute switch to be implemented. If a partial mute only is required a resistor should be placed in series with the mute switch.



View of Crossover board.

Construction

The complete set of components are mounted on a PCB (Figure 13 a & b), including the potentiometers and the mute facility. Note that no earth lead to the power supply is fitted as this connection is made via the screen of the input lead which is connected to the limiter. Assemble the boards (2 for stereo), but do not fit the potentiometers until final case assembly is under way.

Testing

Apply power to the board and connect an input to each filter in turn (since the potentiometers are missing use a croc clip direct to the board). Check that the outputs correspond to the chosen frequency bands - as a guide check: bass - "muffled thumps", mid-range - "transistor radio", and treble - "tinny".

The Power Supply

The power supply is perfectly conventional, generating plus and minus 15 volts.

The Circuit

The mains input is fed, via a 'mains supplied' neon and a 1 amp anti-surge fuse, to the illu-

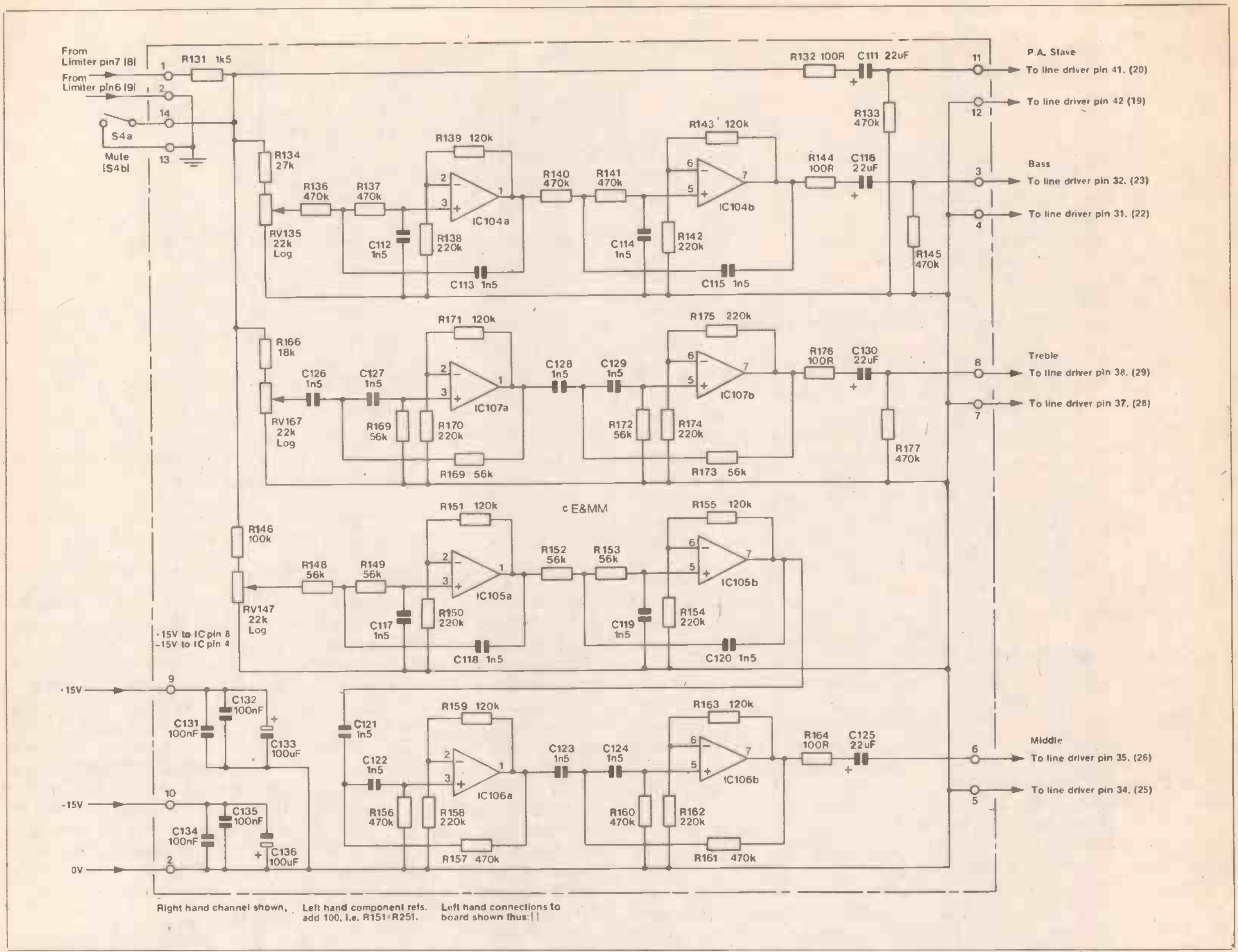


Figure 12. Crossover circuit.

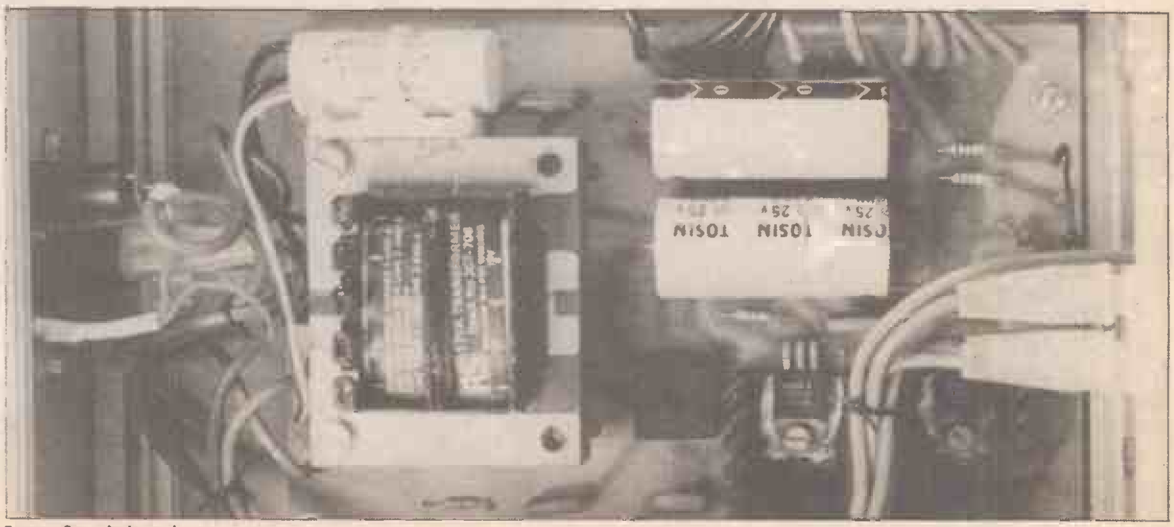
minated double pole rocker switch on the front panel. The output from this switch is connected directly to the PCB. A 15-0-15 transformer feeds a small bridge and two large smoothing capacitors (Figure 14). The bulk of the work is performed by 7815 and 7915 regulators, both mounted on 10°C/W heatsinks. Overall decoupling is provided by several 0.1uF capacitors and the 10uF output capacitors. Two LEDs provide a status monitor on the front panel.

The entire 0 volt rail of the unit is decoupled from mains earth by R1. This ensures that earth loops will not be created when an earthed signal source is used, but keeps the 0 volt line at approximately earth potential.

Construction

All the power supply components are mounted on one PCB (Figure 15). Solder in terminal pins at the relevant points and then fit the transformer. Bolt 4½" 4BA pillars to the PCB, having first marked out the correct positions using the transformer as a template. Ensure that a good contact is made with the earthed area. Fit the transformer by bolting it in place, and finally make the solder connections to its terminals. In the prototype, a delta capacitor was fixed to the transformer with a sticky cable tie. The delta was then connected to the spare mains terminals provided, noting that green/yellow is the earth wire. Assemble the rest of the board, not forgetting the wire link. Mica washers and heatsink compound should be used to insulate the regulator tabs from the heatsinks because the heatsinks may actually touch.

The specified mains transformer is a special PCB mounting type. Alternatively it should be possible to fit an ordinary (non-printed circuit mounting) type having similar ratings.



Power Supply board.

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4 sets of coloured lamps in translucent plastic tube arranged to give the appearance of a running or travelling light. With variable speed control box, ideal for disco or shop window display. Complete, made up, ready to plug into mains. **£36.00 + £2 post.**

COMPUTER KEY SWITCHES (make your own keyboard)
These are for making up on a p.c.b. and consist of a vertical mounting computer type reed switch, which makes circuit when a magnet passes over it. The magnet is located in the plastic plunger which in turn is depressed by a push rod, to which the legended top is fixed. These are made up in banks of 6, price £2.30 per bank of 6 (including tops)

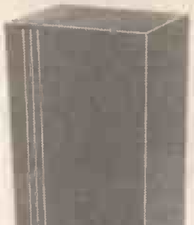
OUR CAR STARTER AND CHARGER KIT has no doubt saved many motorists from embarrassment in an emergency you can start car off mains or bring your battery up to full charge in a couple of hours. The kit comprises: 250w mains transformer, two 10 amp bridge rectifiers, start/charge switch and full instructions. 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 5¼in x 3¾in x 1¼in 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.**

COIN SWITCH
Mounted in sheet metal case with removable coin tray and Yale type lock. Switches on for one hour per 10p coin. **£4.60 + £1 post.**

12 V CAR IGNITION COIL
Suitable for most cars, also for where a high voltage from LT is required. £11.50.

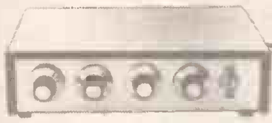
SUPER HI-FI SPEAKER CABINETS
Made for an expensive Hi-Fi outfit – will suit any decor. Resonance free cut-outs for 8" woofer and 4" tweeter. The front material is carved Dacron, which is thick and does not need to be stuck in and the completed unit is most pleasing. Colour black. Supplied in pairs, price £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.

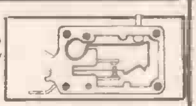
MOTORISED DISCO SWITCH
With 10 amp changeover switches. Multi-adjustable switches all rated at 10 amps, this would provide a magnificent display. For mains operated 8 switch model £6.25, 10 switch model £6.75, 12 switch model **£7.25.**

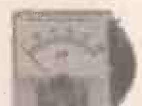
3 CHANNEL SOUND TO LIGHT KIT
Complete kit of parts for a three-channel sound to light unit controlling over 2000 watts of lighting. Use this at home if you wish but it is plenty rugged enough for disco work. The unit is housed in an attractive two-tone metal case and has controls for each channel, and 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. Special snip price is **£14.95** in kit form or **£19.95** assembled and tested.



THIS MONTH'S SNIP
IN FLIGHT STEREO UNIT (for breaking down)
Ex BOAC, hand held unit contains two very well made moving coil transducers, these can be used, either as loudspeakers or microphones, 8 ohm. Other useful parts – 12 position single pole switch, special feature being that its only just over ½" diameter and ½" deep. Unique stereo pot, edgewise control twin 5K, 5 transistors and 2 x 7418 i.c.'s. 1 x 220 uf 12v, and 1 x 100 uf 25v, 1 rocker switch. 1 push switch, many other parts. Break up value probably over £12, our price £2.30.

STACKABLE MICROSWITCHES
Snap action changeover type with 3 amp contacts. These are so designed that they can be mounted in a long line and held together by a length of studding or they could be mounted in a cradle. Approximate size: 30 x 21 x 4mm thick. **Price 28p each.**





100uA PANEL METER
Japanese made (Shinohara Electrical) so very good quality, these have a full vision front, are approx. 2" square and come complete with mounting studs and nuts. A thoroughly reliable instrument usually retailed at over £4, offered at a snip price this month of **£2.85 or 10 for £25.00.**

12v MOTOR BY SMITHS
Made for use in cars, these are series wound and they become more powerful as load increases. Size 3½" long by 3" dia. These have a good length of ¼" spindle – price £3.45. Ditto, but double ended **£4.25.**

EXTRA POWERFUL 12v MOTOR
Made to work battery lawnmower, this probably develops up to ¼ h.p., so it could be used to power a go-kart or to drive a compressor, etc. etc. **£6.90 + £1.50 post.**

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.**

FREE OUR CURRENT BARGAIN LIST WILL BE ENCLOSED WITH ALL ORDERS.

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.

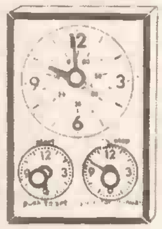
RADIO MIKE *
Ideal for discos and garden parties, allows complete freedom of movement. Play through FM radio or tuner amp. **£6.90 comp. kit.**

FM RECEIVER
Made up and working, complete with scale and pointer needs only a speaker, ideal for use with our surveillance transmitter or radio mike. **£5.85.**

CB RADIO –
Listen in with our 40-channel monitor. Unique design ensures that you do not miss sender or caller. Complete kit with case, speaker and instructions only **£5.99.**

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.**

STEREO HEADPHONES
Japanese made so very good quality. 8 ohm impedance. padded, terminating with standard ¼" jack-plug. **£2.99** Post 60p.



TIME SWITCH BARGAIN
Large clear mains frequency controlled clock, which will always show you the correct time + start and stop switches with the dials. Comes complete with knobs. **£2.50.**

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.**

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**

UNUSUAL MOTORISED PUMP
The motor is a normal ½" stack induction motor, mains operated. To the spindle is fitted a nylon worm drive, this considerably reduces speed and turns a nylon cog wheel to which is coupled a link operating a small bellows pump. The outlet and inlet to and from this pump are nylon pipes to which flexible tubing can be connected. Obviously, there will not be a big flow of air from this pump but quite considerable pressures can be developed. **Price £4.60 + 50p.**

SOLENOID AIR VALVE
made to work with the above pump. This mains operated valve will stop the flow of air or gas when mains is applied to it. 220v - 230v model – **£3.45.** 100v model – £2.30.

*(Not licenceable in the U.K.)

J. BULL (Electrical) Ltd.
(Dept. EM), 34 - 36 AMERICA LANE, HAYWARDS HEATH, SUSSEX RH16 3QU.

J. BULL (Electrical) Ltd – Established 30 years. MAIL ORDER: Cash, p.o., or cheque 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.

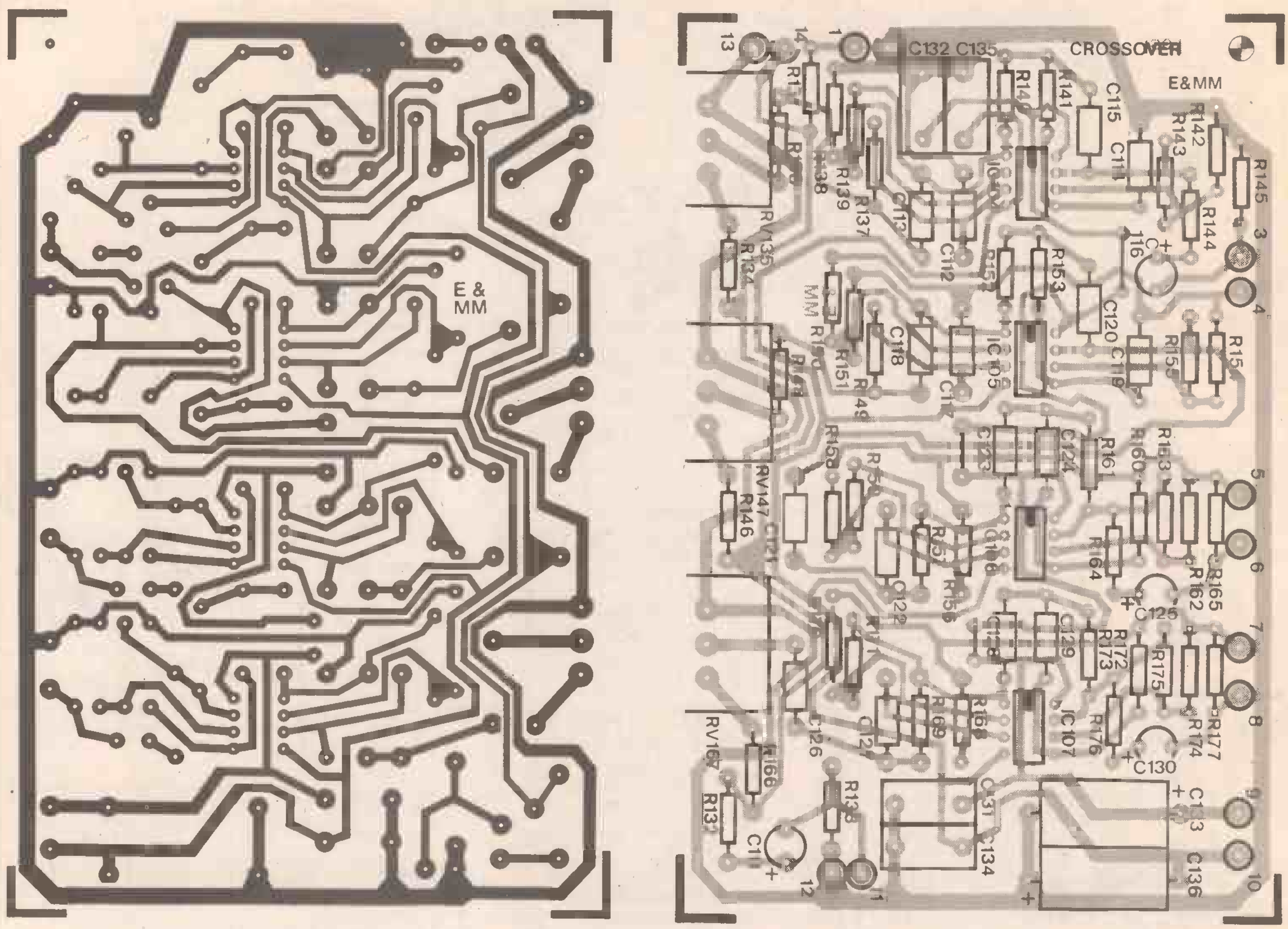


Figure 13. Crossover PCB.

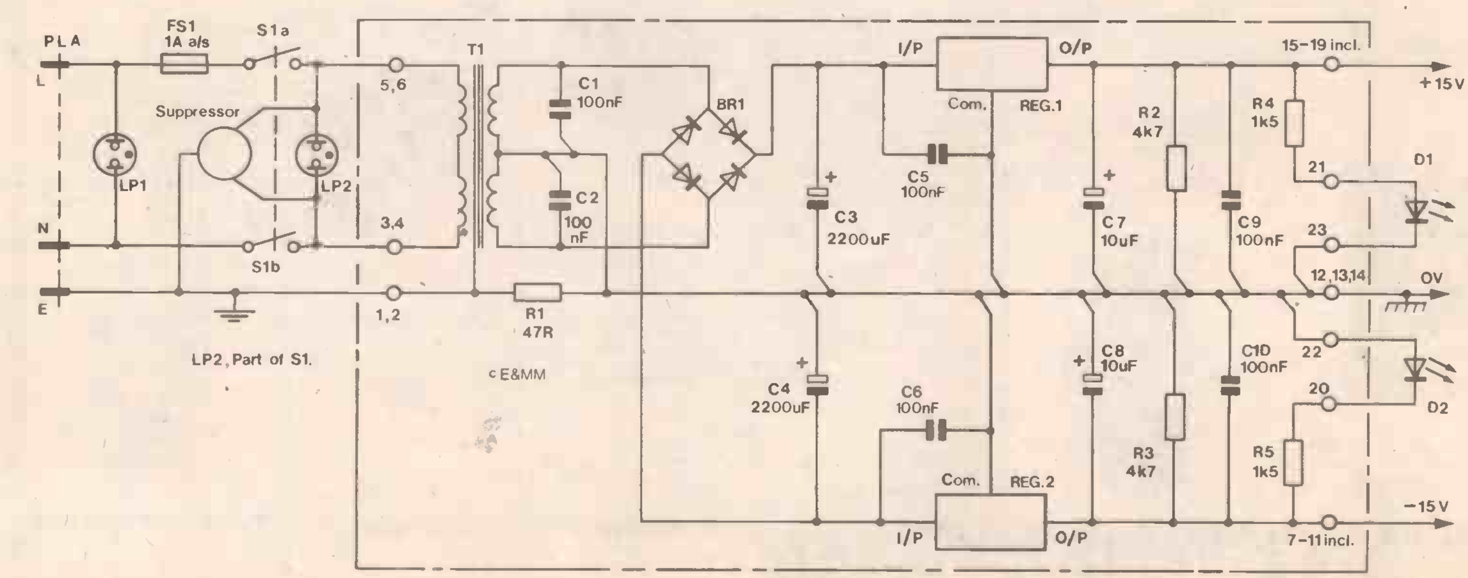
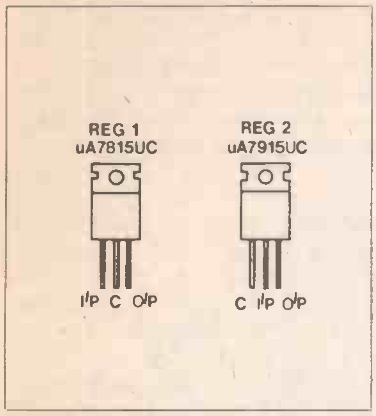


Figure 14. PSU circuit.



PSU Regulator connections.

Testing

Cover all the exposed mains voltage terminals with tape to prevent any nasty accidents. Connect a meter between the positive and negative raw supplies (at the top end of the main smoothing capacitors), stand well back and switch on. The meter should read about 45 volts, and if it does not, switch off immediately, and find the fault. Finally check the outputs are plus and minus 15 volts.

The power supply may now be used to check other modules, but to prevent damage it is suggested that a 100R resistor is used in series with the module supply lines until correct functioning is established.

Balanced line output interface

The prototypes have been regularly used with a 25 metre multicore cable feeding 100K impedance amplifiers without any sign of hum or noise pick-up. It may well be desirable to use the processor with balanced line outputs if longer runs are envisaged and hence an optional board was designed for this purpose.

This interface simply inverts each signal, thus the original signal (audio phase) and the new signal (audio non-phase) are available. Stereo jack sockets (or Cannons) should be used for the outputs, wired as follows:

Jack tip - audio phase
Jack ring - audio non-phase
Jack body - signal ground

A more detailed explanation of balanced lines appears in the first two issues of E&MM (March and April 1981). Figure 16 shows the circuit diagram for one channel of the balanced line driver. The two channels are incorporated on one PCB.

The circuit board is shown in Figure 17. There are no points to note about assembly, but care must be taken to ensure that ground loops are not created as it is wired up. The board has two earth points for left and right grounds, these should be connected to the PA Slave screens which are also connected on the crossover board. The screens from the three crossovers should not be connected at the interface, dummy circuit pins are provided for these connections. The audio non-phase output screens should be connected to the ground at the interface and also to the body of the jack socket, whereas the audio phase screen is only connected at the jack socket.

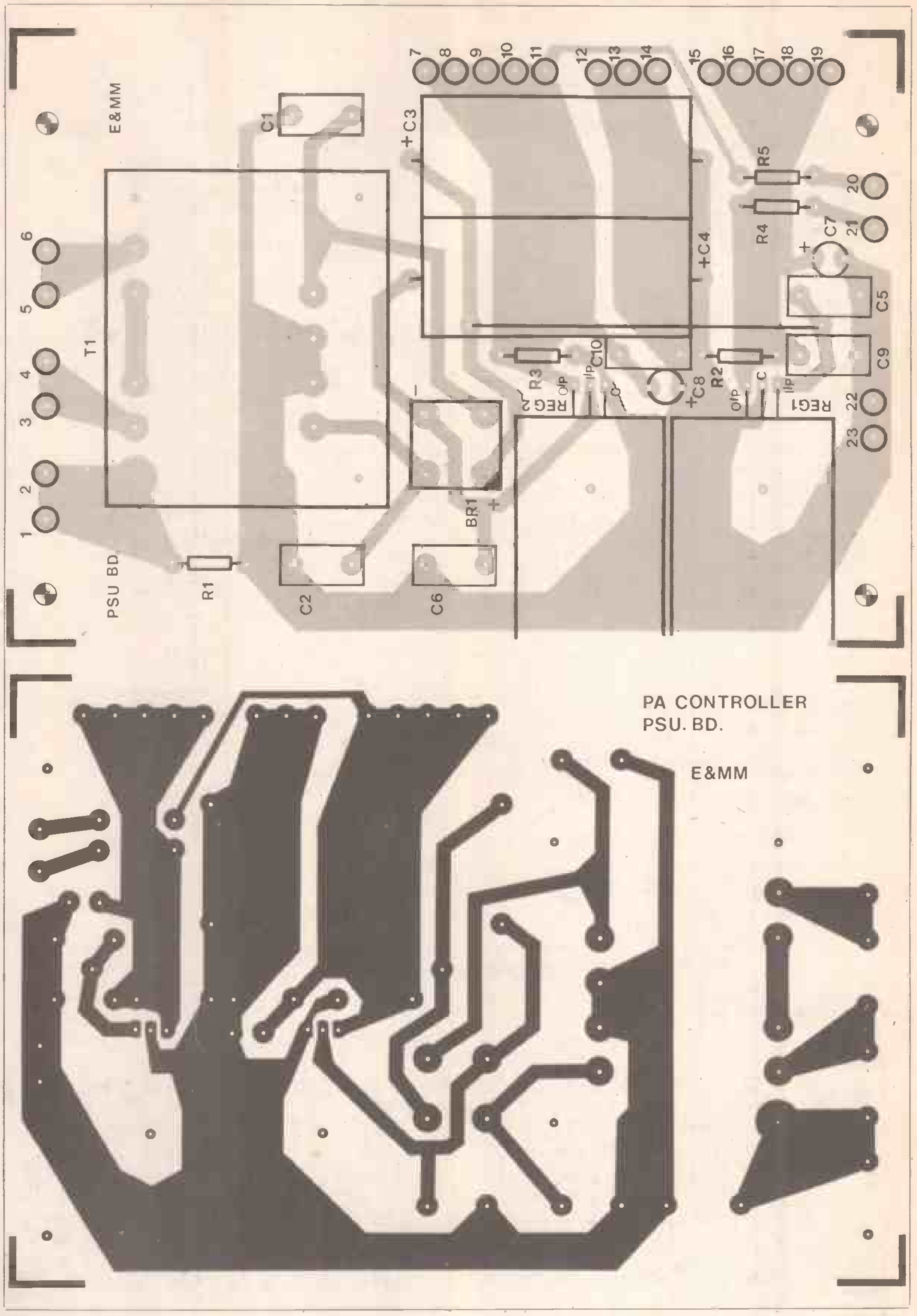


Figure 15. **PSU PCB.**

Overall Construction

The prototype was housed in a Classic 17 x 9 x 3½" instrument case. The front and rear panels were spray painted black, and finished with white Letraset.

The panel drilling details are shown in Figures 18 (front) and 19 (rear). Care must be taken when drilling the holes for the LED display, since any faults will show clearly. The panel should be carefully marked with a scribe, and each hole centre punched with a very sharp punch. A power drill will make drilling easier and it is worth buying a new ⅛" drill bit just for these holes. After drilling the display holes, put a small countersink on the rear to help guide the LED in. The holes to mount the display should be front

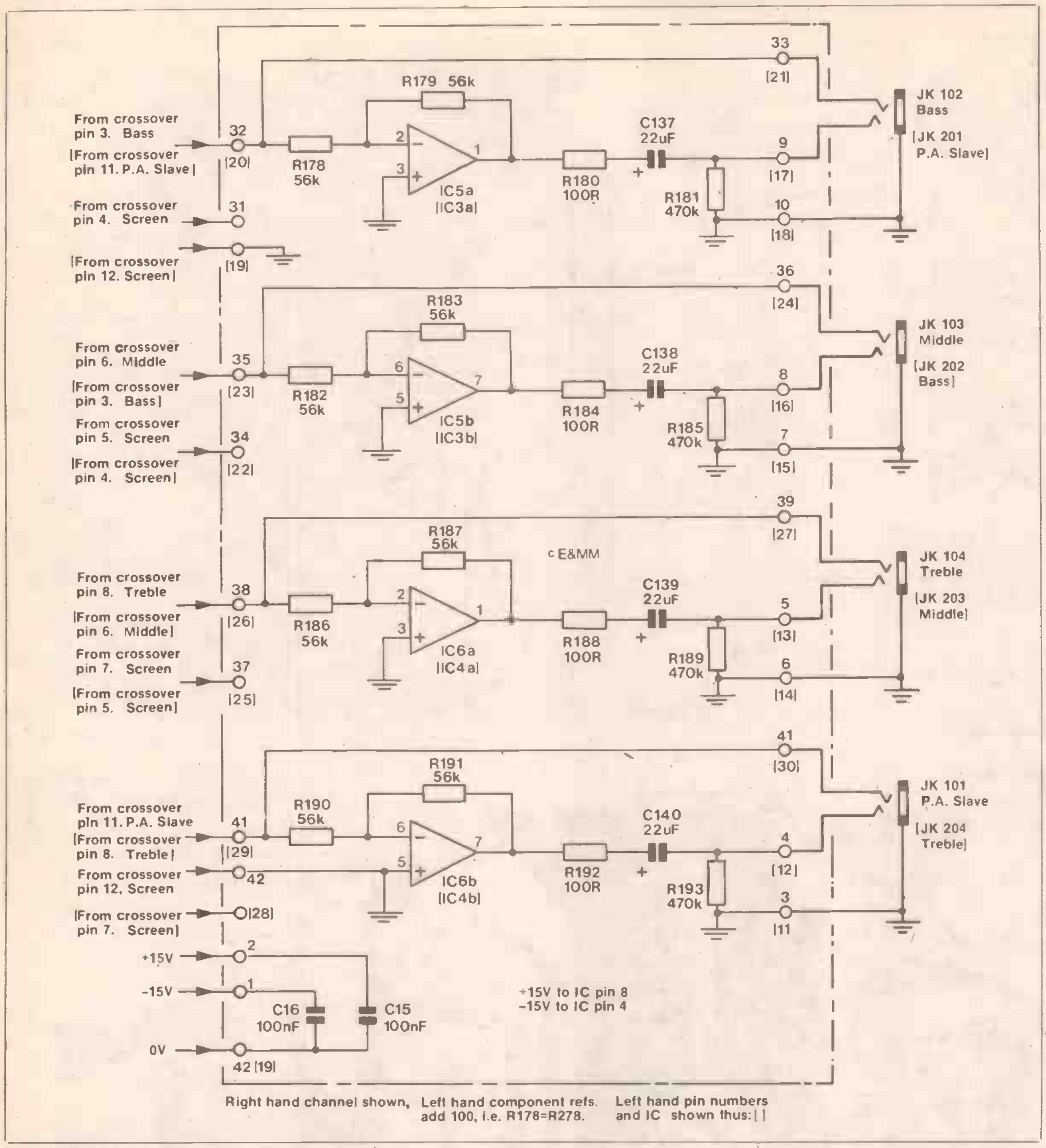
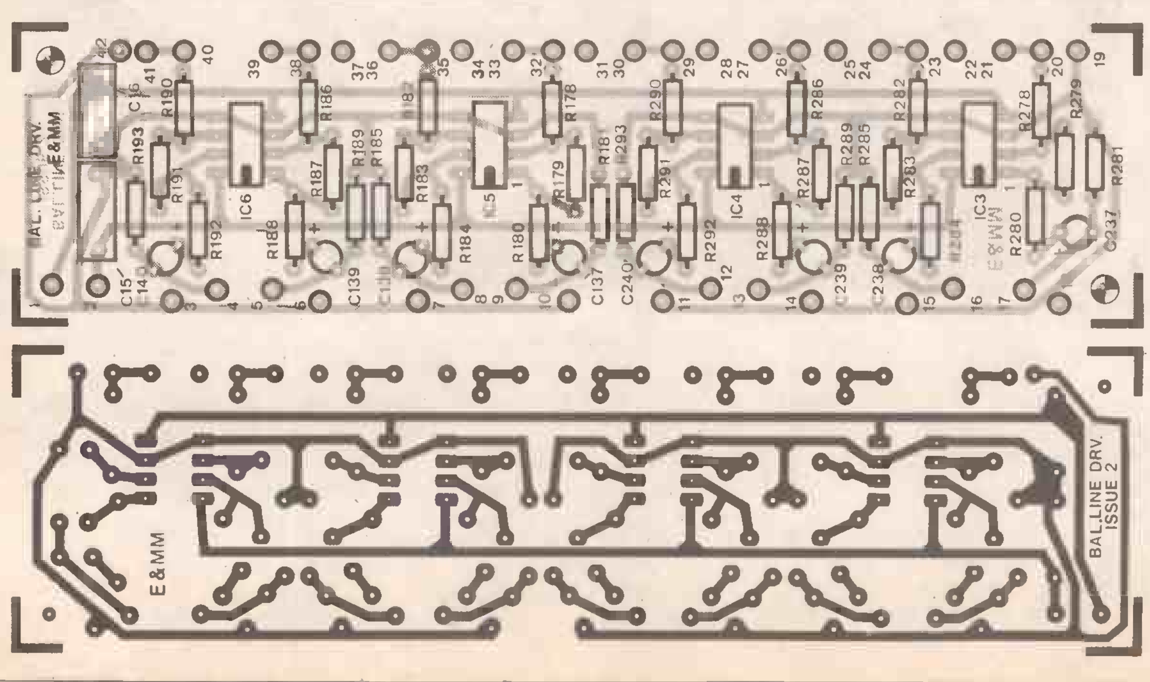


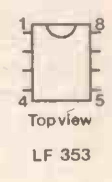
Figure 16. Balanced line driver circuit.

countersunk. The rest of the holes are not as critical, although take care when making the mains switch cutout because the clearances are very tight. The back panel offers no problems.

Once the drilling is complete, two ½" pillars should be bolted to the front panel in the display mount holes. The holes should then be filled with plastic padding, allowed to set and smoothed off. Prime the panels with a metal priming spray paint, and then follow this with several coats of matt black spray, remembering to spray several light coats. It is a good idea to let this set hard for at least 24 hours before lettering it according to the legend. Note that the display was not calibrated except for the 0dB light in order to keep the panel simple. A letraset line or full calibration can be added if required, although it has been found that the colour change provides an adequate indication. The panels should then be varnished and left again for 24 hours or more before attempting final construction. Assemble the back panel first. Fit the IEC socket, neon, fuseholder and finally the jack sockets.

The front panel is next. First clean out the display LED holes and the PSU LED holes with the ⅛" drill, turned by hand from the front. This will remove the surprisingly thick accumulation of paint in them. Fit the mains switch and then the auxiliary function switches. Fit the power supply LEDs and glue them lightly in place with super glue, which incidently is ideal for this purpose. Fit the display as described in the display section, not forgetting to test the bottom board'





Pin connections for ICs 104-107 (Crossover) and ICs 3-6 (Balanced Line Driver).

Figure 17. Balanced line driver PCB.

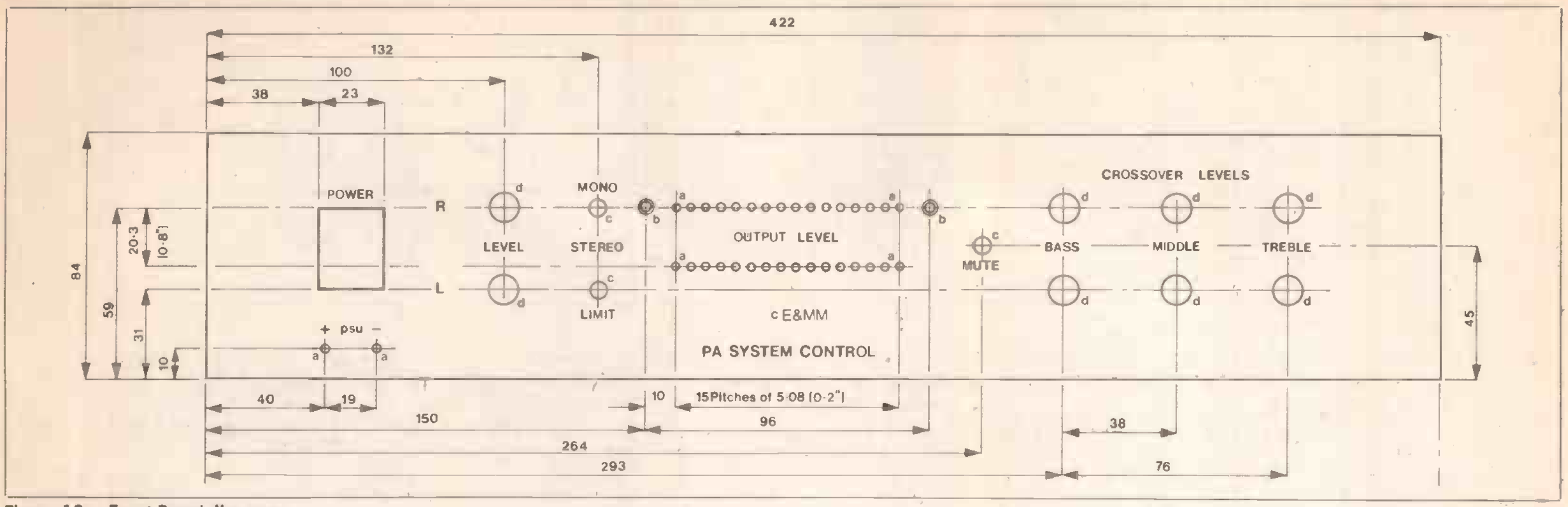


Figure 18. Front Panel diagram.

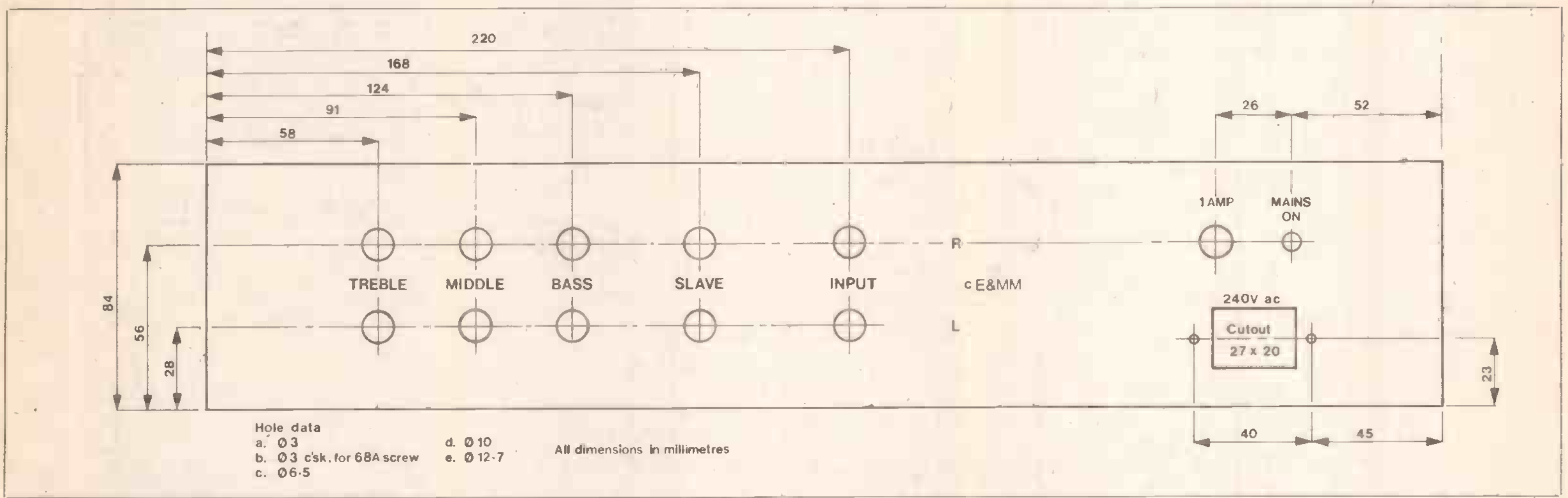


Figure 19. Back Panel diagram.

before assembly is completed. Finally, fit the crossover boards by fitting the potentiometers with nuts partially tightened to the front panel using two ⅜" washers as spacers and then offering up the crossover board and soldering the potentiometer pins into the board. The potentiometer nuts can then be fully tightened. *(Note: If long shaft pots are used – don't forget to trim them before assembly).* After both boards are fitted, join them together with two 6BA pillars by means of the spare mounting hole, a 1" 6BA bolt and a ¼" 6BA bolt.

Drill the relevant mounting holes in the bottom of the case, the layout of which is shown in Figure 20, which also details the point-to-point wiring. Drill four holes for rubber feet and an extra hole to allow the case to be earthed. Fit ½" pillars into all the holes, and then bolt the boards in place.

Start wiring up the unit with the mains connections. First, the earth from the IEC socket is connected to the chassis by means of a solder tag and is then connected to the power supply board and the front panel. The live and neutral are connected to the mains switch, using proper blade connectors if required. Remember to connect the live via the fuse. Finally, the output of the mains switch is wired direct to the PCB. It is a good idea to test that all is well at this point.

Next, the power supply should be connected to all the modules. The ±15 volt rails go to each board (limiter, display, 2 x crossover and line output boards), but earth connections are only made to the limiter and display drivers. Also wire the power supply LEDs, taking care with the polarity.

The auxiliary switches should be wired next. Since the wires are very short, unscreened cable may be used, but single core should be avoided at all costs for reasons of reliability. The two unscreened wires from the limiter board to the relevant display drivers should also be added.

Finally, the signal wiring. Do not forget to mount C100 and C200 on the input socket in series with the input. Connect the screen at both ends to the socket earth and the low end of the input potentiometer. The wiper of the potentiometer is connected to the limiter board, the screen also being connected to the low end of the potentiometer, thus forming an earth connection from the limiter PCB to the input socket. The outputs of the limiter are then wired to the relevant crossover boards and again the screens are connected at both ends to earth the crossover board. The outputs from the crossover board are then wired to the balanced line driver or direct to the output sockets.

Remove all loose bits of wire and check all the connections, particularly checking the earth for continuity. The unit is now ready to be tested.

Final testing and setting up

As the individual boards should have been tested before final assembly, no real problems ought to be encountered. Apply an input signal and check that all the outputs are as expected and that no stereo reversal has occurred during the final wiring.

All that remains to be done is to calibrate the PPM and set up the limiter. If a scope is available, set the presets on the PPM boards so that the orange LEDs light with 2.17 volts peak to peak output from the limiter. If a scope is not available an analogue multimeter can be used instead, by measuring the voltage on the output of the precision rectifier (not the PPM drive) while playing the Blondie track 'Hanging on the Telephone' – the meter should be peaking at 0.95 volts when the LEDs peak on the orange.

The limiter is set up by play-

Balanced line driver board.

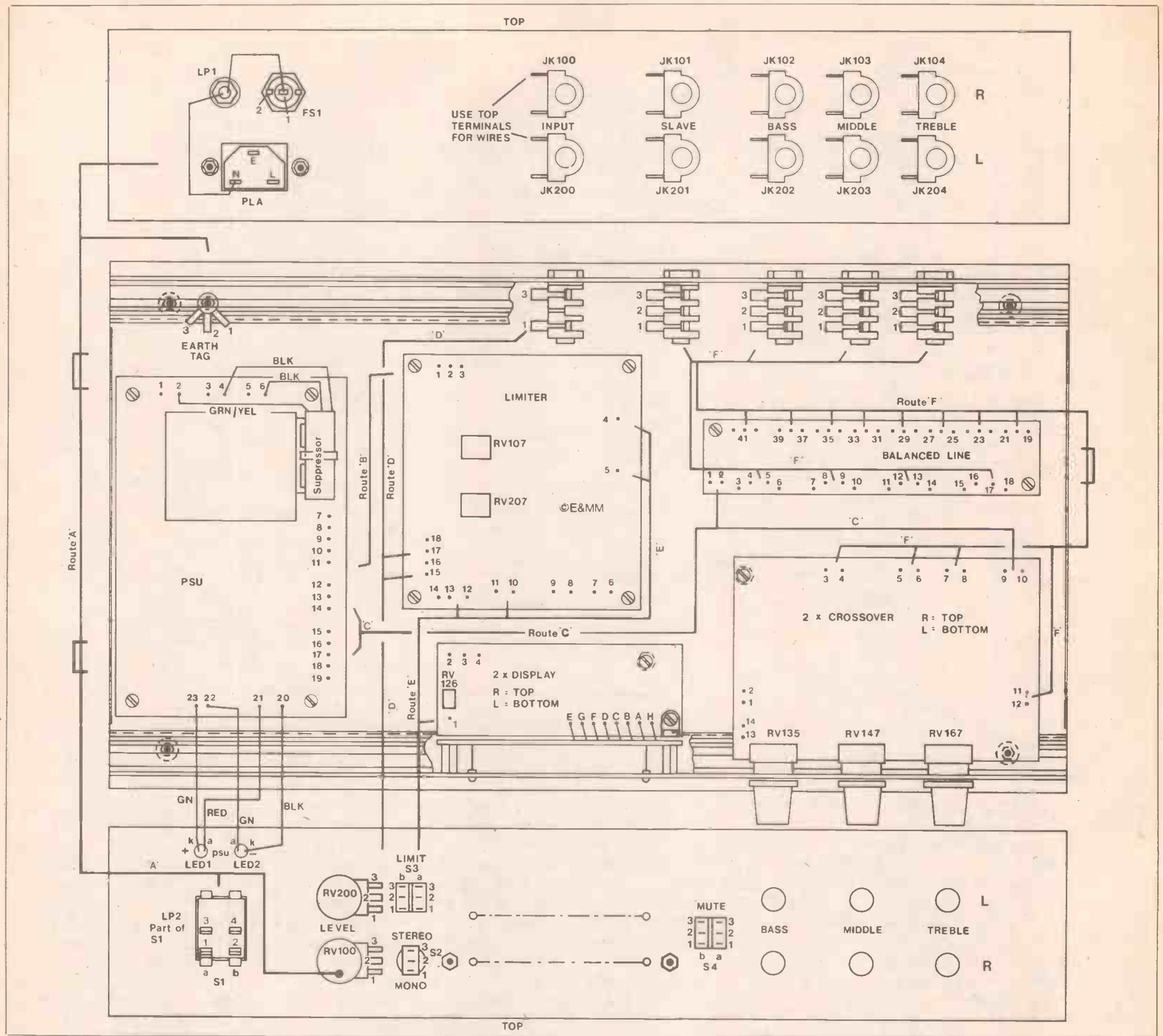


Figure 20. Wiring and mounting holes for the Signal Processor (see Table 1).

ing a music track and adjusting the presets on the limiter so that no peaks exceed the orange LED. The Elton John track 'Funeral for a Friend' makes an excellent test for limiters. On listening to the output the action of the limiter should be clearly audible, particularly on the sudden snare drum about half way through this track.

The processor is now complete. Seal the presets and assemble the case. The unit should be left on for 48 hours at least, preferably kicking it at regular intervals to soak test it. Don't rush it into service though, a few hours testing it properly could well save considerable embarrassment in the middle of a gig since failures are most likely to occur within the first few hours.

Inside view of front panel showing Crossover and PPM boards.

PARTS LIST FOR ACTIVE CROSSOVER

Resistors - all 5% ⅓W carbon unless specified			
R131	1k5	2 off	(M1K5)
R132,144,164,176	100R	8 off	(M100R)
R166	18k	2 off	(M18K)
R134	27k	2 off	(M27K)
R148,149,152, 153,168,169, 172,173	56k	16 off	(M56K)
R146	100k	2 off	(M100K)
R139,143,151, 155,159,163, 171,175	120k	16 off	(M120K)
R138,142,150, 154,158,162, 170,174	220k	16 off	(M220K)
R133,136,137, 140,141,145, 156,157,160, 161,165,177	470k	24 off	(M470K)
RV135,147,167	22k log pot	6 off	(FW23A)
Capacitors			
C111,116,125,130	22u 16V tantalum	8 off	(WW72P)
C112-115,117-124, 126-129	1n5 polystyrene	32 off	(BX36P)
C131,132,134,135	100n polyester	8 off	(BX76H)
C133,136	100u 25V axial electrolytic	4 off	(FB49D)
Semiconductors			
IC104-107	LF353	8 off	(WQ31J)
Miscellaneous			
	Active crossover PCB	2 off	(GA12N)
	Washers for pot spacers	12 off	
S4	DPDT miniature toggle		(FH04E)

PARTS LIST FOR POWER SUPPLY

Resistors - all 5% ⅓W carbon unless specified			
R1	47R		(M47R)
R2,3	4k7	2 off	(M4K7)
R4,5	1k5	2 off	(M1K5)
Capacitors			
C1,2,5 6,9,10	100n polyester	6 off	(BX76H)
C3,4	2200u 25V axial electrolytic	2 off	(FB90X)
C7,8	10 F 16V Tant	2 off	(WW68Y)
Semiconductors			
BR1	2 Amp bridge rectifier		(QL09K)
REG1	7815 15 volt regulator		(QL33L)
REG2	7915 -15 volt regulator		(QL36P)
D1,2	LED green 2.9mm	2 off	(WL33L)
Miscellaneous			
T1	15-0-15 volt 12VA PCB mounting transformer		(YK25C)
	Vaned heatsink	2 off	(FL58N)
	Printed circuit board		(GA06G)
	Cable tie, 140mm long		(BF92A)
	Cable tie base		(BF94C)
	Veropins		(FL24B)
	Push-on receptacle		(HF10L)
	Receptacle cover		(HF12N)
	Delta suppressor		(HW07H)
	T066 mounting kit	2 off	(WR23A)

PARTS LIST FOR BALANCED LINE DRIVER

Resistors - all 5% ⅓W carbon unless specified			
R178,179,182, 183,186,187, 190,191	56k	16 off	(M56K)
R180,184,188,192	100R	8 off	(M100R)
R181,185,189,193	470k	8 off	(M470K)
Capacitors			
C137-140	22u 16V tantalum	8 off	(WW72P)
C15,16	100n polyester	2 off	(BX76H)
Semiconductors			
IC3-6	LF353	4 off	(WQ31J)
Miscellaneous			
	Balanced line driver PCB		(GA13P)

PARTS LIST FOR FINAL ASSEMBLY

Resistors			
RV100,201	100k log pot	2 off	(FW25C)
Capacitors			
C100,200	100n polyester	2 off	(BX76H)
Miscellaneous			
	Collet knob	8 off	(RX16S)
	Collet knob ring	8 off	(RX18U)
	Knob cap red	2 off	(WL49D)
	Knob cap blue	2 off	(WL46A)
	Knob cap green	2 off	(WL47B)
	Knob cap yellow	2 off	(WL50E)
	Panel fuseholder		(RX96E)
	Fuse 1A anti-surge		(WR19V)
	Mains socket		(HL16S)
	Mains chassis plug		(HL15R)
	Double-pole mains rocker switch		(YR70M)
	Neon indicator lamp		(RX82D)
	†Stereo jack socket	8 off	(HF92A)
	Mono jack socket	2 off	(HF90X)
	Heavy duty cable type 3202	3m	(XR32K)
	Hook-up wire		(BL09K)
	Single core screened cable	6m	(XR13P)
	Lacing cord		(BL65V)
	Contil Classic 11 case type CL2CEL		*
	Nuts & Bolts (see hardware list)		

†or Mono jack socket, 8 off, if no line driver.

*The Classic 11 case is available from West Hyde Developments Ltd., Unit 9, Park Street Industrial Estate, Aylesbury, Bucks HP20 1ET. The order code is CL2CEL and the price including postage and packing is £18.25 + VAT.

HARDWARE FITTINGS FOR P.A. SYSTEM CONTROLLER

Itemised list for each board. All bolts round head unless stated.

Limiter:	Mounting:	Spacer 6BA ½" threaded	4 off
		Bolt 6BA ¼"	8 off
		Washer 6BA shakeproof	8 off
Crossover:	Board:	Spacer 6BA ½" threaded (plus two nuts to extend length)	2 off
		Bolt 6BA ¼"	
		Bolt 6BA 1"	
		Washer 6BA shakeproof	3 off
	Mounting:	Washer ⅜" (for pot. separators)	12 off
Balanced Line driver:	Mounting:	Spacer 6BA ½" threaded	2 off
		Bolt 6BA ¼"	4 off
		Washer 6BA	4 off
PSU:	Board:	Spacer 4BA ½" threaded (transformer mounting)	4 off
		Bolt 4BA ¼"	4 off
		Bolt 4BA 1"	4 off
		Washer 4BA shakeproof	8 off
	Mounting:	Spacer 6BA ½" threaded	4 off
		Bolt 6BA ¼"	8 off
		Bolt 6BA ½"	2 off
		Nut 6BA	2 off
		Washer 6BA shakeproof	10 off
PPM:	Board:	Spacer 6BA ½" threaded (plus two nuts to extend length)	
		Bolt 6BA ¼"	5 off
		Bolt 6BA ½"	
		Washer 6BA shakeproof	6 off
		Nut 6BA	6 off
		Bracket	2 off
	Mounting:	Spacer 6BA ½" threaded	2 off
		Bolt 6BA ¼"	2 off
		Bolt 6BA ¼" countersunk	2 off
		Washer 6BA shakeproof	4 off
Case:		Bolt 6BA ½" countersunk	2 off
		Solder Tag	2 off
		Bolt 6BA ½"	
		Washer 6BA shakeproof	3 off
		Nut 6BA	3 off

COLLATED LIST OF HARDWARE

Item:	No.	Pkts.	Maplin code:
Spacer 4BA ½" threaded	4 off	1	(LR71N)
Spacer 6BA ½" threaded	15 off	2	(LR72P)
Bolt 4BA ¼"	4 off	1	(BF02C)
Bolt 4BA 1"	4 off	1	(BF04E)
Bolt 6BA ¼"	28 off	3	(BF05F)
Bolt 6BA ½"	4 off	1	(BF06G)
Bolt 6BA 1"	1 off	1	(BF07H)
Bolt 6BA ¼" countersunk	2 off	1	(LR56L)
Bolt 6BA ½" countersunk	2 off	1	(BF12N)
Nut 6BA	15 off	2	(BF18U)
Washer 4BA shakeproof	8 off	1	(BF25C)
Washer 6BA shakeproof	38 off	4	(BF26D)
Washer ⅜" (for pot. separators)	12 off		
Solder Tag 6BA	2 off	1	(BF29G)
Brackets	2 off		

WIRING DETAILS

From	To	Route	Remarks	
PLA/L	FS1/1	Direct		
PLA/N	S1b/2	A		
PLA/E	Earth tag 1	Direct		
FS1/2	S1a/1	A		
S1a/3	PSU/5	A		
S1b/4	PSU/3	A		
Earth tag/2	PSU/1	Direct		
Earth tag/3	RV 100	A	Solder to case	
PSU/7	Limiter/2	B		
PSU/8	Balanced line/1	C		
PSU/9	Crossover RH/10	C		
PSU/10	Crossover LH/10	C		
PSU/11	Display RH/3	C	Link to LH/3	
PSU/12	Limiter/1	B		
PSU/13	Not used			
PSU/14	Display RH/2	C	Link to LH/2	
PSU/15	Limiter/3	B		
PSU/16	Balanced line/2	C		
PSU/17	Crossover RH/9	C		
PSU/18	Crossover LH/9	C		
PSU/19	Display RH/4	C	Link to LH/4	
Limiter/4	Display RH/1	E		
Limiter/5	Display LH/1	E		
Limiter/6	Crossover RH/2	Direct	Screen	Screened
Limiter/7	Crossover RH/1		Conductor	lead
Limiter/8	Crossover LH/1	Direct	Conductor	Screened
Limiter/9	Crossover LH/2		Screen	lead
Limiter/10	S2/3	E		
Limiter/11	S2/2	E		
Limiter/12	S3a/3	E		
Limiter/13	S3b/2	E		
Limiter/14	S3a/2	E		
Limiter/15	Rv 200/3	D	Screen	Screened
Limiter/16	Rv 200/2		Conductor	lead
Limiter/17	Rv 100/3	D	Screen	Screened
Limiter/18	Rv 100/2		Conductor	lead
Rv 100/1	JK 100/1	D	Conductor	Screened
Rv 100/3	JK 100/3		Screen	lead
Rv 200/1	JK 200/1	D	Conductor	Screened
Rv 200/3	JK 200/3		Screen	lead
S4a/1	Crossover RH/13	Direct		
S4a/2	Crossover RH/14	Direct		
S4b/1	Crossover LH/13	Direct		
S4b/2	Crossover LH/14	Direct		
Crossover RH/3	Balanced line/32	F	Conductor	Screened
Crossover RH/4	Balanced line/31		Screen	lead
Crossover LH/3	Balanced line/23	F	Conductor	Screened
Crossover LH/4	Balanced line/22		Screen	lead
Crossover RH/5	Balanced line/34	F	Screen	Screened
Crossover RH/6	Balanced line/35		Conductor	lead
Crossover LH/5	Balanced line/25	F	Screen	Screened
Crossover LH/6	Balanced line/26		Conductor	lead
Crossover RH/7	Balanced line/37	F	Screen	Screened
Crossover RH/8	Balanced line/38		Conductor	lead
Crossover LH/7	Balanced line/28	F	Screen	Screened
Crossover LH/8	Balanced line/29		Conductor	lead
Crossover RH/11	Balanced line/41	F	Conductor	Screened
Crossover RH/12	Balanced line/42		Screen	lead
Crossover LH/11	Balanced line/20	F	Conductor	Screened
Crossover LH/12	Balanced line/19		Screen	lead
Balanced line/3	JK 101/3	F	Screen	Screened
Balanced line/4	JK 101/2		Conductor	lead
Balanced line/5	JK 104/2	F	Conductor	Screened
Balanced line/6	JK 104/3		Screen	lead
Balanced line/7	JK 103/3	F	Screen	Screened
Balanced line/8	JK 103/2		Conductor	lead
Balanced line/9	JK 102/2	F	Conductor	Screened
Balanced line/10	JK 102/3		Screen	lead
Balanced line/11	JK 204/3	F	Screen	Screened
Balanced line/12	JK 204/2		Conductor	lead
Balanced line/13	JK 203/2	F	Conductor	Screened
Balanced line/14	JK 203/3		Screen	lead
Balanced line/15	JK 202/3	F	Screen	Screened
Balanced line/16	JK 202/2		Conductor	lead
Balanced line/17	JK 201/2	F	Conductor	Screened
Balanced line/18	JK 201/3		Screen	lead
Balanced line/21	JK 201/1	F	Conductor	Screened
Screen not used	JK 201/3		Screen	lead
Balanced line/24	JK 202/1	F	Conductor	Screened
Screen not used	JK 202/3		Screen	lead
Balanced line/27	JK 203/1	F	Conductor	Screened
Screen not used	JK 203/3		Screen	lead
Balanced line/30	JK 204/1	F	Conductor	Screened
Screen not used	JK 204/3		Screen	lead
Balanced line/33	JK 102/1	F	Conductor	Screened
Screen not used	JK 102/3		Screen	lead
Balanced line/36	JK 103/1	F	Conductor	Screened
Screen not used	JK 103/3		Screen	lead
Balanced line/39	JK 104/1	F	Conductor	Screened
Screen not used	JK 104/3		Screen	lead
Balanced line/40	JK 101/1	F	Conductor	Screened
Screen not used	JK 101/3		Screen	lead

Table 1. Point to point wiring details.

Rear panel connections.

The PA System Controller in Use

Obviously, every user of a system such as this will derive their own test sequence after a PA system has been rigged.

A test tape which is carefully recorded so that the peaks are exactly at 0dB makes a convenient sound source. The first job is to set the input level to the controller with the mute control in action. Once the levels are set, the output levels are checked to be zero and the mute switched off. The various parts of the PA are individually checked, starting with the TOP of each side. This is because a reversed connection may switch bass and treble; the result of feeding a treble horn with a 100 watts or so of bass is probably the most efficient way of blowing such a horn. Starting at the top end will avoid this, since any reversals will become quickly apparent. Once the correct operation is established all the levels are turned up and fine adjustments made with a graphic equaliser.

Once the setting up is complete the limiter is usually switched in, particularly if the group are unknown. Care must be taken, since most people tend to mix up, rather than down, and it is not unusual to obtain a 10dB increase over an evening.

An additional point often overlooked (even by professional groups) is to keep the backline levels down. For a group not used to playing with a PA it is natural to turn everything up to 10 (with the exception of the quality control which always seems to be set at zero), but this will not allow a clear sound to be obtained. The only way to convince a group of this is to demonstrate it and show them that the PA should take the full force of the sound rather than the backline. E&MM

CIRCUIT MAKER

Readers contributions can be an original feature or constructional article describing electronic or electro-musical equipment which is ideally a complete building block that will aid the circuitmaker. All Ideas and circuits presented for publication should have been proved before submission and should include a circuit diagram and explanatory text.

Capacitor Discharge Doorbell

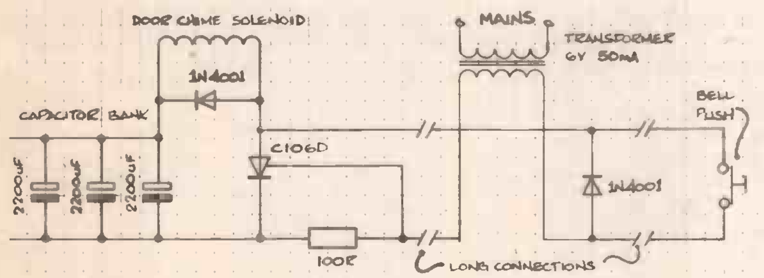
K. Wood, Ipswich, Suffolk

In the way CDI (Capacitor Discharge Ignition) was developed to help car ignition problems CDD was designed to combat the problem of an extremely long length of wire between a chiming doorbell and the bell-push. The resistance of the wire was too great to ring the bell unless the batteries were very new, and I couldn't persuade the other members of the family that a 'Chroma Chime' was a good idea.

The circuit shown solves this problem, as well as offering other advantages including mains operation, with sufficient charge retention to chime once after the mains power is removed, and most desirably, once rung, the bell will not ring again for several seconds - thus defeating persistent bell pushers.

The circuit operates as follows: The capacitor bank charges via the diode at the transformer, the solenoid and parallel diode and the 100R resistor. The negative voltage developed across the resistor holds the thyristor off. When the bell-push is pressed a reverse current flows since the diode is shorted, this develops a positive voltage across the resistor and the thyristor turns on, allowing the charge stored in the capacitors to ring the bell.

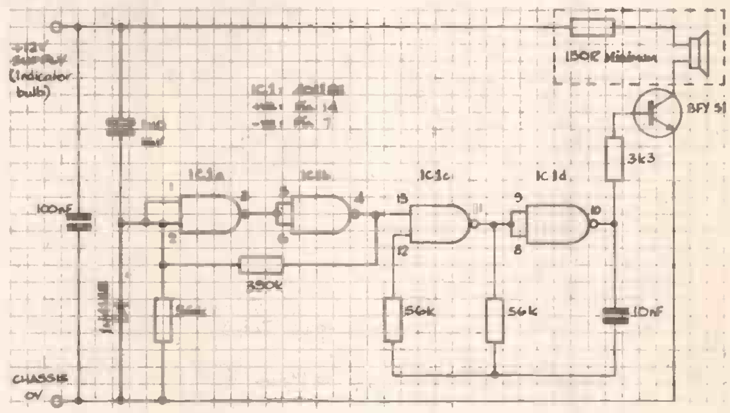
The construction is straightforward. The smallest of mains transformers can be used - if the current drain (in this case 50mA immediately after the bell is rung falling to virtually zero for the rest of the time) is too high, the value of the resistor can be increased. A test meter should be used to identify the terminals of the bell since some makes already have the diode built in. Choose capacitors to fit inside the unused battery compartment, so that they are close to the solenoid, and there is no problem housing them. The total capacitance should be between 5000uF and 10 000uF, 7500uF was used in the prototype, these being 10 volt electrolytics.



Audible Indicator Warning for cars

The self cancelling indicator mechanism provided on many cars does not function on shallow corners and so an audible warning when the indicators are on is very useful. The circuit described here can be easily added to any cars which do not already have a 'clicking' indicator. The circuit gives a short bleep every time the indicator bulbs light; this is less obtrusive than a note sounding all the time the bulbs are on.

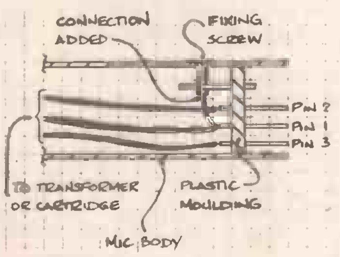
The first part of the circuit generates a ½ second logic high on pin 4 of the IC each time power is applied. This is achieved with the 1uF capacitor which is initially discharged and so pins 1 & 2 go high immediately power is applied, going low as the capacitor charges. Some hysteresis is provided by the 390k resistor to ensure a clean switch between high and low is obtained. The diode is included to protect the gate as power is removed and also provide a quick discharge path for the capacitor. The logic level from this part of the circuit is used to enable a simple oscillator to produce the actual bleep. The output of this oscillator is low when it is disabled, and can be directly connected to a transistor to provide the drive for a miniature loudspeaker. The combined impedance of the speaker and series resistance (if any) must not be less than 150 ohms. The circuit requires only two connections to the car electrics, a ground or chassis, and a link to one of the switched indicator bulb supplies — the most convenient one often being the flashing light on the instrument panel.



'Neutrix' Style Cannon Connectors

It has become popular to use 'Neutrix' style Cannon connectors (as sold by Maplin among others) in place of the traditional Switchcraft or ITT products for the simple reason of cost effectiveness. Most of the economy in the Neutrix style is obtained by making the complete mouldings for the free sockets in plastic, unlike the true Cannon which is all metal with a plastic insert. The plastic moulding in the Neutrix is surrounded by three metal prongs which are connected to the case but have no means of connection to the screen of the connecting cable.

As a rule no problems are encountered with this, but some microphones rely on the metal (and earthed) body of the Cannon connector to ground the actual case of microphone; obviously the Neutrix will not do this, and the microphone tends to be very prone to hum and noise while still working properly. The cure for this is very simple and involves earthing the case of the microphone internally. For example a Shure Unisphere B (one offender) can be modified by loosening the screw which holds the microphone Cannon connector in place (note - screw in to release) and removing the Cannon. A link wire is then soldered in place between the tag which supports the mounting screw and pin 1 (ground) of the Cannon.



Workshop PCB Stand

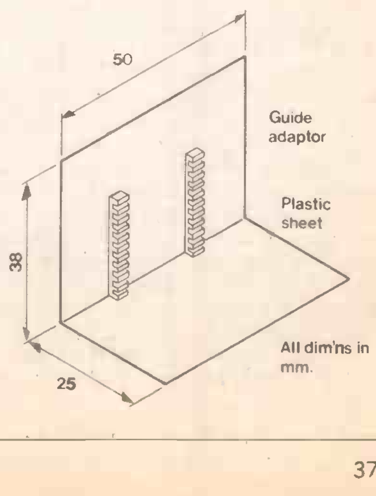
Malcolm Mitchell, Gorleston on Sea, Norfolk

This design makes the soldering of components to printed circuit boards easier, where it seems one needs a hand for the iron, the solder, the board, the component...

The stand is constructed from ⅛ inch (or thicker) plastic sheeting available from model shops, PCB guide adaptors and polystyrene cement. Two stands are made as shown in the diagram, each from two adaptors and two pieces of the plastic card. Cut the plastic to the sizes shown, and cement them together at right angles. Remove the lip from the rear of the adaptors and cement them to the longer side (the vertical) so that it butts up to the base. The adaptors should be level and approximately one inch apart to handle small boards, although larger stands could be made for boards over six inches long.

Care should be taken when soldering, particularly with Veroboard because the copper strips can come into contact with the adaptor and melt it if prolonged heat is used during the making of the joint. Obviously, the board is slotted into the stand after the components have been inserted with the soldering side upwards. Both hands are now free to use the solder and iron because the board is firmly held.

As an economy measure each of the adaptors may be cut in half, leaving each with only 5 slots. The height of the vertical sheet of plastic can also be reduced.



BASICALLY BASIC

Graham Hall, B.Sc.

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

The READ and DATA Statements

Previous parts of BASICALLY BASIC have described how LET statements and INPUT statements can be used to assign values to variables. Another method of assigning a value to a variable uses two statements in combination - the READ and DATA statements. Unlike the INPUT statement, the READ and DATA statements operate within the program instead of interacting at 'run time' with the user at the terminal, consequently large amounts of data can be efficiently assigned to a program.

The READ statement is used to assign the data as the program runs. The DATA statement contains a list of values to be assigned to the variables contained within a READ statement. The following program illustrates how the READ and DATA statements are used in conjunction:

```
10  READ   X, Y, Z
20  PRINT  X, Y, Z
30  DATA   10, 3, 1
40  END
```

Line 10 - The READ statement contains three variables X, Y and Z separated by commas.
Line 20 - The PRINT statement outputs the contents of each variable to the terminal.
Line 30 - The DATA statement contains the values that are provided for the READ statement.
Line 40 - The END statement signifies program completion.

When the program is run, the computer puts all the values in the DATA statement line in an ordered list and places a 'pointer' at the first value. For example, in this program the ordered list would be 10, 3, 1 and the pointer would be placed at the first value in the list (10). When the READ statement is executed, the first value from the list is placed in the first variable of the READ line (X). The pointer then moves to the second value (3) and places this value in the variable Y. Finally, the pointer moves to the last value (1) and places it in the variable Z. So, X, Y and Z contain the values 10, 3 and 1 respectively. The PRINT statement on line 20 outputs the contents of each variable to the terminal, so the output is:

```
10                    3                    1
```

Data statements can be written anywhere in a program, but for clarity it is usual to write them after the READ and immediately preceding the END statement. If more than one READ DATA combination is used, it is advisable to keep all the DATA statements together to avoid possible confusion.

A DATA statement may contain in any combination integers, decimals or numbers expressed in exponential notation (e.g. 3.142×10^2), each separated by a comma. They may not contain variables, arithmetic operations, other functions or fractions. Should a DATA statement line contain an illegal data item, an error message will be output by the BASIC interpreter program. If there are more data items in the DATA statement than variables in the READ statement, the excess values are ignored. However, if the READ statement has more variables than values in DATA, an error message will be output when the program is run. The actual message displayed will depend on the version of BASIC being used, but it would be something like: ? OUT OF DATA IN LINE 30.

For example, if line 30 of the previous program were omitted or changed to contain less than three variables, an error message would be output when the program is run.

It is permissible to have more than one READ statement in a program. A data item from the DATA line is assigned to a READ variable in the order that the computer comes to READ statements when the program is run. For example, the previous program could be written:

```
10  READ   X
20  PRINT  X
30  READ   Y
40  READ   Z
50  PRINT  Y,Z
60  DATA   10,3,1
70  END
```

The output to the terminal would be exactly as before.

The following program illustrates how a large amount of data can be assigned to a program using the READ and DATA statements. This is an extremely useful facility as the DATA can be changed easily and the program re-run to give a different set of results. This particular program could be used as part of a program which analyses the results of a survey questionnaire:

```
 10  REM   DATA  ANALYSIS  PROGRAM
 20  REM   INITIALISE COUNTING VARIABLES TO 0
 30  LET  Y=0  :  LET  N=0
 40  REM  READ DATA AND COUNT THE ANSWERS
 50  READ D   :   IF D=-1 THEN GOTO 100
 60  IF D=1 THEN Y=Y+1   :   GOTO 50
 70  IF D=0 THEN N=N+1   :   GOTO 50
 80  PRINT "DATA ERROR"   :   GOTO 160
 90  REM PRINT THE RESULTS
100  PRINT "YES REPLIES   =";Y
110  PRINT "NO REPLIES    =";N
120  REM DATA 1=YES, 0=NO, -1=END OF DATA
130  DATA  1, 0, 0, 1, 0, 1, 1, 1, 0, 0
140  DATA  0, 1, 1, 1, 0, 1, 1, 1, 0, 1
150  DATA  0, 0, 0, 0, 1, 0, 1, 1, 0, -1
160  END

RUN
YES REPLIES = 16
NO REPLIES = 14
```

The RESTORE Statement

The RESTORE statement allows a program to use the same values in the DATA statement for more than one READ statement. This is best illustrated

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A 4-channel 200-watt light controller giving a choice of sequential, random or full strobe mode of operation.
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Send stamped addressed envelope with all U.K. requests for free list giving fuller details of PCBs, kits and other components. Overseas enquiries for list – Europe send 50p, other countries send £1.00

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A standard keyboard version of the published Elektor 30-note chorus synthesiser with an amazing variety of sounds ranging from violin to cello and flute to clarinet amongst many others.
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FORMANT SYNTHESISER
For the more advanced constructor who puts performance first. This is a very sophisticated 3-octave synthesiser with a wealth of facilities including 6 oscillators, 3 waveform converters, voltage controlled filter, 2 envelope shapers and voltage controlled amplifier. Case and hardware not included – see our lists for further details.
Kit plus keyboard & contacts = M-SET-66 £323.35

P.E. MINISONIC SYNTHESISER
A very versatile 3-octave portable mains operated synthesiser with 2 oscillators, voltage controlled filter, 2 envelope shapers, ring modulator, noise generator, mixer, power supply and sub-min toggle switches to select the functions. A case is excluded, but the text gives comprehensive constructional details.
Kit plus keyboard & contacts = M-SET-38 £169.69

Prices include 15% VAT & U.K. P&P

128-NOTE SEQUENCER
Enables a voltage controlled synthesiser, such as the P.E. Minisonic, to automatically play pre-programmed tunes of up to 32 pitches and 128 notes long. Programs are initiated from the 4-octave keyboard and note length and rhythmic pattern are externally variable.
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16-NOTE SEQUENCER
Sequences of up to 16 notes long may be pre-programmed by the panel controls and fed into most voltage-controlled synthesisers. The notes and rhythms may be changed whilst playing making it more versatile than the name would suggest.
Kit order code = M-SET-86 £60.13

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A very advanced unit using sophisticated I.Q. techniques instead of noise-prone mechanical spring lines. The basic delay range of 24 to 90ms can be extended up to 450ms using the extension unit. Further delays can be obtained using more extensions.
Main kit order code = M-SET-78 £67.22
Extension kit = M-ADN-78 £45.94

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Include specially designed drilled & tinned fibreglass printed circuit boards, all necessary resistors, capacitors, semiconductors, potentiometers and transformers. They also include basic hardware such as knobs, sockets, switches, a nominal amount of wire and solder, a photocopy of the original published text, and unless otherwise stated, a robust aluminium box. Most parts may be bought separately. For fuller kit and component details see our current lists.

Kits originate from projects published in PE, EE and Elektor.

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Compatible with the formant and most other synthesisers.
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Converts saw-tooth waveform into sinewave, mark-space sawtooth, regular triangle, or squarewave with variable mark-space. Ideally one should be used with each synthesiser oscillator.
Kit order code = M-SET-67 £20.13

RHYTHM GENERATORS
Two different kits – the control units are designed around the M252 and M253 rhythm-gen chips which produce pre-programmed switch-selectable rhythms driving 10 effects instrument generators feeding into a mixer.
12-rhythm unit = M-SET-103-258 £64.10
15-rhythm unit = M-SET-103-252 £57.26

6-CHANNEL MIXER
A high specification stereo mixer with variable input impedances. Specs given in our lists. The kit excludes some SW's – see lists for selection. The extension gives two extra channels.
Main kit code = M-SET-90 £88.99
Extension kit = M-ADN-90 £11.74

3-CHANNEL STEREO MIXER
Full level control on left and right of each channel, and with master output control and headphone monitor.
Kit order code = M-SET-107 £18.68

3-MICROPHONE STEREO MIXER
Enables stereo live recordings to be made without the hole in the middle effect. Independent control of each microphone.
Kit order code = M-SET-108 £12.31

HEADPHONE AMPLIFIER
For use with magnetic, ceramic or crystal pick-ups, tapedeck or tuner, and for most headphones. Designed with RIAA equalisation.
Kit order code = M-SET-104 £18.10

VOICE OPERATED FADER
For automatically reducing music volume during disco talk-over.
Kit order code = M-SET-30 £7.80

DYNAMIC NOISE LIMITER
Very effective stereo circuit for reducing noise found in most tape recordings.
Kit order code = M-SET-97 £12.67

DYNAMIC RANGE LIMITER
Automatically controls sound output levels.
Kit order code = M-SET-62 £9.51

TUNING FORK
Produces 84 switch-selectable frequency-accurate tones with LED monitor displaying beat-note adjustments.
Kit order code = M-SET-46 £34.56

TUNING INDICATOR
A simple octave frequency comparitor for use with synthesisers where the full versatility of Kit 46 is not needed.
Kit order code = M-SET-69 £14.41

PULSE GENERATOR
Produces controllable pulse widths from 100NS to 2 sec. variable frequency range of 0.1HZ to 100HZ.
Kit order code = M-SET-115 £21.45

SIGNAL TRACER & GENERATOR
Allows audio signals to be injected into circuits under test, and for tracing their continuity. Includes frequency & level controls.
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WAVEFORM GENERATOR
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using an example program:

```
10  READ   X,Y,Z
20  PRINT  X,Y,Z
30  RESTORE
40  READ   A,B,C
50  PRINT  A,B,C
60  DATA   3,4,5
70  END
    RUN
    3                    4                    5
    3                    4                    5
```

This program has six READ statement variables, three on line 10 and three on line 40. However, the DATA statement on line 60 has only three values. The effect of the RESTORE statement at line 30 is to place the pointer back at the beginning of the DATA list after the first READ statement has used the three values. These same three values are now available for the second READ statement. If the RESTORE statement were not included, the program would run out of data at line 40.

String Variables

So far the only type of variables used in programs have been numeric variables, which set aside a storage location in the computer's memory for numbers. BASIC also allows memory space to be reserved for strings of characters using 'string variables'. A character string is any combination of symbols enclosed on quotation marks (already strings have been used in the form of quoted messages to be output to the terminal by the PRINT statement). For example "THIS IS A STRING!" is a character string. The characters enclosed within the quotation marks may include letters, numbers, punctuation marks and relational or arithmetic operators in any combination (this is called 'alphanumeric data').

String variables are designated by a single letter (A to Z) immediately followed by a 'dollar' sign ($). Some versions of BASIC also allow a letter and number combination followed by a dollar sign as a string variable. For example, A$, Z$, J$, A1$, A9$ and Z0$ are all permissible names for string variables. Some examples of variable names which are invalid are: A1, 1A$, $B and B$1. Should an invalid name be used as a string variable, the BASIC interpreter program will output an appropriate error message.

The number of characters which can be placed in a string is restricted; the limit varies from system to system. It is possible to reserve additional space by explicitly declaring the maximum length a string variable can take using the DIM (DIMension) statement. For example, space for 50 characters will be reserved for the string variable B$ by the statement: 10 DIM B$ (50). Usually this is only necessary if the string is to be greater than 10 characters in length.

String Assignment

Alphanumeric data can be assigned to string variables with a LET statement, INPUT statement or READ DATA statements. First, assignment with the LET statement will be considered. The assignment is made by specifying the LET statement followed by the variable name, an equal sign, and the string data enclosed in quotation marks (also called a 'string constant'). For example, the following statement is a valid string assignment:

```
10 LET B$="BASICALLY BASIC"
```

This string can be output to the terminal using the PRINT statement:

```
10  DIM B$ (20)
20  LET B$="BASICALLY BASIC"
30  PRINT B$
40  END
```

When this program is executed by typing the 'RUN' command the output to the terminal is:

BASICALLY BASIC

The assignment of a string constant to a string variable at RUN time is achieved by using the INPUT statement as follows:

```
10 INPUT B$
```

where B$ is the string variable name representing the storage location of the data. When this statement is executed an INPUT prompt appears on the terminal. In response to this, as many characters as will fit on one line can be typed (providing space has been allocated for a string of this length to be stored). The following program accepts a string constant as a response to the INPUT prompt:

```
10 INPUT B$
20 PRINT B$
30 END

RUN
?BASICALLY BASIC (input to the terminal is underlined)
BASICALLY BASIC
```

After typing RUN, the question mark input prompt is output to the terminal after which any string can be typed. (Note that quotation marks are not required as part of the input string.)

To assign string data to a program using the READ and DATA statements, the READ statement is specified with string variables that represent memory locations for the strings that are assigned by the DATA statement. For example, this program assigns a string to each of three string variables:

```
10  READ   A$, B$, C$
20  PRINT  A$, B$, C$
30  DATA   ONE, TWO, THREE
40  END

RUN
ONE             TWO             THREE
```

The output of the program is shown after the RUN command. The strings in the DATA statement do not normally need to be enclosed in quotation marks. However, there are certain cases where they must be - these are if the string contains commas, or leading, embedded, or trailing spaces, or begins with a number. The following program demonstrates this:

```
10  READ   A$, B$, C$
20  PRINT  A$; B$; C$
30  DATA   "THE MONTH IS", "SEP.,", "1981"
40  END

RUN
THE MONTH IS SEP., 1981
```

(Note that the output is not spaced out because a semicolon has been used in the PRINT statement to separate the string variables).

Later in this series, the complete set of operations which can be performed on BASIC strings will be described. These operations include calculation, conversion, and manipulation by means of string functions. **E&MM**

USING MICROPROCESSORS

Peter S. Kershaw B.Sc (Eng.)

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

Part 6 — A complete hardware/software design exercise

In part five, we looked in detail at the hardware design of a hypothetical 'car computer'. This month the example is considerably more practical - a scanned synthesiser keyboard. This circuit has been built and is now in continuous use in a digital synthesiser. The hardware design is presented in less detail as most of the main points were covered last month, but the software, construction and testing are described in full.

Specification

The requirement is for a 5-octave (C-C) keyboard which interfaces directly to the data bus of the synthesiser's processor and which when read will give the number of any key which has changed (numbered sequentially from bottom C=1) and whether it has been depressed or released. It must be able to handle multiple depressions and releases between reads from the main processor. This means that some sort of output buffer is required, implemented in software. All switch contacts bounce when closed, that is they open and close several times before finally remaining closed. Experiment showed that the keyboard contacts (gold-plated wire) finished bouncing within 2ms. If the key is examined too frequently it may register as being pressed, released and pressed again in very quick succession. Thus, the status of each key should be examined no more frequently than once every 2ms, but often enough that there is no audible delay in response. In fact, the scan time of the final circuit is 7.5ms.

Hardware

The complete circuit of the keyboard controller is shown in Figure 1. Again, the Z80 CPU has been used. The use of other processors is discussed at the end of this article.

Memory and I/O address decoding is performed by IC2. The ROM is the standard 2K x 8 2716, although only a very small amount of program space is actually required. Also, very little RAM is required (for key status, output buffer and stack) and the 128 x 8 MC6810 should be adequate. This is one of the few RAMs which are a whole byte wide.

IC5 and IC6 handle the keyboard scanning. IC5 is an octal D-type flip-flop. Data is written to the device, to ground one output at a time. The inputs to IC6 (an octal 3-state buffer) are read and any zeros indicate a key closure in the row currently being grounded by IC5. A diode (e.g. IN4148) is required for each key to isolate it from all the others. The circuit would work without the 4k7 pull-up resistors as TTL inputs 'float' high. However, these resistors improve noise immunity, particularly necessary if the leads from IC5/6 to the keyboard are long.

IC7 is an octal D-type flip-flop with 3-state outputs (like a 74LS273 followed by a 74LS244). Its outputs are connected directly to the data bus of the main processor.

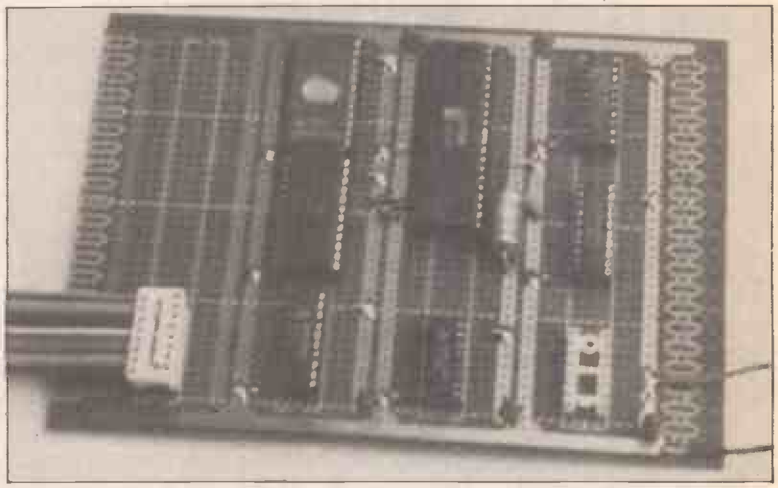
The circuit operates as follows. The keyboard is scanned continually by the software. When a key depression or release is detected, the key number is entered into the output buffer. When IC7 is read by the main processor, IC8 is set and an interrupt is signalled. In interrupt mode 1, this causes a jump to address 38H. The interrupt handling routine gets data from the output buffer (if there is any) and writes it to IC7, simultaneously clearing the interrupt source (IC8). Bits 0-5 give the key number (1-61), bit 6 indicates key depression/release and bit 7 is connected to the INT input to show whether the data in IC7 has been replaced since the last KEYBOARD READ.

The memory and I/O addressing is as follows:

0000 - 07FF	ROM
0800 - 087F	RAM
1000	Key scan out
1800	Key sense in
2000	Data out

Construction

Several methods may be used to construct a prototype board. One of the quickest and cheapest is to use Verowire on a DIP board. The DIP board is a pre-drilled, double-sided PCB which accepts digital ICs and has special lines for power supplies. The Verowire is fine gauge wire insulated with a material which melts when raised to soldering temperature. Using a special dispenser, the wire is wrapped around the pin of an IC (or IC holder). The wire is then run to other ICs along special combs. The entire circuit of Figure 1 was built in less than two hours and the resultant board is shown in the photos.



Completed controller board.

Note the 10nF decoupling capacitors. At least one of these is required for each IC, in order to stop noise spikes on the supply causing spurious switching. One 10nF capacitor each should be used for the 'current guzzlers' such as the CPU.

Software

In the May issue of E&MM, we discussed the various ways of writing microprocessor software. For such a simple application as this, there is little point in using a high-level language, and Z80 assembler code has been used. Some programmers draw flowcharts and code from them, whilst others prefer to code directly. My approach is a compromise - the simple routines are coded directly whilst logically complex routines are flowcharted first. The software can be split into several main areas:

Initialisation
Interrupt handling (fetch from output buffer)
Store data in output buffer
Keyboard scanning

A listing of the software is shown in Table 1. The columns are from left to right: line number, address, object code, label, opcode, operands, comments.

System Equates will allow us to refer to addresses and constants by labels in the program.

RAM Allocation - allocates the RAM area starting from 0800H (this assembler interprets numbers as hexadecimal by default). The 64-bit KEYTAB holds the current keyboard status and is constantly compared with the data from the keyboard scanning routine to check for a depression or release. The DEFS statement reserves areas of memory and assigns addresses to labels.

FIFO - the output buffer is of the First In-First Out (FIFO) type. For this we require a buffer area, an input pointer (FIFOIN), an output pointer (FIFOUT) and a character counter (NUMCHR). When a character is entered into the FIFO, the input pointer and character counter are incremented. When a character is removed, the output pointer is incremented and the character counter is decremented. The buffer is circular so when either pointer reaches FIFEND it wraps around to FISTRT again.

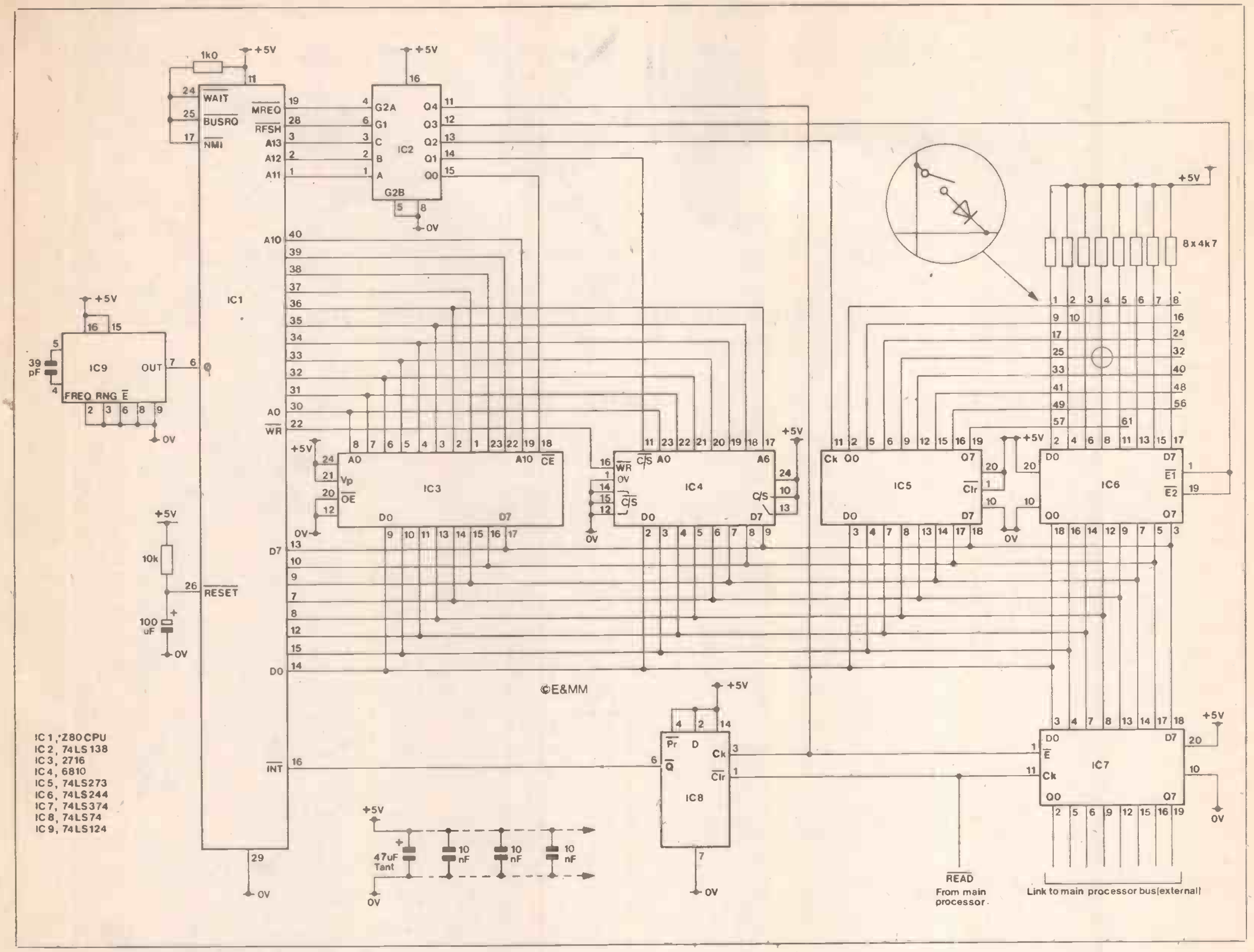


Figure 1. Complete circuit of the Keyboard Controller.

Table 1.

```
1000          ;SCANNED  KBD
1000          ;SOFTWARE
1000          ;P. S. Kershaw   1981
1000          ;
1000          ;SYSTEM EQUATES:
1000          ;
1000          KYOUT  EQU   1000          ;Keyboard scan lines
1800          KEYIN  EQU   1800          ;Keyboard sense in
2000          DOUT   EQU   2000          ;Key data output
0020          FISIZE EQU   20            ;Size of output buffer
1000          ;
1000          ;RAM ALLOCATION:
0800                 ORG   0800
0800          ;
0800 00000000 KEYTAB DEFS  8             ;Keyboard status table
0808          ;
0808   0000   FIFOIN DEFS  2             ;FIFO input pointer
080A   0000   FIFOUT DEFS  2             ;FIFO output pointer
080C   00     NUMCHR DEFS  1             ;Number of chars in FIFO
080D          VAREND EQU   $
080D 00000000 FISTRT DEFS  FISIZE        ;Start of FIFO
082D          FIFEND EQU   $             ;End of FIFO
082D          ;
082D          ;ROM
0000                 ORG   0000
0000          ;
0000          ;INITIALIZATION
0000          ;
0000   210000 INIT   LD    HL,INITAB
0003   110008        LD    DE,KEYTAB
0006   010D00        LD    BC,VAREND-KEYTAB
0009 EDB0            LDIR                ;Load initial variable valu
000B          ;
000B   AF            XOR   A             ;Clear accumulator
000C   320020        LD    (DOUT),A      ;Initialize output data
000F   310008        LD    SP,0880       ;Initialize stack
0012 ED56            IM    1             ;Set interrupt mode
0014   FB            EI
0015   1849          JR    KSCAN         ;Jump to keyboard scan
0017          ;
```

continued ▶

Table 1 continued

```
0017          ;INTERRUPT HANDLER
0038                 ORG   0038
0038          ;
0038 08       INT    EX    AF,AFG       ;Exchange registers
0039 D9              EXX
003A          ;
003A          ;FETCH DATA FROM FIFO:
003A 210C08   FIFGET LD    HL,NUMCHR
003D 7E              LD    A,(HL)
003E B7              OR    A            ;FIFO empty?
003F 2817            JR    Z,INT1       ;If so, write data=0
0041 35              DEC   (HL)         ;Otherwise dec char count
0042 2A0A08          LD    HL,(FIFOUT)
0045 7E              LD    A,(HL)       ;Get data from FIFO
0046 23              INC   HL           ;Move output pointer
0047 220A08          LD    (FIFOUT),HL
004A 112D08          LD    DE,FIFEND
004D 3F              CCF
004E ED52            SBC   HL,DE        ;End of FIFO exceeded?
0050 2006            JR    NZ,INT1
0052 210D08          LD    HL,FISTRT    ;If so, wrap around
0055 220A08          LD    (FIFOUT),HL
0058          ;
0058 320020   INT1   LD    (DOUT),A     ;Write data to output
005B D9              EXX                ;Restore registers
005C 08              EX    AF,AFG
005D FB              EI                 ;Re-enable interrupts
005E ED4D            RETI               ;and return
0060          ;
0060          ;KEYBOARD SCANNING ROUTINE
0060          ;
0060          ;Read key status:
0060 210008   KSCAN  LD    HL,KEYTAB    ;Pointer to key status
0063 0EFE            LD    C,0FE        ;Initialize scan mask
0065 1600            LD    D,0          ;and counter,
0067 79       KSC1   LD    A,C
0068 320010          LD    (KYOUT),A    ;Ground one scan output
006B 3A0018          LD    A,(KEYIN)    ;Read back sense inputs
006E 5F              LD    E,A
006F AE              XOR   (HL)         ;Comp with previous status
0070 73              LD    (HL),E       ;Update status
0071          ;
0071          ;TEST EACH BIT:
0071 0608            LD    B,8          ;Load bit counter
0073 5F              LD    E,A          ;Transfer difference byte
0074 CB03     KSC2   RLC   E            ;Shift MSB into carry
0076 3009            JR    NC,KSC3      ;Jump if not difference
0078 7E              LD    A,(HL)
0079 E680            AND   80           ;Set/reset bit 7
007B 0F              RRCA               ;Shift it to bit 6
007C 82              ADD   A,D          ;Add scan count
007D 80              ADD   A,B          ;Add bit count
007E CD9600          CALL  FIFSTO       ;Put in output buffer
0081 CB06     KSC3   RLC   (HL)         ;Rotate byte in KEYTAB
0083 10EF            DJNZ  KSC2         ;and test next bit
0085          ;
0085 0628            LD    B,28         ;Timing delay
0087 10FE     DELAY  DJNZ  DELAY
0089          ;
0089 7A              LD    A,D          ;Load scan counter
008A FE38            CP    38           ;Scan finished?
008C 2802            JR    Z,KSCAN      ;If so, start again
008E 23              INC   HL           ;Otherwise inc KEYTAB point
008F C608            ADD   A,8          ;and scan count
0091 57              LD    D,A
0092 CB01            RLC   C            ;Update mask
0094 18D1            JR    KSC1         ;then continue scan
0096          ;
0096          ;STORE BYTE IN OUTPUT BUFFER
0096          ;PLACES BYTE IN REGISTER A INTO FIFO BUFFER
0096          ;
0096 D5       FIFSTO PUSH  DE           ;Save registers
0097 E5              PUSH  HL
0098 F3              DI
0099          ;
0099 5F              LD    E,A          ;Save data
009A 3A0C08          LD    A,(NUMCHR)
009D FE20            CP    FISIZE       ;FIFO full?
009F 281B            JR    Z,EXSTO      ;If so, exit
00A1 3C              INC   A            ;Otherwise, inc char count
00A2 320C08          LD    (NUMCHR),A
00A5 7B              LD    A,E          ;Restore data
00A6 2A0808          LD    HL,(FIFOIN)
00A9 77              LD    (HL),A       ;Store data in FIFO
00AA 23              INC   HL           ;Move input pointer
00AB 220808          LD    (FIFOIN),HL
00AE 112E08          LD    DE,FIFEND+1
00B1 3F              CCF
00B2 ED52            SBC   HL,DE        ;End of FIFO?
00B4 2006            JR    NZ,EXSTO
00B6 210D08          LD    HL,FISTRT    ;If so, wrap around
00B9 220808          LD    (FIFOIN),HL
00BC          ;
00BC FB       EXSTO  EI
00BD E1              POP   HL           ;Restore registers
00BE D1              POP   DE
00BF C9              RET
00C0          ;
00C0          ;INITIAL VALUES OF VARIABLES
00C0          ;
00C0 FFFF     INITAB DEFW  0FFFF        ;KEYTAB
00C2 FFFF            DEFW  0FFFF
00C4 FFFF            DEFW  0FFFF
00C6 FFFF            DEFW  0FFFF
00C8 0D08            DEFW  FISTRT       ;FIFOIN
00CA 0D08            DEFW  FISTRT       ;FIFOUT
00CC 00              DEFB  0            ;NUMCHR
```

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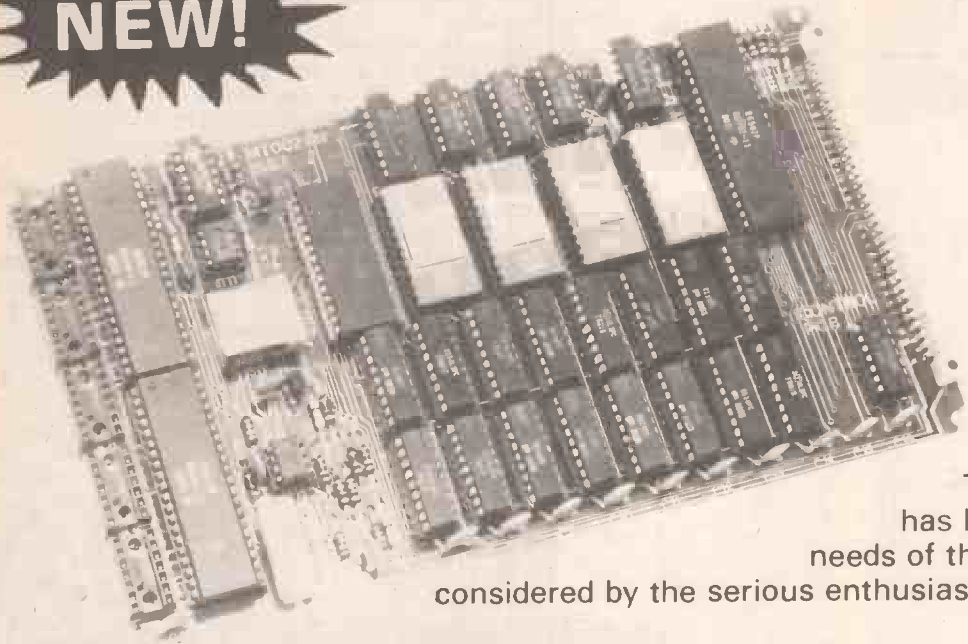

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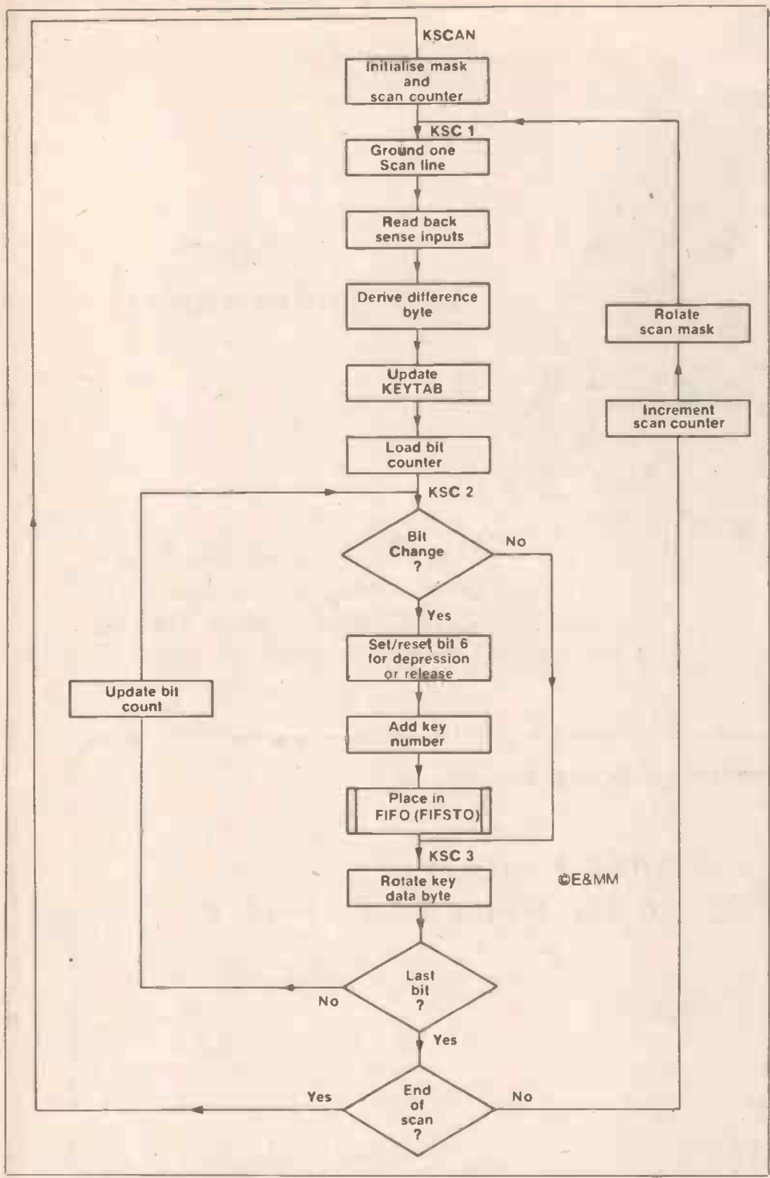


Figure 2. Keyboard Scanning Routine.

Initialisation - first sets the initial values of variable data. The Load and Increment Repeat (LDIR) instruction loads the block of data starting at (HL) to the area starting at (DE) for the length in BC. The XOR A instruction is frequently used to clear register A. The stack pointer is initialised at the end of RAM, interrupts are enabled and a relative jump executed to the keyboard scanning routine.

The Keyboard Scanning Routine is flowcharted in Figure 2. This is referred to as the background routine. A scan mask is initialised with one bit set to zero. This is rotated left by the RLC instruction to ground each keyboard line in turn. At line 4F0 the data read from IC6 is exclusive - OR'ed with the previous key status. This will leave a byte which is zero everywhere except where the two bytes being compared differ. By then shifting this different byte into the carry flag (line 550) each bit is tested in turn. If a difference is found, the output data is calculated (lines 570-5B0) and placed in the FIFO by the FIFSTO subroutine. The appropriate byte in KEYTAB is rotated before returning to test the next bit.

The DJNZ instruction is very useful for program loops. Register B is decremented and a relative jump occurs if register B is not zero. This is illustrated clearly in the timing delay loop (lines 600-610). This delay is necessary to give a scan period of 7.5ms. The time taken to execute the KSCAN routine may be found either by calculation from data in the Z80 manual or by trial and error. The latter approach is usually far quicker. Remember, though, that execution times may vary, depending upon the results of software decisions.

FIFSTO is the subroutine used to place output data into the FIFO. The contents of DE and HL are saved at the start of the routine and restored at the end. Also, interrupts are disabled for the duration of the routine. This is because the same variables (FIFOIN, FIFOUT and NUMCHR) are changed by the interrupt handler. Note that the 16-bit addresses (FIFOIN) and (FIFEND+1) must be compared. As there is no 16-bit compare instruction, this is done by subtracting the two numbers in line 7F0. This is a subtract-with-carry (SBC) so the carry flag must first be cleared (line 7E0).

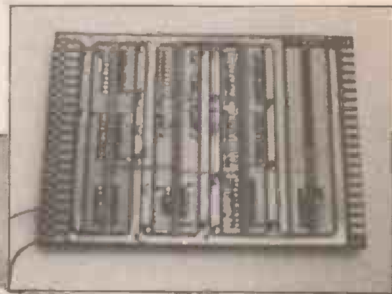
The Interrupt Handler gets data from the FIFO buffer and writes it to IC7. The routine is similar to FIFSTO. The alternate register set is used during the routine and interrupts are disabled automatically for its duration and so must be re-enabled before returning.

Testing

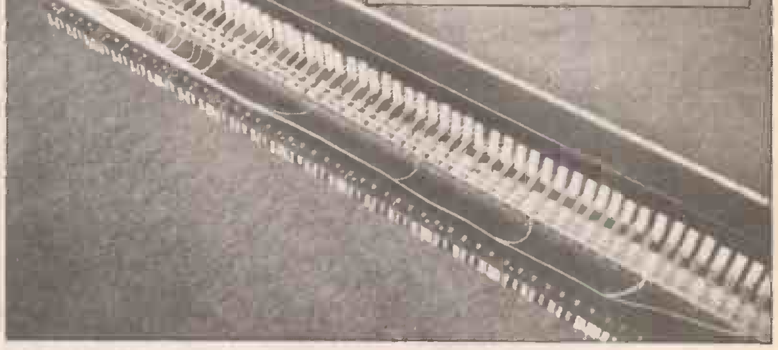
The signals present within a microprocessor system are complex and problems are often difficult to track down. Many very sophisticated (and expensive) pieces of equipment are available to the professional engineer. For example, logic analysers monitor the system buses and trace program execution, and in-circuit emulators simulate operation of the processor enabling the engineer to monitor precisely the circuit functions.

However, few people can afford to have such equipment in their home. But it is still possible to test and debug systems with nothing more than an oscilloscope and some imagination. The following is a description of the methods used to test the keyboard scanner.

First, the Z80 CPU was installed in its socket and set to free-run. This is done by forcing on to the data bus an instruction which is executed entirely internally to the processor. In this case, the no-operation instruction (NOP, code 00H) was used. This was done using 9 short pieces of wire all joined at one end. Eight of them were inserted into the data pins of the IC3 socket, the last being connected to 0V. When IC1 was powered up and the clock applied the NOP instruction was executed, the address bus incremented, NOP executed again, etc. Thus, the address bus cycled continuously through its 64K address range. This was monitored using an oscilloscope. A_7-A_{15} produce squarewaves at frequencies in ratios of powers of 2. A_0-A_6 are a little more complex as refresh addresses are also produced. However, simultaneous monitoring of $\overline{\text{RFSH}}$ can be used to locate



Wiring side of circuit board.



Keyboard wiring.

the refresh cycles. Free-running the processor confirms that the address bus has no short or open circuits and confirms that some of the processor functions are working.

IC2 was then installed and this produced a cycling between the $\overline{Q}$ outputs confirming that address decoding worked.

Next, a very simple program was written which wrote data to IC5 and read from IC6. For testing purposes, the outputs of IC5 were temporarily connected to the inputs of IC6. The result was written to IC7. This program confirmed that IC3 was connected correctly and that ICs 5, 6 and 7 were working. It also provided further testing of the CPU. The special test program also included a verification of the RAM.

To test the functioning of the complete system, a special circuit was made up on a breadboard. This comprised a pulse generator to synthesise the $\overline{\text{KEYBOARD READ}}$ signal and two hexadecimal displays to monitor the outputs of IC7. Whilst providing regular pulses and pressing and releasing keys, the output data was verified as correct.

It is, of course, quite possible to simply plug in the final program ROM and try the complete circuit immediately. However, complex microprocessor circuits rarely work first time, if only due to wiring errors, and it is then necessary to strip the circuit down again to locate faults.

If errors are found in the Verowiring, it is only necessary to cut the appropriate wire at both ends and put a new wire in. It is not necessary to remove the old wire from the loom.

Most microprocessor development systems offer some assistance in debugging software. In particular, they allow you to execute programs one instruction at a time (single-stepping) whilst monitoring register contents and flags.

Alternative Implementations

The package count of the system could have been greatly reduced by using a single-chip microcomputer. For example, the 8039 has 128 bytes of RAM, a clock oscillator and 3 I/O ports. Thus a complete keyboard controller would require only an 8039, a ROM and a crystal. For high volume production, devices are available which also have internal ROM, allowing the implementation of a single-chip keyboard controller.

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Organ Talk

Ken Lenton-Smith

"One difficulty", remarked a reader recently, "is how to play the thing once it has been made!" He went on to mention that he had obtained some music scored in Klavarscribo, which he thought avoided the difficulties for the beginner reading conventional scores.

There will be a number of readers who sympathise with his remark. It certainly does seem a pity that the constructor has to ask someone else to play his instrument - which was probably made with his own enjoyment at the keyboard in mind.

Well, this is where I feel I have to stick my neck out somewhat - and no doubt wait for the brickbats! The problem with electronic music generally is that the subject attracts those who, by and large, hail from two different sources. The skilled musician who tackles a constructional project may well get bogged down for a while with unfamiliar technicalities and have difficulty in understanding circuit diagrams or even reading resistor colour codes!

On the other hand, the electronics expert will sail through these minor details but won't know an acciaccatura from an appoggiatura, will have difficulty in reading even a single line score and will be floored when asked to play F#m7!

Chacun à son goût, as they say. But is it really a case of 'never the twain shall meet'? As far as the practised musician is concerned, reading this magazine ought soon to get him into the ways of electronics generally. In many respects, of the two groups under consideration, he is the better off.

The electronics man turned musician is somewhat at a disadvantage because electronic music is the marriage of a science and an art. Learning that particular science is possibly easier than the art of music: after all, constructing a kit organ is largely a case of following instructions with care. If you query this comment I would add that a science is something that is systematic and obeys certain fixed principles (like Ohm's and Boyle's Laws). An art is a practical skill and, although it may require guiding principles, is largely creative and expressive.

In music, it is necessary to learn those guiding principles before one can hope to begin the creative and expressive experiments. Those principles are the Rudiments of Music: all music shops stock this publication and I would strongly advise any budding musician to own a copy.

This deals, of course, with *conventional* music notation and I recommend the conventional as that system is not only universal but eventually leads to a good *understanding* of what you are doing.

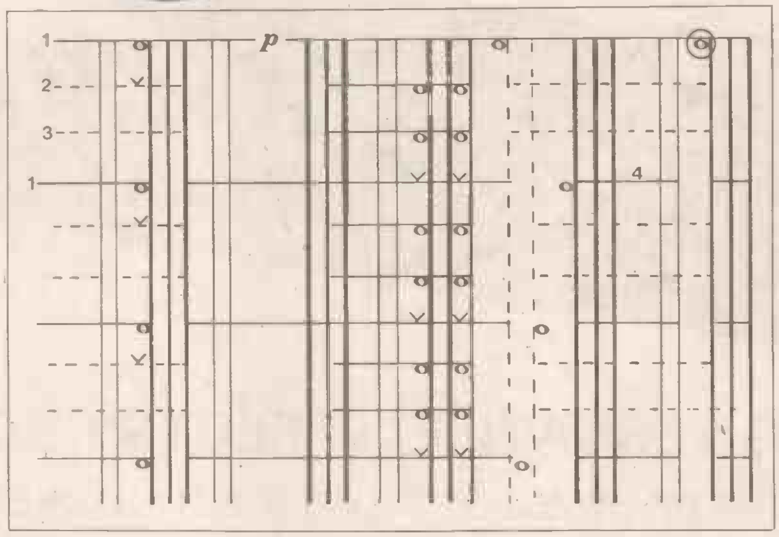

Figure 1. Klavarscribo.

The modern home organ is usually bristling with aids to the beginner - rhythm unit, one finger chords, autochord and even lights under the keys. Automatic Orchestra Computer and pedal systems that find the notes for you or offer automatic bass patterns are other facilities. Some of these can pall after a while, yet oddly enough in the hands of a really accomplished player they can become embellishments to a brilliant performance.

It should be borne in mind that these beginners aids are what sell organs best of all. They cost money, of course, and have to be taken as non-optional extras although many musicians would prefer more 'straight' organ for what they are paying.

With practice, there comes a time when one wishes to dispense with many of these frills - except perhaps the rhythm unit. For the purposes of this dissertation, let us ignore the aids for a moment and concentrate on the organ we are left with: in all probability it will amount to two 44-note manuals and 13 pedals, most of the tonal variation being available on the upper manual.

The 'King of Instruments' was crowned long before gimmicks were added and - even in the case of the small basic instrument just mentioned - what makes playing it a most exciting and enjoyable experience is that it is the most complete musical instrument devised. You make what you will of your 'one man band' (- or 'one man orchestra' in view of synthesised orchestral voices?) using every limb you possess!

In order to get the best out of the organ, it is necessary to know something about harmony and chord structure. Neither one finger chords nor Klavarscribo will help in this direction.

Let's take a closer look at Klavarscribo, which was first introduced in Holland in 1931 by a Dutchman, Cornelius Pot, and has a certain following on the Continent. Although some 20,000 editions of Klavar are available, it cannot be purchased everywhere - and this figure covers scores for various musical instruments. The music is written on a *vertical* 'stave' and read from top to bottom - ideally suited to Oriental musicians? Figure 1 is an example.

Can you guess the title of the tune portrayed without going to a keyboard? The 'stave' consists of lines that are mentally extended above the black notes of the keyboard. The group of three black keys has thicker lines than those relating to the other two black notes.

A black dot is placed on the line to indicate a black note and white dots between lines to show white notes. This music is a pictorial representation of finger positions, so the names of notes do not matter. There is no key signature or accidentals, the system being the musical equivalent of painting by numbers.

Fine - you can produce pleasing music without having a clue... The publishers think it is a simple system because:

1) The same image in all octaves, clefs being superfluous.
2) 12 notes per octave instead of 7.
3) Nothing to remember, all information being pictorial.
4) Duration symbols not required as graphic portrayal is self-evident.
5) It indicates which hand should be used.
6) No ledger lines to contend with.
7) Subdivision of the bar is shown accurately.

At first sight, this is the proverbial answer to a maiden's prayer. When you sit down and play, even the parrot will compliment you with "Who's a Klavar boy, then?" So why haven't we all adopted this sytem and thrown away the conventional dots?

Certainly there are advantages for the very raw beginner - but he will always stay at that level: the main disadvantage is that you don't have to think. The whole point of music for many people is as a means of relaxation - but lack of thought will not get anyone far in the field of electronics or music.

With Klavarscribo, the beginner can not progress very far musically as he will have no idea of the pictorial chord he is playing or the key concerned.

The organ has always been a excellent instrument for extemporisation, which requires a good knowledge of chord structure and harmonic progression. Admittedly, there are some who can play by ear with a semblance of perfect harmonic accompaniment, but not very many: in any case, they would not require any type of music notation.

It is only too easy to get into the habit: once hooked on Pot (I mean Klavar, of course!), it might be difficult to get out of it and really learn something of music.

Better still, get into the habit of conventional notation which might seem more difficult at first but the *structure* of the music will soon begin to mean something. Once this stage has been reached, music starts to become a pleasure (instead of the drudgery associated with school-days).

Modern circuit diagrams are often rather complex, so it is necessary to settle down and study them quietly in order to grasp what is actually happening. The same approach - and both need practice - should be applied to learning music.

You may tell me that the peak age for learning is reputed to be around 15 years. If that appears to exclude the majority of E&MM readers from learning music, the same must apply to electronics - the main reason this magazine is sought after!

So, if you happen to be at the threshhold of music, stick to conventional scores and buy 'Rudiments of Music' for light bedtime reading!

Organ scores for the type of music you may most wish to play may not be available, so it will be necessary to re-think piano scores (as they sound ghastly, as written, on an organ). To do this, some musical knowledge is required, especially concerning chord symbols and harmony. In subsequent articles I hope to offer some practical ideas on these subjects - for which the bedtime reading will be necessary.

Whether you buy an organ kit or design and build, a great deal of patient, hard work is involved. One has to be tenacious and prepared to spend plenty of spare time on the project. May I leave certain readers with the thought that if they have expended time, energy and cash on a constructional project, the very least they owe themselves is to learn to play their new toy! **E&MM**

(Roses from the South - Johann Strauss)

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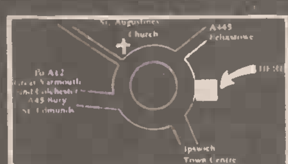

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HI-FI

Jeff Macaulay

One subject in Hi-Fi that has been shrouded — I believe deliberately — in mystery is crossover design. Every speaker construction project that I have read glosses over many of the finer design points. In an attempt to show that crossovers are well within the design capability of most enthusiasts I will explain how it's done.

The first thing needed when designing a multiway speaker system is the crossover frequency. Most woofers are not renowned for their treble response and tend to roll off at a few kHz. Tweeters, on the other hand, have a 'bass' resonance, usually around 1kHz. Naturally they cannot be used below this frequency. When choosing units the frequency ranges handled must overlap preferably by at least an octave. Having established this crossover frequency, it should be placed in the centre of the overlap. For example let's assume we have a woofer that will respond to 4kHz and a tweeter that goes down to 2.5kHz.

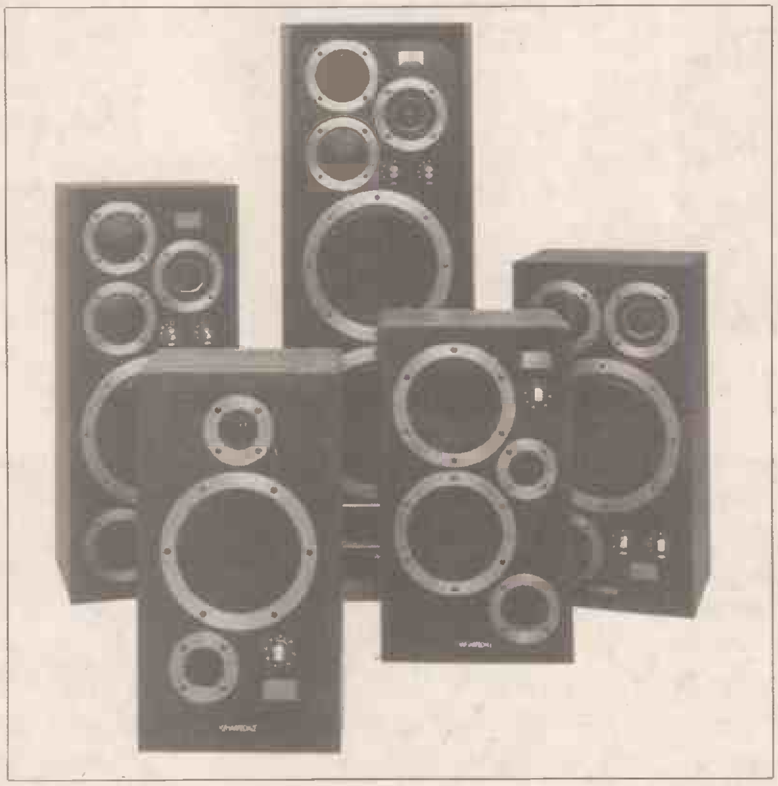
Subtracting 2.5kHz from 4kHz gives us 1.5kHz. Half of this is 750Hz so our crossover will be at 2.5kHz +750Hz =3.25kHz.

It is now necessary to measure the impedances of the drive units at 3.25kHz. To do this you will need a signal generator, a 100R resistor and an oscilloscope. The resistor is wired in series with the speaker and a sine wave at the crossover frequency, 3.25kHz, fed to it. The impedance of the speaker is then found from the relationship, $Z=\frac{100\ V_d}{V_o-V_d}$

Where Z is the impedance in Ohms, V_d is the RMS voltage across the speaker and V_o the RMS output voltage fed into the network.

When the impedances of the speakers have been determined, they should be mounted in the cabinet and the relative efficiencies measured. This is achieved by measuring the output of each speaker in isolation, when fed from the signal generator. The procedure is as follows:

Take the speaker cabinet outside and lay it on the ground with the drive units pointing upwards. Position a microphone about a foot away and between the two drive units. Feed a sine wave at the crossover frequency into the woofer and adjust the output to a convenient level observing the mic output on an oscilloscope. Feed the sine wave into the tweeter and adjust the output until the 'scope shows the same level as the woofer. By noting the inputs required for each unit the relative efficiencies can be found. Usually the tweeter will be much more efficient than the woofer. The simplest way to get the efficiencies equal is to put a resistor in series with the tweeter. It's best to use a 22R pot in series and adjust it, monitoring the tweeter's output with the aid of the mic and 'scope. Measure the resistance setting and use the nearest value component in series with the tweeter in the crossover network.



$L1=\frac{\sqrt{2}Z_w}{2\pi f}$ $\qquad C1=\frac{\sqrt{2}}{4\pi f Z_w}$

$L2=\frac{\sqrt{2}Z_t}{2\pi f}$ $\qquad C2=\frac{\sqrt{2}}{4\pi f Z_t}$

Where L is in Henrys, C is in Farads.
f=crossover frequency in Hertz.
Z_w=woofer impedance at fHz.
Z_t=tweeter impedance at fHz.

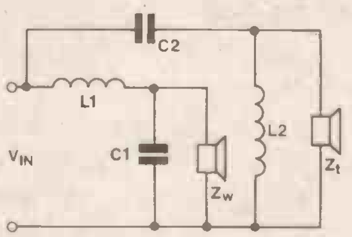


Figure 1. Basic crossover circuit and equations for determining component values.

Remember though that this will now modify the impedance of the tweeter and this must now be remeasured as before with the resistance in series. Crossovers have various electrical slopes dependent on their complexity. Generally, as one might expect, the higher the slope the more difficult the design equations become. The nearest thing to a universal crossover is the second order type and I will concentrate on this type. Figure 1 details the basic circuit and the equations for determining the component values.

That's all there is to it really, although you have to be careful when selecting components. Electrolytics are out. Apart from their wide tolerance they tend to explode when subjected to AC! Paper types are ideal although polyester types are probably easier to obtain. Awkward values can be formed by wiring standard values in series/parallel. Chokes can either be air cored, or wound on low hysteresis iron cores. Again, non-standard values can be produced by combining standard values.

Hopefully I will be able to come back to this subject at greater length at some future date.

I read with some interest Ben Duncan's comments on amplifier sound in the last issue of E&MM. And while I would agree with most of what he said, I would take issue with the impression left in the reader's mind that all transistor amplifiers sound the same. Transistor amplifiers do tend to sound ropey when overloaded but there is a solution. NAD in their excellent 3020 power amplifier have incorporated soft limiting. This effectively reduces the gain of the circuit as the overload point is approached. The result is that instead of overloading and producing large amounts of odd harmonic distortion, the circuit sounds like a valve amplifier in overload.

The other major difference between valve and transistor amplifiers is their modus operandi. Valve amplifiers almost invariably work in class A whilst transistor types tend to work in AB. If you listen to a Class A transistor amplifier it is very difficult to detect the difference between it and a valve type. Unbelievers should go to their nearest stockist and listen to the Electrocompanient amplifier. Although this only produces about 20W RMS its sound is very valve like. It operates entirely in Class A. The reason for the different sound is not hard to find. Crossover distortion is the major drawback of Class AB amplifiers. Overall feedback will reduce the level to theoretically imperceptable levels. Trouble is that crossover is a spiky waveform and its peaks are of much higher amplitude than the RMS level would indicate.

Probably, the advent of VFET output stages will render the above problem of academic interest only. I must admit though that the sliding bias amplifiers which the Japanese have foisted upon us this Hi-Fi season don't sound at all like Class A to me.

Next month I hope to discuss the ins and outs of active speaker systems.

To whet your appetites a little though, it may be as well to note briefly the advantages of the active approach over the passive one. As you will have realised having read this far, the design of a conventional crossover network is critically dependent on the impedances and relative efficiencies of the drive units used.

Further, these impedances are not simple pure resistances so there is always the risk of unwanted interaction between the various complex (reactive) parts of the networks. They absorb amplifier power, an insertion loss of 6db or more being commonplace. Last but by no means least, they prevent full advantage being taken of the damping factor available at the amplifier output.

Active crossovers suffer from none of these problems. The slope and crossover frequency are independent of the speaker impedance. The relative efficiency of the drive units can be equalised simply by means of a balance pot between the power amplifiers used. They are cheap, no costly inductors are used. A textbook response is automatically obtained assuming standard equations are used. In short they offer the ultimate performance possible at the present state of the art.

E&MM

WORKING WITH VIDEO

Andy Emmerson

Seventy-nine percent of USA citizens find statistics a bore or so it was said in a recent comedy programme. That aside, I will give you only one statistic this month. I quote Matsushita's spokesman Akiri Harata who estimates that worldwide sales of video recorders this year will exceed six million units. That is some number and underlines the rapidly growing interest in home video. Matsushita owns Panasonic and JVC and can be presumed to be fairly knowledgeable on the subject. Interestingly, only 27 percent of these machines will be sold in the USA - perhaps they are approaching market saturation there. The United Kingdom can be considered to be relatively well-developed video-wise but countries such as France and West Germany are not nearly so video-minded. I thought you'd like to know that if you're already a video owner you are still in something of a minority.

Turning to matters more practical, I thought we would talk this month about music and video. Considering the musical bias in this magazine there's more than a fair chance that you are interested in music as well as video. I know this is a great column but I don't flatter myself to the extent of believing that you buy the magazine for this article alone! The shame is that music and home video do not always mix, or to be more precise, high fidelity reproduction of audio is difficult on the average home video machine. This is due to three factors, the slow (and not even constant) tape speed employed, the audio processing in the video tape recorder and the indifferent audio amplifier and tiny (tinny?) speaker used in the average domestic TV set. Despite these shortcomings, you can get quite decent music off a video tape!

Let's dig a little deeper and see what's involved. First of all the speed of the tape: given typical tape speeds and audio track widths it's amazing that you can record and replay usable audio at all. Still, with most TV speakers you cannot notice the deterioration in frequency response and signal to noise. Things would be more bearable if tape speeds were constant, but if you record a continuous tone on most VCRs you get a very sad result. Try dialling a non-existent number on your telephone and record the unobtainable tone on your VCR. You may be horrified at the result. Some machines are better than others in this respect e.g. the Panasonic, Akai, Sony and the new "super" machines. Early JVC-based

VHS machines were pretty awful; I have one myself and it's impossible to enjoy music tapes on it.

Audio processing in the VCR is the second factor. Because the manufacturers think the controls are complicated enough already, they don't allow you to play with the audio input levels. Instead they fit an automatic gain control (AGC) circuit which is very effective but can be noticeable on sudden transitions from low to high audio outputs. The result on music is a "pumping" sound. There is nothing you can do to defeat the AGC circuit. Fortunately, the newer machines are including Dolby noise reduction processing which is a welcome step.

The third weak link in the chain of reproducing music on video is in the TV receiver. With the exception of one or two expensive "hi-fi" sets from people like Philips and the late lamented Tandberg, the audio is disappointing. Fortunately all VCRs provide an audio out socket and you can connect this to your hi-fi system. Results can be agreeably good - once you have got over the fact that the sound is not coming from directly in front of you! Frequency response is at least the equal of 16mm film optical soundtracks and if you have a scratch filter you will find this eliminates the hiss without losing high notes.

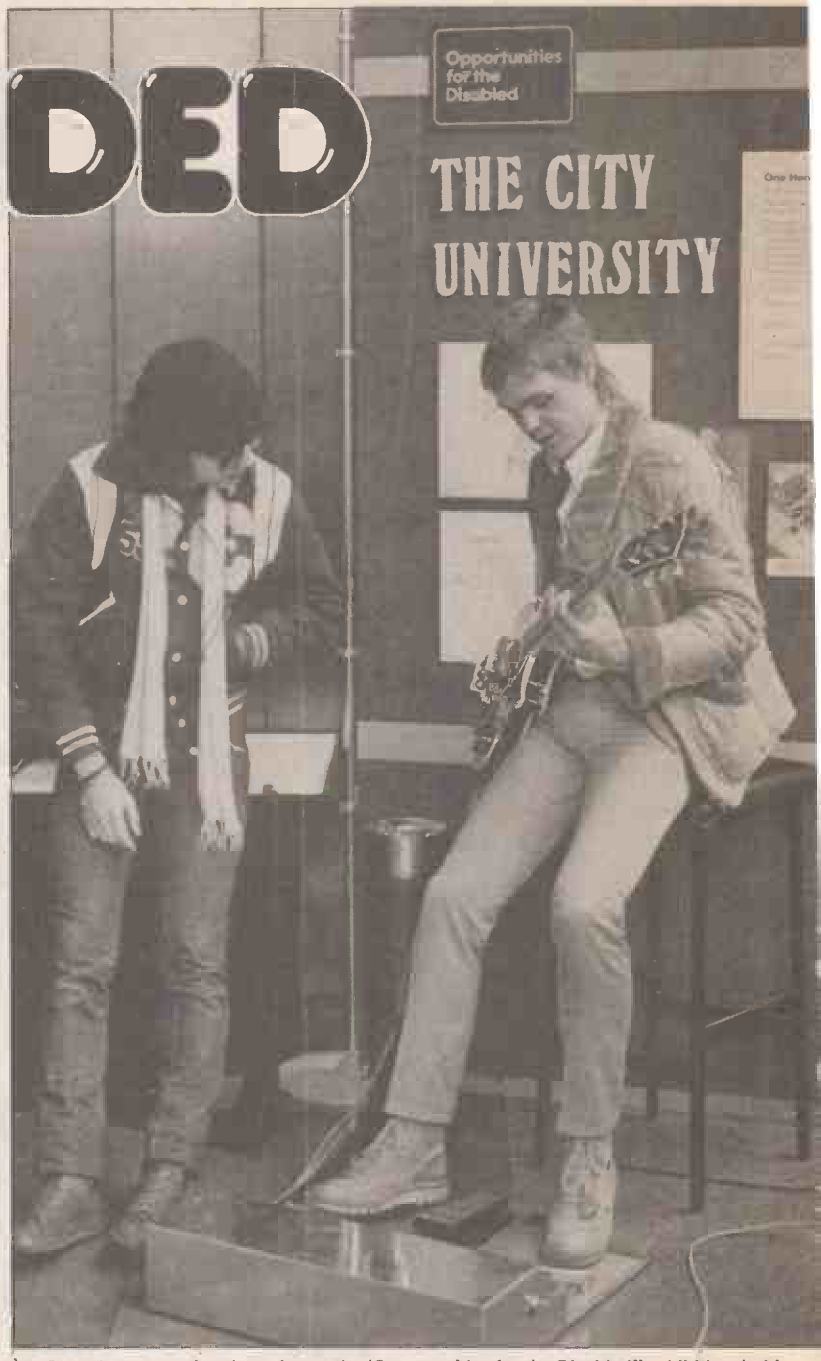
So far I have said nothing about the music on video tapes, either prerecorded or the music you record yourself. In the latter category I had in mind TV programmes but of course you may well be into making demo tapes for a local rock group. The range of prerecorded tapes is a bit restricted, due no doubt to contractual problems, and is unevenly balanced. VCL stand out for their creditable range of music tapes with quite a few big names like Thin Lizzy and Average White Band. I bought one of these and found the production and quality very reasonable although the performances were not exactly "prime time" material. There are several other music tapes on video - Blondie's "Eat to the Beat" has been plugged to death - and you can buy full length epics like "Woodstock". Trouble is that £20 or £30 seems a lot of money to pay for thirty or forty minutes of music when you can watch similar artistes on "Rockstage" or "Whistle Test" for nothing and record them for the cost of a blank tape.

Despite some criticisms of current VCRs and their music performance, I am hopeful for the future. If you recall how the audio compact cassette developed from a scorned gimmick to a respectable hi-fi medium in a decade I think you can expect a similar improvement in VCRs. This will come for three reasons. First, there will be keen competition from video disc machines which will have full hi-fi (and stereo) capability. Second, new metal tape formulations will enable better recording quality to be achieved. Third and most important, the manufacturers will be under pressure to bring out new features to make us dissatisfied with last year's model. Already they seem to have perfected video features (clean edits, shuttle search, stable freeze frame) so they may well turn their attention to the audio circuits which are still primitive by comparison. Stereo capability may well be with us within five years - it has been a reality for three years in Japan. Over 2.5 million stereo TV sets or adaptors have been sold since 1978, although only 30 hours of stereo television are broadcast weekly. Stereo TV will soon be a reality in the USA also, possibly by mid-1982. It is only a matter of time before Europe has stereo television too. It will be worth waiting for.

E&MM

ONE HANDED GUITAR

A. E. Malison



Ian Style demonstrating the guitar at the 'Opportunities for the Disabled" exhibition, held this year.

Until now handicapped people not having the use of one of their arms have been very limited in their choice of musical instruments . . .

In this article a specially modified electric guitar which attempts to widen the scope for disabled musicians is described. It was designed as a student project in the Final Year of a B.Sc. Honours Degree Course in Electronic Engineering at the City University, London and was supervised by Mrs M. Watkins, a lecturer at the University. A prototype has been built for ex-Kenny guitarist Yan Style who lost the use of his right arm in a motorcycle accident 4 years ago, and who feels confident enough to start making music again with the one handed guitar (the band by the way, will be a five piece called the Nine Arms!).

The basic arrangement is shown in the picture. The player leans on a stool and controls a set of pedals and switches which activate a plucking device near the bridge of the guitar.

First, some points about guitar playing. There are basically three ways or modes of playing a guitar. You can play a single line melody (or lead line), strum through the strings or play a number of strings simultaneously. An effective system must enable the one-handed player to use these modes of playing.

How it works

The guitarist selects the mode of playing by use of 3 mode switches labelled Lead, Strum and Simu (simultaneous). He taps on either of the side pedals whenever plucking of the strings is desired. A finger position detector on the neck of the guitar gives information on the strings the player is touching at any given moment. This detector is quite simply a circuit formed with the strings, neck of the guitar and hand as depicted in Figure 1.

The neck of the guitar is coated with a conductive paint so that when the hand is touching both a string and the neck, the inverting gate gives a high output. This is an example of CMOS at its best since the hand resistance can vary from about 5 MΩ down to 200 kΩ. The extremely high input impedance of CMOS gates allows a simple design for detection. The only catch is that on most guitars the strings form a short circuit at the bridge and string holder, but this is easily overcome by replacing these parts with a hard insulating material.

Now back to the playing. If the guitarist is in the Lead mode the system scans the strings starting from the low E going up the strings towards the high E. When one of the Rhythm pedals is tapped, only the lowest string being touched is played and any high strings being touched are ignored. This has to be so since, when playing lead, it is almost impossible

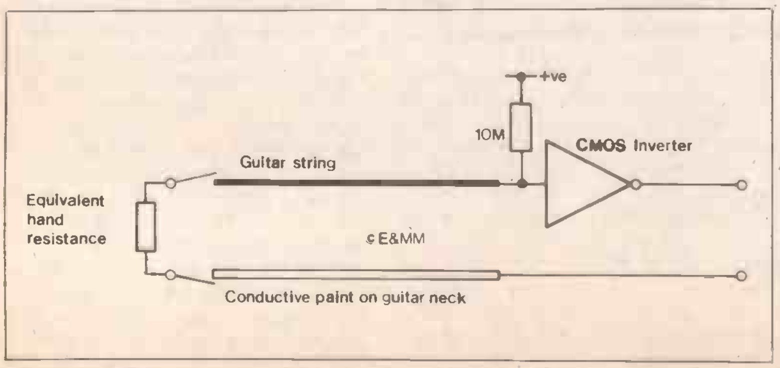


Figure 1. 'String touched' detector: the output is high for any hand resistance.

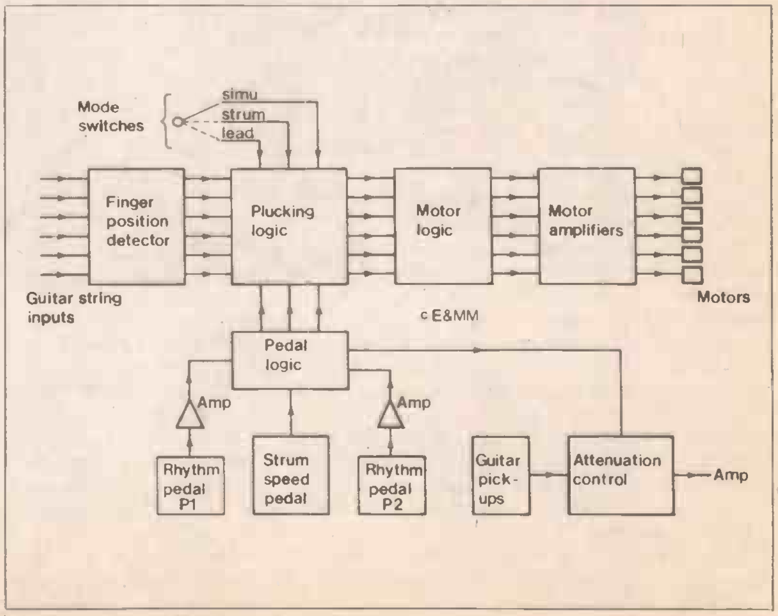
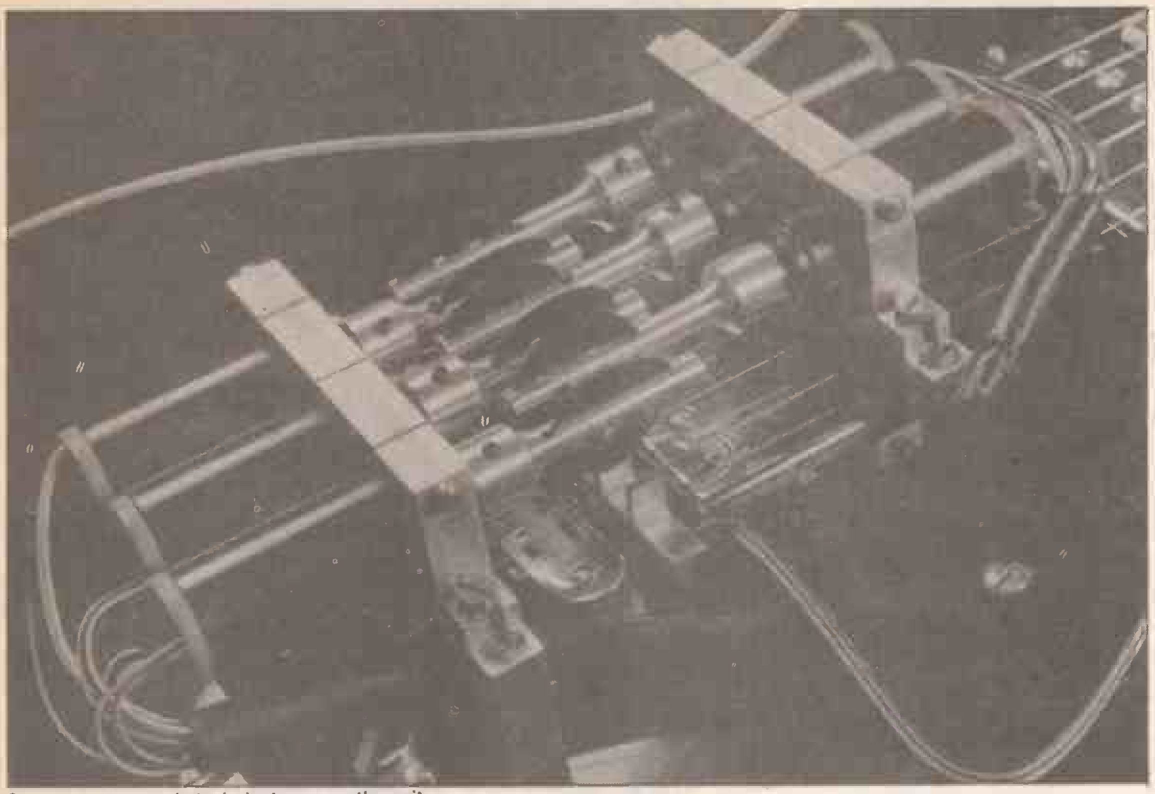
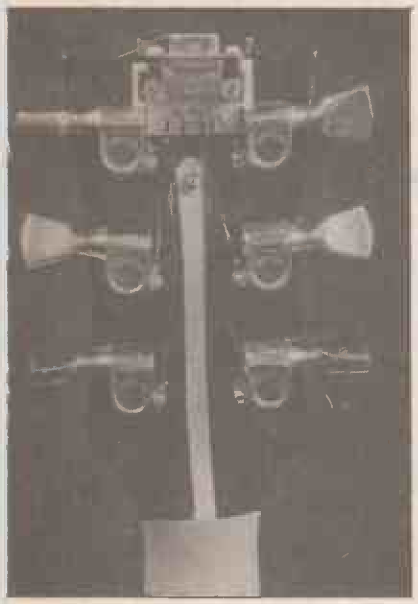


Figure 2. System block diagram.

YEAR OF THE DISABLED



Stepper motors and steel plectrums on the guitar.



Back of the guitar, showing the coated neck and the interconnections to the strings.

not to accidentally touch strings which are not to be played. Luckily, these strings are, most of the time, of higher pitch than the one which is to be plucked.

In the Strum mode, tapping one of the rhythm pedals causes the plectrum to strum through whatever strings are being touched. If the right hand side pedal is struck, the strum is from top to bottom and vice versa for the left hand side pedal being tapped. The player chooses the speed of strumming via the central preset pedal (Strum speed control) and a row of LEDs, gives an indication of the set strum speed. At slower strum speeds a finger picking effect is obtained.

In the Simultaneous mode, a pedal being pressed causes whatever strings are being touched to be plucked at the same time.

The system also provides a dynamic mode when in Lead or Strum. This comes into operation when both pedals are pressed at the same time and causes the system to go momentarily into the Simultaneous mode, causing the strings being pressed at that given moment to be plucked as one chord. This mode of operation increases the versatility in playing dramatically as, for example, mixtures of lead and chords are easily achieved with a little practice.

The Pluckers

As can be seen in the picture, the plucking mechanism consists of motors perched over the strings with plectrums attached to their shafts. The motors are made to step backwards and forwards, simulating the movement of a hand plucking a string with a plectrum. The plucking has to take place quite near the bridge due to angle considerations and so the sound obtained has quite a high treble content. However, with good Bass/Treble controls an acceptable sound is produced. Another limitation of the plucking devices is that they always pluck at the same strength and hence a dynamically flat output is obtained from the pick-ups. This problem is solved by having an automatic gain control system.

Automatic Gain Control

The rhythm pedals incorporate strain gauges, so that a voltage is derived which is proportional to the maximum force applied to the pedal at any given time. This voltage is used to control the gain of a preamplifier stage for the guitar output. In this way the effect of different plucking strengths is simulated and the player has complete control over the loudness of the notes being played.

Although the system works satisfactorily there is plenty of room for improvement, the most pressing one being that of designing a special plucking device since higher torque is desirable for the faster plucking speeds and for a better sound. Hopefully, this will be followed by students at the City University in the near future. For now, keep your ears open for the Nine Arms! **E&MM**

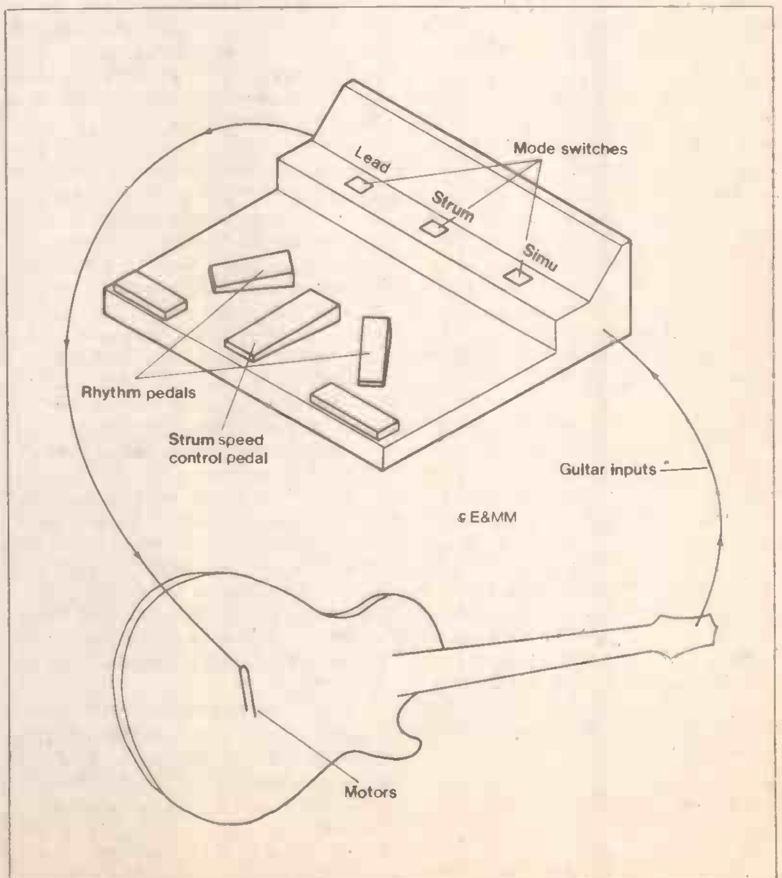


Figure 3. External appearance of pedal unit.

Electronics mounted in the pedal unit.

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.

Chromascope Video Synthesiser

The professional chromascope.

As one of the great meglomaniacs of the past, Scriabin was probably the first composer to inflict some highly dubious ideas of marrying music with the other sensations on a hitherto unsuspecting public. Like those that delve into the Soho backstreets, Scriabin never had enough, and is quoted as saying: "You will live in this music with all sensations, harmony of sounds, of colours, of fragrances". His 'Prometheus, The Poem of Fire' included a concertante part for a colour organ, or "clavier à lumières", which played colours according to notes played on the keyboard. Attempts by psychologists and others to ascribe particular pitches, keys or timbres to particular colours haven't exactly made much sense, and it's generally recognised that synaesthetic experiences, or the way one sensory input (such as music) conjures up the impression of another sensation (such as colours or smell), is best left up to the individual listener to sort out to his own subjective convenience. However, for the enterprising contemporary artist wishing to indulge in his own interpretation of a son et lumière experience, a system capable of video synthesis could be a rather exciting idea. Unfortunately, it's often rather difficult to avoid commonplace associations such as green and orange with the consecutive fifths of Vaughan Williams in his most pastoral mood, or red with the stabbing string glissandi of the shower scene in 'Psycho'!

Background and Design

Units for translating sound into light have been around for some years, but the standard technique of using band-pass filters to trigger triacs leaves a lot to be desired in terms of subtlety. The Chromascope moves this potential for visual titillation well into the Eighties, though it doesn't exactly fullfil all the promises of true visual synthesis. Some background first: the Chromascope is the brain-child of Robin Palmer and it's his company, CEL Electronics, that launched the "Chroma-Chime", the first microprocessor musical door chime, in 1977. The Chromascope has been in development for the past six years, partly as a result of waiting for necessary advancements in chip technology, and partly to ensure that the market-place was in a suitably receptive state. As the video business is in a somewhat uncertain interim state between video tape and video disc technology, I'd say that they've chosen their launch time rather astutely, but a product like this is likely to sink or swim on the basis of long-term adaptability rather than its immediate appeal.

Currently, there are two versions of the Chromascope: the first is a domestic version priced at £295 inclusive of VAT; the second is a professional unit priced at £675 inclusive of VAT. Both units offer the same basic video synthesis features but with important distinctions that we'll come to later.

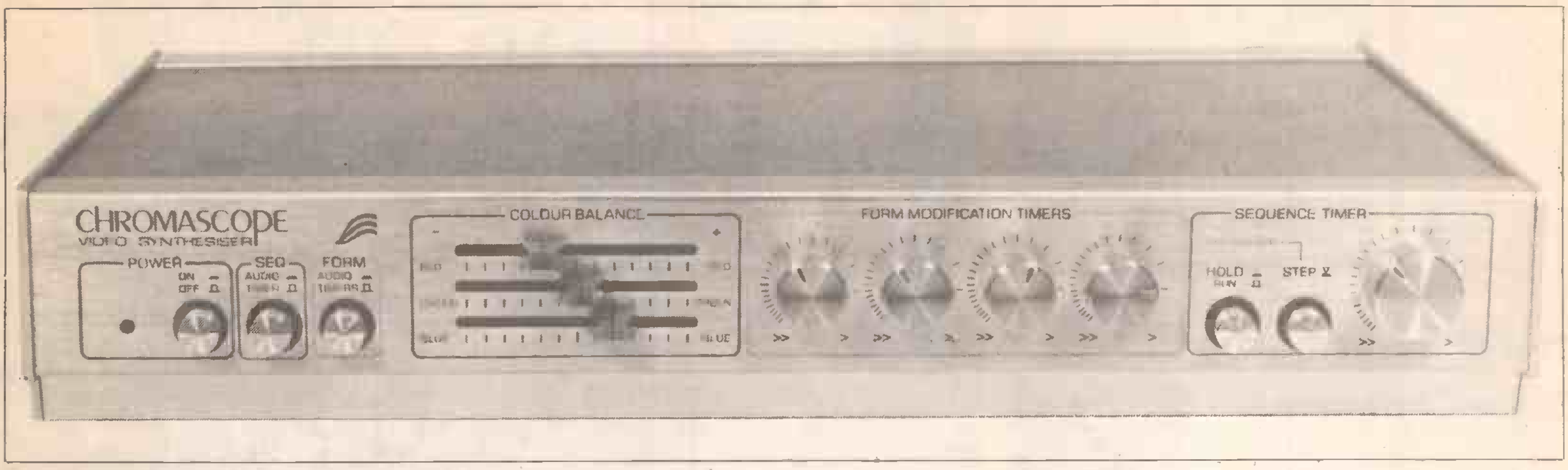
There are two modes for the operation of both units: either it can operate without an audio input, in which case all the colours and shapes are determined on a time cycle basis, or else it can work in the audio mode where some of the timers are put out of action and substituted with band-pass filters for very basic frequency

Black and White photograph of colour-enhanced Video input.

analysis of the audio input. Like earlier, simpler units, four band-pass filters are used to analyse bass, low and high mid-range, and the treble components of the audio spectrum.

There is a mixture of digital and analogue circuitry to provide the best of both worlds. Apparently, if you use digital pattern synthesis, you're limited to rectangular forms, whereas analogue techniques give you nice wholesome circular shapes (the Lissajous figures). Basically, the unit operates by using a large number of synchronised function generators which produce all sorts of different waveforms. These are selected on a random basis, intermixed together, and, in some cases, with long and short feedback loops introduced on a random basis, then processed and fitted into a colour matrix.

An audio input has the effect of modulating a random picture, so that, instead of sequences and colours moving under the control of internal timers, these are at least partially controlled by the outputs of the four band-pass filters. Also, as a separate function, the change from one pattern to another, can be controlled by the bass rhythm derived from the music. Because music is so complicated, Robin Palmer suggests that it doesn't make sense to translate fast pitch and dynamic changes into visual terms. I'd agree with this point of view if the Chromascope offered a viable alternative; instead the viewer is obliged to view the product of internal programming with only (it seemed to me) a



The domestic chromascope.

minimal interaction with the audio input. The main problem lies in the saturation of the senses that a constantly and randomly changing pattern of colours engenders. I tried concentrating on a display demonstrating a Genesis-modulated product of the Chromascope, but just ended up with a headache and a confused visual cortex; after all, of such stuff are brain-washing techniques made!

I'd like to see a video synthesiser offering the visual equivalent of additive synthesis of sound by actually building up patterns on the basis of the frequency structure of the music rather than by internal function generators more-or-less randomly intermixing. One of the most captivating visual displays that I've ever seen used fifteen or so band-pass filters to derive control voltages from an audio input; these were then patched to synthesise concentric colour rings, the pattern synthesis following a progression from dark 'bass' rings in the centre to light 'treble' rings at the edge.

Controls and Other Options

If the music interpretive qualities of the Chromascope leave a lot to be desired, other areas of the unit compensate for this, at least in part. Whereas the domestic version is limited to either the free-running sequencer mode, with timing of sequences selected by front panel controls, or the audio mode, with some elements of timing derived from the music itself, the professional model includes some very interesting facilities for processing external video inputs.

This version accepts visual sources such as a VTR or camera, and a cross-fade control allows patterns and colours to be superimposed on the visual source material. This is also true for a monochrome input and the colourising is really very impressive. At the demonstration I attended, the unit was being used in conjunction with a VTR playing 'Yellow Submarine'; the results can only be described as hyper-psychedelic, and, even though this could be regarded as an attempt to gild the lily, it does demonstrate that the use of the Chromascope, to superimpose abstract patterns of colours on familiarly-structured material, offers much scope for video studios and those amongst us with a Kenny Everett mentality. It's encouraging to see a British manufacturer producing a product that looks so thoroughly well-engineered; in fact rather Japanese in appearance! However, I suspect that the pricing of these units is likely to put the Chromascope out of reach of all but 'the man who has everything'. I, for one (but not one), wouldn't gain much more than transient amusement from the domestic model; for half the price maybe I wouldn't mind so much.

Availability: directly from the manufacturers, CEL Electronics, Coachworks House, River Way, Harlow, Essex CM20 2DP (0279-418611).

Dr David Ellis E&MM

INSTRUMENT REVIEW

The Linn LM-1 Drum Computer

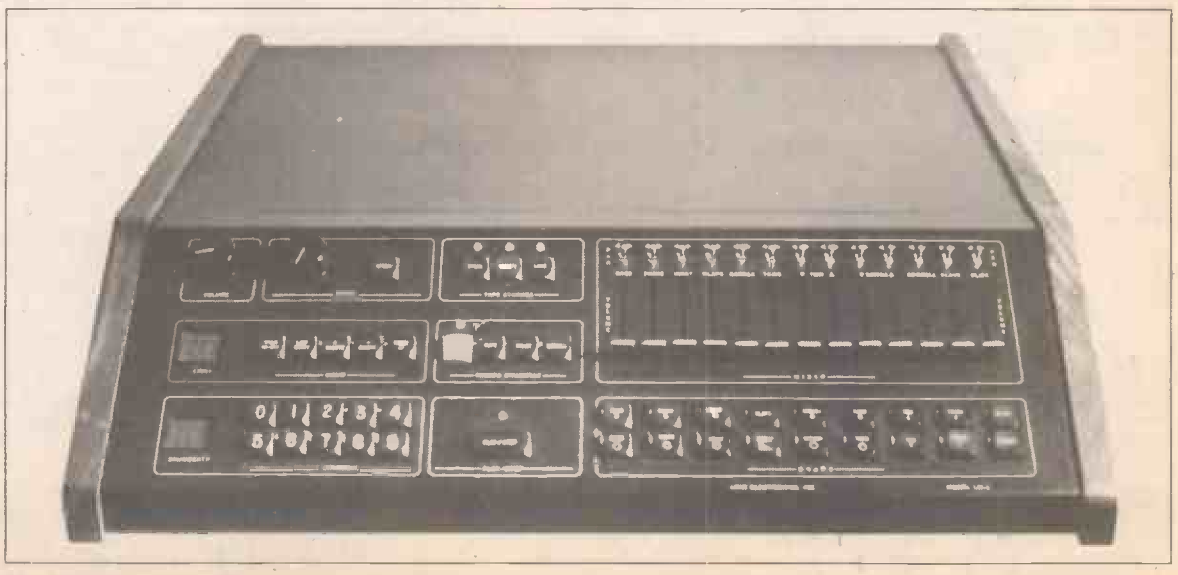
We have watched the horizons of the electric guitar expand constantly as new technology enables the musician to bend, distort, and mutate his sound in ways the original makers of the instrument could never have dreamed of. The very nature of the instrument, once electrified, lent itself so readily to such experimentation. Over the past decade modern musicians have taken to the synthesiser far more rapidly than anyone would once have imagined. The synthesiser is now an established part of the musical world and, as players master them, synth design and technology grows in sophistication almost daily. Indeed, keyboard instruments will never be the same again . . .

The technological Genie has now been applied to the process of rhythm making, not with the hesitant steps of before but with a real bang. The result is the Linn LM-1 Drum Computer. The Californian based company have produced a drum machine in the truest and most literal sense for, unlike other units available, the Linn gives you real drum sounds. They've been digitally recorded and encoded on to chips. Like any other example of ground-breaking hardware it has its share of faults; some petty and perhaps a matter of taste, and others which are not petty, perhaps even serious. Even so, there is still only one word with which I would unhesitatingly describe the Linn - incredible.

The quality of its sounds? They're going to be a shock for people used to the artificialness and hitherto general wetness of rhythm machines. True, the obviously synthetic nature of their sounds can be very appealing but it is eventually very limiting. Also to be considered are sounds that are good at front room listening levels or through a guitar amp's spare channel in a rehearsal room soon prove to be an entirely different matter when put under the magnifying glass of studio monitors or when cranked up through thousands of watts of PA at a gig.

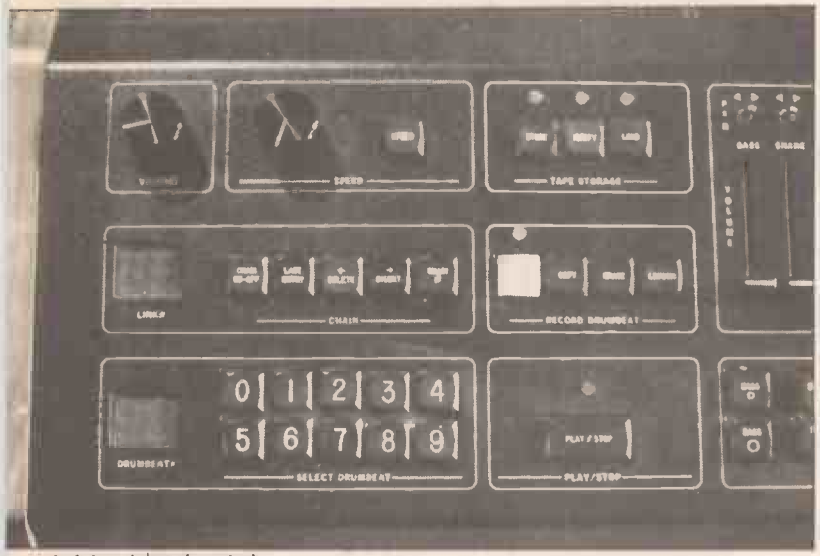
I've exhausted a lot of time and money developing and experimenting with my drum machines to achieve more versatility under such conditions and to try and get more 'guts' into the sounds, with varying degrees of success. Companies producing rhythm machines appear to have paid


Warren Cann, electro-percussionist for Ultravox.


Linn LM-1 Drum Computer.

remarkably little attention to these aspects, for they knew their products were being utilised by the home-organ crowd (hence the proliferation of bossa-novas and tangos) or by people desiring a token rhythmic backing in order to cut down on their compliment of musicians (ship's cabaret acts, lounge pianists etc.), all not necessarily the most discriminatory of users. Even so, most of the rhythm voices were a joke. But, gradually, as a few musicians who were not afraid of the future and who wanted to find new and more interesting ways of providing percussion began to pioneer new techniques, things changed. They experimented upon and bastardised those rudimentary machines until finally the manufacturers took note of the trends in modern music to electronics and came up with some slightly better efforts.

Generally, one is faced with units possessing marginally more realistic patterns of beats and a few more controls in addition to the usual 'tempo' and 'stop-start' are featured. So much for the past.



Left-hand panel controls.

Features

The Linn's 12 drum and percussion voices, which range from that of a basic drum kit (bass drum, snare, high-hat, high & low toms) through to tambourine, clave, cabasa, high and low congas, cowbell, and handclaps, are all immaculately real. Because they *are* real. Thus, each one possesses the accepted 'classic' sound characteristics that are the general norm when one thinks of, say, a snare drum. Although, almost of necessity, they are very M.O.R. sounds, they are all ideal source sounds and eminently recordable – the ideal jumping off point for the musician and sound engineer to doctor or pervert wherever their whims lead.

All voices are tuneable for pitch and ALL are sensibly available separately via their own individual outputs if you decide not to use the master stereo high or low level outputs. At last you can give separate treatments to a snare or bass drum without having to suffer the treatment of the entire rhythm; this one feature alone gives endless possibilities.

The relative levels of all the drums/percussion are controlled by a master volume and via a 13 channel mixer which can also place any of the voices exactly left, centre, or right, within the stereo picture if you decide not to run mono.

That's the barest and most basic description of what the Linn operates with. The idea of using regenerated sounds from the real thing is a major step forward in this field, but it's not that particular breakthrough that I want to rave about here. The *real* essence of what makes the Linn important lies – if you haven't guessed by now – in its name. Not the Linn Drum Machine or the Linn Rhythm Unit or what have you but the Linn *DRUM COMPUTER*.

Programming

Yes, you program this machine to do what *you* want it to do. You tell it what you want and when you want it, you don't have to wade through blocks of silly factory pre-set rhythms and blow dust off of antiquated 'fill-in's' that some clown at the manufacturers thought sounded good. You don't have to drive yourself mad trying to outsmart and double-think the Linn into playing something that's leagues away from the limited applications other rhythm units were designed for. And you don't have to modify it mechanically or otherwise to achieve any of this. Great!

You achieve this by programming the beats into the Linn's memory by tapping on the keys situated below the level faders. One plays along to a programmable metronome (hence that 13th channel you've been wondering about) whereby you then overdub, erase, accent, copy, edit, or ad lib to your requirements. A further refinement is the memory's ability to build complex chains of different rhythms link by link.

You can store up to 100 different beats in the memory. If you want more and have run out of memory you simply dump the information on to any reasonably decent cassette tape thus making room for new efforts. To retrieve the stored information you just reverse the process.

When recording you can lay down a 'code' on to tape so that you are not bound to the rhythm that other instruments were overdubbed to. If you change your mind you can go back, wipe the drum tracks, use the code on tape to drive the Linn, and then try something else. It'll all be in sync. The freedom this allows in a studio is incredible, the now-or-never days are over.

Another vital feature is the Internal Clock Out. By means of a rotary switch at the back of the unit you can select clock pulses to trigger sequencers or synths at whatever is required by that piece of equipment's design, at anywhere from ¼ notes to 1/192 notes. Again, you're not bound by the design dept's ideas of what you need, you can tailor your clock pulses to what is required for the song.

Using the chain facility enables one to place different beats in an order determined by the user. You can program an entire song format; an intro, verses, chorus, solo, fills, breaks, etc., whatever the arrangement calls for. You type in the number corresponding to the beat wanted and continue this for the order you want the beats to occur and the Linn will replay them in the order that they were entered. There are eight chains and each will hold up to 99 links. Editing these chains is easy, you can delete, insert, 'fast forward', or 'rewind' via the chain controls. By now you should see how the Linn justifies its computer name.

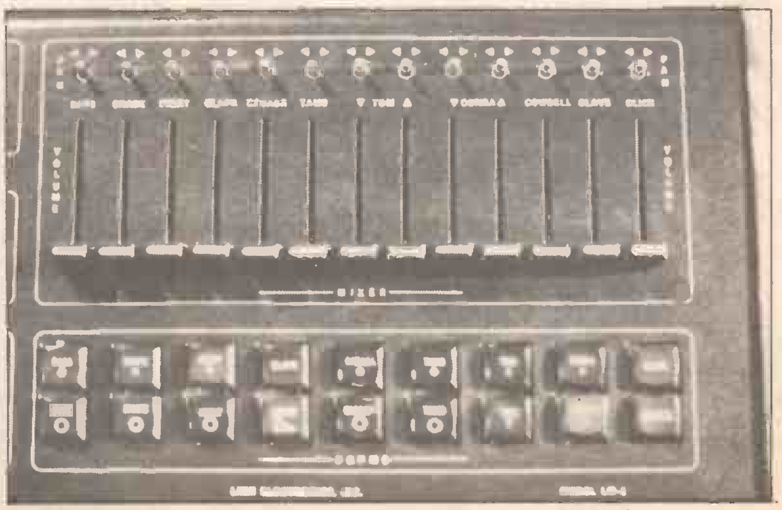
An utterly non-drummer type person can sit down with the Linn and, after an hour or so of familiarisation, have fun producing some quite respectable results. Practically speaking, your only limitations are your imagination and the degree to which you can master the somewhat tricky and dexterous knack of programming but, even here, the Linn can assist. Programming is made easier by varying types of self-correction settings which help you pull your small timing errors into time. You use the Auto-Correct facility in the mode most suitable for the type of rhythm being played to get the most accurate results, the auto-correct can move programmed 1/8th notes to the nearest 1/8th note and thus makes up for slight user errors. You can use the auto-correct in 1/8th note triplet, 1/16th note, 1/16th note triplet, 1/32nd note, and 1/32nd note triplet modes. Or you can turn it off entirely and enter programs totally in real time. I found this facility great and could only approach it in limited doses, but you'll find the auto-correct is a BIG help.

When you want to swing or shuffle the beats, you can use the auto-correct to place differing values of gain on the odd and even numbered notes, taking away any stiffness there may be on a rhythm. By combining some of the rhythmic voices which have been programmed with varying amounts of emphasis placed on them with other more rigid voices, some rhythmic variation can be used which would be impossible to obtain otherwise. Again, the programming takes practice but once you get into it more and more possibilities present themselves.

Electronic or Acoustic

Now, lest more orthodox drummers feel the cold breath of insecurity and/or redundancy begin to blow down their backs, let me make a few things clear. As soon as someone says 'drum machine' I can immediately see whole battalions of drummers scoffing in disgust and deriding them for any number of real or imagined reasons. Most musicians in general, too. A number of people over the past few years have experimented with them and incorporated them into their songs or have even based their entire sound around them. Such efforts have so far attracted a certain label or stigma for them being cold and unfeeling, this may be so but in many instances this was the very aim of the people using them. The ultimate interpretation of the dictionary definition of the word 'rhythm' must surely be best realised by something incapable of human irregularity: a machine. I can't blame them for utilising drum machines then available for such uses because that's about all they were good for.

It seems even the public at large have an attitude quite similar to that of most musicians. While momentarily intrigued by some sounds, most appear to think 'it sounds stiff and artificial, it's too boring and metronomic to be raunchy or emotionally moving, they might be pleasant to occasionally toy with but they'll never amount to much . . .' Producers find them handy for laying down click tracks and people with home studios tend to use them when writing songs, either because they can't play drums or because the real thing is unavailable and would raise hell with the neighbours anyway. I don't agree with the people who shun them, they're


Right-hand panel controls.

going to be in for a big surprise, and the people who do use them are kidding themselves if they think they're doing anything beyond the merest scratching of surface potential.

Electronic advancements in the field of percussion are now being made and the time is nigh for a new breed of drummers to emerge, one who physically may never actually do anything more strenuous than tap keys but who has the potential for more power, attack, and tonal variation in his playing than any acoustic player. The key phrase in that provocative statement is ACOUSTIC. It's truly surprising just how many people forget that, like a violin (an instrument rarely considered akin to drums!), drums are an acoustic instrument. As such, I think they've been developed just about as much as they're ever going to be, for drums are essentially the same now as they were when they were merely hollowed logs covered with animal skin - but refined to a phenomenal degree. Face it, a modern top quality kit isn't going to get drastically much different. It'll get better in minor points due to better materials and innovative production techniques but the basic design work was all over years ago. Technology isn't going to make acoustic drums obsolete, it's just going to introduce many new percussion instruments. But, because drums and percussion have been to-date almost exclusively acoustic as opposed to electric in nature, everyone seems to have different and conflicting opinions as to how this field should be approached.

Electronic Percussion

Electronic percussion falls basically into two categories; the units activated by the player as if they were drums themselves and the player programmable 'drum machine' rhythm units where the player pushes buttons corresponding to beat patterns and then lets the machine produce the sounds.

At the present time the player activated units are the most popular, and certainly they are the easiest and most obvious - the present state of the art technology makes substituting a key on a keyboard for a rubber pad a very straightforward, logical step. You hit the pad with hand or drumstick thus sending a trigger and control voltage to an assortment of VCOs, VCAs, filters, etc., to initiate and modify a sound. This, without a doubt, is the easiest way for someone to depart from the traditional path of acoustic drumming. One plays the pads, either partially by interspersing accents on the pads with the main rhythmic work provided by the drum kit or by going the whole route and replacing the *entire* kit with equivalent pads.

This area has its benefits to be sure and it places much more rhythmic and tonal variation at the drummers disposal, for better or worse, than before. One can even record thunderous drum tracks in the front room of a thin-walled apartment whilst making no more noise than the comparatively quiet clicking of the sticks hitting the rubber practice-like pads. That last comment might seem to be of small consequence but when you think about the sheer volume of the phenomena, the possibilities for innumerable home studios take on different proportions.

Drummers and percussionists will incorporate such products into their playing more and more as prejudices are overcome, interest grows, and better products become available. Already,this type of equipment seems to be attracting the majority of the players and designer/manufacturers attention. A lot can be done with this idea and, when perfected further, this type of percussion synthesiser will attain a sizeable number of devotees so that soon they'll be as common as 'ordinary' drums are now.

Until the Linn, design in the second area of Player Programmable equipment has lagged lamentably behind. Why? Because there are simply not yet enough people conversant enough with the relevant, related areas of electronics, modern music (in *both* composition and live performance), and percussion, to realise exactly which paths the development of such equipment should follow, what facilities and functions it should have, what its behaviour in both studio and live performance environments should be, and how it should relate to other electronic instrument modes already available. Through my work in progressive music with all manner of synthesisers, sequencers, rhythm machines and multi-track recording techniques, I feel that I've the experience to conclude that at the present rate of development, even allowing for extrapolation, the truly definitive percussion synthesiser will not arrive for years.

But why a Player-Programmable unit instead of the Player-Activated type? Why opt for this direction? The advantages of the player-programmable percussion synth over either a drum kit or player activated units are multiple:

1) The immensely hypnotic effect of the perfect time-keeping of a machine.
2) The versatility and ease with which one can manipulate incredibly complex beat patterns and time signatures - often at tempos too demanding for human dexterity.
3) The convenience, efficiency, and elegance of dealing with electronically 'pure' source signals.
4) The scope of sound permutations and rhythm variations available when linked with other electronic hard/software.

Rear Panel connections.

Playing percussion

So far, the Linn is the most advanced of its kind. And this is no reason at all for drummers to feel that their jobs are in danger, that's utterly ridiculous. The Linn may be able to play rhythms that no two-arm'd, two-legged person can play. It can play them faster and much more accurately than a human could play. But it will take time for people to learn just how to exploit these particular traits to their best advantage - that will come with experience.

What has to be understood now is that the computer in the Linn will only do what you tell it to do (we'll leave 'happy accidents' out of this) and, rather than recoiling with thoughts of "Oh, we drummers don't have a chance now that the machines are here . . .' the positive attitude must be taken.

Yes, anyone *can* work out by rote the programming for the ingredients of a complex and impressive sounding polyrhythm - it's all just mathematics - but it takes an instrumentalist's vision and imagination to inject human feeling into what he's doing. And that's equally applicable to physically sticking a good solid shuffle or backbeat or programming a machine to do it. And, like any computer, the programmer's old adage still holds true: Garbage In equals Garbage Out. To get the most out of the Linn you have to know how to *think* rhythm, how to layer, how to compliment, *what to leave out*.

Conventional acoustic drummers are actually streets ahead with regards to the utilisation of these computers. You can't get the Linn to tell you when you're overplaying, whether or not a break is in the 'right' place, exactly how to compose a fill-in, and where to put it. These are things that are learned only from experience. They're learned by playing . . . the actual vehicle of expression, be it drum kit or drum computer, is irrelevant because exactly the same principles apply to both.

Drummers have a headstart in this area over everyone else, it's only that so much of their time and effort has been spent learning their instrument physically. Time wasted? Even while learning tedious motor skills and muscle co-ordination/independence they've usually known far in advance what they want the accomplished end result to sound like . . . in their mind. Fundamentally we know there aren't many differences between the human brain and a computer, so what does a drummer do if not develop a whole mental catalogue of scores of different drum beats and their variations? One learns myriads of fills, breaks, and 'feels' to draw upon and insert here and there in whatever combination he wants . . . just like a computer would, with the appropriate programming. Just like the Linn can. And, as always, it's the person with the most interesting ideas who will capture people's attention, not necessarily the person with the most blinding technique.

Limitations

Now, as I said earlier, nothing this new is perfect and the Linn is no exception. Quite amazingly, the guy who designed it was not a drummer. I think he did an incredible job under the circumstances but when I gave the Linn a good thrashing I quickly discovered a few flaws in the design. They weren't enough to discourage me but on a machine the quality of the Linn I certainly found them annoying.

Tempo is discerned via an LED display and adjusted by a rotary dial, this is adequate for normal usage but as a sole source of determining the speed, especially in the context of live performance, it simply isn't enough.

A 'fine tune' type of control is needed. The psychological aspects of performing in sync to the perfect, never varying tempo of a machine are fascinating. The perceived tempos are deceptively vulnerable to one's state of mind. If it seems 'too fast' when it's the same speed as previously decided upon it's often that the musicians are tired from, say, a long exhausting performance or effects from extensive touring. Or even ambient temperature or humidity. Mental, if not physical, fatigue may have set in. If it's 'too slow' then everyone could be buzzing from the feedback of an especially receptive audience reaction. Also, how one feels the first minute or so of a song can be greatly influenced by the tempo and general demeanor of the song preceding it. A loud fast song makes a slow song following it seem even slower. The acclimatisation of a slow song can influence you into starting the fast song that follows it too slow. A machine isn't affected but people are. The necessary adjustments that have to be made from time to time (ones which are usually done without conscious thought as well as deliberate ones, i.e. ritardandos) are too minute to be satisfactorily made with the existing control. It's important to be able to ride emotions with the tempo control and not remain a slave to one constant tempo from start to finish.

One incredibly silly thing is that

the speed from the tempo LED display can only be determined whilst the Linn is *not* in the Run mode. You must be able to see at all times what the tempo is. Especially while the Linn is running! The display in beats per minute is fine but, again, provision must be made for much finer tempo increments to be dealt with. It makes for a less complicated facia on the Linn with the present method but it's vital that the tempo control has its own constant readout capable of indicating to one tenth beat per minute, i.e. 128.5 b.p.m.

My next gripe. When one has a fairly complicated rhythm set up and many voices are in use, it is often very desirable to be able to simply drop out one or more voices from the whole beat pattern instantly or to drop one out as one simultaneously adds another. The present system of faders does not provide any way to do this without actually moving the faders manually. This can prove to be awkward and, as often occurs, a very finely adjusted sound balance between voices is needlessly disturbed. The volume of the voices may have been set to obtain just a certain 'feel' and this is going to negate the effort involved in setting it all up.

The entire fader system is great but provision must be made to cut voices in or out instantly. I'd suggest some very small buttons at the bottom of each fader to insert or delete that voice from the pattern regardless of that voice's fader position. This now has some relation to my next complaint.

When using the individual separate voice output jacks at the rear of the unit their respective faders on the front facia no longer have any bearing on their volume level. You cannot control their volume with the faders. In the studio this is not necessarily any problem but for a live situation it is important that you should still be able to control the volume of a voice with the fader and of all of the individual outputs with the master level control. The afore-mentioned cut buttons should also be effective on the separate outputs.

The Linn has five buttons duplicating the voices of the bass drum, snare, high-hat, cabasa, and tambourine. They are exactly the same except that they are louder and are meant to be used as accent buttons for programming more emphasis and variation. Fine. But they have far too much volume on them. In some voice modes the level isn't too bad but on the majority they are set with far too high a level for accents within the context of the voice output. Again, it should be of the utmost importance for the Linn to have a control with which the level of the accent buttons can be varied according to taste and intended function. And if they could be programmed at varying levels even better! In fact, more memory capability all round would greatly enhance the Linn. I believe an additional memory expansion option is available from Linn which gives about 2½ times more available memory for drumbeats but the chain memory remains the same. I think a more equal split between beat and chain memory would be much more desirable.

My Linn (this isn't a solicited testimonial, I bought mine) had a few other faults but these were of the glitch variety and easily put right, probably because I had one of the first made and a few things had worked themselves astray. I realise that most of these criticisms are angled towards the Linn's shortcomings in a live performance situation but I feel it's very important that the Linn has the capability to emerge from the closet of studio wizardry and out on to the stage where it can be exploited to the fullest extent.

Your own sound chips

I'm told by Syco Systems, the people who handle Linn in Great Britain, that it's possible to change the chips of the individual voices. If you want you can send a tape of the relevant item(s), individually recorded, and Linn will make a chip out of it for you. Go into a studio with your own kit and then feed your Linn with your favourite drum sound. Or, and here things get even more interesting, someone else's drum sound! A possible thriving bootleg chip black market may be on its way. We may see electronic necrophilia. Actually, I don't think it makes any difference at all who hits the snare drum for making a chip as it's just a single beat which is needed, the criteria is its sound and how it was recorded. Personally I'd much rather see the Linn made capable of recording and storing any sound that's fed into it in an immediate process somewhat along the lines of the Fairlight synth. I can easily envisage an alternative method of programming the beats which many might find simpler to become accomplished with than the present method where, even with the Auto-Correct, one can make mistakes and become lost and frustrated in the maze of possible solutions before the path to the intended result is traced.

On the other hand, incredibly obvious needs like being able to alter the length of the measure to any duration you desire which has been overlooked by everyone else has been incorporated into the Linn. No doubt the company are proud of the LM-1 and justifiably so, for it is a vast advance on any other drum machine now available.

Drum Talk

People have been experimenting with new ways of getting sounds since the year dot. Instruments that have enjoyed a term of popularity at any given time have also simultaneously spawned scores of weird variations and abberations which couldn't overcome player prejudice and which usually failed to capture the public's interest or affection. The number of instruments commonly extant are only the hardiest specimens of all those that have been concocted. All along the way technology has been a strong influence on the sounds of an era, for once the first electric guitar was plugged into an amplifier, the effects its volume had wrote indelible writing on the wall for the big bands of swing. The introduction of electronics will broaden the field of music infinitely.

Once instruments could be classified into simple categories: ones you plucked, ones you bowed, ones you hit, and ones you blew into. It's not so simple anymore! Advances made in the area of keyboards illustrates my point. Once you just played the piano (we'll overlook harpsichords for now), simple, right? Then someone came along once there was electricity to utilise and invented the tone-generator and we had the Hammond Organ. Some people eagerly took to the possibilities this offered and others criticised it saying 'It's not a piano!' Well . . . obviously.

'I *was* going to do an ordinary review of an extraordinary item but then realised there were far too many things needing to be said about the implications stemming from use of such an item . . . things which I feel need to be said; these stray far from the usual review format but are so relevant to the core of this subject that I've included them all.'

The electric piano appeared. Then things really went askew – the synthesiser appeared. Keyboard players split into so many differing factions regarding the relative merits of their instruments, at one extreme purists maintained that the unadorned acoustic piano was the only *true* keyboard. I mean, so what??? Fine . . . for them. At the other end of the scale some players just got on with using all the types of keyboards available to them. Sound familiar, drummers out there?

Developments in all instruments paralleled this type of thinking. Spanish and jumbo Western guitars faced the new electric guitars from Leo Fender and even the traditional upright string bass faded upon the introduction of the new portable, light (relatively), and LOUD electric bass. Even brass players were aghast at the invention of the saxophone and it was years before it was regarded as an instrument in its own right and not just some quack trombone-gone-wrong. Like the keyboards situation, there will be those who steadfastly remain loyal to an acoustic drum kit, those who go totally electronic, and all possible permutations in between. And no one will be more 'right' about their chosen mode of expression than another because it's all a matter of what is tasteful and applicable for the personality of the player and the context of the music.

Percussionists' horizons will broaden – what I find truly fascinating is that there are many people who, due to other people's past efforts in the exploration and development of the synth, now find it an entirely sensible and wholly reasonable proposition to go and buy a synth as their introductory musical instrument, totally bypassing the hitherto more conventional steps of keyboard or guitar first, then synth. It'll be the same for drummers. One doesn't have to be bound to getting a drum kit first if 'drums' are what appeals to you.

There is absolutely a definite need and demand for a professional class percussion synthesiser, one which is not a knock-up job thrown on the market to test reaction with no real thought of what is required, and one which is not erringly considered to be the zenith of development. The synth needed is one which can meet, and surpass, the requirements of tomorrow. To date, when compared to keyboard synthesiser evolutionary design, the Player Programmable synthesis of percussion is still in its infancy, but I am convinced that it is this concept which will attain the most flexibility and popularity in future.

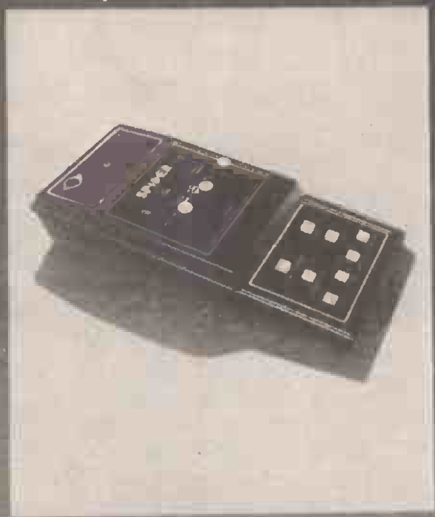
The Linn is so far ahead of anything else in its field at the moment that it's just not worth drawing comparisons. What is more significant about it is, I repeat, not so much the fact that it reproduces real drum sounds but that it is the first synth specifically designed to give so much control over programming and reprogramming rhythms. But, even so, I don't think that they've gone far enough! It offers great facilities to program its contents but nothing in the way of modifying those sounds. Those will be the next steps. The Linn is the 1st but only 50% of the potential of a drum computer is being utilised here. It has been said that good engineering is the art of inventive collation with a minimum of redesign of articles which, though they may be widely dispersed, are basically already in existence and at one's immediate disposal. With relatively short research and development time, it is possible to produce the future's percussion synthesiser TODAY. Soon someone will systematically incorporate all of the vital component functions of a drum machine, a basic synthesiser, a sequencer, a multi-track recording desk, and extensive memory circuitry – in such a fashion as to give the whole a greater value far beyond the sum of its parts. With such vast creative possibilities, with such broad musical value, the potential is staggering. This is not merely a 'substitute' for a drum kit . . . this is a NEW INSTRUMENT.

The LM-1 won't be for everyone, its price alone sees to that, you could buy a new Renault 5 for what the Linn goes for. But it's only the beginning. The LM-1 is a computer but it and the computers which follow are, surely, new instruments and new instruments will breed new players and new techniques. It's just the beginning. . .

Warren Cann **E&MM**

The Wasp

The Spider



The Caterpillar

(£199 inc. VAT) Incorporating everything in the Gnat plus the following features–2 oscillators with pulse and width control and variable pitch. Separate digital white noise and control. Filter A three band filter consisting of low pass, band pass and high pass. Separate positive and negative controls from the low frequency oscillator and the second envelope shaper. Both envelope shapers have individual sustain, repeat and delay functions. Two link outputs and headphone outputs.

(£199 inc. VAT) A digital micro computer based sequencer designed for use with the Gnat and the Wasp synthesisers. Two modes of operation–

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(£149 inc. VAT) A three octave four voice digital moving keyboard controller designed for use with Gnat and Wasp synthesisers. Up to four synthesisers can be connected and played polyphonically. Three modes of key assignment unison, normal polyphonic, and cycle polyphonic.

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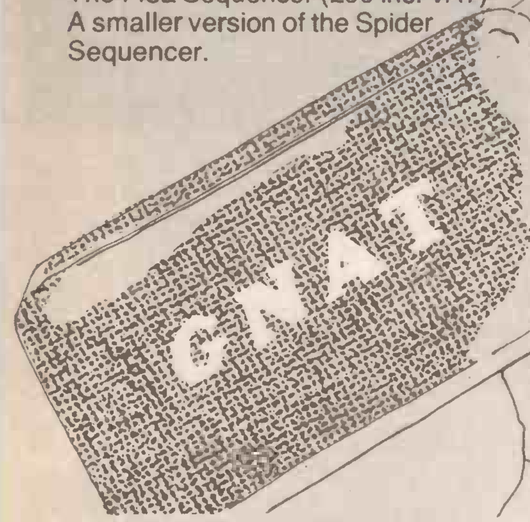

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	Wasp	W	199	
	Spider	S	199	
	Caterpillar	C	149	
			Total	£

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KRAFTWERK

Pocket Calculator.

Ralf Hutter.

An interview with Ralf Hutter

Ralf Hutter first met Florian Schneider in the Dusseldorf Academy, Germany in 1968, where courses were being held in musical improvisation. From this essentially classical background they teamed up to try their newly acquired skills with experiments in electronic sound that began by simply using amplifiers, echo machines and feedback effects.

"Not only were we interested in Musique Concrète but also in playing organ tone clusters and flute feedback sounds that added variety to the repeated note sequences that we recorded and mixed on tape. Then we used several acoustic drummers as we turned our attention to more rhythmic music, and soon found that amplifying drums with contact mics was desirable for us but not readily accepted by the players."

"We started off 'Kling Klang' studio in 1970, which really marked the beginning of Kraftwerk. The studio was, in fact, just an empty room in a workshop premises that was a part of an industrial area in Dusseldorf. We fitted sound isolation material into the 60sq metre room, and we now use other adjoining rooms where we make instruments. When we first moved in, we started recording with stereo tape machines and cassette recorders in preparation for our first record. The master tapes were then taken to the recording studio for final mixdown. This allowed us to be 'self-producing' at the time as far as we could with our own limited resources, so we did another three LPs in this way."

"Don't forget in those days successful musicians used important producers to promote and launch their records, but we took on every aspect of the production ourselves," Ralf commented. "It's very encouraging in England today to see people bringing out their record/cassette labels. From the start we used cassettes for recording 'in the field' and mixed these sounds with our instruments in the studio.

"It's been quite a common thing for groups to have their own 'home studios' in Germany with the emphasis very much on 'do-it-yourself' activities. We made our own record covers by taking Polaroid pictures and designing the artwork, and did our own management. In 1971 Kraftwerk was still without a drummer, so I bought a cheap drum machine giving some preset dance rhythms. By changing the basic sounds with tape echo and filtering we made the rhythm tracks for our second album. Our instrumental sounds came from home-made oscillators and an old Hammond organ that gave us varied tonal harmonies with its drawbars. We manipulated the tapes at different

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1 REM SHARP BASIC:PRINT"E":DIM E$(8)
2 E$(1)="COMPUTER WORLD":E$(2)="POCKET CALCULATOR":E$(3)="NUMBERS"
3 E$(4)="COMPUTER WORLD 2":E$(5)="COMPUTER LOVE":E$(6)="HOME COMPUTER"
4 E$(7)="IT'S MORE FUN TO COMPUTE":E$(8)="RALF.KARL.WOLFGANG.FLORIAN"
5 REM K=GRAPHIC SYMBOL CODE:FORK=222TO250:Z=-1:FOR T=1TO8
6 X=X+π/10:Y=INT(12*COS(X))+12:Z=-Z
7 IFZ=-1THENFORR=1TOY:PRINTCHR$(K);:NEXT:PRINT"KRAFTWERK";
8 IFZ=-1THENFORR=1TO31-Y:PRINTCHR$(K);:NEXT:GOTO6
9 FORR=1TOY:PRINTCHR$(K);:NEXT:PRINTE$(T);
10 FORR=1TO40-LEN(E$(T))-Y:PRINTCHR$(K);:NEXT
11 NEXTT:NEXTK
12 END
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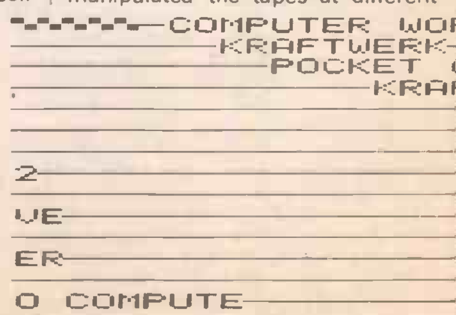

REVEALED!

'Robots' — a lifesize model stands motionless by each player.

speeds for further effects.

"Commercial synthesisers came fairly late into Germany and it was not until the third album that we started to use them. By that time, Wolfgang Flur had joined us to play a custom built drum system and was our first percussion player to accept electronically produced drums.

"Electronic music was quite new as a musical medium in the early '70's, of course, and many people were just starting, like the Can group in Cologne.

"I think we were one of the first groups to have an electric drummer with Wolfgang Flur. As well as the custom drum console, we now have two sets of drums that consist of six metal pads triggered by metal sticks on contact. These are not touch sensitive, so accents and dynamics come from separate volume foot pedals. Sometimes we link one or more pedals to change other parameters; such as tone or pitch."

A year later Karl Bartos became the fourth Kraftwerk musician because he also believed that music could be made satisfactorily through entirely electronic means.

"We feel music is more a product of the imagination and the instruments are made as a result of everything we do. We don't see ourselves as specific instrumentalists - I am not just a keyboard player, nor is Wolfgang simply a drummer, this is too limiting for each player who has developed skills in making harmonies and melodies as well as rhythms."

The Kling Klang studio equipment continued to be designed by all four musicians and since their knowledge of electronics was limited, they employed a full time engineer to make and service equipment as well as a mathematician to devise the computer programs.

"Our daily schedule of work lasts some 8-10 hours in the studio. We don't regard ourselves just as musicians but as *Musik-Arbeiter* (musical workers), and we designed and built up our complete portable studio set that includes the stage backdrops, curtains, lighting, frames, staging and stereo PA system as well as the instrument equipment stands. Multi-wired cable looms are used for quick dismantling of each section of the movable instrument frames. The players stand on metal box staging that hides the mass of wiring. Fortunately, we are all about the same stature, so each of the four players sections of the instrument gear is built to be suitable for any of us. All the instrument racks are standard 19" width and pack away into cases for transit."

In Performance

I asked Ralf about their style of performance. "So many people move or even jump around on stage these days and it's important for our music that we do not do this - our rather static performance is also necessary for emphasising the 'robotic' aspect of our music (in the new 'Computer World' LP).

"The physical layout of the equipment, besides being functional, was to imply the idea of the 'man-machine' which we've always talked about - that the music does not become dominated by one or the other. For example, some people perform with their musical machines built up high around them in an impressive way - we prefer the low profile image, bringing man and machine together in a 'friendly partnership' of musical creation.

"We have been building the set for the last three years (since the 'Man Machine' album), whilst composing the music and and preparing the video graphics. Most of the instruments were obtained in previous years, but they were wired in a more typical electronic music studio fashion. Besides looking rather messy, the earlier layout caused problems in transport and hours of rewiring for each performance. It actually takes two hours at most to install or dismantle the new set. We always bring our own German stage crew but of course other people often help in the local halls. To minimise component failure and rough handling, we use industrial high spec./ heavy duty devices in the equipment."

It is very easy for audiences to be 'fooled' into thinking that electronic music groups play all the music when in fact, much if not all the music can be pre-recorded. In this way, the live performance can be made to sound like the artists' LP version. A most important point here is that Kraftwerk DO play most pieces completely LIVE and EVERY item on their futuristic equipment consoles is usable in performance. On both sides of the large stage set are the PA stacks which deliver up to 12K watts output. Their grey cabinet colour was deliberate to match the set and the group's own image in 'sombre' black. When I attended Kraftwerk's concert at the Hammersmith Palais in

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London, the sound was clear without distortion, even with the computer speech.

Equipment

The instrument and equipment used by the players contain items collected since 1971. The four large video screens were made by Sony in Japan and the recent UK tour was delayed because it took much longer than expected to compile the video film and rehearse with the music and video in sync.

"The paint was literally just drying off as the items were packed," remarked Ralf, "and just in case any problems were encountered, two engineers started off our tour through Southern Europe."

The video screens were chosen to compliment the four players who have their own personal monitor screen on their part of the main consoles. The video programmes all appear at the same time on each screen and consist of film and microcomputer material. These are not exactly synchronised to the music but simply start a new sequence for each piece. Occasionally the fluorescent strip lights, overhead spots or floor strobes were used, while the screens had a 'white snow' blank transmission picture. Some of the computer programs were made on Atari and Texas microprocessors and Ralf plans to install a keyboard terminal beside each TV monitor for a player to select and alter the display in time to the music.

"Everybody seems to limit themselves by saying 'I'm an instrument player' but we like to 'play pictures' as well as share the instruments available. Gunter Spachtholz is the video and lighting engineer handling all the visuals and he sits on the left hand side of the stage (viewed from the audience). On the other side of the performers is the sound engineer (we call him our dB man!), Joachim Dehmann. Although he makes the final balance of the total sound output, each player mixes his instruments separately from up to eight sound sources."

The Robots

"We like to portray the things we do on a day-to-day basis in our music - other people might be fascinated by space flights to the moon and so on. We did try a space lab kind of set once, but always prefer now to relate to everyday technology, such as cars, trains and other human-controlled machines.

"Our 'trip' for these current performances is based on robots. The idea of the robot came from a tour that covered 65 places in America. As a result we started to become automatic and 'robotic' ourselves - even new pieces were written in 5-10 minutes (one evening in a discotheque I wrote 'Showroom Dummies' like that). We were intrigued that the Russian word *'Robotnic'* means 'Worker' and so much related to our ideas.

"We generally keep our audience contact to a metaphysical level - really because we have little time to look around - although we are very aware of their response. The only exception is with 'Pocket Calculator'."

Here, Ralf had a mini-synth instrument, Karl and Florian had a calculator each and Wolfgang provided the drum taps. This current single for the group was certainly brought to life on stage and promoted audience participation in playing the extra instruments. These were connected by signal cable to the consoles (even though they could have used radio control), because it gave the feeling of being linked like a robot to its main control machine. "Again, we found the instruments in a department store last Christmas, so we took everyday items into our music - from 'street-level'!

"We both agreed the way musical equipment is designed in the future could be as an extension from the human being, with suitable feedback between machine and man. The emphasis on keyboards could turn to instruments, controlled by some part of the body, using piezo pick-ups, special electrodes and heat sensitive elements. Even 10 years ago, I used to rub a contact mic on my clothes and skin to produce different sounds that would change at each performance."

Backgrounds

Ralph is 34 with the others also in the late 20's/early 30's. None of the group are married and Karl, like Ralf and Florian has a classical music background. Wolfgang's musical experience prior to Kraftwerk was in popular music. Ralf originally studied as an architect and certainly none of the group intended to become professional musicians.

"We like the audience to dance and move to our music - especially as in recent years people tended towards a more concert-listener approach, even more so with electronic music. Electro-music is a much suitable title than electronic music for the way music in general is going. The instruments of electro-music help to liberate people's creativity, allowing individuals to use studio technology in their home for almost any sound they want.

"When we select an instrument sound, we don't worry if, for example, the strings are not authentic - we simply take the sounds we like!

"On stage we use sheet music, graphic diagrams and settings which cue us in our pieces to switch on or off devices and adjust instruments, as well as reminding us of note sequences, lead, harmony lines and rhythmic structures.

"The philosophy I have is that the music becomes so complex that it has to be written down. I have this tendency that if I can't remember it from memory then maybe that music is not worth doing. I tend to play more like a busking musician and my rather simplistic view is that if I forget it then it's worth forgetting so I play something else!"

Kraftwerk's latest "Computer World" was prepared over the last 3 years along with the present Kling Klang studio.

"The pieces in many ways 'compose themselves' by us finding sounds from experimenting with interfacing and settings. During the week, we work from 5 p.m. until 1 or 2 at night. During other times in the day we do the administration for Kraftwerk and liase with our engineers and visitors."

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Bandwith	10hz —	100KHz± 1dB	
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THD (20Hz—20KHz)	≤0.008%	≤0.005%	
(KHz at rated output)	0.004% typ.	0.002% typ.	
SNR	120dB		
Slew Rate	>20V/µS		
Gain	X22		
Rin	30K		
Vs max	±70V		
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(built)	£15.95	£22.85	P/P 75p
(kit)	£13.95	£20.85	

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Input	100mV into 50K
Cost (Built)	£5.80 P/P 40p

PAN 1397

PSU 101

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Specification	
B.W.	20Hz-30KHz ± 1dB
THD at rated o/p	0.003% typ.
SNR	85dB (ref. 5mV RIAA) 105dB (ref. 100mV flat)
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Cost (built board less controls)	£4.75 2 needed for stereo P/P 40p

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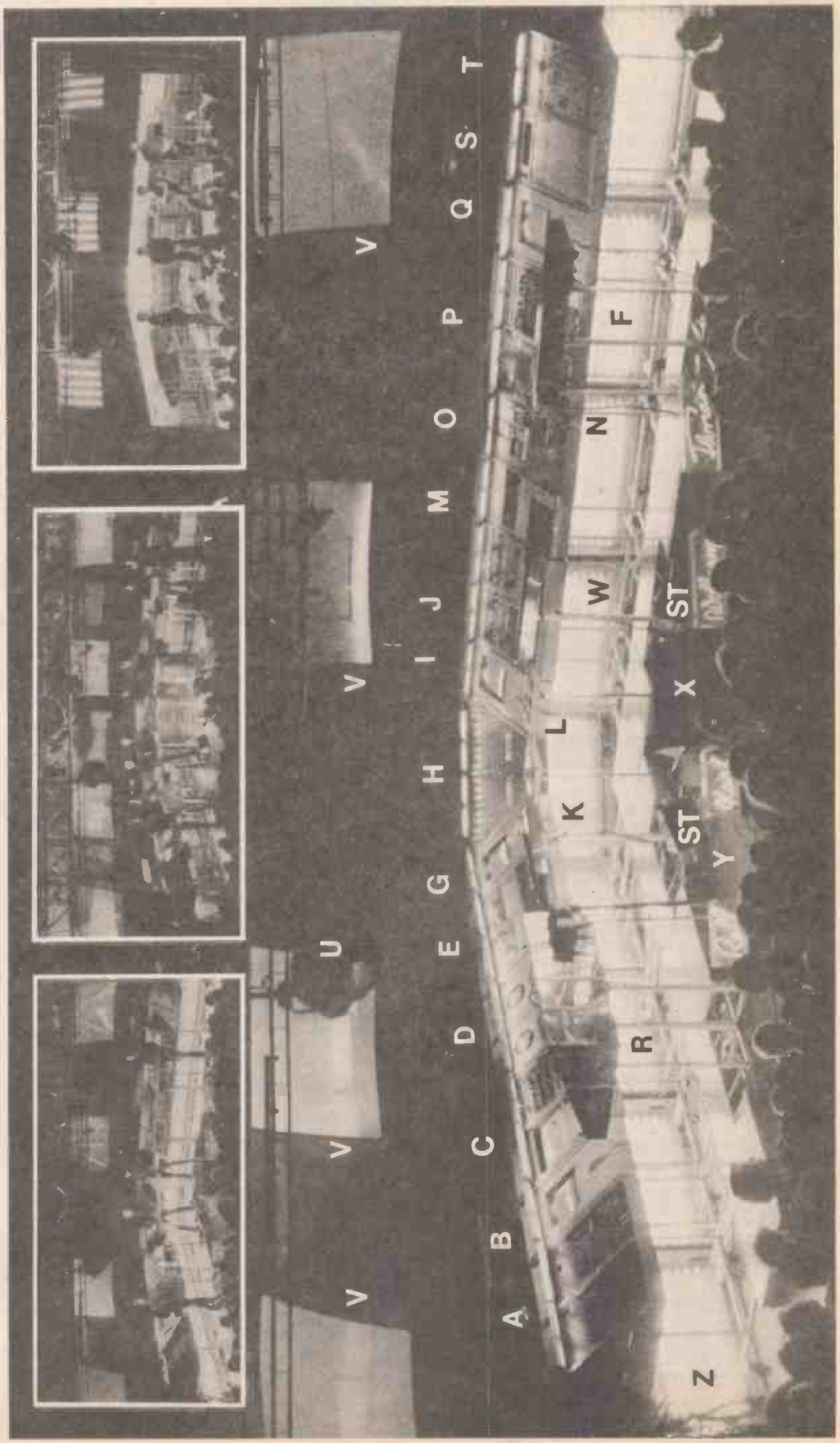
KRAFTWERK STUDIO
KLING KLANG



Kling Klang

The Kling Klang studio arrangement gives an intriguing insight into music of the future. Ralf and I examined the layout in the labelled photograph and discussed the equipment working from left to right (from Ralf to Florian). The letters in the text relate to the locations on the picture.

A First, there are two analogue sequencers which will produce up to 64 notes. The many rows of switches have 'in, shift and stop' settings for trigger, rest and reset points, as well as pitch control. The sequence can run as two x 32 in parallel or 1 x 64 in series. LED indicators can be clearly seen from the audience during operation. The triggers can be outputted wherever Ralf desires, generally to the console instruments (except Karl's who prefers to play manual bass lines).

So here is the secret of Kraftwerk's superb synchronisation throughout their performance. "Remember, we have been playing this kind of synchronised music for about 10 years. To play along with machines is very difficult - a lot of people speed up or slow down when doing it. Our 'dialogue' with the machines is to choose whenever we want the machine or human pulse. Although we don't yet have the perfect set-up, the 'friendship' or inter-relationship we create with the machines makes them an extension of the musician. If one instrument breaks down we are still able to continue, and when we finish our current series of tours we'll be modifying the set still further."

Several master clocks are positioned around the console so that any player can be selecting a tempo for the next piece. This explains the short gap between numbers - "It could be even shorter but we are a little nervous sometimes! We can also trigger other synthesisers off stage and the clock times are set via a digital display and key pad."

B Ralf's TV monitor and telephone communication to engineers.

C The Roland Micro-Composer (with expanded memory) plus a bank of switches for routing signals. "The composer can be used for extra tracks in one or two pieces or as the time clock in performance, although we prefer to use it when we are at home for trying out sequence combinations. This is much easier than using the analogue sequencers but it still takes a fair amount of time to set up."

D The Eventide Digital Delay and Flanger with a small stereo mixer. Panning of sounds can be done by the players mixers or by the sound engineer. "We are not the biggest fans of panning!" comments Ralf. "We think stereo is a 'privileged sound' since only those that sit in the middle hear it properly, and so we are happier to use a mono output that has plenty of depth. Electronic Reverberation is not used very much in performance because most venues have enough (or too much) already."

Both Ralf and Florian use headsets. Ralf does the 'straight' vocals, often shielding the mic with his hand to avoid feedback and increase bass volume. Florian's mic feeds the vocoder and this adds subtle changes to Ralf's voice and provides extra effects.

R "I am playing three keyboard instruments stacked on my console: a special light-disc instrument from Florida for mono choir sounds, with the Polymoog and Minimoog synthesisers. We all have 4 foot pedals under our front consoles for volume and/or effect control."

K This is Karl's keyboard - specially made in Italy to replace Korg's keyboard controller, which operates the Korg PS-3300 polyphonic synthesiser set in **E** console. One of its special features for us is its ability to merge harmonic with 'non-related' overtones and its parameters stretch attack and decay times to their limits. In **E** there are also a tuning device, volts/amps meters for checking power supplies and graphic equalisers. Incidentally, LEDs on the keyboard console panel show notes being played to the audience.

G Karl's TV monitor.

H Ventilation grilles in corner section linking the two straight console rows.

I Wolfgang's TV monitor.

J The custom-built drum consoles. Here are the electronics for the two drum controllers containing 6 metal pads mounted on stands **L**. Also various filtering devices plus a Syndrum unit. One drum pad is played by Karl occasionally and the other by Wolfgang.

M Next come some more equalisers including parametric types, filters, mixer rack, Eventide Harmoniser and Digital Delay, and Limiter/compressors.

W Wolfgang's console contains the special drum machine built by Kraftwerk's engineer. There are 6 rows of switches, each row having its own drum sound that can be pulsed on when a switch is set during the sequence run (controlled by a master clock). LED lights on its front show the audience the sequence taking place. Wolfgang is continuously changing these to give the rhythm plenty of variation, at the same time using his pedals to give accent.

O Sennheiser Vocoder rack.

P Mixer, metering and switching facilities.

Q Florian's TV monitor.

S The circuitry for the electronic flute on its stand at **N**. It's not actually blown but uses keys situated in flute pad positions that are 'touched' by the fingers to give a D/A control voltage/trigger output for any of the synthesisers.

T EMS Vocoder with patch panel.

F Florian's keyboard console containing a Prophet polyphonic synthesiser and trigger pad for starting his master clock.

U Overhead stage spots for highlighting players.

V Special Sony Video screens with projection units.

X Foldback at floor level (supplemented by extra underfloor speakers).

Y Fluorescent name boxes.

Z Coloured fluorescent strip lighting (ultra-violet, red, green, yellow, white and blue), running behind the consoles. Over each console rack are lights for illuminating the controls, although between numbers the players use torches to set up. The strobe lights **ST** are triggered automatically from a sequencer.

Kraftwerk performed a substantial 2-hour programme on their UK tour that included the following pieces:

Numbers *Computer World* *Computer Love* *Home Computer*	*Computer World LP*
The Model *Neon-Lights*	*Man Machine LP*
Radio Activity *The Voice of Energy* *Ohm Sweet Ohm*	*Radio Activity LP*
Autobahn (From the LP)	
Hall of Mirrors *Showroom Dummies* *Trans-European Express*	*Trans-European Express LP*
Pocket Calculator *Robots* *It's More Fun to Compute*	*Computer World LP*

"We are working on digital storage for the drums. The drums we use are ideal for our present 'fatalistic' quality - they keep on going like a machine. We keep away from phasing because we find phase effects occurring through the speaker system. Flanging is useful, especially on drums, provided it's carefully controlled (we've blown quite a few speakers!)

"In the future we shall try to make our instruments smaller, with more digital control - micro-electronics should make us more flexible and allow us to perform on smaller stages.

"Because 'Computer World" is based on one theme, we have several pieces in hand at the studio for other LPs.

"We aim to create a total sound - not to make music in the traditional sense with complex harmony. A minimalistic approach is more important for us. We spend a month on the sound and five minutes on the chord changes! Germany has no predominent pop-music scene, unlike England, so we have a thriving communication between electronic music listeners and performers. Cassette tapes are promoting this as well, just like your own E&MM tapes."

The current Kraftwerk tour has so far covered Southern Europe, Germany and England. Next they go to France and then America. Finally East Germany, Russia and Japan.

Meanwhile, the computer world continues and Kraftwerk will no doubt have made a significant contribution to its musical development.

Mike Beecher E&MM

Guide to Electronic Music Techniques

Mixing

Lawrence Casserley

In the last few months I've covered various aspects of basic tape technique. I've talked a little about recording concrete sounds, about ways of manipulating sounds on tape, and about editing. So far we've generally thought about one sound at a time and how each of the processes discussed can be applied to a particular sound. But, if you want to get beyond simple experiments and start making pieces, sooner or later you will want to superimpose one sound (or more), or a group of sounds, on top of another. Perhaps you want two lines, (melodies if you like) running in counterpoint; perhaps you want to play one sound progression over the rhythmic background of a loop; or maybe you want to superimpose several sounds to make one composite sound or a chord.

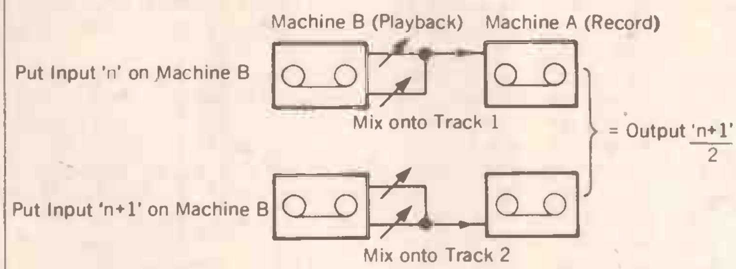
In order to do this it is necessary to have a way of playing from two tape sources at once and mixing the two sources into one composite signal to be recorded. Having more than two sources is an advantage but it is possible to work with only two. If you go into a "classical" tape studio you will notice that there are usually a large number of tape recorders. For example, in the studio that I run, fairly typical, but by no means the largest, there are (at present): one 8-track machine, two 4-track machines, three 2-track machines and two full-track mono machines.

This may sound like a lot, but I've often seen them all in use at once. While a set-up like this makes many things a lot easier, it is possible to achieve a great deal with just two machines; and it is even possible to work with one reel-to-reel and one cassette machine if you use a bit of ingenuity. If you have access to two reel-to-reel machines you will be able to save yourself some copying stages, but the principle is the same, so, for the purposes of this article, I'll assume the second machine is a cassette recorder. A few years ago I would have thrown up my hands in horror at the very idea, but the quality of cassette recording has improved so much recently, and the prices, compared with domestic reel-to-reel machines, are so low that a cassette recorder (particularly a portable one that can be used for location recording) can be very worthwhile in a low-cost set-up. But do get hold of one with noise reduction.

The other thing you will need is a way of mixing two signals into one. Some tape recorders are designed so that, when only one channel is selected for recording, both inputs are mixed to the selected channel. If this facility is available on your machine then you'll be all right. Otherwise you can build a small mixer very cheaply (the one in the May issue of E&MM should do the job nicely), and you'll need some sort of mixer sooner or later anyway.

The basic procedure is as follows: Say you have eight sounds (individual sounds or edited tracks) each of which is on a separate tape. I will call these "layers" 1 to 8. I will call the master recording machine A and the playback machine (or cassette recorder) B. Take layer 1 and put it on machine B, (if machine B is a cassette machine you must put the original tape on A and make a copy of it on one track of the cassette - if B is reel-to-reel you have only to put your original tape on B and record direct).

a) Procedure



b) Results

If Input =		then Output=
Layer 'n' &	Layer 'n+1'	Copy $\frac{'n+1'}{2}$
Copy 'n' &	Copy 'n+1'	Mix $\frac{'n+1'}{2}$
Mix 'n' &	Mix 'n'+1'	Mix^1 $\frac{'n+1'}{2}$
Mix^1 'n' &	Mix^1 'n+1'	Mix^2 $\frac{'n+2'}{2}$
etc.		

c) Notes

1. 'Put Input 'n' on Machine B' will require an extra copy stage if Machine B is a cassette recorder.
2. Inputs might be of mixed types, i.e., if you are mixing six layers your inputs at the last stage might be Mix 1 (four layers) and Copy 3 (two layers).

Figure 1

Now put some clean tape on machine A and record layer 1 on *track 1*. In the same way put layer 2 on machine B and record on *track 2* of the same tape on machine A. You should now have a new tape, which I will call copy 1 with layer 1 on track 1 and layer 2 and track 2. Now repeat this process putting layers 3 and 4 onto tracks 1 and 2 of a new section of clean tape (probably further on the same reel) which I will call copy 2. Note that, at this stage, no actual mixing has yet occurred; all we have done is arrange two separate layers onto one tape so that they can be played simultaneously on one machine.

There are two important points that must be made at this stage. First, *always* make copies at the highest level possible without distortion, even if the sound will end up very quiet. In this way noise levels can be kept to a minimum. Remember that noise is cumulative - it will always be increased at each stage of the process, and once there it cannot be reduced. So the trick is to keep it to a minimum at every stage. If a sound is going to end up quiet try to reduce its level at the latest possible stage, as the accumulated noise will then be reduced with it. If you have to increase a low level later, the noise will be increased too, and you may have the accumulated noise of many layers to worry about.

Secondly, it is often very tricky to get good synchronisation between layers using this method. Sometimes this may not matter, but often it is essential. If you mark the start of the sound on each (reel-to-reel) tape very carefully and make a start mark on the new tape you are recording on, then always line up these marks in exactly the same place you should, with practise, be able to start both machines consistently together. If it doesn't line up exactly the first time, slightly shift one of the tapes forward or backward, as appropriate, and try again. If you are careful and patient you should be able to get it right. Remember, be sure to get the first ones really accurate or you'll have more and more trouble later on.

Now for the second stage, which is almost a repeat of the first. Put copy 1 onto machine B and mix both tracks of machine B into *track 1* of machine A. At this stage it will be necessary to get the *relative* levels of layers 1 and 2 correct, but still keep the *overall* level as high as possible. Now repeat the process, mixing layers 3 and 4 onto *track 2* of the same section of tape. You should now have a tape (I'll call it Mix 1) with layers 1 and 2 mixed onto track 1 and layers 3 and 4 mixed onto track 2 - note that we still have control over the relative levels of these two pairs of layers. Now repeat the whole process so far with layers 5 to 8 replacing layers 1 to 4 to make a new tape (Mix 2) with layers 5 and 6 on track 1 and layers 7 and 8 on track 2 (the intermediate stages will be copy 3 and copy 4). Now repeat from the second stage using Mix 1 and Mix 2 in place of Copy 1 and Copy 2, so that now you have all eight layers on one tape (Mix 1) divided into two groups of four on tracks 1 and 2. If you want to keep it as a stereo mix, with different material on left and right tracks, then that is your finished product; otherwise you can mix the two tracks as necessary onto another tape. If you have more than eight layers the whole process can be repeated using the other layers so that you end up with two tapes equivalent to Mix 1 which can then be combined in exactly the same way as Mix 1 and Mix 2 were; and this can go on indefinitely, with the proviso that noise will increase relative to the number of stages involved. I've successfully done "montages" with as many as sixty layers this way - it can be done if you're careful.

Essentially the process consists of one procedure that can be repeated again and again like a sub-routine in a computer program. I have given a diagram of the basic procedure in Figure 1. Just select the appropriate inputs each time and note that in the first stage, combining two "layers" to make a "copy", the instruction "mix onto track n of machine A" is only a copy as there is only one signal to mix each time.

You will have noticed that I have been very careful to give each stage a clear identifying label. As I've said before it is very important to be meticulous about all this. *Always* label the tapes and keep notes on what each one contains, otherwise confusion is inevitable. The use of different coloured leader may also help to distinguish the different stages. The best thing is to evolve a consistent system which you always use.

Finally, a few hints about specific points. First, try to work out the best order of combining sounds before you start. For example, if you want to end up with a background texture plus a couple of more prominent "voices", do the background as one part of your mix and get that right on its own, then combine your main voices in the correct balance, and, finally, put the two parts together, when all you need to do is get the right relationship between background and foreground. You'll find this sort of thing, both the planning and successful execution, a lot easier when you've had some experience. Don't get discouraged if it all comes out wrong the first time - it *can* be done if you persevere. Another point, try to work with the shortest possible sections and edit them together after they're mixed. It will be much easier to get it right if you do a short section each time, and there won't be so much work wasted if it all goes wrong. Exactly how to divide it up will depend on what you're doing, but some specific examples will be discussed over the next few months, when I plan to go through the whole process of making a short piece of "Musique concrète" from recording the original material through to the finished master. A lot of the things I've talked about so far will be included.

I'll leave you with a little problem which will crop up in the piece. A number of layers start at different times but all finish together with an exactly synchronised chord - what do you think is the best way to do it?

E&MM

America

Tim Schneckloth

An electric piano is an electric piano is an electric piano . . . Right? Well, maybe not. American manufacturers are always racking their brains trying to think of innovations or modifications that will make their products just a bit more successful in a competitive field. By the same token, there are a number of clever, independent entrepreneurs scattered over the North American continent who have an idea for improving the electric piano, and these people are busily putting devices together in their garages and cellars.

They all appear to be making some progress, though. Wurlitzer, for instance, a company that has been cranking out electric pianos since 1955 (as long as Chuck Berry has been playing rock and roll), recently modified its well-known electronic piano for professional use. The new model is called the Model 200B Professional, and it can now be operated from either battery power (DC) or conventional AC current. The instrument can be used with any external amplifier system; it has no internal speakers. According to Wurlitzer, the Model 200B puts out undistorted, clean signals with "the lowest possible signal to noise ratio for recordings and large halls." A carrying case is available for transporting the piano and everything that goes with it - music rack, sustaining pedal assembly, legs, bench . . . everything but the piano player.

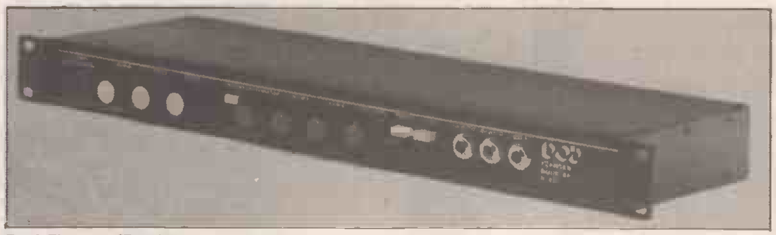
One of those independent companies that feels the need to improve existing pianos goes by the name of Samson Music Products. They are offering the Samson WY Frequency Booster, which they call "an inexpensive and very effective device to improve the sound of a Rhodes Stage piano."

The booster is intended to enhance the natural, bell-like tones of the Rhodes while providing a nice bottom and eliminating the dreaded mushy mid-section. The device consists of a preamp with controls and battery. It can be installed by the player in about ten minutes; soldering or drilling is unnecessary. The controls include one for volume and a double-knob pot for bass and treble. The suggested list price is $89.95.

As if that weren't enough, the same company (Samson Music Products, in case you weren't paying attention) has come out with a low-cost wireless guitar system that consists of a small broadcast unit (which is plugged into the guitar and clipped to the player's belt or shoulder strap) and a small FM receiver that connects to the amplifier. It operates on a fixed band, has a range of about 200 feet, and features special noise squelch circuitry to reduce that hideous background noise. The model number is TR-2 and it carries a suggested retail price of $265.00.

Zeta Systems 'Little Feanc'.

Samson Wireless guitar unit.



Dod Flanger/Doubler.

Another entrepreneurial American enterprise is marketing a programmable compositional aid. I haven't actually seen this in person, but it seems to be a useful device for those who would like to have something like the Roland MicroComposer but don't need all the features and capabilities it offers.

The company is called the MicroTune Corporation and their new product is called, surprisingly enough, the MicroTune IV. The company defines the unit as 'a portable microprocessor-controlled electronic musical instrument capable of producing chord progressions and simple tunes of arbitrary tonality and temperament.' I couldn't have said it any better.

The user may select from three fixed scale temperaments, or he can program an original set of notes by specifying frequencies at will. Chords of up to four notes can be defined, and tunes of up to 16 chords of programmable duration can be defined and synthesised. Notes can be selected from a group of 80 per octave over a three octave range, and chord durations range from 50 milliseconds to one second. All user-defined notes, chords and tunes are stored in non-volatile memory, and are retained indefinitely until redefined. Sixteen tunes can be stored in the memory, which displays the tune definitions in bright, seven-segment characters.

The unit incorporates an integral loudspeaker and rechargeable batteries and charger. The suggested list price is $950, for the time being.

Rack mountable effects units seem to be here to stay, and DOD Electronics, an enterprising young firm on the shores of the Great Salt Lake, is meeting the demand with a new flanger/doubler, the Model 870. It's a full featured short to medium delay device that incorporates all the features necessary for studio use or live performance: flanging, doubling, ADT and stereo chorus. It has in/out, invert and delay time switches; input level control with clip indicator; stereo outputs with dual mix controls; LED status indicators on all switches. Suggested list price is $299.95.

Speaking of effects, at least one company is trying to miniaturise them as much as possible. This company-with-a-mission is Zeta Systems (Analog/Digital Associates, Berkeley, CA), and their latest innovation is called the 'Little Feanc.'

Little Feanc? What's a Little Feanc? Well, the company obligingly explains, it's 'five guitar effects in one noise-free, on board, active package.' Oh, *that* Little Feanc!

The unit consists of a fuzz tone, equaliser, amplifier, noise gate and compressor in a small package, small enough to be easily installed in most guitars. FET technology gives it a wide range of compression, with minimum pop and noise. The switchable noise gate silences output when no signal is present, and the two-band equaliser will filter either the guitar signal or the fuzz tone. The signal passes through a master volume control and exits the guitar as a high level low impedance source capable of driving long cables without signal loss.

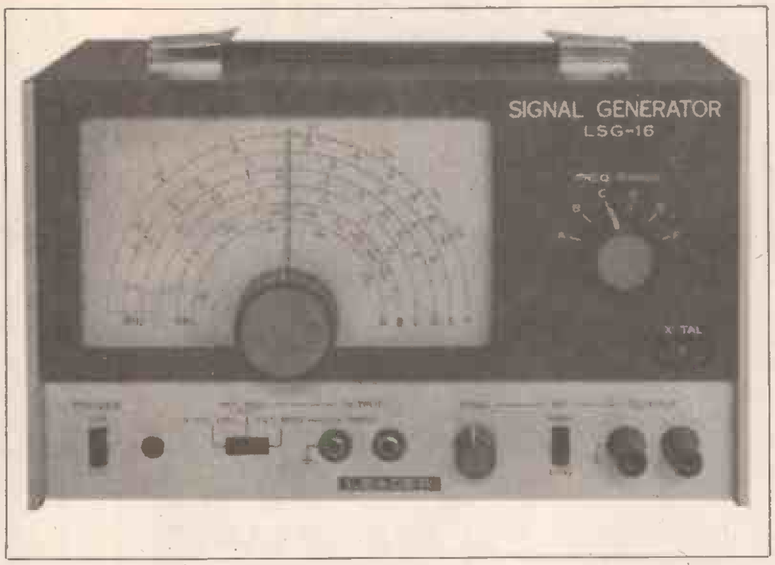
Another new rack mountable product from the States comes from Sunn, a well-respected sound equipment firm from the Pacific Northwest. They have recently introduced a new dual 10-band equaliser suitable for many different applications. It has two identical channels with 15dB cut or boost at ten ISO centre frequencies, a level control with 40dB range, dual LED level sensing, balanced and unbalanced inputs, and a bypass switch that completely disconnects all electronics from the signal path, allowing level matching between equalised and unequalised signal.

And finally, Octave-Plateau Electronics, the people who market CAT Synthesisers, have updated models to tell us about: the revised CAT SRM II and CAT Kitten II. Both units have digital keyboard circuitry, greater back panel patching capabilities, redesigned internal circuitry, and keyboard tracking on the VCF, allowing the VCF to track the keyboard at greater than one volt per octave as well as less than one volt per octave. List prices are $799.00 for the SRM II and $499.00 for the Kitten II.

Companies and manufacturers mentioned:
Wurlitzer, U.K. Distributor: Alfred Smith, Parkgate Industrial Estate, A16-8, Knutsford, Cheshire WA16 8DU.
Samson Music Products, 249 Glen Cove Road, Old Westbury, NY 11568.
MicroTune Corporation, 104 Charles St., Boston, MA 02114.
DOD Electronics, 2953 South 300 West, Salt Lake City, UT 84115.
Analog/Digital Associates, 2316 Fourth St., Berkeley, CA 94710.
Sunn Musical Equipment Company, 19350 S.W. 89th Ave., Tualatin, OR 97062.
Octave-Plateau Electronics, Inc., 928 Broadway, 7th floor, New York, NY 10010.

E&MM

NEW PRODUCTS

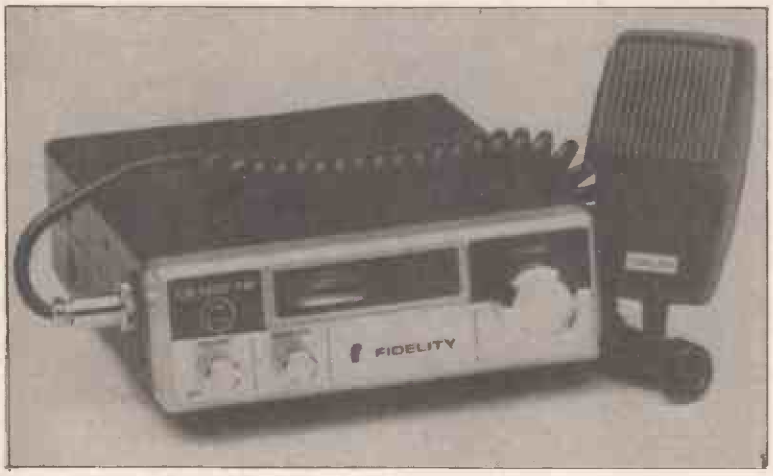


LSG-16 SIGNAL GENERATOR

Sinclair Electronics Ltd have recently introduced the LSG-16 - a new wideband, mains-operated, signal generator, covering the frequency range 100kHz to 100MHz (300 MHz on harmonics) in six ranges. It has internal modulation of 1kHz, or can be modulated externally between 50Hz and 20kHz. A crystal oscillator facility is provided for the range 1MHz to 15MHz.

The LSG-16 is housed in a sturdy case and is priced at £55 plus VAT.

Further details may be obtained from: Sinclair Electronics Ltd., London Road, St. Ives, Huntingdon, Cambridgeshire, Tel. (0480) 64646.



FIDELITY CB

Some time ago Fidelity Radio Ltd. anticipated the choice of FM transmission, for Citizens Band radio, and they went ahead with development of suitable new hardware. Now that the government has announced its intention to establish a CB radio service in the autumn, and has revealed the approved specifications, Fidelity have unveiled their new CB systems.

Two units will be marketed from September - subject to the timing of government legislation. Both operate on 27MHz FM, have 40 channels, and have an output of 4 watts. Both conform to the required UK specifications.

The CB-1000 FM is described by Fidelity as "The ideal starter unit.' It is a basic model intended for first-time buyers and has separate rotary volume and squelch controls, a forty-channel LED indicator and a signal-strength meter. There is a screw fixing for the microphone, which is provided; fixing brackets for the unit itself and the microphone are also included together with fused connecting leads. The price will be around £60.

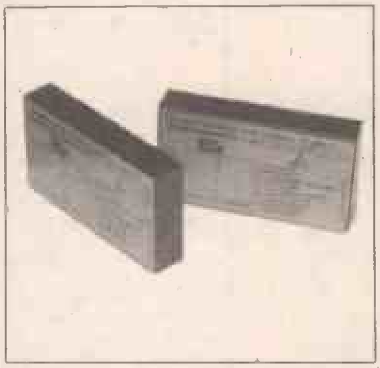
The CB-2000 FM is a more sophisticated design, costing around £80. This model incorporates (in addition to the features of the CB-1000 FM above) rotary tone and RF gain controls, switches for PA, Channel 9 - the emergency channel, and external speaker. There is an LED-dimmer control and a power microphone with microphone gain control.

Further information may be obtained from: Christopher Wright/Therese Pickard, MBP Marketing and Promotional Services, 25 Heddon Street, London W1R 7LG.

DC-DC FOR PCB

Gresham Lion Ltd have five new additions to their 'Gemini' range - they are subminiature DC-DC converter modules, designed for PCB mounting and offering very wide input voltage tolerances with high conversion efficiency.

These new 25 Watt units are designated the 'Gemini 2000 series'; the range has nominal outputs of 3V 6A, 5V 5A, 6V 4.5A, 12V 2.5A and 15V 2A. Conversion efficiencies are between 72% and 85%, all units are fully regulated and all have current limiting. Although nominal input voltage is 48V in all cases, the converters work well on any input voltage between 20 and 72V, so that one unit is



suitable for all commonly used voltage standards (for example, 24, 28, 36, 48 and 60V) and will give only minimal variations in operating performance over this range.

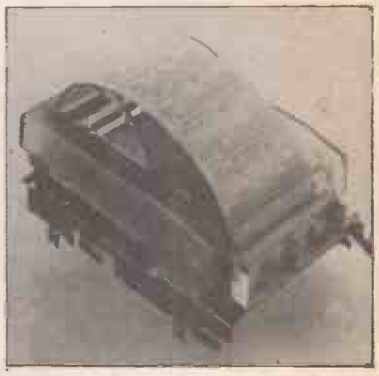
The outputs may be switched on and off remotely with a logic compatible signal or a relay closure. When modules are used in multiple or parallel configuration, the remote on/off input controls may be individually commanded or paralleled for common control. The temperature range for normal operation is -25°C to +75°C. Case size is the same for all units in the range - 116 x 65 x 20mm (excluding mounting pins).

More information may be obtained from Mike Brooks, Gresham Lion Ltd, Gresham House, Twickenham Road, Feltham, Middlesex TW13 6HA. Tel. 01-894 5511.

ESP-1 PORTABLE PRINTER

Weyfringe have released a new portable electro-sensitive printer incorporating the Olympia NMP20 print mechanism which generates full alphanumeric output at fifteen lines per second (twenty characters per line). The printer was designed to be small and lightweight for use in mobile data capture systems or small data terminals.

The ESP-1 is versatile since the 100 electrodes in the printhead may be programmed to print a range of options - for example, graphic symbols, histograms or curves. The printer is controlled by a Z80 processor which can respond to data input rates of up to 9K6 baud and format the information as dictated by the host microprocessor. The matrix print mechanism gives a full ASC11 5 x 7 character set and interfaces are RS232/V24. This is compatible with 20mA current-loop requirements and bit-parallel serial character data is entered by an externally generated strobe signal. A throughput rate of 1K characters per second can be achieved using the internally generated busy line for handshaking. Metallised paper rolls, width 60mm,



are used and these are easily loaded without threading.

Retail price is around £320 per unit (with a discount for large orders).

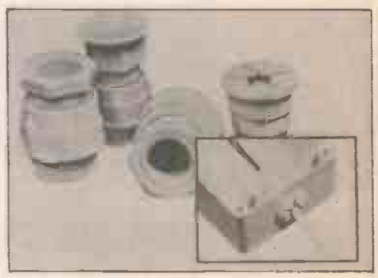
Further information is obtainable from: Mr. R. Landray, Weyfringe Limited, Longbeck Road, Marske, Redcar, Cleveland, TS11 6HQ.

CABLE GLANDS

West Hyde continue to extend their range of products and they have now made available a comprehensive new range of Bopla cable glands.

They are moulded from high quality glass-filled nylon (from Bayer), have high chemical and impact resistance, and suit a wide range of cable diameters from 4mm to 24mm. All except the basic gland type incorporate the Bopla strain-relief mechanism which should ensure a firm grip on the cable with minimum risk of conductor damage.

The glands have a light-grey coloration which matches many West Hyde housings; they are normally supplied with a PVC sealing ring and locknut, but large quantities can be supplied without the locknut for any-



one who prefers to tap a hole in the housing wall.

The whole range appears in the West Hyde catalogue and is now available for immediate delivery. For further information please contact: Chris Long, West Hyde Developments Ltd., Unit 9, Park Street Industrial Estate, Aylesbury, Bucks, HP20 1ET.

OUT NOW!

AMBIT'S NEW CATALOGUE

In an attempt to collate and organize our burgeoning ranges of 'stock' components (now over 7000 line items), we have at last produced a 'concise' 80 page parts catalogue to supplement the popular 'Tecknowledgey' series of 'wordy' applications catalogues, which now lists a wide range of basic components - as well as our unique RF and Communications components. The *World of Radio and Electronics* contains everything the informed electronics user needs, at prices which we guarantee will match the lowest on the market for equivalent product.

Prices appear on the page alongside the part numbers, and the catalogue is now updated quarterly - available either direct from here (60p all inc) or at most newsagents and bookstalls where you can find electronics publications. So as well as all the 'run-of-mill' items like resistor, capacitors, hardware, solder etc - you now have the first genuinely *complete* parts source for the radio, communication, electronics, computer user.

Ambit International
200, North Service Road,
Brentwood,
Essex CM14 4SG

THIS MONTH'S SPECIAL OFFERS

Each month, Electronics & Music Maker gives special offers to its readers that represent a substantial saving on normal retail prices.

MULTIMETER

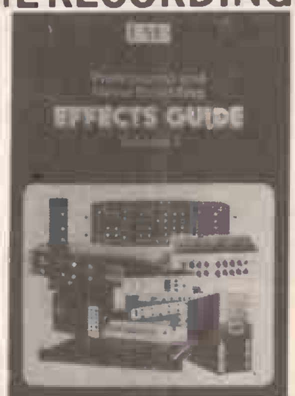
A quality test instrument for the electronics constructor - the Hills HT-320 Multimeter, a combined multimeter and transistor tester.

The meter has a 20,000 ohms/volt DC and 8000 ohms/volt AC movement and the accuracies are +3% FSD on DC, +4% FSD on AC and +3% of arc for h_{FE} measurements. There are 7 DC ranges, 4 AC ranges and 4 resistance ranges. The meter scale is tri-coloured and mirrored to eliminate parallax errors.

The instrument comes complete with one pair of test leads with probes, one set of leads terminated with croc clips for use with the transistor tester, two 1.5V cells (HP7 type), one 9V battery (PP3 type) and a comprehensive instruction manual.

Normally £15.49
Offer Price £11.49

PSP PROFESSIONAL & HOME RECORDING & EFFECTS GUIDE



Here's the first volume of an invaluable book for the keen electro-musician. Over 200 rack/cabinet effects devices illustrated in comprehensive directory format.

Its 135 pages cover Compression, Delay, Equalisation, Image Placement & Pitch-Change, Reverberation, Synthesis (Vocoders), Rack Systems — with articles on effects usage, glossary of terms and manufacturers addresses.

Normally £4.50
Offer Price £3.50

Complete this Order Form for either or both of our Special Offers.
Closing date 30th September - Subject to availability.
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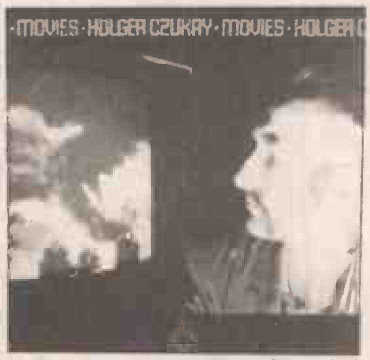
RECORD REVIEW

Movies
by Holger Czukay
EMC 3319

Czukay describes Movies as a musical voyage along directions and parameters that are simply 'different' to those of conventional rock. Certainly, a listener to this intriguing album is immediately captured by a fascinating collage of sounds interspersed with bizarre fragments of recorded speech. Czukay's composition technique involves recording sounds (either from conventional instruments, or abstract sources such as telephones, radio broadcasts or even animal noises), on to a length of tape lasting, when replayed, anything from a few seconds to several hours. Each track is then edited and mixed with other tapes to arrive at desired melodic and rhythmic patterns. He estimates that Movies represents the outcome of repeating the cutting/rejoining process more than ten thousand times!

Movies consists of four tracks which encompass a wide scope from a tongue-in-cheek disco fantasy entitled 'Cool in the Pool' (listen for the frenzied brass playing at the beginning and the Chicken Organ played by Reebop Kwaku Baah!) to a track called 'Persian Love' which features the music of an unknown Persian musician recorded from a short wave radio transmission. 'Hollywood Symphony' combines the voices of an unknown weather forecaster with a



woman broadcaster from Shanghai, to tell the story of a dream of Czukay's. 'Oh Lord Give Us More Money' was inspired by the Reverend Ike after a documentary programme featuring this black priest from New York who simply prays for money when he needs it.

This album should interest connoisseurs of avant-garde Musique concrete, electronic music and contemporary rock alike.

Graham Hall

Floating Music
by Robert Schröder
KS 80 001

This is the first record to be released on the new IC (Innovative Communication) label which has been organised by Klaus Schulze to operate as an Independent (distributed in Germany by Deutsche Austrophon GmbH, Diepholz).

There is little information given on the sleeve but a chat with Dave

Robert Schröder

Lawrence of Pulse Records (who is handling UK distribution) provided a few more details.

Schröder is a technician and musician and has written a number of technical books in Germany. He has been in contact with Klaus Schulze for seven or eight years. Schulze was impressed, and áided and encouraged him in his musical endeavours; his confidence in Schröder now evident in this recording. The synthesiser modules were designed by Schröder and the recording took place at Schulze's IC studio. Some extremely realistic drumming was provided, says Dave Lawrence, by a real drummer, although this is not credited on the sleeve.

Schröder has already had one album released, not apparently available now, which was number two in Germany's 'List of Best' as Schulze says. Schröder seems to be getting a lot of support both in Germany and in the UK and all concerned are confident of great things from him. Now you know as much about the man as anyone. On to the album.

The record, like all IC releases, is to be played at 45 RPM which, Schulze is careful to explain, is not a gimmick but an aid to sound quality. 'Floating Music,' he says, 'can also be played on 33 - with a different effect.' I stuck to 45.

There are 3 tracks on side one and 5 on side two, all of which merge into each other. The music is a curious amalgam of styles. Perhaps, not surprisingly, Klaus Schulze seems to have been an influence somewhere during the composition and, in fact, he produced the album.

Side one begins with layers of sound under which a sequenced bass-line fades up *a la* Tangerine Dream. (Now, comparisons may be odious but 'nothing is good or bad but by comparison' so suspend judgement and read on.)

The last title on side one, Pastimes, is very much in the Tangerine Dream style, including an improvised melody line using a 'telstar/pulsar' sound. Side two fades in with another sequenced bass-line and several (live?) percussive sounds are introduced with a solid drum beat behind and a weaving solo line in between.

Separating the rhythmically active sections, the slower movements consist of a series of shifting layers of sound over which various electronic sounds burst, sweep and swirl.

The whole album is lyrical in the manner to which we have become accustomed from the German school. It lacks the melodic sparkle of, for example, Jean Michel Jarre or Vangelis on a good day (I still haven't forgiven him for Beaubourg) but its heritage would suggest it is intended to be lyrical rather than overtly melodic, in which case it succeeds admirably.

Comparisons to Tangerine Dream are made only because they are so obvious. Whether or not Tangerine Dream originated the 4-note bass-line is irrelevant - use has made it their domain and in order to use it successfully, another musician must at least equal the Tangerine Dream effect. Schröder just about does that.

The album will appeal to Tangerine Dream and Klaus Schulze fans and, hopefully, many others too. It did not strike me as being as innovative as I had hoped from the support Schröder is getting but perhaps future albums will show his talent to greater effect, perhaps with less influence from his producer. He is a very capable synthesist and will, hopefully, go on to better and more original things. Meanwhile, this album is still worth a close listen; the sounds and effects are well handled and the compositions flow easily from start to finish.

Ian Waugh

Switched on Brandenburgs
by Wendy Carlos
CBS 79227

The name 'Carlos' is probably linked by many people to their first experience of synthesised music. Previous records by Carlos, particularly Switched on Bach I and II, did much to establish the synthesiser as an instrument in its own right; even in the face of great opposition to the new technology. The release by CBS of a complete set of the Bach Brandenburg Concertos performed by Carlos on mainly Moog instruments is very welcome indeed. Work on these concertos started around the time of Switched on Bach II and has continued right up to the release. Indeed, some of the pieces on this album have been released before (such as the Fourth Concerto which appeared on 'The Well-Tempered Synthesiser') and others have been remixed and updated in parts (most notably the Second Concerto, first movement which now sounds much smoother than the original on 'By Request').

It is interesting to look back at some of the historical background to these recordings. Carlos, a graduate of Music Studies in Classical Electro-Music Studio Technique, read about the now familiar work of Robert Moog, and as a consequence they met in 1965. Carlos was immediately interested by what Moog proposed, and ordered several Moog modules and set about the task of building an 8-track electro-music studio. Later on several more Moog modules were added; many of these being instigated by Carlos. A Moog catalogue of this era lists the modules available, and probably the first synthesiser, which was referred to as 'an integrated system of voltage controlled modular instruments'. In 1968 the turning point in electro-music was reached when Moog presented a paper to the Audio Engineering Society (a society which is still in the forefront of audio today) on 'Recent Trends in Electronic Music Studio Design' - playing as an example an excerpt from the Carlos Brandenburg Third Concerto. It was from here on that the synthesiser started to gain support and develop into the advanced instrument we know today, some of which, like the Yamaha Polyphonic, appear on this album.

In some ways the limitations of instruments available around 1974 show because the sound is sometimes a little thin and reedy. This does not detract from the overall product, and when the record sleeve announces 'Virtuoso Performances' it is not far wrong.

This double album contains all six Brandenburg Concertos, and the treatment given to each is very tasteful and yet unique. Comparisons with a favourite orchestral recording of the same pieces (Academy of St. Martin in the Fields) revealed the amount of care that has been taken. The sound is obviously different, as is the tempo (but never up-beat), yet all the sense of the originals has been transferred to the electronic version; not an easy task considering the amount of string dominance in the originals to be converted into keyboard formats. While all the pieces

are obviously keyboard based, the strings and the flute seem to come over as they should, and listening to the music as a whole is very satisfying. At the same time Carlos has not been afraid to interpret the score distinctly - in the same way one would expect two conductors to produce different versions of the same piece.

For those people who are familiar with the previous Carlos albums it merely remains to say that this record follows the same format and is well worth buying to fill in the gaps left by the earlier records, at the same time offering improved versions of several of the pieces. The few people who have missed the name 'Carlos' should look out for it and have a listen; the records are unlikely to offend even ardent Classical listeners, although Heavy Rock lovers would probably do well to give them a miss. These two records will undoubtedly join the others in what must be a monument to what can be done with enough skill, care and patience.

Chris Lare

E&MM

BOOK REVIEWS

Learning Music with Synthesisers
by David Friend, Alan R. Pearlman and Thomas D. Piggott
Published by Hal Leonard Publishing Corporation
Available from Music Sales
Price £5.25

A more accurate title perhaps would be "Learning Synthesis with the ARP Odyssey" for the book is primarily concerned with the Odyssey and how to use it. Having said that, it does a remarkably comprehensive job and no Odyssey owner should be without it. (Perhaps it *is* the owner's manual).

The book is divided into three parts. Part 1 describes the basis of sound: pitch, timbre and volume and the synthesis and control of these parameters. Part 2, the practical chapter, demonstrates, on the Odyssey, how the various synthesiser functions actually operate. This is the longest section of the book and it is minutely explicit regarding the function of the controls. Part 3 suggests experiments to demonstrate further the aspects of timbre, melody, harmony and transposition and also gives some basic hints regarding tape techniques and the utilisation of a tape recorder.

The book has a few quirks. Tremolo is described in one part as "a form of timbre modulation" (it is correctly described in the glossary and later in the book as "amplitude modulation") probably because the Odyssey does not permit LFO control of the VCA, and tremolo is produced by LFO control of the VCF. The descriptions of vibrato, tremolo and envelope generation are scant in part 1 and section 2 must be read to form a clear understanding of these.

Good points include the explanation of gate and trigger signals from the keyboard along with semi-exotic niceties such as micro-tones, sample and hold, ring modulators and VCO synchronisation.

Apart from Odyssey owners, other potential readers include: (1) anyone wishing to learn how synthesisers tick (they oscillate, actually), and (2) anyone wishing to expand their working knowledge of their particular synth. Readers in category (2) should be able to transfer the functions to their own synthesisers without difficulty and may well discover more about their instrument. There is no substitute, of course, for hands-on experience and readers in category (1) may have more problems but the book is very clear with numerous front-panel diagrams and the logic is easy to follow.

Ian Waugh

Making & Using Electricity From The Sun
by the Technical Staff of Solarex Corp.
Distributed by W. Foulsham & Co. Ltd.
Price £4.70

In days when the more obvious of the world's power-supplying natural resources, such as the fossil fuels, are slowly dwindling away, it is only common sense to look for other energy sources, and what better endeavour than trying to harness the true source of all power — energy from the sun.

When solar cells were invented in the early 1950's, their applications were struggling against available cheap power. Indeed solar energy as a serious power source may never have come about if it had not been for the space programme.

Here is a fascinating book designed to stimulate the mind of anyone who is interested in the use of solar cells as a source of electricity for any requirement.

The first three chapters explain the workings and the potential of the solar cell and is intended for readers who are not as yet familiar with solar energy or the photovoltaic effect. The ensuing three chapters go on to deal with the more practical aspects of solar cells including many typical applications. Individually, chapters describe many projects and home experiments that can be put to use by the reader and includes information on many commercially available accessories to simplify the installation and use of the particular solar cell system. (This is an American book however and much of the information, especially concerning items commercially available, is not applicable to this country.)

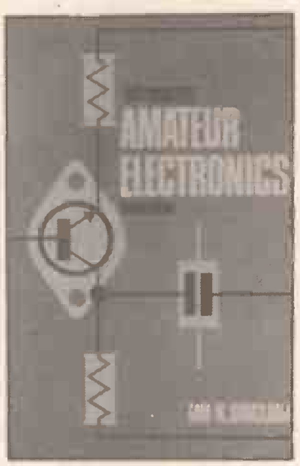
Nigel Fawcett

Introducing Amateur Electronics Second Edition
by Ian R. Sinclair
Published by Keith Dickson (Publishing) Ltd.
Price £3.50

This is a book for the complete novice and has been written by an author whose name will be known to almost everybody interested in electronics. The book has been updated since its original publication in 1975 to bring it in line with the advanced electronics of the 1980's.

I could not possibly assess or outline the contents of this book in a more comprehensive or better manner than the write-up on the rear flyleaf, so I quote:—

"One of the most popular and fascinating hobbies is the building of radio and electronics projects: and it has been from the days when the 'wireless' fan made his own crystal set to the modern enthusiast who makes his own hi-fi and electronics gadgets. However, the intending constructor is often puzzled as to how to make a start in this seemingly complicated business. For, although electronics is now covered in many schools, many would-be hobbyists have not had the opportunity to learn the fundamental technicalities.



Here, then, is the book for the complete novice of any age, in which author Ian Sinclair assumes no previous knowledge of the subject by the reader. He explains how to learn the skills of constructing electronic circuits, giving details of a number of actual practical experiments to show how components and circuits work and behave.

It is a simple introduction which will take the reader to the stage when he can move on with confidence to one or more of the several magazines which specialise in publishing constructional projects for radio, audio, television and electronics equipment for the home enthusiast. It is, in fact, the gateway to a great hobby — or even profession."

Nigel Fawcett

Elements of Electronics Book 5 — Communications
by F.A. Wilson
Published by Bernard Babani (Publishing) Ltd.
Price £2.95

This is the fifth book in a series published under the generic title "Elements of Electronics". The series is not produced as a set of books for experts and is primarily for those who don't know, not those who do. However, they are also useful 'aide memoires' for people at all levels of expertise.

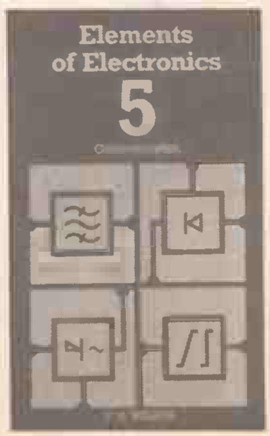
Book 5 is, as its title implies, devoted entirely to communications, covering all the electronics fundamentals related to this subject and dealing with them in a simple but non-patronising manner. Whilst the more complicated theory and mathematics are not dealt with in depth, the basic premises are and appendices are provided to help the less mathematically minded reader to cope with some of the 'heavier' theory.

The book is divided into seven sections; Communications; Transmission quality assessment; Networks; Transmission system techniques; Signal processing; the electromagnetic wave in communication; Optical transmission. Each section is well covered and contains a balanced mixture of descriptive, illustrative and mathematical matter. I was particularly impressed by the lucid treatment of networks (Section 3) and signal processing (Section 5) but must admit that the remaining sections were just as well documented and equally informative.

Mr Wilson not only understands his subject, he also appreciates the problems or problem areas likely to be encountered by many newcomers to the subject and sets out to minimise these by attention to detail particularly in the areas he has recognised as being potentially difficult.

All in all, the book content is well presented, copiously illustrated and very readable. At a price of £2.95 it is a good investment for students and anyone with an interest in acquiring a good technical understanding of the world of communications.

Brian Searle



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EVENTS

Aug. 15th-18th: HARROGATE INT. FEST. OF SOUND. Royal Hall Exhibition Centre & Hotels. Free Entry. Open to the public on 15/16th. Trade only 17/18th. 11.00 a.m.-8.00 p.m.
Aug. 18th-22nd HOME, LEISURE AND MOTOR SHOW, Leisure Centre, Haslet Ave, Crawley. Entrance 50p.
Aug. 28th-31st HOME ORGAN SHOW, Crest Hotel, within Wembley Stadium complex. Displays include makes of Lowrey, Yamaha, Hammond, Elka and many more. Open from 12-10 p.m. For further information phone: City Electronics (01) 427 4511.
Aug. 29th-Sept. 5th NATIONAL ELECTRONIC ORGAN FESTIVAL, Pontins Tower Beach, Prestatyn, North Wales. The programme for this residential event will include: daily concerts by "star" organists - teach-in sessions - sheet music and book sales - exhibitions and demos by leading manufacturers - synthesisers, rhythm units and rotary speakers. Accommodation from £78 for two people. Ring (07456) 2244.
Sept. 3rd-7th Int. Exbn. of MUSIC & HI-FI EQUIPMENT, Milan Fairgrounds. Gen. Secretariat: Via Domenichino, 11-20149 Milan, Italy.
Sept. 7th-8th MICROPROCESSOR WORKSHOP, University of Liverpool.
Sept. 15th-17th WEST OF ENGLAND ELECTRONICS SHOW. Bristol Exhibition Centre. Ring: 09274 28211.
Sept. 10th-12th PERSONAL COMPUTER WORLD SHOW, Cunard Hotel, Shortlands, Hammersmith, W6 8DR. Something for everyone! 10/11th commences 10 a.m.-7 p.m. 12th commences 10 a.m.-6 p.m.
Sept. 13th-16th BADEM DISCOTEK '81 Bloomsbury Centre Hotel, Coram St., London WC1. Complete range of disco equipment: lights, amps, decks etc. Open to trade Sunday 13th. Tickets at door.
Sept. 28th-Oct. 4th IMAGE, SOUND & ELECTRONICS Exbn. 'SONIMAG' Barcelona. Ferial Oficial de Barcelona, Av. Maria Critina, Palacio No 1, Parque de Montjuich, Barcelona, Spain.
Oct. 16th-18th VIDEO SHOW, West Centre Hotel, London. 9.00 a.m.-5 p.m. Free Entry.
Oct. 21st-24th Int. COMPUTER & TECHNOLOGY Exbn & SEMINAR 'COMPUTA' Singapore. Not for the leaflet collector! For further details phone Bob Hackett — 021-705 707.
Oct. 21st-25th HOBBY ELECTRONICS & MINI COMPUTERS Exbn Stuttgart, Germany. Exhibits ranging from electronic games/kits - hi-fi - amateur radio. Special travelling arrangements by Peter Chipperfield Travel Ltd (01) 837 7555. For further details of the fair and other events in Stuttgart, including the annual Hobby Elektronic, phone (01) 236 0911.
Oct. 27th-29th COMPUTER GRAPHICS, Bloomsbury Centre Hotel, London. 09274 28211.
Nov. 6th-8th VIDEO, HI-FI - CB RADIO SHOW, Deeside Leisure Centre, Surrey. Exhibits ranging from electric can openers - the latest in Hi-Fi. Open 12.00-6.00 p.m. Entrance 50p. For further details ring Deeside Leisure Centre, 0244-812-311.
Nov 11th-15th BREADBOARD, Royal Hort. Halls, London. Home electronics exhibition.
Nov. 17th-20th PROFESSIONAL VIDEO SHOW, Wembley Conference Centre. 01-686 2599.
Nov. 17th-20th COMPEC, Olympia, London. Trade only. Small computers for business and all back-up systems. Opens 10.00 a.m. each day.
Nov. 25th-27th PROFESSIONAL SOUND RECORDING EQUIPMENT EXHIBITION, West Centre Hotel. 01-340 3291.
Dec. 1st-3rd SOFTWARE INFO INTERNATIONAL EXHIBITION AND CONFERENCE, Wembley Conference Centre.
Dec. 15th-19th GULF COMPUTER EXHIBITION, Dubai. Trade. For further details phone Clive Lowe 01-930 3881.

Courses

Sept 12th-19th STUDIO ENGINEERS COURSE, University of Surrey, Guildford. This residential/non residential course provides information on a wide range of technical subjects relating to recording operations and by bringing together engineers of differing skills and specialities from all over the world, create a forum for interactive discussion in the exchange of ideas and experience. Further information from The Secretary, APRS, E1L. Masek, 23 Chestnut Avenue, Chorleywood, Herts WD3 4AH.

Sept. 1981 'O' LEVEL ELECTRONICS, St. Vincent Centre, Gosport, is offering a one year 'O' Level Electronics course beginning in September 1981 and leading to the A.E.B. examination in June 1982. The course, which is on Wednesday evenings 7-9 p.m., is suitable both for those who are interested in electronics as a hobby, and wish to pursue their interest and share their enthusiasm, and those who wish to gain a qualification. The course fee is £20.75 (£10.38 for under 18's and O.A.P.'s). Leaflets with full details are available from Mrs Thorpe, St. Vincent Centre, Mill Lane, Gosport.
THEATRE SOUND ENGINEERS COURSE, Paddington College, London W2. This is a one year full time course in association with ABTT, leading to a college diploma, and with a general aim of producing a competent sound technician. Further information from The Secretary, Department of Engineering Technology, Paddington College, Paddington Green, London W2 1NB. Tel: 01-402 6221 ext. 52 or 54.
THANET ELECTRONICS CLUB is for young people to gain a feeling of membership of an on-going group that they run themselves. Based on electronics, a wide range of awareness of technology, sometimes critical, becomes part of the experience. 1981/82 session a GCE Electricity/Electronics examination is arranged. Contact the club direct for more information: Quarter Deck, Zion Place, Margate, Kent.
INTERNATIONAL SYNTHESISER TAPE CONTEST. Roland (U.K.) Ltd. are currently holding their 5th Synthesiser Tape contest. This contest is open to anyone interested in synthesiser music. Full details can be obtained from Roland (U.K.) Ltd., 983 Great West Road, Brentford, Middlesex TW8 9DN. Tel. 01-568 4578. Closing date is August 31st 1981.
DENNIS EMSLEY presents a small item about electronic music every Wednesday evening on the local community radio station in Milton Keynes on cable radio. The item lasts about 15 minutes and goes out at approximately 5.15 p.m. as part of the programme 'Ad Lib'.

We shall be pleased to publish news of forthcoming electronic and eletro-music exhibitions, clubs - also special electronic music concerts.

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Electronics & Music Maker is the first monthly publication to produce its own cassettes that will provide a unique aural complement to the magazine. Produced in our own recording studio, these C60 cassettes will allow you to hear the sound of instruments and electro-musical effects in our projects and reviews.

Demo Cassette No. 1 (March/April issues) contains:
1. The sounds of the Matinée Organ. 2. Musical extracts played on the Yamaha SK20 Synthesiser reviewed last month. 3. Examples of the basic waveforms and effects discussed in 'Guide to Electronic Music Techniques'. 4. Music and sound effects played on the Sharp MZ-80K Microcomputer. 5. Warren Cann demonstrates the Syntom Drum Synthesiser. 6. The PAIA8700 Computer/Controller. 7. Frankfurt Music Fair: the Yamaha GS-1, Electro-Harmonix Clockworks Controller.

Cassette Price: £2.45 inc. VAT and p&p.

Demo Cassette No. 2 (May/June issues) contains:
1. Tim Souster 'feature' examples from his electronic music studio. 2. Electronic Dream Plant: Adrian Wagner plays the Wasp/Spider and some of his music. 3. Lowrey MX 1 Electronic Organ — the essential music complement to the review! 4. Apple Music System — polyphonic computer music. 5. E&MM Word Synthesiser — speech from our friends in Texas. 6. Fairlight Computer Musical Instrument review — because of its price, very few have heard this amazing instrument. 7. Sharp 'Composer' and 'Morse' programs. 8. Yamaha PS20 keyboard — a complete piece on this portable play anywhere instrument. 9. Vero projects: Radio/Metronome/Oscillator 10. Some extraordinary sounds from the creative David Vorhaus.

Cassette Price: £1.99 inc. VAT and p&p.

Demo Cassette No. 3 (July/August issues): 1. The unique sounds of the new PPG Wave 2 synthesiser. 2. Synwave sea effects and other sound possibilities. 3. Wersi Pianostar — the versatile kit instrument demonstrated by German demonstrator Hady Wolff, who also shows some of the special sounds from the Wersi organ range. 4. Musical examples of the immense possibilities from the Alphadac 16 synthesiser controller. 5. Atari's new Music Cartridge programming 4-part compositions. 6. Duncay Mackay makes creative sounds from his 'Visa' LP keyboard set-up. 7. Dynamic bongo sounds from the Hexadrum. 8. MTU Music Synthesis in action. 9. Casio VL-Tone. 10. Extracts from Irmin Schmidt's 'Toy Planet'.

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CORRIGENDA

The following errors and omissions have been noted in previous issues of E&MM and are brought to your attention:

APRIL ISSUE

WORKSHOP POWER SUPPLY UNIT. Page 19, Figure 2, RV3 should be 10k and RV4 1k0, R21 should be 22k and R22 220R. Parts list R7, R21 220R should read R7, R22 220R, R22 22k should read R21 22k. Page 21, setting up step 3 RV4 should read RV3, step 4 RV3 should read RV4.

JUNE ISSUE

WORDMAKER. Page 10, Figure 4. IC10 pin 7 should be connected to 0V. Page 14, Figure 10. IC3a pin 1 should read pin 3 and pin 3 should read pin 1, IC3b pin 4 should read pin 6 and pin 6 should read pin 4. Page 16, Subroutines Line 3 REM A=OUTPUT (DØ-D7), B=CONTROL (DØ=LDAØ, D1=LDA1, D2=CØ, D3=C1, D4=CCLK) should read REM A=OUTPUT (DØ-D7), B=CONTROL (DØ=CØ, D1=C1, D2=CCLK, D3=LDAØ, D4=LDA1).

MOSFET AMPLIFIER. Page 21, Figure 4 and Parts List TR5 2SC1085E should read 2SA1085E.

JULY ISSUE

CAR DIGITAL PETROL GAUGE. Page 45, Parts List R1 1K2 (M1K2) should read R1 390R (M390R), R2 100R (M100R) should read R2 1K (M1K), R3 390R (M390R) should read R3 680R (M680R), R4 1K (M1K) should read R4 100R (M100R), ABS Box MB1 (LH20W) should read Verobox 211 (LL08J).

AUGUST ISSUE

Page 1, Editorial Offices. Tel: (0702) 338878 should read Tel: (0702) 338878/338015.

PA SIGNAL PROCESSOR. Page 8, Limiter pin connections, pin view of TR101 d,g,s, should read s,d,g. Parts List R121 2M2 is 10%, C12, 14 100u 16V should read 25V, D103 0A91 should read 0A90.

POWERCOMP. Page 15, regulator and transistor pin connections, REG 3 in should read com and com should read in.

HEXADRUM. Page 22, Figure 2(d) C2 DRUM 4 68nf should read 22nf and C2 DRUM 6 150nf should read 47nf. Page 24, Parts List C2 47u, 10V axial (3B38R) should read C2 47u, 10V axial (FB38R). B1 Veropins type 214S should read B1 Veropins type 2145.

CAR RACE STARTER. Page 39, Figure 2, upper lead of battery clip -ve terminal, lower lead +ve terminal.

SOFTWARE. Page 58, Flow diagram for colour code program, add the number 3 to the circle leading into the input function F.

MUSIC MAKER EQUIPMENT SCENE. Page 80, Sequence Synthesiser SQ-01 is available from Firstman Corporation, 1, Hachimancho, Higashikurume-Shi, Tokyo, Japan not John Hornby Skewes of Leeds.

CORRIGENDA. Page 95, July issue, SYNWAVE, Page 21, Figure 2. Insert C12 between junction of C6, R12 and junction of R16, TR4 base and TR1 collector should read insert C12 between junction of C6, R12 and junction of R16, TR4 base, deleting existing connections to TR1 collector.

The Editorial staff apologise for any inconvenience that may have been caused to our readers. E&MM

Thanks to Trident Audio Developments Ltd for providing the front cover picture in the August issue and to CEL Electronics for the background Chromascope picture on this month's front cover.

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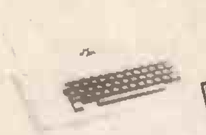

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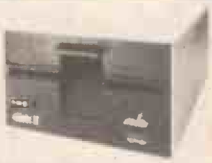

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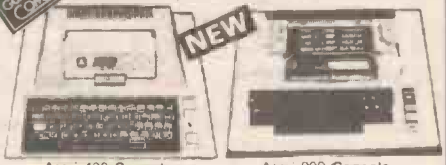

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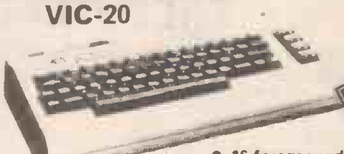

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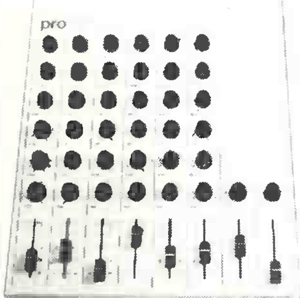

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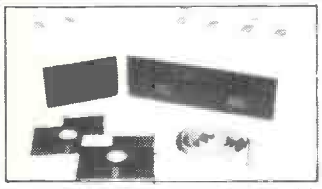

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