PRACTICAL

ELECTRONICS

MARCH 1975 30p

...in this issue

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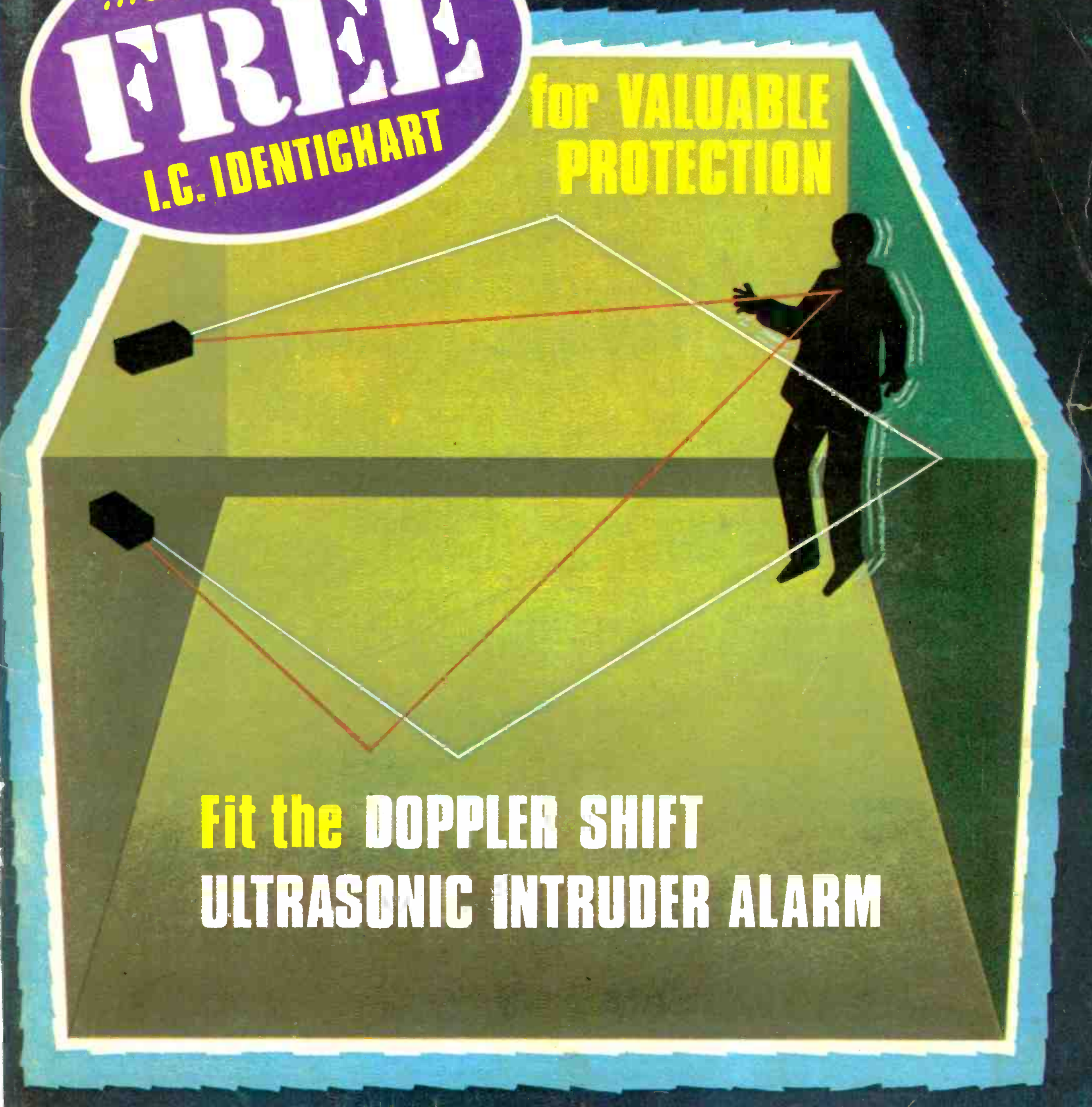
for VALUABLE PROTECTION



Fit the DOPPLER SHIFT ULTRASONIC INTRUDER ALARM

PRACTICAL ELECTRONICS

VOLUME 11 No. 3 MARCH 1975

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I.C. IDENTICHART

An easy-to-read directory of over 450 integrated circuits

CEEFAX and ORACLE
Part 2 of this article will appear next month

Our April issued will be published on Friday, March 14, 1975

RTVC FOR AUDIO AT A BUDGET

COMPLETE STEREO SYSTEM
*

System 1. £51·00

40 Watt Amplifier. Viscount III – R102 now 20 watts per channel.
System I includes:
Viscount III amplifier – volume, bass, treble and balance controls, plus switches for mono/stereo on/off function and bass and treble filters. Plus headphone socket.
Specification
20 watts per channel into 8 ohms. Total distortion @ 10W @ 1kHz 0·1%. *P.U.1* (for ceramic cartridges) 150mV into 3 Meg. *P.U.2* (for magnetic cartridges) 4mV @ 1kHz into 47K, equalised within ± 1dB R.I.A.A. *Radio* 150mV into 220K. (Sensitivities given at full power). Tape out facilities: headphone socket, power out 250mW per channel. *Tone controls and filter characteristics.* Bass: +12dB to –17dB @ 60Hz. Bass filter: 6dB per octave cut. Treble control: treble +12dB to –12dB @ 15kHz. Treble filter: 12dB per octave. *Signal to noise ratio:* (all controls at max.) – 58dB. Crosstalk better than 35dB on all inputs. Overload characteristics better than 26dB on all inputs. Size approx. 13$\frac{3}{4}$" × 9" × 3$\frac{3}{4}$".
Garrard SP 25 Mk III deck with magnetic cartridge, de luxe plinth and hinged cover.
Two Duo Type II matched speakers – Enclosure size approx. 17$\frac{1}{2}$" × 10$\frac{3}{4}$" × 6" in simulated teak. Drive unit 13" × 8" with parasitic tweeter. 10 watts handling.

Complete System £51·00

System 2. £69·00

Viscount III amplifier (As System I)
Garrard SP 25 Mk III deck (As System I)
Two Duo Type III matched speakers – Enclosure size approx. 27" x 13" x 11$\frac{1}{2}$"
Finished in teak veneer. Drive units 13" x 8" bass driver, and two 3" (approx.) tweeters.
20 watts R.M.S., 8 ohms frequency range — 20 Hz to 18,000 Hz.

Complete System £69·00

PRICES: SYSTEM 1

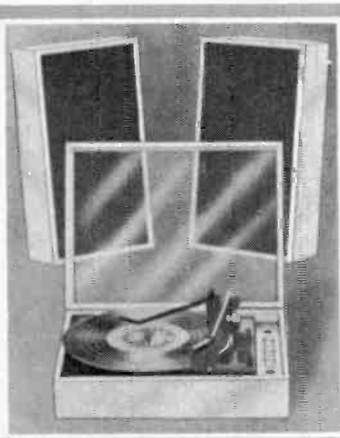
Viscount III R102 amplifier	£24.20 + £1 p & p
2 Duo Type II speakers	£14.00 + £2.20 p & p
Garrard SP 25 with Mag. cartridge de luxe plinth and hinged cover	£21.00 + £1.75 p & p
total:	£59.20

Available complete for only: **£51·00** + £3.50 p & p

PRICES: SYSTEM 2

Viscount III R102 amplifier	£24.20 + £1 p & p
2 Duo Type III speakers	£39.00 + £4.00 p & p
Garrard SP 25 with Mag. cartridge de luxe plinth and hinged cover	£21.00 + £1.75 p & p
total:	£84.20

Available complete for only: **£69·00** + £4.00 p & p



STEREO 21 *QUALITY SOUND FOR LESS THAN £20·00

Stereo 21, easy to assemble audio system kit. No soldering required.
The unit is finished in white P.V.C. and the acrylic top presents an unusually interesting variation on the modern deck plinth.
Includes:– **BSR 3 speed deck**, automatic, manual facilities together with stereo cartridge.
Two speakers with cabinets.
Amplifier module. Ready built with control panel, speaker leads and full, easy to follow assembly instructions.
Specifications: For the technically minded:—
Input sensitivity 600mV. Aux. input sensitivity 120mV. Power output 2.7 watts per channel.
Output impedance 8–15 ohms. Stereo headphone socket with automatic speaker cutout. Provision for auxiliary inputs – radio, tape, etc., and outputs for taping discs. **Overall Dimensions.** Speakers approx. 15$\frac{1}{2}$" × 8" × 4". Complete deck and cover in closed position approx. 15$\frac{1}{2}$" × 12" × 6".
Complete only **£19·95** + £1.60 p & p. Extras if required. Optional Diamond Styli **£1.37.**
Specially selected pair of stereo headphones with individual level controls and padded earpieces to give optimum performance. **£3.85.**

BUILD YOUR OWN * STEREO AMPLIFIER

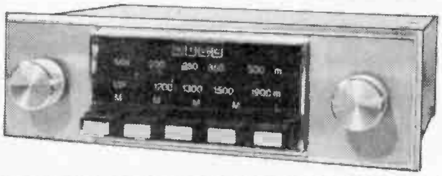
For the man who wants to design his own stereo — here's your chance to start, with Unisound — pre-amp, power amplifier and control panel. No soldering — just simply screw together. 4 watts per channel into 8 ohms. Inputs: 120mV (for ceramic cartridge). The heart of Unisound is high efficiency I.C. monolithic power chips which ensure very low distortion over the audio spectrum.
240V. AC only. **£7·64+55p p & p** Also available with 2 speakers (7" × 4") £9·00 + 75p p. & p.

8 TRACK HOME CARTRIDGE PLAYER
*

Elegant self selector push button player for use with your stereo system. Compatible with Viscount III system, Unisound module and the Stereo 21. Technical specification Mains input, 240V, Output sensitivity 125mV Comparable unit sold eleswhere at £24.00 approx. Yours for only

£11.95 + 90p p & p.

PUSH BUTTON CAR RADIO KIT* ~ The Tourist II



NO SOLDERING REQUIRED!

NOW BUILD YOUR OWN PUSH BUTTON CAR RADIO

Easy to assemble construction kit comprising fully completed and tested printed circuit board on which no soldering is required. All connections are simple push fit type making for easy assembly. Fine tuning push button mechanism is fully built and tested to mate with printed circuit board.

TECHNICAL SPECIFICATION: (1) **Output** 4 watts R.M.S. output. For 12 volt operation on negative or positive earth. (2) **Integrated circuit** output stage, pre-built three stage IF Module. **Controls volume** manual tuning and five push buttons for station selection, illuminated tuning scale covering full, medium and long wave bands.

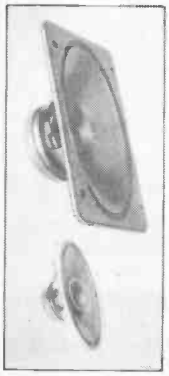
Size chassis 7″ wide, 2″ high and 4¾″ deep approx £7.70 + 55p. p & p.

Speaker including baffle and fixing strip £1.65 + 23p. p & p.

Car Aerial Recommended—fully retractable £1.37 + 20p. p. & p.

The Tourist I Kit For the experienced constructor. If you can solder on a printed circuit board you can build this model.
Same technical specification as Tourist II. **Price £6.60 + 55p p & p.**

EMI SPEAKERS AT FANTASTIC REDUCTIONS

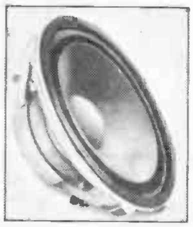


20 WATT SPEAKER SYSTEM *

System consists of a 13″ × 8″ (approx) eliptical woofer unit with a 8″ × 5″ (approx.) mid range unit incorporating parasitic tweeter and crossover components. Circuit diagram.

Technical Specification:
Bass Unit
Flux density—100 K. speech coil—1½″. Cone. Triple laminated paper with P.V.C. surround.
Mid Range Unit
Flux density-33K, speech coil-1″ with parasitic tweeter.
Power Handling
20 watts R.M.S., impedance—8 ohms. frequency response—20 Hz to 18,000 Hz.

OUR PRICE £6.60. Complete + 90p p & p.

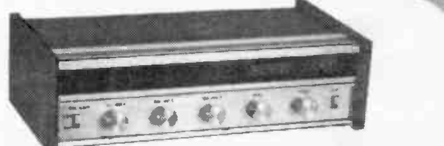


15″ 14A/780 BASS UNIT

Bass unit on a rigid diecast chassis. Superior cone material handles up to 50 watts RMS, and is treated to give a smooth frequency response. Resonance 30 Hz, flux density 360,000 Maxwells. Impedance at 1 kHz is 8 ohms. 3″ voice coil.

Recommended retail price £40·80.

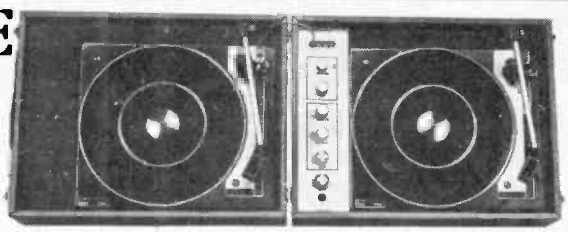
OUR PRICE £18·70 + £1·50 p & p

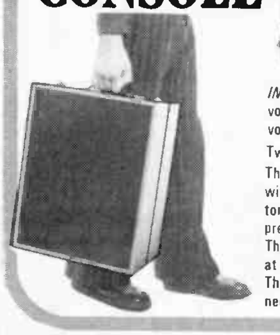


DISCO AMPLIFIER*

Reliant Mk IV Mono Amplifier, ideal for the small disco or house parties.
Outputs 20 watts R.M.S. into 8 ohms (suitable for 15 ohms).
Inputs *4 electrically mixed inputs. *3 individual mixing controls.
*Separate bass and treble controls common to all 4 inputs.
*Mixer employing F.E.T. (Field Effect Transistors) *Solid State circuitry.
*Attractive styling.
INPUT SENSITIVITIES –Input – 1.) Crystal mic. guitar or moving coil mic, 2 and 10mV. (Selector switch for desired sensitivity).
–Inputs – 2), 3), 4). Medium output equipment – ceramic cartridge, tuner, tape recorder, organs, etc. – all 250mV sensitivity. AC Mains, 240V operation. Size approx: 12½″×6″×3½″. **£15.00 + 60p. p & p**

PORTABLE DISCO CONSOLE*





INCORPORATES: Pre-Amp with full mixing facilities, including switched input for mic with volume control, switched input for auxiliary with volume control, bass and treble controls, volume control and blend control for turntables.

Two B.S.R. single play professional series decks, fitted with crystal cartridges.

The turntables are designed and precision engineered. They combine clean modern styling with superb reproduction. Their many special features include square section aluminium tonearms, (high precision low mass design fully counterbalanced, with calibrated stylus pressure control for perfect tracking), and conveniently grouped easy to read linear controls. The turntables have viscous cueing devices which allows the tonearms to be placed or lifted at any point on the record.

The two lightweight cartridge shells have slide-in-holders to facilitate easy inspection of needles and cartridges.

TECHNICAL SPECIFICATION:
Pre-amp – Output – 200mV.
Auxiliary inputs – 200mV and 750mV into 1 meg.
Mic input – 6mV into 100K. 240 volt operation.
Turntables capacity – 7″, 10″ or 12″ records.
Rumble, wow and flutter
Rumble Better than –35dB. Wow Better than 0.2%.
Flutter Better than 0.06% (Gaumont kalee meter).
Finish – Satin black mainplate with black turntable mat inlaid with brushed aluminium trim. Tonearm and controls in black and brushed aluminium.
Console size –
Unit Closed – 17¾″ × 13¾″ × 8¾″ (approx.)
Unit Open – 35¾″ × 13¾″ × 4¾″ (approx.)

This disco console is ideally matched for the Reliant IV and Disco 50 or any other quality amplifier.

The unit is finished in black PVC with contrasting simulated teak edging, diamond spun control knobs with matching control panel.

Yours for only £45.00 + £3.50 P. & P.

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Just write your order giving your credit card number

Mail orders to Acton. Terms C.W.O. All enquiries stamped addressed envelope. Goods not despatched outside U.K. Leaflets available for all items listed thus * Send stamped addressed envelope. All items subject to availability. Prices correct at 1st Jan. 1975 and subject to change without notice. All prices include V.A.T. at 8% rate.

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323 Edgware Road, London W2

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EX-COMPUTER STABILISED POWER MODULES
Complete with circuit diagrams, etc.
99p each plus 22p P. & P.

LOW COST CAPACITORS
0·01μF 400V. 3p each
500μF 50V. Elect. 10p each

FIBRE-GLASS PRINTED CIRCUIT BOARDS
16½ × 4" approx. 2 for 55p

DECON-DALO 33PC Marker
Etch resistant printed circuit marker pen 99p each

VEROBOARDS
Packs containing approx., 50sq. in. various sizes, all 0·1 matric 55p

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RF Chokes
CH1. 2·5mH 29p CH2. 5·0mH 30p
CH3. 7·5mH 31p CH4. 10mH 33p
CH5. 1·5mH 28p
COILS
DRX1 Crystal set 31p DRR2 Dual range 45p

COIL FORMERS & CORES
NORMAN ¼" Cores & Formers 8p
⅜" Cores & Formers 10p

SWITCHES
DP/DT Toggle 36p SP/ST Toggle 30p

FUSES
1¼" and 20mm. 100mA, 200mA, 250mA, 500mA, 1A, 1·5A, 2A
QUICK-BLOW 5p each.

EARPHONES
Crystal 2·5mm plug 42p
Crystal 3·5mm plug 42p
8 ohms 2·5mm plug 22p
8 ohms 3·5mm plug 22p

DYNAMIC MICROPHONES
B1223. 200 ohms plus on/off switch and 2·5mm and 3·5mm plugs £1·85

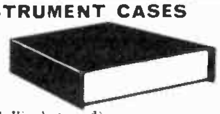
3-WAY STEREO HEAD-PHONE JUNCTION BOX
H1012 £1·87

2-WAY CROSSOVER NETWORK
K4007. 80 ohms Imp. Insertion loss 3dB £1·21

CAR STEREO SPEAKERS
(Angled) £3·85 per pair.

BI-PAK
CATALOGUE AND LISTS
Send S.A.E. and 10p.

INSTRUMENT CASES



(Black Vinyl covered)

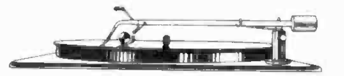
No.	Length		Width		Height	Price
BV1	8"	×	5¼"	×	2"	£1·35
BV2	11"	×	6"	×	3"	£1·75

ALUMINIUM BOXES

BA1	5¼"	×	2¼"	×	1½"	49p
BA2	4"	×	4"	×	1½"	49p
BA3	4"	×	2¼"	×	1½"	49p
BA4	5¼"	×	4"	×	1½"	58p
BA5	4"	×	2½"	×	2"	49p
BA6	3"	×	2"	×	1"	42p
BA7	7"	×	5"	×	2½"	85p
BA8	8"	×	6"	×	3"	£1·10
BA9	6"	×	4"	×	2"	70p

P. & P. 15p on each box

BIB HI-FI ACCESSORIES
De Luxe Groov-Kleen
Model 42 £1·95
Chrome Finish
Model 60 £1·50



Ref. 36A. Record/Stylus Cleaning Kit 33p
Ref. 43. Record Care Kit £2·42
Ref. 31. Cassette Head Cleaner 58p
Ref. 32. Tape editing Kit £1·68
Model 9. Wire Stripper/Cutter 83p
Ref. 46. Spirit Level 62p
Ref. B. Stylus and Turntable Cleaning Kit 34p
Ref. P. Hi-Fi Cleaner 31p
Ref. 32A. Stylus Balance £1·37
Ref. J. Tape Head Cleaning Kit 62p
Ref. 56. Hi-Fi Stereo Hints and Tips 42p
Ref. 45. Auto Changer Groove Cleaner £1·08

ANTEX SOLDERING IRONS
X25. 25 watt £2·05
CCN 240. 15 watt £2·48
Model G. 18 watt £2·26
SK2. Soldering Kit £3·25
STANDS: ST3, suitable for all models £1
SOLDER: 18SWG Multicore 7oz £1·61
22SWG 7oz £1·61. 18SWG 22ft 51p
22SWG Tube 33p

ANTEX BITS and ELEMENTS
Bits No.

102 For model CN240 3/32"	42p
104 For model CN240 1/16"	42p
1100 For model CCN240 3/32"	42p
1101 For model CCN240 ⅛"	42p
1102 For model CCN240 ¼"	42p
1020 For model G240 3/32"	42p
1021 For model G240 ⅛"	42p
1022 For model G240 3/16"	42p
50 For model X25 3/32"	48p
51 For model X25 ⅛"	48p
52 For model X25 3/16"	48p

ELEMENTS
ECN 240 £1·30 ECCN 240 £1·32
EG 240 £1·07 EX 25 £1·16

ANTEX HEAT SINKS 10p

VAT included in all prices. Please add 10p P. & P. (U.K. only). Overseas orders—please add extra for postage.

NEW COMPONENT PAK BARGAINS

Pack No.	Qty.	Description	Price
C1	200	Resistors mixed values approx. count by weight	0·54
C2	150	Capacitors mixed values approx. count by weight	0·54
C3	50	Precision Resistors 0·1%, 0·01% mixed values	0·54
C4	75	⅛th W Resistors mixed preferred values	0·54
C5	5	Pieces assorted Ferrite Rods	0·54
C6	2	Tuning Gangs, MW/LW VHF	0·54
C7	1	Pack Wire 50 metres assorted colours	0·54
C8	10	Reed Switches	0·54
C9	3	Micro Switches	0·54
C10	15	Assorted Pots & Pre-Sets	0·54
C11	5	Jack Sockets 3 × 3·5m 2 × Standard Switch Type	0·54
C12	30	Paper Condensers preferred types mixed values	0·54
C13	20	Electrolytics Trans. types	0·54
C14	1	Pack assorted Hardware—Nuts/Bolts, Grommets, etc.	0·54
C15	5	Mains Slide Switches	0·54
C16	20	Assorted Tag Strips & Panels	0·54
C17	10	Assorted Control Knobs	0·54
C18	4	Rotary Wave Change Switches	0·54
C19	2	Relays 6—24V Operating	0·54
C20	1	Pack Sheets of Copper Laminate approx. 20 sq. ins.	0·54

PLUGS AND SOCKETS
PLUGS

PS 1	D.I.N. 2 Pin (Speaker)	0·11
PS 2	D.I.N. 3 Pin	0·12
PS 3	D.I.N. 4 Pin	0·15
PS 4	D.I.N. 5 Pin 180°	0·16
PS 5	D.I.N. 5 Pin 240°	0·16
PS 6	D.I.N. 6 Pin	0·17
PS 7	D.I.N. 7 Pin	0·18
PS 8	Jack 2·5mm Screened	0·18
PS 9	Jack 3·5mm Plastic	0·12
PS 10	Jack 3·5mm Screened	0·18
PS 11	Jack ¼" Plastic	0·15
PS 12	Jack ¼" Screened	0·22
PS 13	Jack Stereo Screened	0·36
PS 14	Phono	0·10
PS 15	Car Aerial	0·22
PS 16	Co-Axial	0·15

INLINE SOCKETS

PS 21	D.I.N. 2 Pin (Speaker)	0·14
PS 22	D.I.N. 3 Pin	0·20
PS 23	D.I.N. 5 Pin 180°	0·20
PS 24	D.I.N. 5 Pin 240°	0·20
PS 25	Jack 2·5mm Plastic	0·16
PS 26	Jack 3·5mm Plastic	0·16
PS 27	Jack ¼" Plastic	0·30
PS 28	Jack ¼" Screened	0·35
PS 29	Jack Stereo Plastic	0·30
PS 30	Jack Stereo Screened	0·38
PS 31	Phono Screened	0·18
PS 32	Car Aerial	0·22
PS 33	Co-Axial	0·22

SOCKETS

PS 35	D.I.N. 2 Pin (Speaker)	0·08
PS 36	D.I.N. 3 Pin	0·11
PS 37	D.I.N. 5 Pin 180°	0·11
PS 38	D.I.N. 5 Pin 240°	0·11
PS 39	Jack 2·5mm Switched	0·12
PS 40	Jack 3·5mm Switched	0·12
PS 41	Jack ¼" Switched	0·20
PS 42	Jack Stereo Switched	0·30
PS 43	Phono Single	0·08
PS 44	Phono Double	0·10
PS 46	Co-Axial Surface	0·10
PS 47	Co-Axial Flush	0·20

LEADS
LS 1 Speaker Lead 2 pin D.I.N. plug to open ends approx 3 metres long (coded) 0·20

CABLES

CP 1	Single Lapped Screen	0·07
CP 2	Twin Common Screen	0·11
CP 3	Stereo Screened	0·12
CP 4	Four Core Common Screen	0·23
PC 5	Four Core Individually Screened	0·30
CP 6	Microphone Fully Braided Cable	0·10
CP 7	Three Core Mains Cable	0·09
CP 8	Twin Oval Mains Cable	0·07
CP 9	Speaker Cable	0·05
CP 10	Low Loss Co-Axial	0·18

CARBON POTENTIOMETERS
Log and Lin
4·7K, 10K, 22K, 47K, 100K, 220K, 470K, 1M, 2M

VC 1	Single Less Switch	0·15
VC 2	Single D.P. Switch	0·28
VC 3	Tandem Less Switch	0·46
VC 4	1K Lin Less Switch	0·15
VC 5	100 K anti-Log	0·46

HORIZONTAL CARBON PRESETS
0·1 watt 0·06 each
100, 220, 470, 1K, 2·2K, 4·7K, 10K, 22K, 47K, 100K, 220K, 470K, 1M, 2M, 4·7M

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Takes 4, HP7's complete with terminal, clip and lead. 34p.

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JUMBO SEMICONDUCTOR PACK

Transistors, Germ. and Silicon Rectifiers, Diodes, Triacs, Thyristors, I.Cs and Zeners. ALL NEW AND CODED.

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7in EP. 18¾in × 7in × 8in (50 records) £2·10
12in LP. 13¾in × 7⅝in × 12¾in (50 records) £2·95

CASSETTE CASES £1·30
Holds 12, 10in × 3½in × 5in. Lock and handle.

8-TRACK CART. CASES
Holds 14, 13in × 5in × 6in £1·95
Holds 24, 13¾in × 8in × 5⅝in £2·70
Both with lock and handle.

SPECIAL PURCHASE
2N3055. Silicon Power Transistors NPN. Famous manufacturers out-of-spec devices free from open and short defects—every one able! 115W. TO3. Metal Case.
OUR SPECIAL PRICE 8 for £1

REPANCO TRANSFORMERS
240V. Primary. Secondary voltages available from selected tappings 4V, 7V, 8V, 10V, 14V, 15V, 17V, 19V, 21V, 25V, 31V, 33V, 40, 50 and 25V–0–25V.

Type	Amps	Price	P. & P.
MT50/½	½	£1·93	45p
MT50/1	1	£2·42	48p
MT50/2	2	£3·30	60p

CARTRIDGES
ACOS

GP91-1SC 200mV at 1·2cm/sec	£1·35
GP93-1 280mV at 1cm/sec	£1·85
GP96-1 100mV at 1cm/sec	£2·80
J-2005 Crystal/Hi Output	£1·05
J-2010C Crystal/Hi Output Compatible	£1·20
J-2006S Stereo/Hi Output	£1·75
J-2105 Ceramic/Med Output	£1·95
J-2203 Magnetic 5mV/5cm/sec, including stylus	£4·95
J-2203S Replacement stylus for above	£3·00
AT-55 Audio-technica magnetic cartridge 4mV/5cm/sec	£3·30

CARBON FILM RESISTORS
The E12 Range of Carbon Film Resistors, ⅓ watt available in PAKS of 50 pieces, assorted into the following groups:

R1	50 Mixed 100 ohms–820 ohms	50p
R2	50 Mixed 1kΩ–8·2kΩ	50p
R3	50 Mixed 10kΩ–82kΩ	50p
R4	50 Mixed 100kΩ–1MΩ	50p

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C60, 36p; C90, 48p; C120, 60p.

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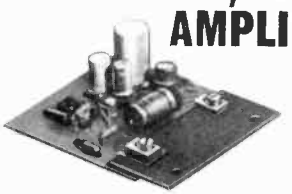
BI-PAK *QUALITY* COMES TO AUDIO!

AL10/AL20/AL30 AUDIO AMPLIFIER MODULES



The AL10, AL20 and AL30 units are similar in their appearance and in their general specification. However, careful selection of the plastic power devices has resulted in a range of output powers from 3 to 10 watts R.M.S.
The versatility of their design makes them ideal for use in record players, tape recorders, stereo amplifiers and cassette and cartridge tape players in the car and at home.

Parameter	Conditions	Performance
HARMONIC DISTORTION	Po = 3 WATTS f = 1KHz	0·25%
LOAD IMPEDANCE	—	8–16 Ω
INPUT IMPEDANCE	f = 1KHz	100 kΩ
FREQUENCY RESPONSE —3dB	Po = 2 WATTS	50 Hz–25KHz
SENSITIVITY for RATED O/P	Vs=25V. Rl=8Ω f=1KHz	75mV. RMS
DIMENSIONS	—	3" × 2½" = 1"

The above table relates to the AL10, AL20 and AL30 modules. The following table outlines the differences in their working conditions.

Parameter	AL10	AL20	AL30
Maximum Supply Voltage	25	30	30
Power out for 2% T.H.D. (RL = 8Ω f = 1KHz)	3 watts RMS Min.	5 watts RMS Min.	10 watts RMS Min.

AUDIO AMPLIFIER MODULES

AL 10.	3 watts	£2·50
AL 20.	5 watts	£2·85
AL 30.	10 watts	£3·20

POWER SUPPLIES

PS 12. (Use with AL10, AL20, AL30) 95p
SPM 80. (Use with AL60) £3·25
FRONT PANELS FP 12 with Knobs £1·00

PRE-AMPLIFIERS

PA 12. (Use with AL10, AL20 and AL30) £4·35
PA 100. (Use with AL60) £13·15

TRANSFORMERS

T461 (Use with AL10) £1·60 P & P 22p
T538 (Use with AL20, AL30) £2·30 P & P 22p
BMT80 (Use with AL60) £2·75 P & P 37p

PA12 PRE-AMPLIFIER SPECIFICATION

The PA12 pre-amplifier has been designed to match into most budget stereo systems. It is compatible with the AL 10, AL 20 and AL 30 audio power amplifiers and it can be supplied from their associated power supplies. There are two stereo inputs, one has been designed for use with *Ceramic cartridges while the auxiliary input will suit most †Magnetic cartridges. Full details are given in the specification table. The four controls are, from left to right: Volume and on/off switch, balance, bass and treble. Size 152mm × 84mm × 35mm.

Frequency response— 20Hz–50KHz (—3dD)
Bass control— ± 12dB at 60Hz
Treble control— ± 14dB at 14KHz
*Input 1. Impedance 1 Meg. ohm
Sensitivity 300mV
†Input 2. Impedance 30 K ohms
Sensitivity 4mV

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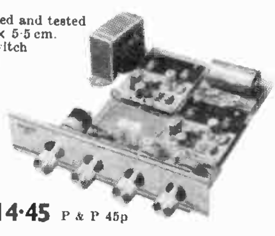
ALL PRICES INCLUDE V.A.T.

The STEREO 20



The "Stereo 20" amplifier is mounted, ready wired and tested on a one-piece chassis measuring 20 cm × 14 cm × 5·5 cm. This compact unit comes complete with on/off switch volume control, balance, bass and treble controls, Transformer, Power supply and Power amps. Attractively printed front panel and matching control knobs. The "Stereo 20" has been designed to fit into most turntable plinths without interfering with the mechanism or, alternatively, into a separate cabinet. Output power 20w peak. Input 1 (Cer.) 300mV into 1M. Freq. res. 25Hz-25kHz. Input 2 (Aux.) 4mV into 30K. Harmonic distortion. Bass control ± 12dB at 60Hz typically 0·25% at 1 watt. Treble con. ± 14dB at 14kHz.

£14·45 P & P 45p

TC20 TEAK VENEERED CABINET

For Stereo 20 (front board undrilled) Size 10¼" × 8½" × 3", £3·95 plus 45p postage.

SHP80 STEREO HEADPHONES

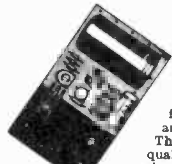
4-16 ohms impedance. Frequency response 20 to 20,000Hz. Stereo/mono switch and volume controls, £4·95

NOW WE GIVE YOU 50w PEAK (25w R.M.S.) *PLUS* THERMAL PROTECTION! The *NEW* AL60 Hi-Fi Audio Amplifier FOR ONLY £4·25

- Max Heat Sink temp 90°C.
- Frequency Response 20Hz to 100KHz
- Distortion better than 0·1% at 1KHz
- Supply voltage 15–50 volts
- Thermal Feedback
- Latest Design Improvements
- Load — 3, 4, 8 or 16 ohms
- Signal to noise ratio 80dB
- Overall size 63mm × 105mm × 13mm

Especially designed to a strict specification. Only the finest components have been used and the latest solid state circuitry incorporated in this powerful little amplifier which should satisfy the most critical A.F. enthusiast.

STABILISED POWER MODULE SPM80

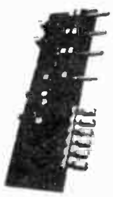


SPM80 is especially designed to power 2 of the AL60 Amplifiers, up to 15 watt (r.m.s.) per channel simultaneously. This module embodies the latest components and circuit techniques incorporating complete short circuit protection. With the addition of the Mains Transformer BMT80, the unit will provide outputs of up to 1·5 amps at 35 volts. Size: 63mm × 105mm × 30mm.
These units enable you to build Audio Systems of the highest quality at a hitherto unobtainable price. Also ideal for many other applications including:—Disco Systems, Public Address, Intercom Units, etc. Handbook available 10p **PRICE £3·25**

TRANSFORMER BMT80 £2·15 p. & p. 40p

STEREO PRE-AMPLIFIER TYPE PA100

Built to a specification and NOT a price, and yet still the greatest value on the market. the PA100 stereo pre-amplifier has been conceived from the latest circuit techniques. Designed for use with the AL60 power amplifier system, this quality made unit incorporates no less than eight silicon planar transistors, two of these are specially selected low noise NPN devices for use in the input stages.
Three switched stereo inputs, and rumble and scratch filters are features of the PA100, which also has a STEREO/MONO switch, volume, balance and continuously variable bass and treble controls.



SPECIFICATION

Frequency Response	20Hz—20KHz ± 1dB
Harmonic Distortion	better than 0·1%
Inputs: 1. Tape Head	3·25 mV into 50K Ω
2. Radio, Tuner	75 mV into 50K Ω
3. Magnetic P.U.	3 mV into 50K Ω

All input voltages are for an output of 250mV. Tape and P.U. inputs equalised to RIAA curve within ± 1dB. from 20Hz to 20KHz.

Bass Control	± 15dB at 20Hz
Treble Control	± 15dB at 20KHz
Filters: Rumble (High Pass)	100Hz
Scratch (Low Pass)	8KHz
Signal/Noise Ratio	better than —65dB
Input overload	+ 26dB
Supply	+ 35 volts at 20mA
Dimensions	292mm × 82mm × 35mm

ONLY £14·25

MK 60 AUDIO KIT

Comprising: 2 × AL60, 1 × SPM80, 1 × BTM80, 1 × PA 100, 1 front panel, 1 kit of parts to include on-off switch, neon indicator, stereo headphone sockets plus instruction booklets. Complete Price: £29·75 plus 45p postage.

TEAK 60 AUDIO KIT

Comprising: Teak veneered cabinet size 16¾" × 11½" × 3½", other parts include aluminium chassis, heatsink and front panel bracket, plus back panel and appropriate sockets, etc. Kit price: £9·95 plus 45p postage.

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AC128	17p	BC169B	12p	MJE3055	68p
AC151R	36p	BC169C	13p	OA91	6p
AC153	27p	BC179B	26p	SD4	8p
AC153K	37p	BC182L	12p	TIP31A	70p
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AD161	42p	BD131	48p	ZTX504	45p
AD162	40p				

ELECTROLYTIC CAPACITORS
Axial Lead

μF	3V	6·3V	10V	16V	25V	40V	63V	100V
0·47	—	—	—	—	—	—	11p	8p
1·0	—	—	—	—	—	11p	—	8p
2·2	—	—	—	—	11p	—	8p	9p
4·7	—	—	—	11p	—	8p	9p	8p
10	—	11p	—	—	8p	9p	8p	8p
22	—	—	8p	—	9p	8p	8p	10p
47	8p	—	9p	8p	8p	8p	10p	13p
100	9p	8p	8p	8p	9p	10p	12p	19p
220	8p	8p	9p	10p	10p	11p	17p	28p
470	9p	10p	10p	11p	13p	17p	24p	45p
1,000	11p	13p	13p	17p	20p	25p	41p	—
2,200	15p	—	—	26p	37p	41p	—	—
4,700	—	—	36p	44p	58p	—	—	—
10,000	42p	46p	—	—	—	—	—	—

RESISTORS

Code	Watts	Ohms	1 to 9	10 to 99	100 up (see note below)
C	⅛	4·7–470K	1·3	1·1	0·9 nett
C	½	4·7–10M	1·3	1·1	0·9 nett
C	¾	4·7–10M	1·5	1·2	0·97 nett
C	1	4·7–10M	3·2	2·5	1·92 nett
MO	½	10–1M	4	3·3	2·3 nett
WW	1	0·22–0·47	16	14	11 nett
WW	1	0·56–3·9Ω	12	10	8 nett
WW	3	1–10K	9p	8p	6 nett
WW	7	1–10K	11	10	8 nett

Codes:
C = carbon film, high stability, low noise.
MO = metal oxide. Electrosil TR5 ultra low noise.
WW = wire wound, Plessey.

Values: All E12 except C ⅛W, C ¾W and MO ½W.
E12: 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82 and their decades.
E24: as E12 plus 11, 13, 16, 20, 24, 30, 36, 43, 51, 62, 75, 91 and their decades.

Tolerances:
5% except WW 10% ± 0 05Ω below 10Ω and ½W MO 2%.

Prices are in pence each for quantities of the same ohmic value and power rating. NOT mixed values. (Ignore fractions of one penny on total value of resistor order). Prices for 100 up in units of 100 only.

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All goods are sold on the understanding that they conform to makers' specifications. No rejects, seconds or sub-standard merchandise.

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4BA NUTS 21p; 6BA NUTS 28p; ¼" 4BA Screws 30p; ¼" 6BA Screws 24p; Threaded pillars 6BA, ¼" hexagonal £1·38; Plain spacers ¼" £1·32.

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1000/100 £1·00
5000/100 £3·56 — 1000/50 50p
2000/150 70p
5000 25V 75p — 5000/50 £1·44

POLYESTER TYPE C.280. *Radial leads for P.C.B. mounting. Working voltage 250V d.c.*
0·01, 0·015, 0·022, 0·033, 0·047 — each 3p
0·068, 0·1, 0·15 — each 4p
0·22 5p; 0·33 7p; 0·47 8p; 0·68 11p; 1·0 14p; 1·5 21p; 2·2 24p.

SILVERED MICA. *Working voltage 500V d.c. Tolerance 1% or 0·5pF.*
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4·7/35V, 10/16V, 22/6·3V — each 21p
10/25V, 22/16V, 27/6·3V, 100/3V, 6·8/25V, 15/25V — each 23p

POLYCARBONATE
Type B42540 Working Voltage—250V. Values in mF:
0·0047, 0·0068, 0·01, 0·015, 0·22 — each 4p
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40 watt	20p	18p	16p	30p	28p	26p
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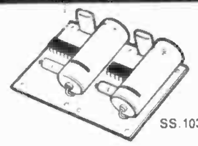
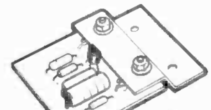

SS.103-3

STIRLING SOUND AUDIO MODULES come to you as basic units assembled on P.C.B.s enabling you to add required components in layouts of your own choice. Modules are tested and boxed before despatch and include well printed instructions.

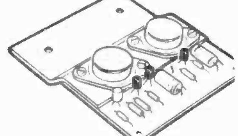
AMPLIFIER MODULES

Pre-amplifiers; tone control


SS.105

- SS.100 Active tone control unit to provide bass, treble, balance and volume controls **£1·60**
- SS.101 Pre-amp for ceramic cartridge, tape and radio **£1·60**
- SS.102 Pre-amp for low output magnetic cartridge tape and radio. With R.I.A.A. correction ±1dB at 1kΩ **£2·25**

POWER AMPLIFIERS


SS.140

- SS.103 Compact I.C. amp. with 3 watts R.M.S. output. Operating voltage 6-22. Size 3in × 2in. **£1·75**
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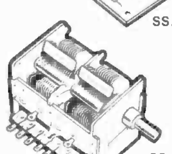
SS.201

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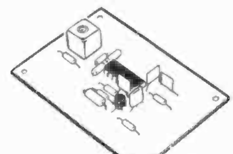
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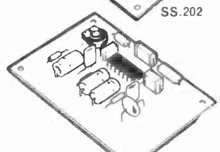
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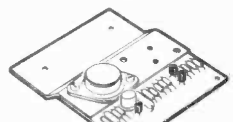
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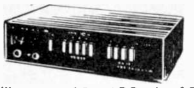

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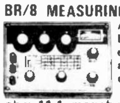

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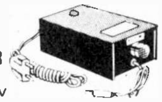

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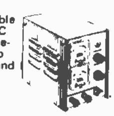

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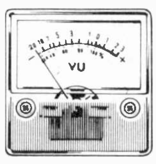

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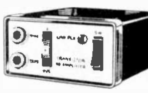

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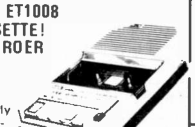

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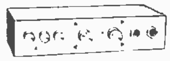

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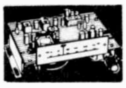

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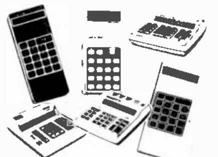

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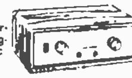

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ON GUARD

WHILE technology continually advances, bringing many improvements at the material level, human nature on the other hand seems to undergo little change with the passage of time. For instance, the struggle waged between occupier and trespasser, and between owner and would-be purloiner goes on just as relentlessly today as it did in times long past.

The odds against the criminal have not altered much either, it seems, despite the increasing involvement of electronic and other technical aids. In fact electronics is probably responsible to some extent for the greater abundance of valuable, and often portable, loot that tempts today's criminals. The villains also have access to advanced technology and can, if they are sufficient determined, surmount or otherwise render innoxious many of the security systems created to deter or defeat them. The safest intruder detection systems obviously are those that do not advertise their presence, or at any rate their vital sensing elements. For in the final reckoning it is immunity from hostile action that makes a security system really 100 per cent. effective.

In this regard security systems relying upon invisible radiations have considerable advantages. Both infra-red and radio frequencies are used in security applications. Some of the more advanced commercial systems employ microwaves and exploit the Doppler shift effect to detect the presence and movement of a body within a protected area. But the use of radio transmitters does bring both the equipment and the intended user within the jurisdiction of the official licensing authority (currently the Home Office, Radio Regulatory Division). The complications involved (which include obtaining design approval for the apparatus concerned) are not likely to be worthwhile for the average person who wishes to build and install his own intruder detection system without fuss or bother. Such needs however are likely to be fully met by a Doppler shift system using ultrasonic radiations. This method can be highly effective in detecting the slightest of movements within the area under surveillance and presents none of the problems of licensing which are associated with radio frequency versions.

This month's design for an Ultrasonic Doppler Shift Intruder Alarm has been fully tested and has proved highly sensitive and consistent in performance in rooms of varying size. Undoubtedly this project will be the answer in many cases where effective monitoring of an enclosed area is required. The equipment can be installed unobtrusively so that its presence (or purpose) is not suspected by unauthorised persons, thus saving it from malicious attentions of technically knowledgeable anti-social types. The importance of this aspect cannot be over-stressed. Electronic techniques can be used for defensive or offensive purposes, and the technical capabilities and resources of today's criminal classes must not be underestimated in any degree.

INCREASE IN COVER PRICE

With effect from this month, the cover price of PRACTICAL ELECTRONICS is increased by 5p to 30p. Further substantial rises in the cost of paper are chiefly responsible. We naturally regret the need for this increase but trust our readers will understand that it is unavoidable.

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ULTRASONIC INTRUDER

A SIMPLE ultrasonic intruder alarm can be made in which the alarm is triggered when the intruder breaks the ultrasonic beam. Unfortunately such a simple arrangement is not very satisfactory since it may be impossible to ensure that an intruder will always pass through the beam. In addition, this type of equipment must be set up very carefully or a sufficient part of the ultrasonic signal will reach the receiver even when the intruder is in the beam and his presence will remain undetected.

This article describes an ultrasonic intruder alarm based on the Doppler shift principle. It can detect the movement of any object within a room when the object has dimensions of not less than a few cms. For example, it has been found that if a person inside the protected area breathes in, the movement of his chest can trigger the alarm. The movement of a person's hand at a speed exceeding about one inch per second can trigger the alarm.

Whilst there is some variation in sensitivity from one point to another the equipment is usually effective throughout most of the volume of a room and there is no necessity for a burglar to be in any particular region of the room for detection to take place.

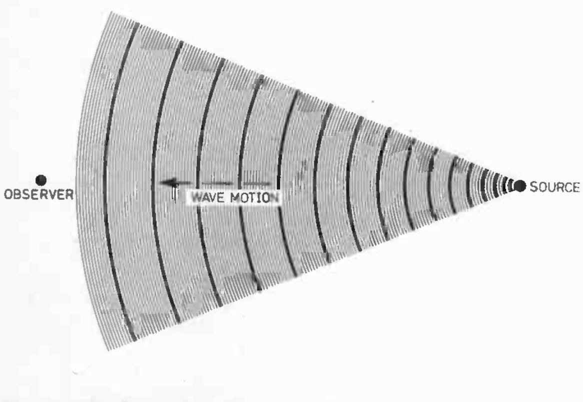


Fig. 1. Wave motion from source to observer, showing how Doppler effects can be observed

DOPPLER SHIFT

The basics of Doppler shift are familiar to everyone who has detected a fall in the frequency of the note received as a fast moving noisy object passes by him. This fall is very apparent in the case of low flying aircraft or when a car passes close to the observer with its horn sounding.

Similarly, if an observer moves towards a stationary source of sound, the frequency he observes will be higher than that emitted by the source.

THEORY

Let us imagine that the stationary source shown in Fig. 1 emits waves at a frequency of fHz. If the observer is stationary, f waves will pass him per second and he will therefore observe this frequency. If, however, the observer moves towards the source, he will meet more waves per second, since these additional waves are distributed in the space through which he is moving.

The wavelength, λ, of the waves is equal to v/f metres where v is their velocity in metres/second. If the observer moves towards the source with a velocity of b metres/second, he will meet an additional $b/\lambda = bf/v$ waves per second. Thus he meets a total of $(f + bf/v) = f(1 + b/v)$ waves per second. In other words, the movement of the observer towards the source causes the frequency he receives to be raised from f to $f(1 + b/v)$ Hz.

If the observer moves towards the source with a velocity of 1% of the velocity of sound (namely about 3 m/s), the received frequency will be raised by 1%. If the waves are reflected from the observer back towards the source, a person at the source will find that the reflected waves are raised in frequency by twice this amount (that is, by 2%). This is because the observer is reflecting the waves at the

DOPPLER SHIFT ALARM

By J. B. DANCE M.Sc.

frequency he is receiving them, but these reflected waves occupy a shorter distance in space owing to the movement of the observer towards the source.

A similar change will occur when the observer moves away from the source, but the frequency of the reflected waves will then be lower than the transmitted frequency.

ULTRASONICS

Let us consider the Doppler effect in ultrasonics when a transducer is employed which emits waves at the typical frequency of 40kHz. If a reflecting object moves at 3m/s, the reflected waves reaching the transducer will have a frequency shift of about 2% of 40kHz, namely 800Hz.

In the case of an intruder moving about in a room, the major components of the velocity of parts of his body are more likely to be in the range 20 mm/s to 1 m/s. The reflected waves therefore reach the transmitter with a frequency shift of roughly 5Hz to 300Hz.

In the present project the transmitting transducer and the receiver of the reflected waves are not in the same position. This will cause the frequency shift to be somewhat reduced (depending on the relative position of the reflecting object), but nevertheless the frequency change will be of the same order. The equipment must therefore be designed to detect shifts in the low audio and sub-audio frequency ranges.

POSSIBLE TECHNIQUES

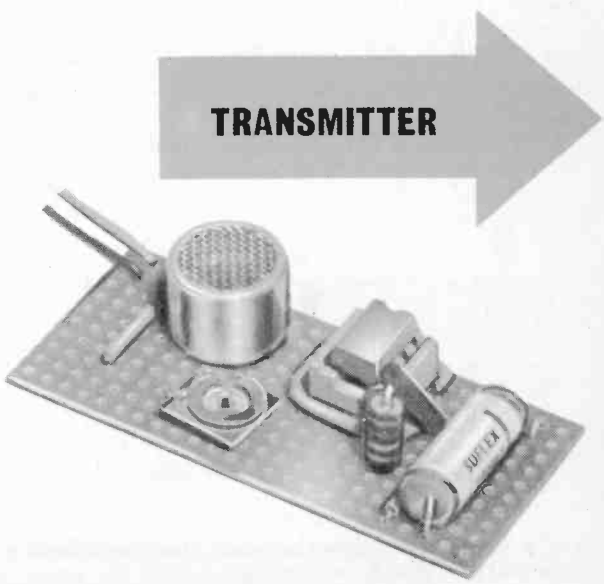
Various techniques can be employed to detect the frequency shift. All depend on the detection of the frequency difference between the emitted and received frequencies and not on measurement of the frequencies themselves.

It is possible to employ a single ultrasonic transducer to transmit ultrasonic pulses and during the intervals between the pulses, use the transducer as a receiver of the reflected signals. This would complicate the circuit so much that it would outweigh the saving in the cost of an extra transducer.

BEAT NOTE

In order to keep the project as simple as possible a system which will detect the beat note developed when the transmitted frequency and the Doppler shifted reflected frequency reach the receiver simultaneously is used.

The signal from the receiver transducer is greatly amplified at 40kHz before it is fed to a diode pump circuit. By a suitable choice of time constant, most of the 40kHz signal can be filtered out to leave the audio or sub-audio beat note. This is used to drive a level detector circuit which, in turn, operates a relay.



TRANSMITTER CIRCUIT

The circuit of the transmitter is shown in Fig. 2. A 555 integrated circuit is employed so that the circuit can be as simple as possible.

The output at pin 3 continually switches between potentials slightly above that of the negative line and slightly below that of the positive line. This square voltage waveform drives the transducer. The frequency is set by VR1.

THE TRANSDUCERS

The output of the 555 is used to operate a new type of miniature ultrasonic transducer, the 96D-40. This is available in "T" and "R" types for the transmitter and receiver respectively. Optimum results will be obtained only if the "T" type is used in the transmitter and the "R" type in the receiver, although results may be obtained if these units are interchanged.

These transducers contain small piezo-ceramic "bimorph" plates sealed in a small aluminium cylinder slightly over ½in in diameter. There are two connecting pins on the back and the one connected to the aluminium case should be earthed. The ceramic plates resonate at about 40kHz and cannot be used at frequencies which are more than about 1kHz from this frequency.

When the square wave voltage from the 555 circuit is applied to the transmitter transducer, the ceramic plate resonates and emits an ultrasonic pressure wave into the air through the metal grille at the front of the device.

TRANSMITTER

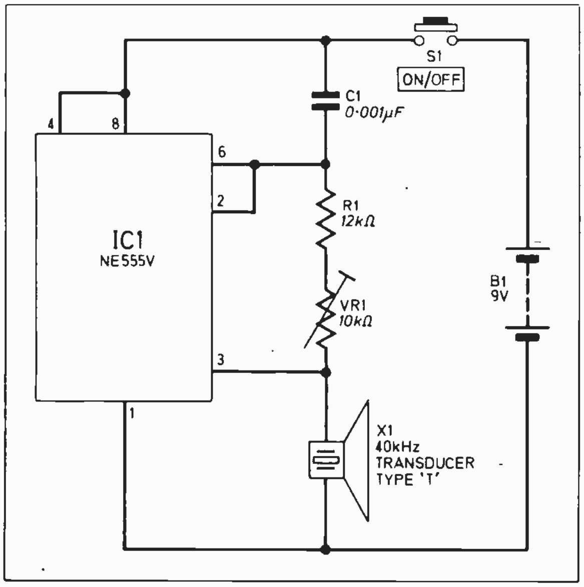


Fig. 2. The transmitter circuit

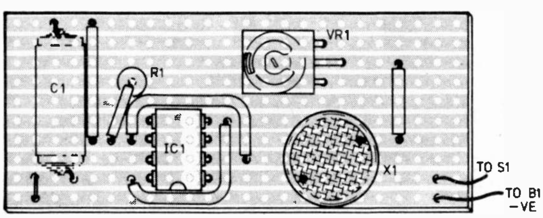


Fig. 5. Component layout and Veroboard cuts for the transmitter of Fig. 2

COMPONENTS . . .

TRANSMITTER

IC1	NE555V timer i.c.
C1	0·001μF, 15V, 10% mica or polystyrene
R1	12k Ω, 10%, 0·1W
VR1	10k Ω preset trimmer
X1	40kHz transducer type T, 96D–40 (Hall Electronjcs)
S1	SPST on/off switch
B1	9V battery or suitable p.s.u.

RECEIVER

Resistors

R1	6·8k Ω
R2	100 Ω
R3	100k Ω
R4	390k Ω
R5	10k Ω
R6	10k Ω

All 10%, 0·1W or larger.

Capacitors

C1	25μF (Fig. 3), 8μF (Fig. 4), 15V elect.
C2	8μF 15V elect.
C3	8μF 15V elect.
C4	8μF 15V elect.
C5	47pF polystyrene or mica
C6	0·01μF 63V polyester
C7	10nF (Fig. 3), 0·1μF (Fig. 4)
C8	0·1μF (Fig. 3), 1·0μF (Fig. 4)
C9	500μF (Fig. 3), 0·01μF (Fig. 4)
C10	1μF
C11	0·1μF

Semiconductors

IC1	TAA930 (Phoenix Electronics Ltd., 139 Havant Rd., Portsmouth, PO6 2AA)
IC2	LM380N audio power amplifier
TR1	C450, BC109, etc.
TR2	D40C1 Darlington device (Jermyn Industries Ltd., Vestry Estate, Sevenoaks, Kent)
D1–5	HG1011, OA95, OA81, 1N914, 1S914, etc. (5 off)

Miscellaneous

Transducers, 96 D–40 types T and R for transmitter and receiver respectively (Hall Electronics, 48 Avondale Rd., Leyton, London, E.17.). 8Ω loudspeaker. Relay RLA, 12V with 2 pair changeover contacts, e.g. GPR100 (Pye TMC Components, Roper Rd., Canterbury, Kent). 8- and 14-pin d.i.l. sockets if required. Veroboard to suit. Die-cast boxes or cases made to suit. Batteries or power supply, wire, solder, etc.

BASIC RECEIVER

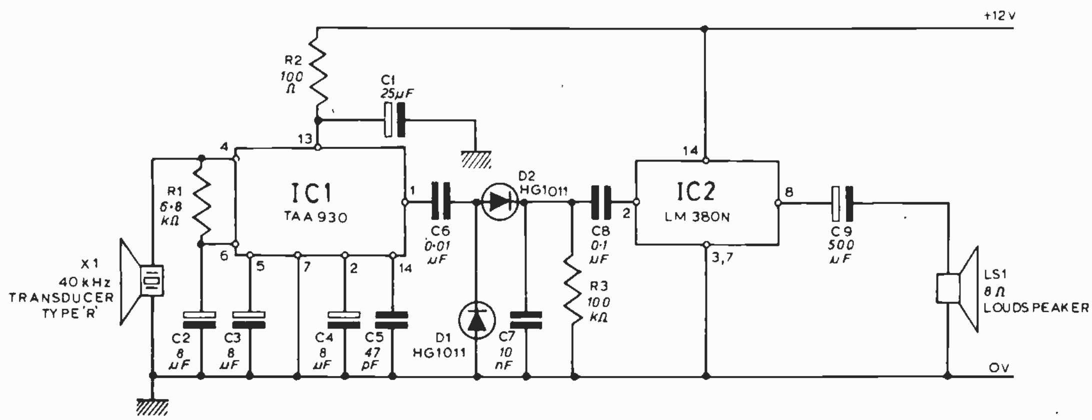


Fig. 3. Circuit diagram of the basic ultrasonic receiver

THE RECEIVER

When an ultrasonic signal strikes the transducer in the receiver a 40kHz signal appears across the transducer terminals. The amplitude of this signal may be of the order of 100μV. One can amplify this signal by using discrete transistors, but a TAA 930 integrated circuit has been used in this project since it greatly reduces the number of components required.

One of the first circuits used by the writer to detect the beat frequency is shown in Fig. 3. The 40kHz signal from the transducer is first amplified by the TAA 930.

This integrated circuit is actually intended for use in the sound section of television receivers as a 5·5MHz i.f. amplifier/limiter and demodulator. It contains four cascaded differential amplifiers coupled by emitter followers and allows a high gain to be obtained with stability.

The 40kHz output of the amplitude limiter at pin 10 is just over 1V peak-to-peak when the input to pin 4 exceeds the threshold value of about 50μV. However, the signal at pin 10 is internally connected to the section of the TAA 930 intended for use as an f.m. demodulator. It was found that a low impedance 8V peak-to-peak 40kHz signal could be obtained from pin 1 (which is the audio output when the device is used in television receivers).

In the circuit shown, the output from pin 1 is fed to a diode pump which has a load with a 1 ms time constant. The audio beat note is developed across this load and in Fig. 3 is fed to an LM380N audio power amplifier which drives a loudspeaker.

IN USE

The transmitter is placed a few feet from the receiver and VR1 of Fig. 2 is adjusted until a maximum voltage is obtained across C7 of Fig. 3. Whenever a person moves his hand or any other object fairly rapidly in the room, the beat note is heard in the loudspeaker. If the movement is very slow, the beat note frequency becomes too low to be heard, as would be expected from the theory.

RELAY DRIVE

The circuit of Fig. 4 is used with the transmitter of Fig. 2 as a true intruder alarm.

As in the circuit of Fig. 3, a low amplitude beat note is formed across C7 of Fig. 4. This is amplified by TR1. This transistor may be any low cur-

RECEIVER ALARM CIRCUIT

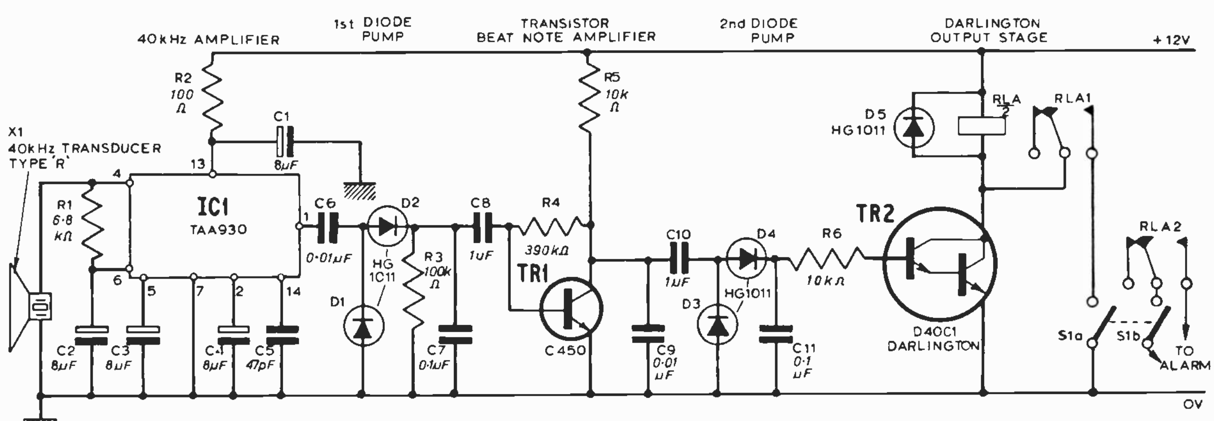


Fig. 4. An alarm receiver circuit including a latching relay at the output

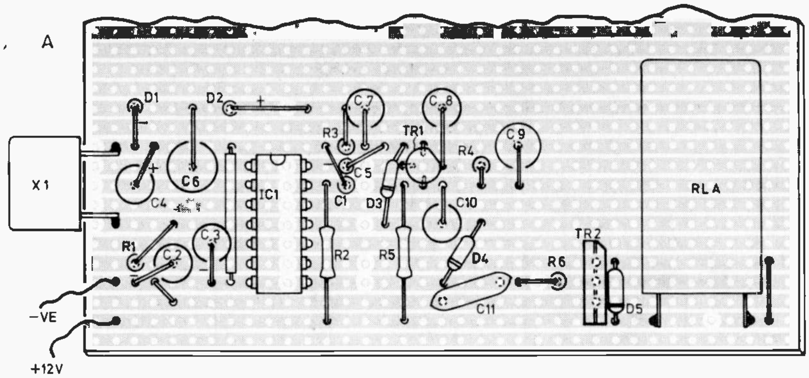


Fig. 6. Component layout and Veroboard cutting details for the receiver of Fig. 4. Note the mounting of the transducer and the extra board space which may be used for power supply or other items

rent, high gain *npn* transistor. Large coupling capacitors are used so that the circuit will be sensitive to the low (sub-audio) frequency beat notes which occur when the intruder moves slowly.

The output from TR1 is fed to a second diode pump, D3 and D4. This converts the beat note into a steady voltage. When this steady voltage across C11 exceeds about 1·1V, it drives the D40C1 Darlington device into conduction and the relay closes.

The diode D5 across the relay merely removes the transient reverse voltages which appear across the relay coil when the current falls. If D5 is omitted, these transients may damage the D40C1 device. Whilst the writer employed HG1011 diodes, any small low power germanium (or silicon) diodes should be satisfactory in this application. OA95 and OA81 are suitable.

LATCH-ON

When the switch S1 is open, the relay will open and close as the amplitude of the beat note rises and falls. The circuit should be tested with S1 open so that one can ascertain how much movement is required to close the relay without having to open S1 in order to de-energise the relay for the next test.

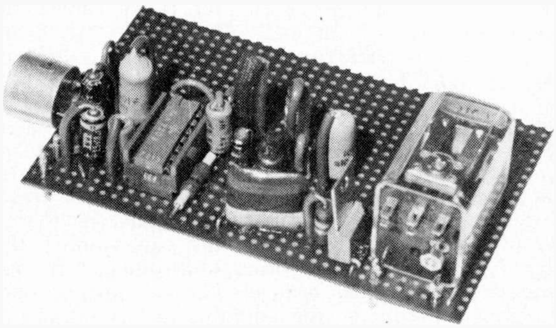
When S1 is closed, the relay will be energised by the beat note as before, but a current will now continue to flow through the relay coil and the contacts RLA1 even when the beat note has ceased. The relay will therefore remain latched on. Contacts RLA2 remain closed after the alarm has been triggered until the equipment is reset by opening the switch S1.

CONSTRUCTION

The transmitter and the final form of the receiver may be made up to suit individual requirements on Lektrokit, p.c.b. or on Veroboard. The transmitter layout is not at all critical but it would be wise with the receiver to keep the input leads as short as possible as the high amplification used can make the unit sensitive to external stimuli.

The prototypes shown in Figs. 5 and 6 are mounted on Veroboard for convenience and component layouts and board cutting details are shown in the figures.

Both models were constructed with a view to mounting in fairly confined spaces both because they are in any case not very large anyway and because this aids concealment if it is not wished to advertise the presence of security equipment. Each unit could be mounted in a false book back made from an old



book from which the "heart" had been cut. The aperture required in the book spine can be covered with fine muslin and painted or dyed to suit the rest of the book.

As can be seen, the receiver is mounted on a larger than needed piece of Veroboard so that, if required, a power supply or, for that matter, batteries, can be mounted on the same board.

If the constructor wishes to mount the units in plain boxes this is equally simple and 6 B.A. holding bolts can be used to secure the boards in place in any suitable die-cast or plastic box without trouble. Of course an aperture would have to be provided in one box wall to which the transducer is presented.

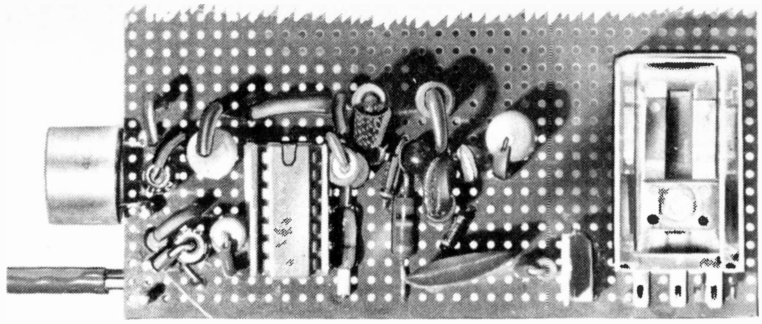
The switch S1 is not mounted on the receiver board as its operation "arms" the system when the transmitter is operating. If set-up by someone in the same room who then leaves, obviously the alarm will be actuated. Under normal circumstances one would house this set/reset switch outside the area to be protected.

ADJUSTMENTS

When each power supply is first connected the current consumption should be checked. It should be about 8mA for the transmitter and about 15mA for the receiver with the relay not operated.

The units should be placed so that the transducers are close together and facing each other. A high impedance voltmeter is placed across C7 of Fig. 4. VR1 of Fig. 2 is adjusted for a maximum reading on this meter. The units are then separated by a few feet and rotated so that the transducers no longer face one another as shown in Fig. 7. A fine adjustment is made to VR1 for maximum reading on the meter connected in the relay unit.

This frequency adjustment ensures that the 555 oscillator frequency matches the resonant frequency of the two transducers.



PRACTICAL POINTS

When the prototype units were close together with the transducers facing one another, it was found that the relay always remained closed even when no movement was occurring within the room. Presumably enough of the 40kHz signal then reaches TR1 for it to operate the second diode pump. Variations will occur with the gain of the components used in the relay unit, but the equipment should be set up so that swamping of the receiver transducer by the transmitted frequency does not occur.

Variations of the arrangement shown in Fig. 7 seem to be best. The two transducers point away from one another towards opposite walls of the room. The reflected signal from an intruder and the reflected signal from the walls of the room will then have amplitudes of the same order and optimum sensitivity will be obtained.

As shown the area immediately in front of the transducers is the most sensitive. Regions well away from the front of the transducers are less sensitive, whilst the areas behind the equipment are least sensitive of all. When testing the equipment, remember that one cannot always expect to obtain a beat note if one moves so that one keeps the same distance from the equipment. In practice this is virtually impossible in the most sensitive areas but it may be possible by moving one's hand above the transducers.

CONCLUDING COMMENTS

The circuit is sensitive to movement over almost the whole of the room containing the equipment. It is virtually impossible for an intruder to enter the room without triggering the system when the equipment is working.

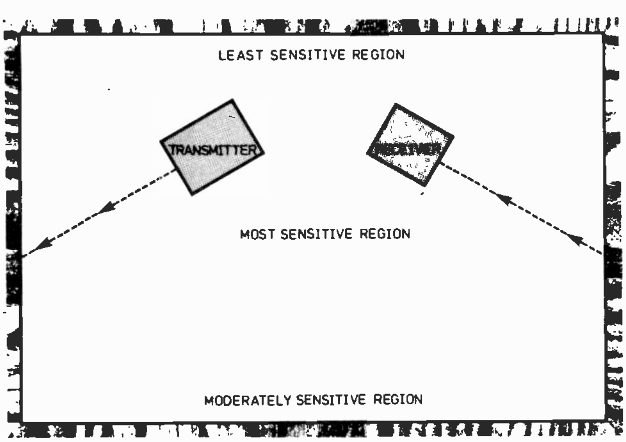


Fig. 7. Locations of the transmitter and receiver in a room for best general effect showing, in general terms, the variations in sensitivity

Obviously the equipment has room size limitations but it has been tested successfully in rooms up to 17 × 17ft. Clearly, in a large room some thought should be given to the placing of the equipment in relation to the doors and windows of the room and in relation to any valuable objects requiring special protection.

Remember to shut all windows in the protected room before the equipment is switched on. Otherwise a curtain blowing in the breeze or a bird entering the window can easily trigger the alarm and someone may be aroused from his bed in the early hours of the morning!

If one wishes to have very complete protection, one may arrange that the alarm sounds when either the normally closed contacts of RLA open or when the normally open contacts close. If the intruder cuts the wires to RLA or joins them, the alarm will then sound.

The intruder alarm can, incidentally, form a useful party game where one has to move out of the room extremely slowly without triggering the alarm. In order to give people a reasonable chance, the gain may be reduced by including a resistor in the emitter circuit of TR1.

CRITICAL SETTINGS

The basic circuit does not include the gain control mentioned above and readers may find that in use the receiver is sometimes too sensitive, reacting constantly. A simple way of avoiding this is to detune the transmitter slightly by adjusting VR1.

Further, the receiver will not operate with a reduced power supply and operation will in any case be erratic if supply variations are allowed. So good batteries or a stabilised supply are needed.

The manufacturers' tolerances for the transducers used dictate the final maximum voltages used. As this is 7V the transmitter line voltage should not exceed 9V.

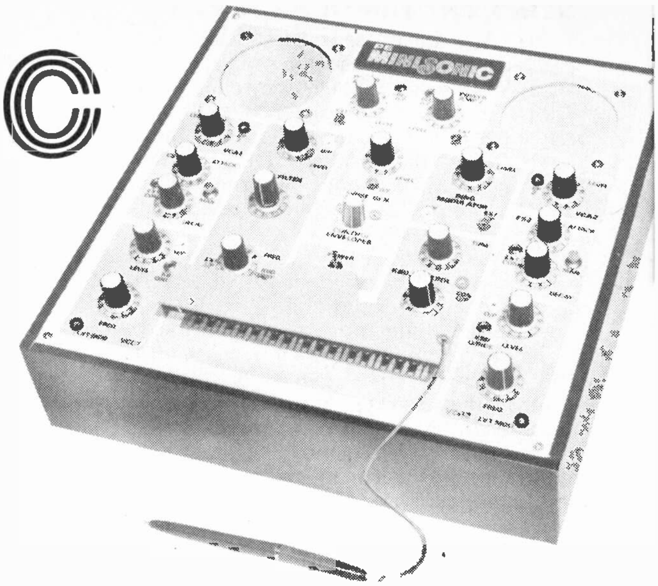
The larger board used in the prototype receiver was selected specifically to accept a small power supply suitably stabilised and set to give the required rail voltages. If the two units are positioned close together, as perhaps in a pair of book ends, then it is not difficult to envisage interconnection and of course supply of the mains voltage.

Output could be along a three-core cable carrying both the connections for S1 and the output switched with a common wire. Thus the system can be wired into an existing system as a simple switch if required. ★

PE MINISONIC

By G. D. SHAW

PART FIVE



● Making the most of the MINISONIC

IN THIS the final part of the Minisonic series we will look at some of the ways in which the units of the Minisonic can be connected to produce some interesting effects. These are only suggestions, since the ways in which the Minisonic can be used are limited only by the imagination of the user.

THE VOLTAGE CONTROLLED FILTER

There are three principal ways in which the filter may be used as a sound treatment, of which two have been examined during the check-out procedure. Before going into these in any detail however let us look for a moment at what exactly it is that the filter does to the sawtooth waveform.

Fig. 5.1 illustrates a number of waveforms with the filter control voltage at different levels. In stage one the control voltage is very low i.e. with the frequency control just off the minimum end stop. If the sawtooth signal is around 1kHz say, the effect of the filter is to remove virtually all the upper harmonics leaving the fundamental which is almost of sine form.

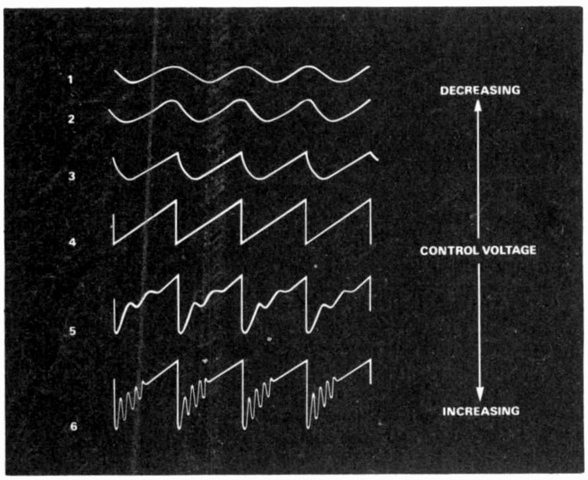


Fig. 5.1. These waveforms illustrate the effect of the VCF on a sawtooth waveform with varying control voltages. The control voltage increases from a minimum at 1 to a maximum at 6

Stage two and three illustrate the situation which occurs when the control voltage is increased successively; in each case the output waveform is assuming more of the sawtooth characteristic albeit still severely rolled off.

In stage four the control voltage is such as to allow the filter to admit the whole of the sawtooth without any roll-off.

Q CONTROL

The degree of roll-off of the filter is affected very largely by the amount of feedback admitted to the ladder network by means of the Q control. With Q at minimum the roll-off is much less accentuated and, indeed, the signal level from the filter is significantly greater than when the Q is at maximum.

Thus, with the Q at minimum the filter can act very much in the same way as a tone control i.e. passing all those frequencies lying below that set by the control voltage and rolling-off all those which lie above the set value at around 6dB per octave.

Increasing the feedback above a critical point will induce the filter to commence self oscillation. Similarly when operating at high Q the filter will also begin to oscillate when the control voltage is advanced beyond a point where the input signal is wholly accepted. This situation is illustrated in stages five and six of Fig. 5.1, the frequency of oscillation being proportional to the increase in ladder current.

What applies, in general terms, to the changes occurring in a sawtooth waveform also applies to other waveforms which are rich in harmonics. In the case of a sine wave input however the effect of the filter is simply to cause a variable degree of attenuation to the signal in a manner dependent on the input frequency, control voltage and Q control settings.

USING THE FILTER AS A VCA

Fig. 5.2 illustrates schematically the method of patching to enable the filter to act as an automatic Waa-Waa or as a voltage controlled amplifier.

In this case the negative output of the CONTROL ENVELOPE INVERTER is patched into the control input (jack socket) of the filter. The VCA level control on channels 1 and 2 should be turned to minimum level and the output of the filter patched into either one of the PA stages.

Set the INVERTER level control about midway with the attack and decay controls of ES1 set about one third of their full rotation.

Place the stylus momentarily on the keyboard and when the resultant sound has decayed away—say in four or five seconds—adjust the frequency control of the filter so that the VCO signal is just barely audible.

The keyboard may now be played in the normal way during which time the attack, decay and control envelope controls may be adjusted to achieve the desired effect. Note that the greater the level of the control envelope the harsher will be output signal when the envelope is at its peak.

An inverted Waa-Waa effect can be achieved by setting the filter frequency control to maximum and using the positive going envelope to programme the filter. In this case the output of the filter should be patched into VCA1 external input with VCO1 level control set to minimum.

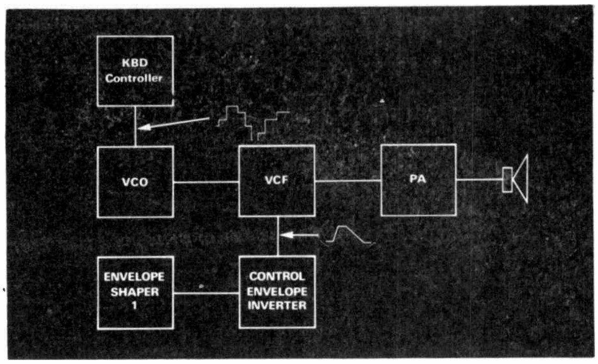


Fig. 5.2. Diagram showing the patching arrangement to use the voltage controlled filter as a Waa-Waa

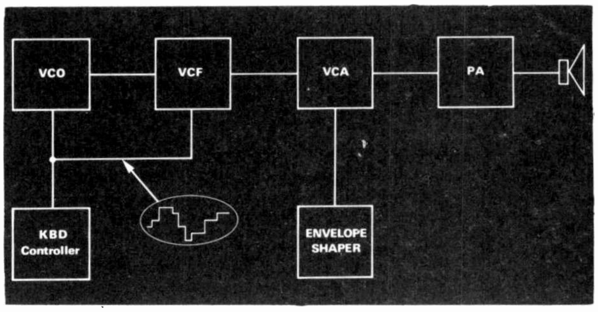


Fig. 5.3. With the patching arrangement shown here the VCF will track the frequency of the VCO's

TRACKING THE VCO's

With the arrangement of patching as shown in Fig. 5.3 the filter may be used to track the frequency of the VCO's. This is because the control input of the filter is directly linked to the output of the HOLD circuit and thus variations in this level will adjust the passband of the filter.

This method of operation is particularly useful if the instrument is being used in an imitative sense or if the constructor wishes to achieve a softer, harmonically reduced output signal. With this mode, the keyboard should be played at the same time adjusting the filter frequency and Q controls until the desired sound is achieved.

It will be found that a number of acoustic instruments can be effectively imitated using this method. For example, wind instruments such as the horn and trombone, string instruments such as the violin and cello and a clarinet tone have all been successfully synthesised with the prototype Minisonic.

THE FILTER AS A TONE CONTROL

In the previous method of operation the passband of the filter was continuously being adjusted as the keyboard was being played such that the proportion of harmonic roll-off was effectively constant regardless of the frequency of the input signal.

If an open circuit jack plug is now placed into the control input socket of the filter the passband is now entirely dependent on the setting of the frequency control. With this at maximum the filter will pass frequencies up to 15kHz (−6dB) more, in fact, than the Minisonic would normally produce in a strictly musical sense.

With the frequency control near its minimum setting the −6dB passband is only 3Hz and thus the greater part of any filtered musical signal from the VCO's would not reach the power amplifier stages. The filter is now acting as a treble cut system with the degree of cut obtainable being varied by the Q control. With this at minimum the roll-off is about 6dB per octave and at maximum about 15dB per octave.

THE RING MODULATOR

The overall function of the RING MODULATOR has been described elsewhere in this series but it might perhaps be useful to consider some of the uses to which it can be put. In a musical sense the RING MODULATOR can be used to create very rich chord structures.

For example, with both VCO's tuned apart by the interval of a fifth, i.e. the frequency of one oscillator is 1·5 times the frequency of the other, the output from the ring modulator will be, in the case of the sum frequency, 2·5 times, and in the case of the difference, 0·5 times, the frequency of the oscillator producing the lowest pitch.

If the output of this latter oscillator is taken as being the fundamental then the output of the RING MODULATOR may be said to comprise the sub-octave and twelfth with respect to the fundamental.

If this signal is now mixed with the outputs of the VCO's originating the signals then the end result is a four note, musically concordant chord.

Similar effects may be obtained when the VCO's are in unison, an octave apart or tuned to other recognisable musical intervals. In all cases the richness of the resultant sound quite belies the size and complexity of the instrument producing it.

Two methods of patching in the RING MODULATOR to give composite chords are illustrated in Fig. 5.4a and 4b.

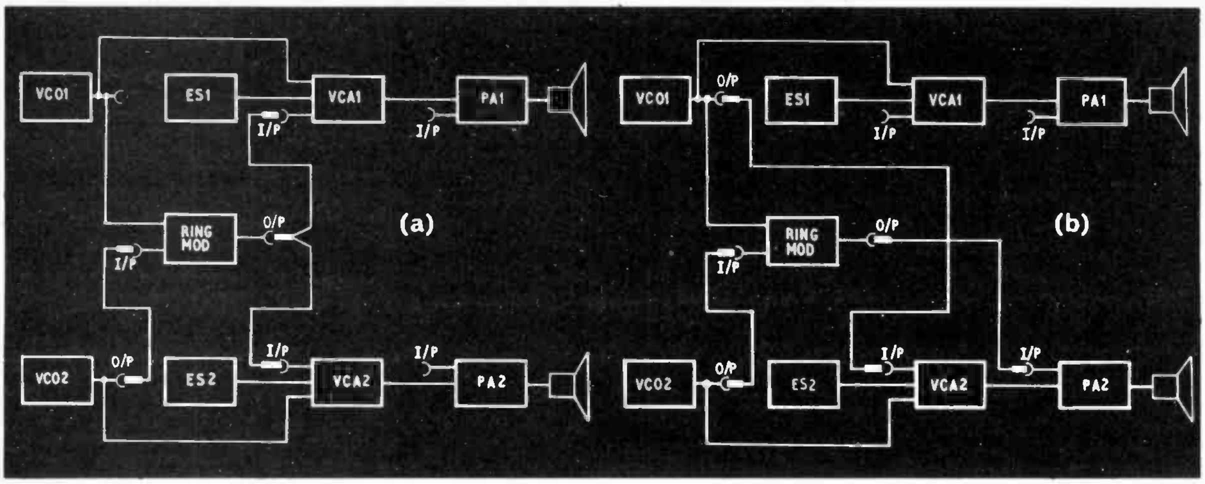


Fig. 5.4a and b. Two methods of patching to give chord effects. In (a) PA1 gives VCO1 + RING MODULATOR output and PA2 gives VCO2 + RING MODULATOR output. In (b) PA1 output is silent and PA2 gives VCO1 + VCO2 + RING MODULATOR. In this case ES1 must be disabled by placing an open circuit jack plug in its control input

OTHER RING MODULATOR EFFECTS

Apart from its musical possibilities the RING MODULATOR may be used extensively in the production of sound effects. For example with white noise patched into the uncommitted input and with VCO1 running at low frequency—say around 10Hz—the reset point of the sawtooth will be differentiated by the RING MODULATOR input decoupling capacitor such that the output of the RING MODULATOR will comprise a series of staccato cracks akin to machine gun fire. Filtering the output of the modulator can ring the changes quite widely over this one, very simple sound.

Dalek type voices can be produced by the patching arrangement shown in Fig. 5.5. The microphone should be of the ceramic cartridge variety having a fairly substantial output of 100mV or so.

Remember to connect the screen of the microphone lead to the body of the DIN socket. A range of effects may be achieved by varying the frequency of VCO1 between about 20Hz and 1kHz bearing in mind that the greater part of the resultant audio signal will be derived from this oscillator.

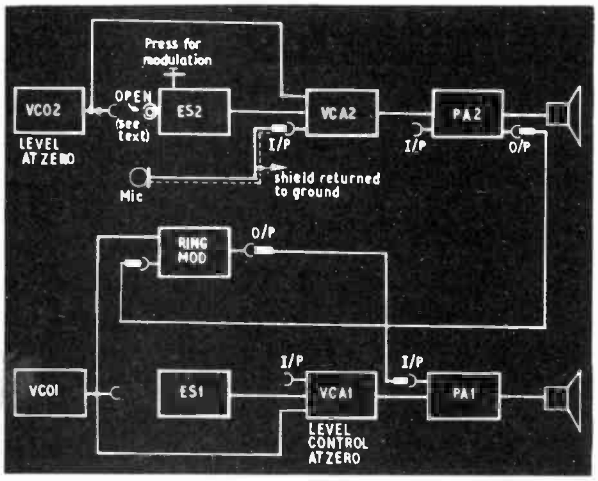


Fig. 5.5. Patching arrangement to give "Dalek" voices. Place open circuit jack plug in ES2 jack socket

If the microphone output appears to be insufficient to fully drive the RING MODULATOR a tape recorder can be employed by first of all taping the required speech and replaying through the Minisonic from the external speaker or earphone output.

NOISE GENERATOR

Other forms of sound effects may be derived from the NOISE GENERATOR in conjunction with the filter. With VCO2 level control at zero and the NOISE GENERATOR patched into the audio input of the VCF, set the Q control to maximum and manually swing the frequency control between half and full rotation. The resultant sound will be closely akin to that of howling wind.

Resetting the Q control just off its zero point and swinging the frequency control within its lower half rotation will simulate the sound of heavy, squally rain.

Another interesting experiment with the NOISE GENERATOR and filter combination is to play the passband of the filter from the keyboard. Set Q to a maximum and adjust the keyboard span control so that there is a wider than normal voltage span between consecutive notes. Patch the output of the filter into VCA1 and set VCO1 level control to zero.

While playing the keyboard adjust the filter frequency control and keyboard span control until there are distinct pitch changes in the audio signal resulting from the playing of successive keys. Pure tones cannot be achieved of course but the ability to change the noise pitch rapidly and predictably comes in very useful when creating say a brush accompaniment line to a pre-recorded melody.

SIMPLE "MULTI-TRACKING"

Those fortunate owners of reel-to-reel recorders with "sound-on-sound" facilities will need no introduction to the methods whereby so-called "multi-tracking" may be employed to produce composite recordings. It is not generally realised however that the humble cassette recorder can also be employed in this way if a second recorder is available.

Fig. 5.6 shows schematically how the "hook-up" may be accomplished bearing in mind that with the

2mm input socket on the PA stage it will be necessary to connect the screen of CR1 output lead to either the DIN socket casing on the Minisonic or to the jack plug shield of the input lead to CR2.

Let us assume that the composite recording is to comprise a simple melodic line punctuated by sound effects of various kinds. The method is as follows:

1. Set the recording level of CR2 and switch to "Record."
2. Play the melodic line as required and check the recording by replaying.
3. If satisfactory, rewind the cassette and transfer to CR1.
4. Set up the patch for the required sound effect and check it.
5. With a fresh cassette in CR2 switch to "Record". Switch CR1 to replay and, at the appropriate time, bring in the required sound effect. This is not as difficult as it might seem because, in order to get the sound effect on to the tape in CR2, the PA level control has to be set fairly high and thus the signal coming from CR1 can be quite clearly heard on the Minisonic loudspeaker. (Remember to set the replay level on CR1 to zero).
6. Repeat steps three to five as necessary until all the required effects have been recorded.

The number of transfers which can be made in the above manner with a cassette recorder is fairly limited due to the generally poor signal to noise ratio of these machines. Nevertheless, if the operation is carried out with care and with regard to recording levels and so on the results are likely to surprise even the most cynical.

ELECTRONIC REVERBERATION

Reverberation in an acoustic sense implies the presence of a series of multiple echoes each following rapidly on the heels of the other, each with a phase difference relative to the other and each, on successive returns, having a diminished intensity.

While the Minisonic does not possess any of the accoutrements normally associated with the production of artificial reverberation, it is nevertheless possible to utilise the long decay characteristic of the ENVELOPE SHAPERS together with the filter to provide a kind of reverberant quality which can be quite pleasing.

REVERBERATION PATCHING

One possible method of patching to achieve this effect is illustrated in Fig. 5.7. Two acoustic channels are used. Channel 2 carries the output from VCO2 together with that of the VCF and has a relatively short envelope decay period. Channel 1 carries the output of VCO1 and the output of the VCF and has a prolonged decay.

If the oscillators are tuned nominally in unison but with a slow beat between them the effect at the VCF is that when the outputs of both oscillators are in phase the total input signal level at the VCF is greater, and therefore more harmonically enriched than when the signals are in antiphase.

Thus when the outputs of the Minisonic are played through the domestic hi-fi system which has the loudspeakers placed reasonably far apart the effect is for the onset of the sound to be central to the listener with a sighing decay to one side or the other.

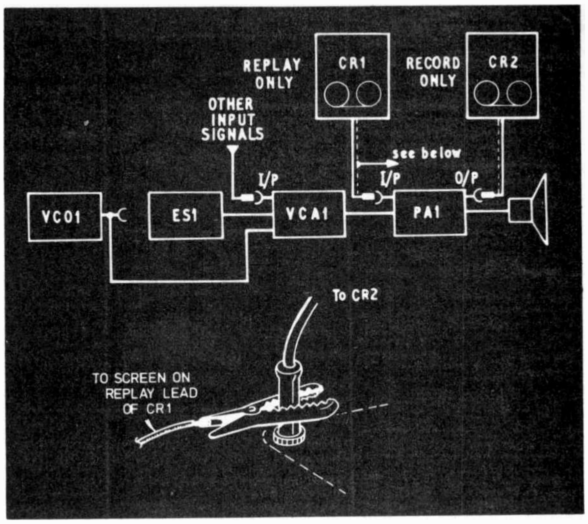


Fig. 5.6. Using two cassette recorders to obtain "multi-tracking". The inset shows how the screen of the replay load can be earthed to the lead from CR2 if metal jack plugs are used

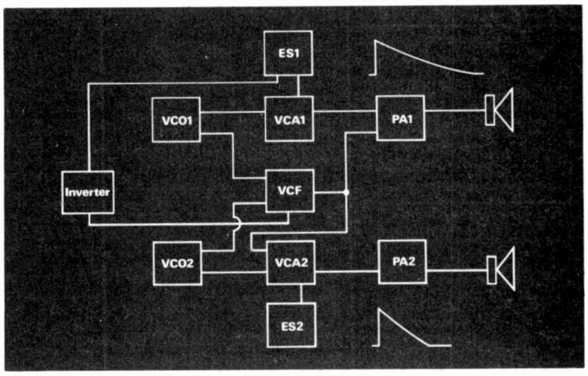


Fig. 5.7. A suggested patching arrangement to give a reverberation effect

With some adjustment to the controls the reverberant quality and spatial movement of the sound can be strikingly effective.

PLAYING THROUGH POWER AMPLIFIERS

The recorder outputs of the Minisonic can be considered to be compatible with the high level inputs to almost all makes of domestic power amplifier. In fact, the playing of the instrument through the domestic system is preferable to using the small monitoring speakers which only have a poor low frequency response. ★

ERRATA:

In Fig. 2.8 (*December 1974*), breaks shown in column 40 should be repeated in column 21

In Fig. 3.10 and 3.11 a 470μF 16V electrolytic should be connected between +9V rail and 0V. It may be conveniently placed on the Veroboard panel between the two power amplifiers

In Figs. 3.5 and 3.11 (HF DETECTOR), the cathode of D1 should go to −9V not ground

BY FRANK W. HYDE

PIONEER II

The second look at Jupiter, a close look, was achieved by *Pioneer 11* early in December. The spacecraft passed inside the proton belt where it was subjected to contact with high energy protons. *Pioneer 10* passed inside the outer shell only. Normally it was to be expected that the spacecraft might have suffered considerably in this passage but the speed of *Pioneer 11*, over 100,000 miles an hour, enabled a safe flight through the proton belt. This remarkable flight took *Pioneer 11* within 26,000 miles of the cloud tops of the planet.

Many of the results from the encounter of Jupiter by *Pioneer 10* were confirmed by *Pioneer 11*. In particular, the very energetic electron emissions into space, modulated in intensity due to the rapid rotation of Jupiter, were encountered when the spacecraft was at the 100,000 mile distance.

It was found that Jupiter is radiating both protons and electrons. This is a puzzle that the teams are attempting to solve. These are found both at the edge and inside the magnetosphere. The extent of this magnetosphere has been confirmed by *Pioneer 11* to be as much as 40 Jupiter radii in the plane of the planet's orbit and as much as 80 radii in the vertical direction. The decametric radiations suggest that the electrons with energies above 3·5MeV existed as a cause of the radiations. *Pioneer 11* has shown that the flux, deduced from the earthbound observations of radio waves, is rather less than the actual value.

These findings could have far reaching consequences because the level of flux from other sources are usually calculated from the level of radiations that are received. There are some objects, such as the Crab Nebula, that may need a rechecking. On the other hand the synchroton theory of the radiations, that is the decametre radiations, may need a reappraisal.

Since the fluxes that have been observed at Jupiter are some ten times greater than those calculated from the groundbased observations, there arises very important questions in astrophysics.

JUPITER FINDINGS

The results from *Pioneer 11* are already giving still another possible model of Jupiter. It would appear to be a planet with an extended large magnetosphere which is greatly disturbed by the solar wind and stirred up by the passage of the satellites Amalthea, Io, Ganymede, Callisto and Europa. There appear also to be some special effects of the magnetic fields. For example the electron densities appear not at the equator of the magnetic field but to the north and to the south.

The convective model suggested by the *Pioneer 10* results is confirmed. Also confirmed is the drop in cloud level towards the poles. The fluid nature and hydrostatic equilibrium of the planet seems to be established beyond doubt.

RED SPOT

The red spot observed by *Pioneer 10* has changed somewhat now. A large white spot has appeared and caught up with the red spot. The tail of the spot seems to be extending. The small red spots that were previously observed have disappeared. The great red spot projects above the surface of the general cloud level by about 5 miles.

The bands at the various latitudes north and south of the planet's equator are in fact the clouds of gas rising from the interior. Because the rotation of Jupiter has a surface velocity of the order of 22,000 miles an hour the clouds are stretched out round the planet to form the bands. This is strikingly different from the clouds on Earth which are formed in circular cyclonic or hurricane patterns.

Other points from the preliminary data refer to the density of the four Galilean satellites. Io is shown to have a density of 3·5 grammes/cubic centimetres, Europa 3·4, Ganymede 1·8 and Callisto 1·5. The meteoroid particles which were detected around Jupiter by *Pioneer 10* have been confirmed by *Pioneer 11* as being infalling to the planet. The experiments to detect such particles have been continued by *Pioneer 11* after leaving the Jovian orbit and suggest that these meteoroids originate from comets.

SATURN FLYPAST

Pioneer 11 has left Jupiter and is on its way to Saturn. Certain resetting of the track of the spacecraft has been made and it seems that the path will take it through the rings as was hoped. The actual passage should be from above the rings between the gap bounded by the inner rings and the crepe ring.

At the point of "fly through" the spacecraft will be in the shadow of the planet. However, the angle of approach and the angle of departure will be such that the mystery of the rings will be finally settled. The spacecraft will, it is hoped, have a favourable position to take pictures of Titan.

So far calculations point to the date of the encounter of the spacecraft and the planet as being about September 3, 1979.

Pioneer 11 will leave for its journey out of the Solar system in the opposite direction to *Pioneer 10*. Also *Pioneer 11* will be the first of the spacecraft to chart the region above the plane of the ecliptic.

RADIO WAVES FROM EARTH

Since 1970 it has been known that the Earth radiates in a manner similar to the Sun and Jupiter. It was first observed when *OS1* carried very low frequency detectors in orbit. This work has been continued on later satellites, one in 1971 and another in 1973. A team from Iowa University have now made a special study of this part of the radio spectrum.

The radiation is very intense and lies between the frequencies of 50 and 500kHz. It would seem that the level of intensity lies around 10^9W, as compared with 2×10^7W of the radiations from Jupiter. The Earth radiation occurs at an altitude of under three earth radii. This is the region of high auroral activity.

The team from Iowa have compared the radio storms with auroral photographs from the US Airforce satellite and there seems to be a significant correllation between the pictures and the time of the radio emissions. Usually the radio bursts last for about half an hour to several hours.

The amount of energy which is dissipated during the auroral activity is about 10^{11}W. This suggests that there is 1 per cent dissipated as radio noise. Donald Gurnett, the leader of the Iowa team, thinks that the radiation may originate from a cyclotron process.

INGENUITY UNLIMITED

A selection of readers' suggested circuits. It should be emphasised that these designs have not been proven by us. They will at any rate stimulate further thought. Any idea published will be awarded payment according to its merits. Why not submit YOUR IDEA?

SIMPLE TOUCH SWITCH

THE circuit shown in Fig. 1 was developed as a simple switch for a hand torch. In basic form it will switch itself off after a given delay dependent on the value of C1.

The three transistors form one effective very high gain device and each conducts in turn when a resistance, in this case a finger-tip, is placed between the "on" touch plates. The bulb lights up when the "on" plate is touched and then slowly goes out at a rate set by C1 once the finger is removed.

An off touch plate could be added as shown dotted so that immediate switching can be effected.

The battery voltage and final transistor selection depends on the bulb used and this in turn depends on the application but in the prototype a BFY51/52 was used. Provided low leakage silicon devices are used no switch is required as the standing current should drop to below 0·5μA.

The switch S1 is used to keep the torch alight without holding it if this feature is required.

Of course there are other applications for this simple circuit including room lighting and indeed the lamp could be replaced by a triac or relay and be used to give locked switching if required.

P. Sanhen
Sutton, Surrey.

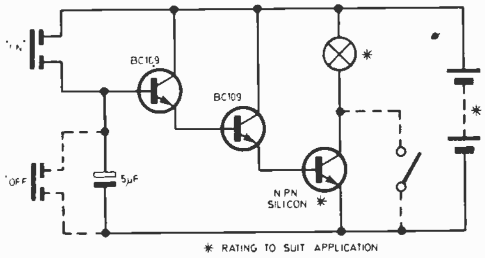


Fig. 1.

TWO-WAY MORSE TRAINER

THIS simple circuit (Fig. 1) using one i.c., consists of a relaxation oscillator formed by gates G1 and G2 of a 7400 with timing components C1, C2, R1 and R2. The outputs are gated through gates G3 and G4 to the loudspeakers LS1 and LS2 when associated morse keys MK1 and MK2 are operated.

Whilst the frequency may be varied by choice of the capacitors and resistors mentioned, it is probably advisable to stick to the values given since there can be problems with the circuit not starting.

A number of loudspeakers were tried, as well as headphones and all worked well. Although the recommended logic supply voltage is 5V, a 6V lantern battery has been used over a long period with no trouble. Drain in use is about 20mA so battery life is good.

The resistors R5 and R6 are included as current limiters and the loudspeakers may be replaced by l.e.d.s if visual display is required as for example with deaf operators.

A. Ward,
Jersey.

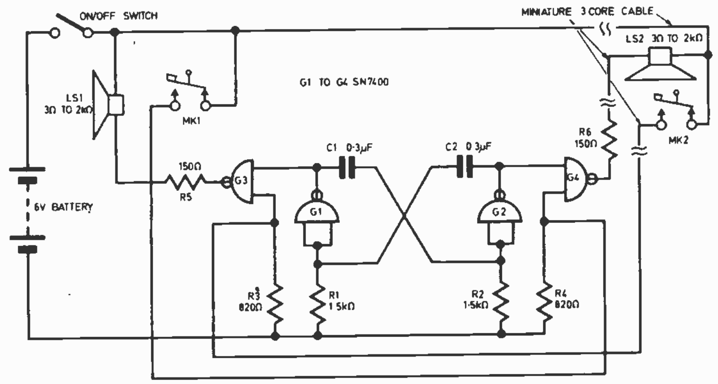


Fig. 1.

TRANSISTOR TESTER

With a view to holding costs at a reasonable level and using ex-equipment devices where possible the circuit of Fig. 1 was developed to test transistors.

Used as a plug-in extension to an existing multimeter, the tester will measure I_{coe} from 0 to 30µA and 0 to 300µA and β from 0 to 120 and 0 to 300 at 5mA. The values of the components given are for a multimeter with a 30µA, 1kΩ movement, but calculations for other instruments are quite straightforward.

Heart of the unit is the constant current source, R3, R4, R5, D1, D2, which feeds a known I_b to the transistor under test. The choice of voltage for D1 and D2 is fairly restricted as it has to be high enough to overcome V_{be} variations but sufficiently low to allow a reasonable use of the battery supply. In the event, 6V seems a good compromise.

Neglecting a small I_{coe}, β is given by I_c/I_b which gives

$$R_{base} = \frac{V_{effective}}{I_b} \text{ or } \frac{V_{eff} \times \beta}{I_c}$$

The voltage across the base resistance R_b is only the effective voltage V_{eff} of one diode as the forward voltage of the other is approximately equal to V_{be}. R3 is chosen such that it allows I_b to flow even at a low battery voltage but does not consume excessive power.

As constant alteration of meter setting is not attractive in such an application the flexibility is accommodated in the circuit of Fig. 1 and the meter is used on its most sensitive range. R9 protects overcurrent from flowing in the event of a shorted device. R10 shunts the still protected meter up to 300µA.

For leakage measurements S3 is open circuit and even though the base is connected to ground via D1 and D2 it is effectively open circuit.

R9 must be shorted for β measurements and R8 is used to shunt the meter to 5mA. In this position R6 gives some protection, limiting the current to about 15mA on short circuit. For a diode test R7 limits the current to 3mA.

For reliable operation the battery voltage should be greater than 7V and the battery should be capable of supplying 6mA.

For a transistor holder I used half an 8-pin d.i.l. socket soldered on a piece of Veroboard which in turn was Araldited to the top of a box containing the circuitry and switches.

S4 is connected so that with S4a open and S4b closed both h_{fe} and leakage measurements are at their least sensitive. The meter is less likely to be overloaded if S4 is kept in this state and switched if needed.

S2 gives *npn* in position a, *pnp* in position b and battery test in position c. For diode testing the device to be tested is inserted in the anode and cathode sockets. If it conducts on *npn* then the anode and cathode terminals indicate actual terminations, if the reverse then the opposite connections apply.

The unit is not intended to be accurate beyond about 10 per cent but devices can be matched to about 2 per cent.

N. E. Thomas,
Oxford.

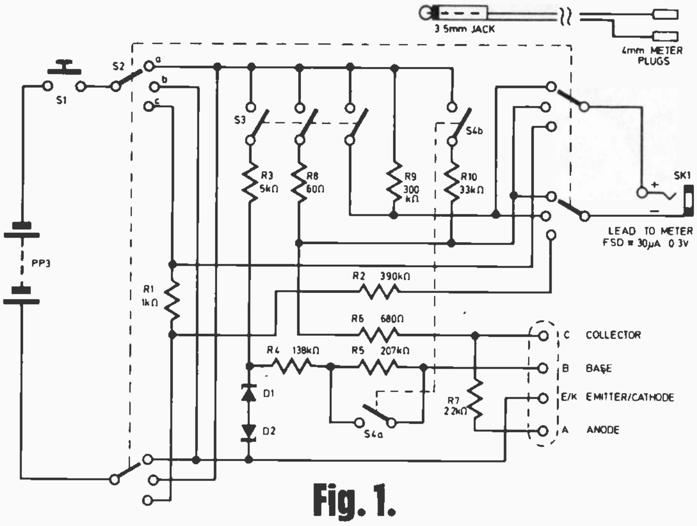


Fig. 1.

LIGHTING CONTROL MODIFICATIONS

Some readers may find that the circuit used in the "Lighting Control Unit" (July 1973 issue) is not entirely suited to some salvaged components. In particular the transistor TR1.

If a silicon device is used in this position there is a danger of base-emitter breakdown due to reverse bias and this indeed occurred with two BC169C's used in the writer's circuit.

The insertion of protection diodes in the base leads has served to cure the problem quite easily and readily available OA81 devices were used. Equally, OA71 could be used.

A further modification to this useful circuit, shown in Fig. 1, is to include two controls for the original VR1 so as to obtain greater control over some of the effects.

J. Adams,
Oxford.

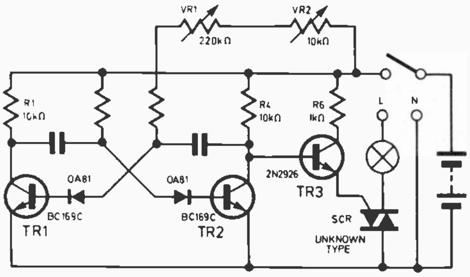


Fig. 1.

POINTS ARISING

P.E. ORION *(January and February 1975)*
In the components list the case was quoted as being GB3, this should be GB1.
The mains transformer SL8 can be obtained direct from Gardners Transformers Ltd. see Market Place page 234.

P.E. MINISONIC—3 *(January 1975)*
In the components list, for the H.F. Detector transistor, TR1 was not listed. This should be type BC184.

DIGITAL LEAF *(January 1975)*
See Market Place page 234.

MARINE SPEEDOMETER *(February 1975)*
Due to poor reproduction of Fig. 3 it is impossible to identify the breaks in the copper strips of the Veroboard. Assuming the board is annotated from the top left corner, strips *A* to *NN* and holes *1* to *46*, the breaks should be made at the following points: *26G, 9J, 12T, X38, CC10, DD10, EE10, FF10, HH19, II19, LL38.*

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AF279	74p
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ASY27	72p
BA138	35p
BB103	27p
BB104	50p
BB105	37p
BC107	16p
BC107/BC177	46p
BC108	14p
BC108/BC178	49p
BC109	16p
BC109 BC179	44p
BC109C	18p
BC140	52p
BC147	16p
BC148	16p
BC149	16p
BC157	17p
BC158	15p
BC159	17p
BC147 157	33p
BC148 158	31p
BC149 159	33p
BC167	15p
BC168	14p
BC169	14p
BC169C	15p
BC177	30p
BC178	35p
BC179	28p
BC182	15p
BC182L	15p
BC183	14p
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1N5400	16p
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1S44	4p
1S920	10p
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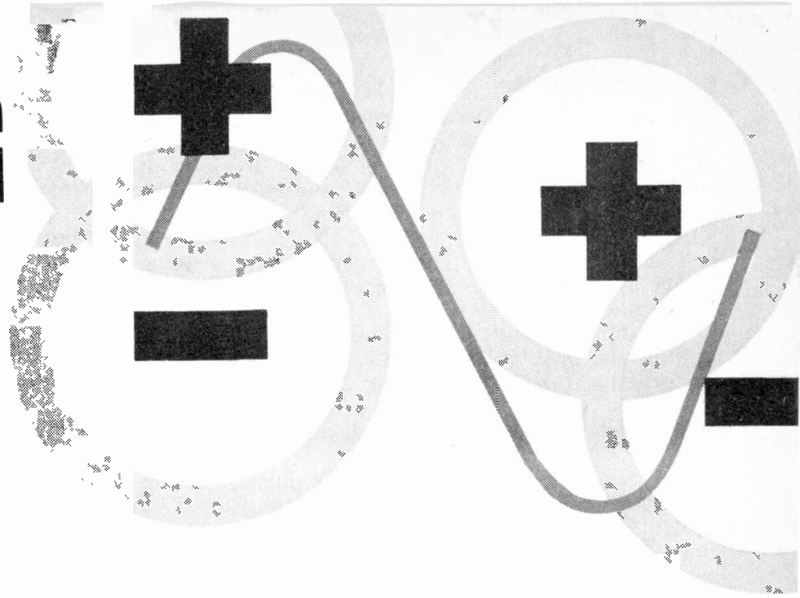
SWITCHING POWER SUPPLIES



In the majority of power supplies, the mains transformer and the smoothing and reservoir capacitors account for most of the bulk and weight. This situation, although unavoidable in the past, is unfortunate because the mains transformer, which contributes a major part of the weight, plays no vital part in the functioning of the power supply, its only real purpose being to isolate the mains from the output of the power supply. In practice the main transformer is also used to step down the input voltage to a convenient level, but this could easily be achieved by other means.

The basic concepts behind transformerless, or switching, power supply units have been known for some considerable time. Unfortunately, until two or three years ago, components capable of putting the ideas into practice were not available.

Switching regulators dispense with bulky 50Hz transformers and smoothing components, yet achieve isolation between the mains and power supply output. The reduction in size and weight achieved is in the order of 8:1 but as with everything else, one does not get something for nothing. However, in the vast majority of cases, the trade-off is extremely worthwhile. In some cases the performances may not be as high as with linear techniques. This point will be dealt with in more detail later in the article.

OPERATING PRINCIPLES

Transformerless or switching power supplies achieve isolation between mains and output by employing a high-frequency transformer as against the conventional 50Hz transformer and herein lies the secret of the small size of switching power supplies. It is a fundamental fact that the higher the frequency employed the smaller a transformer can become to handle a given amount of power.

The basic principles of switching regulator operation are illustrated in Fig. 1. The mains input is converted to d.c. by a bridge rectifier and smoothing circuit after high frequency filtering. This d.c. is applied to a pair of switching transistors which are driven at tens of kHz by the control circuitry. The square wave output of the switching transistors is applied to a small h.f. transformer, the output of which is rectified and smoothed to provide the output of the power supply. This voltage is compared with a reference voltage and, if a difference exists, an error signal is generated and fed to the control circuitry. The control circuitry adjusts the mark-space ratio of the signal applied to the switching transistors in such a way as to reduce the error signal to zero. Another method relies on a frequency variation. This ensures that the output of the power supply remains constant.

It will be noted that two small high-frequency transformers are employed, one in the main current path and one in the feedback loop, to ensure that the output is isolated from the mains.

The two high-frequency filters stop spurious voltages at the switching frequency and its harmonics from being fed back into the mains wiring and into equipment powered by the power supply.

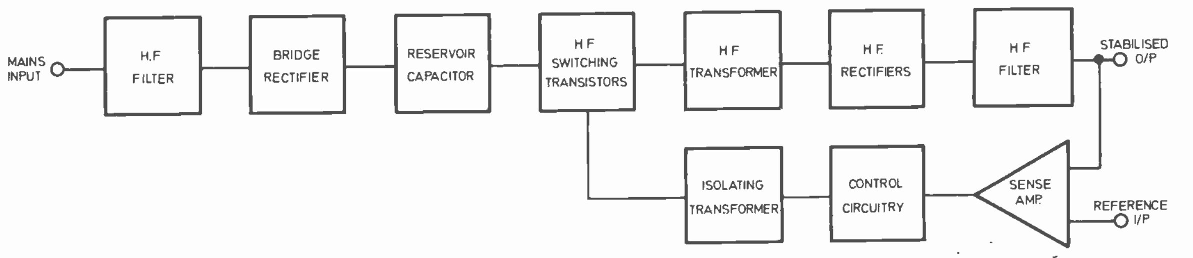


Fig. 1. Block diagram of switching regulator

FIRST SYSTEM

Several circuits have been developed which give a variety of different advantages. The first (see Fig. 2) used a conventional inverter circuit working at 20kHz. This was driven from a multivibrator, the main transistors TR1 and TR2 being alternately on and off.

The output from the transformer is a square wave, which is rectified by fast recovery rectifiers and then smoothed.

The input voltage to the inverter is 150V, thus limiting the peak voltage on the transistors to 300V. To generate this 150V rail, the 240V mains supply is rectified and smoothed to give 340V, which is fed to a switching regulator that reduces the voltage to 150V.

This regulator is a constant frequency circuit with the "on" time of the switching transistor TR3 controlled to keep the rectified output constant via the 150V rail. The two circuits are driven from the same oscillator so that they do not beat together.

Such a unit has four active loss stages and three passive. To remove one of these active loss stages the switching regulator and the inverter must be combined. The normal inverter has alternate stages fully on or fully off, and at all times one stage is on.

The output is set by the turns ratio of the transformers which is fixed, and the input voltage. In the next inverter (Fig. 3) a variable off time is injected between each on period by controlling the ratio of the on and off pulses, thus controlling the output.

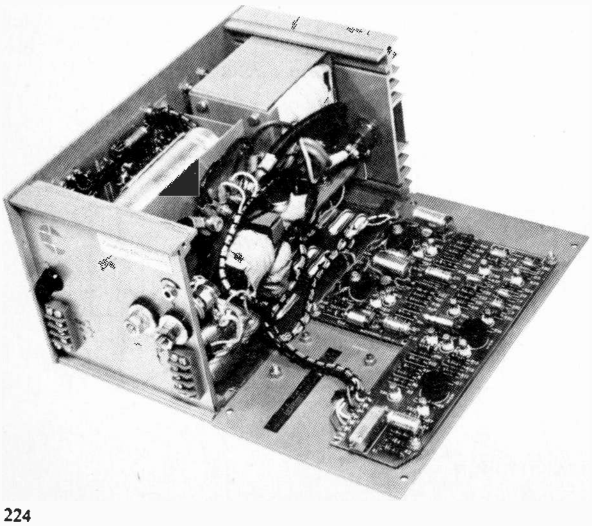
The secondary output is a series of pulses of variable mark-space, so that it is now only necessary to filter those pulses to get a mean output, which can then be varied.

CIRCUIT VARIATIONS

Two variations of the circuit are possible depending on the manner in which the mark-space ratio is varied. We can have either a constant on pulse with a variable off time, or a fixed frequency with variable on and off times.

Fixed pulse width gives a system that is free of restraints and is thus more able to overcome sudden overloads interference or mains loss. Since the pulse width determines the ripple voltage for a given choke and output capacitance value, the ripple will remain constant against line and load variations.

Transformerless 4½ to 6V, 50A power supply



Also the circuit can give very large swings of output voltage and input voltage without unlocking. The main disadvantages are that since it operates near the audio range it can, under light load conditions, break into the audio range. Furthermore, as the ripple frequency is variable, it is more difficult to filter out.

The other system (constant frequency) offers an almost exact complement to the fixed pulse width. It is completely quiet under normal working conditions, and filters used external to the equipment can be tuned to give maximum attenuation at this frequency.

It cannot be used over such a wide range of input and output variations, however, and is more prone to jump into an uncontrolled frequency mode of operation.

Both systems are currently in use, depending upon the application.

COMPONENT CONSIDERATIONS

In these two circuits, the components under most danger are the inverting transistors. By using the series type of inverter to limit the peak transistor volts, we have both transistors in series across the line. Control circuits must ensure that both transistors are not turned on at the same time, or a short circuit would be placed across the line, thus destroying one or both of the transistors.

Also, the pulse widths supplied to both transistors on alternate cycles must be identical, or the energy drawn from the series capacitors will be unbalanced. If this happens, the centre voltage will move towards the greater pulse width and the transformer will tend towards saturation.

The output voltage of one side will then fall, and if it falls too low it will not bring its rectifier into conduction. Such a condition is much easier to control in the constant pulse width system.

CONTROL

All control in these systems is by non-dissipating elements apart from saturated switches. Thus the highest dissipation is in the high current output rectifiers. Fast recovery rectifiers have been used for some years with proven reliability, but their saturation voltage is of the order 1 to 1·2V at the currents being used.

Schottky diodes offer an answer to the high dissipation problem in that they have a forward voltage drop of only 0·4V at very high currents and thus considerably reduce dissipation. At present, they only offer an increase in efficiency and not a reduction in size of the heat sink required. This is because their maximum junction temperature is 100°C, so they have to be kept extremely cool.

Transformerless supplies, examples of which are shown in the accompanying photographs, offer three major advantages that are very difficult to provide with linear units. They can operate from mains voltages of from 200 to 264V without tap changes; they can maintain their output voltage at full load with a mains interruption of 30ms, and they can be used over a 0V to 6V range at full current with no tap changes.

In fact they run cooler with lower output voltages, and a 250A 2V unit could easily be produced if it were required. They are thus ideal for use as constant-current units or as bench variables.

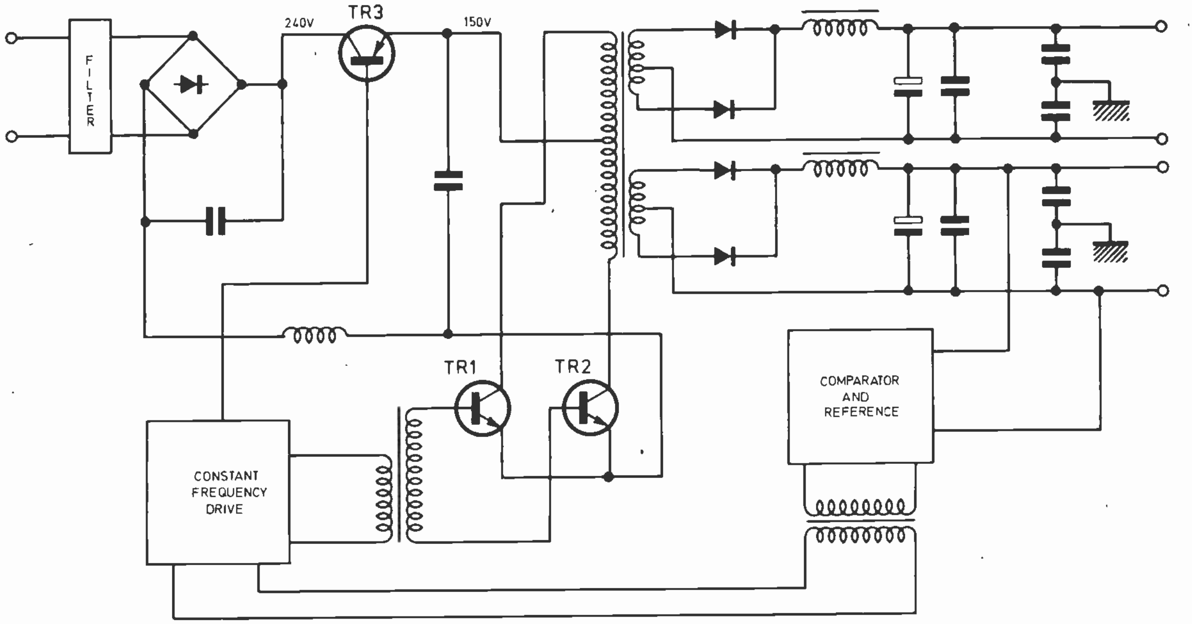


Fig. 2. Conventional inverter circuit diagram

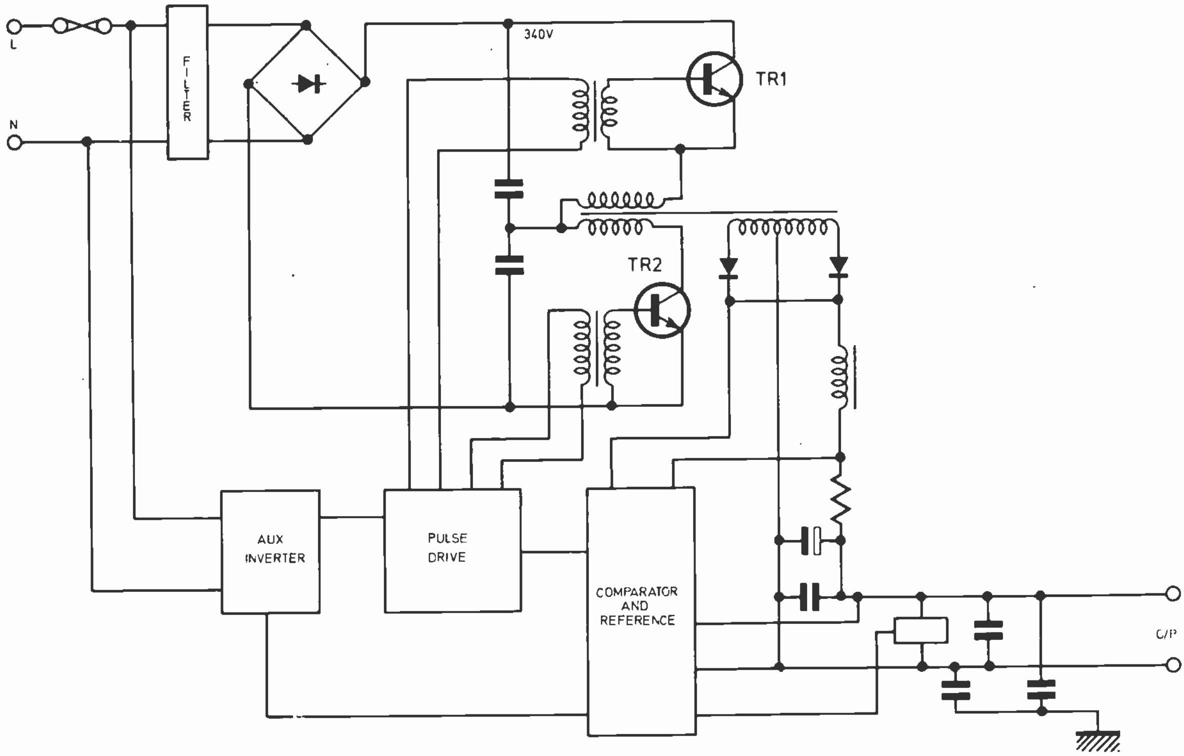


Fig. 3. Variable output inverters

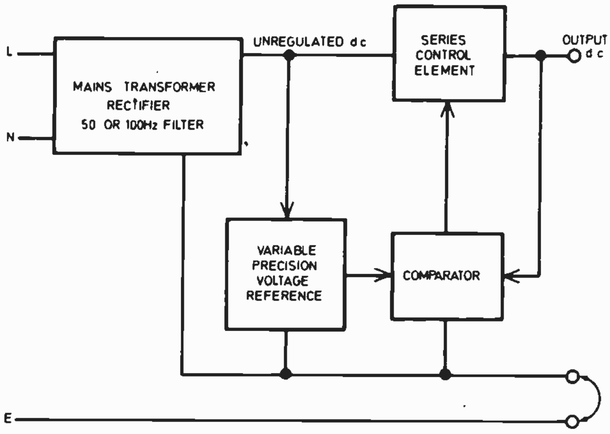


Fig. 4. Linear regulator block diagram

The output specification of these units is satisfactory for TTL circuits, and their use in lightweight desktop equipment is advantageous because of their size and weight.

If any communications equipment is used with these power units, additional screening will probably be required; but even with a large amount of screening their size will prove most attractive.

LIMITATIONS

For highly critical applications, the switching regulator would not normally be used because, inevitably, a small amount of ripple at the switching frequency appears on the output and the transient response is not up to the best that can be achieved by good linear regulators.

However, for many purposes these factors are of no consequence and then the switching regulator really comes into its own. From the equipment manufacturer's point of view, the space and weight savings enable more compact equipment to be produced at a lower cost.

ONE STEP FURTHER

Having looked at the relative advantages and disadvantages of the switching regulator when compared with the linear regulator, it is now necessary to look at one of the disadvantages of the conventional linear regulator. A block diagram of a typical linear regulator appears in Fig. 4.

The output voltage is compared with a precision voltage reference. If the two differ the comparator either increases or decreases the impedance of the series control transistor to correct the output voltage. To allow the series control element to do its job, the unregulated d.c. from the transformer and rectifier assembly must always be of a higher voltage than the output voltage.

If the power supply had an output which could be varied from 0 to 50V at 10A then the unregulated d.c. supply must be around 55V. At 1V, 10A output, 54V would be dropped across the series control element and 540W would be dissipated in it. This problem is usually overcome by having a range switch which varies the output of the unregulated section so as to limit the power dissipation in the series control element to a reasonable value.

However, large efficient heat sinks are needed for the series control transistor which add to the bulk of the power supply. Due care must be taken with cooling air-flow through the power supply, further adding to the size and weight problems.

A new approach has been recently announced which was developed by APT Electronics Ltd. This involves combining switching and linear regulators in an attempt to achieve the best of both worlds.

COMBINED TECHNIQUES

A number of the disadvantages of both switching and linear regulators can be overcome or minimised by a new technique which combines both linear and

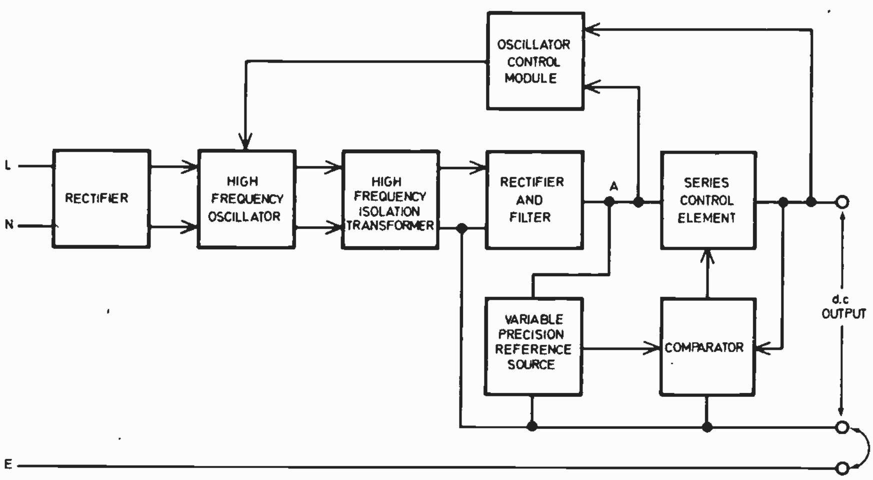


Fig. 5. Power unit incorporating both linear and switching principles

switching regulators in a single unit. A block diagram of a laboratory bench power supply, currently being manufactured by APT, is shown in Fig 5.

Operation of the system is best described by imagining that the unit is switched on and is supplying an output, say 40V, to a load. Point A on the circuit must be at a potential of more than 40V for the series control element to function. For reasons which will become clear later we will state that point A is at 45V.

If the voltage reference source output is deliberately lowered to 30V the comparator will provide an output which will increase the impedance of the series control transistor so as to reduce the output of the power supply to 30V. As this is taking place the voltage drop across the series control element would tend to rise. The oscillator control module senses this increase and lowers the duty cycle of the oscillator so the input voltage to the series element falls. Circuit values are such that the voltage across the series element is maintained at 5V.

With 30V now at the output, therefore, point A will be at 35V. The technique ensures that even for a 0 to 50V 10A power supply, power dissipation in the series control element is limited to 50W even at the normal worst case condition of 1V output at 10A.

The main advantages of the technique are therefore the elimination of the 500W mains transformer and bulky 100Hz smoothing components, and a considerable reduction in internal power dissipation allowing smaller heat sinks to be used.

Such a power supply does not perform as well as a good quality series linear regulator but is much better than a straight switching regulator. For a 50V, 10A power supply the relative advantages of the linear series, switching and combined switching series regulators are summarised in Table 1.

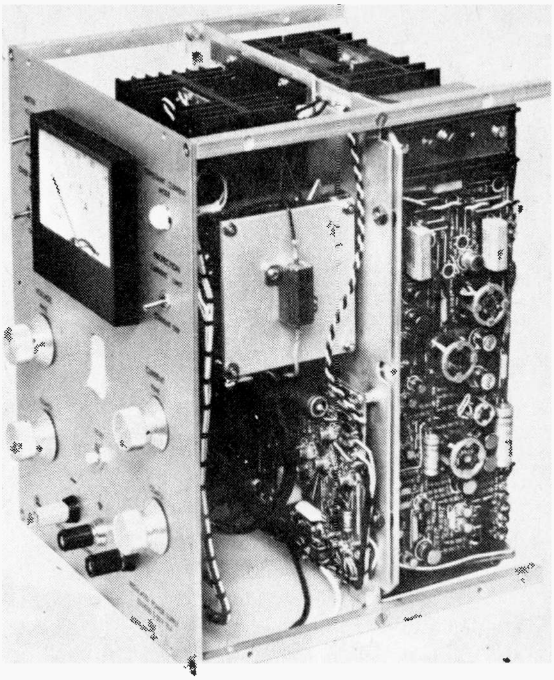
Table 1.

Parameter	Linear	Switching	Linear/ Switching
Regulation	Excellent	Good	Good
Transient response	Excellent	Poor	Fair
Ripple and noise	Excellent	Poor	Good
Ease of output voltage adjustment	Fairly easy	Fairly difficult	Easy
Size	Very large	Very small	Small
Weight	Very heavy (90lb)	Very light (10lb)	Very light (16lb)

A photograph of the combined switching and linear regulator is shown.

THE FUTURE

Power supply performance will continue to improve and will be assisted by monolithic integrated circuit and thick film hybrid microcircuit developments.



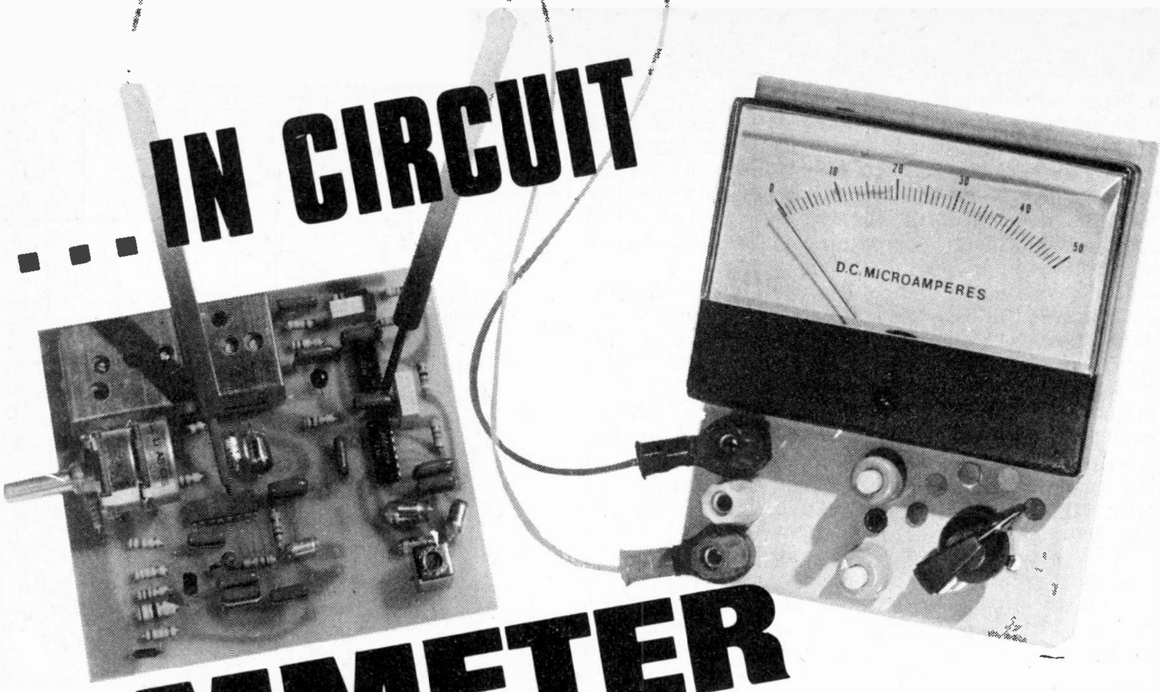
The SSU 10-50, 0 to 50V, 500W laboratory power supply from APT Electronics

Thick film microcircuits consists of a substrate (or base material) on which the circuit to be manufactured is printed. Conductors are printed with palladium, or similar ink and resistors will be formed by printing with one of the many inks available for this purpose. The printed substrate is "baked" in a furnace and then active components such as transistors and integrated circuits are added.

Hybrid microcircuits are very reliable, much more reliable than the printed circuit board with separate components, and can be designed to have a uniformity of performance very difficult to achieve by other means.

This last point is very important in power supply manufacture and indeed complete regulator control circuits using monolithic chips and discrete components are manufactured in hybrid microcircuit form at Coutant's Ilfracombe factory.

Any improvement in the monolithic results in an improvement in the hybrid. The two techniques are therefore complementary. ★



...IN CIRCUIT OHMMETER

By O.N. BISHOP

THIS instrument can be used for measuring the resistance of a component without the need to disconnect it from its circuit. This facility can save a lot of time in circuit checking, particularly when working with miniature components on circuit boards. It may also be used in the normal manner for checking unconnected components.

Like a conventional ohmmeter, it can be used for discovering short-circuits and checking continuity—again without removing components from the board.

Utilising a 50μA meter, it covers five ranges with full scale deflections of 500Ω, 5kΩ, 50kΩ, 500kΩ and 5MΩ respectively. Scaling is linear with an accuracy of ± 1 per cent. This means that the meter face does not have to be calibrated.

Other applications include go/no-go checks for semiconductors and capacitors.

HOW IT WORKS

The action of this ohmmeter depends on a special property of the operational amplifier, when connected as shown in Fig. 1. Here, the potential at the inverting input is automatically held at zero, with respect to negative potential. We sometimes say that the inverting input is a "virtual ground".

The non-inverting input (+) is at negative potential simply because it is wired to the negative rail. But the inverting input has a current (I_r) flowing to it. To keep the potential at zero, the amplifier detects this current and almost instantaneously adjusts its own output voltage (E_o) to cause a current (I_x) to flow in its feedback loop. This current is just sufficient to keep the potential of the inverting input at ground, or zero. In other words, the current I_x is equal in magnitude to I_r, but opposite in sign. It flows away from the inverting input. Mathematically we can say that

$$I_x = -I_r$$

The input, or reference current, comes from a reference cell, of voltage E_r and before reaching the inverting input flows through a reference resistor, R_r, so that

$$I_r = \frac{E_r}{R_r}$$

Similarly for the current in the feedback loop:

$$I_x = \frac{E_o}{R_x}$$

Since I_x is equal but opposite to I_r, we can combine these two equations and get

$$\frac{E_o}{R_x} = -\frac{E_r}{R_r}$$

which by rearrangement of terms gives:

$$R_x = -\frac{R_r}{E_r} \cdot E_o$$

This is the basis of resistance measurements by the ohmmeter. R_x is the unknown resistance which we want to measure. R_r and E_r are known and are constant. For different values of R_x we obtain different values of E_o, and E_o is linearly though inversely related to R_x. If we place a voltmeter between the output of the amplifier and the ground rail we can measure E_o, and use this value to derive the value for R_x. In practice we do not have to do any actual calculation; we simply calibrate the meter scale of the voltmeter to read "Ohms" instead of "Volts".

IN-CIRCUIT OPERATION

Fig. 2 shows R_x as part of a complex network of resistors. Some of the "resistors" in the diagram might be other components with some degree of electrical resistance, such as diodes, transistors, inductances or capacitors. To operate the ohmmeter in these circumstances the distant terminals of all resistors adjacent to R_x must be grounded. In the diagram, points C, D, E and F would need to be grounded.

Terminal A of R_x is at ground potential owing to the nature of the amplifier circuit, as explained above. Points C and D are also grounded. Since both ends of R_c and R_d are at ground potential, no current can flow through these resistors—they might just as well not be there. We can ignore them. Terminal B has a potential E_o provided by the output of the amplifier. Within very wide limits of load this potential is constant. So current flows from ground through R_f and R_e, but without affecting E_o. In this way the meter reads the resistance R_x, and is entirely unaffected by the network around.

The only circumstance in which this circuit will not ignore other resistors is when another resistor is wired in parallel with R_x. Then it is not possible to ground its distant terminal without also grounding either point A or B. The meter will indicate the parallel resistance of R_x and the second resistance, but not the resistance of R_x alone. If the second resistor should be a variable resistor there is no problem, for by grounding the wiper of the resistor we can treat it as two separate resistors.

CIRCUIT DETAILS

The practical circuit is shown in Fig. 3. The current I_r comes from B1, which also powers part of the amplifier IC1. The Zener diode D1 gives a regulated 5·1 volts and the resistors R2 and VR1 connected across D1 act as a potential divider. By adjustment of VR1 a voltage of 0·1 volts can be obtained at the wiper. This is E_r.

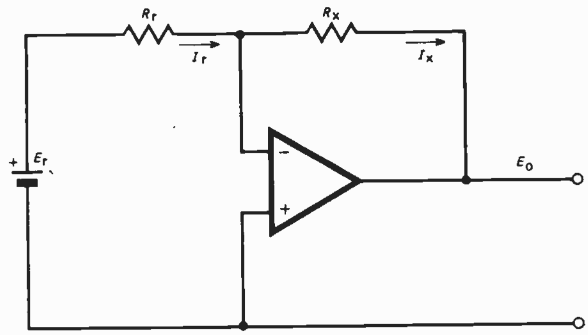


Fig. 1. Basic op. amp. circuit

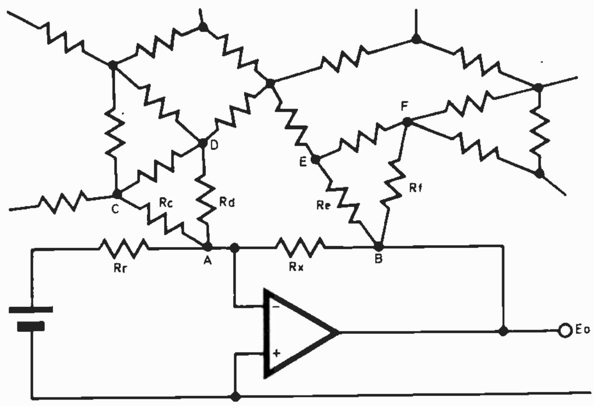


Fig. 2. In-circuit measurement

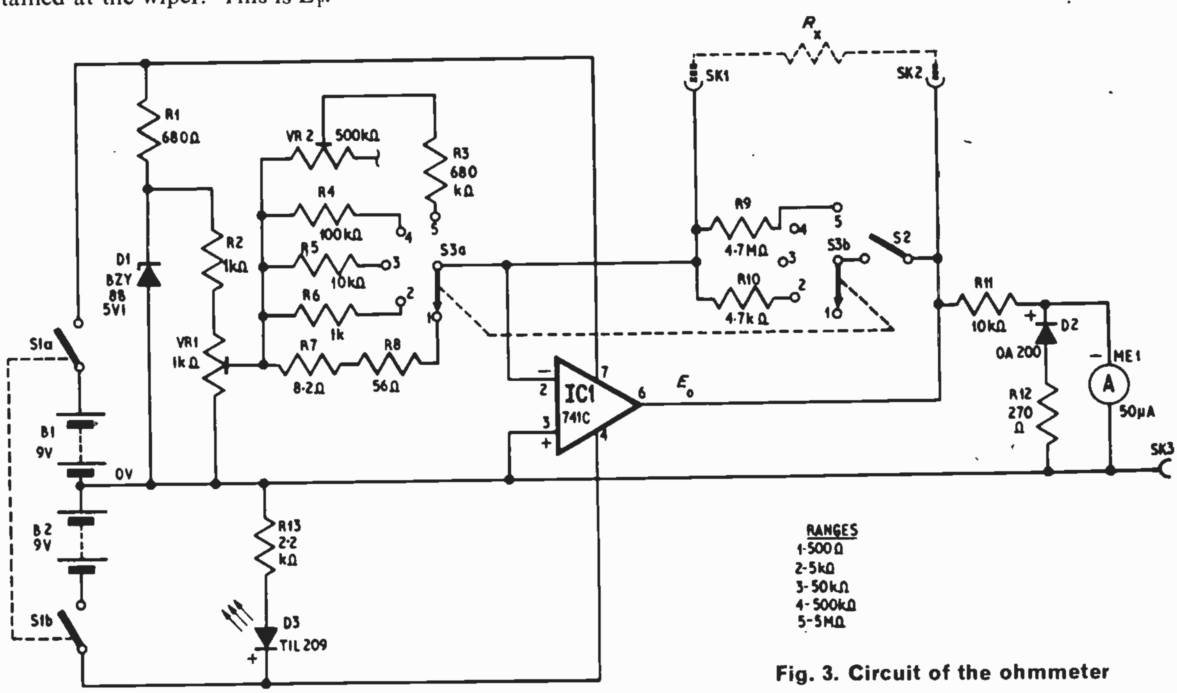
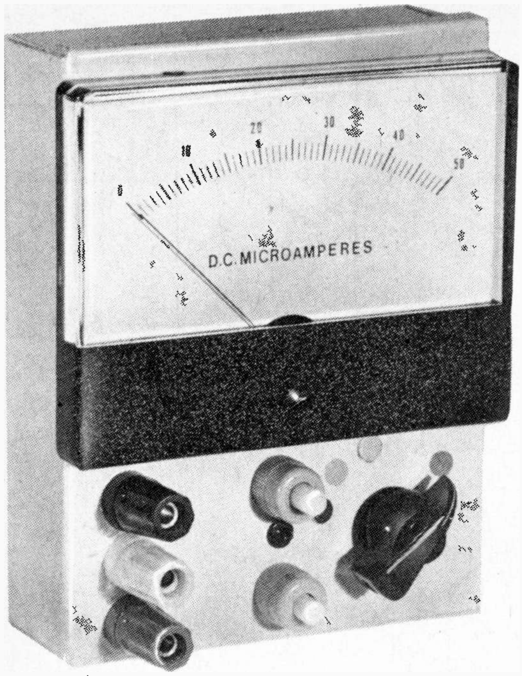


Fig. 3. Circuit of the ohmmeter



To provide a number of ranges any one of the resistors or resistor combinations R3/VR2, R4, R5, R6, or R7/8 can be switched into circuit, to act as R_r of Fig. 1. The output from the amplifier is fed out to the resistor to be measured through a terminal SK2 and back through SK1 to the inverting input of the amplifier. The voltmeter for output is a microammeter in series with resistor R11. So connected, the meter will give full-scale deflection for $E_o = -0{\cdot}5$ volts. Inserting these working values of E_r and maximum E_o in the equation, we can calculate that for any range the maximum resistance measurable is:

$$R_{x(max)} = -\frac{R_r}{0{\cdot}1}(-0{\cdot}5)$$
$$= 5R_r$$

So, when R6 is in circuit, f.s.d. of meter indicates R_x = 5kΩ; similarly, when R5 is in circuit, f.s.d. indicates 50kΩ and with R4, f.s.d. indicates 500kΩ. For a f.s.d. of 500Ω one might think that R7 and R8 should total 100Ω, but in practice they total only 64Ω. This is because such a low resistance draws a heavy current from the potential divider, and the potential (E_r) of the wiper falls. A corresponding reduction of R_r from theoretical 100V to practical 64V restores the balance of the equation, and gives f.s.d. at 500Ω. At the highest range, 5MΩ at f.s.d., the amplifier output does not reach the theoretical level, so the reference current has to be increased by using a reference resistor less than 1MΩ. This is provided by R3, with VR2 in series for adjustment to the correct total value.

CONTINUITY CHECKS

On all ranges short-circuiting of SK1 and SK2 puts R_x at zero, so E_o falls to zero. So this instrument can be used for checking continuity. When the terminals are unconnected, R_x is infinite and E_o is infinite too, at least theoretically, though the characteristics of the amplifier limit it to about −7 volts. Such a high voltage across a meter rated at 0·5 volts would damage the winding so D2 and R12 are wired in parallel to the meter to limit meter current to about 75μA. At low potentials the diode is non-conducting, but with increasing potentials the meter exceeds f.s.d. and the diode begins to conduct in its forward direction so that excess current is shunted through it.

The l.e.d. indicator is important for, unlike an ordinary ohmmeter which uses current only when actually connected to a resistor, this ohmmeter uses current as long as it is switched on. It draws about 7mA from B1 and, with the indicator l.e.d. in the B2 circuit, draws about 4·5mA from B2. These are low requirements, so small PP3 batteries can be used.

INTERNAL RESISTORS

By closing S2, one of two internal resistors (R9, R10) can be connected across the sockets, if the meter is also switched to range 2 (5kΩ f.s.d.) or range 5 (5MΩ f.s.d.). The purpose of these is threefold. They provide a simple check on battery condition and meter adjustment. They are used when checking capacitors or when measuring resistances greater than 5MΩ. The calculation for this is given later.

COMPONENTS . . .

Resistors

R1	680Ω
R2	1kΩ
R3	680kΩ
R4	100kΩ 2%
R5	10kΩ 2%
R6	1kΩ 2%
R7	8·2Ω
R8	56Ω
R9	4·7MΩ
R10	4·7kΩ
R11	10kΩ
R12	270Ω
R13	2·2kΩ

All 5% ¼ W carbon unless stated otherwise

Potentiometers

VR1	1k Ω
VR2	500k Ω
VR3	100 Ω (optional, see text)

Semiconductors

D1	BZY88 Zener 400mW, 5·1V
D2	OA200
D3	TIL209, l.e.d.

Integrated circuit

IC1 741C op. amp.

Miscellaneous

ME1	Microammeter, 50μA f.s.d. SEW SD830 or similar
S1	Push-switch or toggle switch, DPST
S2	Push-switch or toggle switch, SPST
S3	Rotary wave-change switch, 2-pole, 6-way
SK1–3	Terminals, yellow, green, black

Veroboard, 0·1 in matrix, 24 holes×24 strips (half a 5″×2½″ board)
Veropins; knob for S3, battery connectors.
1% or 2% resistors for calibration (470Ω, 4·7kΩ, 47kΩ, 470kΩ, 4·7MΩ.)

OHMMETER WIRING DETAILS

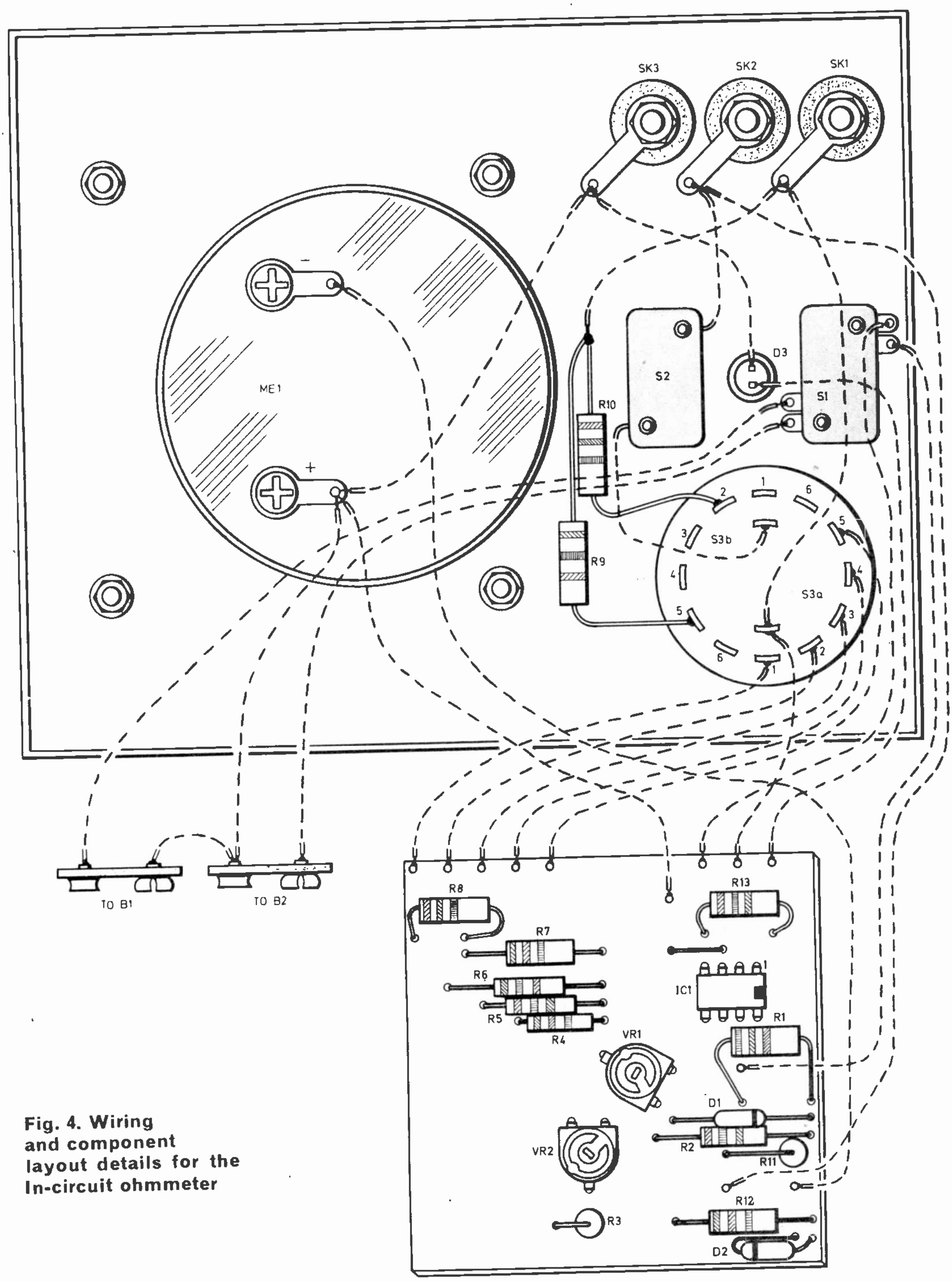
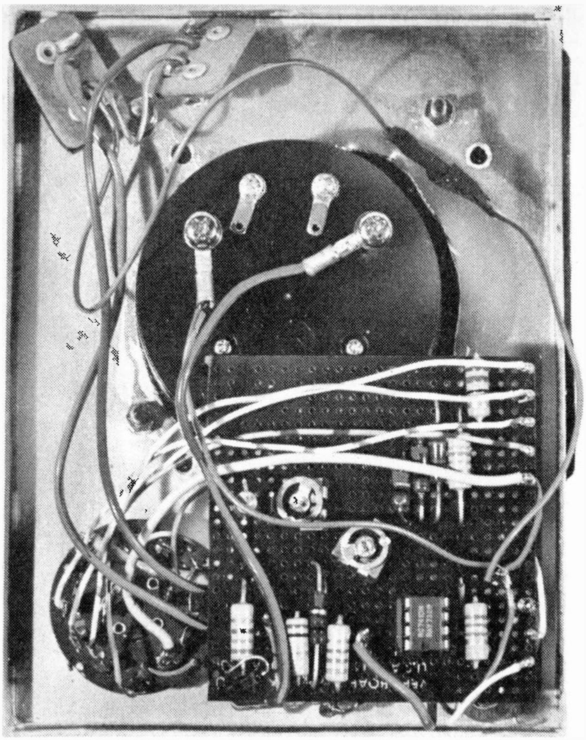


Fig. 4. Wiring and component layout details for the In-circuit ohmmeter



CONSTRUCTION

This presents few problems. Details of layout of circuit board are given in Fig. 4, and are not critical.

The lid of a 10·5cm × 13·5cm × 4cm box was drilled for meter, terminals, switches and l.e.d., and the connections between these were completed before wiring to the circuit board. Fairly long leads were routed to these components, ready for making connections to the Veropins on the circuit board. For convenience the circuit board, with components ready mounted on it, was stuck to the back of the meter case, using contact adhesive; connections to the board then being made.

Apart from marking switch positions for S3, no panel labelling was thought to be necessary. The switch positions were indicated by coloured discs stuck in position on the panel. In order from low to high range these discs were brown, red, orange, yellow and green. This corresponds to the resistor colour code, being the third colour of a resistor corresponding to f.s.d. on each range. Coloured self-adhesive spots sold as colour-slide spots were used for red, yellow and green, and the other discs were punched from coloured card.

SETTING UP

Make sure S2 is open, then connect a 4·7kΩ resistor across terminals SK1 and SK2. If possible, use a 1% or 2% resistor but, if not, try with several 5% resistors. Switch to the 5kΩ range and switch on the batteries. The needle may rest anywhere on the scale, or even swing violently beyond 50. Adjust VR1 until the needle comes to 47 (corresponding to 4.7kΩ on this range). It can now be seen why a precision resistor is not required for R11. Any inaccuracy in R11 is compensated for by adjusting VR1. The value of E_r is only nominally 0·1V and f.s.d. is only nominally 0·5V, but the ratio between them remains the same (1 : 5) and the equation still applies.

Now check the 50kΩ and 500kΩ ranges, using 47kΩ and 470kΩ external resistors. These should give correct readings (47 on the scale in each case) without further adjustment of VR1. If not, check wiring—particularly correct connections on the rotary switch, and also that R10 really was out of circuit when you set the 5kΩ range!

Now put a 4·7MΩ resistor across the terminals and switch to the 5MΩ range. Adjust VR2 until the meter reads 47. Finally switch to the 500Ω range, with a 470Ω resistor across the terminals; the needle should read 47. If it reads low, reduce the value of R8; if it reads high, increase R8. Some constructors may prefer to use a 100Ω preset in place of R7 and R8 and adjust this to get the correct reading.

Check the internal resistors by closing S2. The needle should read 47 on the 5kΩ and 5MΩ ranges, with no resistors connected externally to the terminals. Battery condition can also be assessed by this.

USING THE METER

Individual components are connected across SK1 and SK2. Components in circuit are tested by first disconnecting any power supply from the circuit and discharging any capacitors. Then the device under test is connected to SK1 and SK2. The distant terminals of any devices which are joined to the device under test are grounded by connecting them to SK3. A number of leads with crocodile clips will be found useful for this.

When measuring resistances, be sure to have S2 open, or there will be false readings on the 5kΩ and 5MΩ ranges.

The internal resistor of the 5MΩ range can be made use of for measuring resistances higher than 5MΩ. The formula for such resistances in series is:

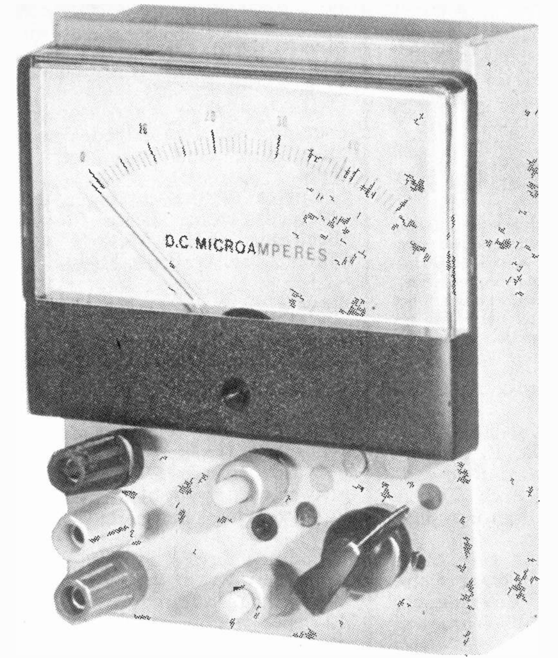
$$\frac{1}{R} = \frac{1}{R_x} + \frac{1}{4{\cdot}7}$$

Where R is the resistance measured as shown on the scale, R_x is the unknown external resistor, and all values are expressed in megohms. This equation can be rearranged to give:

$$R_x = \frac{4{\cdot}7 \times R}{4{\cdot}7 - R}$$

So if R is measured, R_x can be calculated. If scale reading is 46 (normally equivalent to 4.6MΩ on this range), this would indicate a value of $R_x = (4{\cdot}7 \times 4{\cdot}6)/(4{\cdot}7 - 4{\cdot}6) = 21{\cdot}62/0{\cdot}1 = 216$MΩ. So by using the internal resistor one can estimate very high resistances, though with reduced accuracy, for with high resistances the difference between 4·7 and R is only a few scale-divisions, which cannot be estimated to a high percentage accuracy. Still, one is no worse off than when measuring high resistances at the crowded end of the scale of an ordinary ohmmeter.

Diodes and transistors can be tested for shorts and open-circuit—often a sufficient means of confirming that a component is useless. Switch to the 5MΩ range for these tests. Terminal SK1 is positive to SK2, and by connecting a diode first one way round then the other it can soon be found if it passes negligible reverse current (equivalent to high resistance—often in excess of f.s.d.). Similarly an *npn* transistor will conduct from base to emitter and



from base to collector, but not in reverse or from collector to emitter. A *pnp* transistor will conduct only from emitter or collector to base. When connected for conduction, the meter will indicate some resistance less than f.s.d. When otherwise connected, a greater resistance (usually greater than f.s.d.) will be shown.

CAPACITORS

To test capacitors, switch to either the 5kΩ range (for capacitors of 1μF or more) or the 5MΩ range (for capacitors less than 1μF). Close switch S2. Without the capacitor in place, the needle should read 47. When a capacitor is connected across SK1 and SK2, the needle kicks sharply toward zero, then steadily returns to 47. The higher the capacitance the greater the swing, and the longer time taken to return to 47. It is important to discharge the capacitor before testing and re-testing. With electrolytic capacitors observe correct polarity (positive to SK1). Take care not to charge the capacitor unknowingly; if you touch one terminal of the capacitor with one hand, and have the other hand in contact with a lead from the instrument, a current can pass through your body sufficient to charge the capacitor appreciably, and give a false reading—possibly *no* kick, which would be taken to indicate a useless open-circuit capacitor.

It is worth remembering this point too when measuring high resistances. The resistance of the human body from hand to hand is about 1–2MΩ. If this is shunted across a high resistor under test a very false reading will be obtained.

Readers may observe that the time taken for the needle to fully return to its starting point (47) is proportional to the capacitance of the capacitor. This could be the basis of a simple and rough way of estimating capacitance. Similar capacitance testing can be done with an ordinary ohmmeter, but usually a barely perceptible kick is obtained below 10,000pF. With this ohmmeter a useful check can be made on capacitors as low as 30pF. ★

NEWS BRIEFS

New Loudspeaker

THE application of modern technology to a loudspeaker concept proposed over 30 years ago has resulted in the development of a new loudspeaker construction which promises to overcome many of the mechanical drawbacks associated with normal cone-construction driver units.

The innovator, Mr Josef K. Manger, a German radio retailer, has used modern materials to produce a so-called resistive diaphragm driver which was demonstrated to the I.E.E. and the Technical Press last month using pre-production models and normal disc records.

Whilst all such demonstrations are subjective, this one indicated that the new units will bear close watching in the near future since, to the writer, they seemed to come closer to representing the actual sound experienced when standing in, for example, an orchestra, than anything heard so far.

This is perhaps an exaggerated claim but certainly the units are capable of reproducing a square wave as such which (again to the writer's limited knowledge) no other equipments seem able to do.

Currently the units are to be made in Germany in the near future on a commercial scale and it is understood that Mr Manger is looking for a possible British manufacturer to make here under licence.

World's Best Timekeeper Goes On Show

WHAT is claimed to be the world's most accurate wristwatch will soon be on display at the Science Museum in London. The Omega "Marine Chronometer" has a guaranteed accuracy of within one second per month which is achieved by using a quartz crystal vibrating at 2359296Hz as the reference.

A special feaure of this watch is that the hour and second hands can be set independently without affecting the accurate timekeeping.

Before each watch is put on the market it is sent to an independent laboratory where a certificate is awarded confirming the watch's performance.

Complete with stainless steel case and bracelet the Marine Chronometer sells for £680.

New Year Award For Radar Executive

THE New Year Honours List included the name of Dr K. Milne who has been awarded the OBE for outstanding work as Research Executive with Plessey Radar.

A recognised authority in microwave antenna research and design, Dr Milne has been responsible for many major projects including advanced radar, satellite communications and navaid systems. He is an active member of the Electronics Research Council and of international committees, contributing to the recognition of Britain's high status in microwave technology.

Ipswich News

A LECTURE entitled "Sound Synthesis for the Amateur" will be given by Douglas Shaw at The School of Engineering Technology, Rope Walk, Ipswich, on **February 26** at 7 p.m.

This lecture is part of a Hi Fi course, currently running at the Civic College, but P.E. readers in the Ipswich area who have an interest in sound synthesis are cordially invited to attend by the course tutor, P. B. Broadribb Esq.

MARKET PLACE

Items mentioned in this feature 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.

P.E. ORION

Good news for P.E. Orion amplifier builders, the manufacturers of the cabinet used in the prototype unit, H.M. Electronics Ltd, have recently informed us that they hope to be able to produce a pre-drilled cabinet with a self-adhesive anodised aluminium front panel as an optional extra.

H.M. Electronics have also informed us that we have quoted the wrong type number for the cabinet in our components list. The correct type number for the case is the GB1 and not GB3 as stated in the article.

Full details and a price list of their complete range of equipment cabinets can be obtained from **H.M. Electronics Ltd., 275a Fulwood Road, Sheffield, S10 3DB.**

We have been informed that some readers have experienced difficulty in obtaining the mains transformer. This transformer, type SL8, can be purchased from **Gardners Transformers Ltd., Christchurch, Hants., BH23 3PN,** for £10·23 including postage and VAT.

Alternatively, the transformer for the P.W. Texan amplifier can be used in the P.E. Orion. This has a lower current rating and will give a slightly reduced output power, but it should be entirely satisfactory for speech and music. This transformer is available from **Henry's Radio Ltd., 303 Edgware Road, London, W2 1BN,** for £5·94 including postage and VAT.

LOUDSPEAKER KIT

Readers who have completed or nearing completion of the P.E. Orion, and are shopping around for a reasonable speaker system that they can build for themselves, may find the range of SEAS hi-fi loudspeaker kit now being marketed by Macel Electronics worth investigating.

Designed for sealed enclosures, there are five kits available, capable of handling outputs ranging from 20W to 70W. The frequency response of the units ranges from 25 to 20,000Hz, according to speakers used and size of enclosure. Each kit includes a tweeter, main driver(s), crossover unit and connecting wire with a din plug. The speaker impedance is 4 to 8 ohms.

A feature of the systems is that each kit contains a recommended enclosure design with full measurements and constructional guidance notes.

Further information and full details of their complete range of SEAS hi-fi loudspeaker kits can be obtained from **Macel Electronics Ltd., P.O. Box 64, 14 High Street, Ipswich, Suffolk.**

DIGITAL LEAF

Suitable inexpensive valves for use with the "Digital Leaf" greenhouse automatic moisture system, described in our January issue, are available from Concordia Automation Components.

Several types are available with ⅛in, ¼in, ⅜in and ½in B.S.P. connections for mains or low voltage supplies at prices from £6 each. This is approximately half the figure quoted in the article.

Further information on these valves can be obtained from **Concordia Automation Components Ltd., 6 Central Park, Worcester Park, Surrey, KT4 8HZ.**

NEW LITERATURE

Recently formed to market p.c.b. hardware, heat sinks and modules manufactured by Assmann KG, Germany, Dieter Assmann Electronics announce the availability of a new catalogue.

The catalogue contains 50 pages of detailed information covering the whole of the Assmann product line. Dual-in-line sockets, for example, can be supplied with from 8 to 40 pins, including the popular 14- and 16-pin units. Sockets and mounting pads for transistors are also available in most of the popular configurations.

The range additionally includes p.c.b. connectors, and bread boards for experimental and development work. Details of jumper links, terminal pins, u-pins, eyelets and insulated terminals form a complete section in the catalogue. A very broad range of heatsinks is also covered, including extruded and cast aluminium, and staggered finger types.

Copies of the catalogue can be obtained from **Dieter Assmann Electronics Ltd., Victoria Works, Water Lane, Watford, Herts.**

SEAS hi-fi loudspeaker kit from Macel Electronics

SEMICONDUCTORS

High Speed 741

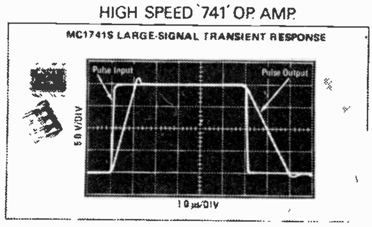
In many areas of application engineers need a higher slew rate from their operational amplifiers than can be obtained from the everyday 741 chip.

Motorola have provided the answer to this problem with a plug-in alternative designated MC1741-SCP1.

The new device, available ex-stock from Jermyn at a 1-off price of £0·92 each, boasts a slew rate of 10V per microsecond, suiting it to digital-to-analogue converters and amplifiers where bandwidth from d.c. to over 100kHz is important.

Further details available from **Jermyn Industries, Vestry Trading Estate, Sevenoaks, Kent.**

HIGH SPEED '741' OP. AMP.



Audio Transistors

Five new complementary pairs of silicon epi-base, epi-collector power transistors designed for a complete voltage range have just been announced by SGS/ATES.

The first pair, BD433 and BD434, have been developed for in-car entertainment applications with power requirements up to 12W. The second and third pairs BD435 and BD436, and BD437 and BD438, are particularly suited to hi-fi audio amplifiers up to the 15/20W range.

All types in the range are suitable for industrial applications such as power drivers, switching circuits and current regulators up to 4A and, of course, for automotive applications such as flashing lights, lamp dimmers and direction indicators.

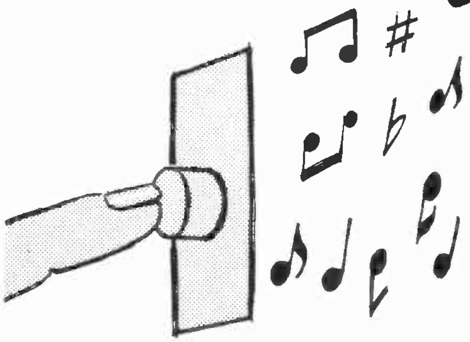
All the devices are rated at 36W P_{tot}, 4A I_c and an f_t of 3MHz, whilst the V_{ceo} values for pairs are as follows: BD433/34, 22V; BD435/36, 32V; BD437/38, 45V; BD439/40, 60V and BD441/42, 80V.

Further details available from **SGS/ATES (U.K.) Ltd., Planar House, Walton Street, Aylesbury, Bucks.**

NEXT MONTH...

THE PE COMPENSATED PHOTO TIMER

The P.E. compensated photo timer not only provides simple selection of time interval from 0·1s up to 120s with controls designed specifically to suit darkroom conditions, but additionally provides for exposure compensation of mains voltage variation effects on enlarger lamp light output.



STARTLE YOUR FRIENDS WITH THIS MUSICAL DOORBELL

Capable of playing a tune of welcome (or rejection!) dependent on the choice of programme you put in. Integrated circuitry and state-of-the-art logic make for simplicity of construction.

STARTING NEXT MONTH...
INTRODUCTION TO TRANSDUCERS

An important and informative series on Transducers, their operation, types, uses and technical features. Make certain not to miss any of this in-depth study of these important tools in the art of measurement.

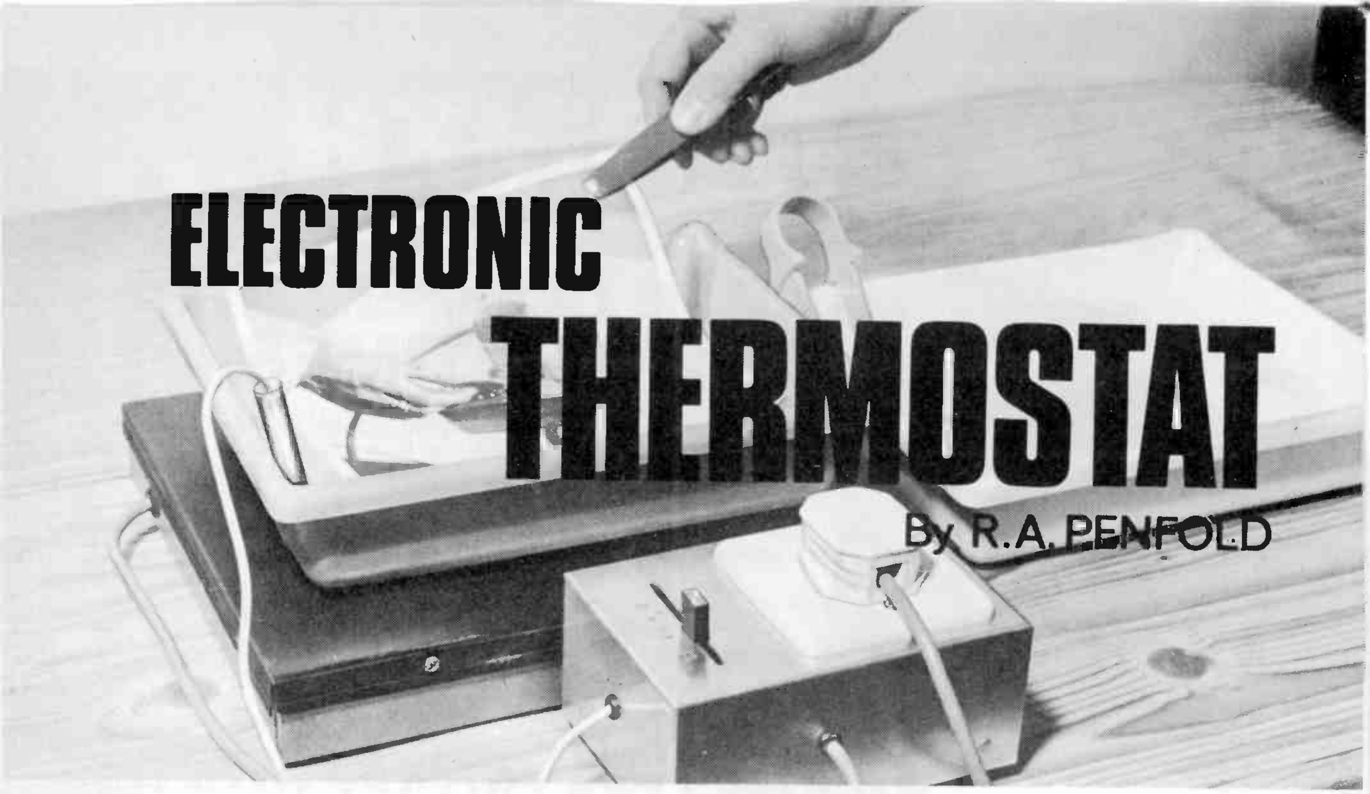
TEMPERATURE
HEAT LIGHT WEIGHT
DISTANCE SOUND
FREQUENCY DEPTH

PRACTICAL
ELECTRONICS

APRIL 1975 ISSUE ON SALE MARCH 14, 1975—PRICE 30p

ELECTRONIC THERMOSTAT

By R.A. PENFOLD



In photographic work it is often necessary to keep solutions at a constant temperature during the printing process. The situation is especially critical when it comes to colour printing, where it may be necessary to maintain the temperature of the solutions to within a fraction of a degree.

The normal method of achieving this is to place the dishes containing the photographic chemicals on a thermostatically controlled dish warmer. However, many devices of this type use mechanical thermostats which are far too insensitive for accurate temperature control, and can often only keep the solutions to within a couple degrees of the required temperature.

PRECISE CONTROL

The device which forms the subject of this article was built to give a much more precise control over a system such as that just described, and has proved to be very successful in use. Exactly how accurately it will maintain a given temperature will depend to a certain extent on the apparatus with which it is employed, and also on the efficiency of the sensor. It should however, be able to maintain a temperature to an accuracy of about plus or minus 0·2 degrees.

It can of course be used for any similar purpose where it is necessary to maintain a liquid at a constant temperature. The range covered by the unit is from slightly below 50°F to a little more than 100°F.

Circuits of this type can be rather complicated, but in this design the utilisation of an i.c. operational amplifier enables a very simple and straightforward circuit to be used.

THE CIRCUIT

A complete circuit diagram of the electronic thermostat is shown in Fig. 1. The unit is designed around the 741C i.c., which is used here as a differential amplifier.

COMPONENTS . . .

Resistors

R1, R2	5·6Ω (2 off)
R3	33kΩ
R4	27kΩ
R5	10kΩ
R6	4·7kΩ
R7	430Ω
R8	220kΩ

All ½W 10% carbon

Potentiometer

VR1	10kΩ linear slider

Capacitors

C1, C2	220μF 16V elect. (2 off)

Semiconductors

TR1	BC109
D1–D4	1N4001 (4 off)
D5, D6	BZY88 C10 10V 400mW Zener (2 off)
D7	OA200 or any general purpose silicon diode
IC1	741C 8-pin d.i.l.

Thermistor

TH1	VA1066S

Miscellaneous

SK1	Surface mounting mains socket
RLA	Miniature 12V relay (Omron 1051, 465 Ω Home Radio)
T1	Mains primary, 9–0–9V 80mA secondary (Osmor MT9, Home Radio)
S1	Single pole on/off
FS1	500mA with holder

0·1in matrix Veroboard 35 × 15 holes

6in × 4in × 2½in aluminium chassis with base plate

Screened cable, hardware for sensor

As the name suggests, this amplifies the difference between the two input voltages. The output will be near ground if the inverting input is at a higher potential than the non-inverting input. On the other hand the output will be near the supply rail if the non-inverting input is at a higher potential than inverting one.

The gain of the i.c. is extremely high, and the voltage difference required at the inputs to cause the output to swing fully one way or the other is only a fraction of a millivolt. This tends to give the circuit built-in triggering, as there is such a restricted range of voltages which will give an intermediate state at the output.

BRIDGE CIRCUIT

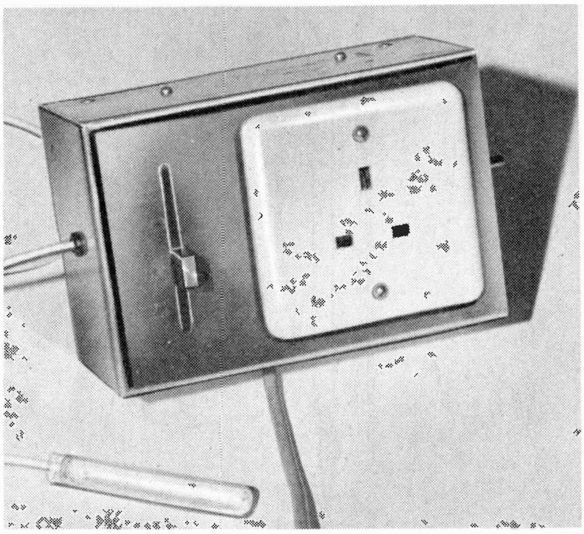
At the inputs to the i.c. there is a bridge circuit. One arm of this is formed by R3, VR1, and R4, and the other by R5, R6, TH1. The supply is connected to the input of the bridge.

Thermistor TH1 is mounted in a probe which is immersed in the liquid to be controlled. Its resistance will therefore increase if the temperature of the liquid drops, and decrease if the temperature increases. This change in resistance will cause the voltage at the non-inverting input to change also, a positive change in temperature causing a negative change in voltage.

The output from IC1 is coupled via R8 to TR1, which has the relay in its collector circuit. The contacts of the relay are taken to a mains socket, into which the dish heater is plugged. When the output of IC1 is high (+20V) the relay is energised. R7 is required in order to reduce the supply to a more suitable level to power the relay. Diode D7 is the normal protective diode. Even when the output of the i.c. is low there is an output potential of about two volts. R8 is therefore required to prevent the relay from being permanently held on.

CALIBRATED SCALE

In practice VR1 is marked with a scale calibrated in degrees. If, for example, this is set to 100°F, at the start the liquid will probably be at about room temperature, and considerably less than 100°F. The voltage at the non-inverting input will be high in comparison to that set at the other input by VR1. The output of IC1 will thus be high and the heater will be turned on. As the liquid warms up the voltage at the non-inverting input will decrease, until eventually when the liquid reaches 100°F, this voltage being equal to that at the other input, will cause the output of IC1 to go low, and the heater to be turned off.



The completed Electronic Thermostat showing layout of controls on the front panel

The liquid will now of course begin to cool, but will not be allowed to cool much, as this cooling will be sensed by the thermistor, which will unbalance the input voltages resulting in the heater being turned on again. The circuit will continue to oscillate in this way, thus stabilising the temperature of the liquid.

POWER SUPPLY UNIT

A simple stabilised mains power supply is used. This consists of two full wave supplies, each providing 10V, connected in series to give 20V, which is

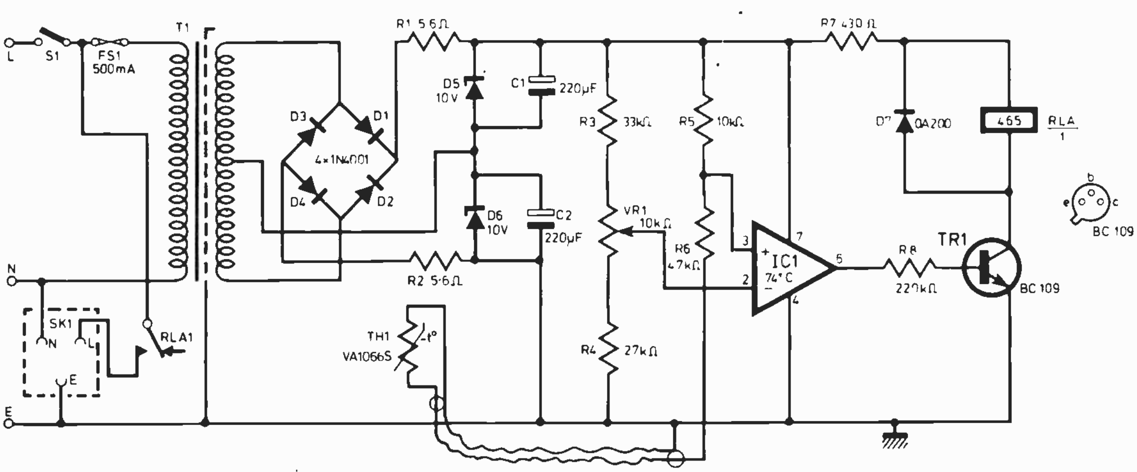


Fig. 1. Complete circuit diagram of the Electronic Thermostat

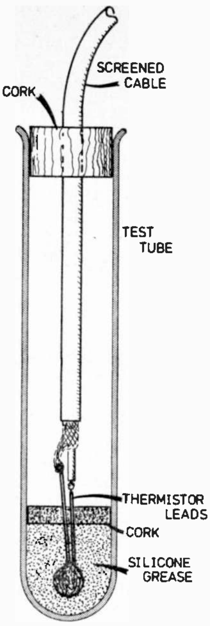
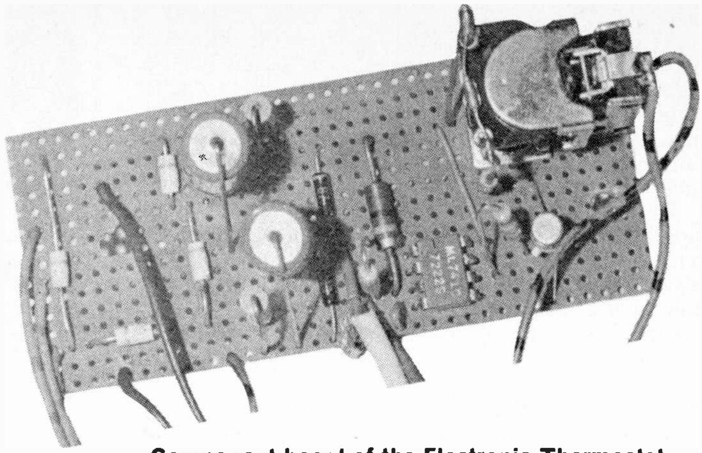


Fig. 2. Construction of the sensor using a small test tube and some silicone grease



Component board of the Electronic Thermostat

adequate for the 741C. D5, and D6 in conjunction with R1 and R2, and the relatively high secondary impedance of T1 give the stabilisation. C1 and C2 provide the necessary smoothing.

SENSOR CONSTRUCTION

The thermistor must be contained in a watertight compartment, and it must also be in good thermal contact with the outer surface of the container. Fig. 2 illustrates the construction of the sensor used with the prototype. The outer casing is a small glass test tube. The thermistor is mounted at the bottom of the tube, and is immersed in silicone grease to ensure a good thermal contact with the test tube.

The small slice of cork above this helps to keep the thermistor firmly in place, and also helps to prevent its leads from shorting together. Also, the silicone grease is rather thick, and needs to be pushed to the bottom of the tube. The slice of cork is very good for this task. Thin microphone cable is used to connect the sensor to the main body of the instrument.

CASE CONSTRUCTION

A suitable case for the unit consists of a 6in × 4in × 2$\frac{1}{2}$in aluminium chassis fitted with a base plate. Four rubber cabinet feet are bolted to the base. The general layout of the case can be seen from the photographs. The mains socket is mounted on top of the case on the right hand side. This mounted by two 4BA $\frac{3}{4}$in bolts.

A large part of the socket fits behind the panel, and a large cut out must be made for this to fit through. This is easily made by drilling a string of $\frac{1}{8}$in holes around the perimeter of the cut out, and then using a $\frac{1}{8}$in "Abrafile" to join the holes.

The slider potentiometer is mounted on the left of the mains socket, and it is glued into position. The cut out for this can be made in a similar way as that for the mains socket. A nail file can be used to smooth up the edges of the slot.

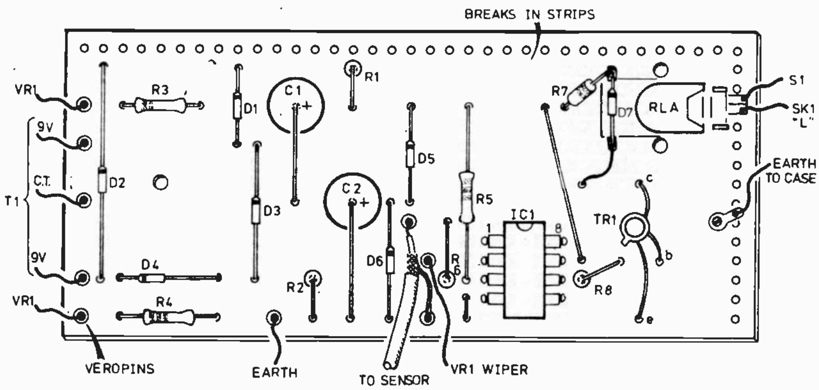


Fig. 3. Layout of components on the Veroboard. The diode D7 is connected directly across the coil contacts of the relay

The on/off switch is mounted on the centre of the right hand side panel. The lead from the sensor enters the case opposite this on the left hand side, and the mains lead enters on the lower edge of the case. The holes for both these leads must be fitted with rubber or p.v.c. grommets.

COMPONENT PANEL

Most of the components, including those of the p.s.u. (except T1), are mounted on a 0·1in matrix Veroboard panel. Fig. 3 shows the layout of this.

The mounting holes for the relay are $\frac{1}{8}$in diameter. The mounting screws and washers are supplied with the relay. There are two mounting holes for the board, and these are for 6BA clearance. The outer braiding on the lead from the sensor is too large in diameter to go through the holes in the Veroboard, and is therefore taken to a pin.

When completed, the board is mounted on the upper side of the case by two 6BA $\frac{1}{4}$in bolts. Two stand off insulators are required to hold the board a little way clear of the case.

ADDITIONAL WIRING

T1 is glued to the inside of the case opposite the Veroboard panel. Unfortunately the lead out wires of this are too short to reach the Veroboard panel. The leads from T1 are taken to a miniature three way connector block, and three insulated wires are taken from this to the component panel. The mains input is also taken to one side of a three-way connector block, and from here the connections are made to the various parts of the circuit.

Only the two connections to the relay contacts at the top, and middle of the relay are used, the lower one being ignored. Up to five amps at 250V can be handled by the specified relay.

It is essential that the negative supply is earthed, as if this is not done the relay will not switch over cleanly. For reasons of safety the case must also be earthed. A solder tag on one of the mounting bolts of the component panel is used to make the connection to the case. The two connector blocks can be bolted to the case, but on the prototype these were left supported only by the leads connected to them.

CALIBRATION

A scale is marked along the run of VR1. The various points along this are easily found. If for example it is required to find the setting which corresponds to 100°F, the sensor is placed in some water which has been heated to precisely this temperature. Once the sensor has had time to adjust to the temperature of the water, the slider of VR1 is brought as far down the scale as possible without the relay turning off. This point is then marked 100°F.

The scale is rather broad, as a fairly wide range of temperatures is covered. If absolute accuracy is required, it is advisable to initially use a thermometer to monitor the temperature of the liquid, and then if necessary, small adjustments can be made to the setting of VR1 to bring the temperature to exactly that required. ★

21st London International BOAT SHOW 75

ONCE again the annual International Boat Show has brought forward a variety of new and interesting developments in electronics associated with the sea. One of the most important and significant innovations on display this year was the Lucas Marine safety buoy. The buoy is automatically released from a sinking vessel and remains anchored to the vessel at depths up to 3,000ft. It sends out a distress signal at 121·5 and 243MHz, emits a high intensity flashing light, releases a 50ft floating line with light to act as a rallying point for survivors and releases an automatically inflating four to six man life-raft. Other facilities are also available, such as marker dye and calming oil.

The electronics are powered by lithium batteries which have a recommended replacement life of four years. The transmitted distress signal has been satisfactorily received at a range of 180 miles.

Another new device to aid safety at sea is the G.H.T. Gas Safety Unit. Using solid state gas sensors and electronic control, this unit not only senses the presence of dangerous gases, but turns off the gas at source. The unit is fitted with voltage failure protection and has to be reset once triggered or if the supply fails.

One of the most popular ranges of instruments among the racing yachtsmen, Brookes and Gatehouse, has this year been increased and modified. A new unit, the Halycon—they must run out of names soon—is a repeating compass with dead reckoning indicator providing information on position in two co-ordinates. This year B. and G. have introduced a quartz crystal controlled chronometer and l.e.d. internal lighting for their repeater instruments.

Baron Instruments have introduced a Square Mk. 2 range—re-designed housings and dials. Two versions of the log are available (0–15 knots and 0–35 knots) and three versions of the depth sounder 0–30, 0–60ft/fathoms and 0–10/100 metres.

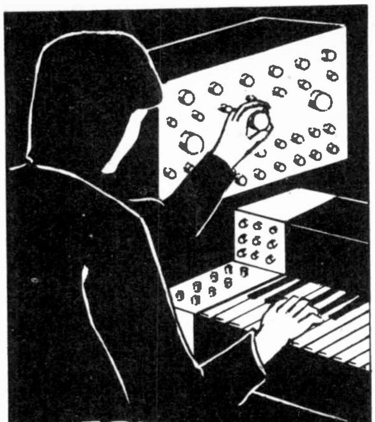
Decca were showing the 36 mile 110 Radar for the first time; this equipment employs a 4ft scanner and therefore is not likely to be seen on anything but the largest private yachts. This set is basically an improved version of the 101 Radar that has proved itself over the years.

Space Age Electronics were displaying a doppler speedometer with audible output for dingy tuning—the transducer is inserted in the centre board case and an increase in speed increases the frequency of the output. However, at £40 it may not be very popular.

Also from Space Age a portable echo sounder for fishermen; using l.e.d. output it is claimed that fish can be easily recognised. Can be used in a boat or from the river bank.

Finally, two points concerning EMI. The first is rather sad—The Electrascan radar will soon be discontinued, presumably competition from others, the servicing requirements and the general financial situation have all taken their toll. The second item—looking ahead to next year's Boat Show—the CCTV Division of EMI Sound and Vision Equipment Limited, is providing additional security in the form of an automatic closed circuit TV alarm system.

The system is in no way intended to inhibit normal movement through the entrances and exits, but it is intended to assist the existing security services to prevent the unauthorised entrances of people into the show halls.



ELECTROMUSE

By Malcolm Pointon

THE time has come to introduce a few practical projects in the production of taped music. In the coming months it is hoped to bring out some hints on the creative use of the P.E. Minisonic Synthesiser, but for the moment it seems advisable to get into practice with tape manipulation, to perform a short composition and settle on the kind of equipment required to get the best out of the Minisonic—or any other sound source destined to be frozen on tape.

Firstly the equipment. It is generally advisable to have two tape machines available, although both need not necessarily be sophisticated stereo (or quadrasonic) units. Preferably both should be reel-to-reel machines (for ease of editing) though one can get along quite well with one stereo reel-to-reel machine and a cassette deck. In the interest of increased versatility a choice of tape speeds should be available (19, 9·5, and 4·75cm/s being normal on domestic equipment).

If one or both machines are stereo with track-to-track dubbing (so-called multi-play) one can extend the number of superimposed recordings without unduly affecting the final quality. Personally, however, I tend to ignore this facility and use two stereo machines through a mixer in order to produce a stereo result.

Basic set-up

The mixer unit need not be an elaborate affair. A very workable battery-powered stereo unit can be built around a couple of 741 op.amps with as many input and output connections as required. For the coming projects, including this month's, I recommend at least eight inputs, individually switchable from left to right channels, and three-plus-three outputs.

Any stereo amplifier will serve in the set-up since it is to be used only for monitoring purposes; one of the stereo outputs from the mixer will be permanently connected to its Auxiliary, Tape, Radio or Phono socket.

The final piece of equipment for this month's project is a short-wave radio receiver, see Fig. 1.

Method of composing

As a student some years ago I felt the urge to attempt some electronic music, spurred on by the apparent simplicity of the sound material in Stockhausen's "Study II". Without the mass of equipment necessary I had to rack my brains to find an alternative sound source. The problem was partially solved by a domestic four-waveband a.m. radio set. After hours of patient (and enjoyable) knob-twiddling I managed to find a selection of "electronic" sounds which promised to be of use. Armed with a splicing block, razor blade, splicing and leader tape and a four-speed mono tape recorder I spent a fortnight's spare time producing a two-minute piece.

The project outlined below works along these lines, but since stereo is pretty commonplace nowadays I have decided to compose a two-channel work. Those who may only have access to mono machines could still, with a bit of juggling, produce a mono version of it.

PELORIA

I have called my piece "Peloria"* which is laid out in time, the numbers 1 to 20 across the top and bottom of the score referring to equal time intervals chosen by the performer, see Fig. 2.

Each channel has three imprecisely laid out pitch bands—high, medium and low. The dynamic levels are similarly imprecise: *pp*=very soft, *p*=soft, *mf*=moderate level, *f*=loud, *ff*=very loud. The short-wave sound material, chosen by the performer, is shown largely in rectangular blocks, variously shaded; blocks containing horizontal lines indicate a rich or busy sound with no discernible melodic or rhythmic consistency;

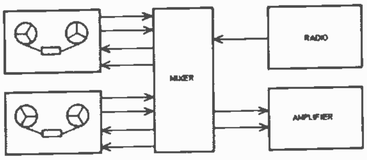


Fig. 1. Simple tape effects set-up

similar vertical narrow bands represent a very short event.

The areas shaded with dots represent fleeting pitches which may be discernibly rhythmic or melodic yet move at great speed. The blocks shaded with short curved lines represent melodic and rhythmic patterns of a moderate-to-quick speed. Horizontal broken lines signify a decrease in level towards silence if placed after continuous lines, an increase if they appear before.

The sound material for "Peloria" is available, from my experience, all year round. I suggest that all the sounds required for the piece be recorded at some length and at all speeds available on your tape machine; this gives sufficient length to cut out unwanted blips and to ensure an increased variety of pitch bands. Decide on the length of your time interval—you may do this roughly with the seconds hand of a watch or more precisely by measured lengths of tape. Those events which require an increase or decrease in level should be re-recorded using the level controls on the mixer.

From the material you now have snip out the measured lengths for channel one, not forgetting the periods of silence. Record the whole of the sequence on to the left-hand channel of your stereo machine. Now edit the tape for channel two, placing leader tape between events; this will allow you to pause during the gaps and come in on time for the final transfer to the right-hand channel of your stereo machine. Absolutely exact synchronisation is not necessary in this piece.

*Peloria: The regularity in a normally irregular flower (Chamber's Twentieth Century Dictionary).

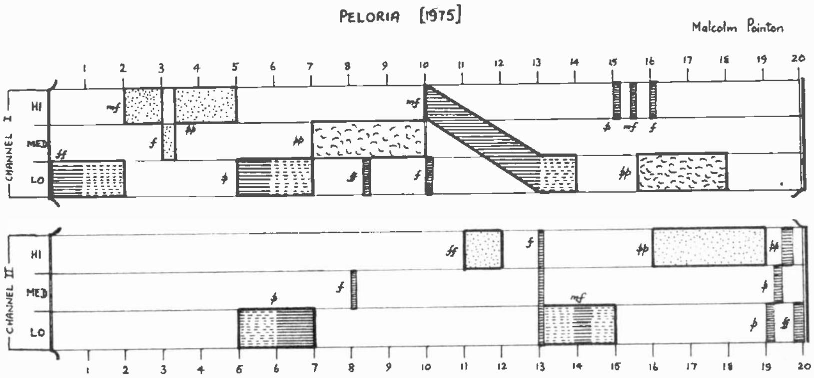
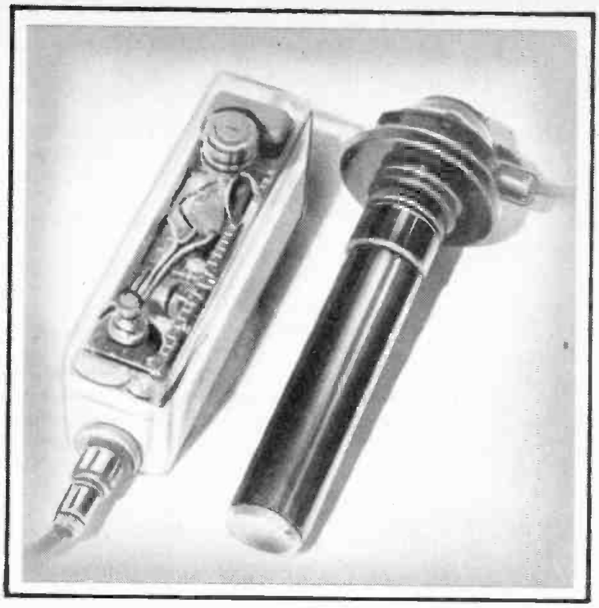


Fig. 2. Mr. Pointon's method of composing electronic music for his piece called "Peloria"

THE Geiger counter described in this article is small enough to be slipped into the pocket and taken out into the country to look for radioactive minerals. Quarries and old mine workings are good hunting grounds, particularly if geologically old rocks are being uncovered. Unfortunately, your search is not likely to be very rewarding in this country.

Nevertheless, the instrument will show that we are being exposed continually to a natural background radiation made up of cosmic rays and the emissions from radioactive materials in the ground and air around us and over which we have very little control. The instrument can also be used to locate sources of radioactivity should these be mislaid in the workshop and laboratory.

The instrument is quite sensitive, it will count by producing a click in an earpiece, a single beta particle (an electron) whose mass is about one million billion billionth of a kilogram (10^{-30}kg) and which could be moving at about 800 million kilometres per hour!



GEIGER COUNTER

By M. PLANT M.Sc.

The accompanying photographs show one form of the completed Geiger counter with the electronics housed in a plastics slide box. In use the box is held close to the ear, the thumb holding the push-button switch down.

THE GEIGER TUBE

The Geiger counter tube is the part which is sensitive to the atomic radiations which are emitted from radioactive sources and which make up cosmic rays. The type of tube shown in the photographs is fairly common and consists of a central anode surrounded by the cathode. Photos show the kind of tube which has an end window to allow it to respond to alpha particles (the nuclei of helium atoms) and to low energy beta particles, both of which are most easily absorbed by the material through which they pass. The less sensitive tube shown in the model responds to the very penetrating radiation of gamma rays and high energy beta particles.

Geiger tubes (strictly called Geiger-Muller or GM tubes) are available on the government surplus market for a few pounds and are often advertised in the pages of this journal or are available from suppliers of Mullard equipment.

The tube selected should have an operating voltage of about 400V. An important feature of the counts per minute versus voltage across the anode-to-cathode of a geiger tube is the so-called plateau of operating voltage which is shown in Fig. 1. The sensitivity of the tube increases gradually over this plateau and it is important to operate the tube within this range of voltage; the midpoint of the plateau is usually chosen and the present instrument can be adjusted to operate the tube at this voltage. Geiger-Muller tubes have commonly a two-pin base requiring a special holder, but some have an octal base although just two of these pins actually make connection to the tube.

THE CIRCUIT

Fig. 2 shows the circuit which consists essentially of three parts, an inverter or d.c.-to-d.c. converter, a voltage doubler, and an amplifier. The inverter and voltage doubler enable a 9V battery to provide up to 500V to operate the GM tube, and the amplifier is required to amplify the voltage pulses obtained across a resistor in series with the tube when the tube responds to the effect of a particle passing through it.

THE INVERTER

The inverter is a simple resistance-coupled oscillator which gives about 250V across the secondary of the 9-0-9V/250V transformer at a frequency of about 40Hz.

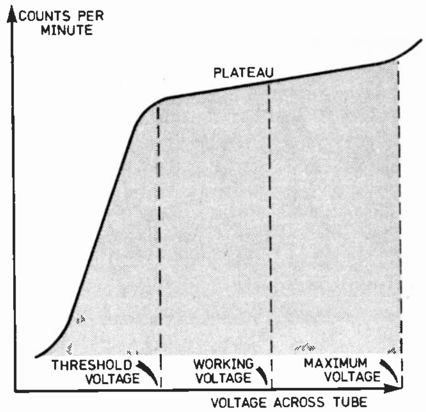


Fig. 1. The characteristic curve of a GM tube

Up to 250V a.c. is available across the secondary winding of the transformer and this is doubled and rectified by the diodes D1 and D2 and the capacitors C2 and C3 to provide about 500 V d.c.

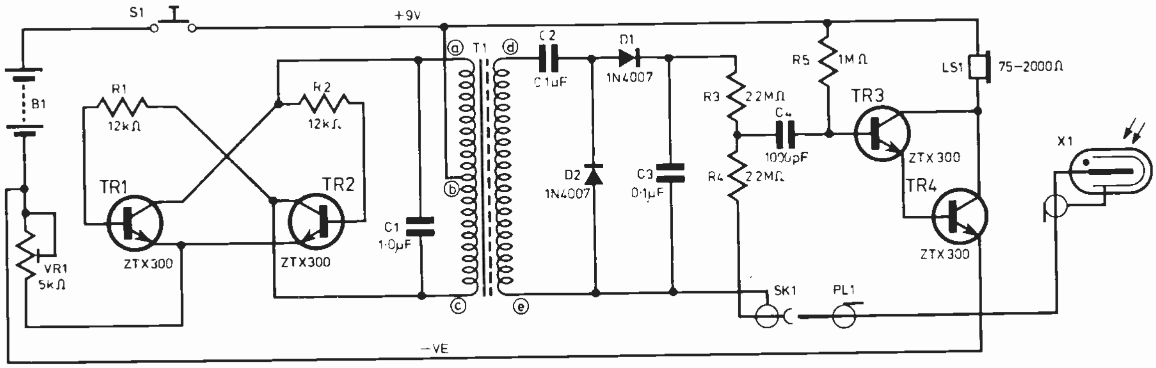


Fig. 2. Circuit diagram of the power supply, GM tube and amplifier

TR1 starts to conduct when the circuit is switched on and current increases in the associated half of the primary winding of the transformer, induces a voltage in the other primary half which rapidly drives TR1 into saturation via the base coupling resistor R1 and thus biases TR2 off.

Flux increases in the core of the transformer until saturation is reached when the positive feedback provided by the induced primary voltage falls to zero. TR1 is returned to the off state and this ends the first half cycle of the period of oscillation. The collapsing flux in the transformer core induces a voltage in the primary winding associated with TR2 to drive it on, so initiating a second similar half-cycle.

Capacitor C1 across the collectors of the transistors eliminates the possibility of high frequency oscillation and makes for reliable starting of the inverter. The actual primary voltage being switched by the two halves of the primary winding of the transformer can be varied by means of the variable resistor VR1 in series with the 9V battery so that the voltage available from the voltage doubler can be varied to suit the characteristics of the tube used.

The output from the supply is applied across the GM tube via R3 and R4. The passage of a radioactive particle through the gas filling the tube causes some of the gas to be ionised. Under the high voltage between the anode and cathode, a rapid avalanche of ionisation occurs and ions are collected by the electrodes resulting in a very small current through the external resistors R3 and R4. This pulse of ionisation is short-lived and the tube is quickly ready to respond to another ionising particle passing through it. The voltage change across the external resistors is coupled to a two-transistor amplifier by the coupling capacitor C4 so that a loud click is heard in the earpiece.

ASSEMBLY

A piece of Veroboard was selected for assembling the circuit, the precise dimensions depending on the physical size of the components to hand and the case used. In the present instance the case used in the prototype was a Kodak slide box measuring 108 × 32 × 52mm and the Veroboard measured 46 × 54mm.

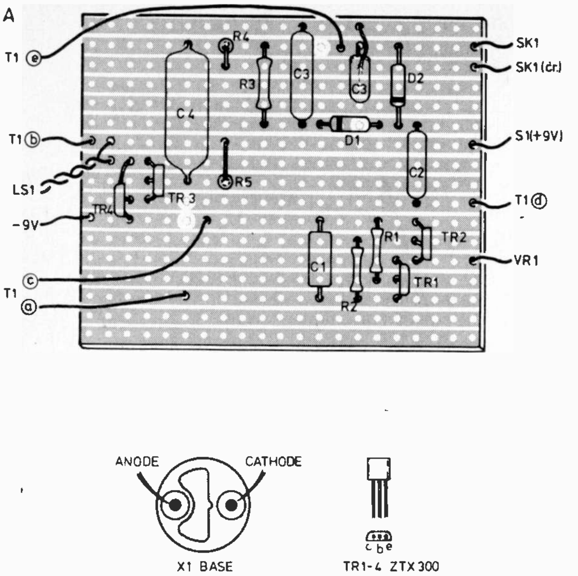
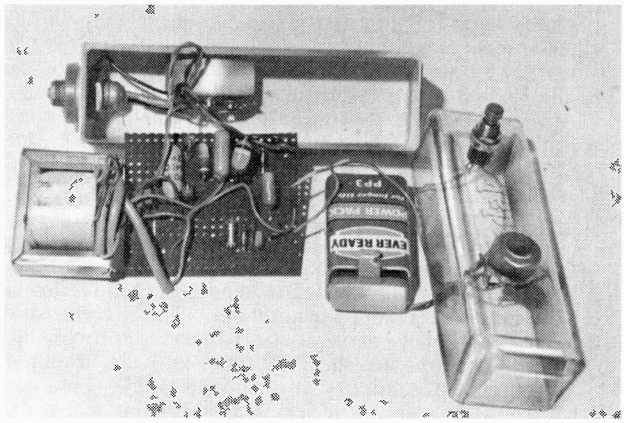


Fig. 3. Component layout and Veroboard cutting details for the counter



Completed Geiger Counter ready for installing in a photographic slide case

COMPONENTS . . .

Resistors
R1, R2 12kΩ, 2 off
R3, R4 2·2MΩ, 2 off
R5 1MΩ
All ¼W, 10%

Potentiometers
VR1 5kΩ skeleton pre-set

Capacitors
C1 1μF, 250V
C2 0·1μF, 250V
C3 2 off 0·22μF, 250V to make up 0·1μF, 500V
C4 1,000pF mica

Semiconductors
TR1, 2, 3 & 4 Silicon *npn* ZTX300 or similar, 4 off
D1, 2 1N4007, 2 off

Switches
S1 Push-to-make button switch or slide switch

Miscellaneous
T1 Transformer, 9–0–9V primary, 240V secondary. Midget mains type such as Osmor MT9
LS1 Small earphone, 75Ω or above (to 200Ω)
X1 Mullard MX168 or similar low voltage type GM tube. Possible sources Henry's Radio, 20th Century Electronics Ltd., New Addington, Croydon, Surrey
B1 9V, PP3 or PP6 suits
Tube holder; co-ax cable; co-ax plug and socket; Veroboard; wire; solder; suitable box.

Fig. 3 shows the component layout of the prototype circuit in which C3 is made up of two 0·22μF, 250V capacitors connected in series to give, effectively, a 0·1μF, 500V capacitor. However, a suitable single capacitor may be obtained for this circuit, although physical size may preclude use. The main precaution to be taken is to ensure that the high voltage cannot be inadvertently connected to the low voltage side of the circuit, otherwise damage to the transistors and C1 may result.

SETTING-UP

After assembly and before connecting the Geiger tube, switch on the circuit and listen for a faint low frequency hum coming from the earpiece which indicates that the inverter is working. Rotate the high-voltage-adjust variable resistor VR1 and the hum should change in intensity and frequency slightly.

Next, use a high impedance voltmeter to measure the voltage available at the socket for the GM tube and adjust this voltage to that required to drive the tube. Sometimes this voltage is marked on the side of the tube.

If the voltage is not marked and you are unsure of the correct operating voltage, connect the tube and increase the voltage slowly by means of VR1 until the tube begins to respond to the background radiation and clicks are heard. Increase the voltage by about 20V and then leave VR1 alone. The counting rate due to the background depends upon your locality, the operating voltage of the tube and the volume of the gas in the tube as well as its construction.

Using a gamma-ray sensitive tube, a background count rate of about 45 clicks per minute should be obtained.

Bring up a luminous watch or clock face to the tube and the count rate will increase. The Geiger counter is now ready for use. From time to time it will be necessary to adjust VR1 to compensate for the fall with use of the terminal voltage of the battery. Never operate the tube at too high a voltage so that it breaks into continuous discharge for this will decrease its useful life markedly. ★

INDUSTRY NOTEBOOK

By Nexus

SMALL IS BEAUTIFUL

From time to time I have been criticised for writing too often about the smaller enterprises in the electronics industry. But there's a lot to be said in favour of the homely neighbourhood store compared with the supermarket. Both have their role to play in our complex world. The same with electronics where there is still plenty of room for the small man in among the giants. And it is still demonstrable that for sheer profitability in the electronics industry the optimum size of the workforce is about 300 people. This is the maximum size where the boss still knows everyone and everyone knows the boss. Where people know what's going on, feel appreciated, have some job satisfaction.

It's the sort of size, too, where a company is still flexible. Reaction times are less and response is quicker. Product lines can be switched quickly to meet changing conditions. There is no multi-million pound investment in a single product line that might, and often does, go sour when brought to the market place.

A good example of what I mean is Brandenberg Ltd. which celebrated its 21st anniversary recently. It's a comfortable little unit employing 160 people in a 25,000ft^2 plant at Thornton Heath.

Turnover is running at over £1 million with £100,000 going for export. The company makes high voltage power supplies. Buy one of those super Cambridge 'Stereoscan' scanning electron microscopes and you'll find the high voltage supply made by Brandenberg.

The lethal punch in Rentokil electronic fly-killers comes from another Brandenberg unit and radar displays, photocopiers, nuclear physics, all are grist to the Brandenberg mill for EHT assemblies. Anything up to 100,000 volts—more if a "special" is required.

BUT GROWTH NECESSARY

Having said all that, it still has to be admitted that growth remains a prime business objective, even with companies like Brandenberg. Nearly all managing directors are dedicated to growth as a desirable end in itself. The challenge is to keep growth profitable. With present rates of inflation it is natural that turnover should increase by, say, 20 per cent a year from the same volume of business, but if running cost increases are in excess of 20 per cent then the company is slipping behind. So you need greater efficiency.

GDS Sales Ltd., the Slough-based component distributors, have now implemented a computerised inventory management and order processing system based on an IBM 3/10 with disk file and video display terminals. The system is the result of over a year of planning and it really does its job. It gives a quicker order turnround for the customer but, equally important, it spins off all the management information needed for true efficiency, especially in stricter control of the £400,000-worth of components stored in the main warehouse. GDS, in one of the most hotly competitive areas of electronics, has doubled turnover in two years and is keeping ahead of the game. In the same period the company has opened distributor operations, though as yet on a smaller scale, in Holland, Switzerland and Denmark.

TOP SECRET

High-flying Racal Electronics Group is still showing the rest how to conduct a profitable world-wide business. Last published figures show increased turnover at £34·62 million and almost £3 million profit. And 1975, despite the prevailing gloom, is again forecast as a record year. Racal chairman Ernest Harrison is one of the most forthright men in the industry. But even he keeps mum over what Racal is up to in the speech privacy market. Last year a new company was formed called Racal-Datacom based in Salisbury. It is manufacturing equipment for speech scrambling—all rather hush-hush and we are told only that "the speech privacy market will grow in the next two years".

Harrison is a firm believer in small companies where people are well-motivated. As soon as a Racal company gets too big for real efficiency it is split and a new company formed. There are acquisitions, too, such as British Physical Laboratories who recently joined the Group.

THE BIG LEAGUE

Of course you've got to be big and have huge resources to cope with projects of great magnitude. Satellites, for example.

This year sees Marconi getting its teeth into MAROTS, the European marine communications satellite due for launch in the Autumn of 1977. Marconi is prime contractor for the satellite payload with a contract price of £11 million.

Hawker Siddeley Dynamics has a budget of £9 million for the spacecraft. And MAROTS itself is only the experimental and pre-operational unit paving the way for a more advanced system.

British Aircraft Corporation has a £1·25 million contract for satellite sub-systems for the ISEE-B in the International Sun Explorer Satellite System. All these satellite contracts have been placed through the European Space Research Organisation.

BAC will also be busy this year working through the backlog of orders for the Rapier low-level air defence missile in which quite a number of electronics companies are engaged on sub-contracts. BAC took orders last year for a staggering £100 million of Rapier systems, the bulk of them from the Middle East. Total Rapier sales are now well over £200 million.

NORTH SEA ELECTRONICS

And whatever the dividends from North Sea oil in the years ahead, there's certainly plenty of business there today. The Post Office, for example, is spending a cool £8 million on quadruple diversity troposcatter systems out to the rigs operated by the Total, Mobil and Occidental Groups. Marconi gets £1·5 million of the work for the shore terminals. Marconi is also supplying huge quantities of other equipment including the privately owned troposcatter links run by BP and Phillips Petroleum.

Nobody has yet worked out the cost of defending the rigs once they become operational. Certainly there will be a need for patrol vessels and aircraft fitted with radar, sonar and communications. It's a whole new world of opportunity for the electronics industry.

Just in case anyone gets the idea that the giants can only move slowly, let me recount a story out of the £200 million a year turnover Pye of Cambridge Group. Pye TVT did a rush job for Australia to get colour TV outside broadcast vans delivered in time for the opening of the colour service on March 1, 1975. By working round the clock a twelve week installation and testing procedure was telescoped to four weeks.

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PATENTS REVIEW...

BANISHING THE STEREO SEAT

Domestic stereo systems suffer from the disadvantage that a good stereo image is obtainable only at that part of the room where the axes of the two speakers intersect. Omni-directional speakers are less critical over listening position, but are unable to produce a truly firm stereo image anywhere in the world. In BP 1 368 070 Andrei Vladimirovich Borisenko, of Leningrad, has a proposal which could well enable a good solid stereo image to be obtained over a wide area of a listening room.

As the inventor points out, image localisation depends on the intensity of sound heard from each loudspeaker and the time at which it arrives at the listener's ears. As the listener varies his position in a room, so both the relative level heard at each ear and the relative arrival time sensed at each ear also varies. The proposal is to use acoustic focusing devices to ensure that the intensity and arrival time of sounds heard by a listener are effectively constant over a wide area of the listening room.

As in conventional systems, two loudspeaker cabinets are used, each with three types of transducer (woofer, tweeter and mid-range) are used. But two mid-range units are arranged in each cabinet as a horizontal pair and they beam their sound into the room via a laminar acoustic lens. This takes the form of a number of vertical parallel plates, see Fig. 1.

BP 1 368 070

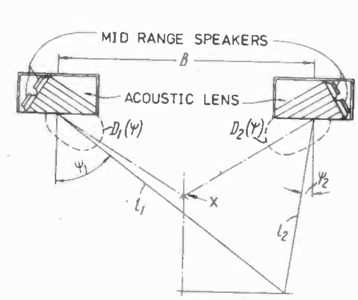

Fig. 1.

The plates are made from wood or plastic, are arranged vertically, and are of varying length. When the listener stands at position *X* the plates have virtually no influence or effect on the sound waves from the mid-range speakers. But as the listener moves away from the position *X* towards one side, the nearest speaker's plates both diminish the level of sound to that ear and delay it in dependence on how close and thus how far off the axis of the plates he is standing.

Obviously, the dimensions and angling of the plates will be critical and the patent suggests that, with the speakers 2·4 metres apart, each should have between six and eight plates, set at 40 degrees to a straight line drawn between the speakers.

PHASE CONVERSION

Single phase supplies may be converted into multi-phase supplies either by using a single phase motor driving a multi-phase alternator or by phase shifting the single phase supply in advance and retard by passive networks.

In BP 1 362 195 Raymond Russell of Newcastle-upon-Tyne claims that accurate phase shift results may be obtained from simpler passive networks, than those usually recommended. He suggests taking as a starting point the observation that a single phase supply can be regarded as an unbalanced three phase system.

In Fig. 1 three identical arms are arranged in delta configuration. Each arm has a resistor *R* and a capacitive impedance Z_C. The reactive component X_C of the impedance Z_C is such that current leads voltage by 60 degrees. A single phase supply is connected across any two of the junction points 1, 2, 3 and the resulting three phase supply is taken off across the three star-connected windings *T*. The windings are connected between neutral point *a* and junction points, *b*, *c*, *d* between the resistors *R* and impedance Z_C.

The inventor specifies that it is essential to arrange for *R* to be equal in magnitude to the 60 degree capacitive impedance Z_C. A null method of achieving this is described by way of example. The first step is to take three nominally equal capacitors and, by putting trimmers in parallel with the two smallest, match them accurately with parallel resistors they are connected at *Z* in Fig. 2.

The next step is to provide, from a balanced three phase supply, three voltage outputs, V_A, V_B and V_C. This is achieved by connecting the supply to 1, 2 and 3 via three adjustable load resistors arranged in star configuration, connecting voltmeters across points 1, 2; 2, 3 and 3, 1 and adjusting the resistors to balance the system. Voltmeters *V* can then be located between *a* and *b*, *c* and *d*, and null deflections obtained with trimmers, see Fig. 2.

It is claimed that a very high order of accuracy can be achieved.

BP 1 362 195

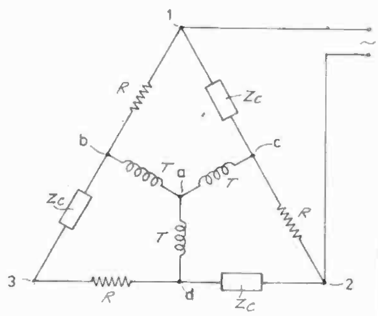

Fig. 1.

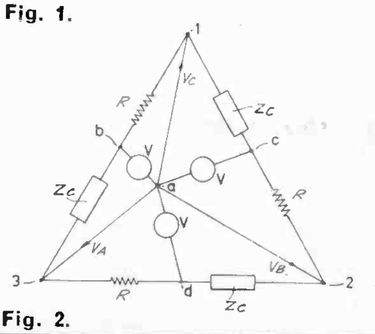

Fig. 2.

Copies of Patents can be obtained from the Patent Office Sales, St. Mary Cray, Orpington, Kent. Price 25p each

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.

I hope this letter may serve to clarify the thoughts of any non-mathematically-minded P.E. readers, especially those who run hotels, and have found unexpected losses on their December balance sheets.

J. Dickson,
Rochester, Kent.

"Wee Morag"

Sir—With regard to Mr Parfitt's letter January issue, I was astounded to discover that "wee Morag" from the local hamburger stall has at last made good, and is serving Boolean Breakfasts, incognito, in a Croydon hotel.

I met the lady under much the same unfortunate circumstances. I had occasion to ask her for "one hamburger with onion, and one without". Imagine my chagrin when I was served with one salt and one pepper, one tomato ketchup and one bill for 45p, but no hamburger and certainly no onion.

I questioned Morag, inquiring as to the whereabouts of the food, only to be told, that, according to Boolean Algebra "hamburger and onion and hamburger and no onion, equals nothing", and was shown a truth table to verify that remarkable statement. The column of zeros at the end of the analysis somewhat overcame me. I must confess, and I was therefore too perplexed to see through the deception. Had I been less staggered, I would have pointed out that a hamburger is neither true nor false; it is instead merely present or absent; and that Boole is correct when his A's and B's are logical statements, and wrong when they are hamburgers and onions (or for that matter, eggs and bacon).

Alistair C. Thompson,
Lanarkshire.

On the table

Sir—The fallacy lies in the use of A + A.B = A to describe Mr Parfitt's breakfast, see *Readout*, January issue. This equation is good only when A and B are independent events.

The breakfast choice was "egg or egg and bacon". The "egg and bacon" is really "bacon if and only if egg and bacon together", which is not A.B (in Mr Parfitt's notation) but $B \equiv A.B$. Thus we have to consider two breakfasts (mutually exclusive)

Egg (A) or
Egg and bacon ($B \equiv A.B$)
in an enclosure OR relationship.

Mr M. J. Hughes dealt with this in "Logic Tutor", Part 5 (P.E. Sept. 1973) and gives the equation

$Q = A\bar{B} + B\bar{A}$

with truth table

A	B	Q
0	0	0
1	0	1
0	1	1
1	1	0

No one can say that some P.E. readers are guilty of not doing their homework.

C. F. Tozer,
Dorset.

Misconception

Sir—There is a very simple answer to Mr Parfitt's problem (*Readout*, January 1975).

By applying his own brand of mathematical analysis, he should have seen that he had only to walk out of the hotel or walk out and pay his bill. He would then argue that both courses of action are equivalent to the first, and he would never notice that he had paid his bill in full.

To be more serious, the apparent paradox comes from a misconception of the nature of Boolean variables. In the expression: A + (AB) = A, "A" and "B" are statements which may be "true" or "false". The expression should be read "If A, or both A and B are true, then A is true."

When written in this manner the validity of the expression is patently obvious.

The paradox of the "Boolean bed and breakfast" arises because Mr Parfitt has thought of Boolean variables as objects instead of as statements.

Bacon and eggs

Sir,—One of the wonderful attractions of mathematics is how easily confusion can arise. Confusion is wonderful because it is the opposite to "Blue Peter": it can be resolved only by going into it more deeply, providing great pleasure and satisfaction.

In mathematics many different algebras use the same symbols for different meanings, + and . vary according to whether they are applied to numbers, vectors, matrices, sets, truth statements, switching circuits or whatever. Mathematicians deliberately introduce this joyous confusion in order that it should be resolved *by comparing the different algebras*. If this comparison is not done, you may as well have different symbols for each different algebra (as in O-level SET algebra which use ∪ and ∩ instead, reducing the depth to superficial levels).

If we were in the algebra of numbers, then given

$$A.B + A = A$$

we could deduce A.B = 0 by subtracting A from both sides or by adding −A to both sides. But in Boolean algebra, + does not mean number or quantity addition, and subtraction does not exist.

If comparison is not acceptable, the alternative is to put more depth into the Boolean algebra: + meaning "either one or other or both" and "=" also not being straightforward. In the eggs and bacon situation, the algebra should be interpreted as "Given Bacon and Eggs or Eggs, necessarily implies being given Eggs." The nearest to the number−A in Boolean algebra is $\bar{A}$ meaning the opposite of A (no eggs or maybe the rest of the menu).

If $\bar{A}$ is used the A.B + A = A gives $\bar{A}.A.B + \bar{A}.A = \bar{A}.A$ which gives 0 = 0

Translated this means that although the study of mathematics, or breakfasts or waitresses or managers can give 1/0 pleasure, staying in hotels always leaves one penniless.

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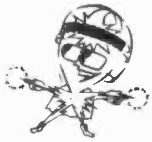

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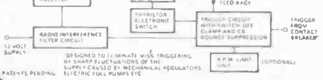

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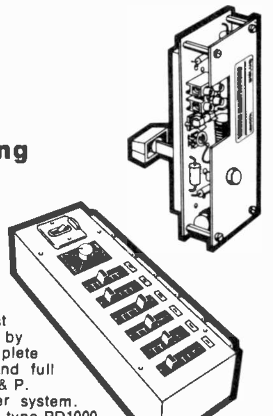

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CF—High Stab Carbon Film, 5% MF—High Stab Metal Film, 5%.

W.	Type	Range	1–99	100–499	500–999	1000 +	Size mm
⅛	CF	12–1M	1	0·75	0·60	0·55	2·4x7·5
¼	CF	22–2M2	1	0·75	0·60	0·55	3·9x10·5
½	CF	22–1M	1	0·75	0·60	0·55	5·5x16
¼	MF	10–2M7	2	1·54	1·32	1·1	3x7
½	MF	10–2M2	2	1·43	1·21	0·99	4·2x10·8
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3·3μF	63V	6½p	100μF	25V	6½p
4·0μF	40V	6½p	100μF	63V	14p
4·7μF	63V	6½p	150μF	16V	6½p
6·8μF	63V	6½p	150μF	63V	15p
8·0μF	40V	6½p	220μF	6·4V	6½p
10μF	16V	6½p	220μF	10V	6½p
10μF	25V	6½p	220μF	16V	8p
10μF	63V	6½p	220μF	63V	21p
15μF	16V	6½p	330μF	16V	12p
15μF	63V	6½p	330μF	63V	25p
16μF	40V	6½p	470μF	6·4	9p
22μF	25V	6½p	470μF	40V	20p
22μF	63V	6½p	680μF	16V	15p
32μF	10V	6½p	680μF	40V	25p
33μF	16V	6½p	1000μF	16V	20p
33μF	40V	6½p	1000μF	25V	25p
32μF	63V	6½p	1500μF	6·4V	15p
47μF	10V	6½p	1500μF	16V	25p
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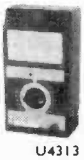

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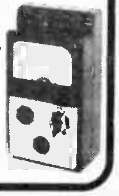

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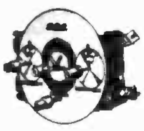

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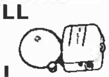

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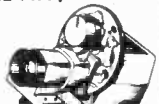

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750W Solid State Fader, with three functions. Manual fade; Auto fade-up; Auto fade-down. Automatic cycling up and down. Functions selected with 'three-position' rocker switch. Two ranges of cycling for 'Flashing' or 'Slow blending'. Ready built module 6″ × 3″ glass fibre board incorporating 10 amp TRIAC. Two or more modules for top quality colour blending and flashing effects. PRICE **£15.** Post 30p.
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Superior Quality Precision Made
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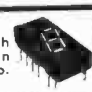

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Col.(1) Coil ohms
Col. (2) Working d.c. volts
Col. 3 Contracts
Col. (4) Price
HD = Heavy duty

1	2	3	4
52	4–8	2 c/o	**70p**
58	5–9	6 c/o	**80p**
185	8–12	6M	**60p•**
230	9–18	2 c/o	**70p**
308	9–14	4 c/o	**75p•**
430	15–24	4 c/o	**80p**
700	16–24	4M 2B	**60p•**
700	16–24	4 c/o	**80p•**
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2,500	36–45	6M	**60p**
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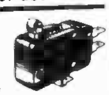

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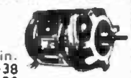

(Type J) 71 r.p.m. torque 10 lb. in. **Reversible 1/70th** h.p. cycle 0·38 amp. **(Type 2) 28 r.p.m.** torque 20 lb. in **Reversible 1/80th** h.p. 50 cycle 0·28 amp. The above two precision made U.S.A. motors are offered in 'as new' condition. Input voltage of motor 115v A.C. Supplied complete with transformer for **230/240v A.C. input.**
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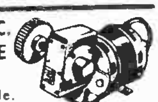

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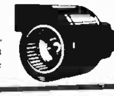

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27/A	12V	17M/A	700	All
21/A	12V	28M/A	430	£1·30
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Heavy duty contacts 2,500 ohm coil. All new and unused D.P.D.T. mains relays 50p, Carr. free. Special quantity £40 per 100 off.

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Varnish Impregnated
Size 45mm × 36mm × 31mm

PRI 240V

Sec	3.0·3	100mA
Sec	6·0·6	100mA
Sec	9·0·9	100mA
Sec	12·0·12	100mA
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Specification:
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170W r.m.s. sq. wave 300W instantaneous peak into 8 ohm (60W into 16 ohm).

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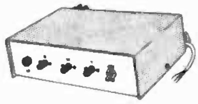

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149	60	3	12	9·9 × 7·7 × 8·6	3·98	45
150	100	5	8	9·9 × 8·9 × 8·6	4·45	45
151	200	8	0	12·1 × 9·3 × 10·2	7·39	53
152	250	13	12	12·1 × 11·8 × 10·2	8·93	73
153	350	15	0	14·0 × 10·8 × 11·8	10·80	73
154	500	19	8	14·0 × 13·4 × 11·8	12·41	91
155	750	29	0	17·2 × 14·0 × 14·0	18·65	*
156	1000	38	0	17·2 × 16·6 × 14·0	26·50	*
157	1500	46	0	21·6 × 13·4 × 18·1	30·23	*
158	2000	60	0	21·6 × 15·3 × 18·1	33·70	*

AUTO TRANSFORMERS

Ref. No.	VA (Watts)	Weight lb	oz	Size cm.	Auto Taps	£	P & P p
113	20	1	0	5·8 × 5·1 × 4·5	0-115-210-240	1·52	30
64	75	2	4	7·0 × 6·7 × 6·1	0-115-210-240	2·64	38
4	150	3	4	8·9 × 7·7 × 7·7	0-115-200-220-240	3·75	45
66	300	6	4	9·9 × 9·6 × 8·6	,, ,,	5·29	53
67	500	12	8	12·1 × 11·2 × 10·2	,, ,,	8·02	67
84	1000	19	8	14·0 × 13·4 × 14·3	,, ,,	12·44	91
93	1500	30	4	14·0 × 15·9 × 14·3	,, ,,	16·65	*
95	2000	32	0	17·2 × 16·6 × 14·0	,, ,,	22·00	*
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213	1·0	0·5	1	4	6·1 × 5·8 × 4·8	0-12V at 0·5A × 2	1·58	30
71	2	1	1	12	7·0 × 6·4 × 6·1	0-12V at 1A × 2	2·09	38
18	4	2	2	12	8·3 × 7·7 × 7·0	0-12V at 2A × 2	2·60	38
70	6	3	3	8	8·9 × 8·0 × 7·7	0-12V at 3A × 2	3·75	45
108	8	4	5	8	9·9 × 8·9 × 8·6	0-12V at 4A × 2	4·15	45
72	10	5	6	4	9·9 × 9·6 × 8·6	0-12V at 5A × 2	4·67	53
116	12	6	6	12	9·9 × 10·2 × 8·6	0-12V at 5A × 2	5·02	53
17	16	8	8	12	12·1 × 9·9 × 10·2	0-12V at 8A × 2	6·62	60
115	20	10	11	8	14·0 × 9·6 × 11·8	0-12V at 10A × 2	9·45	73
187	30	15	15	8	14·0 × 12·1 × 11·8	0-12V at 15A × 2	12·29	85
226	60	30	32	0	17·2 × 15·3 × 14·0	0-12V at 30A × 2	15·30	*

30 VOLT RANGE

Ref. No.	Amps	Weight lb	oz	Size cm.	Secondary Taps	£	P & P p
112	0·5	1	4	6·1 × 5·8 × 4·8	0-12-15-20-24-30V	1·65	30
79	1·0	2	4	7·0 × 6·7 × 6·1	,, ,,	2·18	38
3	2·0	3	4	8·9 × 7·7 × 7·7	,, ,,	3·18	38
20	3·0	4	8	9·9 × 8·3 × 8·6	,, ,,	4·12	45
21	4·0	6	4	9·9 × 9·6 × 8·6	,, ,,	4·67	53
51	5·0	6	12	12·1 × 8·6 × 10·2	,, ,,	5·83	53
117	6·0	8	0	12·1 × 9·3 × 10·2	,, ,,	6·51	60
88	8·0	12	0	12·1 × 11·8 × 10·2	,, ,,	9·00	67
89	10·0	13	12	14·0 × 10·2 × 11·8	,, ,,	8·97	73

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Ref. No.	Amps.	Weight lb	oz	Size cm.	Secondary Taps	£	P & P p
102	0·5	1	12	7·0 × 6·4 × 6·1	0-19-25-33-40-50V	2·35	30
103	1·0	2	12	8·3 × 7·4 × 7·0	,, ,,	3·08	38
104	2·0	5	8	7·9 × 8·9 × 8·6	,, ,,	4·26	45
105	3·0	6	12	9·9 × 10·2 × 8·6	,, ,,	5·28	53
106	4·0	10	0	12·1 × 10·5 × 10·2	,, ,,	6·91	67
107	6·0	12	0	14·0 × 10·2 × 11·8	,, ,,	11·00	67
118	8·0	18	0	14·0 × 12·7 × 11·8	,, ,,	11·80	85
119	10·0	25	0	17·2 × 12·7 × 14·0	,, ,,	15·45	*

60 VOLT RANGE

Ref. No.	Amps.	Weight lb	oz	Size cm.	Secondary Taps	£	P & P p
124	0·5	2	4	7·0 × 6·7 × 6·1	0-24-30-40-48-60V	2·12	38
126	1·0	3	4	8·9 × 7·7 × 7·7	,, ,,	3·10	38
127	2·0	6	4	9·9 × 9·6 × 8·6	,, ,,	4·62	45
125	3·0	8	12	12·1 × 9·9 × 10·2	,, ,,	6·84	60
123	4·0	13	12	12·1 × 11·8 × 10·2	,, ,,	7·96	67
40	5·0	12	00	14·0 × 10·2 × 11·8	,, ,,	8·87	73
120	6·0	15	8	14·0 × 12·1 × 11·8	,, ,,	10·27	85
121	8·0	25	00	14·0 × 14·7 × 11·8	,, ,,	13·64	*
122	10·0	25	0	17·2 × 12·7 × 14·0	,, ,,	15·93	*
189	12·0	29	00	17·2 × 14·0 × 14·0	,, ,,	18·16	*

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212	1A, 1A	1	4	6·1 × 5·8 × 4·8	0-6, 0-6	1·67	30
13	100		4	3·9 × 2·6 × 2·9	9-0-9	1·28	13
235	330, 330		4	4·8 × 2·9 × 3·5	0-9, 0-9	1·42	19
207	500, 500	1	00	6·1 × 5·4 × 4·8	0-8-9, 0-8-9	1·75	30
208	1A, 1A	1	12	7·0 × 6·4 × 6·1	0-8-9, 0-8-9	3·00	38
236	200,200		4	4·8 × 2·9 × 3·5	0-15, 0-15	1·30	19
214	300, 300	1	4	6·1 × 5·8 × 4·8	0-20, 0-20	1·76	30
221	700 (d.c.)	1	8	7·0 × 6·1 × 6·1	20-12-0-12-20	1·98	38
206	1A, 1A	2	12	8·3 × 7·7 × 7·0	0-15-20, 0-15-20	3·15	38
203	500,500	2	4	8·3 × 7·0 × 7·0	0-15-27, 0-15-27	2·73	38
204	1A, 1A	3	4	8·9 × 7·7 × 7·7	0-15-27, 0-15-27	3·50	38

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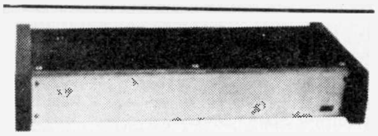

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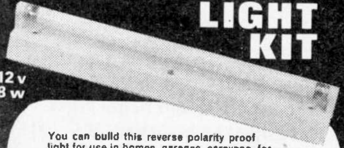

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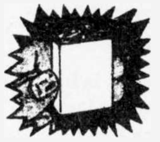

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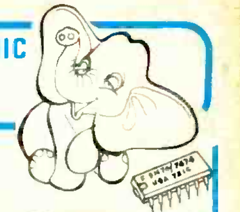

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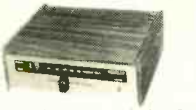

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104	9 volt 1 watt	3·10
304	9 volt 3 watt	3·95
555	12 volt 3 watt	4·10
5555ST	12 volt 1½ + 1½ watt	5·95
E1208	12 volt 5 watt	5·10
608	24 volt 10 watt	4·95
410	28 volt 10 watt	4·95
620	45 volt 30 watt	9·95
Z40	30/35 volt 15 watt	5·45
Z60	45/50 volt 25 watt	6·95
SA6817	24 volt 6 + 6	10·20

Amplifiers with controls

E1210	12 volt 2½ + 2½ watts 8 ohms	8·25
R500	Mains 5 watts 4–16 ohms	6·30
SAC 14	Mains 7 + 7 watts 8 ohms	11·75
SAC30	Mains 15 + 15 watts 8 ohms	14·95
CAO38	9 volt 1½ + 1½ watts 8 ohms	6·95
CAO68	12 volt 3 + 3 watts 8 ohms	10·50

AM/FM MODULES

Mullard LP 1186 FM tuner (front end) with data 10·7 MHZ O/P	4·85
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Mullard LP 1185 10·7 MHZ IF unit with data	4·50

FM & AM TUNERS & DECODERS

FM5231 (TU2) 6 volt FM tuner	7·95
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*P15 28V, ½A	3·30
*P1080 12V 1A 4 70	7·80
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P12 4½–12V 0·4–1A	7·15
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