

PRACTICAL

ELECTRONICS

JUNE 1978

45p

**Free Entry
Competition!**

**FINANCIAL BACKING FOR
YOUR IDEAS and £490
worth of Oscilloscopes
TO BE WON**



Linear Capacitance Meter

Also inside: KILN CONTROLLER

You need never buy a colour film again!

thanks to the Practical Electronics Colour Print Service

FREE Kodak colour film

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see your prints
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LUXURY colour prints
with a borderless
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sheen finish

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Hundreds of thousands of magazine readers are delighted with this outstanding Colour Print service. So why don't you give it a try?

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Send us any make of colour print film inside the envelope enclosed in this issue. Or fill in the double coupon below and send it with your film in a strong envelope to: The Practical Electronics Colour Print Service, FREEPOST, Teddington, Middlesex, TW11 1BR. No stamp is required.

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In return you will receive a free Kodak colour film worth over £1, the same size as the one you sent us for developing. Meanwhile we produce your prints, every one of which will be checked by professionals at our laboratories before being sent to you.

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UNBEATABLE FOR QUALITY AND VALUE

What about our prices? Certainly much less than you pay in most shops, and remember you get another film FREE. With our Colour Print service, you only pay 14p for each print, plus 85p towards developing, postage and packing. The minimum charge is 85p (assuming no prints can be made) inc. VAT. The offer is limited to UK, Eire, CI and BFPO.

A SERVICE TO BENEFIT YOU

You benefit in two additional ways. Firstly, you enjoy a personal service, with every care taken over each individual order. And secondly, you pay only for what you get - with no credit vouchers like many other companies. An invoice comes with your prints, so it's a straight business transaction.

Films accepted on Standard Terms of Business (available on request).

Use these labels if you haven't got an envelope, or pass them to a friend who might like to take advantage of our offer.



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PLEASE FILL IN
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This label
used to
send your
prints

This label
used to
send your
free film

From: Practical Electronics Colour Print Service,
Freepost, Teddington, Middlesex TW11 1BR

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Address _____

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PRACTICAL ELECTRONICS

VOLUME 14 No. 10 JUNE 1978

CONSTRUCTIONAL PROJECTS

- LINEAR CAPACITANCE METER** *by A. A. Luha* 722
A battery powered instrument for the home lab
- KILN CONTROLLER** *by G. I. Williams* 732
For protection of both workpieces and kiln from overheating
- CHAMP—10** *by R. W. Coles and B. Cullen* 735
Using CHAMP-PROG and construction of CHAMP-U.V. (conclusion of series)
- HEADPHONE AMPLIFIER** *by J. P. Macaulay* 744
A flexible stereo system
- TEMPERATURE PROBE** *by R. W. Jones* 746
An accessory for use with analogue or digital voltmeters
- STRING ENSEMBLE—4** *by A. J. Boothman* 752
Voice Circuitry
- BATTERY VOLTAGE MONITOR** *by S. V. Essex* 758
Gives visible indication of battery condition

GENERAL FEATURES

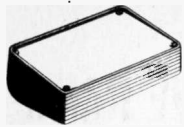
- SEMICONDUCTOR UPDATE** *by R. W. Coles* 751
A look at some recently released devices
- MICROBUS** *by D.J.D.* 760
A bi-monthly focus on micro's for the home constructor
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Musical Calculator—Stereo Expander/Compressor—Waveform Generator—
Simple Waa-Waa—Speed Controller

NEWS AND COMMENT

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Skylab, Cosmos 954, Shuttle, Jupiter
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Digital Multimeter—Auto Ranging D.C. Voltmeter

Our July issue will be on sale Friday, 9 June 1978
(for details of contents see page 765)

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MINI CONSOLES

Ideal for small desk control panels and consoles. Moulded in orange, blue, black and grey ABS. Incorporates slots for holding 1.5mm thick pcb's

Aluminium panel sits recessed into front of console and held by screws running into integral brass bushes.

MC 161 x 96 x 58mm £2.12 (1-9) (Includes VAT)
MC 215 x 130 x 75mm £2.94 (1-9) (Includes VAT)
(Prices include VAT & P.P.)

ECONOMY QUALITY LED's

50 for only £5 - 100 for only £9
Mixed bags, all sizes, various colours

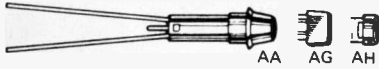


Full specification LED's also available

Red (specify size) 75p per pack
Green, Yellow, Orange (specify size) £1.20 per pack
Packs contain 5 LED's, mounting clips and data

TYPE A NEON INDICATORS

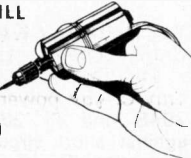
Supplied with resistor for 240 Volts operation
Held in 8mm hole by plastic bezel
150mm wire leads



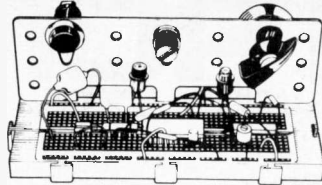
Red, Amber, Clear, Opal 19p each
Green 28p each

12 VOLTS MINI HAND DRILL

Ideal for drilling pcb, chassis etc as well as model making. Supplied with 2 collets that accept tools and drills with 3/32" and 0.50" dia shanks. £7.56 (Includes VAT & P.P.)



Stop wasting time soldering
The NEW MW BREADBOARD accepts
Transistors, LED's, Diodes, Resistors, Capacitors
and all DIL packages with 6 to 40 pins



Includes slot-in Component Support Bracket and has 470 individual sockets, plus Vcc and Ground Bus Strips
Price £9.72 (includes VAT & P.P.)

TYPE MP NEON INDICATOR

Supplied with resistor for 240 Volts operation
150mm leads, held in 6.4mm hole by nut



Red, Amber, Clear, Opal 20p each

SEVEN SEGMENT DISPLAYS

Economy quality
Red, yellow and green
Only 45p each
Common Anode - 0.3" Left Decimal
Full specification displays
also available as above
Red @ 98p each
Green and Yellow @ £1.35 each.
Data supplied with full spec.
displays only.



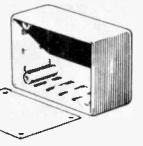
Quantity quotations on request

P.P. Note Unless included in price add 25p Post & Packing for orders totalling under £10. All prices include VAT and are valid in UK only for 2 months from journal issue date

Michael Williams Electronics
47 Vicarage Av. Cheadle Hulme, Cheshire SK8 7JP

SC BOXES

Easily drilled or punched, orange, blue, black and grey ABS. Incorporate slots for holding 1.5mm thick pcb's. Aluminium panel sits recessed into front of the box and held by screws running into integral brass bushes.

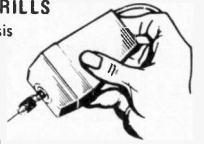


SC 85 x 56 x 35mm 97p (1-9) (Includes VAT)
SC 111 x 71 x 48mm £1.29 (1-9) (Includes VAT)
SC 161 x 96 x 59mm £1.81 (1-9) (Includes VAT)

Add 25p per £1 order value for Post & Packing

240 VOLTS MINI HAND DRILLS

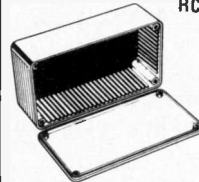
Ideal for drilling pcb's, chassis etc as well as model making. Supplied with 3 collets that accept tools and drills with 1mm, 2mm and 1/8" dia shanks.



£9.72 (includes VAT & P.P.)
Accessory tools... 5 Burrs, 1mm, 2mm, 1/8th Drills, 3/32" Collet Price £1.75 (Includes VAT & P.P.)

RC BOXES ABS and DIECAST

1.5mm pcb slots and close fitting flanged lids. ABS in orange, blue, black or grey colours. Diecast in natural or grey hammertone colour. Lid held by screws running into integral brass bushes.



	ABS	Natural Diecast	Hammertone Diecast
RC 100x62x25mm	68p	70p	93p
RC 112x62x31mm	79p	94p	1.23
RC 120x65x40mm	88p	1.22	1.59
RC 150x80x50mm	1.03	1.64	2.11
RC 190x110x60mm	1.77	2.53	3.08

Polystyrene version

in grey only, no slots, no integral brass bushes

RC(P) 112 x 61 x 31mm 61p

All prices are 1-9 off, include VAT, but please add 25p per £1 order value for Post & Packing



HOME MICROCOMPUTER

Z80

Monitor Program

2K R.A.M.

P.C.B.

Querty Keyboard

VDU Interface (TV)

Cassette Interface

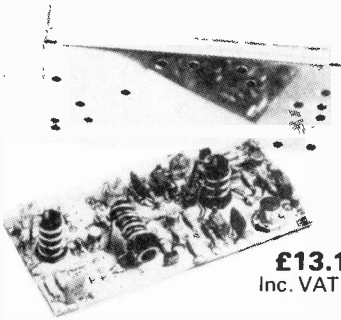
Teletype Interface

Expandable System

NASCOM I £197.50 + VAT

LYNX ELECTRONICS (LONDON) LTD, 92 BROAD STREET, CHESHAM, BUCKS. 02405 75151

HF 7948 FRONT END



£13.12
Inc. VAT P&P

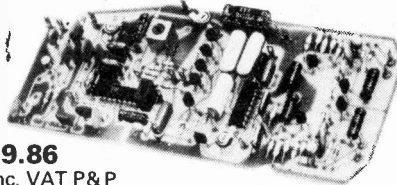
TECHNICAL CHARACTERISTICS:

Output terminal for digital frequency meter; Antenna impedance – 75 to 300 Ohms; Frequency ranges 87.5 to 104 MHz or to 108 MHz; Sensitivity – 0.9 uV 26dB signal to noise ratio + 75 kHz deviation; Inter-modulation 80dB Image rejection – 60dB; Tuning voltage – 1V to 11V; Total gain – 33dB; Intermediate frequency – 10.7 MHz; Power supply voltage + 15V; Power consumption 15mA; Dimensions 104 x 50 mm.

TECHNOLOGY:

Double sided epoxy printed circuit board with plated through holes. Dual gate effect transistors; Silvered coils.

**FI 2846
IF AMP AND DECODER**



£9.86
Inc. VAT P&P

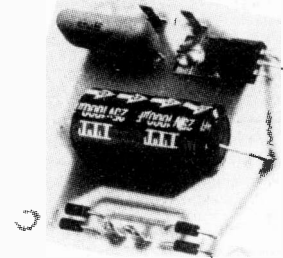
TECHNICAL CHARACTERISTICS:

Intermediate frequency – 10.7MHz. IF Bandwidth – 280kHz; Signal to noise ratio – 70dB with 1mV input; Distortion – mono 0.1%, stereo 0.3%; Sensitivity – 30uV up to the 3dB limit; Channel separation – 40dB at 1kHz; Pass band – 20 to 15,000Hz; Rejection at 38kHz greater than 55dB; Am rejection – 45dB; De-emphasis – 50 to 75µs; Pilot capture at 19kHz + 4%; Channel matching within less than 0.3dB; Output impedance – 100 Ohms; Output voltage – 500mV; Phase locked loop stereo decoder; Output for LED VU-meter; Null indicator; Outputs for AGC AFC and inter-station muting; Consumption – 55mA LEDs extinguished; 100mA LEDs illuminated; Power supply – 15V; Dimensions 195 x 76mm.

CIRCUIT TECHNOLOGY

Epoxy printed circuit board; Monolithic integrated circuits; ceramic filter.

**ALS 1500
STABILISED POWER SUPPLY**



£2.53
Inc. VAT P&P

TECHNICAL CHARACTERISTICS:

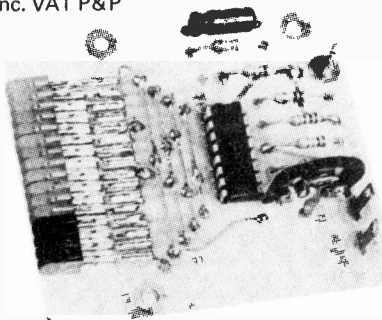
Output voltage – 15V; Max. output current – 500mA; Thermal coefficient less than 1mV/C; 15V power supply for modules HF 7948 and FI 2846; Supply protected against short circuit (power and current protection); Dimensions – 65 x 55mm.

TECHNOLOGY:

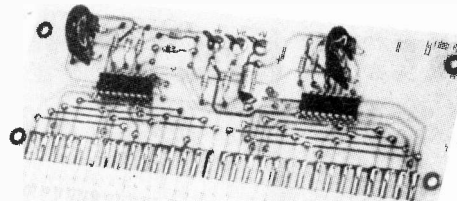
Double sided epoxy circuit board; Monolithic integrated circuit.

OPTOELECTRONIC OPTIONS

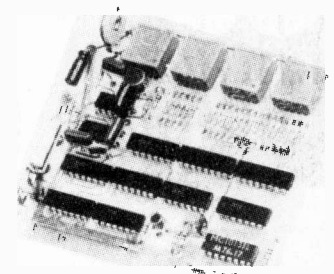
£8.06
Inc. VAT P&P



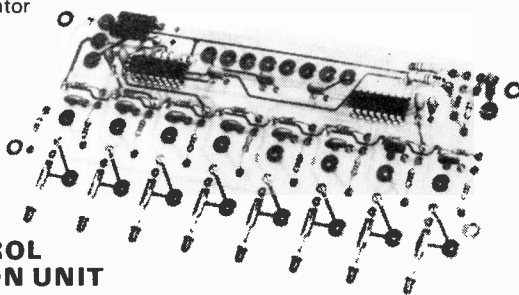
LED VU-METER
Station strength indicator



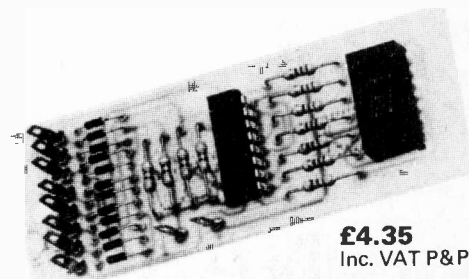
£13.50
Inc. VAT P&P
ILLUMINATED POINTER
Station finder



£22.74
Inc. VAT P&P
FREQUENCY METER
Digital display of received station frequency.



£8.77
Inc. VAT P&P
**TOUCH CONTROL
PRE-SELECTION UNIT**
LED channel indication.



£4.35
Inc. VAT P&P
NUMERICAL DISPLAY
Pre-selected channel number

EASY BUILD SPEAKER DIY KITS

Specially designed by RT-VC for cost-conscious hi-fi enthusiasts, these kits incorporate two teak-simulate enclosures, two EMI 13" x 8" (approx.) woofers, two tweeters and a pair of matching crossovers. Supplied complete with an easy-to-follow circuit diagram, and crossover components.

£28.00
STEREO PAIR Input 15 watts rms, 30 watts peak, each unit. + p & p £5.50 Cabinet size 20" x 11" x 9 1/2" (approx.)

SPEAKERS AVAILABLE WITHOUT CABINETS.
It's the units which we supply with the enclosures illustrated. Size 13" x 8" (approx.) woofer (EMI) 2 1/2" approx. **£17.00** per tweeter, and matching crossover components. stereo pair Power handling 15 watts rms, 30 watts peak. + p & p £3.40

COMPACT FOR TOP VALUE

These infinite baffle enclosures come to you ready milled and professionally finished. Each cabinet measures approx. per stereo pair 12" x 9" x 5" deep, and is in wood simulate.

Complete with two 8" (approx.) speakers for maximum power handling of 7 watts. **£8.50** + p & p £2.20

SPEAKERS

Two models - Duo IIB, teak veneer, 12 watts rms, 24 watts peak, 18 1/2" x 13 1/2" x 7 1/2" (approx.) Duo III, 20 watts rms, 40 watts peak, 27" x 13" x 11 1/2" approx Duo IIB **£17 PER PAIR** Duo III **£52 PER PAIR** p & p £6.50 p & p £7.50

DECCA 20 WATTS STEREO SPEAKER

stereo pair This matching loudspeaker system is hand made, kit comprises of two 8" diameter approx. base drive unit, with heavy die cast chassis laminated cones with rolled P.V.C. surrounds, two 3 1/2" diameter approx. domed tweeters complete with crossover networks. **£4.00 p & p £20.00**

PERSONAL SHOPPERS

STEREO CASSETTE record/replay fully built P.C. board. (Used without guarantee. (Ex Equipment)) **£1.95**

AM. FM. TUNER P.C.B. with Mullard L.P. 1:86. **£9.50**
1185, 1181 modules.

100K Multiturn Varicap tuning pots. 6 for **£1.00**


MUSIC CENTRE CABINET

with hinged smoke acrylic top, finished in natural teak veneers size 30 1/2" x 14 1/2" x 7 1/2" approx. **£5.95**

DECCA DC1000 Stereo Cassette P.C.B. **£2.95**
complete with switch oscillator coils and tape-heads

FERGUSON, 3-speed, 7" Hi Fi tape transport mechanism, complete with top covers. **£15.95**

MULLARD Built power supply. **£1.50**



20 x 20 WATT STEREO AMPLIFIER

£29.90
Superb Viscount IV unit in teak-finished cabinet. Silver fascia with aluminium rotary controls and pushbuttons, red mains indicator and stereo jack socket. Function switch for mic, magnetic and crystal pick ups, tape, tuner, and auxiliary Rear panel features two mains outlets, DIN speaker and input sockets, plus fuse. 20 + 20 watts rms, 40 + 40 watts peak.


SPECIAL OFFER: PACKAGE PRICE WITH 30 x 30 KIT

Specially designed by RT-VC for the experienced constructor, complete in every detail. Same facilities as Viscount IV amplifier, 60 + 60 peak supplied with 2 GOODMANS COMPACT 12" Bass woofers with crossed sides, 14,000 Gauss magnet, 30 watts R.M.S. handling + 3 1/2" approx. tweeters and crossovers. **£49.00** + £4.00 p & p

NOW AVAILABLE fully built and tested. Output 30 + 30 watts rms, 60 + 60 peak. **£39.00** p & p £2.50

ADD-ON STEREO CASSETTE TAPE DECK KIT

Designed for the experienced D.I.Y. man This kit comprises of a tape transport mechanism, ready built and tested record/replay electronics with twin V.U. meters and level control for mating with mechanism. Specifications: Sensitivity - Mic 0.85 mV // 20K OHMS; Din, 40mV // 400K OHMS; Output 300mV RMS per channel // 1KHz from 2K OHMS source; Cross Talk -30db; Tape Counter - 3 Digit, Resettable; Frequency Response 40Hz - 8KHz ± 6db; Deck Motor 9 Volt DC with electronic speed regulations; Key Functions - Record, Rewind, Fast Forward, Play, Stop & Eject. **£19.95** p & p £2.50
Opt. extras: Mains transformer to suite **£2.50** + £1 p & p.




Order by giving credit card number ONLY.

323 EDGWARE ROAD, LONDON W2
210 HIGH STREET, ACTON W3 8NG
ALL PRICES INCLUDE VAT at 12 1/2%
All items subject to availability. Price correct at 14.78 and subject to change without notice



45 WATT MONO DISCO AMP

£35.00 p & p £2.50
Size approx. 13 1/2" x 5 1/2" x 6 1/2"
45 watts rms, 90 watts peak output. Big features include two disc inputs, both for ceramic cartridges, tape input and microphone input. Level mixing controls fitted with integral push pull switches. Independent bass and treble controls and master volume.



70 & 100 WATT MONO DISCO AMP

Size approx. 14 1/2" x 4 1/2" x 10 1/2"
Brushed aluminium fascia and rotary controls. Five vertical slide controls - master volume, tape level, mic level, deck level, PLUS INTER DECK FADER for perfect graduated change from record deck No. 1 to No. 2, or vice versa. Pre fade level control 70 watt (PFL) lets YOU hear next disc before fading 140 watt peak. it in. VU meter monitors output level. **£57** p & p £4.00
Output 100 watts RMS 200 watts peak. 100 watt **£65**

CHASSIS RECORD PLAYER DECKS

GARRARD DECK CC10A £7.95
Record changer with cue, stereo ceramic cartridge. p & p £2.00
BSR MP60 TYPE Single play record deck less cartridge. p & p £2.55
Cartridges to suit above
Acos, magnetic stereo **£4.95**
Ceramic stereo **£1.95**
approx BSR automatic record player deck cueing device and stereo ceramic head, p & p £2.55 **£9.95**
BSR MP 60 type, complete with magnetic cartridge, diamond stylus, and de luxe plinth and cover. p & p £4.50
Home 8 Track cartridge player. This unit will match with the Viscount IV 9" x 8" x 3 1/2". p & p £2.50 **£16.50**

EASY TO BUILD RECORD PLAYER KIT

for the D-I-Y man who requires a stereo unit at a budget price, comprising ready assembled stereo amp, module, Garrard auto / manual deck with cueing device, pre-cut and finished cabinet work. Output 4 watts per channel, phones socket and record/replay socket. Without Speakers. **£17.95** p & p £2.00

Personal Shoppers EDGWARE ROAD LONDON W2 Tel: 01-723 8432. 9.30am-5.30pm. Half day Thursday. ACTON Mail Order only No callers GOODS NOT DESPATCHED OUTSIDE UK



Random Flasher Unit

Wired ready for use. Complete with three 100 watt coloured lamps that flash independently at random. **£19.95**



TWIN BANK 6 LIGHT UNIT

(less lamps) LENGTH 14 1/2 inches
BC Fitting **£11.35**
ES Fitting **£11.35** each



Sound to Light MASTER UNIT

600 WATTS PER CHANNEL
£30.95
INCLUDES CHANNEL OUTPUT PLUGS AND MAINS INPUT SOCKET



TYPE A SPOT

(less lamp)
BC Fitting **£2.30** each
ES Fitting **£2.30** each



TYPE B 3 BANK UNIT

(Less Lamps)
BC Fitting **£7.99** ES Fitting **£7.99**



TWIN BANK 12 LIGHT UNIT

Length 31 1/2"
(less lamps)
BC Fitting **£18.50** ES Fitting **£18.50**

100 WATT SPOT LAMPS
RED, YELLOW, GREEN
BLUE CLEAR **£1** 50 each
Maximum 3 lamps **£4.50**
B.C. or E.S. Fitting

ALL PRICES INCLUDE V.A.T. AND POST & PACKING (These prices apply to the United Kingdom only)

Send 20p for illustrated leaflet & price list

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DEPT. PE THE CRESCENT, WORSTHORNE,
BURNLEY, LANCS. Tel: Burnley 20940

CRESCENT RADIO LTD.

MAIL ORDER DEPT.
1 ST. MICHAELS TERRACE, WOOD GREEN,
LONDON N22 4SJ
PHONE: 888-4474

GLOBAL CAR SPEAKERS

Eagle's CG2 high-performance car speakers. The CG2's have adjustable pedestals and are intended for rear parcel shelf mounting. Supplied in pairs with connecting cable. Dimensions: 120 x 140mm. Impedance: 4 ohms. Power Handling: 5 watts. OUR PRICE: **£6.45** + 12 1/2% VAT.

STEREO JUNCTION BOX

This popular stereo junction box has the facility for two pairs of headphones and two L/Speakers. A 3 position switch enables you to select headphones, loudspeakers or both. All speaker terminations are 2 pin din type. OUR PRICE: **£3.20** + 12 1/2% VAT.

ITI 1 SIGNAL INJECTOR

AF/RF signal for quick fault-finding on audio and allied in pairs with detachable probe; indicator light. Complete with battery and instructions. PRICE: **£4.95** + 8% VAT.

TI 206 2-STATION INTERCOM

Ideal for home, office or shop. Resilient high-quality plastic housing with concealed speaker. Master station has call/talk button and on-off/volume control. 4 transistor circuit gives clear speech. Supplied ready for table-top or wall mounting with approx. 12 metres of connecting lead, staples and battery. Dimensions: 115 x 78 x 38 mm. OUR PRICE: **£6.75** + 12 1/2% VAT.

EFFECTS PROJECTOR "150"

(150 watt)
Ideal for disco work, this versatile machine takes a range of accessories and is of a sturdy metal construction. Comes complete with bulb and 6in. Liquid Wheel. Ready to use.
A bargain at **£34** + 8% V.A.T.

3 KILOWATT PSYCHEDELIC LIGHT CONTROL UNIT

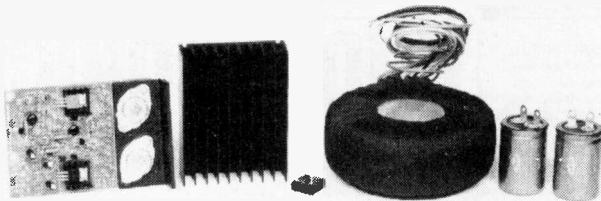
(1000 Watt per channel)
Three channel. Bass, Middle, Treble. The input of this unit is connected to the loudspeaker terminals of an amplifier and the required lighting is connected to the output terminals of the unit thus enabling you to produce a fascinating sound to light display. Full instructions supplied or S.A.E. for details.
Fantastic Value at **£20.00** - 8% V.A.T.

LOUDSPEAKER SELECTION

+ 12 1/2% V.A.T.
2 1/2in. 8, 40, and 75 ohm at **£1.10** (please state which impedance is required)
5in. 8 ohm Ceramic at **£1.70**
8in. Goodmans "Audiom 8PA" 8 ohm 15W **£5.25**.
10in. ELAC Dual Cone 8 ohm 10 watt at **£4.75**

ACCESS AND BARCLAYCARD ACCEPTED—PHONE ORDERS WELCOMED
ALL PRICES INCLUDE POSTAGE—PLEASE ADD V.A.T. AS SHOWN—S.A.E. WITH ALL ENQUIRIES PLEASE
Personal callers welcome at: 21 GREEN LANES, PALMERS GREEN, N13. Phone: 888 3206
and 13 SOUTH MALL, EDMONTON N9. Phone: 803 1685

TWO NEW SUPERMODULES: 170W INTO 4 OR 8 OHMS



By popular demand we have designed higher powered versions of our well known modules. The CE 1704 which gives 170W into 4 ohms and the CE 1708 which gives 170W into 8 ohms are physically similar to the original types and have the same combination of compatible performance features which makes CRIMSON amplification audibly superior to the competition and the only choice if you have an ear for music. We have also produced suitable power supplies which again use our superb TOROIDAL TRANSFORMERS, only 50mm high, with a 120-240 primary and single bolt fixing. Write or phone for more information and biased opinions.

POWER AMPLIFIER MODULES	Home	Europe
CE 608 60W/8 ohms 35-0-35V	£16.30	£16.80
CE 1004 100W/4 ohms 35-0-35V	£19.22	£19.30
CE 1008 100W/8 ohms 45-0-45V	£23.22	£23.00
CE 1704 170W/4 ohms 45-0-45V	£28.12	£28.46
CE 1708 170W/8 ohms 60-0-60V	£31.90	£31.04

TOROIDAL POWER SUPPLIES	Home	Europe
CPS 1 for 2 x CE 608 or 1 x CE 1004	£14.47	£14.40
CPS 2 for 2 x CE 1004 or 2/4 x CE 608	£18.82	£20.57
CPS 3 for 2 x CE 1008 or 1 x CE 1704	£17.88	£21.36
CPS 4 for 1 x CE 1008	£15.31	£18.18
CPS 5 for 1 x CE 1708	£22.89	£24.50
CPS 6 for 2 x CE 1704 or 2 x CE 1708	£23.98	£27.70

HEATSINKS	50mm	2°C/W	£0.80	£1.30
LIGHT DUTY	50mm	2°C/W	£1.80	£2.40
MEDIUM POWER	100mm	1.4°C/W	£2.30	£3.65
DISCO/GRUP	150mm	1.1°C/W		

THERMAL CUT-OUTS	Recommended for improved reliability	70°C for use with Free Air Heatsink	£1.60	£1.90
	40°C for use with Fan Cooled Heatsink		£1.60	£1.90

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T.H.D. : TYPICALLY <0.2% ANY POWER, 1kHz, 8 OHMS
T.I.D. : INSIGNIFICANT
SLEW RATE LIMIT: 20V/μS
S/N RATIO : 110dB
FREQ. RESPONSE: 10Hz - 35kHz, -3dB
STABILITY : UNCONDITIONAL
PROTECTION : DRIVES ANY LOAD SAFELY
SENSITIVITY : 775mV (250mV or 100mV ON REQUEST)
SIZE : 120 x 80 x 25mm

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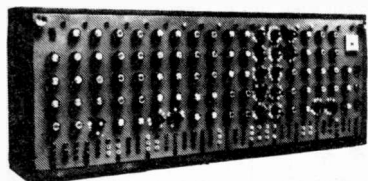
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KITS FOR SYNTHESISERS, SOUND EFFECTS



COMPONENTS SETS include all necessary resistors, capacitors, semiconductors, potentiometers and transformers. Hardware such as cases, sockets, knobs, keyboards, etc. are not included but most of these may be bought separately. Fuller details of kits, PCBs and parts are shown in our lists.

CIRCUIT AND LAYOUT DIAGRAMS are supplied free with all PCBs unless "as published".

PHOTOCOPIES of all P.E. texts for most of the kits are available—prices in our lists.

PHONOSONICS

MAIL ORDER SUPPLIERS OF QUALITY PRINTED CIRCUIT BOARDS, KITS AND COMPONENTS TO A WORLD-WIDE MARKET.

P.E. MINISONIC Mk. 2 SYNTHESISER

A portable mains-operated Miniature Sound Synthesiser, with keyboard circuits. Although having slightly fewer facilities than the large P.E. Synthesiser the functions offered by this design give it great scope and versatility. Consists of 2 log VCOs, VCF, 2 envelope shapers, 2 voltage controlled amps, keyboard hold and control circuits, HF oscillator and detector, ring modulator, noise generator, mixer, power supply.

Set of basic component kits **£82.23**
Set of printed circuit boards **£9.71**

P.E. SYNTHESISER (P.E. Feb. 73 to Feb. 74)

The well acclaimed and highly versatile large-scale mains-operated Sound Synthesiser complete with keyboard circuits. Other circuits in our lists may be used with the Synthesiser to good advantage.

The Main Synthesiser: PSU, 2 linear VCOs, 2 ramp generators, 2 input amps, sample hold, noise generator, reverb amp, ring modulator, peak level circuit, envelope shaper, voltage controlled amp.

Set of basic component kits **£83.03**
Set of printed circuit boards **£13.20**

The Synthesiser Keyboard Circuits (can be used without the Main Synthesiser to make an independent musical instrument): 2 logarithmic VCOs, divider, 2 hold circuits, 2 modulation amps, mixer, 2 envelope shapers and PSU.

Set of basic component kits **£48.18**
Set of printed circuit boards **£7.86**

GUITAR EFFECTS PEDAL (P.E. July 75)

Modulates the attack, decay and filter characteristics of an audio signal not only from a guitar but from any audio source, producing 8 different switchable effects that can be further modified by manual controls. Possibly the most interesting of all the low-priced sound effects units in our range. Circuit does not duplicate effects from the Guitar Overdrive Unit.

Component set with special foot operated switches **£7.59**
Alternative component set with panel switches **£4.96**
Printed circuit board **£1.43**

SOUND BENDER (P.E. May 74)

A multi-purpose sound controller, the functions of which include envelope shaper, tremolo, voice-operated fader, automatic fader and frequency-doubler.

Component set for above functions (excl. SWs) **£7.84**
Printed circuit board **£1.81**

Optional extra—additional Audio Modulator, the use of which, in conjunction with the above component set, can produce 'jungle-drum' rhythms.

Component set (incl. PCB) **£2.88**

PHASING UNIT (P.E. Sept. 73)

A simple but effective manually controlled unit for introducing the 'phasing' sound into live or recorded music.

Component set (incl. PCB) **£2.87**

PHASING CONTROL UNIT (P.E. Oct. 74)

For use with the above Phasing Unit to automatically control the rate of phasing.

Component set (incl. PCB) **£4.48**

SOPHISTICATED PHASING AND VIBRATO UNIT

A slightly modified version of the circuit published in 'Elektron', December 1976, and includes manual and automatic control over the rate of phasing and vibrato.

Component set **£17.89**
Printed circuit board **£2.33**

WAH-WAH UNIT (P.E. Apr. 76)

The Wah-Wah effect produced by this unit can be controlled manually or by the integral automatic controller.

Component set (incl. PCB) **£3.55**

AUTOWAH UNIT (P.E. Mar. 77)

Automatically produces Wah-pedal and Swell-pedal sounds each time a new note is played.

Component set, PCB, special foot switches **£7.27**
Component set and PCB, with panel switches **£4.83**

POST AND HANDLING

U.K. orders—under £15 add 25p plus VAT, over £15 add 50p plus VAT. Keyboards £2.00 plus VAT.
Optional insurance for compensation against loss or damage in post, add extra 50p for cover up to £50, £1.00 for £100 cover, £2.00 for £200 cover.

Eire, C.I., B.F.P.O., and other countries are subject to Export postage rates.

P.E. JOANNA PLUS ORGAN VOICING

The basic five octave electronic piano (P.E. May/Sept 75 and Sound Design) has switchable alternative voicings for Honky-Tonk, ordinary piano, and Harpsichord or a mixture of any of these three, together with facilities including fast and slow tremolo, loud and soft pedal switching, and sustain pedal switching. The modification retains all the circuitry associated with the piano but in addition provides an organ-voice envelope facility with 5 switchable pitches, variable attack and sustain, phasing and vibrato.

Set of components (excl switches) for PSU, Frequency generator, Pitch and Note Divider, Envelope Shapers, Voicings, and Control circuitries. (Order as KIT 71-5) **£109.75**
Set of PCBs (Order as PCB SET 71-6) **£29.18**

SYNTHESISER TUNING INDICATOR (P.E. July 77)

A simple 4-octave frequency comparator for use with synthesisers and other instruments where the full versatility of the P.E. Tuning Fork is not required.

Component and PCB (but excl sw.) **£7.45**

GUITAR FREQUENCY DOUBLER (P.E. Aug. 77)

A modified and extended version of the circuit published.

Component set and PCB **£4.22**

GUITAR SUSTAIN (P.E. Oct 77)

Maintains the natural attack whilst extending note duration.

Component set, PCB and foot switches **£4.90**
Component set, PCB and panel switches **£3.48**

WIND AND RAIN UNIT

A manually controlled unit for producing the above-named sounds.

Component set (incl. PCB) **£3.72**

GUITAR OVERDRIVE UNIT (P.E. Aug. 76)

Sophisticated, versatile Fuzz unit, including variable and switchable controls affecting the fuzz quality whilst retaining the attack and decay and also providing filtering. Does not duplicate the effects from the Guitar Effects Pedal and can be used with it and with other electronic instruments.

Component set using dual slider pot **£8.86**
Component set using dual rotary pot **£8.20**
Printed circuit board **£1.62**

FUZZ UNIT

Simple Fuzz unit based upon P.E. "Sound Design" circuit.

Component set (incl. PCB) **£2.05**

TREMOLO UNIT

Based upon P.E. Sound Design circuit.

Component set (incl. PCB) **£3.64**

TREBLE BOOST UNIT (P.E. Apr. 76)

Gives a much shriller quality to audio signals fed through it. The depth of boost is manually adjustable.

Component set (incl. PCB) **£2.40**

P.E. TUNING FORK (P.E. Nov. 75)

Produces 84 switch-selected frequency-accurate tones. A LED monitor clearly displays all beat note adjustments. Ideal for tuning acoustic or electronic musical instruments.

Main component set (incl. PCB) **£15.59**
Power supply set (incl. PCB) **£7.03**

SEE OTHER PAGE FOR KEYBOARDS, AND OUR LISTS FOR OTHER COMPONENTS AND ACCESSORIES STOCKED

DON'T FORGET VAT!

Add 12½% (or current rate if changed) to full total of goods, post and handling. (Does not apply to export orders).

P.E. SYNCHRONOME (P.E. Mar. 76)

An accented-beat electronic metronome, providing dupe, triple and quadruple times with full control over the beat rate. Can also be used as a simple drum-beat rhythm generator. Includes power supply.

Component set (incl. loudspeaker) **£11.62**
Printed circuit board **£2.04**

TAPE NOISE LIMITER

Very effective circuit for reducing the hiss found in most tape recordings. All kits include PCBs.

Standard tolerance set of components **£2.96**
Superior tolerance set of components **£3.76**
Regulated power supply (will drive 2 sets) **£4.69**

ENVELOPE SHAPER WITHOUT VCA (P.E. Oct. 75)

Provides full manual control over attack, decay, sustain and release functions, and is for use with an existing voltage controlled amplifier.

Component set (incl. PCB) **£4.66**

ENVELOPE SHAPER WITH VCA (P.E. Apr. 76)

This unit has its own voltage controlled amplifier and has full manual control over attack, decay, sustain and release functions.

Component set (incl. PCB) **£6.88**

TRANSIENT GENERATOR (P.E. Apr. 77)

An envelope shaper, without VCA, having the usual attack, decay, sustain and release functions, and in addition it also provides a Repeat Effect enabling a synthesiser to be programmed to imitate such instruments as a mandolin or banjo.

Component set **£4.52**
Printed circuit board **£1.62**

WAVEFORM CONVERTER

Slightly modified from a circuit published in "Elektron". Converts a saw-tooth waveform into four different waveforms: sine-wave, mark-space saw-tooth, regular triangle form, and squarewave with an externally variable mark-space ratio.

Component set (incl. PCB but excl. sw/s) **£8.19**

VOLTAGE CONTROLLED FILTER (P.E. Dec. 74)

Part of the P.E. Minisonic now released as an independent kit for use with other synthesisers.

Component set (incl. PCB) (Order as Kit 65-1) **£8.22**

RING MODULATOR (P.E. Jan 75)

Part of the P.E. Minisonic now released as an independent kit for use with other synthesisers.

Component set (incl. PCB) (Order as Kit 59-1) **£5.50**

NOISE GENERATOR (P.E. Jan. 75)

Part of the P.E. Minisonic now released as an independent kit for use with other synthesisers.

Component set (incl. PCB) (Order as Kit 60-1) **£3.35**

SOPHISTICATED POWER SUPPLIES

A wide range of highly stabilised low noise power supply kits is available—details in our lists.

MICROPHONE PRE-AMP (P.E. Apr. 77)

Component set (incl. PCB) **£3.78**

VOICE OPERATED FADER (P.E. Dec. 73)

For automatically reducing music volume during talk-over—particularly useful for Disco work or for home-movie shows.

Component set (incl. PCB) **£3.97**

DYNAMIC RANGE LIMITER (P.E. Apr. 77)

Automatically controls sound output to within a preset level.

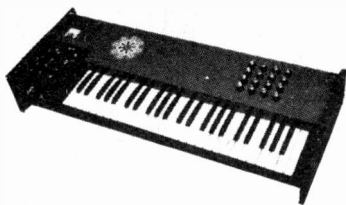
Component set (incl. PCB) **£4.58**

AND OTHER PROJECTS

PHOTOGRAPHS in this advertisement show two of our units containing some of the P.E. projects built from our kits and PCBs. The cases were built by ourselves and are not for sale, though a small selection of other cases is available.

LIST—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 20p; other countries—send 50p.



KIMBER-ALLEN KEYBOARDS AND CONTACTS

Kimber-Allen Keyboards as required for many published circuits. The manufacturers claim that these are the finest moulded plastic keyboards available. All octaves are C to C, the keys are plastic, spring-loaded, fitted with actuators, and mounted on a robust aluminium frame.

3 Octave (37 notes)	£25.50
4 Octave (49 notes)	£32.25
5 Octave (61 notes)	£39.75

Contact Assemblies (gold-clad wire) for use with the above keyboards (1 required for each note):

Type GJ: Single-pole change-over	each 24p
Type GB: 2 pairs of contacts, each pair normally open	each 27p
Type GC: 3 pairs of contacts, each pair normally open	each 36p
Type GE: 4 pairs of contacts, each pair normally open	each 45p
Type GH: 5 pairs of contacts, each pair normally open	each 57p
Type 4PS: 3 pairs of contacts plus single-pole changeover	each 53p

Printed Circuit Boards for use with GJ, GB and 4PS contacts (thus eliminating much interwiring) are available. Details in our lists.

RHYTHM GENERATOR

15-Rhythm Tempo, Timing and Logic control unit (excl. sw's but incl. PCB)	£12.90
10-Instrument Effects circuits	£13.56
PCB for Effects circuits	£4.25
Power Supply incl. PCB	£12.00

128-NOTE TUNE-PROGRAMMABLE SEQUENCER

(P.E. Nov/Dec 77)

Enables a voltage controlled synthesiser to automatically play pre-programmed tunes of up to 32 pitches and 128 notes long. Programs are keyboard initiated and note length and rhythmic pattern are externally variable. (Please use order codes quoted in brackets.)

Main Circuit (Nov) excl. sw's (KIT 76-1)	£20.60
Power Supply (KIT 76-3)	£6.05
Trigger Inverter and Alt. Output (KIT 76-2)	£1.35
LED Counter (KIT 76-4)	£2.45
PCB for Kits 76-1 & 3 (PCB 76A)	£2.61
PCB for Kits 76-2 & 4 (PCB 76B)	£2.54

P.E. STRING-ENSEMBLE (P.E. commencing Mar 78)

The new keyboard string-instrument synthesiser.

Power Supply Basic component set	£9.22
Tone Generators (incl. Test components)	£14.93
PCB for PSU and Tone Generator	£3.40

Details of further kits and PCBs in our list.

FORMANT SYNTHESISER (Elektron 1977/78)

Very sophisticated music synthesiser for the advanced constructor who puts performance before price. Details in our lists.

3-CHANNEL SOUND-TO-LIGHT (P.E. Apr. 76)

A simple but effective sound-to-light controller capable of operating 3 lamps each of approximately 700 watts. Includes power supply, thyristors, and by-pass switches.

Component set (incl. PCB)	£11.95
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DISCOSTROBE (P.E. Nov. 76)

4-channel light-show controller giving a choice of sequential, random, or full strobe mode of operation.

Basic component set	£18.19
Printed circuit board	£3.45

BIOLOGICAL AMPLIFIER (P.E. Jan./Feb. 73)

Multi-function circuits that, with the use of other external equipment, can serve as lie-detector, alphaphone, cardiophone etc.

Pre-Amp Module Components set (incl. PCB)	£4.22
Basic Output Circuits—combined component set with PCBs, for alphaphone, cardiophone, frequency meter and visual feed-back lampdriver circuits.	£6.59
Audio Amplifier Module Type PC7	£7.75

10% DISCOUNT VOUCHER (PE66)

TERMS: Correctly costed, C.W.O., U.K. orders over £40 goods value. Valid until end of month on cover of P.E. This voucher must accompany order.

TRANSISTORS

AC128	26p
AC176	26p
BC107	14p
BC108	14p
BC109	14p
BC109C	15p
BC177	14p
BC184	12p
BC187	25p
BC204	14p
BC209C	14p
BC213	15p
BC214	15p
BC262	25p
BC415	16p
BC478	29p
BD131	44p
BD132	54p
BF244A	24p
BF245A	24p
BSY95A	22p
MD8001	172p
OC71	20p
OC72	30p
RFY56A	48p
TIS43	50p
ZTX108	9p
ZTX301	13p
ZTX384	16p
ZTX501	13p
2N2219	27p
2N2646	50p
2N2905	35p
2N2905A	36p
2N2906	22p
2N2907	22p
2N3054	60p
2N3055	60p
2N3702	12p
2N3704	12p
2N3819	35p
2N3820	64p
2N3823E	39p
2N5458	48p

INTEGRATED CIRCUITS

301 8-pin DIL	48p
318 8-pin DIL	230p
320-15	58p
324 14-pin DIL	87p
341-15	195p
709 8-pin DIL	48p
723 T05	105p
723 14-pin DIL	105p
726 T05	980p
741 8-pin DIL	32p
748 8-pin DIL	63p
4024 14-pin DIL	48p
4069 14-pin DIL	18p
4136 14-pin DIL	126p
7805 TO220	205p
7806 TO220	205p
7808 TO220	205p
7812 TO220	205p
7815 TO220	205p
7818 TO220	205p
AY10212 16-pin DIL	650p
AY16721/6	195p
CA3046 14-pin DIL	90p
CA3080 8-pin DIL	82p
CA3084 14-pin DIL	209p
M252 16-pin DIL	680p
MC3340 8-pin DIL	150p
MC3810 24-pin DIL	670p
SG3402N 14-pin DIL	262p
STK025	595p
TDA1022 16-pin DIL	672p
XR2207 14-pin DIL	420p
2N425E 16-pin DIL	375p

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PHONOSONICS

The latest kit innovation!

from **Sparkrite**

the quickest fitting
CLIP ON
capacitive discharge
electronic ignition
in KIT FORM

Introductory
SPECIAL OFFER
£2 OFF Kit



- Smoother running
- Instant all-weather starting
- Continual peak performance
- Longer coil/battery/plug life
- Improved acceleration/top speeds
- Optimum fuel consumption

Sparkrite X4 is a high performance, high quality capacitive discharge, electronic ignition system in kit form. Tried, tested, proven, reliable and complete. It can be assembled in two or three hours and fitted in 1/3 mins. Because of the superb design of the Sparkrite circuit it completely eliminates problems of the contact breaker. There is no misfire due to contact breaker bounce which is eliminated electronically by a pulse suppression circuit which prevents the unit firing if the points bounce open at high R.P.M. Contact breaker burn is eliminated by reducing the current to about 1/50th of the norm. It will perform equally well with new, old, or even badly pitted points and is not dependent upon the dwell time of the contact breakers for recharging the system. Sparkrite incorporates a short circuit protected inverter which eliminates the problems of SCR lock on and, therefore, eliminates the possibility of blowing the transistors or the SCR. (Most capacitive discharge ignitions are not completely foolproof in this respect). The circuit incorporates a voltage regulated output for greatly improved cold starting. The circuit includes built in static timing light, systems function light, and security changeover switch. All kits fit vehicles with coil/distributor ignition up to 8 cylinders.

THE KIT COMPRISES EVERYTHING NEEDED

Die pressed epoxy coated case. Ready drilled, aluminium extruded base and heat sink, coil mounting clips, and accessories. Top quality 5 year guaranteed transformer and components, cables, connectors, P.C.B., nuts, bolts and silicon grease. Full instructions to assemble kit neg. or pos. earth and fully illustrated installation instructions.

NOTE—Vehicles with current impulse tachometers (Smiths code on dial RV1) will require a tachometer pulse slave unit. Price £3.35 inc. VAT, post & packing. Electronic Design Associates, 82 Bath Street, Walsall, WS1 3DE. Phone: (0922) 614791.

Electronics Design Associates, Dept. PE6.
82 Bath Street, Walsall, WS1 3DE. Phone: (0922) 614791.

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Access or Barclaycard No.		Cheque No.

Send SAE if brochure only required.

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ALL EX-STOCK—SAME DAY DESPATCH. VAT 8%

12 AND 24 VOLT OR 12-6-12V PRIMARY 220-240 VOLTS

Ref	12V	24V	£	P & P
111	0.5	0.25	2.80	0.45
213	1.0	0.5	2.64	0.78
71	2		3.51	0.78
18	4		4.03	0.96
70	6		5.35	0.96
108	8		6.98	1.14
72	10		7.97	1.14
116	12		8.99	1.32
17	16		10.39	1.32
115	20		13.18	2.08
187	30		17.05	2.08
226	60		28.82	OA

30 VOLT RANGE

Prim 220/240V Sec 0-12-15-20-24-30V
12V-0-12V or 15V-0-15V available by connection to appropriate taps.

Ref	Amps	£	P & P
112	0.5	2.84	0.78
79	1.0	3.57	0.96
13	2.0	5.27	0.96
20	3.0	6.29	1.14
21	4.0	7.44	1.14
51	5.0	8.37	1.32
117	6.0	9.92	1.45
88	8.0	11.73	1.45
89	10.0	13.33	1.84

50 VOLT RANGE

Prim 220/240V Sec 0-24-30-40-48-60V
24V-0-24V or 30V-0-30V available by connection to appropriate taps.

Ref	Amps	£	P & P
124	0.5	3.88	0.96
126	1.0	5.58	0.96
127	2.0	7.60	1.14
125	3.0	10.54	1.32
123	4.0	12.23	1.84
40	5.0	13.95	1.64
120	6.0	15.66	1.84
121	8.0	20.15	OA
122	10.0	24.03	OA
189	12.0	27.13	OA

SCREENED MINIATURES

Ref	mA	Volts	£	P & P
238	200	3-0-3	1.99	0.55
212	1A	0-6, 0-6	2.85	0.78
13	100	9-0-9	2.14	0.38
235	330, 330	0-9, 0-9	1.99	0.38
207	500, 500	0-8.9, 0-8.9	2.59	0.71
208	1A, 1A	0-8.9, 0-8.9	3.53	0.78
236	200, 200	0-15, 0-15	1.99	0.38
214	300, 300	0-20, 0-20	2.58	0.78
221	700 (DC)	20-12-0-12-20	3.41	0.78
206	1A, 1A	0-15-20-10-15-20	4.63	0.96
203	500, 500	0-15-27-0-15-27	3.99	0.96
204	1A, 1A	0-15-27-0-15-27	5.39	0.96
S112	500	12-15-20-24-30	2.64	0.78
239	50	12-0-12	1.99	0.38

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AVO 8 MK5	£77.00
AVO 71	£31.30
AVO 73	£42.50
AVO MM5	£28.10
AVO TT169 in circuit	£32.50
Transistor Tester	£30.00
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2.5A AC/DC 5000 res. in robust steel case & lead	
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400V	4A	£0.80
400V	6A	£1.05
500V	10A*	£2.35
VAT 12 1/2%	VAT 8% 15p P & P	

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ISOLATOR 1KVA 240V to 240V enclosed style terminal connection Special Offer @ £18.70. Carriage £2.75. Ref B7.

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2A	9.89	1.38
3A	11.47	1.48
4A	13.90	1.84
5A	16.74	2.15
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£	£	£	
2" 0-50uA	5.50	4" 0-50uA	6.70
0-500uA	5.50	0-500uA	6.70
0-1mA	5.50	0-1mA	8.40
0-50V	5.50	0-50V	8.40
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Carriage 65p VAT 8%

Prices correct 7.11.77. Please add VAT after P & P PE1

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07*	20	4.40	0.79
149	60	6.20	0.96
150	100	7.13	1.14
151	200	11.16	1.50
152	250	12.79	1.84
153	350	16.38	1.84
154	500	19.15	2.15
155	750	29.06	OA
156	1000	37.20	OA
157	1500	45.60	OA
158	2000	54.80	OA
159	3000	79.85	OA

*Please specify 115 or 240V required

AUTO TRANSFORMERS

Ref	VA (Watts)	Volts	£	P & P
113	15	0-115-210-240	2.48	0.71
64	75	0-115-210-240	3.95	0.96
4	150	0-115-210-240	5.35	0.96
67	500	0-115-210-240	10.99	1.64
84	1000	0-115-210-240	18.76	2.08
93	1500	0-115-210-240	23.36	OA
95	2000	0-115-210-240	34.82	OA
73	3000	0-115-210-240	48.00	OA

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240V cable in & 115V USA 2 pin outlet

Ref	VA	P	P	Ref
15	4.96	0.96		113W
150	8.48	1.14		4W
200	9.92	1.45		65W
250	10.49	1.45		69W
500	15.73	1.64		67W
750	18.55	1.76		83W
1000	22.68	OA		84W
1500	26.02	OA		93W
2000	37.65	OA		95W

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Prim 200/220V or 400/440V Sec 100/120V or 200/240V

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DIAC	23p
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RESISTORS. 33W 5% 22 ohm to 10M ohm 2p
Push Button, push to make 13p

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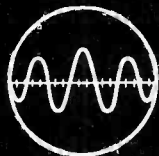
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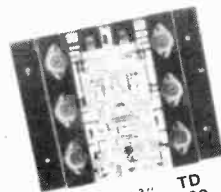
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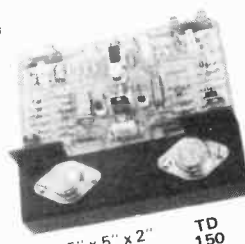


7" x 9" x 1 1/2" TD 500

NEW FROM TUAC ULTRA QUALITY HIGH POWER New D.C. Coupled Design AMPLIFIERS

Featuring Electronic Short Open & Thermal Overload Protection.

Brief Spec.
Input Sensitivity 0.775v. R.M.S. (0.D.B.) at 25 K Ohms
Frequency Response 20 Hz-20 KHz
Hum & Noise - 100 dB Relative full output



5" x 5" x 2" TD 150

T.H.D. at full powr 0.1%
T.D. 500 300W into 2 Ohms
220W into 4 Ohms
Size 7" x 9" x 1 1/2" 140W into 8 Ohms
Power supply P.S. 300
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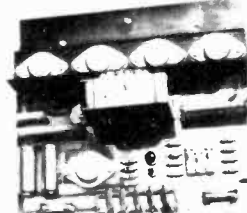
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£15.25

Note P.S. 300 will drive 2 T.D. 150 amplifiers

All output ratings are R.M.S. continuous sine wave output.

AMPLIFIER MODULES



SPEC. INPUT SENSITIVITY 60 mV for full output
Frequency response 20 Hz-20 KHz
HUM & NOISE - 70 dB

TL60 5 x 5 x 3in

• 60 watt R.M.S. continuous sine wave output
• 2 R.C.A. 110 watt 15 amp transistors

£18.25

TL100 5 x 5 x 3in

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• 2 R.C.A. 150 watt 15 amp transistors

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TP125 7 x 6 1/2 x 3in

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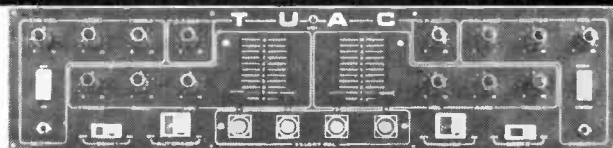
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- Full wave control
- RCA 8A Triacs
- 1000W per channel
- Fully suppressed and fused
- Switched master control for sound operation from 1/2W to 125W
- Speed control for fixed rate sequence from 8 per minute to 50 per second
- Full logic integrated circuitry with optical isolation for amplifier protection

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Model 501 500W per channel as above without sound triggering

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STEREO DISCO MIXER

With touch sensitive switching and auto fade

INPUTS: Four identical stereo inputs available with any equalisation. Two magnetic and two flat supplied as standard. High quality slider control on each channel. Volume, treble and bass controls for each pair of sliders. Sensitivity mag., 3mV (R.I.A. comp.) Flat 50mV at 1kHz. Bass controls ± 18dB at 60Hz. Treble controls ± 18dB at 15kHz.
OUTPUT: Up to 3 volts (± 12dB) available. Attenuated output for TUAC Power Modules. Rotary master and balance controls. Band width 15Hz - 25kHz ± dB.
P.F.L.: Output 250mV into 8 ohms. Rotary volume control. Monitoring facility for all 4 channels. Selection via touch sensitive illuminated switches. Switched visual cue indicator.
Miscellaneous Facilities: Two illuminated deck on/off switches. Mains illuminated on/off switches. Auto fade illuminated on/off switch. Mains powered with integral screen and back cover. Complete with full instructions.
Size: 25in long x 6in high x 3in deep

Mono Disco Mixer with autofade £45.00

£129.00

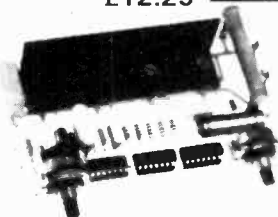
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- RCA 8A Triacs
- 1000W per channel
- Each channel fully suppressed and fused
- Master control to operate from 1W to 125W
- Full wave control

£20.25

Single Channel Version 1500 Watts

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FRONT PANEL FOR LIGHTING EFFECT MODULES

(complete with switches, neons and knobs)
as illustrated



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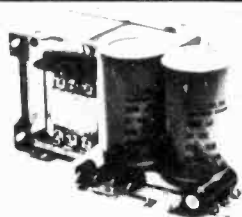


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Red, Green, Blue,
Amber £23.50



S1LMB £7.50
Combined with 3SDM1
Size 9" x 4 1/2"

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- Full logic integrated circuitry
- Dimmer control to each channel

3SDMI

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2BA	852	£0.28	6BA	854	£0.22

SWITCHES

Description	No.	Price
DPDT miniature slide	1973	£0.11*
DPDT standard slide	1974	£0.14*
Toggle switch SPST		£0.33*
1/2 amp 250V a.c.	1975	
Toggle switch DPDT		£0.42*
1 amp 250V a.c.	1976	
Rotary on-off mains switch	1977	£0.50*
Push switch — Push to make	1978	£0.13*
Push switch — Push to break	1979	£0.18*

ROCKER SWITCH	Colour	No.	Price
A range of rocker switches SPST — moulded in high insulation.	RED	1980	£0.26*
Material available in a choice of colours ideal for small apparatus.	BLACK	1981	£0.26*
	WHITE	1982	£0.26*
	BLUE	1983	£0.26*
	YELLOW	1984	£0.26*
	LUMINOUS	1985	£0.26*

Description	No.	Price
Miniature SPST toggle, 2 amp 250V a.c.	1958	£0.50*
Miniature SPST toggle, 2 amp 250V a.c.	1959	£0.55*
Miniature DPDT toggle, 2 amp 250V a.c.	1960	£0.70*
Miniature DPDT toggle, centre off, 2 amp 250V a.c.	1961	£0.85*
Push button SPST, 2 amp 250V a.c.	1962	£0.78*
Push button SPST, 2 amp 250V a.c.	1963	£0.83*
Push button DPDT, 2 amp 250V a.c.	1964	£0.98*

MIDGET WAFER SWITCHES
Single-bank wafer type — suitable for switching at 250V a.c. 100mA or 150V d.c. in non-reactive loads make-before-break contacts. These switches have a spindle 0.25in dia. and 30° indexing.

Description	Order No.	Price
1 pole 12 way	1965	£0.48*
2 pole 6 way	1966	£0.48*
3 pole 4 way	1967	£0.48*
4 pole 3 way	1968	£0.48*

MICRO SWITCHES	Order No.	Price
Plastic button gives simple on-off action		
Rating 10 amp 250V a.c.	1969	£0.20
Button gives 1 pole change over action		
Rating 10 amp 250V a.c.	1970	£0.25

FUSE HOLDERS AND FUSES

Description	Order No.	Price
20mm x 5mm chassis mounting	506	£0.07*
1 1/4 x 1/2 in chassis mounting	507	£0.12*
1 1/2 in in-line type	508	£0.15*
Panel mounting 20mm	509	£0.20
Panel mounting 1 1/2 in	510	£0.30

QUICK BLOW 20mm	Type	No.	Type	No.
	150mA	611	1A	615
	250mA	612	1.5A	616
	500mA	613	2A	617
	800mA	614	2.5A	618

All 5p each excepting 616 which is 7p.

ANTI-SURGE 20mm	Type	No.	Type	No.
	100mA	622	1A	625
	250mA	623	2A	626
	500mA	624	1.6A	627

All 7p each

QUICK BLOW 1 1/4 in	Type	No.	Type	No.
	250mA	631	500mA	632

All 7p each

Type	No.	Type	No.	Type	No.
1A	635	2.5A	638	4A	641
1.6A	636	3A	639	5A	642
2A	637				

All 6p each

CASES AND BOXES

INSTRUMENT CASES. In two sections vinyl covered top and sides, aluminium bottom, front and back.

No.	Length	Width	Height	Price
155	8in	5 1/2 in	2in	£1.52*
156	11in	6in	3in	£2.12*
157	6in	4 1/2 in	1 1/2 in	£1.30*
158	9in	5 1/2 in	2 1/2 in	£1.76*

ALUMINIUM BOXES. Made from bright aluminium, folded construction each box complete with half inch deep lid and screws.

No.	Length	Width	Height	Price
159	5 1/2 in	2 1/2 in	1 1/2 in	62p*
160	4in	4in	1 1/2 in	62p*
161	4in	2 1/2 in	1 1/2 in	62p*
162	4 1/2 in	4in	1 1/2 in	74p*
163	4 1/2 in	2 1/2 in	2in	64p*
164	3in	2in	1in	44p*
165	7in	5in	2 1/2 in	£1.04*
166	8in	6in	3in	£1.32*
167	6in	4in	2in	86p*

MIDGET WAFER SWITCHES

1965	1 pole 12 way	48p*
1966	2 pole 6 way	48p*
1967	3 pole 4 way	48p*
1968	4 pole 3 way	48p*

TRANSFORMERS

MINIATURE MAINS Primary 240V			
No.	Secondary	Price	
2021	6V-0-6V 100mA	90p*	
2022	9V-0-9V 100mA	90p*	
2023	12V-0-12V 100mA	95p*	

MINIATURE MAINS Primary 240V with two independent secondary windings			
No.	Type	Price	
2024	MT1280-0 6V, 0-6V RMS	£1.50*	
2025	MT150-0 12V, 0-12V RMS	£1.50*	

1 AMP MAINS Primary 240V			
No.	Secondary	Price	
2026	6V-0-6V 1 amp	£2.50*	P & P 45p
2027	9V-0-9V 1 amp	£2.00*	P & P 45p
2028	12V-0-12V 1 amp	£2.60*	P & P 55p
2029	15V-0-15V 1 amp	£2.75*	P & P 66p
2030	30V-0-30V 1 amp	£3.45*	P & P 86p

STANDARD MAINS Primary 240V
Multi-tapped secondary mains transformers available in 1/2 amp, 1 amp and 2 amp current rating. Secondary taps are 0-19-25-33-40-50V.

Voltages available by use of taps:
4, 7, 8, 10, 14, 15, 17, 19, 25, 31, 33, 40, 25-0-25V.

No.	Rating	Price	
2031	1/2 amp	£5.50*	P & P 86p
2032	1 amp	£6.60*	P & P 86p
2033	2 amp	£8.40*	P & P £1.10

AUDIO LEADS

107	FM Indoor Ribbon Aerial	£0.60*
113	3.5mm Jack plug to 3.5mm jack plug. Length 1.5m	£0.75*
114	5 pin DIN plug to 3.5mm. Jack connected to pins 3&5. Length 1.5m	£0.85*
115	5 pin DIN plug to 3.5mm. Jack connected to pins 1&4. Length 1.5m	£0.85*
116	Car aerial extension. Screened insulated lead. Fitted plug & skt.	£1.10*
117	AC mains connecting lead for cassette recorders & radios. 2 metres	£0.68*
118	5 pin DIN phono plug to stereo headphone jack socket	£1.05*
119	2+2 pin DIN plugs to stereo jack socket with attenuation network for stereo headphones. Length 0.2m	£0.90*
120	Car stereo connector. Variable geometry plug to fit most car cassette. 3 track cartridge & combination units. Supplied with inline fused power lead and instructions.	£0.60*
123	6.6m Coiled Guitar Lead Mono Jack Plug to Mono Jack Plug BLACK	£1.50*
124	3 pin DIN plug to 3 pin DIN plug. Length 1.5m	£0.75*
125	5 pin DIN plug to 5 pin DIN plug. Length 1.5m	£0.75*
126	5 pin DIN plug to Tinned open end. Length 1.5m	£0.75*
127	5 pin Din plug to 4 Phono Plugs. All colour coded. Length 1.5m	£1.30*
128	5 pin DIN plug to 5 pin DIN socket. Length 1.5m	£0.80*
129	5 pin DIN plug to 5 pin DIN plug mirror image. Length 1.5m	£1.05*
130	2 pin DIN plug to 2 pin DIN inline socket. Length 5m	£0.68*
131	5 pin DIN plug to 3 pin DIN socket. 1 & 4 and 3&5. Length 1.5m	£0.83*
132	2 pin DIN plug to 2 pin DIN socket. Length 10m	£0.98*
133	5 pin DIN plug to 2 phono plugs. Connected pins 3&5. Length 1.5m	£0.75*
134	5 pin DIN plug to 2 phono sockets. Connected pins 3&5. Length 23cm	£0.68*
135	5 pin DIN socket to 2 phono plugs. Connected pins 3&5. Length 23cm	£0.68*
136	Coiled stereo headphone extension lead. Black. Length 6m	£1.75*
178	AC mains lead for calculators etc.	£0.68*

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Containing a range of first quality miniature ceramic capacitors.

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16161 - 24 - 3 of each value - 100pf, 120pf, 150pf, 180pf, 220pf, 270pf, 330pf, 390pf	60p*
16162 - 24 - 3 of each value - 470pf, 560pf, 680pf, 820pf, 1000pf, 1500pf, 2200pf, 2200pf, 3300pf	60p*
16163 - 21 - 3 of each value - 4700pf, 6800pf, 01uf, 015uf, 022uf, 033uf, 047uf	60p*

ELECTROLYTIC PAKS

A range of paks each containing 18 first quality, mixed value miniature electrolytics.

16201 - values from .47mFD	60p*
16202 - values from 10mFD	60p*
16203 - values from 100mFD	60p*
16204 - values from 1000mFD	60p*

CARBON RESISTOR PAKS

These paks contain a range of Carbon Resistors assorted into the following groups.

16213 - 60 mixed $\frac{1}{2}$ W 100ohms - 820 ohms	60p*
16214 - 60 mixed $\frac{1}{2}$ W 1K ohms - 8.2K ohms	60p*
16215 - 60 mixed $\frac{1}{2}$ W 10K ohms - 83K ohms	60p*
16216 - 60 mixed $\frac{1}{2}$ W 100K ohms - 820K ohms	60p*
16217 - 40 mixed $\frac{1}{2}$ W 100 ohms	60p*
16218 - 40 mixed $\frac{1}{2}$ W 1K ohms - 8.2K ohms	60p*
16219 - 40 mixed $\frac{1}{2}$ W 10K ohms - 82K ohms	60p*
16220 - 40 mixed $\frac{1}{2}$ W 100K ohms - 820K ohms	60p*
16221 - 40 mixed $\frac{1}{2}$ W 1 Meg - 10 Meg ohms	60p*
16231 - 40 mixed $\frac{1}{2}$ W 1 Meg - 10 Meg ohms	60p*

COMPONENT PAKS

16164 - 200 Resistor mixed value approx (Count by weight)	60p*
16165 - 150 Capacitors mixed value approx (Count by weight)	60p*
16166 - 50 Precision resistors mixed values	60p*
16167 - $\frac{1}{2}$ W resistors mixed values 80	60p*
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16171 - 10 Reed switches	60p*
16172 - 3 Micro switches	60p*
16173 - 15 Assorted pots	60p*
16174 - 5 Metal jack sockets 3 x 3.5 mm 2 x standard switch types	60p*
16175 - 30 Paper condensers - mixed values	60p*
16176 - 20 Electrolytics trans. types	60p*
16177 - 1 Pack assorted hardware - Nuts/bolts, gromets etc	60p*
16178 - 5 Mains slide switches assorted	60p*
16179 - 20 Assorted tag strips and panels	60p*
16180 - 15 Assorted control knobs	60p*
16181 - 3 Rotary wave change switches	60p*
16182 - 2 Relays 6-24v operating	60p*
16183 - 1 Pak, copper laminate approx 200 sq inches	60p*
16184 - 15 Assorted fuses 100mA 5amp	60p*
16185 - 50 metres PVC sleeving assorted size and colours	60p*

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Containing 50 metal foil Capacitor like Mullard C280 series. Mixed values ranging from .01uf - 2.2uf. Complete with identification sheet. O/N:16204

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16192 - 6 Slider potentiometers all 10K Ohm	60p*
16193 - 6 Slider potentiometers all 22K Ohm	60p*
16194 - 6 Slider potentiometers all 47K Ohm	60p*
16195 - 6 Slider potentiometers all 47K Ohm	60p*

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Type	Price	Type	Price	Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
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AC127	£0.18	BC147	£0.08	BC555	£0.14	8P19	£0.38	TIS43	£0.38	2N3709	£0.07		
AC128	£0.18	BC148	£0.08	BC570	£0.13	8P20	£0.38	TIS90	£0.22	2N3710	£0.07		
AC128K	£0.26	BC149	£0.08	BC558	£0.12	8P19S	£0.38	UT46	£0.22	2N3711	£0.07		
AC132	£0.20	BC157	£0.10	BC559	£0.14	20MP		ZTX107	£0.10	2N3711	£0.07		
AC134	£0.20	BC158	£0.10	BD115	£0.50	BRV39	£0.45	ZTX108	£0.10	2N3819	£0.20		
AC137	£0.20	BC159	£0.10	BD116	£0.50	BU105	£1.70	ZTX109	£0.10	2N3820	£0.35		
AC141	£0.22	BC167	£0.12	BD121	£0.65	BU105/02	£1.95	ZTX300	£0.12	2N3821	£0.60		
AC141K	£0.30	BC168	£0.12	BD124	£0.70	BU204	£1.70	ZTX500	£0.14	2N3823	£0.60		
AC142	£0.20	BC169	£0.12	BD131	£0.65	BU205	£1.40	2N1613	£0.20	2N4058	£0.12		
AC176	£0.18	BC169C	£0.12	BD132	£0.40	BU208/02	£2.95	2N1711	£0.20	2N4059	£0.14		
AC176K	£0.26	BC170	£0.10	BD131P		E122	£0.38	2N1889	£0.45	2N4060	£0.14		
AC178	£0.25	BC171	£0.10	132MP	£0.85	MJE2955	£0.98	2N1890	£0.45	2N4061	£0.12		
AC179	£0.25	BC172	£0.10	BD133	£0.40	MJE3055	£0.60	2N1893	£0.30	2N4062	£0.12		
AC180	£0.20	BC179	£0.16	BD135	£0.35	MJE3440	£0.52	2N2147	£0.75	2N4284	£0.18		
AC180K	£0.28	BC177	£0.16	BD136	£0.35	MP8113	£0.52	2N2148	£0.70	2N4285	£0.18		
AC181	£0.20	BC178	£0.16	BD137	£0.35	MPP102	£0.35	2N2160	£1.00	2N4286	£0.18		
AC181K	£0.28	BC179	£0.16	BD138	£0.40	MPP104	£0.38	2N2192	£0.38	2N4287	£0.18		
AC187	£0.18	BC180	£0.25	BD139	£0.36	MPP105	£0.38	2N2193	£0.38	2N4288	£0.18		
AC187K	£0.20	BC181	£0.25	BD140	£0.36	MPSA05	£0.30	2N2194	£0.38	2N4289	£0.18		
AC188	£0.18	BC182	£0.10	BD139P	£0.30	MPSA06	£0.30	2N2217	£0.22	2N4290	£0.18		
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AD161	£0.42	BC209	£0.12	BD178	£0.68	OC25	£1.00	2N2905	£0.18	2N5136	£0.10		
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AF124	£0.30	BC251	£0.16	BDX77	£0.90	TIC45	£0.35	2N2926B	£0.08	2N5459	£0.35		
AF125	£0.30	BC251A	£0.16	BF457	£0.37	TIP29A	£0.40	2N2926R	£0.08	2N5551	£0.36		
AF126	£0.30	BC301	£0.28	BF458	£0.37	TIP29B	£0.52	2N2926B*	£0.08	2N6027	£0.39		
AF127	£0.32	BC302	£0.28	BF459	£0.38	TIP29C	£0.50	2N3053	£0.16	2N6121	£0.70		
AF139	£0.58	BC303	£0.28	BF594	£0.30	TIP30A	£0.50	2N3054	£0.40	2N6122	£0.70		
AF180	£0.40	BC304	£0.28	BF830	£0.28	TIP30B	£0.60	2N3055	£0.40	40311	£0.38		
AF181	£0.60	BC327	£0.16	BF839	£0.24	TIP30C	£0.60	2N3414	£0.16	40313	£0.95		
AF186	£0.58	BC328	£0.16	BF840	£0.25	TIP31A	£0.45	2N3415	£0.16	40316	£0.95		
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BC108A	£0.08	BC547	£0.12	BFX90	£0.55	TIP42B	£0.55	2N3705	£0.07	40406	£0.45		
BC108B	£0.08	BC548	£0.12	BFY50	£0.16	TIP42C	£0.57	2N3706	£0.08	40407	£0.35		
BC109C	£0.08	BC549	£0.12	BFY51	£0.16	TIP2955	£0.65	2N3707	£0.08	40408	£0.52		
BC109B	£0.08							2N3708	£0.07	40409	£0.75		

MIDGET WAFER SWITCHES

1965 - 1 pole 12 way	48p*
1966 - 2 pole 6 way	48p*
1967 - 3 pole 4 way	48p*
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16140 - 25 NPN TO39 2N2905 silicon	60p
16141 - 30 PNP TO18 2N306 silicon, switching	60p
16142 - 25 NPN 8FV50/51	60p
16143 - 30 NPN plastic 2N3906	60p
16144 - 30 PNP plastic 2N3905 silicon	60p
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7401	£0.14	7410	£0.14	7442	£0.64	7483	£0.85	7494	£0.88	74123	£0.70		
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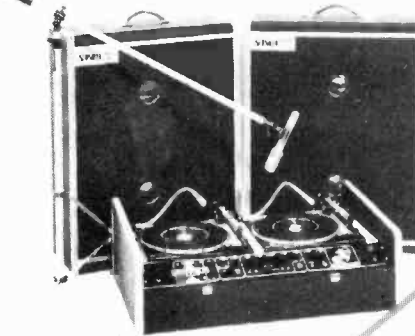


Illustration shows GXL Centaur System

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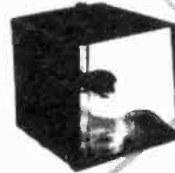
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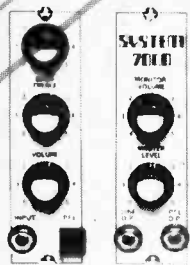
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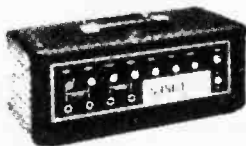
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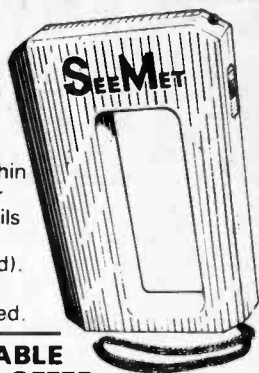
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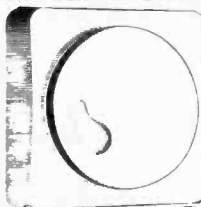
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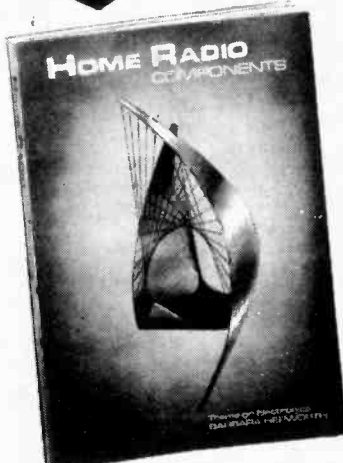
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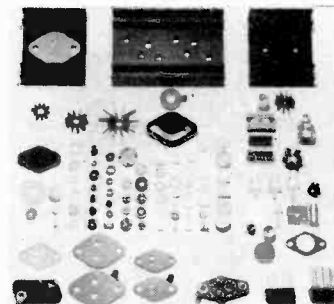
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MONEY

PROBABLY one thing that is of universal interest is cash. As electronics enthusiasts we have particular interests in money. Will the chancellor reduce the tax rate? Surely that interests all earners? Will he change the V.A.T. rates? More about that later. Will the government impose further wage restraints?

We now know the answers to most of these points—this is being written a few days after the budget. Although we doubt if many M.P.s are constructors or, even if they have the interest, have time to read this, however a couple of points are worth making . . .

CAREERS

At the time of writing it is still not obvious if we will be returning to "free collective bargaining". For the last two years many in the electronics industry have found that their qualifications and experience no longer give them any monetary advantage. For some time we have seen the "electronics workers" on the move; more applicants for jobs than ever before simply because it is one way to get ahead financially.

It may be argued that this movement is healthy for the industry although we

doubt it. What it does mean is that people are finding a way of beating the system and that they are finding it necessary to do this.

It has now been suggested that four year degree courses should be introduced. Great, we are in favour. The rate technology is moving we are going to need some of the best, most highly educated people we can find, and make no mistake the British educational system can produce the best. It may mean fewer degrees but we will need the elite; there is already a danger of too many chiefs and too few indians. But will we find these people, can we continue to encourage them to take a degree course, and a longer one than at present—perhaps not if the rewards are not there at the end of the rainbow!

V.A.T.

No doubt many readers, in particular those in the component supply business, will remember all the fuss a while back over the introduction of two rates of V.A.T. to electronic components. It may be necessary to remind some that this system is still in force.

It means that one component—say a loudspeaker—can be subject to different rates if sold for different

applications. It would probably be interesting to carry out a survey now that manufacturers, distributors and retailers have been living with this system for some time. For instance, it may be that proportionately fewer speakers are now made and sold for radio applications—an application that is subject to the higher tax rate—although just as many will find their way into radios. This is no doubt more prevalent in the amateur world than anywhere else.

We can only hope that at some stage someone will be able to make enough fuss about the component situation to get the whole thing reviewed and then maybe, just maybe, we could get back to the lower rate for all components. This would reduce the workload of all concerned in their supply and, most important, reduce the price of some of them to us.

One point that we are thankful for is that this product (P.E.) is not subject to V.A.T. We are sure that all readers will stand behind us on that one, even if their views do not concur with those expressed above.

Mike Kenward

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PRINCIPLE OF OPERATION

The operation is based on the integrator shown in Fig. 1a. The behaviour of this circuit is described by the mathematical expression:

$$V_{OUT} = -\frac{1}{RC} \int V_{IN} dt \quad (1)$$

Solving this equation gives

$$V_{OUT} = -\frac{V_{IN}}{RC} \Delta t \quad (2)$$

By making $V_{OUT} = -V_{IN}$ and rearranging equation 2 as an expression for C, we have:

$$C = \frac{\Delta t}{R} \quad (3)$$

It follows that we can measure the capacitor in the feedback loop of the integrator by measuring the time taken for the output voltage to fall to $-V_{IN}$. The measurement of time interval is the most accurate measurement available and it follows that this need not limit the accuracy and precision of the measurement. In the meter to be described the limitations of accuracy are imposed by the meter movement, range resistors, and timer capacitor, but the accuracy could be greatly improved if required, by measuring time digitally.

CIRCUIT DESCRIPTION AND OPERATION

The operation of the instrument is indicated in the block diagram Fig. 1b. The integrator is fed from a reference voltage generator and the integrator output is compared with this voltage in an inverting comparator. An analogue timer, based on a second integrator, measures the time taken for the output of the integrator to fall to $-V_{REF}$, and the output is shown on a panel meter. In use the unknown capacitor is connected across the input terminals and the RESET/START button depressed. At the end of the measurement period a green l.e.d. indicates that measurement is complete. A second push of the RESET/START button discharges the unknown capacitor and resets the circuit for a further measurement. The reset state is indicated by a red l.e.d. and is automatically entered on initial application of power.

The complete circuit is given in Fig. 2 and its operation is best understood with the aid of the timing diagrams in Fig. 3. The instrument consumes little power and may be battery operated. In Fig. 2, can be seen the supply arrangement and the V_{REF} generator, which is a simple zener diode source buffered by an operational amplifier connected as a voltage follower. The temperature stability of this circuit is not particularly good but is maximised by ensuring a constant Zener current of about 1mA. This is insignificant compared to the performance limitations of the analogue meter movement. If a digital version was constructed it would be worthwhile using a more expensive reference diode here. The reference voltage is adjusted to 1V by VR1. It should be noted that this adjustment is only needed in an analogue instrument because V_{REF} is also used in the time measurement circuit.

The reference voltage is supplied to the first integrator IC2 via the transmission gate IC7a and one of the range resistors. The unknown capacitor is connected as the feedback element of this integrator in parallel with the transmission gate IC7b. The negative going integrator output is compared with V_{REF} at the summing junction of IC3 which operates open loop as a comparator. The output voltage of the comparator is

SPECIFICATION

Ranges	8 ranges: 300pF–3000μF in decade steps
Accuracy*	Typically 2.5% on all ranges (dependent upon meter movement, range resistors and capacitor)
Precision	1% on range 1 (300pF) 0.25% all other ranges
Measurement time	3 seconds max from 3μF–3000μF 300ms all other ranges
Power consumption	25mA max (each battery)

*Precision is defined as the relative standard deviation for repeated measurements on the same capacitor, calculated from the equation:

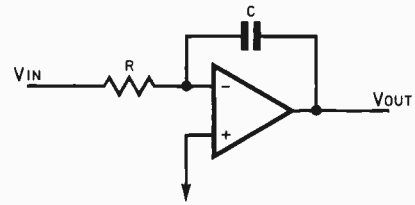
$$\text{Percentage Precision} = \frac{\sqrt{\frac{\sum (x-\bar{x})^2}{n}}}{\bar{x}} \times 100$$

where \bar{x} is the mean of n measurements, and x is an individual measurement. The precision is a guide to the accuracy which can be obtained if measurements are referred to a known value capacitor.

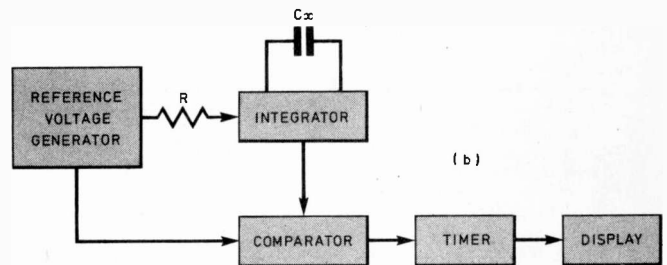
monitored by the indicator circuit comprising R15, R16, TR1 and D3, and is also fed into the NOR gate IC4a. The comparator output is gated with the output of the RESET/START generator, and the resultant output of IC4a is the actual time taken for C_x to charge to the reference voltage (which relates to the value of C_x). In a digital instrument this time would be measured directly with a clock generator.

In the analogue instrument described here, time is measured by the second integrator comprising IC5, C3 and one of the range resistors R10–R14. The way this circuit measures time is apparent from equation 2. We see that in Fig. 1a the output voltage of the integrator is proportional to the time for which the input voltage V_{IN} is connected, for constant R and C . In the meter unit the input voltage to the second integrator is V_{REF} and it is connected through the transmission gate IC7c which is open only during the integration period of the unknown capacitor C_x . This time measuring integrator is reset by the transmission gate IC7d. It is this second integrator which requires V_{REF} to be set accurately to 1V in order to measure time accurately. It is further important that the time measuring integrator capacitor is a precision component. Although 1% precision capacitors are expensive it is worth pointing out that this design requires only one such component in order to cover an eight decade range. This is because the input resistors of the two integrators can both be varied.

In the RESET AND RUN circuitry of Fig. 2 half of a dual JK FLIP FLOP is used, connected as a simple toggle circuit. The initial condition of reset is established by holding the SET input of the CD4027 high during the period when power is first applied. As C5 charges through R22 the output of IC4d eventually goes low which then enables the CLOCK input. The CLOCK input is driven from the output of the monostable comprising IC4b, c, R21, C4 and S3. The input of IC4b at pin 1 is normally held low by R20, C4 is uncharged, and the input applied to IC4c is high. The output of IC4c is therefore low and this is applied to the second input of IC4b. As soon as pin 1 of IC4b receives a positive pulse from S3 via R19, the output goes low (being a NOR gate). This is transmitted via C4, which can only charge slowly via R21, to the input of IC4c whose output therefore goes high. This high is applied to the input of IC4b which therefore remains low even if the other input has now gone high. This condition remains until C4 has charged through



(a)



(b)

Fig. 1 (b) Block diagram of Linear Capacitance Meter

R21 when the circuit reverts to its initial state. The long time constant of C4, R21, was chosen by experience to prevent false output pulses. It is surprising how long human fingers dwell over pushbuttons!

INITIAL RESET

Fig. 3 shows the initial conditions as produced by the "power-up reset" function. The first integrator output V_{INT} is held at zero because IC7b is open and IC7a is closed. The second integrator output is similarly zero. As soon as the push button is pressed the first and second integrators ramp negatively until the first integrator crosses $-V_{REF}$. At this point the comparator IC3 changes state and disables the transmission gate IC7c via the NOR gate IC4a. The timing capacitor C3 remains charged because the off resistance of the transmission gates IC7c and IC7d is extremely high and the input bias current of the CA3140 is extremely low. The output of IC2 continues to ramp negatively until the amplifier saturates. This is close to the negative rail. The circuit is now in a stable state with the meter displaying the measured capacitance. Capacitor C3 will of course be discharging slowly, but the rate is measured in only fractions of a millivolt per second. In the author's instrument no discernable movement of the pointer takes place in a one minute period after completion of a measurement. A second press of the push button initiates a reset and returns the circuit to its initial state ready for the next measurement.

CONSTRUCTION

The circuit was built on a piece of stripboard measuring 36 conductors by 43 holes (see Fig. 4.) and then mounted against the back of the meter, using the meter screws for fixing. The case size or shape is not too important, but the prototype used a plastics box of dimensions 172 × 100 × 55mm, and was fairly compact at this size. The battery holders were clamped under a stiff cardboard plate, and fastened by two 6BA nuts and screws.

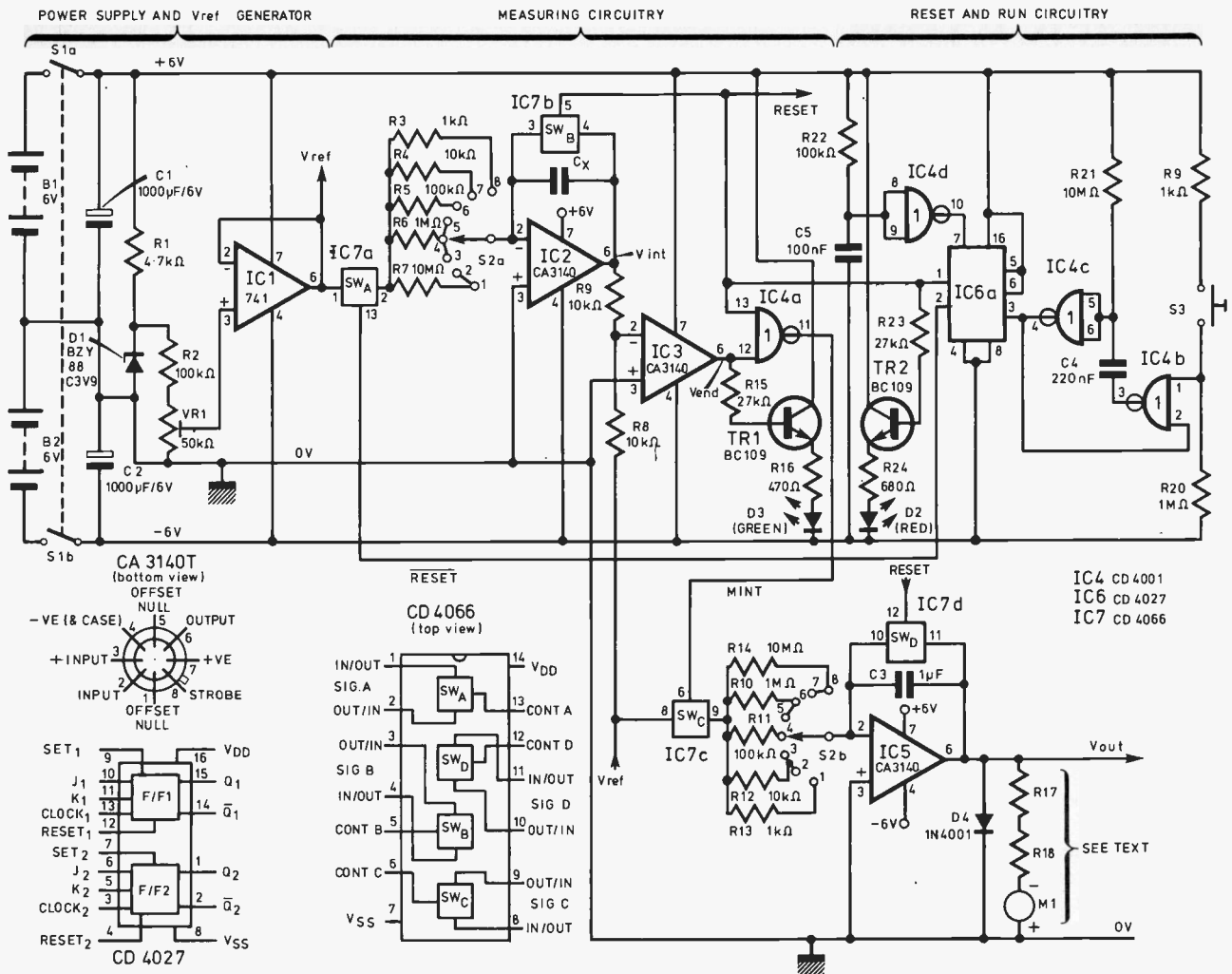
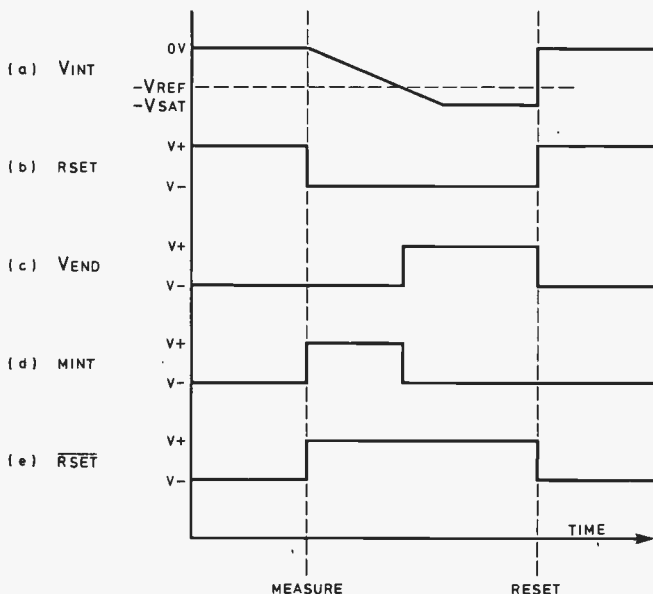


Fig. 2. Circuit diagram. Cx is the capacitor under test. The MINT line is the measurement period integration signal

Fig. 3. Timing diagram



COMPONENT SELECTION

A number of components call for some comment, and a few are best selected during setting up of the meter. The use of the relatively new CA3140 operational amplifier is of prime importance in the design. This device is one of a new family of BIPOLAR amplifiers which incorporate the advantages of MOS and BIPOLAR technologies on a single chip. They seem destined to take over from the 741 in many areas because they can offer greatly improved performance, albeit currently at somewhat increased cost. Both integrators in the present circuit use the CA3140 to minimise errors caused by the integrator capacitor charging (or discharging) via the input bias current of the amplifier. The maximum input bias current for the device is 50pA (typical 10pA) at 25°C compared with 1μA for the standard 741. This current is small compared with the smallest charging current used in the circuit, which is 100nA, and therefore is not a significant source of error. The CA3140 also has a very creditable slew rate of 9V/μS making it some 15-18 times faster than the 741, and therefore quite useful as a comparator. In this circuit the positive and negative extremes of the comparator output are directly compatible with the CMOS logic circuits. The CA3140 does contain MOS transistors in its input stage and is susceptible to the same problems of static as any CMOS logic i.e.

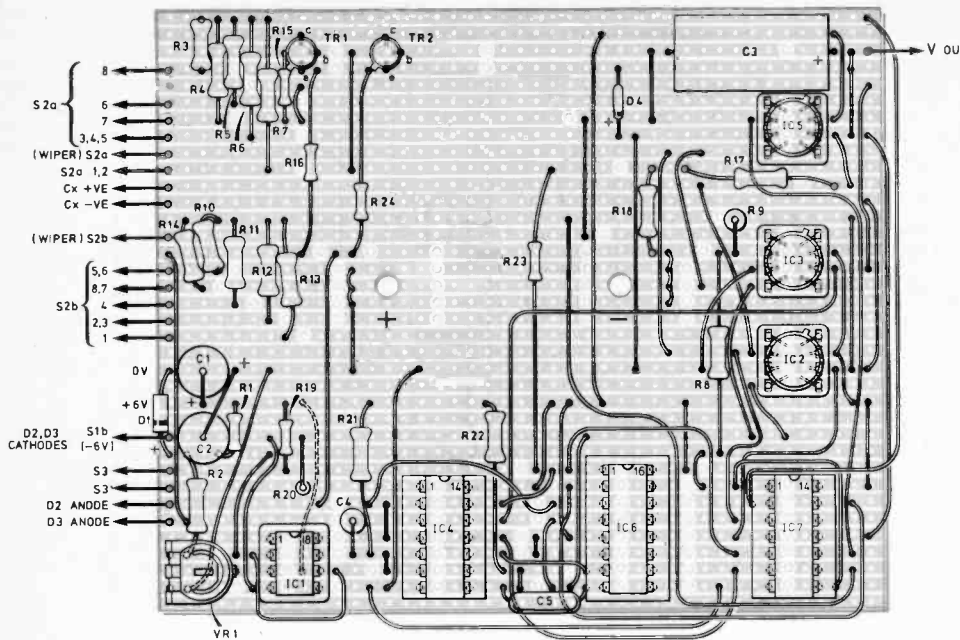
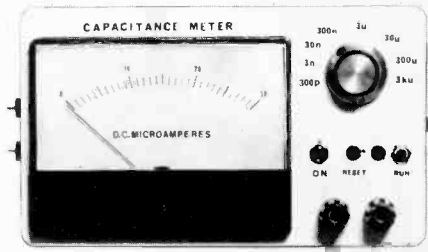


Fig. 4. Component layout (actual size). Ensure that the fixing holes are spaced correctly for the meter being used

TABLE 1. METER RANGES		
switch positions	output voltage	f.s.d. with 30µA meter (see text)
1	1V/100pF	300pF
2	1V/1nF	3nF
3	1V/10nF	30nF
4	1V/100nF	300nF
5	1V/1µF	3µF
6	1V/10µF	30µF
7	1V/100µF	300µF
8	1V/1000µF	3000µF



C=?

Electrolytic capacitors may have tolerances as wide as -25 + 100%. In multiple time constant systems the meter can be used to ensure that, for example, "period A" really does outlive "period B" when near-value capacitors are used

In general the accuracy of the instrument is dependent on the range resistors, the timer capacitor C3, and the reference voltage VREF. The latter can be set accurately if the constructor has access to a digital voltmeter, otherwise it can be set up with a multimeter to ±2%. The range resistors should be high stability 2% metal oxide types and could be selected with a digital multimeter to advantage. Note, however, that the range resistors are in series with the transmission gates IC7a and IC7c. They therefore define the charging currents only when they are large compared with the "on" resistance of the gates. The typical resistance of a CD4066 at room temperature can be as much as 550Ω. Ideally this device should be selected for low "on" resistance but if this is impracticable the most serious error occurs on range 1 and this can easily be circumvented.

When range 1 is selected the input resistor of the second integrator is nominally 1kΩ. Thus with a typical CD4066 the actual input resistance defining the charging current would be about 1.12kΩ with a worst case of 1.55kΩ. This would obviously give rise to errors of 12% and 55% respectively, with the indicated capacitance being too small. The simplest solution is to select this resistor by direct calibration with a known capacitor. This is quite simple on this particular range because silver mica capacitors of 100pF-200pF of 1% tolerance are cheaply and easily available.

The procedure for calibrating the instrument on this range is therefore as follows. Using 1kΩ as the range resistor, press the RUN button and record the reading. Now reset the meter by pressing the button again and place a known 100pF (or similar value) capacitor across the input terminals and press the button. The difference between the second and first readings should be the value of the capacitor. If the reading is too low reduce the value of the range resistor and vice versa. Alternatively a 1kΩ skeleton preset could be fitted. Note that the reason for making two measurements

is that the circuit does not contain provision for eliminating stray wiring capacitance which will be of the order of 5-10pF. This only affects the lowest range and can be otherwise neglected.

The meter multiplier resistances R17, R18, have not been defined because the actual values will depend on the meter movement used. This is not critical since the output of the second integrator is of low impedance and can swing close to the negative rail. Thus any voltmeter with a sensitivity of 5V f.s.d. or better could be used directly without R17/R18, because the output is defined in terms of volts/µF according to Table 1. Alternatively if a current meter is available the multiplier resistors R17/R18 must be used. Two resistors have been specified because in general it is not possible to select a single resistor from the preferred values available to make a meter multiplier. Note that it is essential to know or to measure the internal resistance of a current meter in order to calculate the multiplier resistance. This should be borne in mind if a purchase is made since many of the cheapest meters available through retail outlets do not have this information supplied. The method of calculating R17/R18 is best illustrated by example. The author had available a 30µA movement of internal resistance 1400Ω. This is converted to a 3V f.s.d. meter by a multiplier resistor fulfilling the equation:

$$E_{f.s.d.} = I_{f.s.d.} \times (R_{meter} + R_{multiplier})$$

where $E_{f.s.d.}$ is the required full scale deflection voltage, and $I_{f.s.d.}$ is the meter sensitivity for full scale deflection. Thus in the present example

$$3.0 = 3.0 \times 10^{-5} (1400 + R_{multiplier})$$

$$\therefore R_{multiplier} = 10^5 - 1400 = 98600\Omega$$

COMPONENTS . . .

Resistors

R1	4.7k Ω
R2	100k Ω
R4, R8, R9, R12	10k Ω 2% m.o. (4 off)
R5, R11	100k Ω 2% m.o. (3 off)
R6, R10	1M Ω 2% m.o. (2 off)
R7, R14	10M Ω 2% m.o. (2 off)
R3, R13	1k Ω 2% m.o.
R15, R23	27k Ω (2 off)
R16	470 Ω
R17, R18	see text
R19	1k Ω
R20	1M Ω
R21	10M Ω
R22	100k Ω
R24	680 Ω

All resistors $\frac{1}{4}$ W 5% unless otherwise stated. R7 and R14 may be difficult to obtain and so selection from 5% tolerance resistors may be necessary

Potentiometer

VR1 50k Ω min preset

Capacitors

C1, C2	1,000 μ F/12V elect (2 off)
C3	1 μ F 1% polycarbonate (Electrovalue)
C4	220nF polyester
C5	100nF polyester

Transistors and diodes

D1	BZY88 C3V9
D2	l.e.d. red
D3	l.e.d. green
D4	1N4001
TR1, TR2	BC109

Integrated circuits

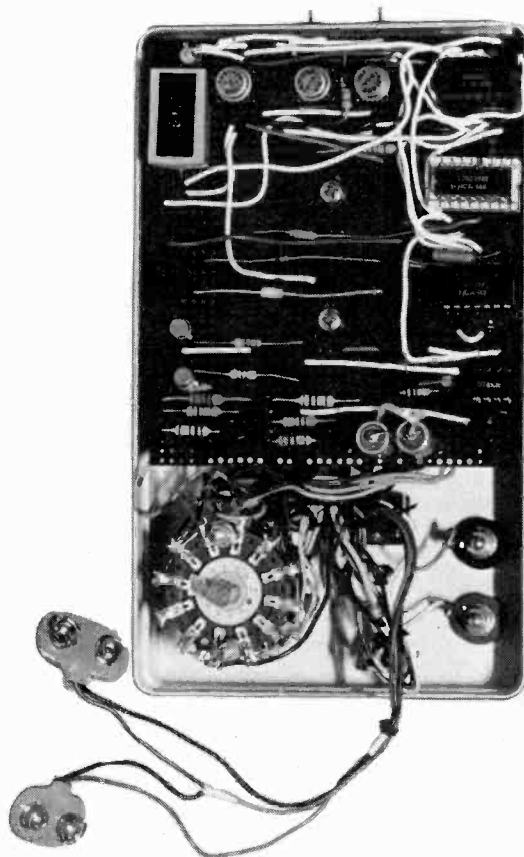
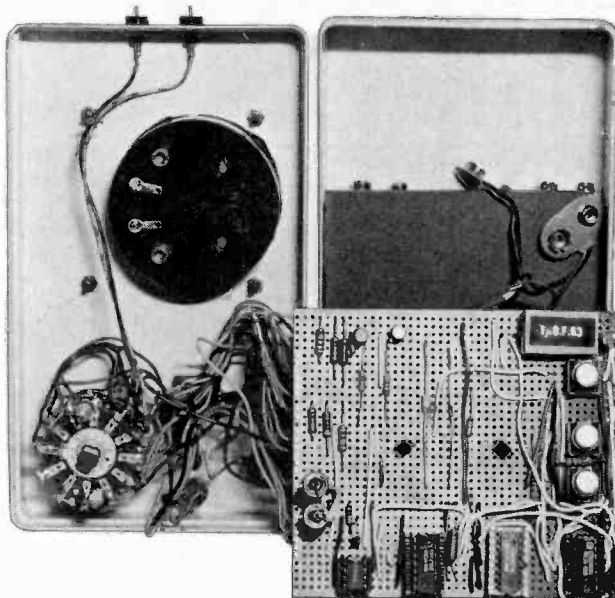
IC1	741
IC2, IC3, IC5	CA3140 (3 off)
IC4	CD4001
IC6	CD4027
IC7	CD4066

Switches

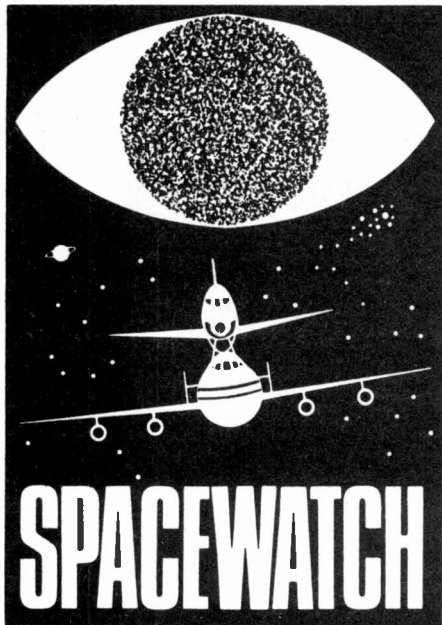
S1	d.p.s.t. switch
S2	2-pole 8-way (make before break)
S3	push to make (momentary contact) switch

Miscellaneous

B1, B2 4 off HP7 each. Battery holder to suit 4mm terminals red, black
1mm sockets red, black
Pointer knob
Meter (see text)
Clips for l.e.d.s
Plastics box (prototype used 172 \times 100 \times 55mm)
Stripboard 0.1in matrix



This can be made up from 91k Ω and 7.5k Ω to an acceptable accuracy from E24 resistors. It is worthwhile making the output voltage of the final integrator available externally if a digital voltmeter is available, because although the accuracy of the instrument is limited, the precision or reproducibility is very high indeed. This makes it possible to measure capacitors to better than $\pm 0.2\%$ providing a known standard capacitor is available to correct the readings. ★



FRANK W. HYDE

SKYLAB

In March this year space engineers of the USA successfully re-established contact with Skylab. The space station has been dormant for four years. It was necessary to do this as a first step towards the boosting of the vehicle to a higher Earth orbit.

In April a further manoeuvre was made. Another will be needed in or about October 1979. These actions are required because Skylab is losing height faster than was predicted when it was launched in May 1973.

At that time it was expected that Skylab would remain in stable orbit until the 1980s when the Shuttle would be available to assist.

The fear that made these decisions necessary was that Skylab might make an unscheduled and perhaps disastrous re-entry and not burn up without mishap. The effect of the early demise of Cosmos 954 no doubt has had some effect on the decision about Skylab. It is perhaps relevant to point out that large units may not completely burn up and that some 5 to 10 per cent may fall to Earth. Should the second action on Skylab, in April, subsequently prove ineffective then the vehicle can be targeted to remote regions of the oceans.

The first corrective move commenced in March. A series of commands were sent to Skylab to activate the receivers and speaker systems. It was expected that the telemetry system would operate even after the interval of four years. The condition of the temperatures and pressures, the orientation of the vehicle in space and the gas that was still available for its thruster motors. The first command did in fact bring a response but this was lost after two minutes.

As the space station passed over the

Bermuda tracking station some 92 minutes later a second command was sent. There was a "hum" response but no data. The flight control then resorted to the back-up system for communication. This was entirely successful. Further commands were then sent to charge the station's batteries from the solar panels. Finally the computer was checked out on March 13th.

If the plans work out successfully then Skylab may have a second lease of life. Studies are already being undertaken as to how the station could be used in conjunction with the European Spacelab brought up in the Shuttle.

If the problems are solved then Skylab might well become the first space platform for the construction of large space structures to collect energy from the Sun or as a launch pad for other missions.

COSMOS 954

The post mortem on Cosmos 954 has so far yielded a few scraps and a little information. The parts that have been found have been radio active at about 20 roentgens/hour. One large piece found in a crater two metres in diameter showed a level of 100 roentgens/hour and was removed in a safety package for examination. New equipment was sent out to search for parts which might have been buried in the ice.

From the information available it has been estimated that the satellite was of 6,000 kilogrammes. Specialists have estimated that a satellite of such mass would have a residue of 5 to 10 per cent which was not vaporised. It would seem therefore that it was as the USSR said, the satellite was intended and indeed did burn up almost completely on re-entry.

The nuclear reactor on board was thought to be about 50 kilogrammes of enriched uranium. It is worth noting that a killer satellite could be used in emergencies of the Cosmos 954 type. It is perhaps a significant point that a few days after the scare the Soviet Union launched Cosmos 967, and in a circular orbit at 66 degrees from the equator. Eight days later Cosmos 970 was launched into a highly elliptical orbit inclined at 65 degrees to the equator. Before one whole revolution had been completed Cosmos 970 had been moved to a more circular orbit and at the same inclination as Cosmos 967, so that it passed close to Cosmos 967. On command from control on the ground Cosmos 970 blew up. It was considered that this was a satisfactory indication that Cosmos 967 would have been destroyed had control so wished when they were close together.

It should be noted that both the USSR and the USA are examining the use of high energy laser beams for use against spacecraft. Already a level of generation has reached hundreds of joules per pulse.

The USA has been attempting to close the gap in defence against satellite vulnerability. One of the most sensitive areas is that of solar "sails". Although they are transparent to most forms of radiation they

are susceptible in the region of the wavelengths which absorb power. The positive step is to remove the solar arrays and use radio isotope generators. Already two US satellites have been fitted with such generators and a range of new applications were planned with generators from 10 to 100 kilowatts. However, President Carter has proposed a ban on reactors in orbit. This is ironic because the USSR has already adopted the thermal isotope generator. At least ten of the recent launchings have had them.

SHUTTLE BOOKINGS IN ADVANCE

The US Space Agency is now taking reservations for the years 1982 and 1983. This information comes from the manager of flight cargo schedules, Chester M. Lee.

Iran and West Germany have made partial payments for 1982/83 launches. Japan is considering a spaceflight in 1983. Canada, India and the European Space Agency (ESA) have also reserved Shuttle flights.

Mr Lee said: "We have all the cargo we can handle for 1980 and a few spaces left in 1981."

The Goddard Memorial Symposium on the international uses of the space shuttle and space laboratory drew 400 participants from the United Kingdom, Italy, Canada, Germany, France, India, Japan and the United States. The prime topic at the symposium was the European Spacelab, built by ESA to fly in the Shuttle's cargo bay. This multi-purpose facility will be used for experiments in Earth observations, astronomy, physics, solar and atmospheric chemistry, biology and space manufacturing.

NASA and ESA will equally share the first Spacelab flight, now scheduled for December 1980. Spacelab 1 will be truly of an international content. Spacelab 2, scheduled for April 1981 will carry the experiments of 47 USA scientists and 12 United Kingdom scientists. Among the principal investigators are Allen Gabriel of the Appleton Laboratory and Peter Willmore of the University of Birmingham. Spacelab 1 will be carried by Shuttle Orbiter 102. It is being built in California. The first of its six test flights will take place in June 1979.

JUPITER: PLANET OR STAR

A Soviet scientist has produced some evidence to add to the theory that Jupiter is a star rather than a planet. The suggestion is that Jupiter is either a star in formation or a dying one.

Professor N. Kozyrev of the Leningrad Pulkovo Observatory told a scientific meeting that the nucleus of Jupiter has a temperature of 196,000 degrees Centigrade. The professor constructed a mathematical model of Jupiter's nucleus and the results of using this model seem to agree with those obtained from astrophysical observations and also from details of the Jupiter heat stream recorded by Pioneer 10 and Pioneer 11 probes.

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Entries must be written/drawn clearly on one side of plain paper with the entrant's full name and address at the top of every sheet. Each entry to comprise:

- a brief summary of the design (about 50 words);
- any such further descriptions, drawings, sketches, photographs and circuit diagrams, etc., you consider the judges may need to form the best appraisal of your design. **DO NOT SEND ACTUAL MODELS.**

Each entry must have a properly completed entry coupon cut from P.E. firmly affixed to the back of the summary. Entrants may be requested to supply prototypes for evaluation at later stages of the judging. All entries must be in English.

Readers may be assured by P.E. that ideas submitted will not be misused or transmitted to other parties by anyone concerned with the competition.

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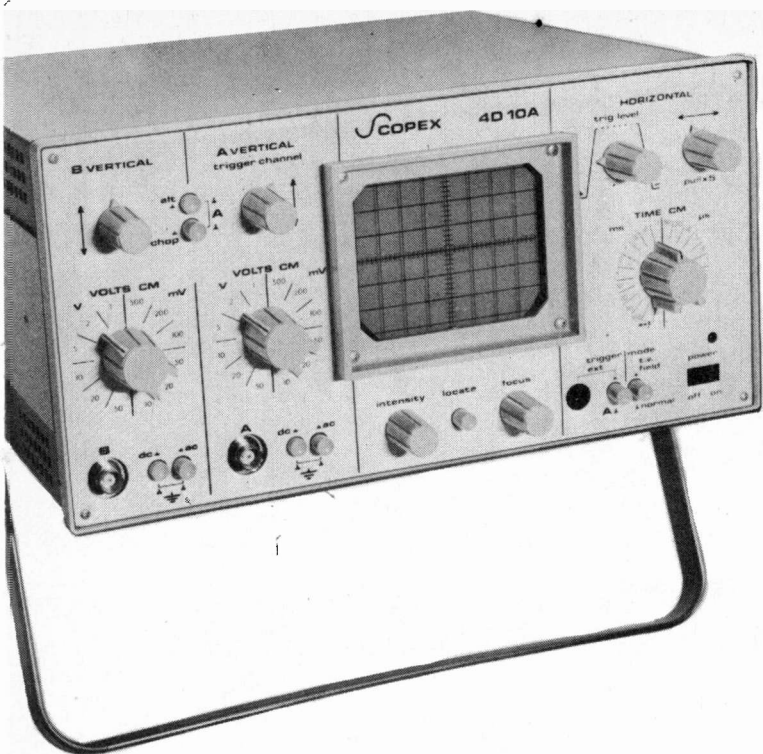
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SECOND CHANCE

Another free entry coupon will appear next month.

The closing date is August 31st 1978.

RULES AND CONDITIONS

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All accepted entries will be examined by a panel of expert judges including the Editor of Practical Electronics, and assessed on (a) originality of the idea, (b) technical merit, (c) practicability, (d) economic viability, (e) market potential, (not necessarily in that order). The prizes will be awarded for the best entries in order of merit. In the event of the same idea being submitted by two or more entrants, presentation of the entry (clarity, best expression, etc.) will decide such winner(s) or winning order.

In the event that the judges consider there are not enough entries of a sufficiently high standard, the Editor reserves the right not to award any prize(s) at his discretion.

Entries arriving after closing date will not be considered, nor will any received that are illegible, not wholly understandable, are not accompanied by a properly completed entry coupon or in any other way do not comply exactly with the instructions and rules.

No responsibility can be accepted for entries lost or delayed in the post or otherwise; proof of posting will not be accepted as proof of receipt. No entries can be returned.

The competition sponsors reserve the right to adapt or amend any entry—after judging has been completed—for purposes of publication and/or commercial development. They also reserve the right to consider any other entries for commercial production. Where any idea is adapted or developed for commercial production payment and/or royalties and/or direct involvement in the company concerned will automatically be negotiated with the designer or person named on the entry coupon.

Winning entries will not necessarily be developed commercially, but Practical Electronics will pay the usual reproduction fee for any entries published.

Ideas already covered by a patent owned by the representer, but not already in or on offer for commercial production, may be submitted but this fact must be clearly stated together with the relevant patent number.

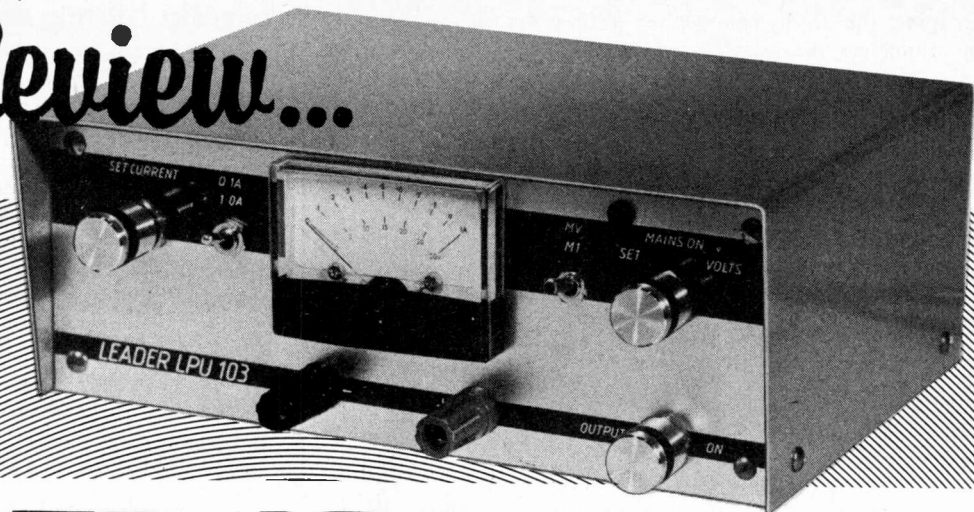
Decisions of the judges, and of the Editor in all other matters affecting the competition, will be final and legally binding. No correspondence will be entered into nor interviews granted.

Winners will be notified by post and brief details of winning entries published later in Practical Electronics.

The contest is open to all readers, but those outside the U.K. may be requested to provide a British address to which any prize may be sent. Development of any idea must take place within the U.K.

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Kit Review...



LEADER 103 P.S.U.

THE LPU103 power supply unit reviewed here is one of a new range of kits available from Arrow Electronics. The company claim the kits are of "bug proof" design and because they are only supplied in kit form the minimum of components have been used whilst still retaining a high standard in both performance and reliability.

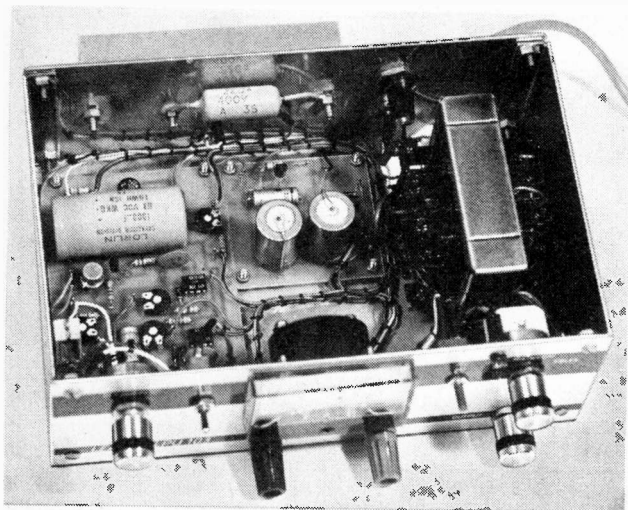
Nickel cadmium batteries can also be recharged using the p.s.u. with the charging voltages and currents being displayed on the meter of the instrument.

SPECIFICATION

The output voltage of the LPU103 is variable from 0 to 30V with current limiting available in two ranges: 0 to 100mA and 0 to 1A.

The unit can sustain short circuits at full current for considerable lengths of time but because of heat dissipation, when the short is removed the meter calibration will alter by 3-5 per cent until the case temperature is reduced.

Therefore sufficient space must be left around the unit to allow adequate air circulation.



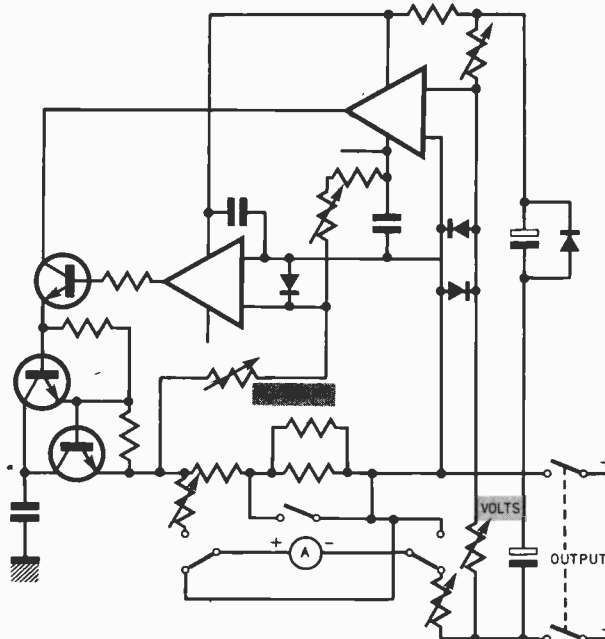
CIRCUIT DETAILS

The circuit of the LPU103 is designed around two 741 operational amplifiers connected as differential voltage comparators, one to control the current and the other the voltage. The outputs of these two i.c.s are fed to a triple Darlington of which one transistor, a 2N3055, is used as the series pass transistor and is mounted on a heatsink.

The problem of output transients when switching the unit on is eliminated by the inclusion of an output switch. This switch allows the unit to be on continuously with the output terminals only showing a voltage when it is on.

TOOLS

The only tools required to build the unit are, small wire cutters, a suitable earthed soldering iron with a 3/32 inch bit, fine nosed pliers, screwdriver, 4BA spanner and, to avoid



Circuit diagram of the LPU103

damaging the front panel when fitting the switches and potentiometers, the correct sized spanners.

The kit includes solder, plenty of wire and also rubber sleeving for the soldered joints.

ASSEMBLY INSTRUCTIONS

If any type of kit is to be constructed successfully clear instructions are of paramount importance. Therefore before starting to build the unit the instructions were read through carefully and using the component list provided each part was checked and identified. The p.c.b.s were also checked for any short or open circuit.

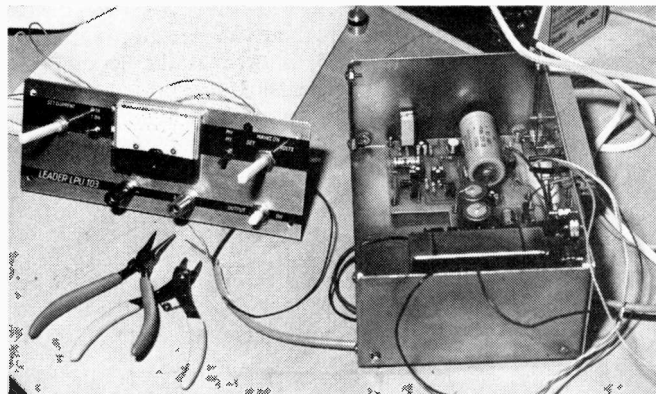
The instructions advised that all the components should be placed so that their values or type printed on the body can be read from above the board to enable them to be easily checked in case of incorrect positioning; with this noted the first of the two p.c.b.s could be soldered.

The assembly instructions are very comprehensive and any constructor who reads them carefully should have no difficulty in successfully building the kit.

CONSTRUCTION

Vero pins were supplied for connecting wires to and from the p.c.b.s and these were inserted using a layout drawing to ensure correct positioning and then soldered to give a good connection to the track.

The instructions gave a point by point soldering guide with a p.c.b. component layout for visual checking.



The only criticism of the p.c.b. assembly was the fitting of a 1000 μ F 63V capacitor which according to the instructions should be soldered second. As this is such a large component it was felt that this would hamper the assembly of the rest of the board and so noting its position the board was soldered leaving this capacitor to be fitted last.

After both p.c.b.s had been soldered they were cleaned and checked for any shorts and then placed to one side and the front panel assembly started.

As the front panel of the unit is anodised, care was taken to avoid handling it with dirty hands or marking it when fitting the switches, potentiometers and sockets.

The heatsink and transformer were already mounted onto the chassis so only the power transistor and p.c.b.s had to be fitted. The main p.c.b. had to be filed on one corner to enable it to fit correctly. With this completed the unit was ready for wiring.

To reduce the noise to a minimum in the finished unit the position and length of the interconnecting wires is of prime importance and for this reason the length of every wire used is given.

With the wires soldered into position and sleeved where appropriate the unit was then ready for testing.

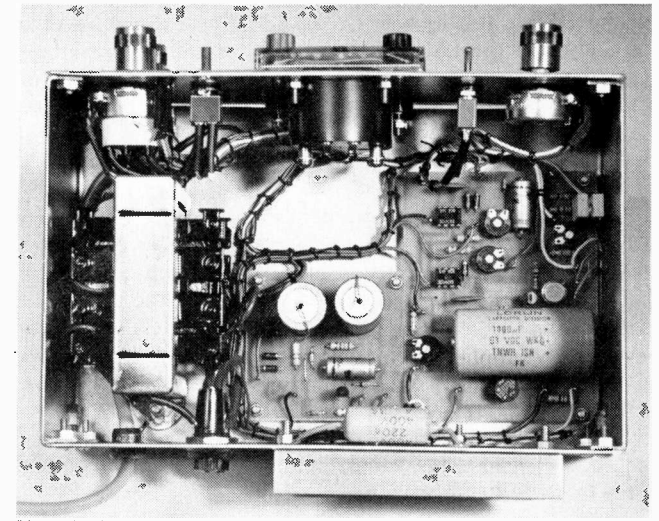
TESTING AND CALIBRATION

All the supply connections were rechecked and using a multimeter both phases of the mains lead and earth were tested for shorts. The interconnecting wires were also checked to ensure they were soldered correctly.

With the testing completed without problems the unit was connected to the supply and as the unit worked first time the voltage and current outputs were calibrated.

The final test to be carried out on the p.s.u. was to check the output noise level.

The reading obtained for the output noise was outside the manufacturer's stated limit. The instructions advised that this figure could be improved by adjusting the front panel wiring and after several attempts the best reading obtained was 0.15mV which was inside the stated limits.



FINISHED UNIT

The LPU103 is a rugged reasonably priced instrument capable of meeting the needs of most constructors. The specification matches many of the more expensive ready built units available. As each kit is housed in an attractive hammer finished case with a distinctive red stripe across its front panel, constructors can if they wish build up a complete range of matching test equipment.

The LPU103 kit can be obtained from Arrow Electronics Limited, Leader House, Coptfold Road, Brentwood, Essex. Price £29.99 (including VAT and Post and Packing).

FOOTNOTE

Peter Clarke of Arrow tells us that he had so many problems trying to get instructions for his kits printed that eventually, being faced with a further three weeks delay, he went out and bought himself a printing machine and the equipment to make the plates. He then taught himself how to print and printed the instructions, all within a week.

It's good to hear of a company that is prepared to take such steps to supply the goods.

★

WORK FOR PE!
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THE EDITOR

POTTERY has become a very popular hobby with many amateur potters now possessing their own small electric kilns. Many such kilns are only supplied with an indicating pyrometer and have no automatic temperature control. The sight of a kiln which has been forgotten and gone above its firing temperature is heart-breaking because the clay melts (vitrifies) at high temperatures and can cause many pounds worth of damage to the inside of the kiln.

The unit described here does two things. Firstly, it enables a control temperature to be set, and holds the kiln at this temperature; secondly, it enables the potter to "soak" his glazes, thus improving the glaze quality. The controller can also be used with enamelling kilns.

THE PYROMETER

It is assumed that a thermocouple and indicator (indicating pyrometer) are already fitted to the kiln. Fig. 1 shows how the voltage across the indicating meter varies with temperature. This particular pyrometer is for a stoneware kiln capable of reaching 1300°C, so the thermocouple will be of the platinum-rhodium type.

CIRCUIT DESCRIPTION

The complete circuit diagram of the controller is shown in Fig. 2. The unit is connected directly across the pyrometer meter at points A and B using nickel-plated terminals and a short length of single-core screened cable. With the high input impedance of IC1 (when used as a voltage follower) the connection of the controller across the meter will not affect the meter reading. No cold-junction temperature compensation has been included since it is assumed that the controller

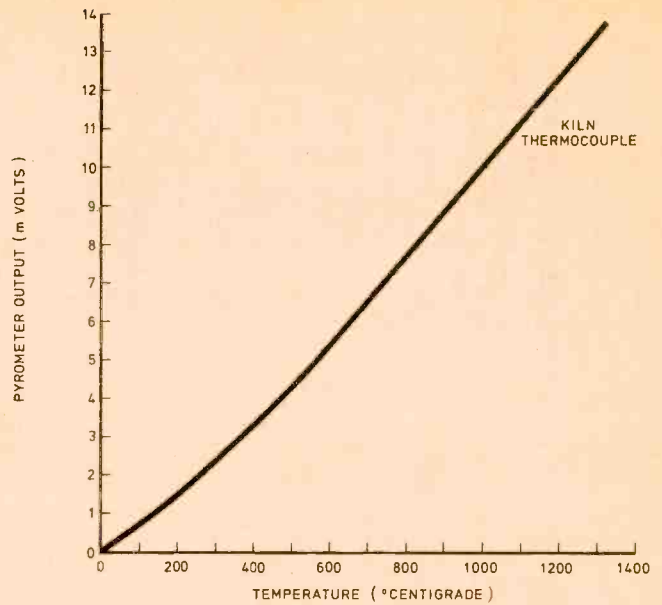


Fig. 1. Graph showing the millivolt/temperature curve of the platinum-rhodium thermocouple

will always be working above 1000°C, therefore compensation will have little effect.

The output of IC1 is amplified 100 times by IC2. The voltage variation at the output of IC2 is therefore 0.1-1.3 volts



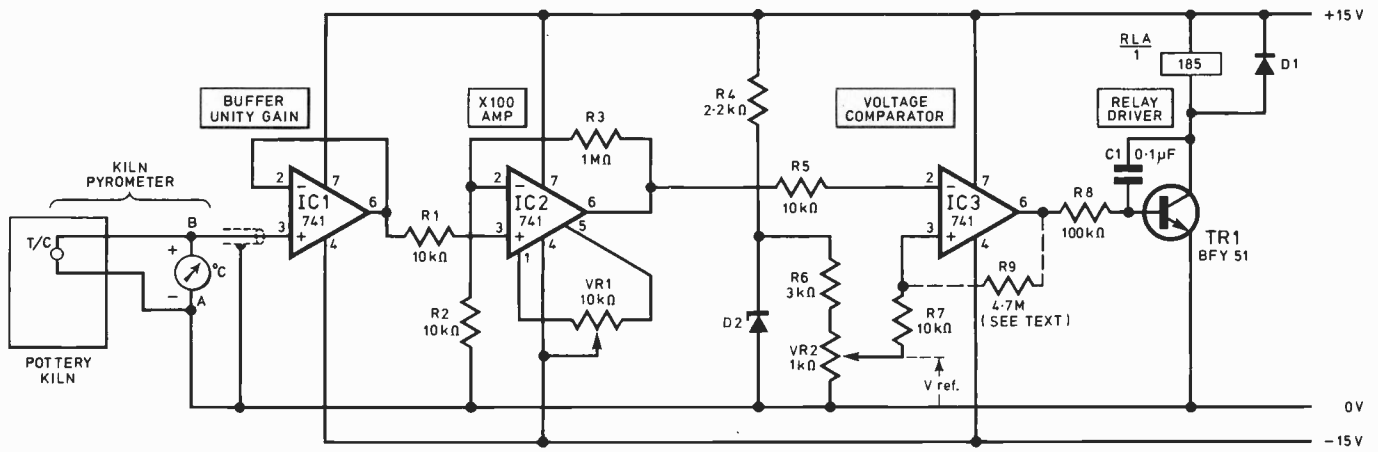


Fig. 2. Circuit diagram of the controller

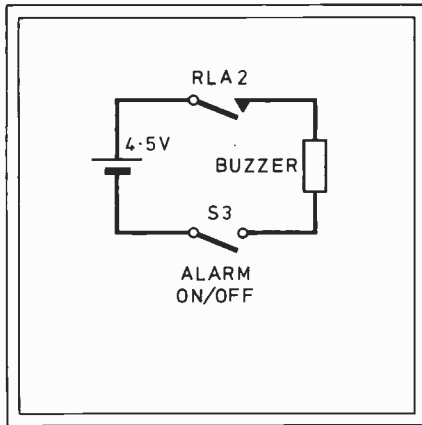


Fig. 3. Kiln up to temperature alarm (optional)

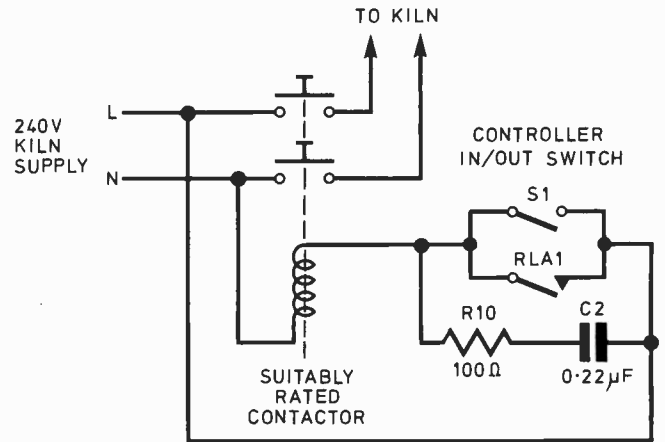


Fig. 4. Wiring diagram of the kiln contactor

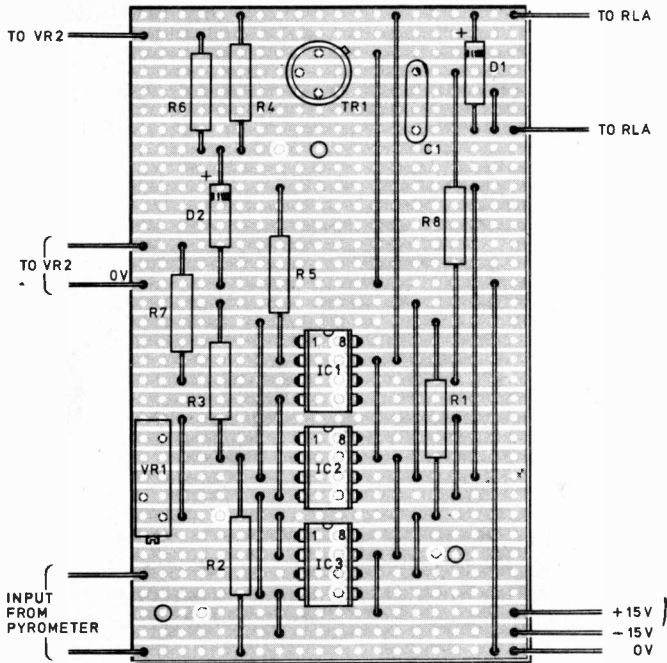


Fig. 5. Main circuit board

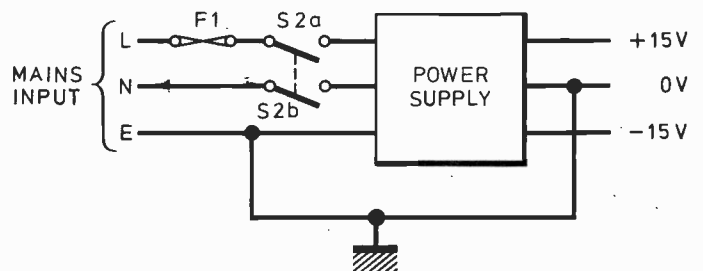
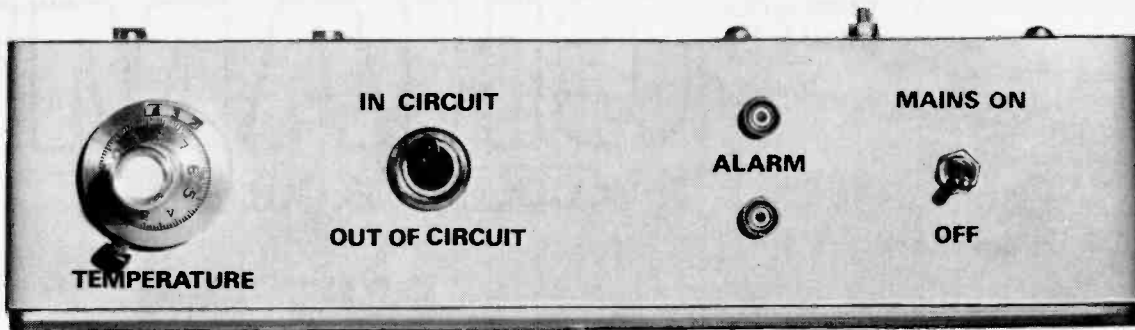


Fig. 6. Wiring diagram of power supply unit

for the thermocouple response shown in Fig. 1. IC3 acts as a voltage comparator with its reference voltage derived from a temperature-compensated, 6.2 volt, zener diode.

When the voltage of pin 2 of IC3 goes positive with respect to pin 3 (reference) then the output of IC3 will go negative, turning off TR1, de-energising RLA and switching off the kiln. On the author's controller no hysteresis was included as the relatively long thermal time constant of the thermocouple and kiln prevented erratic operation. However, hysteresis may be added by the inclusion of R9 if erratic operation occurs. VR2 should be a ten-turn wirewound potentiometer fitted with a turns counting dial.



COMPONENTS . . .

Resistors

R1, R2, R5, R7, R8	10k Ω (5 off)
R3	1M Ω
R4	2.2k Ω
R6	3k Ω (see text)
R9	4.7M Ω (see text)
R10	100 Ω
All 5% $\frac{1}{4}$ W carbon	

Potentiometers

VR1	10k Ω 20-turn cermet trimmer $\frac{3}{16}$ in
VR2	1k Ω 10-turn wirewound

Capacitors

C1	0.1 μ F ceramic
C2	0.22 μ F 45V polycarbonate

Semiconductors

D1	1N4148
D2	1N821 (6.2V Zener)
TR1	BFY51

Integrated Circuits

IC1, IC2, IC3	741 op amp (3 off)
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Switches

S1	5A toggle
S2	1A toggle D.P.S.T.
S3	Single pole on/off toggle

Miscellaneous

Heavy duty relay RS type 348-920 with mounting plate and socket
 Chassis mounted fuse holder (2 off)
 100mA fuse (2 off)
 Turns counting dial for VR2
 Thermocouple
 Outlet plug and socket
 Diecast box 180 × 120 × 60mm
 Contactor (if req.)

Constructor's Note

A suitable *outlet plug and socket* can be obtained from **Harrison Mayer**, Craft and Education Division, Uttoxeter, Meir, Stoke-on-Trent.

The catalogue number is 365741.

CONSTRUCTION

In the prototype the components were soldered on to 0.1in. matrix stripboard using the layout shown in Fig. 5.

After soldering, the board was mounted into a 180 × 120 × 60mm diecast box and secured in position using 6BA countersunk screws and spacers. The heavy duty relay was fitted into the case on a mounting plate and socket.

The mains power supply used in the prototype was a fully encapsulated commercial unit, but any regulated dual supply with an output current of 100mA could be used. The mains input to the power supply was protected with two 100mA fuses fitted into chassis mounted fuse holders.

If the kiln to be used is fitted with safety switches on the doors a mains contactor is normally fitted in the back compartment. If it is not, a suitably rated contactor should be fitted into the back compartment and can either be permanently wired to the controller using high temperature cable or by using an outlet plug and socket. If a plug and socket is to be used care should be taken to ensure that it is capable of handling the high temperatures involved. For this reason it is recommended that constructors use the type given in the component list.

A "kiln up to temperature" alarm circuit is shown in Fig. 3. This unit can be incorporated into the controller if required using the relay contact RLA2. The 4.5V battery, switch 3 and the buzzer were all enclosed in a separate case outside the unit.

SETTING UP

Those constructors with access to a high impedance d.c. millivoltmeter or a d.v.m. can produce a millivolt/temperature curve for their own thermocouple.

If a chrome-alumel thermocouple is used its output will be approximately four times that shown in Fig. 1 and the resistor R6 should be lowered so the reference voltage V can be varied from zero to Vt:

$$\text{Where } V_t = \text{mV} \times 100.$$

At the highest working temperature needed.

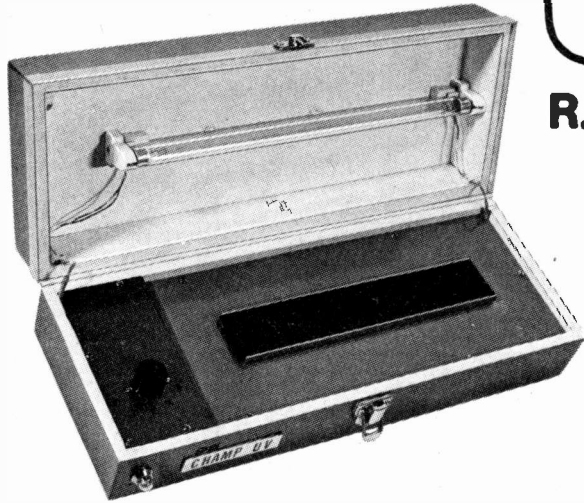
With R6 selected the input leads should be shorted together and VR1 adjusted to give zero volts at the output of IC3. The unit can either be calibrated by applying known millivolt levels to the input of the IC1 and adjusting VR2 until the relay de-energises or it can be directly calibrated in use from the pyrometer reading.

When in use the controller should be placed a short distance away from the kiln, otherwise the components will become overheated.

Finally a table (or graph) showing the setting of VR2 against temperature cut-out should be produced. ★

PE CHAMP

R.W. COLES B. CULLEN



CHAMP—U.V.

THE combination of CHAMP and CHAMP-PROG produces a microprocessor development system which can be used not only to experiment with software techniques, but also to produce other working microprocessor systems with dedicated PROM based programs and hardware interface circuitry which has been fully tested in advance on the CHAMP breadboard.

This month we conclude the CHAMP series with a deeper examination of the uses to which CHAMP-PROG can be put, and with the constructional details of the CHAMP-U.V. PROM erasing system.

USING CHAMP-PROG

You may remember that in part one of the CHAMP series we stated that CHAMP-PROG extended the CHAMP system not only in its role as a PROM programmer but also as a system for copying data *already* stored in a PROM *back* into the CHAMP program RAM. A facility for copying data into RAM makes the whole system even more flexible and allows the following:

- (i) Programs can be "dumped" into a PROM to release the valuable CHAMP CMOS RAM area for more pressing jobs with the knowledge that the original programs can be easily reloaded into RAM when necessary.
- (ii) PROMS can be modified by loading their contents into CHAMP RAM, making the necessary changes, and then reloading the erased PROM with the updated contents.
- (iii) PROMS can be "insert/delete" edited using the relocating ability of the PROMPT program.
- (iv) PROMS can be duplicated by first copying them into RAM and then using CHAMP-PROG in the usual way.

The PROMPT software published last month does not have the ability at present to load data back into RAM, because there simply was not room in the single 4702A chip to do this. The PROMPT program is, however, laid out in such a way that it is very easy to produce a new version, say PROMPT II, which *will* perform this useful function. Before you start to groan at the prospect of *another* financial outlay for software, remember that if you already have a CHAMP-PROG and PROMPT, then PROMPT II will only cost you the price of

PART TEN

an additional PROM because of course you can now do all the programming yourself! In addition, the generation of PROMPT II makes an excellent introduction to the use of the CHAMP-PROG system, and so we have treated the production of this new firmware as a worked example accordingly.

WUNBYTE II

If you examine the flowchart and listing of PROMPT published last month you will notice that the only part of the program directly involved with the programming hardware is the subroutine WUNBYTE which addresses the source and destination, and generates with software the accurately timed program-enable pulse. To generate the new PROMPT II firmware all that is required is the replacement of this subroutine by a new one which transfers data in the other direction. The new subroutine can be called WUNBYTE II and does not need to be as lengthy or as complex as the original because there is no longer a need for the program-enable timing counter. A listing of the new subroutine is shown in Fig. 10.1. and as you can see WUNBYTE II starts at the same address as WUNBYTE so that the JMS WUNBYTE call is still effective. The new subroutine is shorter than the original, but this is of no consequence because the BBL instruction will pop the stack as usual, and operations will recommence at the line immediately following the JMS.

Apart from the new subroutine and an area of blank space following it, the rest of PROMPT II is identical to the original PROMPT, and of course the new PROM is destined for the same socket on the CHAMP main board, where it can be used alternately with the original when required.

PROGRAMMING SEQUENCE

To create PROMPT II the following sequence must be followed.

- (i) Connect up CHAMP-PROG to CHAMP and connect the mains supplies. Ensure that CHAMP and PROMPT are in their respective sockets on the CHAMP main board, and place an erased PROM in the CHAMP-PROG programming socket.
- (ii) Switch on CHAMP and enter the 56 lines of WUNBYTE II into CHAMP program RAM starting at, say, address 200H (you could of course start *anywhere* in the CHAMP RAM space).
- (iii) Press RESET then TEST to enter PROMPT, turn on the CHAMP-PROG mains, and then enter Adr1, Adr2 and Adr3 as follows to copy WUNBYTE II into the new PROM at location 15AH.

Adr1 = 200H (for example)

Adr2 = 237H (200H + 56 decimal)

Adr3 = 05AH (destination in PROM)

(Remember to turn the PROM POWER switch to the ON position immediately before pressing the ENTER DATA button after Adr3 has been keyed in).

MCS 40 PROGRAM SHEET						
TITLE			WUNBYTE II			DATE 09 01 78
(ALTERNATIVE TO WUNBYTE FOR PROMPT)						PAGE NO. 1 OF 3
HEX	BIN	MEMORIC				
PAGE	LINE	ROM CODING	LABEL	OPERATION	OPERAND	COMMENTS
1	4					* THIS SUBROUTINE CAN BE USED IN PROMPT INSTEAD OF WUNBYTE & HAS THE EFFECT OF LOADING SOURCE DATA IN PROM BACK INTO CHAMP PROGRAM RAM *
	1					
	2					
	3					
	4					
	5					
	6					
	7					
	8					
	9					
A						Adr 1 = Start of source in PROM
B						Adr 2 = End of source
C						Adr 3 = Start of destination in RAM
D						
E						
F						
1	5					ORIGINAL PROMPT
	1					
	2					
	3					
	4					
	5					
	6					
	7					
	8					
	9					
1	5	A	WUNBYTE	LDM	1	PROM → RAM ROUTINE
B		FD		DCL		ADDRESS 4265 No 1
C		28		FIM	8	
D		80		B	0	
E		29		SRC	9	LOAD PORTS W&X
F		A3		LD	3	WITH SOURCE ADDRESS

MCS 40 PROGRAM SHEET						
TITLE			WUNBYTE II			DATE 09 01 78
						PAGE NO. 2 OF 3
HEX	BIN	MEMORIC				
PAGE	LINE	ROM CODING	LABEL	OPERATION	OPERAND	COMMENTS
1	6	E4		WRO		
	1	A2		LD	2	IN P.R.O.M.
	2	E5		WR1		
	3	D2		LDM	2	ADDRESS 4265 No 2
	4	FD		DCL		
	5	29		SRC	9	
	6	0B		SBI		SECRET REG. BANK 1
	7	EC		RDO		READ PROM (1 st NIBBLE)
	8	F4		CMA		COMPLEMENT IT
	9	B1		XCH	1	PUT IN REG 1
A		ED		RD1		READ PROM (2 nd NIBBLE)
B		F4		CMA		COMPLEMENT IT
C		BO		XCH	0	PUT IN REG 0
D		DO		LDM	0	
E		FD		DCL		
F		28		FIM	8	SELECT DATA RAM
1	7	0		I	0	CHIP 0 REG 1 CHAR 0
	1	29		SRC	9	
	2	A1		LD	1	
	3	E0		WRM		STORE 1 st NIBBLE FOR MATCH
	4	69		INC	9	NEXT RAM CHAR
	5	29		SRC	9	
	6	AD		LD	0	STORE 2 nd NIBBLE FOR MATCH
	7	E0		WRM		
	8	28		FIM	8	
	9	00		O	0	ADDRESS CORRECT
A		29		SRC	9	PROGRAM RAM
B		AE		LD	E	DESTINATION CHIP
C		E1		WMP		
D		2D		SRC	D	SELECT PROGRAM RAM
E		A1		LD	1	BYTE
F		E3		WPM		WRITE 1 st NIBBLE

(iv) When the "done" message is displayed, turn the PROM POWER switch to the OFF position and then press RESET and TEST to re-enter PROMPT. Enter the following addresses to copy the part of PROMPT before WUNBYTE into the new PROM, and then initiate programming in the usual way.

Adr1 = 100H (start of PROMPT)

Adr2 = 159H

Adr3 = 000H (start of PROMPT II)

(v) When "done" is displayed once more, turn the PROM POWER switch to the OFF position, and then press RESET and TEST to re-enter PROMPT. The following addresses are then entered to program the remaining part of PROMPT into the new PROM in the usual way.

Adr1 = 1A6H (start of MATCH)

Adr2 = 1FFH (end of PROMPT)

Adr3 = 0A6H

(vi) When "done" is again displayed turn off the PROM power and remove the newly programmed PROM. PROMPT II now lives!

USING PROMPT II

Apart from the subroutine WUNBYTE, the new PROMPT II is identical to the old one, and addresses are entered exactly as before with the same meanings:

Adr1 = start of source data

Adr2 = end of source data

Adr3 = start of destination area

The important difference is of course that the *source* addresses now refer to a PROM in the programming socket, and the *destination* address refers to a location in CHAMP program RAM. This also means that the most significant digit of addresses 1 and 2 is redundant and can be set to anything (usually zero to avoid confusion), and that the most significant digit of Adr3 now becomes important and is used to select the destination chip in CHAMP program RAM. Provided you think in terms of source and destination rather than RAM and PROM no confusion should arise when swapping

MCS 40 PROGRAM SHEET						
TITLE			WUNBYTE II			DATE 09 01 78
						PAGE NO. 3 OF 3
HEX	BIN	MEMORIC				
PAGE	LINE	ROM CODING	LABEL	OPERATION	OPERAND	COMMENTS
1	8	A0		LD	0	
	1	E3		NPM		WRITE 2 nd NIBBLE
	2	00		NOP		
	3	00		NOP		
	4	0E		RPM		READ DATA BACK
	5	B5		XCH	5	FOR LUTCH CHECK
	6	0E		RPM		
	7	B4		XCH	4	
	8	28		FIM	8	
	9	20		Z	0	
A		29		SRC	9	STORE MATCH DATA
B		A5		LD	5	IN DATA RAM
C		E0		WRM		
D		69		INC	9	
E		29		SRC	9	
F		A4		LD	4	
1	9	0		WRM		
1	9	1		BBL	0	END OF WUNBYTE II
	2					
	3					
	4					
	5					
	6					
	7					
	8					
	9					
A						
B						
C						
D						
E						
F						

Fig. 10.1. WUNBYTE II program listing

from one PROMPT version to the other! Data transfer is initiated as usual by the depression of ENTER DATA after keying in Adr3, although now the "done" message is displayed almost immediately because the transfer to RAM is very much faster. When using WUNBYTE II, there is no need to turn the PROGRAM POWER switch to ON of course, since all the necessary power is supplied by CHAMP itself.

OTHER POSSIBILITIES

No doubt many readers have spotted the fact that with extra PROM space available on CHAMP, the two versions of PROMPT could both be available simultaneously, and of course there would be no need to duplicate all of the original PROMPT, only the WUNBYTE II would be needed, with some means of selecting *which* subroutine is used by PROMPT when it is run. (This would require a reference to switches, and the ENTER DATA and ENTER ADDRESS buttons could easily be redefined for this purpose.)

Of course the addition of an extra PROM or PROMS is a major modification to CHAMP, but this could nevertheless be done without too much trouble.

If you *did* add this extra PROM it would of course be mostly empty, and then your thoughts could turn to what other goodies you could add to the system. How about a WUNBYTE III which would not *transfer* data but simply check one area against another, thus providing a new VERIFY facility in fact. Or how about a WUNBYTE IV which would be used to move data around in CHAMP RAM and would not need the benefit of CHAMP-PROG at all. Insert/delete editing would be possible with WUNBYTE IV providing some spare locations were left at the start of a program (think about it). Flow charts for these other WUNBYTE variants are shown in Fig. 10.2 and these could be the source of a lot of fun for CHAMP users, with many other possibilities no doubt suggesting themselves as experience is gained.

PROM ERASER

An essential companion to a PROM programmer like CHAMP-PROG is of course a PROM eraser, and fortunately these units are not difficult to build. All that's really required is a lightproof box with a short wave ultraviolet (U.V.) lamp mounted inside it and a resting place for the PROMS being erased. We decided against the minimal "lash up" approach to the design of an eraser at a very early stage for two very important reasons:

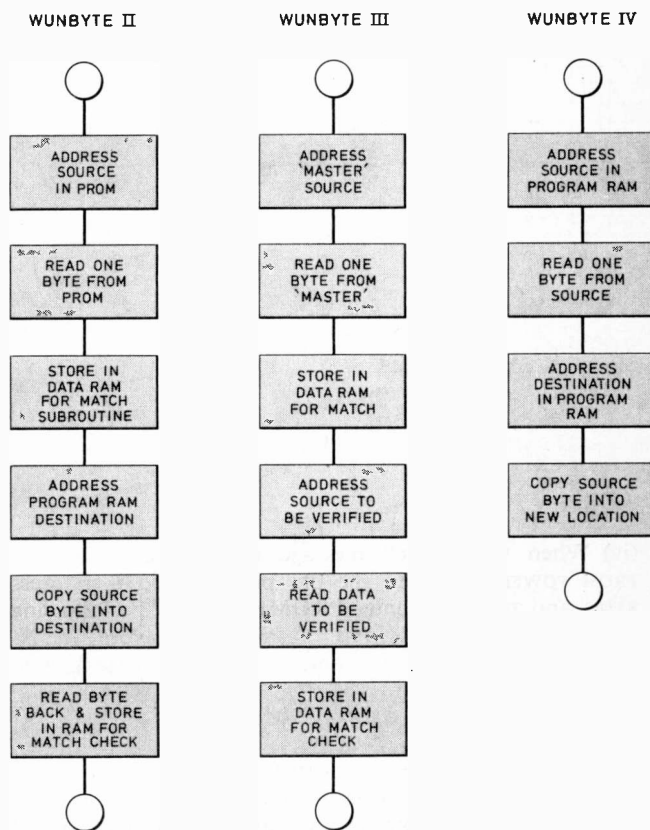
- (i) Short wave U.V. light at the correct wavelength of 2537 Angstroms can be harmful to living organisms, and this of course includes CHAMP programmers!
- (ii) Over exposure of 4702A PROMS to the erase light can shorten their life.

In order to avoid the implications of both (i) and (ii), a good deal of thought was put in to make CHAMP-U.V. safe for both the programmer *and* PROM. Technically, there is no real problem to building a PROM eraser, short wave lamps are available from specialist companies such as Anderman who seemingly stock them primarily for medical purposes. The lamps resemble normal 8 watt fluorescent strip lights, and use exactly the same miniature 2-pin base, and the same ballast choke and starter. Lamp power is provided by the usual 240V a.c. mains supply. The required integrated light dose, which is defined as intensity \times exposure time, is stated by Intel to be six Watt-Seconds per square centimetre, and this can be provided quite quickly by the small 8W tubes when they are placed within 1in of the PROM.

CHAMP U.V.

CHAMP-U.V. is built in a plywood case measuring 380 \times 140 \times 100mm and is completely self contained. Eye safety is ensured by the use of a microswitch which will not allow the lamp to light until the lid is closed and secured. PROM safety is ensured by the incorporation of a clockwork timeswitch which allows "set-and-forget" erasing to be undertaken.

Fig. 10.2. Flowcharts for WUNBYTEs II, III & IV. Note: WUNBYTE IV makes a RAM block-move possible. Source and destination blocks can overlay each other, but with an incrementing address counter data can only be moved *down* in RAM, if over-writing unused source data is to be avoided. Modifying PROMPT to permit address decrementing would be possible, and would allow data to be moved *up* (i.e. to a higher start address). WUNBYTE IV allows program blocks to be moved aside to make room for single extra instructions when required

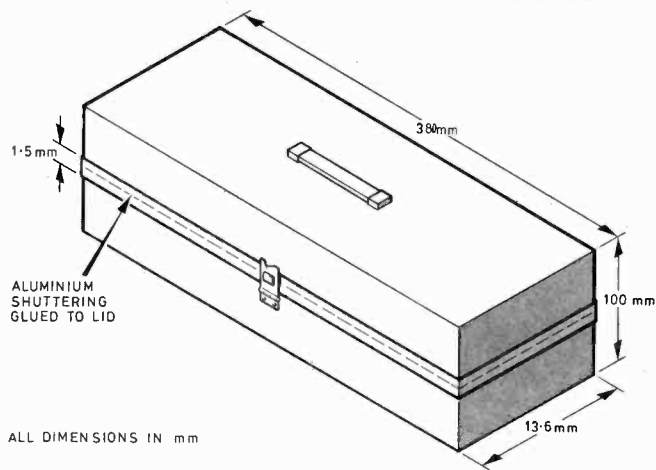


The circuit of CHAMP-U.V. is shown in Fig. 10.4, and as you can see, after the complexities of CHAMP and CHAMP-PROG, CHAMP-U.V. should come as a spot of light relief! The microswitch, which is operated by the box lid, is in series with the mains input, as is the clockwork timer. The neon mains indicator is wired to show that mains is applied correctly when the lid is closed, and not to show that the time-switch is still on. The timeswitch itself makes a distinct sound rather like the ticking of a time-bomb when active, and so there seemed little need for additional facilities to announce the end of an erase cycle. The timeswitch can be set by means of a knob inside the case to provide erase cycles ranging from zero to thirty minutes, with periods of about twenty minutes being the norm for 4702A devices.

The lamp is mounted lengthways in the lid of the case and provides a full 200mm of active length for the erasure of PROMS. A total of twelve PROMS can be erased simultaneously when required, and these are mounted on a strip of conductive plastics foam which is located immediately under the tube when the lid is in the closed position.

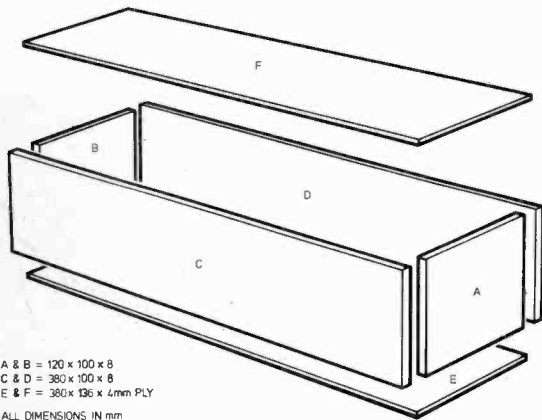
CONSTRUCTION

The CHAMP-U.V. case is made from 8mm plywood and is pinned and glued together using simple butt joints. The best way to build the case is to start by assembling the body and the lid as one piece and then to saw the resulting box completely through to separate the lid. Plywood runners are



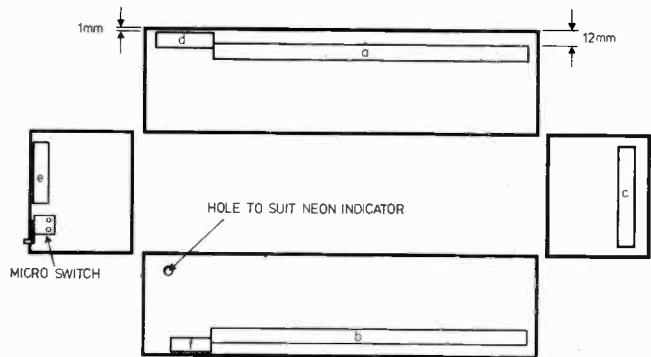
(a) Basic case dimensions

ALL DIMENSIONS IN mm



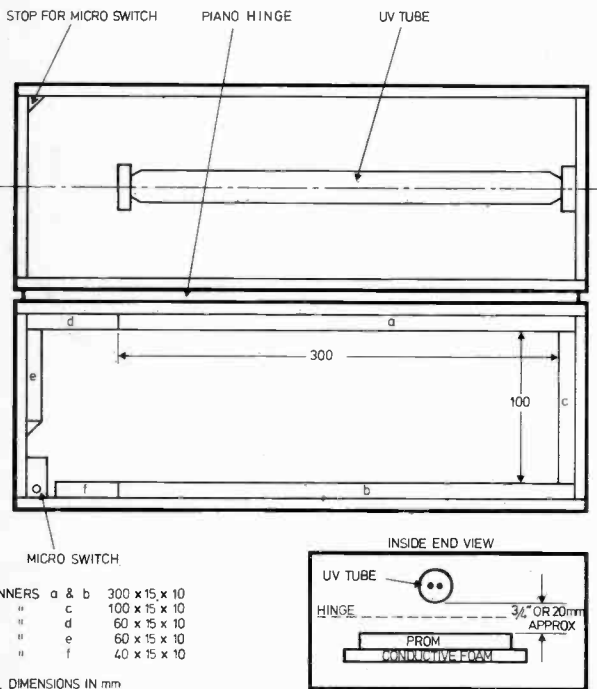
A & B = 120 x 100 x 8
 C & D = 380 x 100 x 8
 E & F = 380 x 136 x 4mm PLY
 ALL DIMENSIONS IN mm

(b) Plywood parts

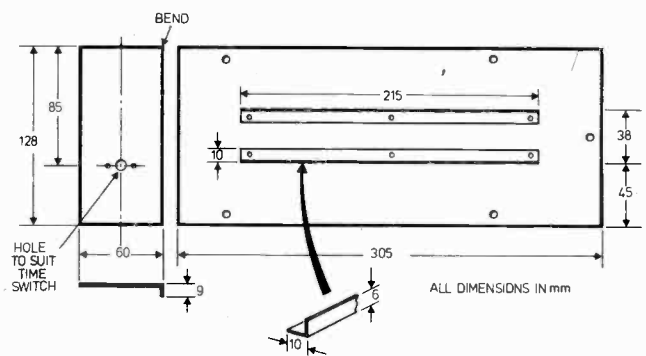


(c) Runner positions

Fig. 10.3. Constructional details of CHAMP-U.V.



(d) Internal layout of case



(e) Aluminium parts

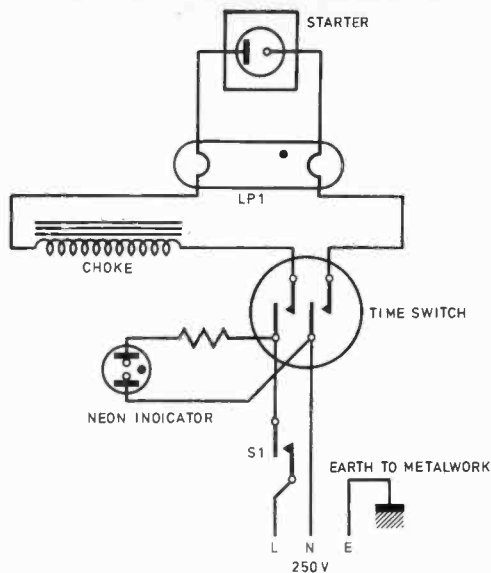


Fig. 10.4. Circuit diagram of CHAMP-U.V.

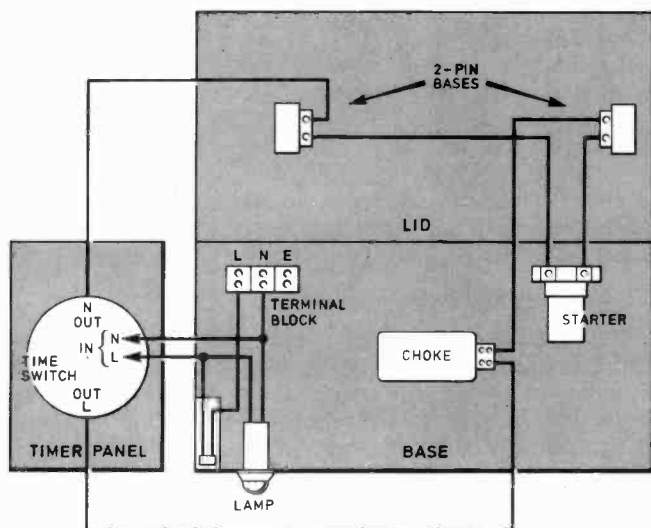
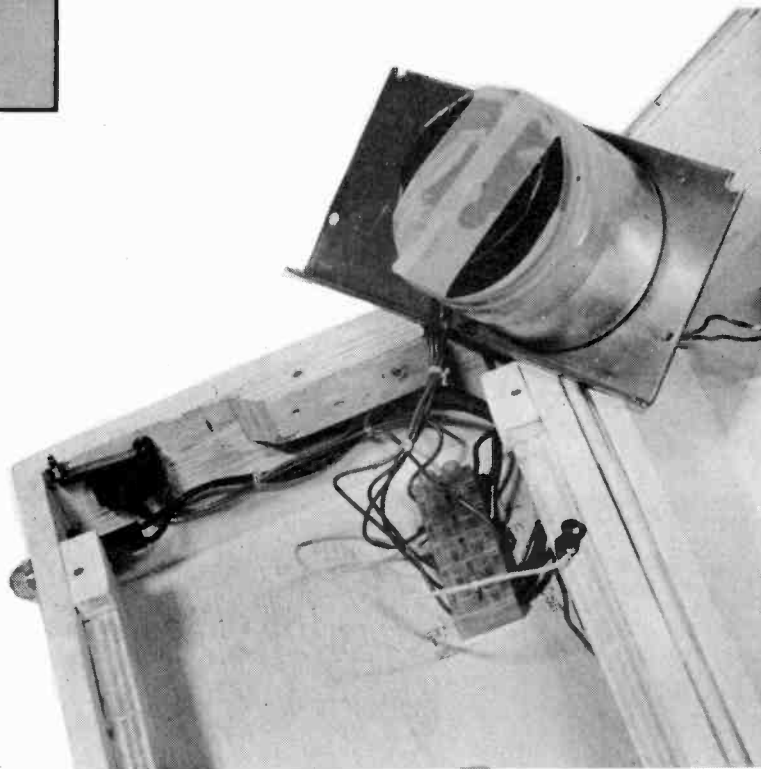


Fig. 10.5. Wiring layout of U.V. unit

It is most important that the lid operated microswitch feature of this design is incorporated, to immediately switch off the U.V. tube when the top is lifted. The optimum position for the micro-switch is near the front of the box as shown in this photograph



COMPONENTS...

Ultraviolet tube. 12 inch, 8 watt, 2537 Angstrom
Choke. Smart & Brown, 69386, 8 watt, 0.16A (or similar).

Starter. GEC 155/100 (or similar).

Timeswitch. 30 minute clockwork timer unit. Contacts closed during timing period, and of mains rating. (Available from many surplus suppliers).

Microswitch. 240V a.c., 2A, with leaf spring and actuating plunger.

Neon indicator lamp. 240V type.

Miscellaneous. 2-pin tube sockets. 3-way terminal block, 4 mm and 8 mm plywood, aluminium sheets, etc.

The U.V. tube is available from **Anderman & Co. Ltd.**, Central Avenue, East Molesey, Surrey KT8 0QZ.

WARNING



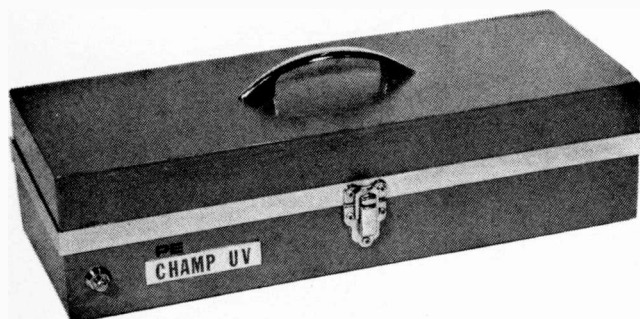
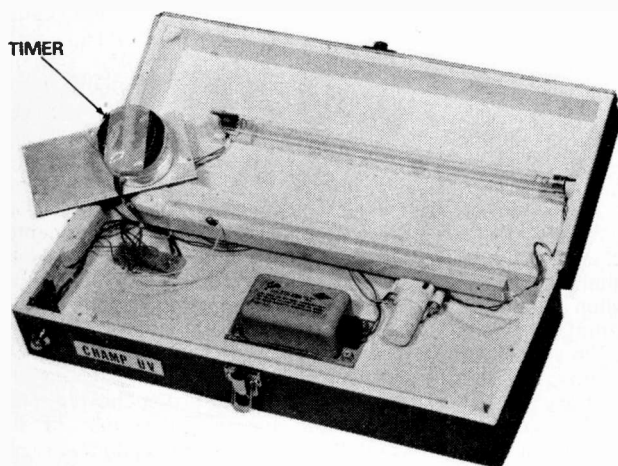
It is essential that these U.V. lamps are used correctly if health damage through U.V. exposure is to be avoided. Observe the manufacturers caution fully.

then pinned and glued inside the box to locate the timer panel and the PROM panel, which are both cut from aluminium sheet. Two aluminium brackets are also cut out and bent to form a PROM carrier which can be lined with conductive plastics foam when the rest of the case is completed (Fig. 10.3).

The lid is attached to the body of the case by means of a plastics piano hinge secured externally with small wood-screws, and this hinge, together with aluminium shuttering glued along the other three edges of the lid, ensures a light-tight seal for complete safety.

The U.V. lamp bases are fitted to the inside of the lid with the aid of small plywood blocks, and the starter, ballast and a terminal block are secured to the bottom of the case using small wood-screws and nuts and bolts. The microswitch is secured to the inside of the case with small wood-screws, and must of course be carefully positioned to ensure correct operation when the lid is closed. A small plywood fillet is mounted in the case lid to actuate the microswitch.

Wiring up should be carried out with mains quality flexible



FREE OFFER NOTICE

No further Intel Programming manuals are available, but many MCS Users Manuals remain. These will continue to be sent free of charge on receipt of an 8 x 10 inch envelope with 25p stamp (32p 1st class).

wire in accordance with Fig. 10.5. Notice that the aluminium panels *must* be connected to the mains earth for safety reasons.

When wiring up is completed, the unit can be connected to the mains and tested for correct operation. A conventional fluorescent tube could be substituted for the U.V. version during the testing phase if it becomes necessary to operate the lamp with the lid open.

The prototype case was finished with aerosol paints and polyurethane varnish using the same techniques as before on CHAMP and CHAMP-PROG. Finally, a carrying handle should be screwed to the lid of the case, and an attache case latch screwed to the front to hold the lid closed for transportation purposes.

USING CHAMP-U.V.

Complete erasure of PROMS prior to reprogramming is absolutely essential for reliable operation. The erasure process is a linear one and does not occur suddenly, and so even when a cell location appears to be erased, further exposure may be required to reach a satisfactory level of gate discharge.

A CHAMP-U.V. system built as described will probably erase all 4702A type PROMS satisfactorily if they are given a 20 minute exposure, but for greater accuracy, system calibration can be an advantage. This is achieved by programming a PROM with all "ones" (FFH in every location) and then giving it short erase increments of say, 2 minutes; checking after each increment for proper erasure. When the chip appears to be completely erased, note the time required and in normal practice always use a cycle of *five times* that duration.

This calibration need only be carried out once, since PROMS are very consistent in their requirements, and a factor allowing for ageing in the lamp tubes has been incorporated.

PROM PREPARATION

Before erasure, always check the quartz window on the PROM for any dirt particles which may cause shadows on the chip, and also wipe them over with a swab soaked in methylated spirit to remove any films which may be opaque to U.V. light. This latter precaution is particularly necessary if gummed labels have been used to cover the PROM when in use.

CHAMP-U.V. is quite capable of erasing any U.V. sensitive PROM including the larger capacity 2704 and 2708 types. The 2704/2708 chips do, however, use a different technology and generally require exposure periods of up to one hour for correct erasure. If CHAMP-U.V. is to be used to erase these devices exclusively, a clockwork timer with a one hour endurance could easily be substituted instead of the thirty minute unit specified earlier.

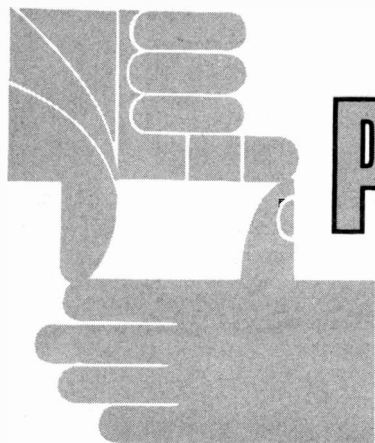
CONCLUSION

This brings us to the end of the CHAMP series, and we feel sure that everyone who has successfully built all, or part, of the CHAMP system will share our enthusiasm in the results obtained. Our CHAMP is in constant use and has been used to develop several dedicated systems and some "just for fun" software. There are of course many possibilities for additions to the basic system, and we will be glad to hear from anyone who has specific needs which may be catered for in subsequent articles, and from those who wish to pass on programs or hardware designs to their fellow CHAMP enthusiasts.

Meanwhile, the CHAMP programming service for CHOMP, PROMPT, and user programs will continue to be available as long as it is required.

Good luck, and successful programming!





PATENTS REVIEW

Copies of Patents can be obtained from :
the Patent Office Sales, St. Mary Cray, Orpington, Kent Price 95p each

SOLO VOICING BP 1 477 217

Several circuits for enabling a would-be singer to perform along with a solo voice on a pre-recorded disc or tape, the pre-recorded voice being routed to one loudspeaker of a stereo pair and the amateur voice to the other have recently been patented by Sony. Now, in BP 1 477 217, Sony patent what is the logical conclusion of this train of patenting activity—a circuit for eliminating a featured solo voice and enabling would-be singers to replace that voice with their own.

The circuit, Fig. 1, shows a right channel amplifier TR1 operating as an emitter-follower. The left channel amplifier (TR2) is operable, under switch control (S1), either in similar manner as an emitter-follower or as an inverting amplifier, e.g. common-emitter configuration.

The adders 1, 2 and 3 together combine the signals from the left and right amplifiers with that from a microphone X1 into which the would-be vocalist sings. The adder outputs are then fed to tape recorder amplifiers with playback through the loudspeakers.

A stereo source from conventional disc or tape, is applied to the inputs of the left and right amplifiers and the right stereo signal is applied to adders 1, 3. The left stereo signal is, in one position of the phase switch S1, inverted in phase. In the alternative switch position, the phase is non-inverted.

It is here important to note that the featured solo sound on a conventional recording (which solo sound the Sony circuit is required to eliminate and replace with an amateur sound) is recorded in phase and in equal amplitude in both channels. In the inverting state

of the left channel amplifier, the adder 2 is supplied with amplified right stereo signal, including the original common solo signal components, along with the phase-inverted left stereo signal, which now includes the same solo signal components as the right but in opposite phase. Adder 2 thus subtracts right from left and in so doing cancels the common solo components.

Fresh solo sounds, produced by microphone X1, can now be added at 1, 2 to the remaining signal, which corresponds to instrumental accompaniments. The reproduced sound thus corresponds to the original accompaniment, plus fresh solo. For the purposes of comparison, a mono mix of the original solo and accompaniment can be reproduced by the left channel loudspeaker either simultaneously or alternatively with the replacement mix.

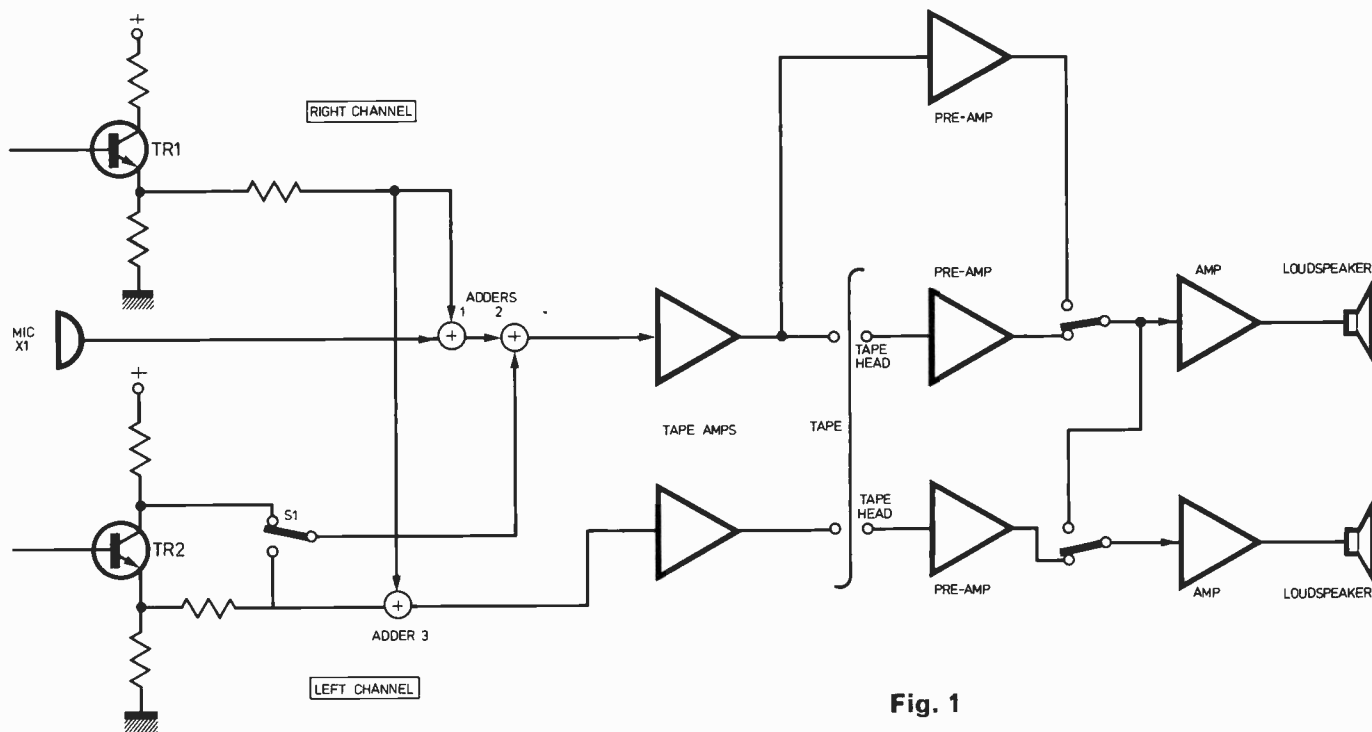
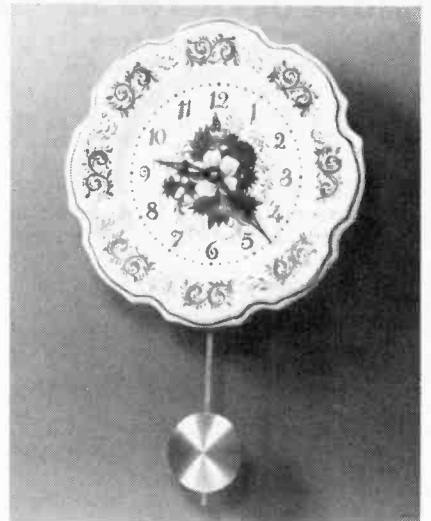


Fig. 1

Market Place

Items mentioned are usually available from electronic equipment and component retailers advertising in this magazine. However, where a full address is given, enquiries and orders should then be made direct to the firm concerned. All quoted prices are those at the time of going to press.

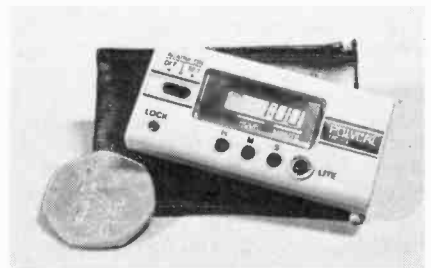


KITCHEN QUARTZ

Smiths Industries have introduced a range of domestic quartz clocks under the brand name "Astral".

The model shown is the "Melanie Pendulum", with blue or brown pattern and battery powered decorative pendulum, at £18.95.

For those not wishing to be pendulous the price is £11.50.



NON TIC TAC

This LCD alarm clock is the size of a packet of razor blades and has a quiet but effective waking tone, a pleasurable change from the old analogue fire bells.

Some digital alarms require a considerable amount of button pushing if an earlier alarm time is needed. This little fellow cleverly uses simultaneous button pressing to advance in 10 minute jumps or straight from a.m. to p.m. etc. Inadvertent resetting is prevented by the incorporation of a hold down setting lock.

Its logic element is MOS-LSI and for insomniacs there is a backlite(sic). The operating instruction booklet does read a little funny at times—"The reminder alarm will ring when the local time four minutes before it automatically cuts off."

Clock accuracy is the familiar ± 30 seconds per month.

The model, TAC-1, which gets its name from the abbreviation of Travel Alarm Clock, is available at £22.50 from Tempus, 19-21 Fitzroy Street, Cambridge.

Tempus also offer a battery change kit—watch case opening tool, battery specifications chart, replacement instructions and non-metallic tweezers—all for 35p. Watch batteries 65p each

ACE CARD

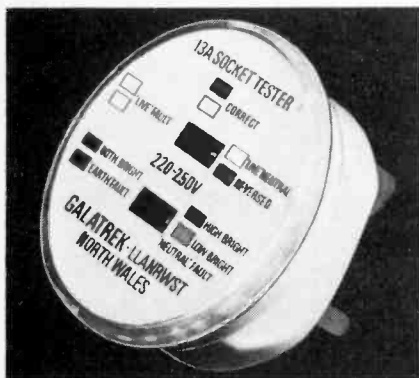
The Casio Mini Card calculator is the same length and width as a playing card. It is as thin as two ice cream wafers. Being so thin it is fragile and in fact will flex without much force. Nevertheless, for the careful user it is an extremely compact shirt pocket masterpiece of miniaturisation.

The LCD display will show up the respective sign when any of the four basic mathematical functions are performed. There are memory plus and minus keys, memory recall, a per cent function and clear and all clear keys.

If an overflow of the eight digit display occurs during calculation, in an answer or in the memory, an E appears and further operations are halted until the all clear key is pressed.

A couple of G-10 silver oxide batteries give approximately 1,000 hours of continuous operation.

Designated the LC-78, it is available at £16.95 from Tempus, 19-21 Fitzroy Street, Cambridge, CB1 1EH.



13 AMP SOCKET TESTER

Here is a tester which could have started out as an idea in Ingenuity Unlimited. It is a very compact 13 amp plug with two indicator lights to show up live, neutral or earth faults.

A positive must for any "sparks" tool box, contractors, installation engineers.

The retail price is £3.95 and quantity discounts are available from Galatrek Engineering, Scotland Street, Llanrwst, North Wales. (0492 640311).

Inventive minds that would relish the opportunity of materialising an electronic idea into a commercial product with financial backing should turn to page 728.

SMOKE DETECTOR IC

A single chip smoke detector i.c. is announced by Siliconix of Swansea. The SM110 operates from a standard 9 volt alkaline battery with a current drain of less than 10 microamps in the standby mode. Its input impedance is very high making it suited to photoelectric sensors; the output needs only a simple drive circuit to power either a piezoelectric or electro-mechanical horn.

Other features include a very low input leakage current, adjustable sensitivity, noise input suppression, adjustable sourcing current and trouble signal timing as well as latching and non-latching operation.

The price of the SM110 is £2. A 12-6 volt version, the SM120 is also available, price soon to be announced.

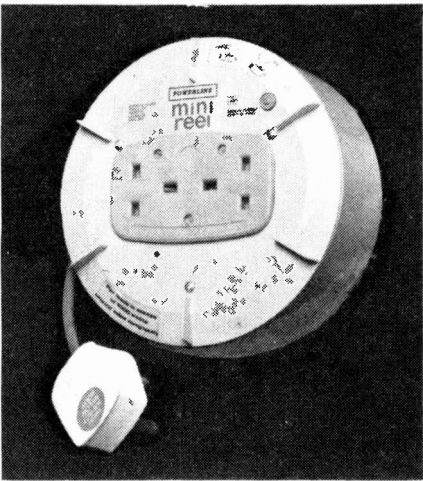
Full data from Siliconix Ltd., Llanllienwen Close, Morrision, Swansea, SA6 6NE.

SEMINAR ON CASSETTE

Late last year Intel held a very successful two-day Memory Designers Seminar at Wembley, London. The proceedings of this seminar were recorded and are now available on C-120 cassettes complete with slide book and explanatory manual.

AVP811 CCD Memory Devices and Systems	£4
AVP812 Static and Dynamic RAMS	£4
AVP813 EPROMS and 22-pin 4K RAMS	£4
AVP814 Memory Design with 4K and 16K RAMS	£6
AVP816 Debugging a Memory System	£4
AVP817 The complete set	£15

Intel Corporation (UK) Ltd, 4 Between Towns Road, Cowley, Oxford OX4 3NB.



MINI-REEL

The Burgess mini-reel extension cable is fitted with a twin 13 amp outlet and eight metres (26 feet) of three core cable.

A thermal and current overload cut-out permits normal usage of up to six amps.

Weighing less than a metric bag of sugar the mini-reel has a recommended price of £8.35 plus VAT.

PRICE REDUCTION

Ampex has announced a price reduction, effective immediately, on the Ampex 220 demagnetizer and headcleaner.

The demagnetizer and headcleaner is a special cassette patented by Ampex in which a rotating ceramic magnet is used to degauss the head of a cassette recorder or player. Simultaneously, a strip of non-abrasive fabric is transported by the machine to clean the head and tape path. This enables the recorder/player to deliver its best performance.

The Ampex demagnetizer cassette works automatically without batteries or mains power and can be used hundreds of times without reduction of its effectiveness.

From its former recommended retail price of £3.32p, the Ampex 220 demagnetizer is now reduced to a recommended price of £2.89.

Ampex magnetic tape products are available throughout the United Kingdom, from leading hi-fi and record shops. Ampex International, 72 Berkeley Avenue, Reading, Berks.

BIG LED

A large (20mm) i.e.d. display has been placed on the market by Hewlett-Packard. The new HDSP-3400 series numeric device is the largest display in Hewlett-Packard's seven segment product line which starts at 2.6mm.

Readable in bright light at distances of up to ten metres the big i.e.d. is designed for use in electronic instruments, point-of-sale terminals, television sets, weighing scales, digital clocks and other applications requiring low power consumption in a large, easy to read display.

Packaging is standard 15mm d.i.l. Price £1.80.

Data, Hewlett-Packard Limited, King Street Lane, Winnersh, Wokingham, Berkshire, RG1 5AR.

IC MOTOR CONTROL

A range of hybrid i.c.s in TO3 8 pin packages for the control of motors up to 0.1 horsepower from low level inputs, has been announced by Rapid Recall.

The devices comprise of a 741 operational amplifier, a special driver chip and a complementary pair of power transistors together with a frequency compensating capacitor all enclosed in a TO3 package. The internal circuitry is electrically isolated from the outer casing thus allowing easy heat sinking.

There are three basic models which differ in output current capability. They are 8510 (1 amp), 8520 (2 amp) and 8530 (2.7 amp), all of which will provide maximum output current at output voltages up to 24 volts. Multiple devices can be connected in parallel to provide even higher currents or voltages. Each device is available in two temperature ranges: -55 to 125°C (suffix M) and -25 to 85°C (suffix I).

The chip has short circuit protection, the maximum current of which is set by a pair of external resistors chosen to suit the application.

The 741 is powered by an internal regulator and will provide a gain of >100dB if required. Quiescent current of the unit is only 50mA max.

An interesting application of the device is in programmable power supplies. The input can be coupled to a digital-to-analogue converter which can, in turn, be controlled by thumbwheel switches. This arrangement allows the output voltage to be set to within $\pm 0.1V$ d.c.

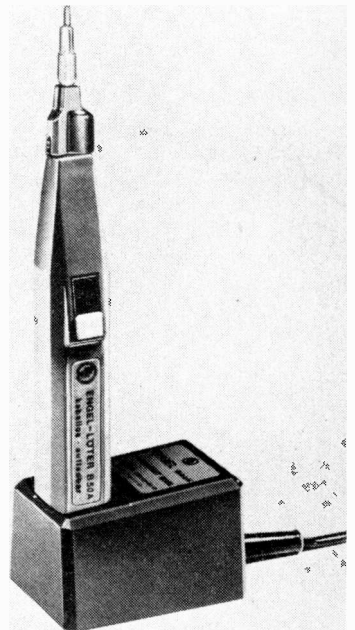
Further details obtainable from Rapid Recall Limited, 9 Betherton Street, Drury Lane, London WC2H 9BS.

RECHARGEABLE IRON WITH SPOTLIGHT

A new version of the Engel B50 rechargeable soldering iron is available.

The iron now incorporates a built-in spotlight to illuminate the working area and has long life rechargeable nickel-cadmium batteries. Of compact design, the B50 will give up to 100 intermittent operations (350 continuous). Recharging can be performed overnight in about eight hours (overcharging is impossible).

The trigger switch is fitted with a safety catch to prevent accidental operation. The bit, for work up to 2.5 sq. mm, heats up to an operating temperature in the region of 350 degrees centigrade in about seven seconds. Other bits are available.



Designed for recharging from normal AC mains, the B50 comes complete with cleaning pad, protective cover, two lighting fittings and screwdriver. A particular advantage is that no stray eddy currents which might damage a sensitive i.c. are generated when the iron is being used.

Priced at £16.50 including carriage, packing and VAT it is available only from the UK agents, Kelgray Products Ltd., Kelgray House, Sandy Lane, Crawley Down, Sussex RH10 4HS.

STEREO HEADPHONE AMPLIFIER

J.P. MACAULAY

High quality stereo headphones have been available for many years now but they are usually considered as merely an adjunct to a full scale stereo system. This is a pity since even a relatively cheap pair are capable of the kind of reproduction usually associated with expensive speakers. There are also many situations which preclude the use of a speaker system at orchestral levels whereas a pair of headphones will deliver the same sound levels with an input of a few milliwatts, without disturbing the neighbours!

It was these thoughts that prompted the design described in this article. The main requirements of such an amplifier are the same as those for any hi-fi unit with the main problem being the minimisation of noise, especially hum.

The amplifier must also possess a fairly high input impedance in order to match most signal sources. In the development stage many different circuits were considered but most were found not to measure up to the requirements already outlined.

Consideration was given to the inclusion of Baxendall tone controls but this was rejected on the assumption that the amplifier would be used mainly as a monitor of high quality sources, many of which would already provide such control.

Sensitivity is 20mV for maximum output, and as this is very high it is recommended that a potential divider, or a log. volume control is used in front of the amplifier. This should have a value of at least 220k Ω in order to avoid shunting the input impedance of the circuit.

CIRCUIT DESCRIPTION

The circuit diagram of one channel of the headphone amplifier is shown in Fig. 1. The transistor TR1 which is connected in the common emitter mode provides all the voltage amplification for the circuit.

IC1 is a 741 op. amp. which is used with 100 per cent negative feedback and operates as a voltage follower with unity gain. In this mode the bandwidth extends from d.c. to over

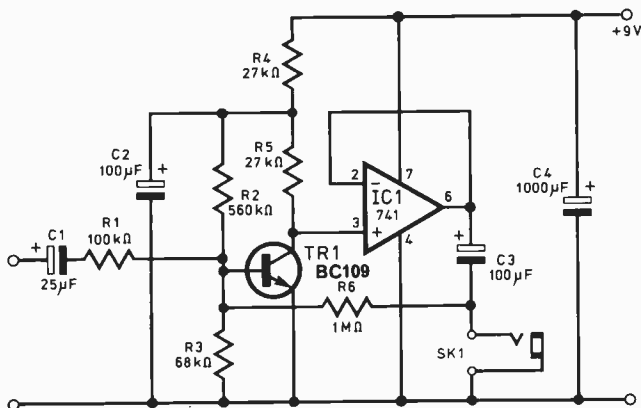


Fig. 1. Circuit diagram of one channel of the Headphone Amplifier

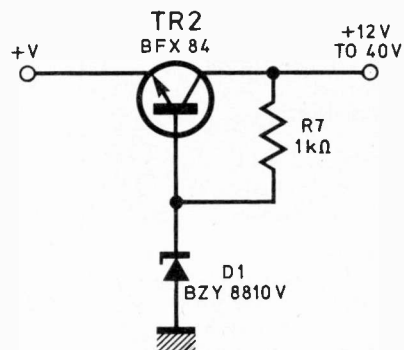


Fig. 2. Series regulator circuit which can be used if the unit is to be fitted into an existing piece of equipment.

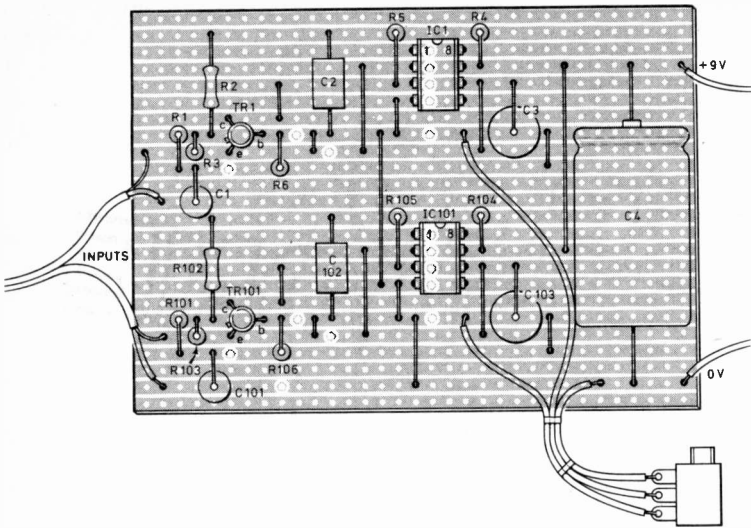


Fig. 3. Circuit board layout for Headphone Amplifier

100kHz.

The non-inverting input of IC1 is taken from the collector of TR1 and the i.c. used as a non-inverting amplifier with signal feedback applied via R6 to the base of TR1.

The complete circuit acts as a virtual earth amplifier, the gain of which is determined by the ratio of R5 to R6. The output power available from this arrangement is limited to about 25mW, which proved sufficient to deafen most listeners!

The current consumption of the circuit is about 6mA and it can be operated either from a 9V battery or the series regulator circuit shown in Fig. 2.

CONSTRUCTION

In the prototype both channels of the amplifier were mounted on 0.1in Veroboard using the layout shown in Fig. 3.

Care should be taken to ensure that the appropriate breaks are made to the copper tracks and that all the electrolytic capacitors are correctly orientated before soldering them to the board. The two i.c.s can either be mounted in holders or soldered directly onto the Veroboard.

After soldering, the board was checked for any solder shorting the copper tracks and the excess flux was also removed.

The output connections from the circuit board to the headphones were made via a stereo jack socket and the two input leads to the amplifier were made using screened cable. The screened lead of each cable should be connected to the 0V line.

HOUSING THE UNIT

The amplifier can either be housed in an existing piece of equipment or in a separate case.

If the unit is to be installed in an existing piece of equipment the series regulator circuit shown in Fig. 2 could be used with the inputs of both channels connected internally and the jack socket fitted to the control panel.

The prototype is used as a piece of test equipment fitted into a separate case and powered by a PP3 battery.

The two screened input leads were terminated using another stereo jack socket and an on/off switch was fitted to the positive lead of the battery.

USES

The headphone amplifier has many applications, the prototype being used mainly for checking f.m. tuners on the author's bench. ★

COMPONENTS . . .

Resistors

R1	R101	100kΩ (2 off)
R2	R102	560kΩ (2 off)
R3	R103	68kΩ (2 off)
R4, R5	R104, R105	27kΩ (4 off)
R6	R106	1MΩ (2 off)
*R7		1kΩ

Capacitors

C1	C101	25μF (2 off)
C2	C102	100μF (2 off)
C3	C103	100μF (2 off)
C4		1,000μF

All 25V electrolytics

Semiconductors

*D1		BZY 88 10V
TR1	TR101	BC109 (2 off)
*TR2		BFX 84
IC1	IC101	741 op. amp. (2 off)

Miscellaneous

- 1 off 0.1 in matrix stripboard
- 2 off stereo jack plug and socket (see text)
- 1 off PP3 battery (see text)
- 1 off battery clip (if req.)
- 2 off holder for i.c. (if req.)
- 1 off S.P.S.T. toggle switch (see text)

* See Fig. 2 and text



Radio Circuits Explained

By Gordon J King

Published by Butterworth Co Ltd

145 pages, 160mm x 240mm. Price £5.50

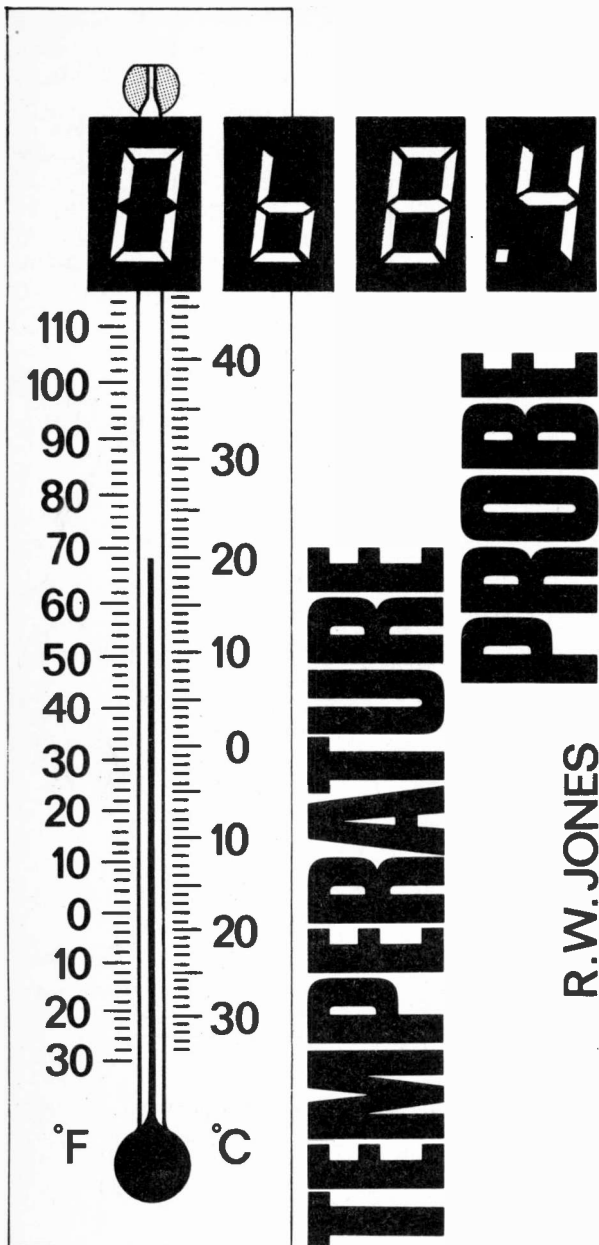
THERE have been many advances made in the field of radio circuits and with the introduction of new devices many different design ideas are being incorporated into modern receivers. The problem for both the technician and hobbyist is keeping abreast of these advances.

This book examines the developments made and explains the principles involved in each section of the receiver with the aid of clear diagrams and graphs.

The opening chapters cover block flow and FIMS diagrams and progress through mixers, RF amplifiers and oscillators to detector circuits. Basic audio and power amplifiers are discussed and with the use of manufacturers' diagrams it is shown how they are employed in practical circuits. Also included are power supplies and regulators with the final chapter dealing with stereo coding and decoding.

Many people should find this book very helpful in developing a clearer understanding of the techniques used in modern radio circuits.

D.J.S.



THIS probe was designed to enable temperature measurements from -10 to 100°C to be made using the 0 – 100mV range of a digital multimeter. It is possible for an analogue meter with the same full scale deflection (0 – 100mV) to be used, but for readings below 0°C the meter connections would have to be reversed.

CIRCUIT DESCRIPTION

The circuit diagram of the probe is shown in Fig. 1. Its operation is dependent on the linear relationship between the changes in resistance and temperature of a p.n. junction.

The two f.e.t.s are used as constant current generators with the 741 amplifying the difference in voltage between the temperature probe (a) and the 0°C reference level (b) which are connected to pins 2 and 3 of the op. amp. The meter is connected across VR2 and measures the amplified

COMPONENTS . . .

Resistors

R1	$2.2\text{k}\Omega$ 2% $\frac{1}{4}\text{W}$
R2	680Ω 2% $\frac{1}{4}\text{W}$
R3	$3.3\text{k}\Omega$ 2% $\frac{1}{4}\text{W}$
R4, R5, R6, R7	$100\text{k}\Omega$ 1% $\frac{1}{4}\text{W}$ (4 off)
R8	$1.2\text{k}\Omega$ 5% $\frac{1}{4}\text{W}$ carbon

All metal oxide types except where stated

Potentiometers

VR1	$1\text{k}\Omega$ 10 turn cermet
VR2	$10\text{k}\Omega$ single turn cermet

Switches

S1	D.P.S.T. pushbutton (latch type)
----	----------------------------------

Semiconductors

D1	1N4148
D2	Miniature I.e.d. (red) T.I.L. 209
TR1, TR2	$2\text{N}3819$ n channel f.e.t. (2 off)
IC1	741 op. amp.

Miscellaneous

1 off	Polystyrene case $100 \times 50 \times 40\text{mm}$
2 off	PP3 batteries
2 off	Battery clips
1 off	Tube of Araldite
	Length of copper tube $\frac{3}{8}\text{in}$ inside diameter
	High temperature wire R.S. type (357-110)
	0.25in 2-pole jack plug and socket

output of the 741. This output is directly read as degrees Centigrade.

If the probe senses a temperature of 0°C , the difference between the two 741 inputs should be zero and the meter should indicate 0°C .

When the probe is exposed to a positive temperature change its resistance is reduced and the voltage applied to pin 2 of the 741 falls. The voltage on pin 3 remains constant and the 741 amplifies the voltage difference between these two pins. The amplifier output is then measured by the meter across VR2.

The I.e.d. is used as an on/off indicator with its current controlled by R8.

CONSTRUCTION

The prototype was housed in an R.S. polystyrene case with the on/off switch, I.e.d. and jack plug fitted into the side of the case and the two 4mm sockets mounted on the top.

The components are soldered onto a printed circuit board, the design of which is shown in Fig. 2 with the component overlay shown in Fig. 3. The two board contacts which are used for the output terminals should be drilled out to 4mm diameter and after the p.c.b. has been soldered and checked it can be mounted into the case (Fig. 4) using the two 4mm sockets to hold it in position.

PROBE

A cross section of the probe is shown in Fig. 5; it can be constructed using $\frac{3}{8}\text{in}$ inside diameter copper tubing and is connected to the unit via high temperature wires and a jack socket.

The diode must be well insulated to ensure that it does not short out to the case of the probe and after the high tempera-

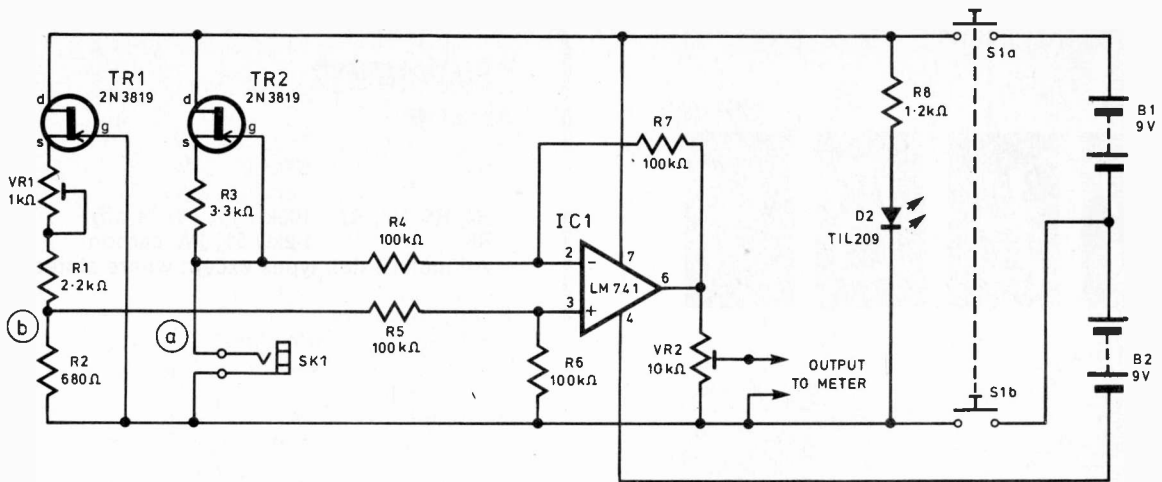


Fig. 1. Circuit diagram of the Temperature Probe

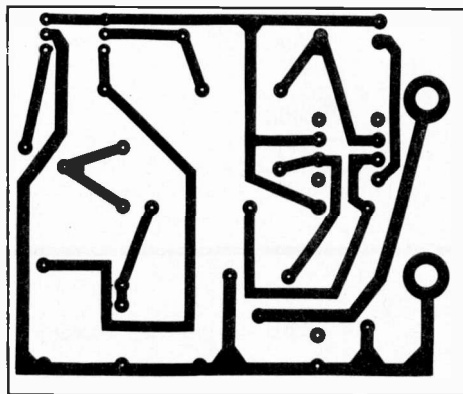


Fig. 2. Printed circuit board design

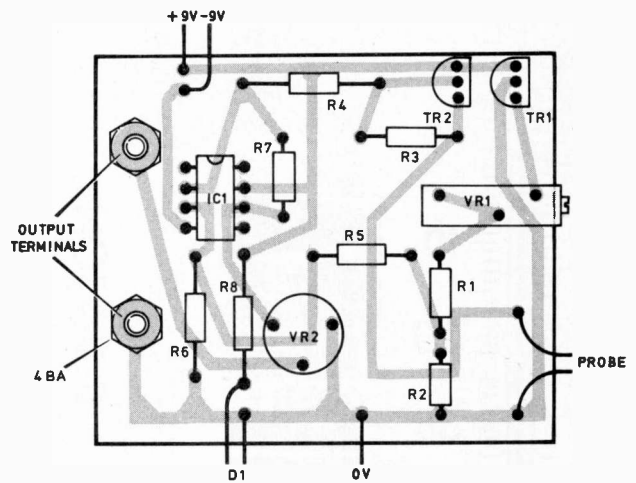


Fig. 3. Component layout for p.c.b.

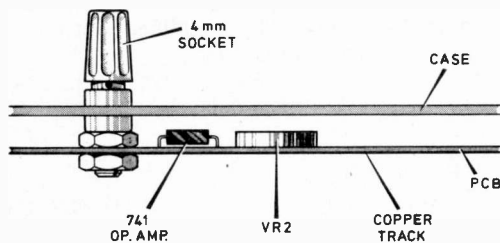


Fig. 4. Mounting details for p.c.b.

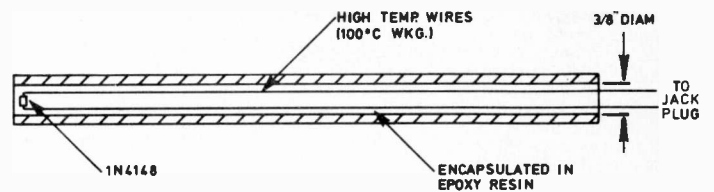


Fig. 5. Probe assembly

ture wires have been connected, the diode should be placed in the tube as close as possible to one-end. The entire probe can then be encapsulated with Araldite.

BATTERIES

The unit is powered by two batteries which are fitted to the bottom of the case and then covered with a piece of foam to protect the back of the p.c.b. from any damage.

CALIBRATION

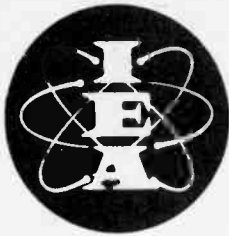
After the unit has been assembled and tested it is then ready

for calibration. As the characteristics of diodes vary from device to device the instrument should be recalibrated whenever the sensing diode/probe is replaced.

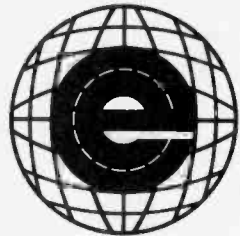
For calibration, boiling water is used as the 100°C standard and melting ice as the zero 0°C standard. The probe should first be immersed in a bowl of melting ice and water and the multiturn pot VR1 adjusted until the meter connected across the output terminals indicates zero. The probe should then be placed in simmering water and VR2 adjusted to obtain full scale deflection on the meter.

With the calibration completed the unit is now ready for use.

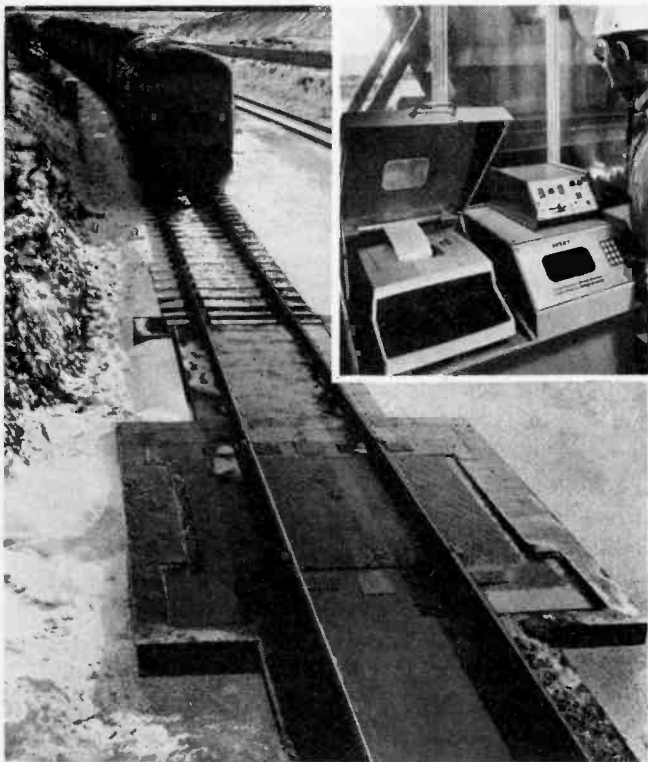




IEA · ELECTREX



A look at some of the more interesting items at the Birmingham Exhibition Centre (13-17 March)



W & T Avery Limited are pioneering the use of microprocessors in the weighing machine industry. A number of successful applications have already been made, one of which is at the National Coal Board's Grime-thorpe Colliery in Yorkshire, where a weighing-in-motion system has been installed as part of a new bulk loading scheme.

In the picture above a locomotive has shunted filled wagons through the loading bay and over the weighing system seen in the foreground.

The system is designed to weigh two-axle wagons whilst travelling at speeds of up to 8 km/h.

The inset shows the instrumentation used. The printer produces individual axle weights for each wagon and the total weight for the entire train excluding the locomotive.

An entirely new type of test instrument for the analysis and synthesis of digital waveforms has been introduced by Gould Instruments Division. Designated the Gould Advance DSA600, it consists of a memory which stores digital waveforms plus peripheral circuitry which permits the capture of signals from a circuit under test, the programming or modification of signals by the operator, the generation of the stored signals and the display of the memory contents.

Analyser applications include logic testing and simulation on both asynchronous and synchronous systems, such as avionics, radar, communications, data processing and industrial control, for research and development, test, service and production purposes. It can also be used to turn a basic oscilloscope into a form of storage oscilloscope and can be used in conjunction with the Gould Advance PG52 pulse generator to provide a programmable high-power data output.

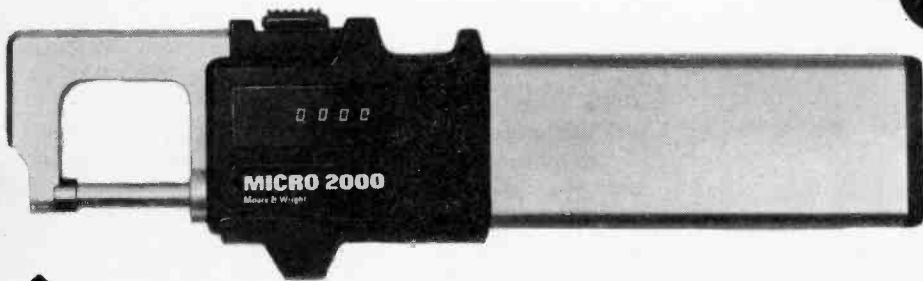


Above is a 2-3 seater open sports car developed by Electraction Ltd., of Maldon, Essex. The glass fibre body is mounted on a galvanised steel tubular chassis arranged to absorb energy in the event of an accident through a safety bumper at the front and an energy absorption compartment at the rear. The batteries are mounted on sliding trays.

Range: Up to 90km (56 miles)

Speed: Up to 58km/h (36 m.p.h.)

Control: Thyristor controller made by Cable-form (Pulsomatic Mark 10).



The Moore & Wright "Micro 2000" electronic hand micrometer. The Micro 2000 uses a unique combination of specially developed solid state electronics and precision optical systems to measure to an accuracy of ± 2 microns and show the reading on a brightly lit integral digital display.



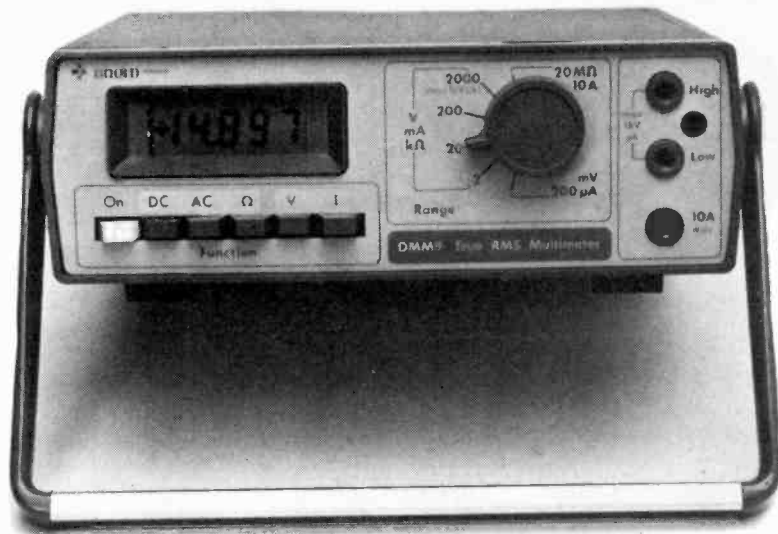
At the F.W.O. Buch stand, visitors could enter realms of Star Trek when trying out the new IE-10A Audio Spectrum Analyser from Ivie Electronics Inc. A slick hand held unit weighing only 15oz (430gms) can be aimed at a sound source to get an immediate breakdown of its frequency components. Powered by rechargeable Ni-Cad cells, the analyser/sound level meter will display graphically on a matrix of l.e.d.s sound pressure levels over a 45dB range.

The 160 l.e.d. display matrix gives ten octave channels on the x axis (32Hz-16KHz), and the y axis is selectable for 1, 2, or 3dB resolution, calibrated from 45dB to 140dB S.P.L. (-116 to +9dBm) on A or C weighting.

A range of inexpensive accessories enable the analyser to measure amplifier power, voltage and harmonic distortion.



The new digital clamp meter KEW 777 from Eagle International is designed for safety and ease of operation. It has large, clear definition liquid crystal display and measures to 1,000 amps a.c. as well as 1,999 ohms and 1,000 volts a.c.



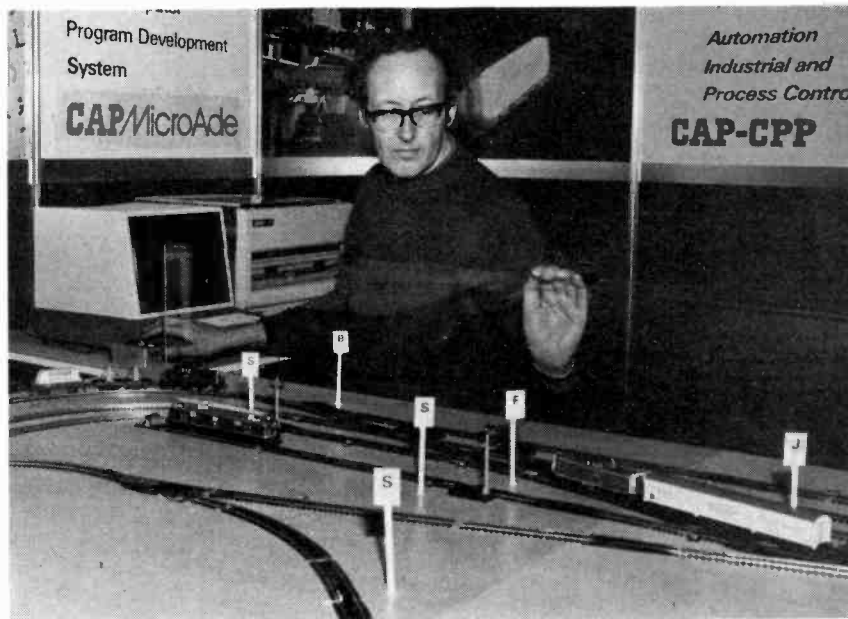
Also from Gould is the DMM9 a new $4\frac{1}{2}$ digit multimeter with a 0.05 per cent measurement accuracy and true r.m.s. measuring facilities.

It features 28 a.c. and d.c. voltage, current and resistance measurement ranges, including a separate 10A current range, and is also available with optional probes for temperature, radio-frequency and high-voltage measurements.

The DMM9 has a maximum reading 19999, and maximum resolutions on the current, voltage and resistance ranges of $10\mu\text{V}$, 10nA and $100\text{m}\Omega$, respectively.

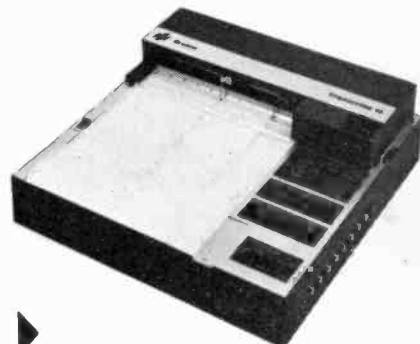
A combined a.c./d.c. facility is also available to measure a.c. waveforms with a d.c. content.

Because true r.m.s. voltage measurement is the only accurate way of assessing the energy content of an a.c. waveform, the DMM9 is ideal for applications where power is the main parameter of interest, e.g. in the electricity supply industry or in applications involving thyristor control.



A railway of the future, controlled by micro computers, was the centrepiece of the CAF MicroSoft Ltd. stand. With 13 points, 25 yards of HO gauge track, an eight stage speed controller, and two Fleischmann diesel-outline locomotives, the layout represents a versatile, flexible, low-cost peripheral to a microcomputer-based industrial control system.

Latest product news from Bryans Southern is of a compact "combination" instrument that they believe to be unique throughout the world. It introduces entirely new transient store electronics developed by Bryans, and fitted within the mainframe of their well-proven 28000 series chart recorder. The resulting instrument offers a facility for processing transient signals and producing precision hard copy plots of them.



readout

... a selection from our postbag

Readers requiring a reply to any letter must include a stamped addressed envelope. We regret that we cannot answer any technical queries on the telephone.

"Camm's Comic"

Sir—Whilst in no way disagreeing with M. Hughes' tribute to Mr Fred Bennett I must object to the disparaging reference to "Camm's Comic". In the immediate post-war years through to the dawn of the transistor age the so-called "comic" provided a fund of information for many embryo radio/electronic engineers where contemporary publications featured circuitry and components beyond the capabilities and finances of most students.

Personally I feel my introduction to the magic of this hobby (and latterly, my profession) owes much to the writings of the late F. J. Camm and I am surprised that no attempt has ever been made to commemorate him—perhaps by an annual competition for the best article from a newcomer?

As for the amateur forsaking the "junk-box", junk box does not equate with junk components nor apparatus. Rather the term junk may be applied to many of the modern gadgets seemingly devised to use as many components as possible instead of offering useful function.

L. G. Rix, BSc,
Melton Mowbray.

Electronics Club

Sir—I wish to inform you that our Club was set up in September 1977 at Shakespear House, Clapcot Way, Wallingford, Oxon.

The Club is a non-profit-making club for the pursuance of electronics as a hobby. The Club exists to provide mutual exchange of knowledge and experience in the fields of radio, electronics, electrical engineering and related sciences and technology. The club also provides education and encouragement to younger members who wish to make electronics their hobby and/or their career.

J. Gilpin,
Wallingford Electronics Club.

Future

Sir—I was prompted by your editorial in the March issue of P.E. to consider the future of the electronics hobbyist. At the present time, nearly all electronics publications are fairly brimming with articles and courses to introduce the hobbyist to the latest arrival on the scene—micro-processors. It seems that any amateur so inclined, providing his pocket will stand

it, can learn all about these devices. Fine!

But what of the future? In a few years, when the enthusiasm has died down, will you continue to deliver elementary articles on such matters? Will it be possible for beginners to work their way up from Ohm's law to micros as has now been the case? Or will you only publish articles which presume the reader to have a working knowledge of the interior of a micro-processor chip, program writing etc.? If that is the case, then the "amateur" electronics field will surely be limited to those already into electronics by virtue of their profession.

Let us hope that this will not be so, and that you will run a series of "Teach-In" articles every few years as *Everyday Electronics* does in an elementary way.

C. Nelms,
Elstead, Surrey.

You are certainly looking ahead, but the point is very valid, and one that is well taken. No doubt many people from all walks of life will ultimately want, or need, to know more about microcomputers and we are sure you will not find this need overlooked.—Ed.

POINTS ARISING

DIGITAL MULTIMETER (October 1977)

The Siliconix LD130 i.c. used in this project is apparently prone to "lock-up" when the power is first switched on. This condition manifests itself by a constant display reading of 007, and it is necessary to re-cycle the power supplies to clear it.

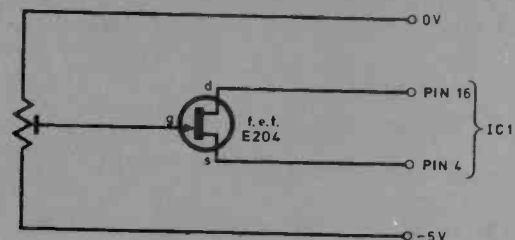
A modification is illustrated (right) which will rectify the fault and not affect the accuracy of the instrument. Adjustment of the instrument is best carried out with the meter set to DC CURRENT, no input applied, and well-used rather than new batteries. With the preset wiper towards 0V the display will flash as if on over-range. As the wiper is revolved towards the negative rail the display will cease flashing, and indicate a number which decreases as the control is further rotated. Correct setting of the preset is just beyond the point where zero is displayed.

Modification kits comprising the preset potentiometer, E204 f.e.t., and necessary stripboard and fixings (with instructions) are available from Sparks Developments, Dept. P.E., 53 North Street, Melbourne, Derby, DE7 1FZ.

AUTO-RANGING D.C. VOLTMETER (February 1978)

A few corrections are necessary in Fig. 5, the component layout (specifically the power supply). Zener diodes D5 and D6 should be transposed, and also R1 with R2, so that they conform to Fig. 3. These are drawing errors which will not affect operation, but a correction which *must* be made is to transpose the labelling of +6V OUT and -6V OUT.

Also, note that in Fig. 2, VR2 is connected between pins 1 and 5 of IC2, and the output of IC3a is pin 3.



Semiconductor UPDATE...

FEATURING : SN75416/17/18/19 BC650/BC651 1435

R. W. Coles

ADC0816/ADC0817

THE HEAVY MOB

Want to make a solenoid an offer it can't refuse? Then call in the heavy mob from Texas. Working under the "SN75416 series" alias, and not using their real names like "Crusher Hargreaves" and "Hammer Hoskins", these new arrivals are guaranteed to beef up any logic team. Each member comes in a smart black fourteen pin package and carries two drivers which can each sink 500mA and hold off over 70 volts. The four members currently in town cater for all four varieties of logic gating, NAND, AND, NOR and OR and have low current p.n.p. input stages so that they can make-out with TTL or MOS families when required. Any loads which try any funny business with inductive spikes get clamped with a 500mA diode, and remember these boys are fast, 100 nanoseconds fast.

THE QUIET ONES

Any advance in the art of hi-fi is sure to be popular, even though most advances these days are pretty marginal! For those who strive to eliminate all sources of noise from their system, so that they are better able to hear the noise generated by their records or tapes, Motorola have something new to offer. The BC650/651 transistors are claimed to be the lowest noise input transistors available today, generating noise voltages of only 4, 3 and 2.5 nanovolts at 10, 120 and 1,000 hertz respectively when run at collector currents of 200mA. The two new transistors are n.p.n. devices and are rated at 30 volts (BC650) and 45 volts (BC651) with a minimum h_{fe} of 380 at 2mA and an f_t of 300MHz. They come in low cost TO92 plastic packages and should be ideal for use in the "front ends" of domestic hi-fi amplifiers and high power disco music systems.

THE FAST ONE

I am including my next offering, not because I expect anyone to rush out and buy one (they are a little expensive), but because it is an interesting new device which has pushed out the frontiers of performance in the analogue amplifier field quite dramatically.

I am talking about the Teledyne Philbrick 1435 which is described as an "Ultrafast differential input operational amplifier" in the data sheet. Ultrafast it *certainly* is because it sports a gain-bandwidth product approaching *one gigahertz*, and can be used in standard operational amplifier configurations to provide a 20db to 40db gain from d.c. to beyond 10MHz! Despite its high speed performance the 1435 is a precision device, offering 0.01% gain accuracies and rapid recovery from input voltage steps, making it ideal for the amplification of complex waveforms in video and other signal processing applications.

When I first read the data sheet I immediately saw in this device the makings of a very simple, but capable, Y amplifier for an oscilloscope, and there seems to be no reason why it should not be used for this purpose when provided with an f.e.t. source follower input stage and a switched attenuator. In this role its 75 nanosecond settling time and less than 1% overshoot on square pulses would be a great advantage.

The 1435 is made using hybrid technology and lives in a small 14-pin hermetic d.i.p. package.

BRIDGING THE GAP

It has been said that any signal conditioning that can be carried out with analogue circuitry, can (in theory anyway), be carried out just as well with digital circuitry. Of course, microprocessors have not yet reached the point at which we can connect an aerial to an input port and a speaker to an output port and then expect to write some software which will tune in "Desert Island Discs". Given a micro that worked sufficiently fast however, this sort of high speed signal processing would become perfectly feasible because the processes involved in converting a modulated r.f. signal into a signal suitable for driving a loudspeaker can be described mathematically, and we all know just how nifty micro's can be at doing sums! Speed is not the only limiting factor though; the conversion of analogue signals to digital form has been an expensive business which precluded its use except for the most demanding

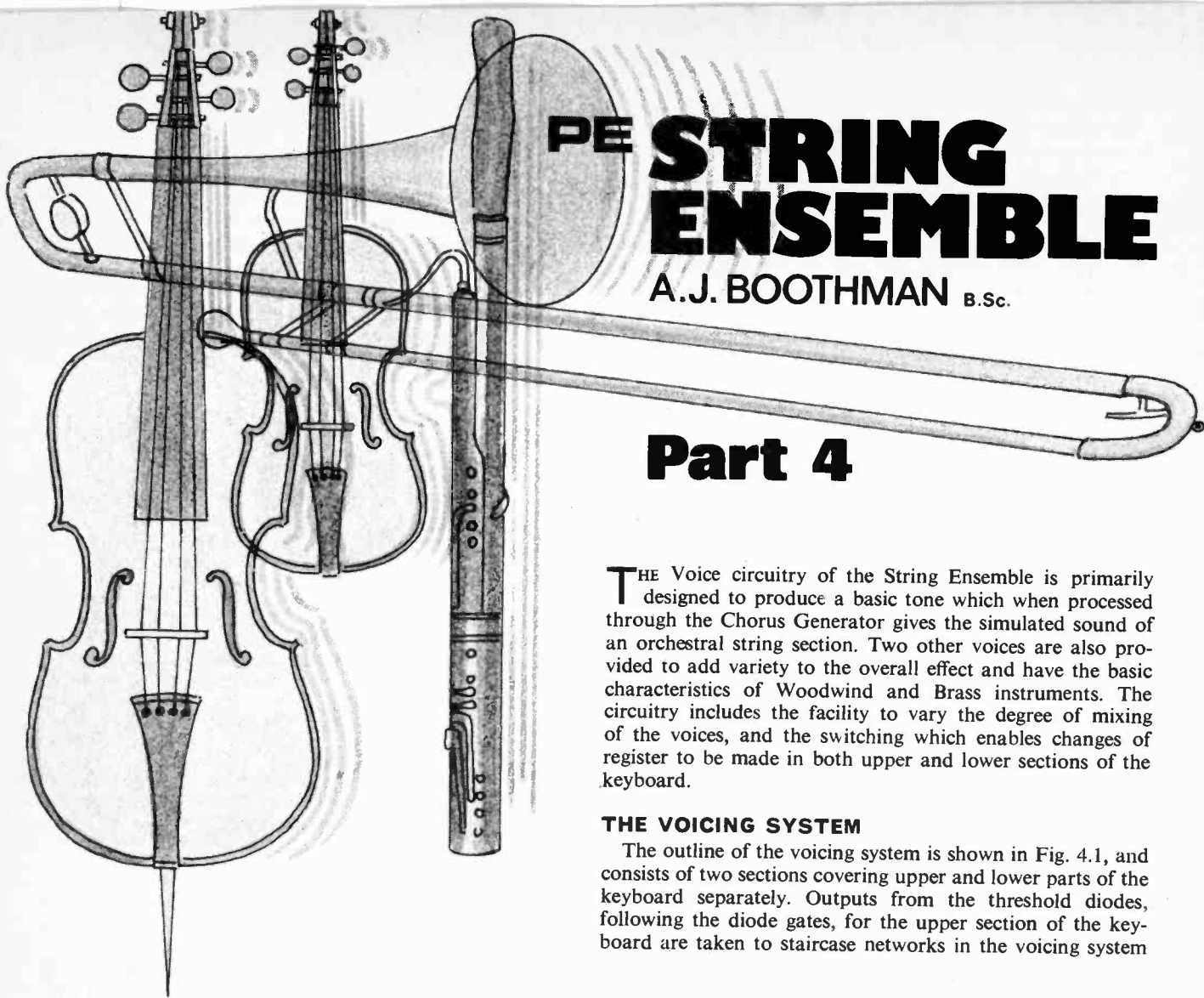
applications, even when only low frequencies were involved.

There *have* been major advances recently which have made the digital processing of analogue signals more practical; modules or circuit boards are now available which contain an analogue-to-digital converter paired with analogue signal multiplexers which permit the converter to be shared by a number of analogue inputs. These modules and circuit boards have been made fully compatible with the popular microprocessor buses, but costing several hundred pounds apiece they are still not the stuff of which revolutions are made. To take the analogue world by storm we need a low cost monolithic converter and multiplexer, and the first example of such a system-on-a-chip has just been announced by National. Termed "Single Chip Data Acquisition Systems", the National ADC0816 and ADC0817 devices really do represent an attempt to bridge the gap between the microprocessor and the essentially analogue world that it lives in. The chips accept up to sixteen separate analogue signal inputs and then select one by means of a multiplexer for conversion to an eight bit digital word. Signal selection is controlled by means of a four bit binary address word which can be latched in directly from a microprocessor bus, or fed via an existing output port.

The eight bit data outputs are tri-state and can also be connected directly to a data bus.

The multiplexer output is brought out to a package pin and must be linked externally to the converter input, allowing signal conditioning and/or multiplexer expansion to be achieved easily. The converter itself is a rather unusual 256R type (256 resistors of value R and a switch tree selection system) instead of the more usual R2R type. Conversion is achieved by means of a successive-approximation sequence, and takes only 100 μ s per channel which means that a.c. signals of up to 300Hz per channel can be coped with (proportionately higher if less channels used), as well as d.c. inputs.

The ADC0816 is specified over a wide temperature range whereas the ADC0817 is specified at 25°C only and has reduced performance, albeit at a lower cost. Both chips are CMOS and draw only about 1mA from a 5V supply.



PE STRING ENSEMBLE

A.J. BOOTHMAN B.Sc.

Part 4

THE Voice circuitry of the String Ensemble is primarily designed to produce a basic tone which when processed through the Chorus Generator gives the simulated sound of an orchestral string section. Two other voices are also provided to add variety to the overall effect and have the basic characteristics of Woodwind and Brass instruments. The circuitry includes the facility to vary the degree of mixing of the voices, and the switching which enables changes of register to be made in both upper and lower sections of the keyboard.

THE VOICING SYSTEM

The outline of the voicing system is shown in Fig. 4.1, and consists of two sections covering upper and lower parts of the keyboard separately. Outputs from the threshold diodes, following the diode gates, for the upper section of the keyboard are taken to staircase networks in the voicing system

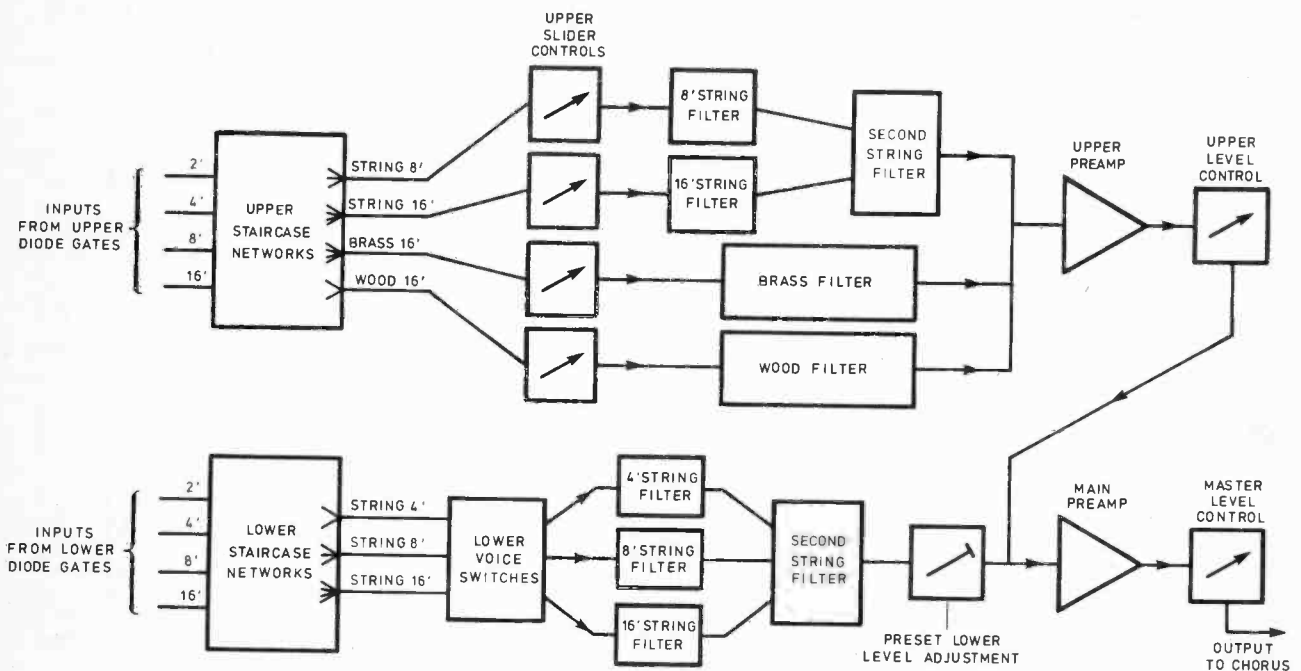


Fig. 4.1. Schematic of the voicing system

which produce stepped waveforms suitable for the four instruments, three at 16ft pitch and one at 8ft pitch. Each instrument is controlled by a slider potentiometer and has its own filter. The string voicing consists of a combination of both high and low pass filters which in conjunction with the second filter, which processes both registers, are in active form. Brass and Woodwind voices are produced by ringing band pass active filters and following a common preamplifier all upper voices are adjusted by a level control on the front panel.

A similar staircase network section produces stepped waveforms for strings in the lower section of the keyboard at 16ft, 8ft, and 4ft, which are then controlled by the lower voice switches and followed by similar string filters to the upper section with a preset level control on the Voice Board.

The combined voices from the full keyboard are amplified together and set by the master level control on the front panel. This signal is passed to the Chorus Generator for processing and returned to the Voice Board for distribution to the Swell Pedal and output sockets.

STAIRCASE NETWORKS

The effect of the Staircase networks is shown in Fig. 4.2 where waveforms (a) to (d) are square waves at 2ft, 4ft, 8ft, and 16ft each coming from the respective diode gate busbar. The square waves contain odd harmonics only which have limited use in the generation of musical instrument tones. Since the square waves on each busbar are octave related even harmonics are available by mixing outputs from each busbar. Generally an amplitude relationship is used where the level of each successively higher even harmonic content is half that of the harmonic below.

Waveform (e) in Fig. 4.2 is produced by mixing an input at 16ft (d) with half the level at 8ft (c), and is used as the base waveform for the woodwind. The description "staircase" can be understood from the shape obtained. Waveform (f) is produced by mixing an input at 16ft with half the level at 8ft, a quarter the level at 4ft, and one eighth the level at 2ft. This waveform is used for all 16ft strings and brass, giving the addition of higher even harmonics.

Waveform (g) is obtained by mixing a fundamental at 8ft with half the level at 4ft and a quarter the level at 2ft for the 8ft strings, whilst waveform (h) has a fundamental at 4ft with half the level at 2ft and is used for the 4ft strings in the lower section.

VOICE CIRCUITRY

Full circuit details are given in Fig. 4.3. Resistors R69 to R76 terminate the output busbars from the diode gate circuits and are essential in any tests of the diode gate system if the Voice Board is removed. R77 to R98 perform the staircasing function prior to slider or switch controllers. The upper string filters are associated with IC32, the brass with IC33, woodwind with IC34 and lower strings with IC35. VR16 and VR17 control the resonant frequencies of the brass and woodwind filters respectively and require setting to avoid the violent peak occurring within the keyboard range. IC36 amplifies all the upper voices and is followed by the upper level control VR18.

LOWER STRING CONTROLS

Switches S3 to S6 are interlinked. With S3 depressed the 16ft and 8ft waveforms from the lower section of the keyboard are linked to String I and II slider controls respectively, and

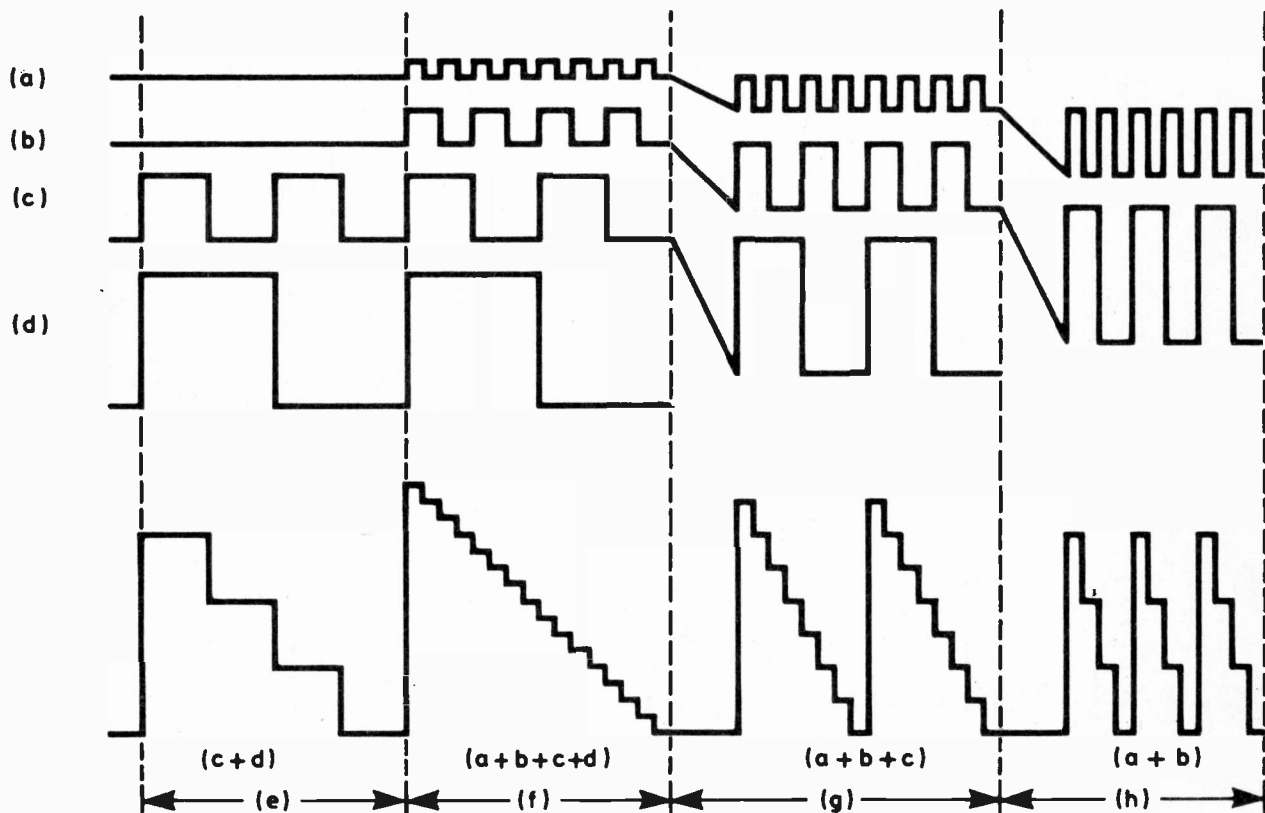


Fig. 4.2. Formation of staircase waveforms from octave related squarewaves

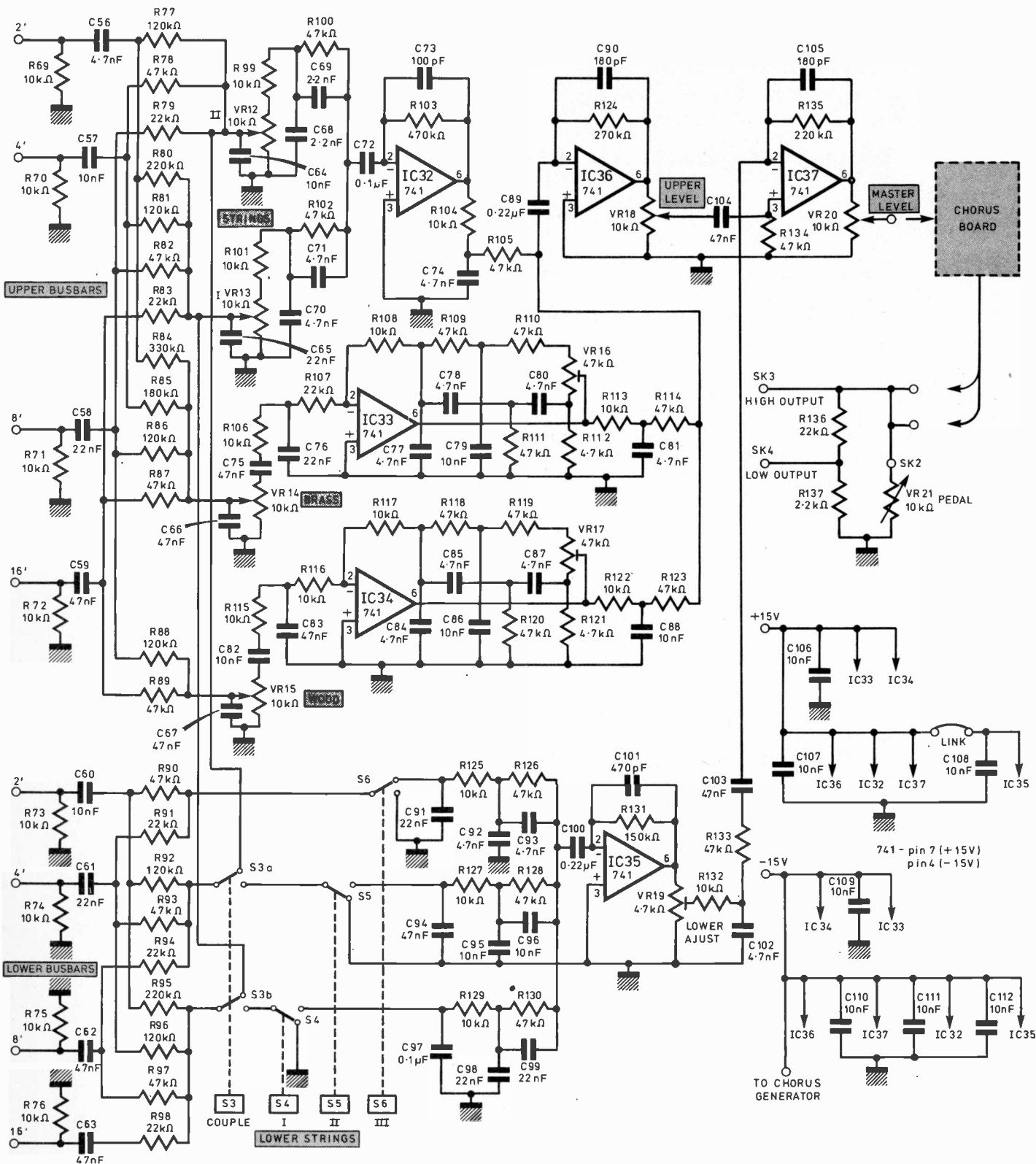


Fig. 4.3. The complete voice circuitry

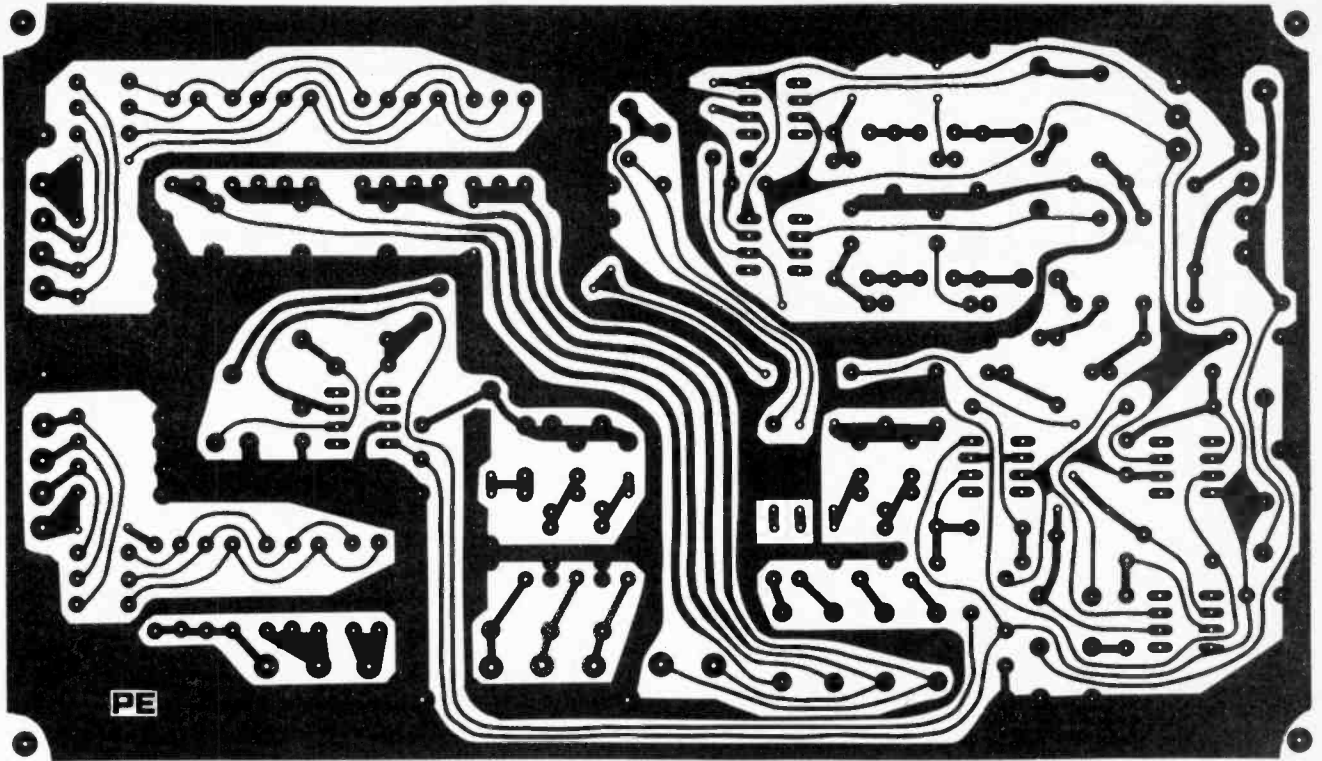


Fig. 4.4. Etching detail for the voice p.c.b.

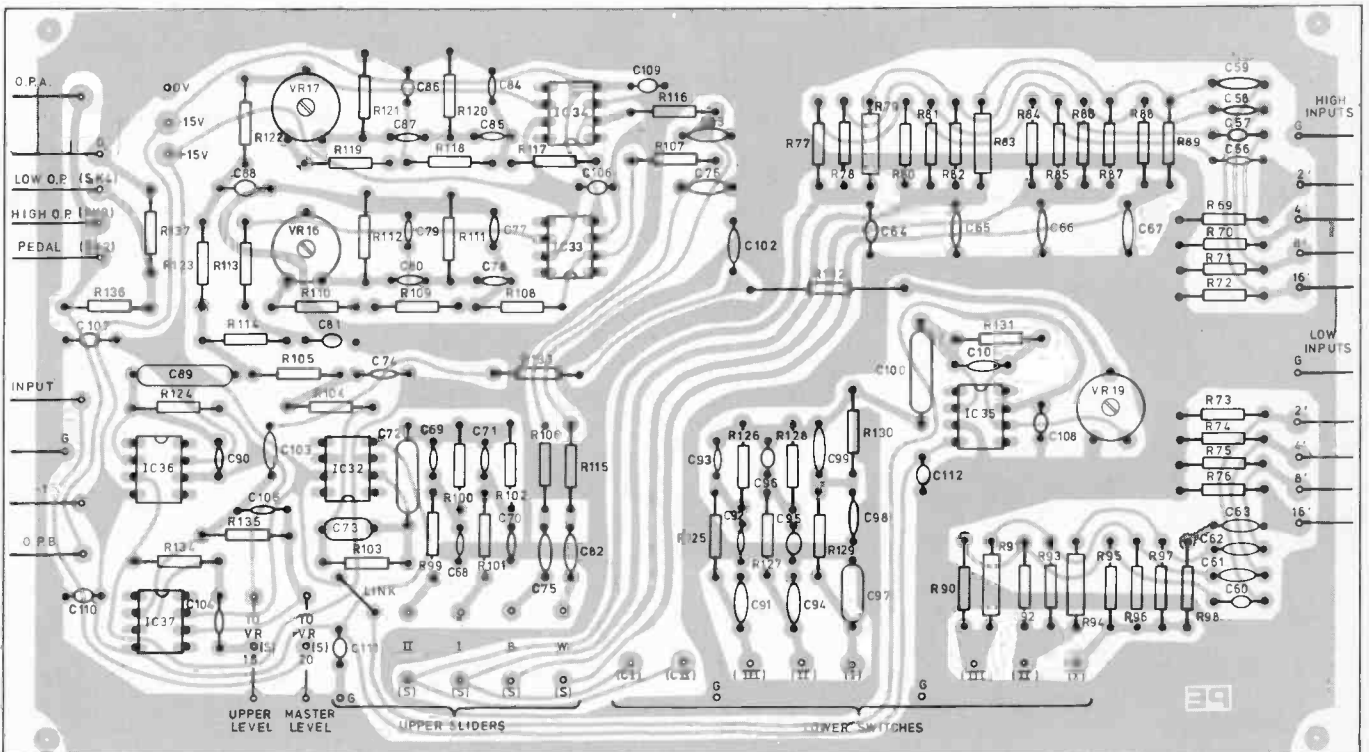


Fig. 4.5. Showing component assembly and drillings

COMPONENTS . . .

VOICING SYSTEM

Resistors

R69-76	10k Ω	R105	47k Ω
R77	120k Ω	R106	10k Ω
R78	47k Ω	R107	22k Ω
R79	22k Ω	R108	10k Ω
R80	220k Ω	R109-111	47k Ω
R81	120k Ω	R112	4.7k Ω
R82	47k Ω	R113	10k Ω
R83	22k Ω	R114	47k Ω
R84	330k Ω	R115-116	10k Ω
R85	180k Ω	R117	10k Ω
R86	120k Ω	R118-120	47k Ω
R87	47k Ω	R121	4.7k Ω
R88	120k Ω	R122	10k Ω
R89-90	47k Ω	R123	47k Ω
R91	22k Ω	R124	270k Ω
R92	120k Ω	R125	10k Ω
R93	47k Ω	R126	47k Ω
R94	22k Ω	R127	10k Ω
R95	220k Ω	R128	47k Ω
R96	120k Ω	R129	10k Ω
R97	47k Ω	R130	47k Ω
R98	22k Ω	R131	150k Ω
R99	10k Ω	R132	10k Ω
R100	47k Ω	R133	47k Ω
R101	10k Ω	R134	47k Ω
R102	47k Ω	R135	220k Ω
R103	470k Ω	R136	22k Ω
R104	10k Ω	R137	2.2k Ω

$\frac{1}{4}$ watt 5% carbon film

Capacitors

C56	4.7nF ceramic	C82	47nF ceramic
C57	10nF ceramic	C83	47nF ceramic
C58	22nF ceramic	C84-85	4.7nF ceramic
C59	47nF ceramic	C86	10nF ceramic
C60	10nF ceramic	C87	4.7nF ceramic
C61	22nF ceramic	C88	10nF ceramic
C62-63	47nF ceramic	C89	0.22 μ F polyester
C64	10nF ceramic	C90	180pF
C65	22nF ceramic	C91	22nF ceramic
C66-67	47nF ceramic	C92-93	4.7nF ceramic
C68-69	2.2nF ceramic	C94	47nF ceramic
C70-71	4.7nF ceramic	C95-96	10nF ceramic
C72	0.1 μ F polyester	C97	0.1 μ F polyester
C73	100pF	C98-99	22nF ceramic
C74	4.7nF ceramic	C100	0.22 μ F polyester
C75	47nF ceramic	C101	470pF ceramic
C76	22nF ceramic	C102	4.7nF ceramic
C77-78	4.7nF ceramic	C103	47nF ceramic
C79	10nF ceramic	C104	47nF ceramic
C80	4.7nF ceramic	C105	180pF
C81	10nF ceramic	C106-112	10nF ceramic

Potentiometers

VR12-15 10k Ω lin Sliders, VR16-17 47k Ω Presets
100mW submin. VR18 10k Ω lin, VR19 4.7k Ω Preset,
VR20 10k Ω lin, VR21 10k Ω Pedal

Integrated Circuits

IC32-37 741

Miscellaneous

SK2-4 Mono standard jack. S3-6 bank of two-pole
two-way switches interlocked. 47 terminal pins
1 printed circuit board.

the 4ft signal is inoperative. S4, 5 and 6 convert the lower section to 16ft, 8ft and 4ft strings only, but more than one control button may be depressed at the same time. Except when in the couple condition the Lower Voices have a fixed amplitude preset by VR19, and balancing of the two parts of the keyboard is achieved with the Upper Level Control.

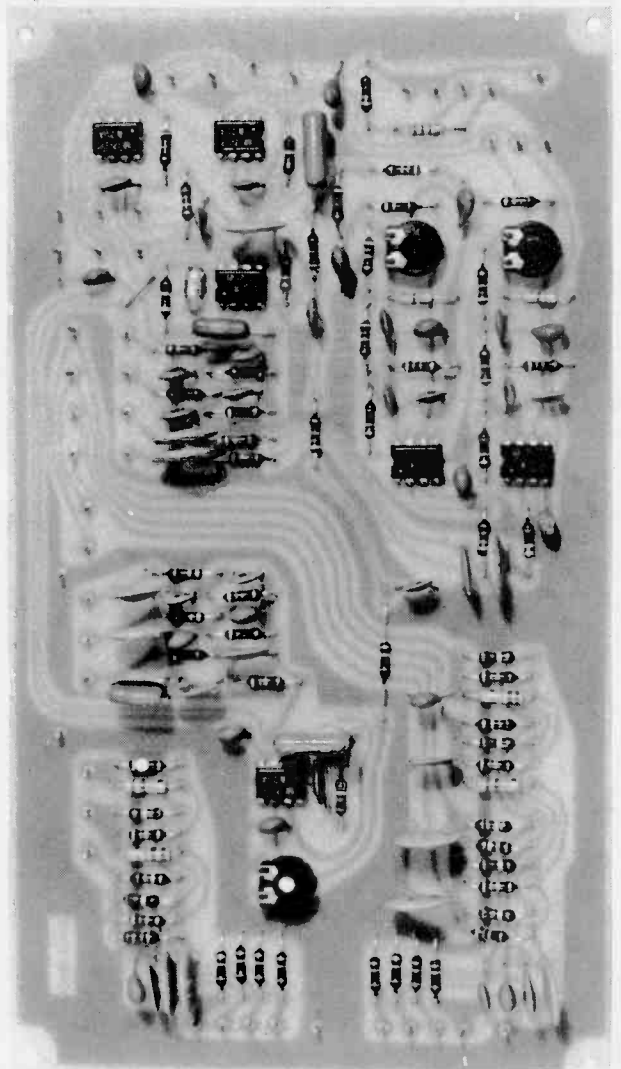
PREAMPLIFIER

Upper and Lower Voices are fed to the complementary (anti-phase) inputs of preamplifier IC37 to compensate for the additional inverting amplifier, IC36, in the upper voice channel. The main purpose of the Master Level Control VR20 is to compensate for the many modes and styles in which the instrument may be played, either melodic or chordal, single or multi-voiced, and it may be used to prevent overloading of the Chorus Generator input under extreme conditions.

OUTPUT AND SUPPLIES

After processing by the Chorus Generator the signal is returned to the Voice Board on which it is controlled by the Expression Pedal via socket SK2. Divider resistors R136 and R137 give high and low level outputs at SK3 and SK4.

The Voice Board is powered by +15 volt and -15 volt supplies obtained from the regulators on the PSU/Tone Generator Board, and capacitors C106 to C112 are incorporated to ensure stable operation to the 741 Operational Amplifiers.



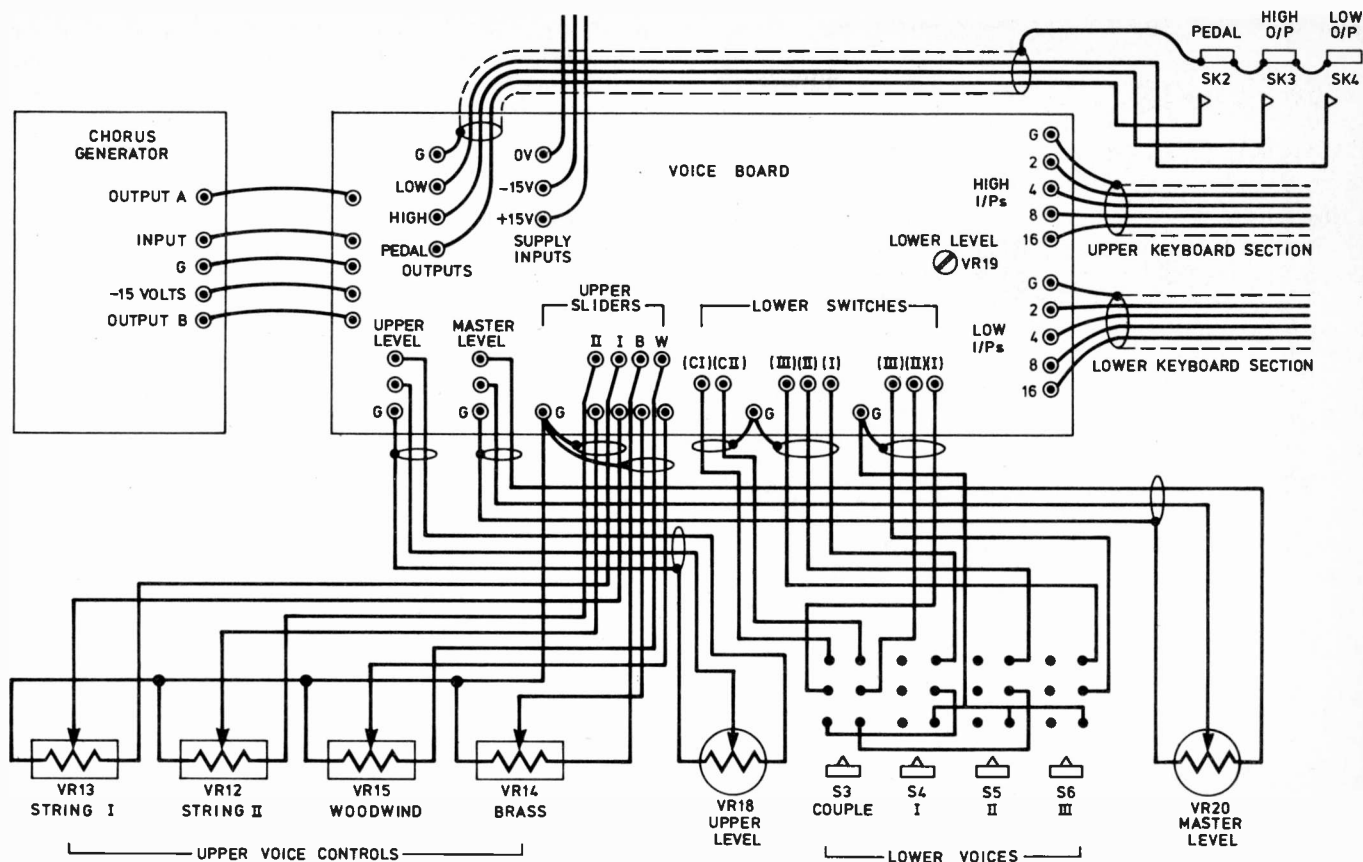


Fig. 4.6. Voice and Chorus interwiring

VOICE BOARD CONSTRUCTION

The Voice circuits described are mounted on a printed circuit board, the etching and drilling details of which are given in Fig. 4.4, with the component assembly details in Fig. 4.5. To assemble the board the terminal pins should first be inserted followed by resistors, i.c.s, preset potentiometers, small capacitors, large capacitors and the wire link next to R103.

INTERWIRING OF THE VOICE AND CHORUS CIRCUITRY

The Chorus Generator interfaces with the Voice Board only, as shown in Fig. 4.6, whilst the Voice Board provides connections to all controls and output sockets. The wiring details given in Fig. 4.6 should be followed carefully, and it should be particularly noted that in some cases screen connections are made at one end of a cable only whilst in others both ends of the screen are connected.

Supply inputs to the Voice Board are taken direct from the PSU/Tone Generator at +15 volts, -15 volts, and 0 volts. Pedal and output signals are taken through a single 3-core screened cable to sockets SK2-SK4 with both ends of the screen connected.

High and low inputs are each taken from the diode gate busbars through a four-core screened cable with the screen connected at each end. The Upper and Master Level Controls are connected by two-core screened cables with the screen soldered at both ends.

UPPER VOICE CONTROLS

A ground lead is taken from the Voice Board and connected to one of the slider controls. A lead is then taken from this point to each voice potentiometer. The remaining terminals on VR12 and VR13 are connected via a four-core screened cable with the screen soldered at the Voice Board end, but not to the potentiometers. Similarly VR14 and VR15 are connected via a four-core screened cable.

LOWER VOICE SWITCHES

A ground lead is taken to the tags (or pins) shown on S4, S5 and S6, which are strapped together. Three multi-screened leads are then used to complete interconnection to the switches and in each case the screen is only soldered to the Voice Board end whilst the other end is cropped and cleaned up to prevent shorting to other switch connections.

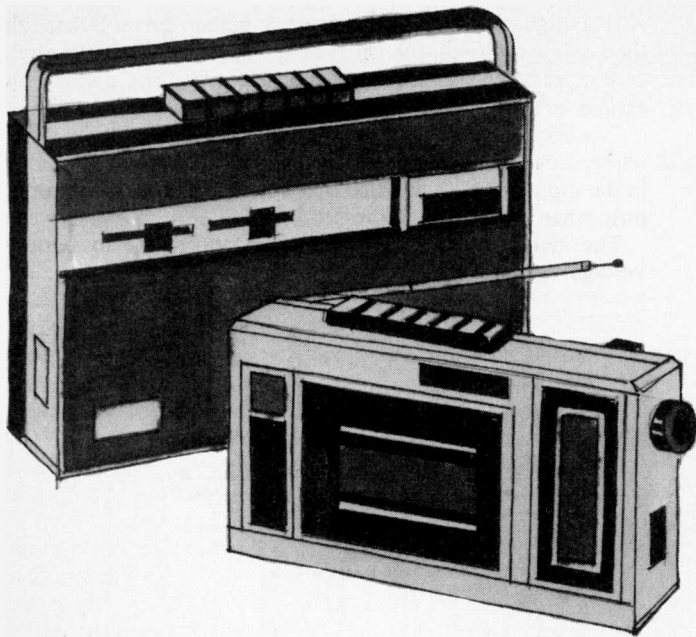
The first lead is two-core and interconnects the relevant pins on the Voice Board to S3. The second lead is three-core and interconnects the Voice Board to S3. The second lead is also three-core and interconnects to the two tags shown on S3 and one tag on S6. Ordinary wire connections are then made as shown between S3 and S4, and between S3 and S5.

Note: Omissions from Part One Components List are C6, C7, C9, C12-10nF ceramic, C8-68pF.

In Fig. 2.5 diodes D23-30 should be reversed. Fig. 2.2 shows them correctly polarised.

In Fig. 3.6 IC28 should be a 14 pin device. The two extreme left pin connections should be ignored.

NEXT MONTH—Cabinet construction



Battery Voltage Monitor

S.V. ESSEX

UTILISING one inexpensive CMOS integrated circuit, the device described in this article gives a positive indication, by means of a light emitting diode, whenever battery voltage falls below a certain preset level.

BATTERY LEAKAGE

Whenever a battery is allowed to discharge too far it usually leaks—as many people have found to their cost at one time or another. Not only is the leakage unsightly and messy, but it is also extremely hard to remove.

Occasionally batteries will leak even when the equipment being supplied gives no indication of falling battery voltage.

Battery voltage is also of paramount importance in connection with test instruments—although these may be stabilised by means of a Zener diode, once the battery voltage falls past a certain level the diode can no longer exercise control and inaccuracies result.

Both leakage and inaccuracy can be prevented by employing a battery voltage monitor, which gives a positive indication of when batteries should be changed well before these problems are encountered.

CIRCUIT OPERATION

The circuit is shown in Fig. 1. Each of the four 2-input NOR gates in the CD4001 CMOS i.c. is used as an inverter by connecting the two inputs together.

The negative supply connection to the four gates is taken to the battery negative line via the light-emitting diode D1, across which an almost constant voltage is developed; even when the circuit is in its quiescent state (i.e. the battery voltage is relatively high), a small leakage current flows through the i.c., which is sufficient to bias the l.e.d. on, although it is not enough to illuminate it beyond a faint glow.

Two of the four gates are connected in cascade, the output from the second gate being connected to the inputs of the two remaining gates, which are connected in parallel. The four gates form one high gain amplifier, such that the output switches very rapidly from high to low when the input voltage to the first gate exceeds a certain proportion—usually 45–50 per cent—of the voltage supplied to the i.c. In figures this is the battery voltage minus about 1.6V developed across the l.e.d.

When the output from the last two gates begins to change state the threshold voltage is thus about 5.3V at a battery voltage of 9V, dropping to about 4.3V when the battery voltage has fallen to 7V.

POTENTIAL DIVIDER

R1, VR1 and R2 form a potential divider across the supply lines; if VR1 is adjusted so that its slider is at a potential of 5.4V (relative to the battery negative line) when the battery voltage is 9V, it will be found that at 7V the slider voltage is 4.2V. Thus, although the slider voltage is higher than the threshold voltage when the battery voltage is high, as battery voltage falls a point is reached where the slider voltage is lower than the threshold voltage and the output of the gates goes from low to high.

Since R3 is connected between the output and the i.c. negative supply pin, it thus draws current which increases the current flowing through D1. This slightly increases the voltage developed across the l.e.d., which, in turn, increases the threshold voltage: a regenerative process is initiated and the i.c. output gates saturate, causing an appreciable current to flow through D1, which then becomes illuminated.

Because the circuit operation is regenerative, there is a certain amount of hysteresis present (about a fifth of a volt), so that if the l.e.d. lights up when the battery voltage drops to 7V, it will remain on until the battery voltage exceeds 7.2V. This characteristic could be useful where a load is drawing high current peaks from a partially discharged battery. Although the battery voltage in between current

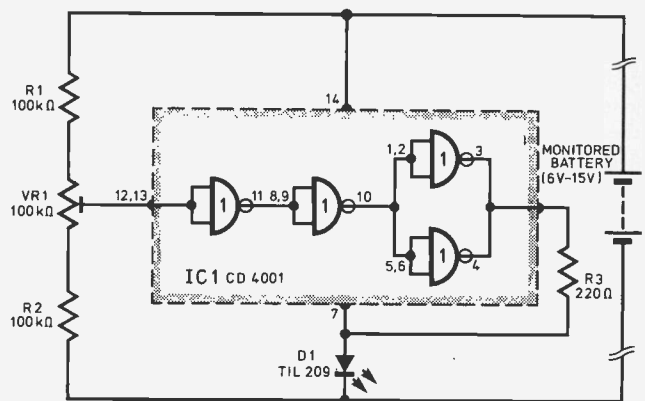


Fig. 1. Circuit of Voltage Monitor

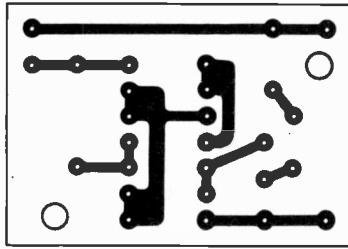


Fig. 2. Suggested printed circuit layout

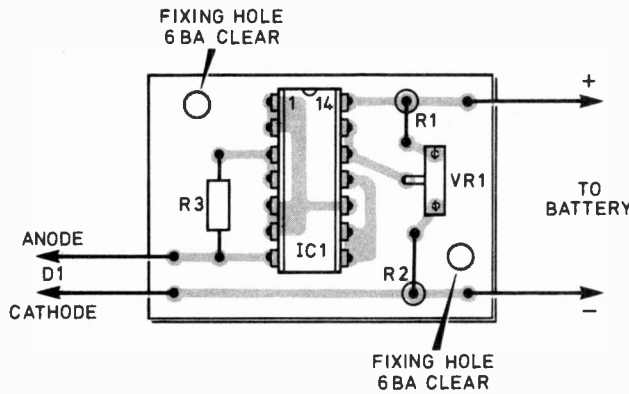


Fig. 3. Showing component assembly and wiring

peaks may be above the safe limit, any excessive rise in the internal resistance of the battery—which in this case could be the deciding factor as to whether or not the battery requires changing—would still mean that the l.e.d. would light up, since the battery voltage would momentarily drop below the preset limit; the hysteresis in the circuit would hold the diode on.

If the hysteresis provided by the basic circuit is insufficient, it can be increased by including a low value resistor (less than 10 ohms) in series with the l.e.d.

WORKING RANGE

The prototype was set to switch on when a nominal 9V battery voltage dropped to 7.2V, although the circuit will work on any voltage in the range 6–15V. With the value of R4 given, the current through D1 is about 10mA just before the l.e.d. cuts out.

COMPONENTS . . .

Resistors

R1, R2 100k Ω
R3 220 Ω
All $\frac{1}{4}$ W 10% carbon

Potentiometer

VR1 100k Ω miniature preset

Semiconductors

D1 TIL 209
IC1 CD4001

If a higher voltage is used, or a higher current through the l.e.d. is required, the value of R4 can be altered, although care must be taken not to exceed the current and dissipation ratings of the i.c.

The standby current is about 0.4mA at 10V, if this is felt to be excessive a small pushbutton switch can be included in the supply to the circuit, so that battery voltage is monitored only when the button is pressed.

The standby current is roughly proportional to battery voltage.

CONSTRUCTION

The circuit, being small, can easily be constructed on a scrap of printed circuit board or Veroboard left over from a larger project: the layout is entirely non-critical although a suggested p.c. board layout is shown (Fig. 2).

When assembling the circuit, small components should be soldered in first and the CMOS i.c. left to last to prevent damage due to overheating. An i.c. socket can be used if desired.

The i.c. should not be handled excessively; although static discharge protection circuits are built into the inputs to the gates, there is no point in taking unnecessary risks. Care should also be taken to connect the i.c. into the circuit the right way round; incorrect connection could lead to an excessively high current flowing through it and the l.e.d.

SETTING UP

The easiest way to set VR1 correctly is to connect the circuit up to a variable voltage power supply, and adjust VR1 so that D1 lights up at the required battery end voltage. The battery voltage monitor can then be connected into the piece of equipment which is to be protected. ★

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MICRO-BUS

Compiled by DJD.

Appearing every two months, Micro-Bus will present ideas, applications, and programs for the most popular microprocessors; ones that you are unlikely to find in the manufacturers' data books. The most original ideas will probably come from readers working on their own microcomputer systems, and payment will be made for any contribution featured here. This is also the place to air your views, in general, on this new technology, so let's be hearing from you!

THIS month's Micro-Bus describes a system which was developed to enable a microprocessor to play waltzes as it composes them. The main part of the program, which will play polyphonic tunes containing up to three notes sounded simultaneously, is described in full, together with the codes to enable it to play the first eight bars of a waltz. With the addition of a random-number generator and some extra control routines the micro can be made to compose as it plays.

MOZART'S DICE WALTZES

The idea of composing music mechanically has its origins in the 18th century when a number of pieces were published which used the throws of dice to randomly select between possibilities at different points in the music. Perhaps the best known of these is the "Musikalisches Würfelspiel" or "Musical Dice Game" attributed to Mozart and published two years after his death in 1793. This pamphlet enables anyone without the least musical ability to compose an almost unlimited number of different waltzes with the aid of a pair of dice. There is some doubt as to whether Mozart actually designed the game, although he was undoubtedly interested in such subjects, and the manuscript for his Adagio KV516 shows the bars arranged by letters in a similar way to the Musical Dice Game.

The Musical Dice Game consists of a set of bars numbered from 1 to 176, and a pair of tables. To compose the first eight bars of a waltz a pair of dice is thrown eight times, and the first table gives the number of the bar to be used at each stage for each throw. The other table is used with a second set of eight dice throws to give the second half of the waltz. The bars are so contrived that, no matter what combination of them is put together, the result will be a pleasant waltz. Since the choices for the eighth bar in each part are the same there are a total of 11^{14} possible waltzes; a number so large that playing a different one every minute it would take 700 million years to hear them all!

MUSIC FROM A MICRO

Although it is simple enough to write a program which uses software timing to play monophonic tunes (only one note sounded at a time), most of the interest of music lies in the simultaneous sounding of several notes to produce harmony and counterpoint, and this dictates the use of some extra hardware to produce the notes independently of the micro. Originally a design was contemplated using a top-octave note generating chip, three 1-of-12 selectors for the note selection, three 6-stage binary dividers and three 1-of-6 selectors for the octave selection, together with latches and addressing logic for interfacing this with the micro. The scheme was soon abandoned when it was realised that the same capability is provided in one Motorola part: the MC6840 Programmable Timer Module. In the mode of operation used here it effectively acts as three independent programmable dividers, so that an organ based on one chip can sound up to three notes at once.

MC6840 PROGRAMMABLE TIMER MODULE

The Programmable Timer Module, or PTM, is a recent addition to the M6800 family, and is Motorola's answer to the Intel 8253 Counter/Timer which it resembles in many ways. It contains three 16-bit counters whose contents can be read at any time, and three 16-bit buffer registers which can be written to by the micro. The contents of these buffers can be transferred to the counters either immediately they are written, or else only under the control of an external gate input $\overline{G1}$, $\overline{G2}$, or $\overline{G3}$. The counters are decremented on each clock pulse derived either from the microprocessor clock ϕ_2 , or from an external signal of lower frequency presented at the respective clock input $\overline{C1}$, $\overline{C2}$, or $\overline{C3}$. When a counter reaches the count of zero, a time-out occurs and a bit is set in the status register. What happens next depends on the mode of operation programmed for that counter by its control register. There are four basic modes of

operation, and any of the three counters can operate in any mode. In single shot mode the counter's output goes low at time-out and remains low until the counter is re-initialized. In continuous mode the content of the buffer register is loaded into the counter at each time-out so that a continuous square-wave is produced at the output. Additionally the timers can be programmed to generate an interrupt when a time-out occurs. In frequency comparison mode an interrupt is generated if the input period is less than (or alternatively, greater than) the counter time-out, and finally, in pulsewidth comparison mode an interrupt is generated if the input "down time" is less than (or greater than) the counter time-out.

The PTM is addressed as eight consecutive memory locations, the first two of which provide access to the three control registers and the status register, and the next three pairs of which are used to write to the buffer registers or read the current values of the counters. The MC6840 is available from Cramer Components Ltd., 16 Uxbridge Road, Ealing, London, W5 2BP, for £12.73 plus 80p postage (VAT extra).

MUSIC INTERFACE

The complete circuit for the music interface is shown in Fig. 1. The three counters of the PTM are used in continuous mode, and the gate inputs are grounded to enable the counters. The clocks are derived from the microprocessor clock, so the inputs $\overline{C1}$, $\overline{C2}$, and $\overline{C3}$ are left unconnected. The three outputs are taken to an adder circuit at the input of an LM386 1 watt audio amplifier chip which drives a loudspeaker. The two MT8T26 quad bidirectional buffer packages and the TTL gates are needed to interface the PTM to the D2 kit's bus. In a small system the PTM could be connected directly to the microprocessor's address and data lines in which case these parts could be dispensed with. As shown, the PTM is addressed as locations \$2010 to \$2017.

The music produced by the circuit sounds "organlike" since the amplifier

is fed with the unmodified squarewave outputs of the PTM, but with extra circuitry it would be possible to add filtering or envelope shaping, possibly under control of the micro, to simulate other instruments or sounds. Once configured, the three counter outputs will produce frequencies equal to half the clock frequency divided by $N+1$, where N is the 16-bit number loaded into the respective buffer register. To obtain silence from any output, zero can be loaded into the buffer to give an inaudibly high frequency. To play tunes a program is needed to read the music stored in some notation in memory, and from this, load the correct divisors chosen to give the musical scale of notes, into the three counters at the correct times.

MUSIC NOTATION

The notation used for encoding tunes to be played by the micro uses one byte for each note, and one byte for each change in duration. The codes are shown in Fig. 2. The note codes use the lower four bits to determine the note, and bits 4 to 6 to determine the octave of the note (7 for the highest octave and 1 for the lowest), giving a total range of 7 octaves. For silence, a code of \$60 is used. The top bit specifies whether the notes will be sounded. If the top bit is zero, the next note code is fetched immediately; if one, the program waits for a certain duration while the notes sound. This duration is set up by specifying a duration code with \$D in the lower four bits. The upper four bits then give a duration of 1 to 16 units. Fig. 3 shows the note codes for a section of the keyboard (the values in brackets give the codes with the top bit set).

The notation is best explained by an example. Fig. 4 shows the music for the first eight bars of a dice waltz, together with the hex codes which, when supplied to the program to be described, will play the tune at the loudspeaker of the music interface.

MUSIC PROGRAM

The main part of the music program is subroutine PLAY, shown in Fig. 5, which converts the note codes into the correct divisors and loads them into the PTM to generate the music. Its operation is shown by the flowchart of Fig. 6. A duration code, when encountered at any time, sets the duration parameter DURN to the value of the top four bits. Note codes cause the divisors for the notes specified to be loaded into successive buffer registers of the PTM until a note code with the top bit set has been encountered; at this point the program delays for the currently standing duration, and the register pointer is reset. The table SCALE gives the divisors for a well-tempered top octave; these are doubled for each successive lower octave.

The main program to call subroutine PLAY and play a tune, such as the one given in Fig. 4, is shown in Fig. 7. This is

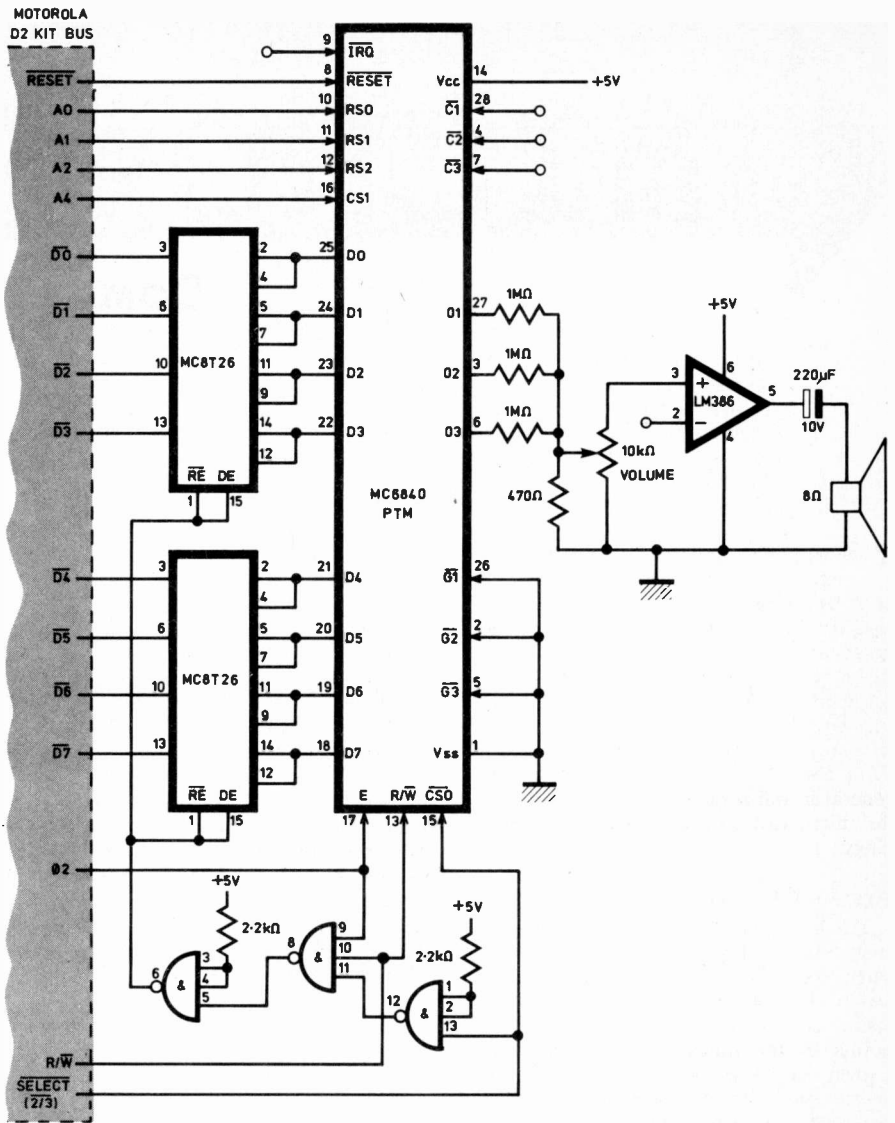


Fig. 1. Circuit for the music interface described in the text, based on the MC6840 PTM

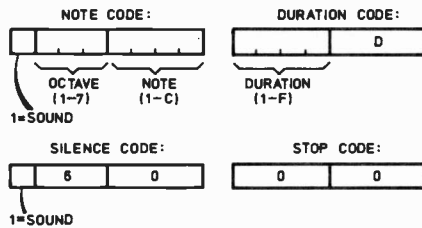


Fig. 2. The four types of 8-bit code used to encode tunes for the music program described

Fig. 3. Note codes corresponding to the notes of a section of the keyboard. The same values with the top bit set are shown in brackets

(D0) 5A	(E1) 61	(E4) 64	(E5) 66	(E8) 68	(E8) 6B	(F1) 71	(F4) 74	(F6) 76	(F8) 78				
(DA) 5A	(DC) 5C	(E2) 62	(E3) 63	(E5) 65	(E7) 67	(E9) 69	(EA) 6A	(EC) 6C	(F2) 72	(F3) 73	(F5) 75	(F7) 77	(F9) 79



WALTZ PCB \$2D, \$72, \$4A, \$80, \$EA, \$65, \$80
 PCB \$72, \$4A, \$80, \$EA, \$65, \$80
 PCB \$1D, \$6C, \$55, \$C9, \$F2, \$F3, \$8C, \$6A, \$C5, \$E9
 PCB \$6A, \$52, \$CA, \$E9, \$EA, \$F2, \$2D, \$65, \$60, \$80
 PCB \$74, \$CA, \$1D, \$F7, \$F4, \$6C, \$80, \$F4
 PCB \$75, \$4C, \$CC, \$F4, \$75, \$4C, \$CC, \$F9, \$2D, \$6C, \$4C, \$CC
 PCB \$1D, \$72, \$4A, \$80, \$EA, \$65, \$CC, \$E7, \$65, \$8C, \$E4
 PCB \$2D, \$45, \$75, \$E9, \$1D, \$D5, \$D3, \$52, \$60, \$80, \$CC, 0

Fig. 4. The music for the first eight bars of one possible Mozart dice waltz, together with the hex codes for playing this on the system described in the article. Each line of codes corresponds to one bar of the music

```

NAM      PLAY
* SUBROUTINE TO PLAY LIST OF NOTES
* POINTED TO BY X.
*
0000 0002  NOTE  RMB  2
0002 0002  PNOTE  RMB  2
0004 0002  PTIMER  RMB  2
0006 0001  DURIN  RMB  1
0007 0001  TOP    RMB  1
*
0240     TEMPO EQU  5240
2010     TIMER EQU  52010  MC6840 PTH
*
* WELL TEMPERED SCALE *
*
0008 0000  SCALE  FDB  0.451,426,402,379
000A 01C3
000C 01AA
000E 0192
0010 017A
0012 0166  FDb  358,338,319,301
0014 0152
0016 013F
0018 012D
001A 011C  FDb  284,268,253,239
001C 010C
001E 00FD
0020 00EF
*
0022 DF 00  PLAY  STX  NOTE
0024 CE 2012 NEWSSET LDX  PTIMER+2
0027 DF 04  STIMER STX  PTIMER
0029 DE 00  MORE   LDX  NOTE
002A A6 00  LDA  A  0.X
002D 26 01  JNE  NSTOP
002F 39     TTS      RETURN
0030 06  NSTOP  INX
0031 DF 00  STX  NOTE
0033 16     TAB
0034 C0 0D  SUB  3  150D
0036 C5 0F  BIT  3  150F  2ND DIGIT D?
0038 26 04
* D = DURATION CODE *
003A D7 06  STA  3  DURIN
003C 20 E8  BRA  MORE
003E 36     SET  PSH  A
003F 16     TAB
0040 84 0F  AND  A  150F  NOTE PAIR
0042 48     ASL  A
0043 83 08  ADD  A  1SCALE
0045 97 03  STA  A  PNOTE+1
0047 4F     CLT  A
0048 89 00  ADC  A  1SCALE/256
004A 97 02  STA  A  PNOTE
004C DE 02  LDX  PNOTE  POINT TO DIVISOR
004E A6 00  LDA  A  0.X
0050 97 07  STA  A  TOP
0052 A6 01  LDA  A  1.X
0054 58     ASL  A
* DOUBLE DIVISOR FOR EACH LOWER OCTAVE *
0055 C0 E0  SHIFT  SUB  3  15ED
0057 24 06  JCC  NSHIFT
0059 49     ROL  A  WITH CARRY SET
005A 79 0007  ROL  TOP
005B 21 F6  BRA  SHIFT
005F 4A     NSHIFT DEC  A  AS DIVIDES BY N+1
0060 DE 04  LDX  PTIMER
0062 D6 07  LDA  B  TOP
0064 E7 00  STA  B  0.X
0066 A7 01  STA  A  1.X
0068 88     INC
0069 88     INX
006A 32  PUL  A
006B 4D     TST  A
006C 2A 39  JPL  STIMER
* TOP BIT SET = SOUND NOTES *
006E 96 86  SOUND  LDA  A  DURIN
0070 CE 0240  LONGER LDX  1TEMPO
0073 89     WAIT  DEX
0074 26 FD  JNE  WAIT
0076 4A     DEC  A
0077 26 F7  JNE  LONGER
0079 20 A9  BRA  NEWSSET
*
END

```

Fig. 5. Subroutine for the MC6800 micro which plays music stored in memory in coded form

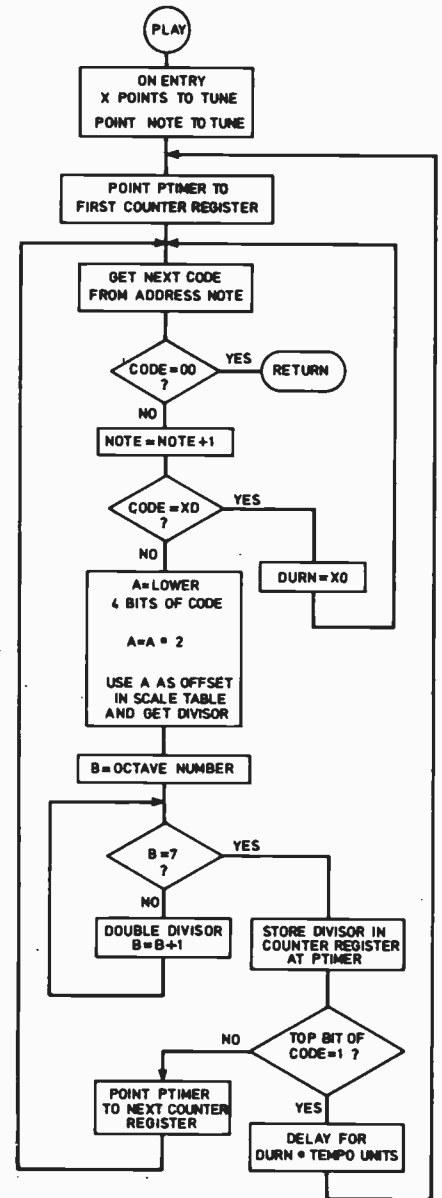
Fig. 6. Flowchart for subroutine PLAY shown in Fig. 5

Fig. 7. Main program for the MC6800 micro which configures the three counters of the PTM for continuous mode, and then calls subroutine PLAY

```

0080     ORG  180
0080 CE 0203 BEGIN  LDX  158203  CONFIGURE PTM
0083 FF 2010     STX  TIMER
0086 86 82     LDA  A  1582
0088 B7 2010     LDA  A  1582
008B CE 0092     STA  A  TIMER
008E DD 0022     JSR  PLAY
0091 3F     SVI

```



entered at BEGIN. These programs were developed and run on a Motorola D2 kit, which is based on the MC6800 micro, although it should be a simple matter to modify them to run on any other. To implement the composing of dice waltzes a random number generator is used to choose between several alternatives for each bar. One approach would be to use the random number as an

offset to a table of pointers to the alternative bars. The composition of music by computer is certainly not exhausted by the techniques described, and it is hoped that those interested will be stimulated to experiment further. It seems as unlikely that music generated in this linear way will be memorable any more than a line of random numbers will form a pleasing overall pattern.

A more enlightened approach might be to compose from the top down; for example, starting with a simple theme which is developed and embellished. Perhaps the most amusing suggestion was to use the Musical Dice Game to generate continuous "musak" which would never repeat itself! When by chance an especially pleasing waltz cropped up, the sequence of bars could be noted down for posterity.

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The MK14 National Semiconductor Scamp based Microcomputer Kit gives you the power and performance of a professional keyboard-addressable unit - for less than half the normal price. It has a specification that makes it perfect for the engineer who needs to keep up to date with digital systems or for use in school science departments. It's ideal for hobbyists and amateur electronics enthusiasts, too.

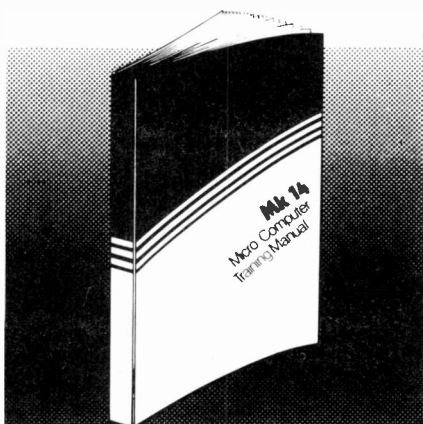
But the MK14 isn't just a training aid. It's been designed for practical performance, so you can use it as a working component of, even the heart of, larger electronic systems and equipment.

MK14 Specification

- ★ Hexadecimal keyboard
- ★ 8-digit, 7-segment LED display
- ★ 512 x 8 Prom, containing monitor program and interface instructions
- ★ 256 bytes of RAM
- ★ 4MHz crystal
- ★ 5V stabiliser
- ★ Single 6V power supply
- ★ Space available for extra 256 byte RAM and 16 port I/O
- ★ Edge connector access to all data lines and I/O ports

Free Manual

Every MK14 Microcomputer kit includes a free Training Manual. It contains



**Just
£39.95
(+ £3.20 VAT, and p&p)**

operational instructions and examples for training applications, and numerous programs including math routines (square root, etc) digital alarm clock, single-step music box, mastermind and moon landing games, self-replication, general purpose sequencing, etc.

Designed for fast, easy assembly

Each 31-piece kit includes everything you need to make a full-scale working microprocessor, from 14 chips, a 4-part keyboard, display interface components, to PCB, switch and fixings. Further software packages, including serial interface to TTY and cassette, are available, and are regularly supplemented.

The MK14 can be assembled by anyone with a fine-tip soldering iron and a few hours' spare time, using the illustrated step-by-step instructions provided.

Tomorrow's technology - today!

"It is not unreasonable to assume that within the next five years... there will be hardly any companies engaged in electronics that are not using micro-processors in one area or another."

Phil Pittman, Wireless World, Nov. 1977.

The low-cost computing power of the microprocessor is already being used to replace other forms of digital, analogue, electro-mechanical, even purely mechanical forms of control systems.

The Science of Cambridge MK14 Standard Microcomputer Kit allows you to learn more about this exciting and rapidly advancing area of technology. It allows you to use your own microcomputer in practical applications of your own design. And it allows you to do it at a fraction of the price you'd have to pay elsewhere.

Getting your MK14 Kit is easy. Just fill in the coupon below, and post it to us today, with a cheque or PO made payable to Science of Cambridge. And, of course, it comes to you with a comprehensive guarantee. If for any reason, you're not completely satisfied with your MK14, return it to us within 14 days for a full cash refund.

**Science of Cambridge Ltd,
6 Kings Parade,
Cambridge,
Cambs., CB2 1SN.
Telephone: Cambridge (0223) 311488**

To: Science of Cambridge Ltd,
6 Kings Parade, Cambridge,
Cambs., CB2 1SN.

Please send me an MK14 Standard
Microcomputer Kit. I enclose cheque/
Money order/PO for £43.55 (£39.95
+ 8% VAT and 40p p&p).
Allow 21 days for delivery.

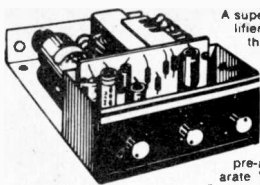
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Science of Cambridge

PE/6

SUPERSOUND 13 HI-FI MONO AMPLIFIER



A superb solid state audio amplifier. Brand new components throughout 5 silicon transistors plus 2 power output transistors in push-pull Full wave rectification. Output approx 13 watts r.m.s. into 8 ohms. Frequency response 12Hz 30KHz = 3db Fully integrated pre-amplifier stage with separate Volume Bass boost and Treble cut controls Suitable for ceramic or crystal cartridge. Sensitivity approx 40mV for full output Supplied ready built and tested with knobs, escutcheon panel, input and output plugs. Overall size 3in high x 6in wide x 7in deep. AC 200/250V

8-15 ohm speakers Input for ceramic or crystal cartridge. Suitability for Public Address system, Disco, Guitar, Gram, etc. Features 3 individually controlled inputs (each input has a separate 2 stage pre-amp.). Input 1, 15mV into 47k. Input 2, 15mV into 47k (suitable for use with mic. or guitar etc.). Input 3, 200mV into 1 meg. suitable for gram, tuner, or tape etc. Full mixing facilities with full range bass & treble controls All inputs plug into standard jack sockets on front panel. Output socket on rear of chassis for an 8 ohm or 16 ohm speaker Output in excess of 20 watts RMS Very attractively finished purpose built cabinet made from black vinyl covered steel, with a brushed anodised aluminium front escutcheon For ac mains operation 200/240 volts Price approx 12in wide x 5in high x 7in deep

HARVERSONIC MODEL P.A. TWO ZERO



An advanced solid state general purpose mono amplifier suitable for Public Address system, Disco, Guitar, Gram, etc. Features 3 individually controlled inputs (each input has a separate 2 stage pre-amp.). Input 1, 15mV into 47k. Input 2, 15mV into 47k (suitable for use with mic. or guitar etc.). Input 3, 200mV into 1 meg. suitable for gram, tuner, or tape etc. Full mixing facilities with full range bass & treble controls All inputs plug into standard jack sockets on front panel. Output socket on rear of chassis for an 8 ohm or 16 ohm speaker Output in excess of 20 watts RMS Very attractively finished purpose built cabinet made from black vinyl covered steel, with a brushed anodised aluminium front escutcheon For ac mains operation 200/240 volts Price approx 12in wide x 5in high x 7in deep

Special introductory price £28.00 - £2 50 carriage and packing. Mullard LP1159 RF-IF module 470 kHz £2.25 + P & P 20p. Full specification and connection details supplied. Pye VHF FM Tuner Head covering 88-108 MHz 10.7 MHz I.F. output. 7.8V + earth. Supplied pre-aligned, with full circuit diagram with precision-ganged F.M. gang and 323PF + 323PF A.M. Tuning gang only £3.15 + P. & P. 35p.

STILL AVAILABLE HA34 3 Valve Audio Amp. 4 1/2w o/p. Ready built and tested £8.50 £1.40 P. & P. Also HSL "Four" Amp. Similar to above but in kit form. £8.00 + £1.40 P. & P.

MAINS OPERATED SOLID STATE AM/FM STEREO TUNER



200 240V Mains operated Solid State F.M. A.M. Stereo Tuner Covering M.W. A.M. 540-1605KHz V.H.F. F.M. 88-108MHz Built-in Ferrite rod aerial for M.W. Full AFC and AGC on A.M. and F.M. Stereo Beacon Lamp Indicator Built in Pre-amps with variable output voltage adjustable by pre-set

control Max o/p Voltage 600mV R.M.S. into 20K Simulated Teak finish cabinet Will match almost any amplifier. Size 8 1/2in wide x 4in high x 9 1/2in deep approx. Limited number only at £28.00 + £1.50 P. & P

VYNAIR & REXINE SPEAKERS & CABINET FABRICS app. 54 in. wide. Our price £2.00 yd. length. P. & P. 50p per yd. (min. 1 yd.). S.A.E. for samples.

10/14 WATT HI-FI AMPLIFIER KIT

A stylishly finished monaural amplifier with an output of 14 watts from 2 EL84s in push-pull Super reproduction of both music and speech, with negligible hum Separate inputs for mike and gram allow records and announcements to follow each other Fully shrouded section wound output transformer to match 3-15Ω speaker and 2 independent volume controls, and separate bass and treble controls are provided giving good lift and cut. Valve line-up 2 EL84s, ECC83, EF86 and E280 rectifier Simple instruction booklet 25p + S.A.E. (Free with parts) All parts sold separately. ONLY £13.50 P. & P. £1.40. Also available ready built and tested £18.00 P. & P. £1.40.

"POLY PLANAR" WAFER-TYPE, WIDE RANGE ELECTRO-DYNAMIC SPEAKER

Size 11 1/2in x 14 1/2in x 1 1/2in deep Weight 19oz Power handling 20W R.M.S. (40W peak) Impedance 8 ohm only Response 40Hz-20KHz Can be mounted on ceilings, walls, doors, under tables, etc. and used with or without baffle Send S.A.E. for full details. Only £8.40 each + P. & P. (one 90p, two £1.10). Now available in either 8in round version or 4 1/2 x 8 1/2in rectangular. 10 watts R.M.S. 60Hz-20KHz £5.25 + P. & P. (one 85p, two 75p).

SPECIAL OFFER. 6 1/2in long throw, roll surround, ceramic magnet 8 ohm 10 watt speaker chassis. Specially suitable for Hi Fi £3.95 75p P. & P.

2in PLASTIC CONE HF TWEETER 4 ohm. £3.50 per matched pair + 50p P. & P.

HIGH POWER HI-FI 8 ohm Dome Tweeter. 1in voice coil. Magnet size 3in dia. Suitable for use in up to 50 watt systems. £4.50 each 60p P. & P.

HARVERSONIC SUPERSOUND 10 + 10 STEREO AMPLIFIER KIT

A really first-class Hi-Fi Stereo Amplifier Kit. Uses 14 transistors including Silicon Transistors in the first five stages on each channel resulting in even lower noise level with improved sensitivity integral pre-amp with Bass, Treble and two Volume controls. Suitable for use with Ceramic or Crystal cartridges. Very simple to modify to suit magnetic cartridge—instructions included. Output stage for any speakers from 8 to 15 ohms. Compact design, all parts supplied including drilled metalwork, high quality ready drilled printed circuit board with component identification clearly marked, smart brushed anodised aluminium front panel with matching knobs, wire, solder, nuts, bolts—no extras to buy. Simple step by step instructions enable any constructor to build an amplifier to be proud of. Brief specification. Power output 14 watts R.M.S. per channel into 5 ohms. Frequency response = 3dB 12-30,000Hz. Sensitivity better than 80mV into 1 MΩ Full power bandwidth = 3dB 12-15,000Hz Bass boost approx to = 12dB Treble cut approx to = 16dB Negative feedback 18dB over main amp. Power requirements 35V at 1A.

Overall size 12in wide x 8in deep x 2 1/2in high. Fully detailed 7 page construction manual and parts list free with kit or send 25p plus large S.A.E.

AMPLIFIER KIT £13.50 P. & P. 80p (Magnetic input components 33p extra)

POWER PACK KIT £5.50 P. & P. 95p

CABINET £5.50 P. & P. 95p

SPECIAL OFFER—only £23.75 if all 3 items ordered at one time plus £1.25 P. & P.

Full after sales service Also available ready built and tested £31.25 P. & P. £1.50

HARVERSONIC STEREO 44

A solid state stereo amplifier chassis, with an output of 3-4 watts per channel into 8 ohm speakers. Using the latest high technology integrated circuit amplifiers with built in short term thermal overload protection. All components including rectifier smoothing capacitor, fuse, tone control, volume controls, 2 pin din speaker sockets and 5 pin din tape rec. play socket are mounted on the printed circuit panel. Size approx. 3 1/2in x 2 1/2in x 1 1/2in max. depth. Supplied brand new and tested with knobs brushed anodised aluminium 2 way escutcheon (to allow the amplifier to be mounted horizontally or vertically) at only £9.00 - 50p P. & P. Mains transformer with an output of 17V a.c. at 500mA can be supplied at £1.50 + 40p P. & P. if required Full connection details supplied

STEREO DECODER

SIZE 2 1/2" x 3 1/2" ready built. Pre-aligned and tested for 9-16V neg. earth operation. Can be fitted to any FM VHF radio or tuner. Stereo beacon light can be fitted if required. Full details and instructions (inclusive of hints and tips) supplied. £6.00 plus 20p P. & P. Stereo beacon light if required 40p extra.

Open 9.30-5.30 Monday to Friday. 9.30-5 Saturday Closed Wednesday. Prices and specifications correct at time of press. Subject to alteration without notice

HARVERSON SURPLUS CO. LTD.

(Dept. P.E.) 170 HIGH ST., MERTON, LONDON, S.W.19 Tel.: 01-540 3985

A few minutes from South Wimbledon Tube Station

(Please write clearly)

PLEASE NOTE: P. & P. CHARGES QUOTED APPLY TO U.K. ONLY P. & P. ON OVERSEAS ORDERS CHARGED EXTRA.

GLOUCESTER INDUSTRIAL SALES AND AUCTIONS LIMITED

Eastington Trading Estate, Nr. Stonehouse, Glos.

Tel: Stonehouse 4118

(M.5 Motorway - Exit No. 13)

We hold regular monthly auction sales of mostly new electronic and electrical goods consisting of transistors, triacs, integrated circuits, diodes, capacitors and resistors, together with fractional motors, transformers, power packs, etc., etc.

Phone or write to be put on our auction mailing list.

Why not get in touch with our Mr. Jack Bailey and enquire about our terms for the disposal of your surplus stocks, etc., through our auctions.

BARGAIN PARCELS SAVE POUNDS

Huge quantities of electronic components must be cleared as space required. 1000's of capacitors, resistors, transistors, Ex equipment panels etc. covered in valuable components. No time to sort. Most sell by weight 7 lbs - £4.95; 14 lbs - £7.95; 28 lbs - £12.00; 56 lbs - £20.00; 112 lbs - £30.00.

BARGAIN PACKS

Don't let your environment dehydrate you. Buy a Honeywell Humidity Controller membrane operated with 1/2" shaft ideal for greenhouses, centrally heated homes, etc. Build your own humidity alarm. 1-75A. Contacts of 250V £1.50 each. 3 for £4. 4 aluminium boxes 128 x 44 x 38 mm ideal for signal injectors, etc. £1.00. 100 miniature reed switches ideal for burglar alarms, model railways, etc. £3.30. 6 x 6-pole 12 volt reed relays on board £2.45. High quality computer panels smothered in top grade components: 5 lbs £4.75; 10 lbs £8.95. Miniature edgewise panel meters 200 uo. fsd £1.00. Miniature transistorised f.m. front end with integral tuning gang 88-108MHz £2.50. New U.H.F. transistor TV tuners 4 pushbutton type £3.50. Aluminium TV coax plugs. 10 for £1.00. Miniature 5K log pots with s/p switch. 4 for £1.00.

Hardware Packs each containing 100's of items including: 8A nuts and bolts, Nylon, Self-tapping, Posidrive, "P" clips, Cable clamps, Fuse holders, Spare nuts etc. etc. £1.00 per pound. 100 1/2in. "P" Clips 60p, 200 for £1.00. Heavily insulated E.H.T. Discharging Probe with lead and earth connector 60p each. Dual 100K Balance Pots, Miniature, PC Mounting with Nuts. 4 for £1.00. 20Ω 16wt. Ceramic W.W. Resistors. 5 for £1.00. 135Ω 15wt. Ceramic W.W. Resistors. 5 for £1.00. 105Ω 10wt. Ceramic W.W. Resistors. 6 for £1.00. 0.22µF 400V Polyester Cops. 12 for £1.00. 470µF 25V Radial, Japanese Caps. 5 for £1.00.

DE LUXE FIBRE GLASS PRINTED CIRCUIT ETCHING KITS

Includes 150 sq. ins. copper clad f/g board, 1 lb ferric chloride, 1 dolo etch resist pen, abrasive cleaner, 2 mini drill bits, etch tray and instructions—only £5.30. 150 sq. in. fibre glass board.....£2.00 Dolo pen.....90p 1 lb ferric chloride to mil spec.....£1.25 5 lbs ferric chloride to mil spec.....£5.00 Instruction sheet.....20p

Miniature mains transformers, fully shrouded. 240V in 6-0-6V at 100MA. out. Ex. New equipment, complete with mains lead and plug on input and short leads on output. 95p.

Semiconductor Bargains

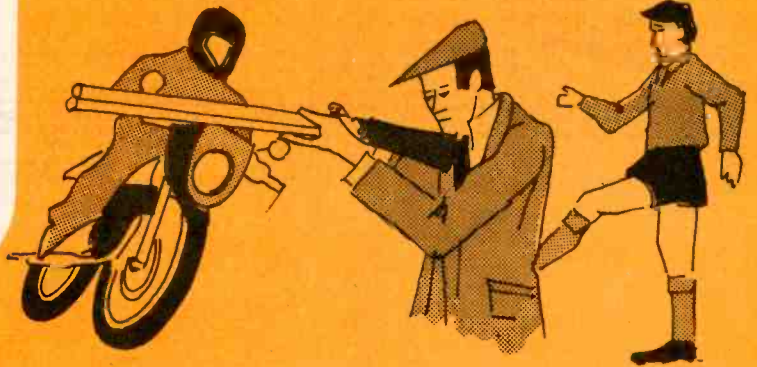
TH3 Thermistors. 10 for £1.00. 100 new and-marked silicon and germanium transistors including 8C148, 8F194, 8C183, etc. £3.95 200 new and marked transistors, including 2N3055, AC128, BFY50, BD131, etc. £6.95. 100 mixed diodes IN4148, etc. £1.20. 100 mixed diodes including zener, power and bridge types £3.30. Bridge rectifier 100V 2.5 amp. 4 for £1.00. Brand new ITT 25kV T.V. triplers for Decca Bradford chassis £2.50. 5 for £10.00. 50 Germanium diodes ideal for crystal sets etc. £1.00. Motorola 1 watt audio amplifier I.C. supplied with dipo and circuits £1.00. Full spec. i.R. diodes, 200V 1A. 20 for £1.00. 100 for £4.50. SN76115N £1.00.

Component Bargains

300 mixed resistors 1/2 & 1/4 watt £1.50. 300 modern mixed caps, most types, £3.30. 200 mixed resistors, mostly 1 & 2 watt, £1.50. 100 mixed polyester caps £2.20. 100 mixed modern miniature and ceramic plate caps, £1.50. 100 mixed electrolytics £2.20. 300 printed circuit resistors £1.00. 25 mixed pots and presets £1.50. 100 mixed carbon film and metal film resistors mostly miniature lots of values, £1.20. 500 for £4.90. 100 mixed high wattage resistors, wirewound, etc. £2.20. 20 assorted VDRs and Thermistors £1.20. 25 assorted preset pots/skeleton, etc. £1.20.

40p P & P ON ALL ABOVE ITEMS. SEND CHEQUE OR POSTAL ORDER WITH ORDER TO SENTINEL SUPPLY, DEPT PE, 149A BROOKMILL RD., DEPTFORD SE8

**NEXT
MONTH**



PE TV GAME CENTRE

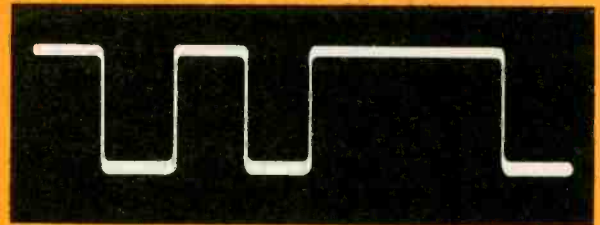
Not just one game that needs two players and may quickly become boring, but 14 games, some of which are for practice by a single player and some which are timed and may thus be played by any number of competitors.

The basic games (many have various options) are: Shooting, Basketball, Ice Hockey, Tennis, Soccer, Squash, Gridball, Motorcycle Jumping, Drag Racing, Motocross.

Joystick controls, colour option, automatic ball speed-up and sound from the set are just some of the features. Probably the most worthwhile set of games available, just right for all the family—from 4 years upwards.

OSCILLOSCOPE LOGIC MONITOR

Provides a visual display of eight simultaneous logic states. Ideal for the speedy testing of i.c.s as gate inputs can be simply monitored. To aid clarity marker pips can be added to the display.

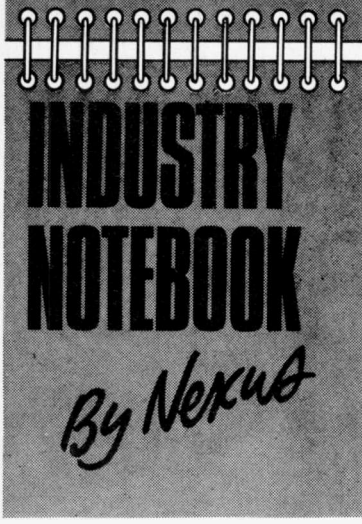


*... Second Chance to enter the
Inventors' Competition!*

See page 728

PRACTICAL ELECTRONICS

OUR JULY ISSUE WILL BE ON SALE FRIDAY, 9 JUNE, 1978



The Common Good

International political and economic quarrels are constantly in the news. The USA and Britain are at odds with the Japanese in matters of trade, for example. And Britain is frequently in dispute with EEC partners, individually or collectively. Such squabbles tend to obscure some fine international co-operative ventures.

One such is *Meteosat*, 22,000 miles up, quietly doing its job of providing world weather maps and met. data for the common good of mankind. It was built for the European Space Agency by the *COSMOS* consortium of aerospace companies and launched by the Americans from Cape Canaveral. In all there will be five satellites to give complete global coverage. The Americans are supplying two and the Japanese and the Russians one each.

Japanese Imports

But having recorded with pleasure something that unites us all through science, we still cannot avoid considering what divides us internationally in trade and industry. In the UK, Japanese car imports have displaced colour TV as the main talking point. Not that the Japanese threat to British electronics goods manufacturers has disappeared although there is some easement in the TV sector where the agreement on restricting sales is reported to be working reasonably well.

The knock-out blow which closed Thorn's Skelmersdale picture-tube plant has left Mullard in a more favourable position as Britain's sole producer. Even so, Mullard have had to adopt an aggressive attitude (i.e. reduce prices and profits margins) to sell 650,000 tubes out of 1.8 million used in the UK last year. The Japanese, however, still managed to sell 583,000 with the rest coming mainly from Canada and the

USA. Mullard also got some help from the rise in value of the Japanese yen. Mullard report having "turned the corner" with the Japanese market share in the UK dropping sharply in recent months.

The British Radio Equipment Manufacturers Federation (BREMA) has been negotiating an agreement on music centres where the Japanese have over half the UK market. Trade in this sector is said to be sluggish and with large stocks of Japanese products already in the UK it seems likely that even if agreement is reached there will be little effect in the short term.

Brain-power Exports

The Post Office Viewdata service, becoming operational in the UK a year earlier than expected, looks like being an export success. Already adopted by Germany, it is now being examined in the United States following its public showing at Atlanta, Georgia, last October. The system is being sold through *Insac Data Systems Ltd*, a company set up by the NEB to market British computer software overseas.

Another software company, *Compeda Ltd*, owned by the National Research Development Corporation, specialises in selling systems based on university and government-sponsored research. Exports of systems packages are expected to account for at least 60 per cent of turnover according to Keith Trickett, managing director of *Compeda*. One of the systems offered is called the *Pipework Design Management System* expected to appeal to the petrochemical, gas and process industries. Another is *Gaelic*, a design system for i.c.s and p.c.b.s.

Setting Up the Arabs

Closely allied to pure brain-power exports such as selling software and supplying consultancy services is technology exporting, a controversial subject because as well as transferring technology it can also transfer jobs, not politically attractive at periods of high domestic unemployment.

Egypt, for example, is anxious to move into high-technology industries such as electronics and aerospace and some British electronics technology has already been transferred to the Cairo area and is in production. Recently announced is a big helicopter deal in which the Anglo-French *Lynx* will be built in Egypt, both airframe and engines, initially from kits of parts but progressively building up an indigenous aerospace industry which eventually could conceivably compete in the world market and with lower labour costs pose a threat to the companies now supplying all the know-how.

The process of educating those nations aspiring to industrial expansion is something we have to learn to live with. It is not new. I remember being

startled to discover an American multinational, well known for antagonism to the Communist political system, cheerfully selling technology, and production machinery to match, to some Eastern Bloc countries. The Americans involved were confident that by the time the Eastern Bloc manufacturers had mastered the technology, they themselves would already be well ahead on the next generation of products, always a step ahead. A supporting argument was that if they didn't supply the know-how and equipment, then somebody else would, so you might as well get the business while it is going.

IEA/Electrex

People are slowly becoming accustomed to the National Exhibition Centre near Birmingham. The IEA/Electrex show attracted a substantially greater attendance than formerly. Facilities for visitors are far greater than at the old London venue but it wasn't just this that brought the crowds along but a more optimistic trade outlook and the stands were certainly busy with good enquiries for products and services. The electrical part of the exhibition was more dominant and busier but I heard no complaints from exhibitors in the electronics section.

An interesting feature was the number of new towns and industrial development areas which took exhibition space, some with very large stands, in an effort to encourage industrial investment. Their full-colour brochures are fully on a par with those from travel agents, and it seems hard to resist the advertised attractions. "When you're in Wakefield you are in the heart of Rugby League country—and among people who work as hard as they play."

Overstretch

Videomaster, who built a £4 million turnover company from scratch in four years has been unable to finance expansion and, although still trading, is in the hands of the Official Receiver. Fresh capital is being sought. Eighty per cent of the business was in the volatile TV games sector where promotional costs are high and price-cutting nothing short of savage.

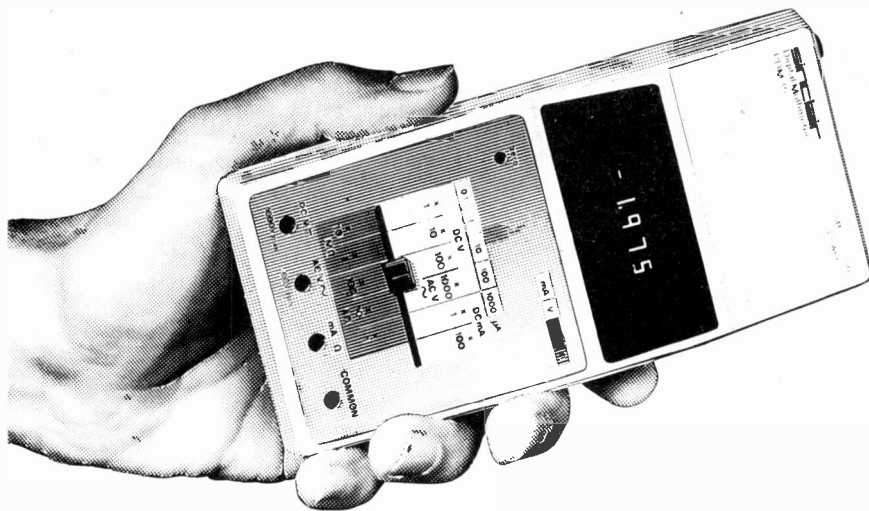
Engineers' Pay

The IEE Salary Survey shows that the hypothetical average professional electrical/electronics engineer had a salary increase of 5 per cent since the last annual survey, well below the rate of inflation. But the gap between those employed in the public and private sectors narrowed. In the public sector the average Fellow or Member engineer was ahead by £1,180 p.a. and this has now fallen to £840. In the case of Associate Members the respective figures are £890 and £630 p.a.

The Sinclair PDM35.

A personal digital multimeter for only £29.95

(+8% VAT)



Now everyone can afford to own a digital multimeter

A digital multimeter used to mean an expensive, bulky piece of equipment.

The Sinclair PDM35 changes that. It's got all the functions and features you want in a digital multimeter, yet they're neatly packaged in a rugged but light pocket-size case, ready to go anywhere.

The Sinclair PDM35 gives you all the benefits of an ordinary digital multimeter – quick clear readings, high accuracy and resolution, high input impedance. Yet at £29.95 (+8% VAT), it costs less than you'd expect to pay for an analogue meter!

The Sinclair PDM35 is tailor-made for anyone who needs to make rapid measurements. Development engineers, field service engineers, lab technicians, computer specialists, radio and electronic hobbyists will find it ideal.

With its rugged construction and battery operation, the PDM35 is perfectly suited for hand work in the field, while its angled display and optional AC power facility make it just as useful on the bench.

What you get with a PDM35

3½ digit resolution.
Sharp, bright, easily read LED display, reading to ±1.999.
Automatic polarity selection.
Resolution of 1 mV and 0.1 nA (0.0001 µA).
Direct reading of semiconductor forward voltages at 5 different currents.
Resistance measured up to 20 MΩ.
1% of reading accuracy.

Operation from replaceable battery or AC adaptor.
Industry standard 10 MΩ input impedance.

Compare it with an analogue meter!

The PDM35's 1% of reading compares with 3% of full scale for a comparable analogue meter. That makes it around 5 times more accurate on average.

The PDM35 will resolve 1 mV against around 10 mV for a comparable analogue meter – and resolution on current is over 1000 times greater.

The PDM35's DC input impedance of 10 MΩ is 50 times higher than a 20 kΩ/volt analogue meter on the 10 V range.

The PDM35 gives precise digital readings. So there's no need to interpret ambiguous scales, no parallax errors. There's no need to reverse leads for negative readings. There's no delicate meter movement to damage. And you can resolve current as low as 0.1 nA and measure transistor and diode junctions over 5 decades of current.

Technical specification

DC Volts (4 ranges)

Range: 1 mV to 1000 V.

Accuracy of reading 1.0% ± 1 count.

Note: 10 MΩ input impedance.

AC Volts (40 Hz-5 kHz)

Range: 1 V to 500 V.

Accuracy of reading: 1.0% ± 2 counts.

DC Current (6 ranges)

Range: 1 nA to 200 mA.

Accuracy of reading: 1.0% ± 1 count.

Note: Max. resolution 0.1 nA.

Resistance (5 ranges)

Range: 1Ω to 20 MΩ.

Accuracy of reading: 1.5% ± 1 count.

Also provides 5 junction-test ranges.

Dimensions: 6 in x 3 in x 1½ in.

Weight: 6½ oz.

Power supply: 9 V battery or Sinclair AC adaptor.

Sockets: Standard 4 mm for resilient plugs.

Options: AC adaptor for 240 V 50 Hz power. De-luxe padded carrying wallet. 30 kV probe.

The Sinclair credentials

Sinclair have pioneered a whole range of electronic world-firsts – from programmable pocket calculators to miniature TVs. The PDM35 embodies six years' experience in digital multimeter design, in which time Sinclair have become one of the world's largest producers.

Tried, tested, ready to go!

When you buy your PDM35 it comes complete with leads and test prods, carrying wallet and comprehensive operating instructions.

The PDM35 is a new concept in multimeters – but over 20,000 have already been sold! If you'd like to know more about the PDM35, and how to get one, complete the coupon and post it to us. We'll send you detailed information by return. Send the coupon today!

Sinclair Radionics Ltd, London Road, St Ives, Huntingdon, Cambs., PE17 4HJ, England.

To Sinclair Radionics Ltd, London Road, St Ives, Huntingdon, Cambs., PE6 4HJ.
Please send me more information of the Sinclair PDM35 personal digital multimeter.

Name

Occupation

Address

.....

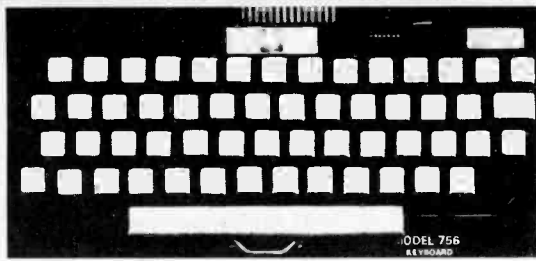
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sinclair

World leaders in fingertip electronics



FULL ASCII KEYBOARD KIT

LOW COST!
Model 756
Full ASCII
Keyboard

Kit or Assembled

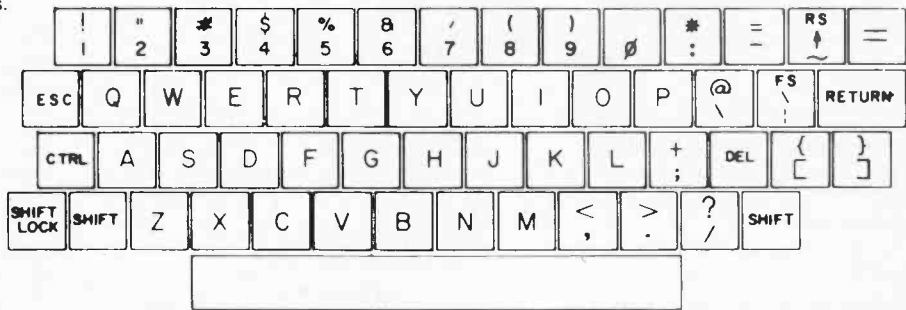
- * Intended for professional micro-processor applications.
- * This one Keyboard will meet most present and future requirements.
- * Full 128-character ASCII 8-bit code. Tri-mode MOS encoding.
- * Applications notes for auto repeat, numeric pad, serial output.
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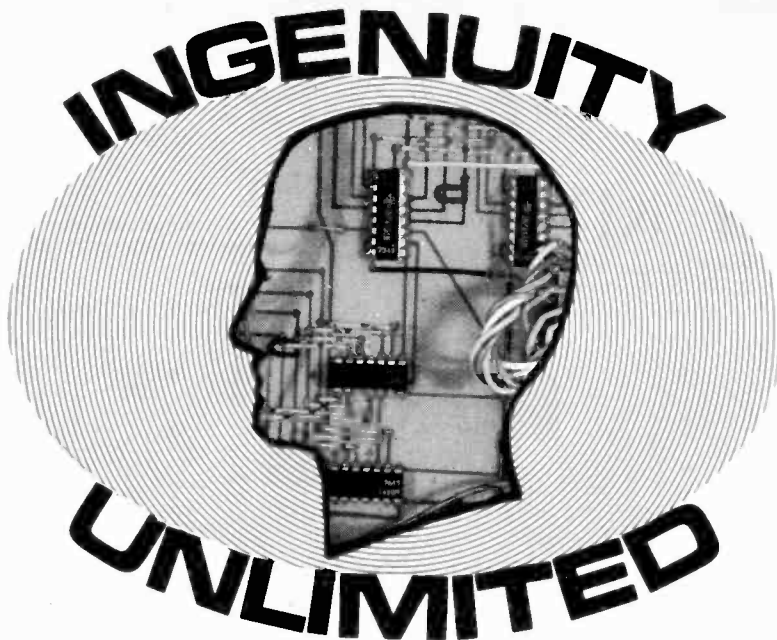
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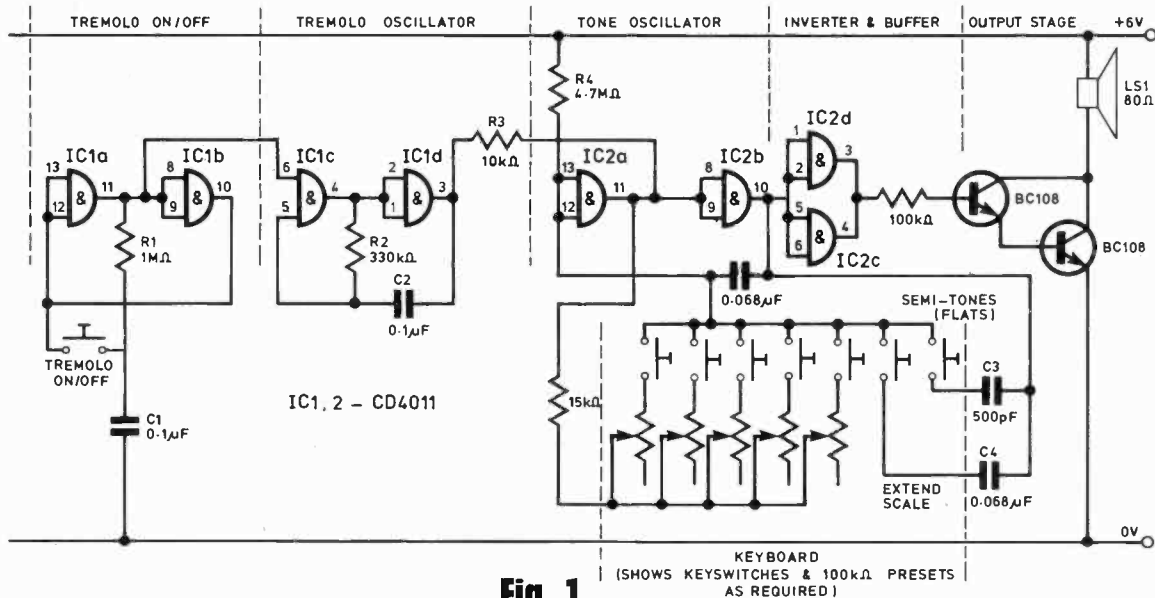


Fig. 1

MUSICAL CALCULATOR

THE rapid advances in pocket calculator technology has resulted in many cheap keyboards being available on the surplus market, several of which are suitable to form the basis of a small electronic organ.

Using the two CD4011 i.c.s as shown in Fig. 1 at least two octaves may be covered, each key selecting an individually adjusted miniature skeleton preset thus producing the required note. The oscillator drives a simple amplifying stage consisting of a Darlington pair and a balanced armature insert producing a more than adequate sound level.

IC2 provides a switchable tremolo

effect needing only one key to turn it either on or off; a further key being used to parallel C4 with C3 to produce the flats to any note pressed. The range covered by the keyboard can be extended by using another "control" key to double the value of the capacitor in the oscillator.

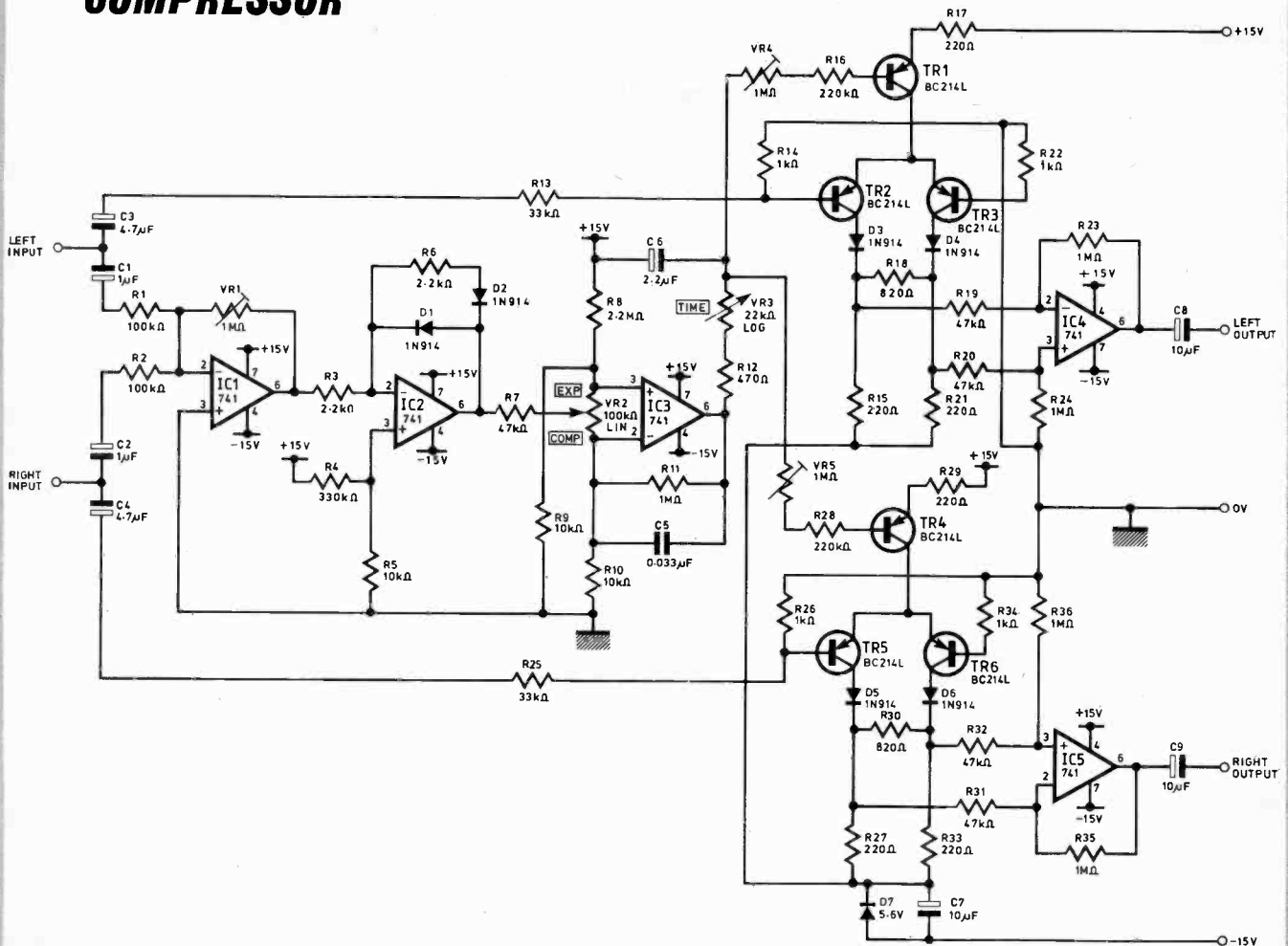
Of especial benefit when used by the forgetful child is the fact that no on/off switch is necessary. With a 6 volt supply, and high gain, low leakage transistors, the quiescent current is unmeasurable on a 50μA meter, although the tremolo should be left in the off condition as it consumes nearly

0.5mA.

Only the simplest keyboards have an independent connection available to each key but the printed circuit of most is easily modified after a little patient examination. The circuit is, of course, monophonic, i.e. depression of two keys produces a third, unrelated note, nevertheless an amusing musical toy can be constructed at very little cost, its accuracy dependant only on careful tuning of each note.

D. Ian,
Hampton Court,
Surrey.

STEREO EXPANDER/ COMPRESSOR



This circuit will help in making low noise, high quality recordings on a good stereo tape recorder. It could also enhance the reproduction from an f.m. tuner or from discs. The input signals are mixed and buffered by IC1, which has a variable gain to enable inputs within the range 10mV to 1V r.m.s. to be accepted. The signal is then half-wave rectified by IC2, and further amplified by IC3, which can work in the inverting or non-inverting mode depending on the setting of VR2, which also dictates the gain of this stage. A control voltage then appears across C6. The attack and decay time of this voltage is controlled by VR3 within the range 20ms to 200ms.

The control voltage is fed to two voltage controlled amplifiers (v.c.a.s), one for each channel. These utilise the forward conducting resistance of silicon diodes, which can be varied according to the current being passed through them.

Looking at the left channel v.c.a., the current through diodes D3 and D4 is controlled by TR1, and hence by the control voltage. The audio signal is injected into TR2 which along with TR3 forms a long tailed pair. Anti-phase signals appear at the inputs of IC4, which amplifies the difference as the output signal. R18 tends to minimise this difference, and hence the gain of the v.c.a. As more

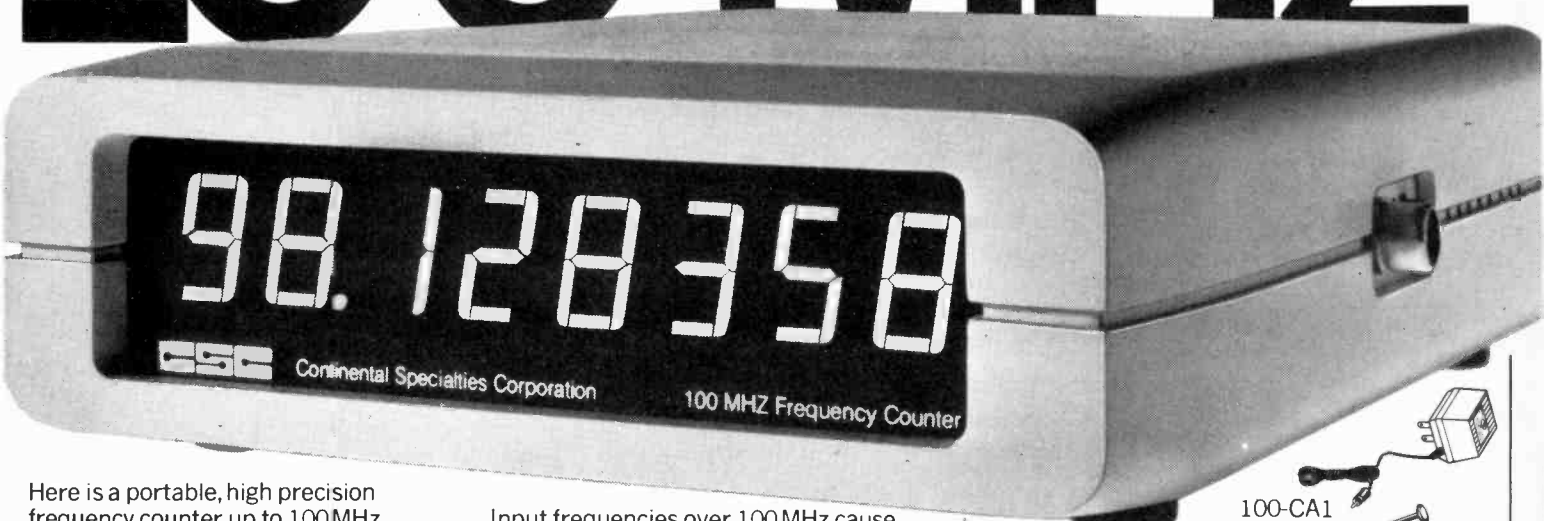
current is passed through the diodes, the gain increases.

VR4 and VR5 are adjusted so that 550mV is dropped across each of the resistors R17 and R29. VR1 is adjusted so that when a signal of normal listening level is fed into the inputs, adjustment of VR2 makes little difference to the overall output level.

P. R. Williams,
Stevenage,
Herts.

8 Digits

100 MHz*

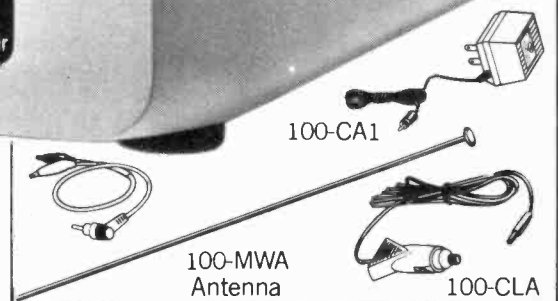


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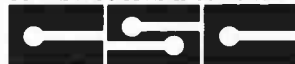
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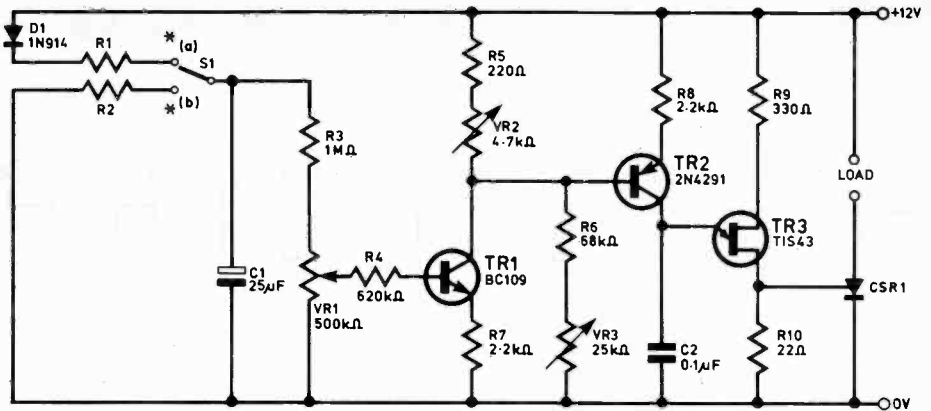


Fig. 1

AMONG the many published thyristor circuits for power control, I do not recall seeing one with a "fade-up/fade-down" feature. The circuit depicted in Fig. 1 will do this; as shown it is applicable to a load requiring 12V, but it could probably be adapted to higher power requirements.

The main controls are VR1 for thyristor firing control, and switch S1 for fade-up/down control. The setting of VR1 determines maximum load current, via two stages of amplification TR1 and TR2, then through a conventional u.j.t. firing circuit based on

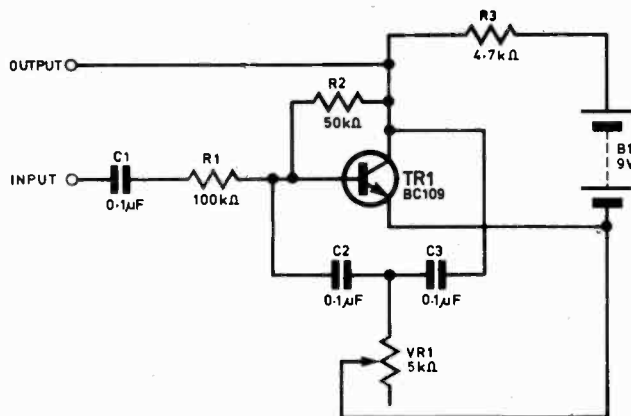
TR3. Fade-up/down is provided by the charging and discharging of C1, as regulated by S1, R1 and R2. With S1 switched to position (a), CSR1 output will gradually rise to the maximum governed by VR1, whilst with S1 switched to position (b), C2 will discharge and fade-down will occur.

Fade times of about 30 seconds were obtained with R1 or R2 equal to 5m Ω , whilst at 68k Ω fade times were nil. R1 and R2 could be made variable if required.

VR2 and VR3 are included for

setting the bias on TR2; they should be adjusted when setting up so that zero output and full output from the s.c.r. are obtained from the extreme settings of VR1 (do this with C1 disconnected and S1 connected to the positive rail).

J. Duffill,
Cheltenham,
Glos.



SIMPLE WAA-WAA

THIS system is very cheap but very effective, and comparable with many commercial circuits now on the market. It was designed chiefly for use with an electric guitar, though it is also very effective on other instruments.

It consists of a basic "T"-filter network in the feedback bias of a transistor amplifier. According to the component values, a small range of frequencies are boosted while others around are attenuated. As VR1 is

rotated, the range is shifted and a different band of frequencies are boosted.

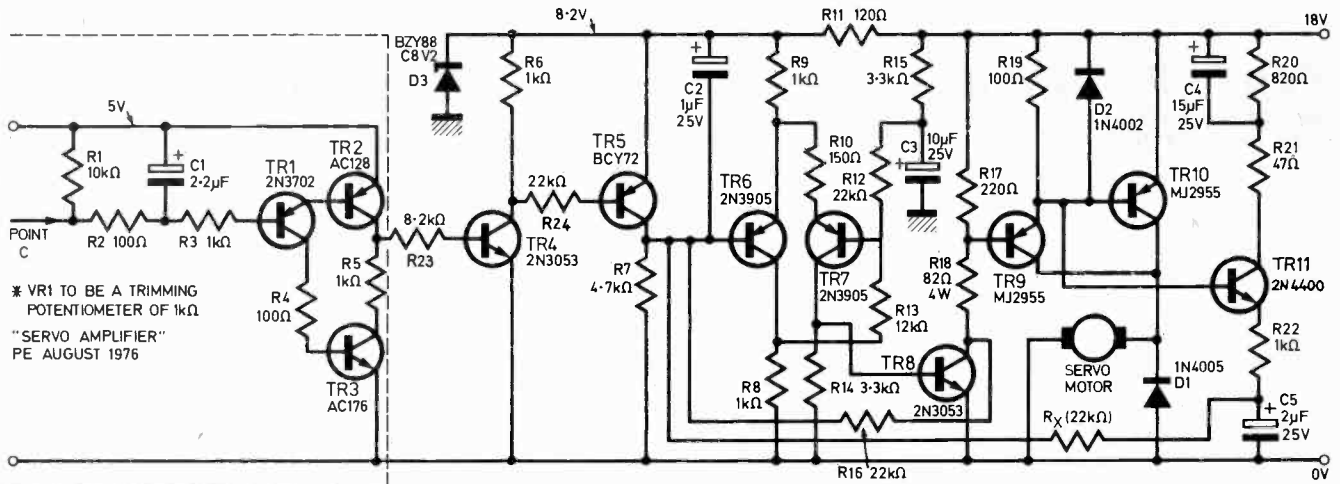
In the circuit shown, the component values have been selected so that with potentiometer rotation the narrow frequency-selective band sweeps over the entire range of the guitar, so giving the desired "Waa-Waa" effect.

The value of VR1 should not be more than 5k Ω as the degree of rotation would then be too small for the musician to be able to control the

effect confidently. If the guitar used with the unit has a particularly weak output signal then R1 can be reduced. The circuit will run on a PP3 9V battery.

S. D. Le Maistre,
St. Laurence,
Jersey.

SPEED CONTROLLER



This system was designed to control the speed of a radio controlled car capable of speeds of up to 35 m.p.h. The circuitry is intended for use in conjunction with the "Proportional Radio Control System" published in P.E.

One of the main disadvantages of using a variable resistor between the supply and the motor to provide speed control is that any control action which varies the speed of the car, also varies the current available to the motor and consequently the torque or pulling power. The speed controller shown in Fig. 1 uses pulse width modulation techniques which not only overcome these problems, but also provide reduced current consumption from the supply of nickel cadmium batteries used in the car.

Since the racing car is to be driven in one direction, i.e. for forward control, only one half of the servo amplifier circuit is required for use. This is shown for convenience in Fig. 1 and comprises transistors TR1, TR2 and TR3. A 1kΩ resistor acts as a dummy load in place of the servo motor. The servo feedback potentiometer on the servo drive board is replaced by a trimming potentiometer of the same value in order to trim the completed system with respect to the transmitter.

A variable d.c. output of 0 to 4V is available between points C and 0V rail when the corresponding joystick movement in the transmitter is 0 to 5kΩ. This available voltage is used to switch transistors TR4 and TR5 to provide a maximum d.c. output of 8V which is necessary to provide the

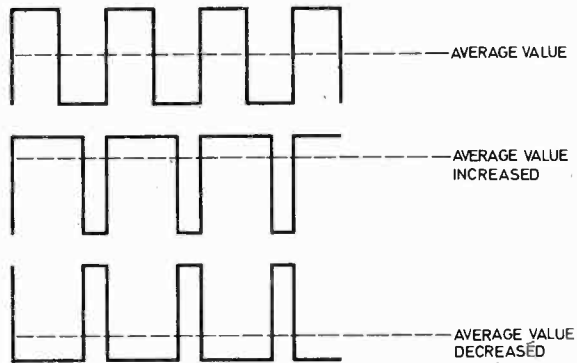


Fig. 2

variable speed control of the car as follows:

TR6 and TR7 form a Schmitt trigger and TR8 provides the phase inversion for oscillations to occur. The output at TR8C is a square wave whose mark/space ratio depends on the d.c. voltage present at point C. When mark/space ratio is 50 per cent, the time that the voltage is on is the same as the time that the voltage is off, giving an average value of the voltage as shown in Fig. 2. If the mark/space ratio is altered so that the on time is increased the average value of the voltage will rise and hence the car will speed up. Consequently when the mark/space ratio is decreased the car will slow down.

The output of the Schmitt circuit feeds a Darlington connected driver and output stage TR9 and TR10 that drives the motor. The motor used in the car is the popular "Bullett" motor supplied by most radio control

shops. This motor was found to have a "start" current of 10A at 18V and a "run" current of approximately 6A which varies at different motor speeds. Diode D1 suppresses inductive kick-back of the motor while D2 protects TR10 from voltage transients of the motor.

Transistor TR11 serves as a current sense amplifier in order to compensate via the feedback resistor Rx for variations in the frequency of the Schmitt trigger output.

A stack of 2 ampere-hour nickel cadmium batteries have been used to provide the 18V supply. The circuit can also be used with a 12V supply by decreasing R11 to approximately 100Ω.

Transistors TR9 and TR10 must be mounted on a heatsink.

L. Sadarangani,
W. Ealing.

WAVEFORM GENERATOR

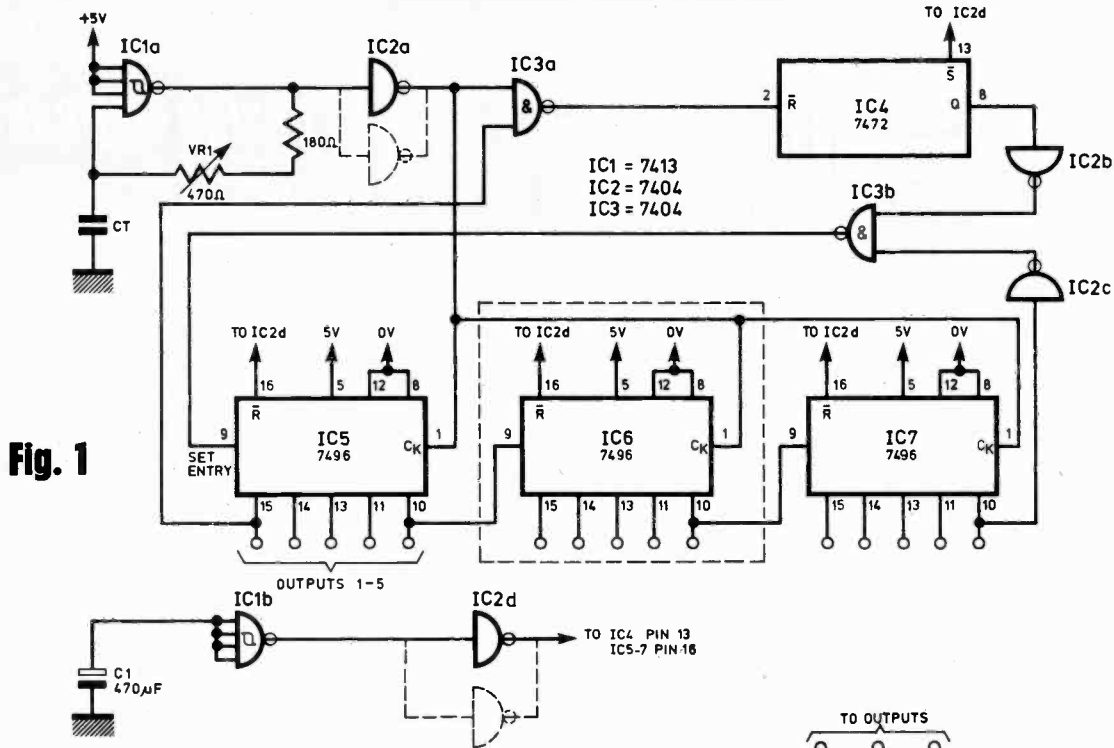


Fig. 1

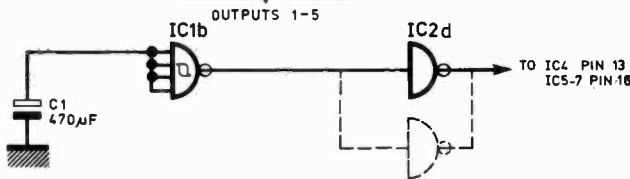


Fig. 2

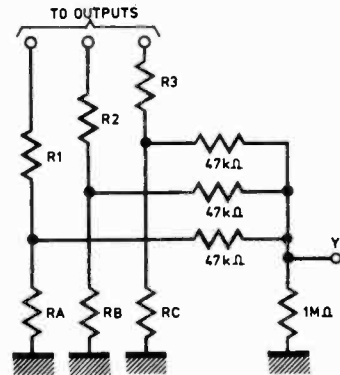


Fig. 3

WHEN the circuit shown in Fig. 1 is switched on, the input of IC1b is held "low" by C1, setting all the outputs of the 7496 shift registers to the "low" state, and setting the Q output of flip-flop IC4 "high". The "Set Entry" of IC5 (pin 9) is, therefore, also "high". When C1 charges to the threshold value, IC1b changes state, thus removing the reset instruction to the shift registers.

IC1a forms a clock whose frequency is determined by CT its output passes via IC2a to the C_k input of the registers and to IC3a. On the first negative going clock pulse, the "high" on pin 9 of IC5 is transferred to output number 1 (pin 15). This "high" is fed to IC3a, and when the clock output next goes "high" the output of IC3a goes "low" resetting IC4 and presenting a "low" to the set entry of IC5. On

subsequent clock pulses the "high" on output 1 is shifted through the registers (ICs 5-7), each of the outputs switching "high" in turn.

When pin 10 of IC7 switches "high", IC2c and IC3b apply a "high" to the SET ENTRY of IC5, thus starting the sequence once more.

IC6 may be duplicated to provide more outputs (circuitry within dotted lines). If this is required, IC2a and IC2d should have one or more inverters connected in parallel with them to facilitate the extra load.

A waveform may be divided into X portions, each portion having a specific amplitude (Fig. 2). By connecting each output of Fig. 1 to a potential divider (Fig. 3), the amplitude of each output pulse may be pre-set, thus enabling the desired waveform to be taken off at point Y. The more

outputs used, the more accurate will be the resulting waveform.

R1, R2, R3... can be around 2.2kΩ and RA, RB, RC... may be varied to provide the required amplitude.

A unit was built in which the variable resistors were built onto a piece of Veroboard which plugged into an edge connector mounted on the case. Each waveform needed could then have its own program card.

The circuit of Fig. 1 could also be used to "scan" a solid state display etc.

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Carshalton,
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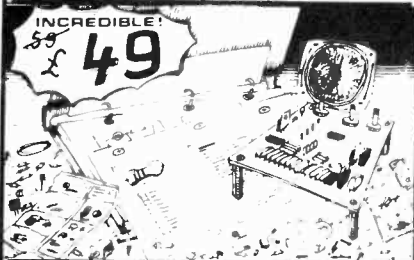
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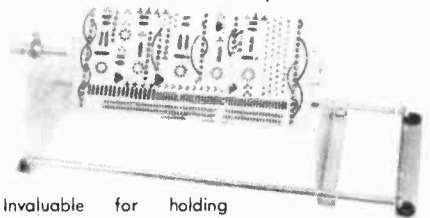
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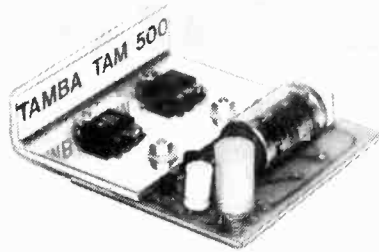
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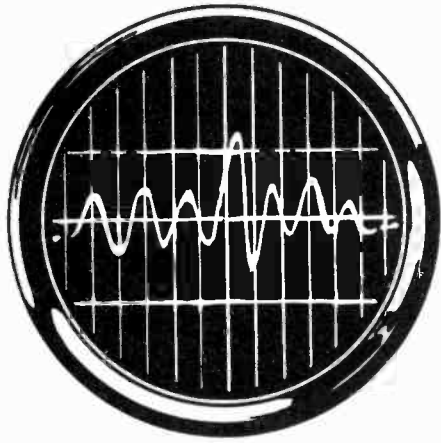
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7401 0.12	7493 0.40	74182 0.72	74LS76 0.32	74LS298 1.60	4053 0.84
7402 0.12	7494 0.80	74184 1.20	74LS78 0.32	74LS352 0.92	4054 1.10
7403 0.12	7495 0.54	74185A 1.20	74LS83 0.78	74LS353 1.05	4055 1.00
7404 0.13	7496 0.60	74186 7.20	74LS85 0.90	74LS365 0.50	4060 0.98
7405 0.13	7497 2.38	74188 2.70	74LS86 0.35	74LS366 0.50	4066 0.48
7406 0.28	74100 0.94	74190 1.05	74LS93 0.95	74LS367 0.50	4067 3.50
7407 0.28	74104 0.40	74191 0.99	74LS95 1.10	74LS368 0.50	4068 0.24
7408 0.14	74105 0.40	74192 0.99	74LS107 0.36	74LS386 0.37	4069 0.17
7409 0.14	74107 0.28	74193 1.05	74LS109 0.36	74LS670 2.00	4070 0.17
7410 0.13	74109 0.45	74194 0.90	74LS112 0.38		4071 0.17
7411 0.18	74110 0.46	74195 0.84	74LS113 0.36		4072 0.17
7412 0.21	74111 0.70	74196 0.90	74LS114 0.36	4000 0.14	4073 0.17
7413 0.25	74116 1.60	74197 0.90	74LS123 0.82	4001 0.15	4075 0.17
7414 0.54	74118 0.82	74198 1.48	74LS124 2.45	4002 0.16	4076 1.05
7416 0.27	74119 1.30	74199 1.48	74LS125 0.44	4006 0.92	4077 0.46
7417 0.27	74120 0.82	74221 1.50	74LS126 0.44	4007 0.16	4078 0.22
7420 0.13	74121 0.25	74273 2.15	74LS132 0.69	4008 0.92	4081 0.17
7421 0.28	74122 0.40	74279 1.25	74LS136 0.40	4009 0.45	4082 0.20
7422 0.17	74123 0.53	74283 1.70	74LS138 0.53	4010 0.48	4085 0.72
7423 0.25	74125 0.44	74284 6.85	74LS139 0.53	4011 0.15	4086 0.76
7425 0.20	74126 0.45	74293 1.35	74LS151 1.05	4012 0.16	4089 1.55
7426 0.25	74128 0.62	74298 1.92	74LS153 0.50	4013 0.42	4093 0.65
7427 0.25	74132 0.88	74390 1.92	74LS154 1.20	4014 0.80	4094 1.80
7428 0.34	74135 0.68	74393 2.12	74LS155 0.86	4015 0.77	4095 1.10
7430 0.13	74136 0.75		74LS156 0.86	4016 0.42	4096 1.10
7432 0.24	74137 0.94		74LS157 0.47	4017 0.77	4098 1.12
7433 0.32	74141 0.58	74LS00 0.19	74LS158 0.53	4018 0.87	4098 1.12
7437 0.24	74142 2.00	74LS01 0.19	74LS160 1.22	4019 0.42	4099 1.90
7438 0.24	74143 2.00	74LS02 0.19	74LS161 0.69	4020 0.92	4404 1.00
7440 0.13	74144 2.00	74LS03 0.19	74LS162 1.22	4021 0.82	4412 0.30
7441 0.52	74145 0.64	74LS04 0.20	74LS163 0.69	4022 0.82	4428 0.80
7442 0.55	74147 1.30	74LS05 0.20	74LS164 1.20	4023 0.15	4445 1.50
7443 0.90	74148 0.19	74LS08 0.19	74LS168 2.00	4024 0.66	4449 0.30
7444 0.90	74150 0.99	74LS09 0.19	74LS169 2.00	4025 0.15	4501 0.17
7445 0.70	74151 0.60	74LS10 0.19	74LS170 1.76	4026 1.28	4502 0.88
7446 0.70	74153 0.60	74LS11 0.19	74LS173 1.05	4027 0.50	4507 0.50
7447A 0.64	74154 1.05	74LS12 0.19	74LS174 1.12	4028 0.67	4508 2.25
7448 0.60	74155 0.63	74LS13 0.46	74LS175 1.05	4029 0.40	4510 1.05
7450 0.13	74156 0.63	74LS14 1.10	74LS189 2.95	4030 0.48	4511 0.98
7451 0.13	74157 0.63	74LS15 0.19	74LS190 0.81	4031 2.34	4512 0.92
7453 0.13	74159 1.70	74LS20 0.19	74LS191 0.81	4033 1.25	4514 2.85
7454 0.13	74160 0.80	74LS21 0.19	74LS192 1.80	4034 2.00	4515 2.80
7460 0.13	74161 0.80	74LS22 0.19	74LS193 1.80	4035 1.00	4516 1.02
7470 0.28	74162 0.80	74LS26 0.24	74LS195 1.12	4036 2.40	4518 0.99
7472 0.22	74163 0.80	74LS27 0.40	74LS196 1.20	4037 0.99	4519 0.50
7473 0.26	74164 0.89	74LS30 0.19	74LS197 1.20	4038 1.00	4520 1.05
7474 0.26	74165 0.89	74LS32 0.25	74LS221 1.12	4039 2.80	4521 2.00
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7483 0.72	74174 0.89	74LS48 0.97	74LS257 1.05	4045 1.40	4553 4.20
7484 0.90	74175 0.68	74LS49 0.97	74LS258 1.05	4046 1.32	4555 0.85
7485 0.88	74176 0.88	74LS51 0.19	74LS266 0.39	4047 0.96	4556 0.85
7486 0.26	74177 0.88	74LS54 0.19	74LS273 2.50	4048 0.60	4558 1.25
7489 0.90	74178 1.20	74LS55 0.20	74LS279 0.50	4049 0.42	4565 1.40
7490 0.35	74179 1.10	74LS73 0.30	74LS283 1.00	4050 0.42	4583 0.75
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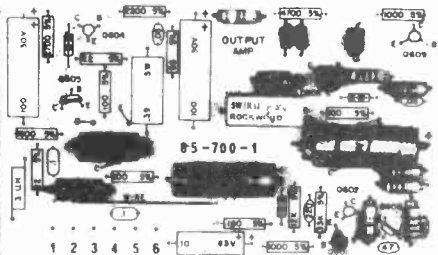
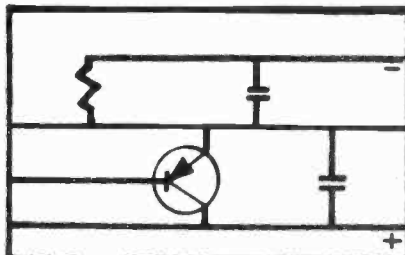
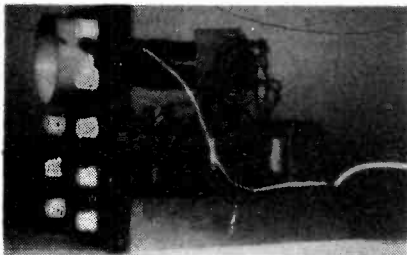
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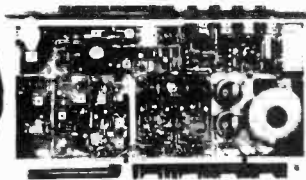
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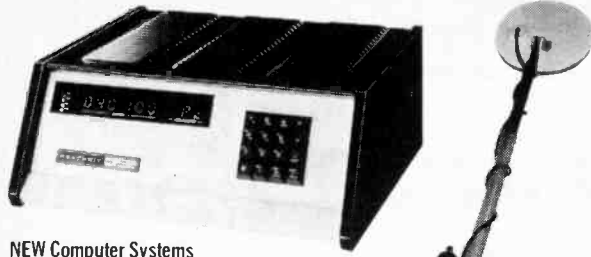
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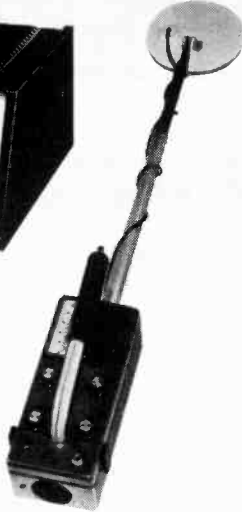
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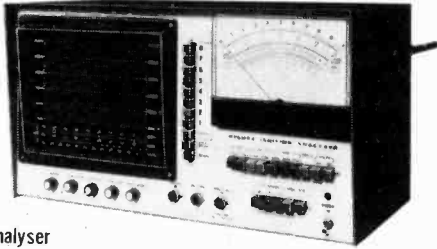
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7402	.15	.14	.12	7496	.62	.58	.495	CD4002	.15	.15	.135	★	26p* each	★	uA741 (14 pin)	.375	78L12AWC	12V .60*
7403	.15	.14	.12	74107	.25	.23	.195	CD4006	.85	.79	.675	★	741 OP-AMP	★	uA741 (TO99)	.40	78L15AWC	15V .60*
7404	.16	.15	.13	74109	.41	.385	.33	CD4007	.17	.16	.14	★	5 for .89	★	uA748 (8 pin)	.375	7805KC	5V 2.01*
7405	.16	.15	.13	74121	.25	.23	.195	CD4008	.85	.79	.675	★	.25p* each	★	CA3089/TDA1200	2.045	7812KC	12V 2.01*
7406	.26	.24	.21	74123	.56	.53	.45	CD4009	.50	.46	.40	★	LIGHT EMITTING DIODES		CA3123/LM1820	1.335	7815KC	15V 2.01*
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7408	.17	.16	.135	74126	.47	.44	.375	CD4011	.17	.16	.14	★	TIL209 Red	.14* .12* .10*	7812UC	12V 1.16*		
7409	.17	.16	.135	74132	.67	.63	.54	CD4012	.17	.16	.14	★	TIL212 Yellow (H.B.)	.25* .255* .16*	7815UC	15V 1.16*		
7410	.15	.14	.12	74141	.71	.67	.57	CD4013	.45	.42	.36	★	TIL216 Red (H.B.)	.25* .255* .16*	7818UC	18V 1.16*		
7411	.23	.21	.18	74145	.70	.65	.555	CD4014	.85	.79	.675	★	TIL222 Green (H.B.)	.25* .255* .16*	7824UC	24V 1.16*		
7413	.25	.23	.195	74147	1.47	1.38	1.185	CD4015	.85	.79	.675	★	2" (inc. clip)		LM301AN (8 pin)	.36	LM05TI	5V 1.39*
7414	.66	.61	.525	74148	.22	1.14	.975	CD4016	.40	.37	.315	★	TIL220 Red	.14* .12* .10*	LM308N (8 pin)	.89	L036TI	12V 1.39*
7416	.23	.21	.18	74150	.94	.88	.75	CD4017	.75	.70	.60	★	TIL224 Yellow (H.B.)	.28* .24* .185*	LM308T (8 pin)	1.245	L037TI	15V 1.39*
7417	.32	.30	.255	74151	.62	.58	.495	CD4018	.85	.79	.675	★	TIL228 Red (H.B.)	.28* .24* .185*	LM339N	.89	LM129	5V .79*
7420	.15	.14	.12	74153	.62	.58	.495	CD4019	.85	.79	.675	★	(H.B.) - High Brightness.		LM370N	2.445	LM130	12V .79*
7423	.23	.21	.18	74154	1.12	1.05	.90	CD4020	.85	.79	.675	★	C-MOS		MC1330P	1.02	LM131	15V .79*
7425	.23	.21	.18	74155	.62	.58	.495	CD4021	.85	.79	.675	★	1+ 25+ 100+		MC1351P	.89	TBA625A	5V 1.16*
7426	.23	.21	.18	74156	.62	.58	.495	CD4022	.85	.79	.675	★	CD4081	.20	.18	.155	TBA625B	12V 1.16*
7427	.36	.34	.30	74157	.62	.58	.495	CD4023	.17	.16	.14	★	CD4082	.20	.18	.155	TBA630Q	1.78
7430	.15	.14	.12	74160	1.12	1.05	.90	CD4024	.60	.56	.48	★	CD4086	.85	.79	.675	TBA530Q	1.78
7432	.23	.21	.18	74161	1.12	1.05	.90	CD4025	.17	.16	.14	★	CD4091	.75	.70	.60	TBA550Q	1.78
7437	.23	.21	.18	74162	1.12	1.05	.90	CD4026	1.70	1.63	1.45	★	CD4092	1.68	1.38	1.35	TBA800	.89
7438	.16	.15	.13	74163	1.12	1.05	.90	CD4027	.65	.61	.525	★	CD4502	.85	.79	.675	TBA800A	.98
7440	.16	.15	.13	74164	.94	.88	.75	CD4028	.65	.61	.525	★	CD4508	2.28	2.14	1.82	TBA810AS	.98
7441	.65	.61	.525	74166	.94	.88	.75	CD4029	1.09	1.03	.93	★	CD4510	.99	.93	.795	TCA940	1.56
7442	.47	.44	.375	74170	1.70	1.58	1.35	CD4030	.52	.49	.44	★	CD4511	.88	.82	.705	TD2020	3.11
7445	.56	.52	.45	74173	1.31	1.23	1.05	CD4032	1.00	.95	.825	★	CD4514	2.50	2.36	2.02	ZN414	.98
7446	.56	.52	.45	74174	.94	.88	.75	CD4035	1.76	1.63	1.395	★	CD4515	2.50	2.36	2.02	ZN417E	1.60
7447	.56	.52	.45	74175	.75	.70	.60	CD4036	.99	.93	.795	★	CD4516	.99	.93	.795	ZN423T	1.00*
7448	.56	.52	.45	74176	.94	.88	.75	CD4037	.99	.93	.795	★	CD4517	3.80	3.65	3.48	ZN424E	1.20
7450	.15	.14	.12	74177	.94	.88	.75	CD4040	.85	.79	.675	★	CD4518	.88	.82	.705	ZN435E	3.36
7451	.15	.14	.12	74178	.94	.88	.75	CD4042	.65	.61	.525	★	CD4521	2.35	2.19	1.875	ZN1034E	1.805
7453	.15	.14	.12	74180	.94	.88	.75	CD4043	.75	.70	.60	★	CD4522	1.75	1.63	1.395	ZN1040E	7.49
7454	.15	.14	.12	74181	2.05	1.93	1.65	CD4044	.99	.93	.795	★	CD4526	1.75	1.63	1.395	ZN116E	6.25*
7455	.15	.14	.12	74182	.75	.70	.60	CD4045	.99	.93	.795	★						
7460	.15	.14	.12	74184	1.68	1.58	1.35	CD4046	.99	.93	.795	★						
7470	.25	.23	.195	74185	1.50	1.40	1.20	CD4047	.40	.37	.315	★						
7472	.21	.19	.165	74186	1.12	1.05	.90	CD4048	.40	.37	.315	★						
7473	.26	.245	.21	74187	1.12	1.05	.90	CD4049	.40	.37	.315	★						
7474	.26	.245	.21	74188	1.12	1.05	.90	CD4050	.40	.37	.315	★						
7475	.41	.385	.33	74189	1.12	1.05	.90	CD4051	.75	.70	.60	★						
7476	.28	.26	.225	74191	1.12	1.05	.90	CD4052	.75	.70	.60	★						
7485	1.09	1.02	.87	74192	1.12	1.05	.90	CD4053	.75	.70	.60	★						
7486	.23	.21	.18	74193	1.12	1.05	.90	CD4054	1.20	1.15	.96	★						
7489	2.41	2.26	1.94	74194	1.12	1.05	.90	CD4055	1.35	1.28	1.18	★						
7490	.32	.30	.255	74195	.94	.88	.75	CD4056	4.80	4.60	4.25	★						
7491	.68	.63	.54	74196	1.10	1.03	.895	CD4057	1.15	1.10	1.02	★						
7492	.43	.40	.345	74197	1.10	1.03	.895	CD4066	.45	.42	.36	★						
				74198	1.68	1.58	1.35	CD4068	.20	.18	.155	★						
				74199	.68	.58	1.35	CD4069	.20	.18	.155	★						
								CD4070	.20	.18	.155	★						
								CD4071	.20	.18	.155	★						
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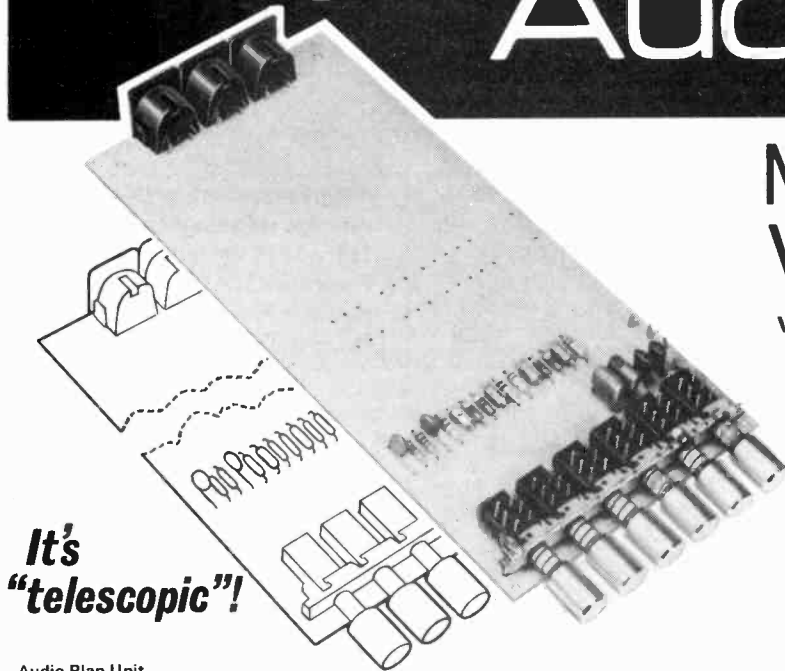
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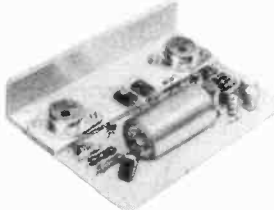
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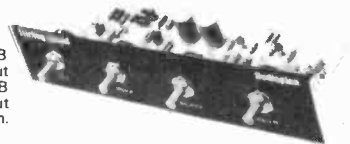
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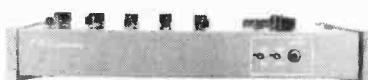
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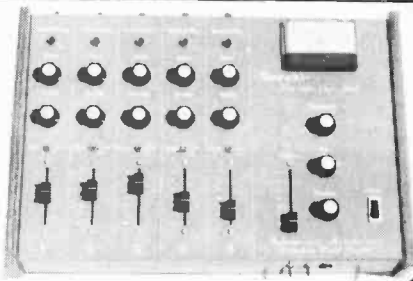
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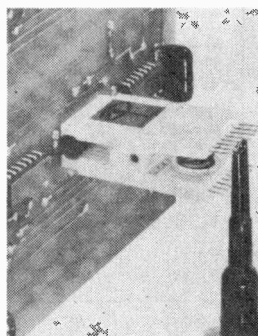
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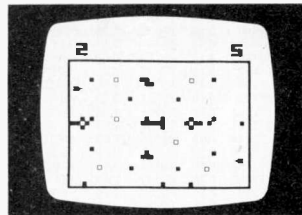
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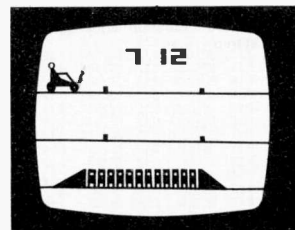
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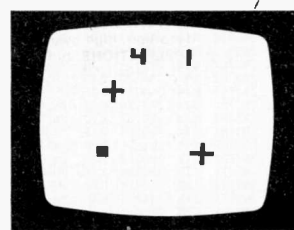
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HY5 Pre-amplifier

The HY5 is a mono hybrid amplifier ideally suited for all applications. All common input functions (mag Cartridge, tuner, etc.) are catered for internally, the desired function is achieved either by a multi-way switch or direct connection to the appropriate pins. The internal volume and tone circuits merely require connecting to external potentiometers (not included). The HY5 is compatible with all I.L.P. power amplifiers and power supplies. To ease construction and mounting a P.C. connector is supplied with each pre-amplifier.

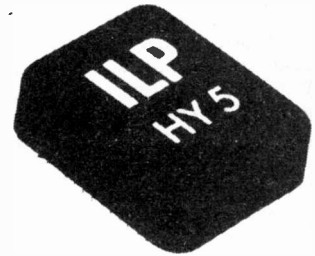
FEATURES: complete pre-amplifier in single pack, multi-function equalisation, low noise, low distortion, high overload, two simply combined for stereo.

APPLICATIONS: hi-fi, mixers, disco, guitar and organ, public address

SPECIFICATION: Inputs—magnetic pick-up 3mV, ceramic pick-up 30mV, tuner 100mV, microphone 10mV, auxiliary 3-100mV, input impedance 47k Ω at 1kHz. Outputs—tape 100mV, main output 500mV R.M.S. Active Tone Controls—treble \pm 12dB at 10kHz, bass \pm 12dB at 100Hz. Distortion—0.1% at 1kHz; signal/noise ratio 68dB. Overload—38dB on magnetic pick-up. Supply Voltage— \pm 16-50V

Price **£5.22 + 65p VAT**. P. & P. free

HY5 mounting board B.1. **48p + 6p VAT**. P. & P. free



HY30 15W into 8 Ω

The HY30 is an exciting New kit from I.L.P. It features a virtually indestructible I.C. with short circuit and thermal protection. The kit consists of: I.C., heatsink, P.C. board, 4 resistors, 6 capacitors, mounting kit, together with easy to follow construction and operating instructions. This amplifier is ideally suited to the beginner in audio who wishes to use the most up to date technology available.

FEATURES: complete kit, low distortion, short, open and thermal protection, easy to build

APPLICATIONS: updating audio equipment, guitar practice amplifier, test amplifier, audio oscillator

SPECIFICATION: Output Power—15W R.M.S. into 8 Ω Distortion—0.1% at 15W Input Sensitivity—500mV. Frequency Response—10Hz-16kHz -3dB.

Price **£5.22 + 65p VAT**. P. & P. free

HY50 25W into 8 Ω

The HY50 leads I.L.P.'s total integration approach to power amplifier design. The amplifier features an integral heatsink together with the simplicity of no external components. During the past three years the amplifier has been refined to the extent that it must be one of the most reliable and robust High Fidelity modules in the World.

FEATURES: low distortion, integral heatsink, only five connections, 7 amp output transistors, no external components.

APPLICATIONS: medium power hi-fi systems, low power disco, guitar amplifier.

SPECIFICATION: Input Sensitivity—500mV Output Power—25W R.M.S. into 8 Ω Load Impedance—4-16 Ω Distortion—0.04% at 25W at 1kHz Signal Noise Ratio—75dB Frequency Response—10Hz-45kHz -3dB. Supply Voltage— \pm 25V Size—105 x 50 x 25mm

Price **£6.82 + 85p VAT**. P. & P. free



HY120 60W into 8 Ω

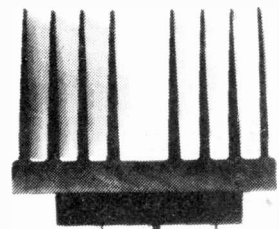
The HY120 is the baby of I.L.P.'s new high power range, designed to meet the most exacting requirements including load line and thermal protection this amplifier sets a new standard in modular design.

FEATURES: very low distortion, integral heatsink, load line protection, thermal protection, five connections, no external components

APPLICATIONS: hi-fi, high quality disco, public address, monitor amplifier, guitar and organ

SPECIFICATION: Input Sensitivity—500mV Output Power—60W R.M.S. into 8 Ω Load Impedance—4-16 Ω Distortion—0.04% at 60W at 1kHz Signal Noise Ratio—90dB Frequency Response—10Hz-45kHz -3dB Supply Voltage— \pm 35V Size—114 x 50 x 85mm

Price **£15.84 + £1.27 VAT**. P. & P. free



HY200 120W into 8 Ω

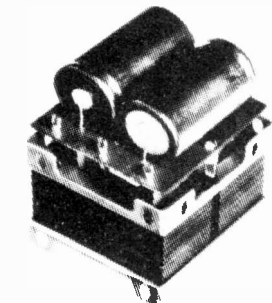
The HY200 (now improved to give an output of 120 watts) has been designed to stand the most rugged conditions such as disco or group while still retaining true hi-fi performance.

FEATURES: thermal shutdown, very low distortion, load line protection, integral heatsink, no external components.

APPLICATIONS: hi-fi, disco, monitor, power slave, industrial, public address

SPECIFICATION: Input Sensitivity—500mV Output Power—120W R.M.S. into 8 Ω Load Impedance—4-16 Ω Distortion—0.05% at 100W at 1kHz Signal Noise Ratio—96dB Frequency Response—10Hz-45kHz -3dB. Supply Voltage— \pm 45V Size—114 x 50 x 85mm

Price **£23.32 + £1.87 VAT**. P. & P. free



HY400 240W into 4 Ω

The HY400 is I.L.P.'s 'Big Daddy' of the range producing 240W into 4 Ω ! It has been designed for high power disco or public address applications. If the amplifier is to be used at continuous high power levels a cooling fan is recommended. The amplifier includes all the qualities of the rest of the family to lead the market as a true high power hi-fidelity power module.

FEATURES: thermal shutdown, very low distortion, load line protection, no external components

APPLICATIONS: public address, disco, power slave, industrial

SPECIFICATION: Output Power—240W R.M.S. into 4 Ω Load Impedance—4-16 Ω Distortion—0.1% at 240W at 1kHz. Signal/Noise Ratio—94dB Frequency Response—10Hz-45kHz -3dB Supply Voltage— \pm 45V. Input Sensitivity—500mV Size—114 x 100 x 85mm

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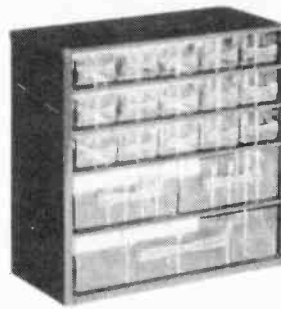
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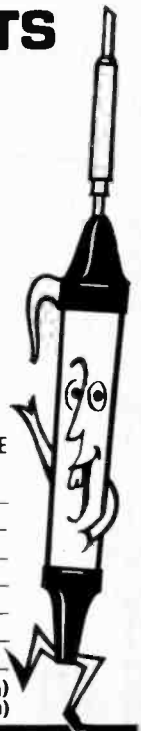
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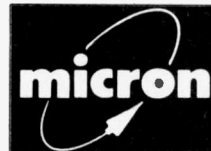
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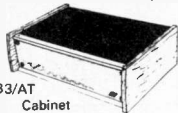
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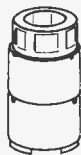
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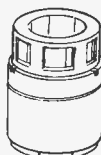
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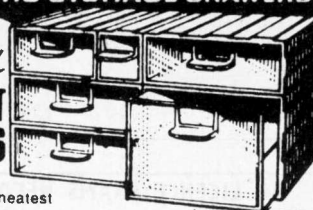
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7401 14p	74116 210p		CA3140 100p	741 150p	D4289 800p	1702A 800p	2N3053 250p	OA47 9p	1A 50V 25p
7402 18p	74118 180p		LM301A 400p	733 25p	B4702A £12	2102-2 160p	2N3055 85p	OA81 15p	1A 100V 27p
7403 18p	74119 225p	4000 21p	LM318N 400p	747 75p	P4002-1 45p	2107 95p	2N3442 151p	OA85 15p	2A 50V 45p
7404 24p	74120 130p	4001 21p	LM324N 175p	748 40p	P4201A 450p	2112-2 300p	2N3706 7 14p	OA90 9p	2A 100V 45p
7405 25p	74121 32p	4002 21p	MC1485P 75p	750 70p	P4265 410p	8080A £11	2N3708 9 14p	OA91 9p	2A 200V 55p
7406 43p	74122 52p	4006 127p			P3205 300p	AYS-1013 650p	2N3709 9 14p	OA95 9p	3A 200V 80p
7407 43p	74123 55p	4007 47p			P5101-8 550p	RO3-2513 850p	2N3773 320p	OA200 10p	4A 100V 90p
7408 22p	74125 70p	4008 180p					2N3815 27p	OA202 10p	4A 200V 75p
7409 22p	74126 85p	4009 87p					2N4125 6 22p	1N914 4p	6A 100V 100p
7410 18p	74128 82p	4010 87p					2N4126 6 22p	1N916 7p	10A 400V 120p
7411 20p	74130 81p	4011 87p					2N4401 3 30p	1N4001 2 6p	25A 400V 43p
7412 25p	74136 81p	4012 23p					2N4427 3 30p	1N4003 4 7p	
7413 40p	74141 85p	4013 55p					2N4431 3 30p	1N4005 7 8p	
7414 85p	74142 300p	4014 90p					2N4432 3 30p	1N4148 4p	
7416 40p	74147 205p	4016 54p					2N4433 3 30p	1N5401 3 15p	
7417 40p	74148 160p	4017 120p					2N4434 3 30p	1N5404 7 20p	
7420 18p	74150 130p	4018 110p					2N4435 3 30p		
7421 43p	74151 81p	4019 57p					2N4436 3 30p		
7422 28p	74153 81p	4020 140p					2N4437 3 30p		
7423 30p	74154 160p	4021 120p					2N4438 3 30p		
7425 33p	74155 97p	4022 140p					2N4439 3 30p		
7426 43p	74156 97p	4023 23p					2N4440 3 30p		
7427 40p	74157 97p	4024 37p					2N4441 3 30p		
7428 40p	74159 250p	4025 23p					2N4442 3 30p		
7430 18p	74160 90p	4026 200p					2N4443 3 30p		
7432 37p	74161 130p	4027 84p					2N4444 3 30p		
7433 43p	74162 110p	4028 490p					2N4445 3 30p		
7437 37p	74163 130p	4029 120p					2N4446 3 30p		
7438 37p	74164 120p	4030 87p					2N4447 3 30p		
7440 18p	74165 150p	4040 150p					2N4448 3 30p		
7441 80p	74166 180p	4042 27p					2N4449 3 30p		
7442 75p	74167 320p	4043 100p					2N4450 3 30p		
7443 120p	74170 260p	4046 150p					2N4451 3 30p		
7444 120p	74172 120p	4047 120p					2N4452 3 30p		
7445 100p	74173 180p	4049 84p					2N4453 3 30p		
7446 100p	74174 130p	4050 54p					2N4454 3 30p		
7447 75p	74175 97p	4054 120p					2N4455 3 30p		
7448 85p	74176 130p	4055 140p					2N4456 3 30p		
7450 18p	74177 100p	4056 145p					2N4457 3 30p		
7451 18p	74180 160p	4060 130p					2N4458 3 30p		
7453 18p	74181 324p	4068 30p					2N4459 3 30p		
7454 18p	74182 150p	4069 30p					2N4460 3 30p		
7460 30p	74184 250p	4071 30p					2N4461 3 30p		
7470 30p	74185 180p	4072 30p					2N4462 3 30p		
7472 32p	74186 990p	4073 45p					2N4463 3 30p		
7473 36p	74190 140p	4078 30p					2N4464 3 30p		
7474 37p	74191 140p	4081 30p					2N4465 3 30p		
7475 45p	74192 120p	4082 30p					2N4466 3 30p		
7476 37p	74193 120p	4093 104p					2N4467 3 30p		
7480 54p	74194 160p	4510 140p					2N4468 3 30p		
7481 100p	74195 110p	4511 140p					2N4469 3 30p		
7482 90p	74196 110p	4522 110p					2N4470 3 30p		
7483 99p	74197 130p	4518 140p					2N4471 3 30p		
7484 100p	74198 270p	4520 110p					2N4472 3 30p		
7485 120p	74199 210p	4528 140p					2N4473 3 30p		
7486 30p	74221 175p	4433 £14					2N4474 3 30p		
7489 340p	74251 150p	14533					2N4475 3 30p		
7490 36p	74265 97p	14583 150p					2N4476 3 30p		
7491 90p	74278 320p						2N4477 3 30p		
7492 50p	74279 150p						2N4478 3 30p		
7493 36p	74283 225p						2N4479 3 30p		
7494 90p	74284 475p	75107 175p					2N4480 3 30p		
7495 75p	74285 475p	75182 250p					2N4481 3 30p		
7498 80p	74290 160p	75451 84p					2N4482 3 30p		
7497 200p	74291 160p	8210 215p					2N4483 3 30p		
74100 140p	74298 220p	9312 160p					2N4484 3 30p		
74104 75p	74365 160p	9316 220p					2N4485 3 30p		
74105 75p	74366 160p						2N4486 3 30p		
74107 30p	74367 160p						2N4487 3 30p		
74109 80p	74390 220p						2N4488 3 30p		
74110 80p	74393 240p						2N4489 3 30p		
74111 75p	74490 250p						2N4490 3 30p		

VOLTAGE REGULATORS—Fixed

Plastic TO220—3 Terminals	1 Amp	ve	100p
L Amp	5V	7905	160p
5V	7805	115p	160p
8V	7808	115p	160p
12V	7812	115p	160p
15V	7815	115p	160p
18V	7818	115p	160p
24V	7824	115p	160p
100mA -ve TO92	100mA	ve	TO92
5V	78L05	70p	50p
6.2V	78L62	70p	50p
12V	78L12	70p	50p
15V	78L15	70p	50p

OPTO-ELECTRONICS

OCPT7	130p	Red	10p
ORP12	100p	Green	22p
ORP80	80p	Infrared	81p
ORP51	90p	0 2n	Red
DSF777	8p	0 2n	Green
		1 2n	Amber

DISPLAYS

Minitron	200p	84p
FD1500 507	Red	75492 96p
DL704	Red	75492 200p
DL707	Red	160p 9376 200p
DL707	Red Green	100p 9374 200p
DL747	Red Green	250p TL312/3 120p
TL321 2	Red	130p TL330 150p

TRANSISTORS

AC125 6	20p	BDY56	225p
AC127 8 <td>20p</td> <td>BF115</td> <td>24p</td>	20p	BF115	24p
AC176 <td>20p</td> <td>BF167</td> <td>25p</td>	20p	BF167	25p
AC187 8 <td>20p</td> <td>BF170</td> <td>25p</td>	20p	BF170	25p
AD149	80p	BF173	27p
AD161	45p	BF178	30p
AD162	40p	BF179	30p
AF114 5	30p	BF180 1	35p
AF116 7	30p	BF184 5	24p
AF127	40p	BF194	13p
AF139	40p	BF195	11p
AF239	48p	BF196	17p
BF107 B	10p	BF197	19p
BF108 B	10p	BF200	80p
BF109	10p	BF249B	60p
BF109C	11p	BF258	60p
BF147	9p	BF257	34p
BF148	9p	BF258	39p
BF157	11p	BF259	40p
BF158 9	13p	BF337	32p
BF169C	15p	BF339	34p
BF172	11p	BF340 1	34p
BF177	20p	BF340 2	34p
BF178	20p	BF341	34p
BF179	20p	BF342	34p
BF182 3	12p	BF343	34p
BF183	12p	BF344	34p
BF187	32p	BF345	34p
BF212	14p	BF346	34p
BF213	12p	BF347	34p
BF214	14p	BF348	34p
BF215	14p	BF349	34p
BF216	14p	BF350	34p
BF217	14p	BF351	34p
BF218	14p	BF352	34p
BF219	14p	BF353	34p
BF220	14p	BF354	34p
BF221	14p	BF355	34p
BF222	14p	BF356	34p
BF223	14p	BF357	34p
BF224	14p	BF358	34p
BF225	14p	BF359	34p
BF226	14p	BF360	34p
BF227	14p	BF361	34p
BF228	14p	BF362	34p
BF229	14p	BF363	34p
BF230	14p	BF364	34p
BF231	14p	BF365	34p
BF232	14p	BF366	34p
BF233	14p	BF367	34p
BF234	14p	BF368	34p
BF235	14p	BF369	34p
BF236	14p	BF370	34p
BF237	14p	BF371	34p
BF238	14p	BF372	34p
BF239	14p	BF373	34p
BF240	14p	BF374	34p
BF241	14p	BF375	34p
BF242	14p	BF376	34p
BF243	14p	BF377	34p
BF244	14p	BF378	34p
BF245	14p	BF379	34p
BF246	14p	BF380	34p
BF247	14p	BF381	34p
BF248	14p	BF382	34p

U.K. RETURN OF POST MAIL ORDER SERVICE also WORLDWIDE EXPORT SERVICE

R.C.S. 10 WATT AMPLIFIER KIT



This kit is suitable for record players, tape play back, guitars electronic instruments or small P.A. systems. Two versions are available. The mono kit uses 13 semiconductors. The stereo kit uses 22 semiconductors. Both kits have printed front panel and volume, bass and treble controls. Spec: 10W output into 8 ohms, 7W into 15 ohms. Response 20c/s to 30kc/s, input 100mV, high imp. Size 9 1/2 x 3 x 2in. A/C mains operated.

Mono kit **£12.50** Stereo kit **£18** post 45p
Easy to build. Full instructions supplied.



ELAC 10 inch £4.50

Ribbed cone. Large ceramic magnet 50-16,000 c/s. Bass resonance 55 c/s. 10W, 15 ohm impedance.

RCS STEREO PRE-AMP KIT. All parts to build this pre-amp. Inputs for high, medium or low imp. per channel, with volume control and P.C. Board. Can be ganged to make multi-way mixers.

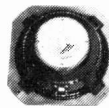
£2.95 Post 35p

MAINS TRANSFORMERS

	ALL POST 50p each
250-0-250V 70mA 6.3 2A	£3.45
250-0-250 80mA, 6.3V 3 5A, 6.3V 1A or 5V 2A	£4.60
350-0-350 80mA 6.3V 3 5A, 6.3V 1A or 5V 2A	£5.80
300-0-300 120mA 2 x 6.3V 2A CT 6.3V 2A	£8.50
220V 45mA, 6.3V 2A	£1.75
HEATER TRANS. 6.3V 3A, £1.45, 5 amp	£1.00
GENERAL PURPOSE LOW VOLTAGE Tapped outputs all	
2A 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 24 and 30V	£5.30
1A 6, 8, 10, 12, 15, 18, 20, 24, 30, 36, 40, 48, 60	£5.30
2A 6, 8, 10, 12, 15, 18, 20, 24, 30, 36, 40, 48, 60	£8.50
3A 6, 8, 10, 12, 15, 18, 20, 24, 30, 36, 40, 48, 60	£11.00
5A 6, 8, 10, 12, 15, 18, 20, 24, 30, 36, 40, 48, 60	£14.50
5, 8, 10, 16V 1A £2, 12V 100mA £1, 12V 300mA £1, 12V 750mA	
£1.30, 40V 2A tapped 10V or 30V £2.95, 20V 2A £2, 40V 2A	
£2.95, 30V 5A 34V 2A ct. £3.75, 2 x 18V 6A £9, 12.0-12V 2 amp	
£2.95 20-0-20V 1A £2.95, 30V 1A £2.75, 20V 1A £2.20	
5V 3 amp £2.75 60V, 40V 20V or 20-0-20V 1A £3.50, 30-0-30 2A £7.	
AUTO TRANSFORMERS 115V to 230V or 230V to 115V 150W £5; 250W £6; 400W £7; 500W £8.	
CHARGER TRANSFORMERS Input 200 250V for 6 or 12V 1.5A £2.75; 4A £5.20.	
FULL WAVE BRIDGE CHARGER RECTIFIERS 6 or 12V outputs 1' A 40p; 2A 55p; 4A 95p. HALF WAVE 12V 1.5A 25p.	

GOODMAN'S COMPACT 12in BASS WOOFER

Standard 12in diameter fixing with cut sides 10in square 14,000 gauss magnet 30 watt rms 4 ohm impedance. Bass resonance 30 c/s. Frequency response 30-8,000 c/s £1.95 each. Post £1.00 20 Watt model £9.95.



10 WATT PER CHANNEL STEREO AMPLIFIER

In chassis form. A.C. mains operated. Volume, balance, treble and bass slider controls. Pick up and tape inputs. Recording output. Front panel size: 16 1/2 x 1 1/2 in. Chassis size: 13 x 1 1/2 in. Bargain **£18.50** Post 50p

HEATING ELEMENTS WAFER THIN

Size 10 1/2 x 8 1/2 in. Operating voltage 200-250V ac 250W approx. Suitable for Heating Pads Food Warmers Convector Heaters etc. Must be clamped between two sheets of metal or asbestos.

ONLY **40p** EACH (FOUR FOR £1.50)

ALL POST PAID—Discounts for quantity

E.M.I. 13 1/2 x 8in SPEAKER SALE!

With tweeter. And crossover. Size 4 or 8 ohm.

10W Model £7.95 Post 45p

15W model £10.50 Post 65p

20W model £11.50 Post 75p

8 or 15 ohms

8 or 15 ohms

8 or 15 ohms

8 or 15 ohms

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8 or 15 ohms

8 or 15 ohms

8 or 15 ohms

MONO PRE-AMPLIFIER

A mains operated solid state pre-amplifier unit designed to compliment amplifiers without low level phono and tape input stages. This free standing cabinet incorporates circuitry for automatic R.I.A.A. equalisation on magnetic phono input and N.A.B. equalisation for tape heads. Power ON/OFF, PHONO/TAPE switches and pilot lamp are on the front panel; phono socket input and output are rear located. AC mains 240V.

Size 6 x 3 1/2 x 2in. **£4.50 ea. — 2 for £8.** Post 50p.



BAKER MAJOR 12 INCH £15



30-14,500 c/s 12in double cone, woofer and tweeter cone together with a BAKER ceramic magnet assembly having a flux density of 14,000 gauss and a total flux of 145,000 Maxwells. Bass resonance 40 c/s. Rated 25W. NOTE 4 or 8 or 16 ohms available.

Module kit, 30-17,000 c/s with tweeter crossover baffle 19 x 12 1/2 in. Instructions As illustrated **£19** Please state 4 or 8 or 16 ohms Post £1 60

'BIG SOUND' BAKER SPEAKERS

Robustly constructed to stand up to long periods of electronic power. As used by leading groups and discos. Useful response 30-13,000 c/s. Bass Resonance 55 c/s

GROUP '25'

12in 30W **£12** Post £1
4 or 8 or 16 ohms

GROUP '35'

12in 40W **£14** Post £1
4 or 8 or 16 ohms

GROUP 50/12in

12in 60W **£21** Post £1 60
4 or 8 or 16 ohms with aluminium presence dome

GROUP 50/15in

15in 75W **£26** Post £1 60
8 or 16 ohms

Disc, Group - PA Cabinets in stock. Send for Leaflet, Cabinet Fittings, Handles, Corners, Feet, Covering Material all in stock.



BAKER 150 WATT ALL PURPOSE TRANSISTOR AMPLIFIER

Ideal for Groups Disco P.A. and Musical Instruments 4 inputs speech and music 4 way mixing Output 4/8/16 ohm. a.c. Mains 240V. Separate treble and bass controls. **£75** Carr. £1 50

NEW 'DISCO 100 WATT' £59

ALL TRANSISTOR AMPLIFIER Carr. £1
2 inputs 4 outputs separate volume treble and bass controls. Ideal disco or slave amplifier chassis. Made by Jennings

R.C.S. SOUND TO LIGHT DISPLAY MK II

Complete kit of parts with R.C.S. printed circuit. Three 1000W channels. Will operate from 20mV signal source. CABINET extra £4. **KIT = £17.00**

GOODMANS CONE TWEETER

18,000 c/s 25W 8 ohm Price **£3.25**

E.M.I. 5in mid range 25W £4.95.

3 WAY CROSSOVER WITH TREBLE & MID RANGE CONTROLS. 50 WATT. £5 POST £1.

R.C.S. 100 WATT VALVE AMPLIFIER CHASSIS



Professional model. Four inputs Treble Bass Master Volume Controls. Ideal disco, P.A. or groups. S.A.E. for details 5 speaker outputs 3 or 8 or 15 ohm 100V line to order. Suitable carrying case £16.50. plus £2.50 carr.

LOW VOLTAGE ELECTROLYTICS
1 2 4 5 8 16 25 30 50 100 200mf 15V 10p. 500mf 12V 15p. 25V 20p. 50V 30p. 1000mf 12V 17p. 25V 35p. 50V 47p. 100V 70p. 2000mf 6V 25p. 25V 42p. 25000mf 50V 62p. 3000mf 25V 47p. 50V 65p. 3900mf 100V 11.60. 4700mf 63V 11.20. 5000mf 6V 25p. 12V 42p. 25V 75p. 35V 85p. 5600mf 76V 11.60. 1200/76V 80p.

R.C.S. LOW VOLTAGE STABILISED POWER PACK KITS

All parts and instructions with Zener diode, printed circuit rectifiers and double wound mains transformer. Input 200-240V a.c. Output voltages available 6 or 7.5 or 9 or 12V d.c. up to 100mA or less. Size 3 x 2 1/2 x 1 1/2 in. Please state voltage required **£2.95** Post 45p

ROBUST BLACK PLASTIC BOX

Size 6 1/2 x 3 1/2 x 2in with brushed aluminium facia. Ideal for constructional projects. **£1.50** Post 30p

R.C.S. GENERAL PURPOSE TRANSISTOR PRE-AMPLIFIER—BRITISH MADE £1.45

Ideal for Mike Tape P.U. Guitar Battery 9-12V or H.T. line 200-300V d.c. operation. Size 1 1/2 x 1 1/2 x 1 1/2 in. 25 c/s to 25 kc/s 26 dB gain. For valve or transistor equipment. Instructions supplied.

ELECTRO MAGNETIC PENDULUM MECHANISM 95p

1.5V d.c. operation over 300 hours continuous on SP2 battery fully adjustable swing and speed. Ideal displays teaching elementary magnetism or for metronome, stroboscope, etc.

BSR HI-FI AUTOCHANGER

Plays 12in, 10in or 7in records Auto or Manual. A high quality unit backed by BSR reliability with 12 months guarantee a.c. 200/250V. Size 13 1/2 x 11 1/2 in. Above motor board 3 1/2 in. Below motor board 2 1/2 in. With STEREO/MONO CARTRIDGE **£12.95** All Post 75p
Single Player version **£15.50**
BSR P128 with Magnetic Cartridge **£24.50**
GARRARD AUTOCHANGER, plays all records **£14.95**
BSR P163 BELT DRIVE DECK, less cartridge **£27.50**
GARRARD AP76 Single Player, less cartridge **£27.50**



BSR DELUXE AUTOCHANGER

Features balanced arm. Cueing device, stylus pressure gauge, 3 speed — plays all size records. Fitted with stereo ceramic cartridge. Size 13 x 12ins. Post £1
£17.50
Or with Sonolone V100 magnetic cartridge **£21.50**



R.C.S. DISCO DECK SINGLE RECORD PLAYER

Fitted with auto stop, stereo compatible cartridge. Baseplate. Size 11 x 8 1/2 in. Turntable. Size 7in diameter a.c. mains 220 250V 3 speeds. Plays all size records. **£7.95** Post 45p
Two for £15. Post 75p.

HEAVY METAL PLINTHS

With PVC Cover. Cut out for most BSR or Garrard decks. Silver grey finish. Model A Size 12 x 14 1/2 x 7 1/2 in. Model B Size 16 x 13 1/2 x 7 in. £7.50. Extra Large Plinth and Cover. For transcription decks. Size 20 x 17 x 9 in. uncut board. Callers only £18.50. **£6.50** Post £1 30

TINTED PLASTIC COVERS ONLY

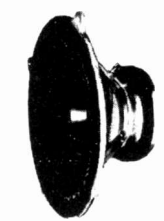
Sizes: 14 1/2 x 12 1/2 x 4 1/2 in. £3. 16 1/2 x 14 1/2 x 3 in. £3.75. 16 1/2 x 14 x 4 in. £4. 15 x 13 1/2 x 3 in. £3.50. 17 1/2 x 9 1/2 x 3 1/2 in. £3. 14 1/2 x 14 1/2 x 2 1/2 in. Rosenwood sides £4. Ideal for record decks, tape decks, etc. Post 75p.

BAKER HI-FI SPEAKERS

HIGH QUALITY—BRITISH MADE

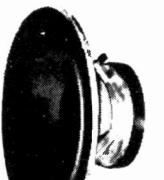
SUPERB 12in 25 watt £22

Quality loudspeaker low cone resonance ensures clear reproduction on the deepest bass. Special copper drive and concentric tweeter cone. Full range reproduction with remarkable efficiency in the upper register. Bass Resonance 25 c/s Flux Density 15,500 gauss Useful response 20-17,000 c/s 8 or 16 ohms models



AUDITORIUM 12in 35 watt £21

A full range reproducer for high power. Electric Guitars, public address, multi-speaker systems, electric organs. Ideal for Hi-Fi and Discotheques. Bass Resonance 35 c/s Flux Density 15,000 gauss Useful response 25-16,000 c/s 8 or 16 ohms models



AUDITORIUM 15in 45 watt £26

Blank aluminium chassis. 18 s.w.g. 2 1/2 in. sides, 6 x 4 in. 95p; 8 x 6 in. £1.40; 10 x 7 in. £1.55; 14 x 9 in. £1.90; 16 x 6 in. £1.85; 12 x 3 in. £1.20; 16 x 10 in. £2.20; 12 x 8 in. £1.70. ALUMINIUM PANELS, 18 s.w.g. 6 x 4 in. 24p; 8 x 6 in. 38p; 10 x 7 in. 54p; 12 x 5 in. 50p; 12 x 8 in. 70p; 16 x 6 in. 70p; 14 x 9 in. 94p; 12 x 12 in. £1; 16 x 10 in. £1.16. ALUMINIUM ANGLE BRACKET, 6 x 1 1/2 x 1 1/2 in. 15p. ALUMINIUM BOXES, MANY SIZES IN STOCK. 4 x 2 x 2 in. 86p; 3 x 2 x 1 in. 65p; 6 x 4 x 2 in. 95p; 8 x 6 x 3 in. £1.50; 9 x 4 x 4 in. £1.70; 12 x 4 x 4 in. £1.95.

THE 'INSTANT' BULK TAPE ERASER & HEAD DEMAGNETISER. Suitable for cassettes, and all sizes of tape reels a.c. mains 200/240V. Leaflet S A E **£4.95** Post 50p



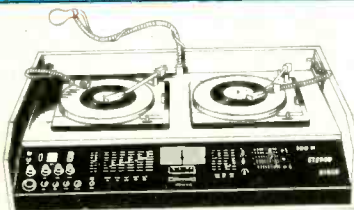
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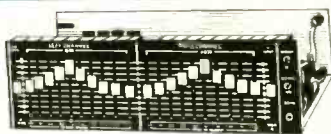
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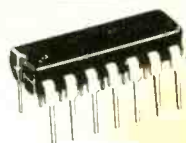
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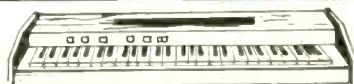
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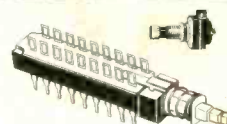
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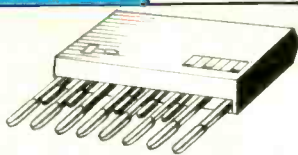
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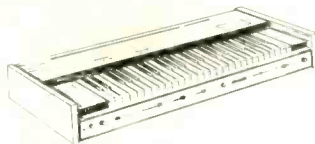
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