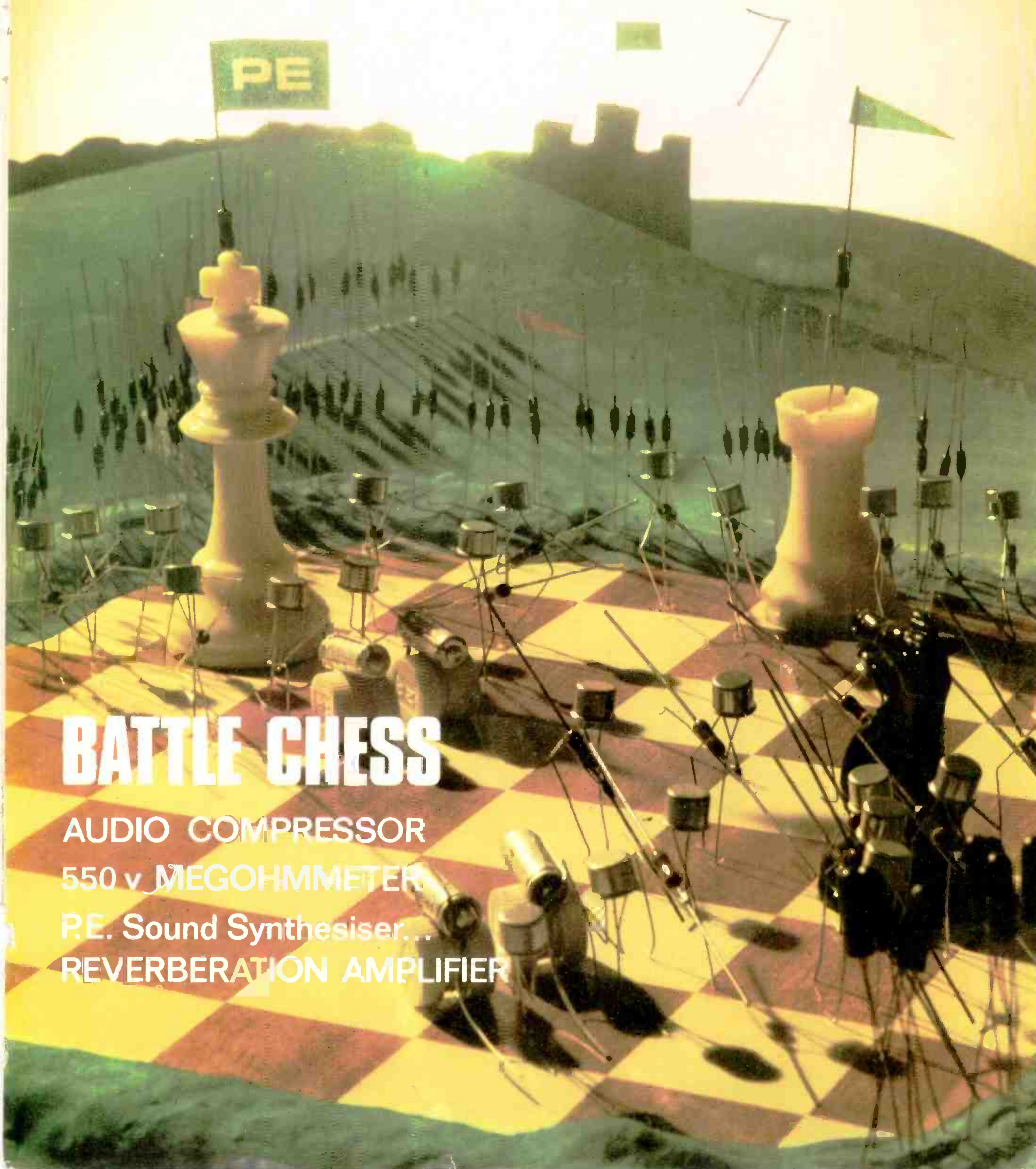
PRACTICAL

ELECTRONICS

AUGUST 1973

20p



BATTLE CHESS

AUDIO COMPRESSOR

550 v MEGOHMMETER

P.E. Sound Synthesiser...

REVERBERATION AMPLIFIER

PRACTICAL
ELECTRONICS
VOLUME 9 No. 8 AUGUST 1973

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

NEWS AND COMMENT

Our September issue will be published on Friday, August 10, 1973

SAXON ENTERTAINMENTS LTD.

STANDARD & CUSTOM-BUILT AUDIO & ELECTRONIC EQUIPMENT. NEW & SECONDHAND MUSICAL INSTRUMENTS. DISTRIBUTORS FOR A.K.G. HIGH QUALITY MICROPHONES

Announcing our improved range of constructor modules

FOR DOMESTIC & COMMERCIAL USE

New Versions using 3A "Plastic Power" Driver Transistors now available.

To meet demand, we have included a more powerful module in our well-established and proven range. All these power amplifiers are carefully assembled, tested and guaranteed. They offer superb value for reliability and versatility.

SA35 35W RMS uses 7 transistors and 7 diodes. Carr. paid. **£4·45**

A NEW ADDITION IS THE

SA50 at £5·65

Carr. paid. A rugged, well built unit, capable of 50W RMS out, with all the advantages of Saxon Amplifier design and quality. Ready now.

SA100 makes an ideal unit in disco assemblies

A real glutton for work. Reliable, tough and compact. 11 transistors, 6 diodes. Carr. paid. **£10·90**

BRIEF SPEC. FOR ALL THREE MODULES

Freq. response	15–40,000Hz ± 1dB	All modules incorporate OPEN AND SHORT CIRCUIT PROTECTION, plus proof against over-dissipation and faulty inductive loads in its SA100
Distortion	0·2% at 1kHz	
Loads	4 to 16 ohms	
Quiescent current	15mA	
Noise	Better than −75dB	
Supply voltage	SA35–45V SA50 45/65V SA100 40–70V	
Size	4½in × 4in × 1in (SA100) 4in × 3in × 1in (SA35/SA50)	

Circuits, connecting instruction and application data are supplied free with all modules.

POWER SUPPLIES FOR THE SA25/35 & SA100 AUDIO MODULES

PU45	Unstabilised supply for 2 SA25/35's	£4·90
PU70	Unstabilised supply for one or two SA100	£7·75 carr. 40p
PS45	Stabilised module for 2 SA25's or two SA35's	£3·50 carr. free
MT45	Transformer for above, heavy duty	£2·85 carr. 20p
MT30	Transformer for unstabilised supply complete with rectifier diodes mounted	£3·50 carr. 20p
PS70	Stabilised supply module for one or two SA100's	£4·90 carr. free
MT70	Transformer for PS70	£4·90 carr. 40p

ALL MODULES ARE BUILT ON GLASS FIBRE P.C. BOARD AND SUPPLIED FULLY TESTED

TWO NEW PA/MIXER CONTROL UNITS

Built for hard work!

In extra slimline easy-fit case.

Using grouped pairs of inputs (high Z and low Z inputs) with individual bass, treble and volume controls on each pair, plus master controls. These low-noise units will feed all makes of amplifiers, making them ideal for clubs, discos, etc. Standard jack sockets, compact design. In strong metal cases. All Units guaranteed for 3 years.

- **HIGH AND LOW IMPEDANCE INPUTS**
- **BASS/TREBLE/VOLUME ON EACH PAIR**
- **MASTER CONTROL ON OUTPUT**

M4H

4 high Z, 4 low Z inputs, 4 sets of controls. Case 10" × 8" and only 2½in deep. Carr. paid. **£18·50 + V.A.T.**

M6HL

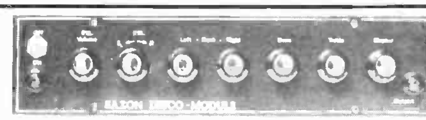
12 inputs (6 high Z, 6 low Z). Carr. paid 18" × 8" × 2½". **£27·50 + V.A.T.**

Channel section modules, for building your own: gain—16 × (24dB) Tone controls—18dB swing. Carr. paid. **£3·50 + V.A.T.**

CONTROL UNITS

Mono (as shown). Carr. 20p. **£6·50**

Stereo. Carr. 30p. **£15·80**



Two decks, and full headphone monitoring. The unit is mains operated and measures 17½in × 3in × 4in deep and is finished with a smart white on black facia. The controls are: Left/Right deck fader, volume, bass, treble, Headphone Selector and volume. Microphone volume, bass treble, mains on/off.

COMPARABLE TO UNITS AT OVER TWICE THE PRICE. (N.B.—Stereo only has mic. Input.)

PLEASE ADD 10% FOR V.A.T. TO TOTAL VALUE OF YOUR ORDER

S.A.E. brings Saxon equipment and bargains list

- 160 watts version with power supply (Carr. 50p) **£27·90**

120 WATT HEAVY DUTY MODULE

Rugged class A driver stage. This module will run from all our mixers, etc., and most other makes. Delivers 120W into an eight ohm load and employs 4 TO3 can (115W) output transistors.

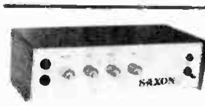
SPECIFICATION

Power output, 120W into 8 ohms
Freq. response, 20–20,000Hz ± 2dB
Input sensitivity, 200mV into 10K
Construction, Fibreglass board
Size, 8in × 4in × 4in (5in with supply)
Low distortion parallel push-pull output stage.

Module only (Carr. 20p) **£13·90**

Module and power supply (Carr. 40p) **£18·95**

SOUND AND LIGHT UNITS



Our popular 3 channel model handles up to 3kW (3,000W) of lighting and incorporates versatile sound control arrangement to enable professional standards to be achieved. Both units are excellent examples of Saxon quality and value.

3 CHANNEL UNIT

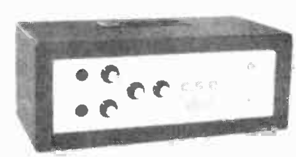
Includes bass, middle and treble as well as master controls, 2 amplifier sockets eliminate need for split leads. Up to 3kW lighting load. Smartly finished steel case. Carr. 30p. **£19·75**

SINGLE CHANNEL UNIT

Operates from 5–100W amplifiers. Supplied for bass note operation, is easily adapted for treble or mid-range at a cost of about 5p. Carr. pd. **£8·90**

COMPLETE AMPLIFIERS

CSE 100 £34·90 carr. free



This versatile unit is now available in a black vynide case and so represents even better value than ever delivering speech and music powers of up to 100W RMS and continuous signal outputs of 70W. Two individually controlled inputs with wide range bass and treble controls.

SAXON 100 £48·50 carr. free

With an RMS output of 120W speech and music, 100W continuous power, four individually controlled FET input stages and wide range bass and treble controls, this amplifier has established itself as a unit offering quality and reliability at low cost.

LOUDSPEAKERS British made bargains!! 12in 25W 8/15 ohms £5·95 carr. 30p. 15in 50W 8/15 ohm £14·50 carr. 50p. 12in 40W 15,000 gauss magnet system 8/15 ohm £11·50 carr. 40p.

600 Watt 3 colour Light Boxes Smart Rexine finish £15 carr. free.

A.K.G. MICROPHONES

D11 DHL IDEAL DISCO MIKE ONLY £9·45 (rrp £11·00). S.A.E. for special price list.

Order and personal shoppers to:

SAXON ENTERTAINMENTS LTD., 329 Whitehorse Road, W. Croydon, Surrey CRO 2HS

Telephone 01-684 6385
From 9.30 a.m.-5.30 p.m.

Prices quoted do not include V.A.T. 10% must be added on to total value of order for V.A.T

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TERMS OF BUSINESS

Cash with order (C.W.O.). For C.O.D. please add 35p extra, cash by regd. letter please.

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COMPLETE TELEPHONES

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ONLY £1·05

POST & PACKING 45p EACH

TELEPHONE DIALS

Standard Post Office type. Guaranteed in working order.

ONLY 27½p

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TESTED AND GUARANTEED PAKS

B79	4	IN4007 Sil. Rec. diodes. 1,000 PIV 1 amp. plastic	55p
B81	10	Reed Switches, 1" long ⅛" dia. Highspeed P.O. type	55p
B99	200	Mixed Capacitors. Approx. quantity, counted by weight	55p
H4	250	Mixed Resistors. Approx. quantity counted by weight	55p
H7	40	Wirewound Resistors. Mixed types and values	55p
H9	2	OCP71 Light Sensitive Photo Transistor	55p
H28	20	OC200/1/2/3 PNP Silicon uncoded TO-5 can	55p
H30	20	1 Watt Zener Diodes. Mixed Voltages 6·8–43V	55p
H35	100	Mixed Diodes, Germ. Gold bonded, etc. Marked and Unmarked	55p
H38	30	Short lead Transistors, NPN Silicon Planar types	55p
H39	10	Integrated circuits 6 gates BMC 962, 4 flip flops BMC 945	55p
H40	20	BFY 50/2, 2N696, 2N1613, NPN Silicon uncoded TO-5	55p
H41	2	BD131/BD132 Complementary Plastic Transistors	55p

UNMARKED UNTESTED PAKS

B1	50	Germanium Transistors PNP, AF and RF	55p
B66	150	Germanium Diodes Min. glass type	55p
B83	200	Trans. manufacturers' rejects all types NPN; PNP, Sil. and Germ.	55p
B84	100	Silicon Diodes DO-7 glass equiv. to OA200, OA202	55p
B86	100	Sil. Diodes sub. min. IN914 and IN916 types	55p
B88	50	Sil. Trans. NPN, PNP equiv. to OC200/1 2N706A, BSY95A, etc.	55p
H6	40	250mW. Zener Diodes DO-7 Min. Glass Type	55p
H15	30	Top Hat Silicon Rectifiers, 750mA. Mixed volts	55p
H16	15	Experimenters' Pak of Integrated Circuits. Data supplied	55p
H17	20	3 amp. Silicon Stud Rectifiers, mixed volts	55p
H20	20	BY126/7 Type Silicon Rectifiers 1 amp. plastic. Mixed volts	55p
H34	15	Power Transistors, PNP, Germ. NPN Silicon TO-3 Can	55p

MAKE A REV COUNTER FOR YOUR CAR

The 'TACHO BLOCK'. This encapsulated block will turn any 0-1mA meter into a linear and accurate rev. counter for any car with normal coil ignition system.

£1·10 each

OVER

1,000,000

TRANSISTORS IN STOCK

We hold a very large range of fully marked, tested and guaranteed transistors, power transistors, diodes and rectifiers at very keen prices. Please send for free catalogue.

600,000 Silicon planar plastic transistors. Unmarked, untested, factory clearance. A random sampling showed these to be of remarkably high quality.

Audio PNP, similar to ZTX500, 2N3702/3, BCY70, etc.

Audio NPN, similar to ZTX300, 2N3708/9 BC107/8/9, BC168/9, etc.

Please state Audio NPN or Audio PNP when ordering.

ALL AT 500 for **£3·30**, 1,000 for **£5·50**, 10,000 for **£44**.

P & P 11p per 1,000

OUR VERY POPULAR 4p TRANSISTORS

TYPE "A" PNP Silicon Alloy, TO-5 can.
TYPE "B" PNP Silicon, plastic encapsulation.
TYPE "E" PNP Germanium AF or RF.
TYPE "F" NPN Silicon plastic encapsulation.
TYPE "G" NPN Silicon, similar ZTX300 range.
TYPE "H" PNP Silicon, similar ZTX500 range.

8 RELAYS FOR VARIOUS TYPES P & P 27½p £1·10

Our famous PI Pak is still leading in value for money

Full of Short Lead Semiconductors and Electronic Components, approx. 170. We guarantee at least 30 really high quality factory marked Transistors PNP and NPN, and a host of Diodes and Rectifiers mounted on Printed Circuit Panels. Identification Chart supplied to give some information on the Transistors.

Please ask for Pak P.I. Only 55p. 11p P & P on this Pak.

A CROSS HATCH GENERATOR FOR £3·85 !!!

YES, a complete kit of parts including Printed Circuit Board. A four position switch gives X-hatch, Dots, Vertical or Horizontal lines. Integrated Circuit design for easy construction and reliability. This is a project in the September edition of Television.

This complete kit of parts costs £3·85, post paid.

A MUST for Colour T.V. Alignment.

STEREO DECODER £4·95

A ready built unit, ready for connection to the I.F. stages of your existing FM Radio or Tuner Unit. A tell tale light can be connected to show the presence of a Stereo transmission and correct operation of the Unit.

The Unit is in the form of a small printed circuit, and no further alignment is necessary, as all preset adjustments have already been carried out at the factory.

It is recommended that a L.E.D. is used as the indicating light and a suitable device is available from us at 36½p.

Supplied with necessary instructions and written guarantee.

FREE CATALOGUE FOR

TRANSISTORS, RECTIFIERS, DIODES, INTEGRATED CIRCUITS, FULL PRE-PAK LISTS

100,000 Plastic Power Transistors

in stock, more on way!

NOW IN TWO RANGES

These are 40W and 90W Silicon Plastic Power Transistors of the very latest design, available in NPN or PNP at the most shatteringly low prices of all time. We have been selling these successfully in quantity to all parts of the world and we are proud to offer them under our Tested and Guaranteed terms.

Range 1	VCE Min. 15	HFE Min. 15	
	1–12	13–25	26–50
40 watt	22p	20p	18p
90 watt	26½p	24½p	22p
Range 2	**VCE Min. 40**	**HFE Min. 40**	
	1–12	13–25	26–50
40 watt	33p	31p	29p
90 watt	38½p	36½p	33p

Complementary pairs matched for gain at 3 amps. 11p extra per pair. Please state NPN or PNP on order.

INTEGRATED CIRCUITS. We stock a large range of I.C.s at very competitive prices (from 11p each). These are all listed in our FREE Catalogue, see coupon below.

METRICATION CHARTS now available. This fantastically detailed conversion calculator carries thousands of classified references between metric and British (and U.S.A.) measurements of length, area, volume, liquid measure, weights, etc. Pocket Size, **15p**, Wall Chart, **18p**.

LOW COST DUAL IN LINE I.C. SOCKETS

14 pin type at 16½p each } Now new low
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Characteristics of 3,000 valves and tubes, 4,500 Transistors, Diodes, Rectifiers and Integrated Circuits.

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	1	25	100+		1	25	100+
SN7400	0·17	0·16	0·13	SN7486	0·35	0·34	0·33
SN7401	0·17	0·16	0·13	SN7489	6·05	5·78	5·50
SN7402	0·17	0·16	0·13	SN7490	0·74	0·71	0·64
SN7403	0·17	0·16	0·13	SN7491	1·10	1·05	0·99
SN7404	0·17	0·16	0·13	SN7492	0·74	0·71	0·64
SN7405	0·17	0·16	0·13	SN7493	0·74	0·71	0·64
SN7406	0·39	0·34	0·31	SN7494	0·85	0·82	0·75
SN7407	0·39	0·34	0·31	SN7495	0·35	0·82	0·75
SN7408	0·20	0·14	0·18	SN7496	0·86	0·93	0·86
SN7409	0·20	0·19	0·18	SN74100	1·82	1·76	1·71
SN7410	0·17	0·16	0·13	SN74104	1·07	1·04	0·97
SN7411	0·28	0·24	0·26	SN74105	1·07	1·04	0·97
SN7412	0·39	0·34	0·31	SN74107	0·44	0·42	0·40
SN7413	0·32	0·29	0·27	SN74110	0·51	0·59	0·55
SN7416	0·48	0·44	0·42	SN74111	1·38	1·27	1·21
SN7417	0·48	0·44	0·42	SN74118	1·10	1·05	0·99
SN7420	0·17	0·16	0·13	SN74119	1·40	1·38	1·21
SN7422	0·55	0·53	0·50	SN74121	0·44	0·41	0·38
SN7423	0·55	0·53	0·50	SN74122	1·54	1·43	1·21
SN7425	0·55	0·53	0·50	SN74123	3·08	2·97	2·86
SN7426	0·50	0·46	0·44	SN74141	0·74	0·71	0·64
SN7427	0·50	0·46	0·44	SN74145	1·65	1·54	1·43
SN7428	0·77	0·72	0·66	SN74150	3·30	2·97	2·75
SN7430	0·17	0·16	0·13	SN74151	1·10	1·05	0·99
SN7432	0·50	0·46	0·44	SN74153	1·32	1·21	1·05
SN7433	0·88	0·83	0·77	SN74154	1·98	1·87	1·76
SN7437	0·71	0·68	0·66	SN74155	1·54	1·43	1·32
SN7438	0·71	0·68	0·66	SN74156	1·54	1·43	1·32
SN7440	0·17	0·16	0·13	SN74157	2·09	1·98	1·87
SN7441	0·74	0·71	0·64	SN74160	1·98	1·87	1·76
SN7442	0·74	0·71	0·64	SN74161	1·98	1·87	1·76
SN7443	1·43	1·88	1·32	SN74162	4·40	4·13	3·85
SN7444	1·43	1·38	1·32	SN74163	4·40	4·13	3·85
SN7445	1·98	1·95	1·93	SN74164	2·42	2·37	2·31
SN7446	1·07	1·04	0·97	SN74165	2·48	2·42	2·37
SN7447	1·10	1·07	1·05	SN74166	3·85	3·58	3·30
SN7448	1·10	1·07	1·05	SN74174	2·53	2·42	2·31
SN7450	0·17	0·18	0·13	SN74175	1·76	1·65	1·54
SN7451	0·17	0·16	0·13	SN74176	2·75	2·64	2·53
SN7453	0·17	0·16	0·13	SN74177	2·75	2·64	2·53
SN7454	0·17	0·16	0·13	SN74180	2·20	1·76	1·54
SN7460	0·17	0·16	0·13	SN74181	6·05	5·50	5·23
SN7470	0·32	0·29	0·27	SN74182	2·20	1·98	1·76
SN7472	0·32	0·29	0·27	SN74184	3·85	3·58	3·30
SN7473	0·41	0·39	0·35	SN74190	2·15	2·09	2·04
SN7474	0·41	0·39	0·35	SN74191	2·09	2·04	1·98
SN7475	0·50	0·48	0·46	SN74192	2·15	2·09	2·04
SN7476	0·44	0·43	0·43	SN74193	2·20	1·98	1·93
SN7480	0·74	0·71	0·64	SN74194	2·97	2·86	2·75
SN7481	1·32	1·27	1·21	SN74195	2·20	2·09	1·98
SN7482	0·96	0·95	0·94	SN74196	1·98	1·87	1·76
SN7483	1·21	1·16	1·05	SN74197	1·98	1·87	1·76
SN7484	1·10	1·05	0·99	SN74198	6·05	5·50	4·95
SN7485	3·96	3·85	3·74	SN74199	6·05	5·50	4·95

LINEAR I.C.'s—FULL SPEC.

Type No.	Price 1–24	25–99	100+
BP201C—SL201C	0·70	0·59	0·50
BP710C—SL701C	0·70	0·55	0·50
BP702C—SL702C	0·70	0·55	0·50
BP702—72702	0·59	0·50	0·44
BP709—72709	0·40	0·39	0·33
BP709P—μA709C	0·40	0·38	0·33
BP710—72710	0·40	0·46	0·44
BP711—μA711	0·40	0·48	0·44
BP741—72741	0·55	0·50	0·45
μA703C	0·31	0·29	0·27
TAA263	0·77	0·66	0·61
TAA293	0·99	0·83	0·77
TAA350	1·87	1·74	1·65
EA1000	2·90		

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LOGIC DTL 930 Series I.C's

Type No.	Price 1–24	25–99	100 up
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BP933	0·14	0·13	0·12
BP935	0·14	0·13	0·12
BP936	0·14	0·13	0·12
BP944	0·14	0·13	0·12
BP945	0·28	0·27	0·24
BP946	0·13	0·12	0·11
BP948	0·28	0·27	0·24
BP951	0·72	0·66	0·61
BP962	0·13	0·12	0·11
BP9093	0·44	0·42	0·39
BP9094	0·44	0·42	0·39
BP9097	0·44	0·42	0·39
BP9099	0·44	0·42	0·39

NUMERICAL INDICATOR TUBES

MODEL	CD66	GR116	3015F Minitron
Anode Voltage (Vdc)	170min	175min	5
Cathode Current (mA)	2·3	14	8
Numerical Height (mm)	16	13	9
Tube Height (mm)	47	32	22
Tube Diameter (mm)	19	13	12 wide
I.C. Driver Rec.	BP41 or 141	BP41 or 141	BP47
PRICE EACH	£1·87	£1·70	£1·50

All indicators 0·9 + Decimal point. All side viewing. Full data for all types available on request.

RTL MICROLOGIC CIRCUITS

Epoxy TO-5 case	Price each 1–24	25–99	100 up
μL900 Buffer	38p	36p	29p
μL914 Dual 2i/p gate	38p	36p	29p
μL923 J-K flip-flop	55p	51p	49p

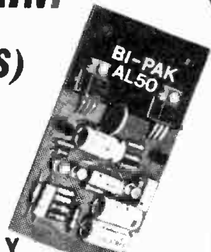
Date and Circuits Booklet for IC's Price 8p.

DUAL IN LINE SOCKETS

(14 & 16 Lead)	1–24	25–99	100+
TSO14	0·33	0·30	0·28
TSO16 16 pin type	0·34	0·35	0·33
BP814 14 pin type (low cost)	0·17	0·15	0·12
BP816 16 pin type (low cost)	0·18½	0·16	0·13

BI-PAK DO IT AGAIN!

50W pk 25w (RMS)



0·1% DISTORTION!
HI-FI AUDIO AMPLIFIER

THE AL50

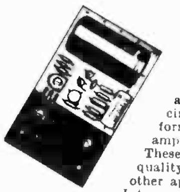
* Frequency Response 15Hz to 100,000—1dB.
* Load—3, 4, 8 or 16 ohms.
* Distortion—better than ·1% at 1KHz.
* Signal to noise ratio 80dB.

ONLY £3·58 each

* Supply voltage 10–35 Volts.
* Overall size 63mm × 105mm × 13mm.

Tailor made to the most stringent specifications using top quality components and incorporating the latest solid state circuitry and AL50 was conceived to fill the need for all your A.F. amplification needs.
FULLY BUILT—TESTED—GUARANTEED.

STABILISED POWER MODULE SPM80



AP80 is especially designed to power 2 of the AL50 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 MT80, the unit will provide outputs of up to 1·5 amps at 35 volts. Size: 68mm × 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. 28p

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 AL50 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	1·25mV into 50K Ω
2. Radio, Tuner	35mV into 50K Ω
3. Magnetic P.U.	1·5mV 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 × 35m

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Sinclair Project 60

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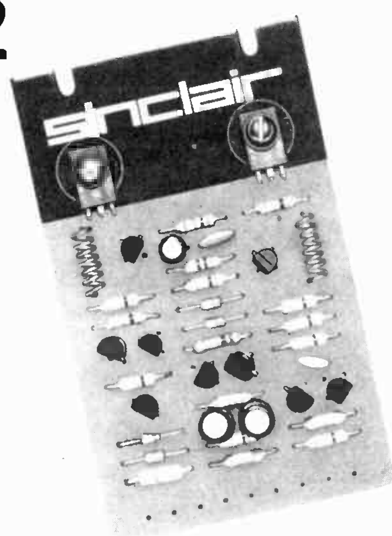
with built-in automatic transient overload protection

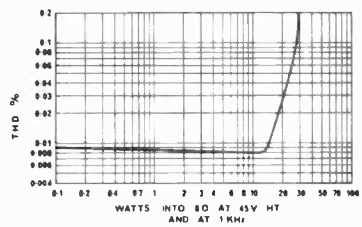


When originally introduced, the Sinclair Z.50 proved how it was possible to design and produce a popularly priced modular power amplifier having characteristics to challenge the world's costliest amplifiers. Many thousands of Z.50's are now giving excellent service day in, day out. But we have also learned that constructors do not always use their Z.50's ideally. That is why we have introduced modifications whereby risk of damage through mis-use is greatly reduced and performance further enhanced. The Z.50 Mk.2 has improved thermal stability, more accurately regulated D.C. limiting to ensure more symetrical output voltage swing and clipping and still less distortion at lower power. Z.50 Mk.2 is compatible with all other Project 60 modules, and may be incorporated to advantage in existing systems. Eleven silicon epitaxial planar transistors are now used, two more than in the original Z.50; circuitry has been re-designed, making this versatile high performance amplifier better than ever.

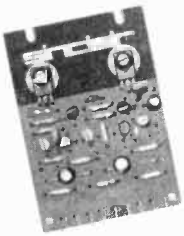
with free manual
£5.48

Brilliant new technical specifications

Input impedance 100 KΩ
Input (for 30w into 8Ω) 400mV
Signal to noise ratio, referred to full o/p at 30v HT 80dB or better
Distortion 0.02% up to 20W at 8Ω. See curve
Frequency response 10Hz to more than 200 KHz ±1dB
Max. supply voltage 45v (4Ω to 8Ω speakers) (50v 15Ω speakers only)
Min. supply voltage 9v
Load impedance – minimum: 4Ω at 45v HT
Load impedance – maximum: safe on open circuit



Z.30 the power amplifier for quality and economy



with free manual
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The Z.30 provides excellent facilities for the constructor requiring a high fidelity audio system of less power than that available from Z.50's. Using a power supply of 35 volts, Z.30 will deliver 15 watts RMS into 8 ohms, or 20 watts RMS into 3 ohms using 30 volts. Total harmonic distortion is a fantastically low 0.02% at 15 watts into 8 ohms with signal to noise ratio better than 70 dB unweighted. Input sensitivity 250mV into 100K ohms. Size 80 x 57 x 13 mm ($3\frac{1}{8}$ x $2\frac{1}{4}$ x $\frac{1}{2}$) Z.30, Z.50 and Z.50 MK.2 modules are compatible and interchangeable.

Typical Project 60 applications

System	The Units to use	together with	Units cost
Simple battery record player	**Z.30**	Crystal P.U., 12V battery volume control, etc.	**£4.48**
Mains powered record player	**Z.30, PZ.5**	Crystal or ceramic P.U. volume control, etc.	**£9.45**
12W. RMS continuous sine wave stereo amp. for average needs	**2 x Z.30s, Stereo 60; PZ.5**	Crystal, ceramic or mag. P.U., F.M. Tuner, etc.	**£23.90**
25W. RMS continuous sine wave stereo amp. using low efficiency (high performance) speakers	**2 x Z.30s, Stereo 60; PZ.6**	High quality ceramic or magnetic P.U., F.M. Tuner, Tape Deck, etc.	**£26.90**
80W. (3 ohms) RMS continuous sine wave de luxe stereo amplifier. (60W. RMS into 8 ohms)	**2 x Z.50s, Stereo 60; PZ.8, mains transformer**	As above	**£34.88**
Indoor P.A.	**Z.50, PZ.8, mains transformer**	Mic., guitar, speakers, etc., controls	**£19.43**

F.M. Stereo Tuner **(£25)** & A.F.U. **(£5.98)** may be added as required.

Guarantee

If, within 3 months of purchasing any product direct from Sinclair Radionics Ltd., you are dissatisfied with it, your money will be refunded at once. Many Sinclair appointed Stockists also offer this same guarantee in co-operation with Sinclair Radionics Ltd.

Each Project 60 module is tested before leaving our factory and is guaranteed to work perfectly. Should any defect arise in normal use, we will service it at once and without any charge to you, if it is returned within two years from the date of purchase. Outside this period of guarantee a small charge (typically £1.00) will be made. No charge is made for postage by surface mail. Air Mail is charged at cost.

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SN7402	0·20	0·18	0·16	SN7453	0·20	0·18	0·16	SN74151	1·10	0·95	0·90
SN7403	0·20	0·18	0·16	SN7454	0·20	0·18	0·16	SN74153	1·35	1·27	1·20
SN7404	0·20	0·18	0·16	SN7460	0·20	0·18	0·16	SN74154	2·00	1·75	1·55
SN7405	0·20	0·18	0·16	SN7470	0·30	0·27	0·25	SN74155	1·55	1·47	1·35
SN7406	0·30	0·27	0·25	SN7472	0·30	0·27	0·25	SN74156	1·55	1·47	1·35
SN7407	0·30	0·27	0·25	SN7473	0·40	0·37	0·35	SN74157	1·80	1·70	1·50
SN7408	0·20	0·19	0·18	SN7474	0·40	0·37	0·35	SN74160	2·60	2·40	2·25
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SN7410	0·20	0·18	0·16	SN7476	0·45	0·42	0·39	SN74162	3·40	3·25	2·70
SN7411	0·23	0·22	0·20	SN7480	0·80	0·75	0·67	SN74163	3·40	3·25	2·70
SN7412	0·42	0·40	0·35	SN7481	1·25	1·15	1·10	SN74164	2·75	2·30	2·10
SN7413	0·30	0·27	0·25	SN7482	0·87	0·80	0·70	SN74165	4·00	3·50	3·00
SN7416	0·30	0·27	0·25	SN7483	1·00	0·90	0·85	SN74166	4·00	3·50	3·00
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IN4002	100	7
IN4003	200	8
IN4004	400	8
IN4005	600	10
IN4006	800	12
IN4007	1000	15
1·5 amp miniature		
PL4001	50	8
PL4002	100	9
PL4003	200	10
PL4004	400	10
PL4005	600	12
PL4006	800	15
PL4007	1000	16

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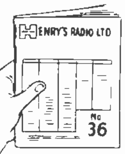

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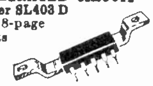

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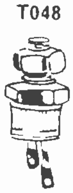
SC35B	200	79p
SC35D	400	85p
6 AMP RANGE (TO48)		
SC40A	100	85p
SC40B	200	90p
SC40D	400	£1·00
SC40E	500	£1·20
10 AMP RANGE (TO48)		
SC45A	100	95p
SC45B	200	£1·00
SC45D	400	£1·25
SC45E	500	£1·45
15 AMP RANGE (TO48)		
SC50A	100	£1·25
SC50B	200	£1·35
SC50D	400	£1·65
SC50E	500	£1·85

3 Amp T048



15 Amp T048

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40430	(TO66)	85p
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BO5/10	100	25p
ONE AMP ¼ × ⅜ H TUBULAR		
B1/05	50	25p
B1/10	100	25p
B1/20	200	30p
B1/60	600	35p
ONE AMP (G.I.) TUBULAR		
W005	50	30p
W01	100	35p
W02	200	40p
W06	600	45p
TWO AMPS ½ H × ½ L × 3/16		
B2/05	50	35p
B2/100	100	40p
B2/200	200	45p
B2/600	600	50p
B2/1000	1000	60p
FOUR AMPS ½H × ½L × 3/16		
B4/100	100	60p
B4/200	200	65p
B4/400	400	70p
B4/600	600	75p
B4/800	800	£1·00
SIX AMPS ½H × ½L × 3/16		
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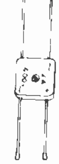
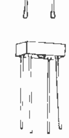
B6/200	200	75p
B6/400	400	90p
B6/600	600	£1·00





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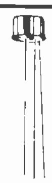

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TWO-WAY LINK

COMMUNICATION is a fundamental function of electronics. It is particularly appropriate therefore to discuss certain aspects of communication relating to this magazine and its readers. First, one unquestionable fact: the link forged between a magazine and its readers is of inestimable value and significance. To this it can be confidently added that a magazine devoted to a creative hobby is especially favoured in that feedback from its readers is often likely to be in the form of examples of readers' own personal efforts and experiences. Such direct positive evidence of a live and actively committed readership is perhaps the best and most encouraging reward the editorial staff of such a publication could wish for.

PRACTICAL ELECTRONICS is proud of the two-way link established between individual readers and the magazine. We believe this is mutually stimulating. The existence of this link has long been evident, and has been demonstrated most effectively in our pages through the medium of *Ingenuity Unlimited*. Reference to the popularity and importance of this feature is not out of place. It has often been commented upon that the circuit ideas published constitute a most valuable source of reference to designers and constructors alike. We agree, and feel sure that many a reader must have saved time and effort through studying the ideas in *Ingenuity Unlimited*.

The varied nature of these miscellaneous circuits is, in itself, quite instructive. It indicates a wide catholic range of interests and shows that the inventive spirit is as much alive as ever; a refreshing and reassuring antidote to the drab uniformity of thought and action which characterises many aspects of modern life.

The circuits published in *I.U.* are generally of modest proportions, but that is no true measure of their actual or potential worth. They represent the new outlook and approach to electronics which has emerged in the course of the last few years. The dramatic scaling down in physical size of components over the last decade has given electronics greater—almost total—freedom in the environmental sense, and in many instances it is released entirely from the shackles of the mains umbilical cord. One result of all this has been the creation of an enormous variety of small circuits, many owing their origination to the enterprising efforts of private individuals to solve some problem or meet some particular need through the agency of electronics, the very thought of which would have been preposterous a few years ago. Many of these are worth recording for the benefit of others.

We are glad to be able to present some of the fruits of this kind of private enterprise in *Ingenuity Unlimited*. And never let it be forgotten that such relatively simple circuits as these may sometimes prove to be the seeds from which bigger and grander concepts grow.—F.E.B.

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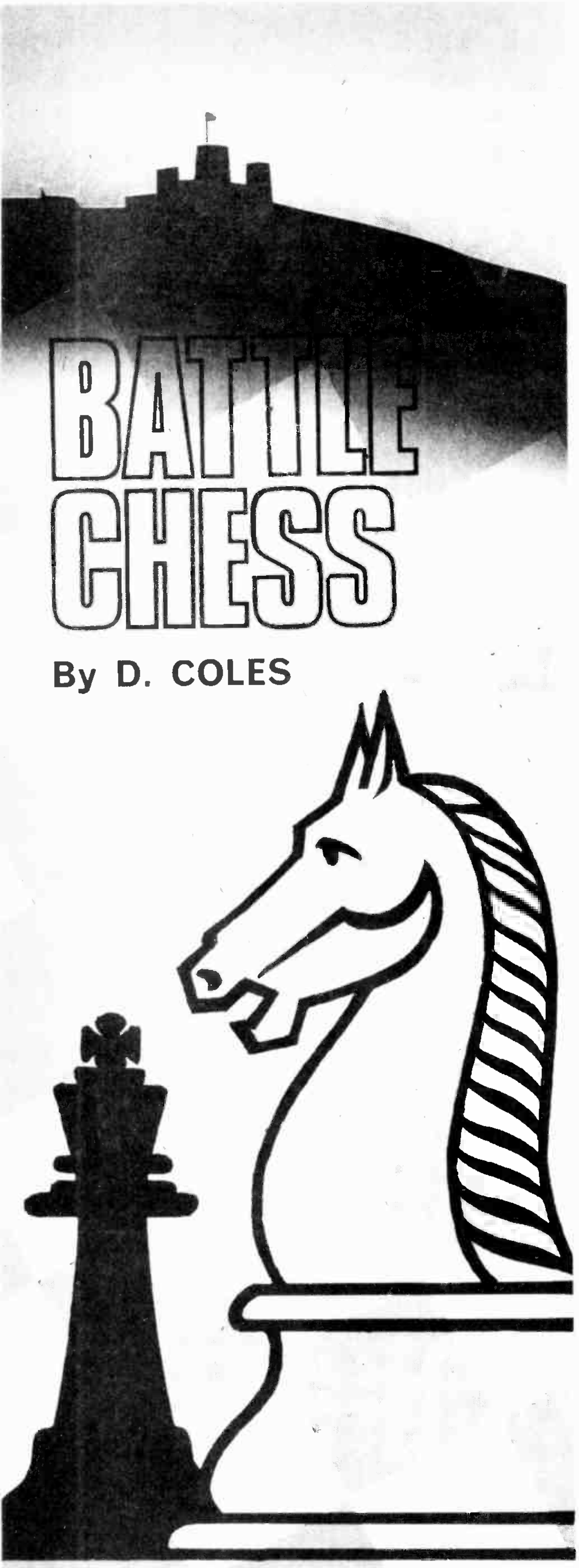
BATTLE CHESS

By D. COLES



THE GAME of chess is more Machiavellian than military in its tactics and strategy and the circuit described here provides a version which is much more like the action of a military battle than court intrigue. Thus: Battle Chess.

No claim to originality is made by the author since Edgar Rice Burroughs—of Tarzan fame—once wrote a book called the "Chessmen of Mars" in which the idea was developed fully. The trouble with the Martian game was the requirement for real people, expected to fight to the death. The finding of 32 people willing to play chess in this way would undoubtedly prove difficult but the Battle Chess circuit is designed to simulate the duels which occur.

THE GAME

In basic concept Battle Chess uses the moves of its namesake but introduces a variety of programmable factors which come into play each time there is a confrontation. Thus one piece does not merely "take" its opponent—they have to fight the situation out in an electronic simulation.

PROGRAMMING

A number of factors have been programmed into the simulation circuit which parallel those found in real life military situations:

1. The strength of the various chessmen.
2. The addition of arms which increase the fighting strength of a chessman.
3. The reduction in fighting power due to supply problems (i.e. ditsance between duelling chessmen and their respective King's squares).
4. The proximity of supporting chessmen.
5. The effects of morale.

Combinations of resistors are used to determine factors 1 to 4. Resistance values interact with each other to affect the frequency of multivibrators (see Fig. 1).

Morale, on the other hand, is time dependent, being at its highest immediately after a successfully completed duel. The charge remaining in a capacitor simulates the effects of morale; the charge leaks away to nothing and the probability of winning the next duel drops from exceptionally high for the previously winning player to the normal value over a period of about ten minutes.

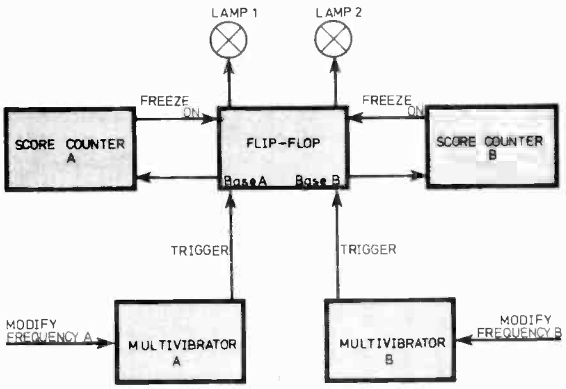


Fig. 1. Block schematic of the Battle circuit showing how the basic units are interconnected

The factors which combine in the game of Battle Chess make it virtually impossible to predict the outcome of a simulated duel. Thus the tactics and strategy which have to be developed by the player are more dynamic, more subject to caprice, than those used in conventional chess and are designed to approximate the real life strategy of a series of military engagements.

THE SIMULATION CIRCUIT

The circuit is shown in block form in Fig. 1 and in detail in Fig. 2.

Two conventional multivibrators A and B have their frequencies determined by external resistances connected between points 1 and 2 and the negative rail. The pulses of each multivibrator simulate the thrusts and parries of a duel and the resistances which combine to set the frequency of oscillation freeze with the winning side indicated by the light which remains lit.

The opposing capacitor's charge is neutralised through diodes D1 or D2 so that the other Darlington remains unswitched. The charge in the winning capacitor remains at the switching voltage as long as the lamp remains lit and leaks away once the circuit is switched off. This slowly leaking charge represents the player-army's morale and if a fight is started before the charge has gone, it takes less time to build up to its switching value.

CONSTRUCTION

The simulation circuit layout is not critical and the Veroboard method of construction is ideal.

The multivibrators may be constructed first and checked by temporarily connecting 3·3kΩ resistors

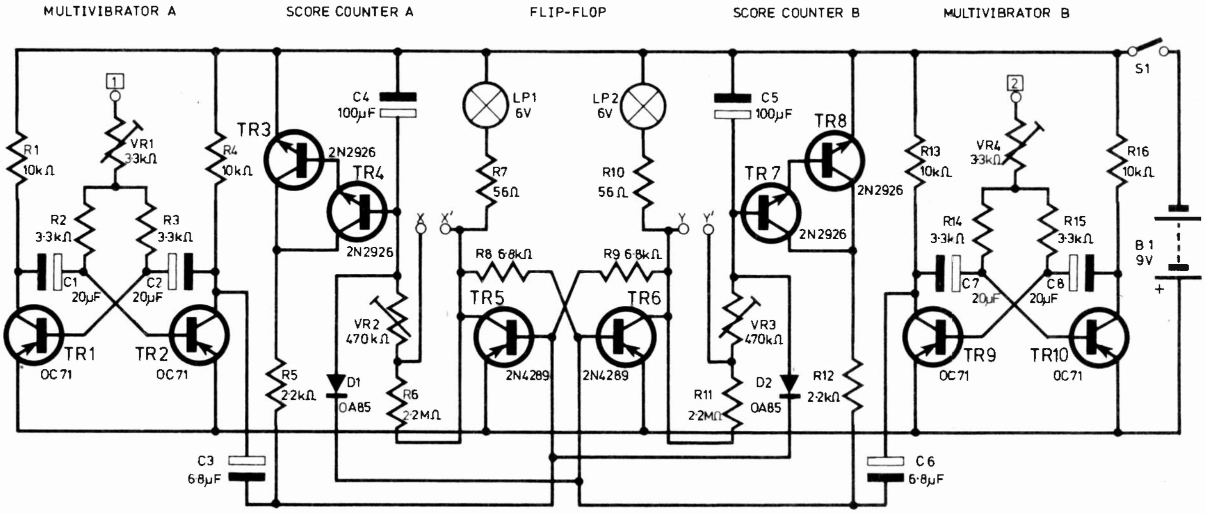


Fig. 2. Detailed circuit diagram of the equipment. When setting the timing of the various sections it may be necessary to select the electrolytic capacitors C1 to C8 if the variable resistors VR1 to VR4 are unable to provide sufficient adjustment to "pull" the periods into agreement

represent the value of the chessman, its distance from its King's square—representing G.H.Q.—and the number of friendly chessmen and their relative positions.

Pulses from each multivibrator are fed to a central flip-flop *via* capacitors C3 and C6. These pulses switch the flip-flop so that lamps LP1 and LP2 are switched on alternately with a continuously varying mark/space ratio. The lamps, as well as providing a visual analogue of the duel, eventually indicate which side has won.

Depending on which flip-flop transistor is ON, a current flows in R7 or R10 providing a potential difference which charges capacitors C4 and C5 through resistors R6 and R11. Additional resistors may be inserted at points XX′ and YY′ to reduce the overall resistance and allow C4 or C5 to charge faster.

These additional resistances simulate weapons used by the battling chessmen. When either C4 or C5 reaches a voltage of about 0·7 volts, the associated score counter, a Darlington pair, switches on, causing two things to happen. The Darlington pair output biases the flip-flop *via* R5 or R12, causing it to

between points 1 and 2 and the negative rail. Connect the 9 volt battery and check oscillation with a voltmeter across R4 and R13.

The flip-flop should be built on next, together with its trigger pulse feeds, C3 and C6. Connecting the battery should now cause the lamps to flash alternately in response to the multivibrators and clearly show the variation in mark/space ratio.

When constructing the score counters remember that diodes D1 and D2 must be good ones. A reverse leak on one or both of these, even if only four to five micro-amps, will upset the impartiality of the circuit. Pliers used as a heat shunt when connecting them will reduce the risk of damaging their characteristics.

To test the score counters, connect the battery once more and briefly touch a 10kΩ resistor, connected to the positive rail, to the positive lead of C3. The lights should cease to flash, LP1 should stay lit and LP2 extinguish.

Leave the circuit in this state to check that it is a stable condition; if the situation changes it will almost certainly be one of the diodes at fault. Repeat the test with C5.

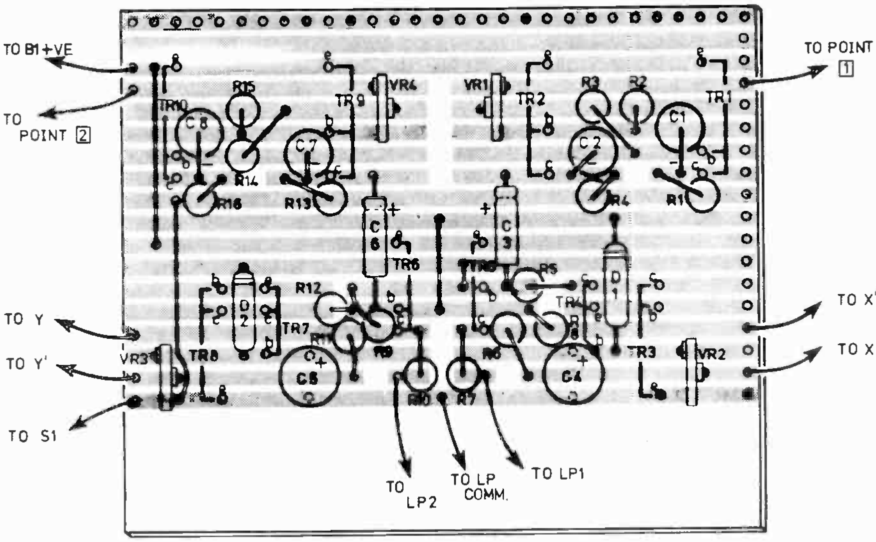


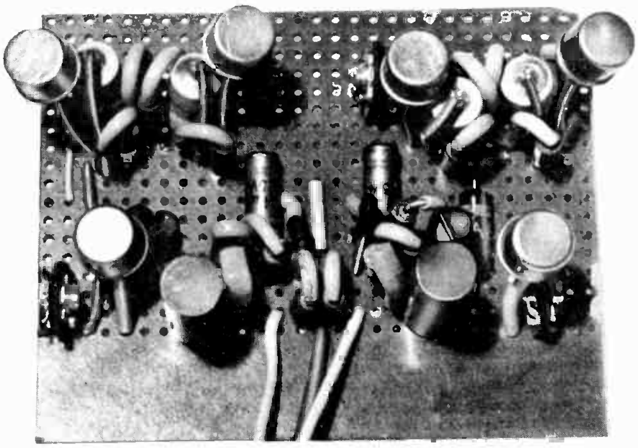
Fig. 3. Veroboard layout of the components on 0·1 inch pitch board. In the present case this was cut from a sheet edge to give a blank area which can be drilled for fixing as required

Finally, test that the flip-flop is charging the score capacitors properly. Temporarily connect a 1MΩ resistor across the points XX′. Discharge the score capacitors by shorting their positive leads to the negative rail before switching on. The lamps should flash for 10 to 15 seconds and then LP1 will remain on and LP2 off. Repeat with the 1MΩ resistor across the points YY′ and the opposite situation should occur. Failure at this stage could be due to poor solder joints, leaky diodes or slight tracking between the Veroboard copper strips.

THE PLAYING BOARD

The playing board consists of a matrix of 64 4-way sockets. Each side utilises two of the pin sockets and the connections to each side are similar and may be considered separately.

One of the pin sockets acts as a power feed and is connected to the negative line through a series resistor and a switch contact as in Fig. 4. Current is transferred to the other pin socket through the resistance of the chessman as shown in Fig. 5 and to the multivibrator through a second series resistor and switch contact. The two switches (1-pole, 8-way) act as Rank and File co-ordinates and locate the



Completed circuit board for Battle Chess

COMPONENTS . . .

BATTLE CIRCUIT

Resistors

R1, R4, R13, R16	10k Ω	R6, R11	2·2M Ω
R2, R3, R14, R15	3·3k Ω	R7, R10	56 Ω
R5, R12	2·2k Ω	R8, R9	6·8k Ω

Capacitors

C1, C2, C7, C8	20μF	
C3, C6	6·8μF	All 12V working
C4, C5	100μF	

Potentiometers

VR1, VR4	3·3k Ω	
VR2, VR3	470k Ω	All Skeleton Preset

Transistors and Diodes

TR1, TR2, TR9, TR10	OC71, OC72 or similar
TR3, TR4, TR7, TR8	2N2926 or similar
TR5, TR6	2N4289 or similar
D1, D2	OA85

Miscellaneous

LP1, LP2 6V, 60mA
S1 Single pole ON/OFF (pushbutton type)
B1 PP7, PP9 or similar
Veroboard

PLAYING BOARD

Resistors

R101, R115	4·4k Ω
R102, R116	3·3k Ω
R103, R117	2·7k Ω
R104, R108, R118, R128	2·2k Ω
R105, R109, R114, R119, R122, R127	1·7k Ω
R106, R110, R113, R120, R123, R126	1·2k Ω
R107, R111, R112, R121, R124, R125	1·0k Ω
RX (28 off)	10k Ω

Miscellaneous

Four Phono sockets
64 four-way sockets
4 single-pole 8-way wafer switches
Wire, hardboard, 2in × ½in section wood, glue, screws, panel pins.

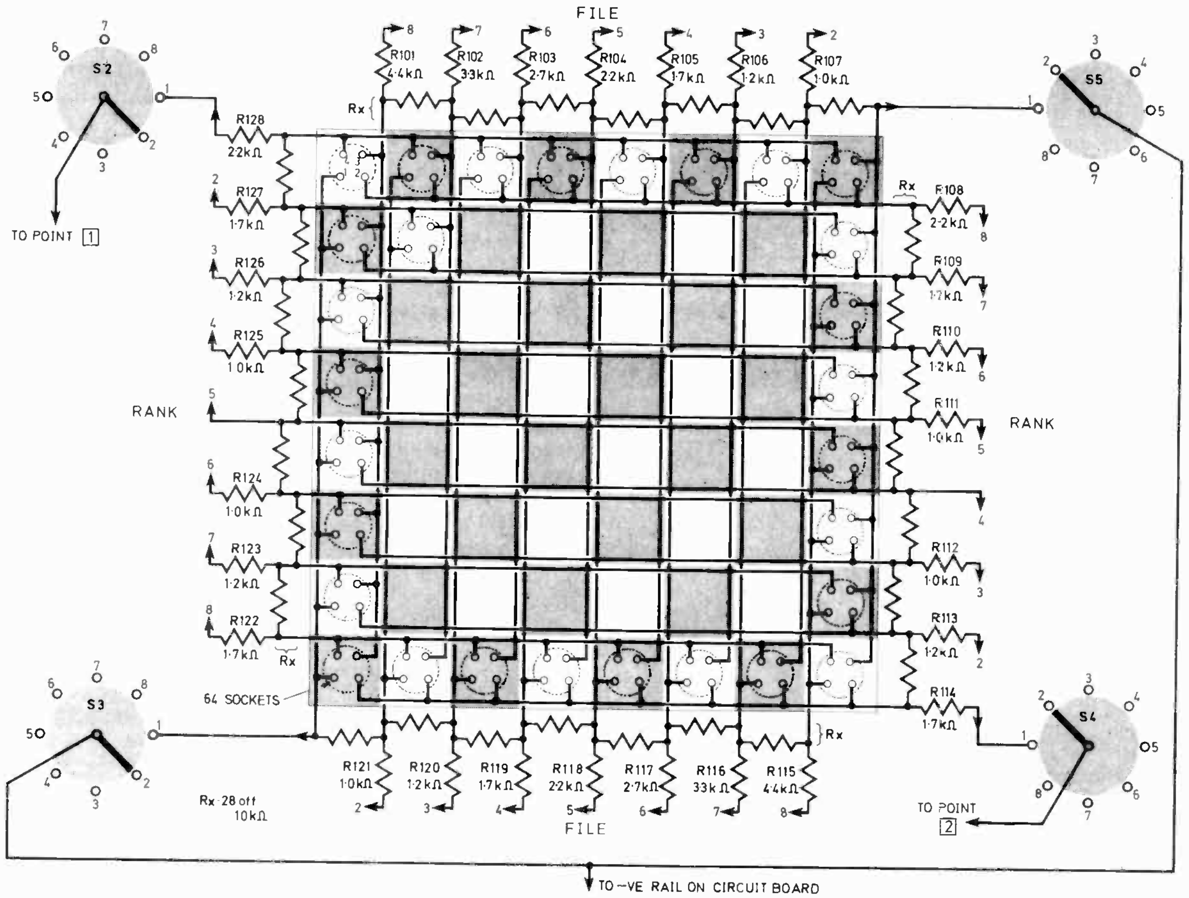


Fig. 4. Wiring of the playing board and Rank & File selection switches. Only the sockets at the periphery have been shown but, of course, there is a socket in each square, wired in a similar manner to all the others

chessmen which are to take part in the duel. The combined resistance of the two series resistors reduces the base biasing current in proportion to the chessman's distance from its King's square.

In addition to the series resistance and the chessman, each Rank and File is connected to its neighbouring Rank or File by a 10kΩ resistor so that a parallel path exists through every other friendly chessman. Thus the number and closeness of the other chessmen modify the final value of the biasing resistance; in effect, they lend their support.

BALANCING

Variations in the chessmen, the weapons, and the playing board resistors are quite in order and may be interpreted as the usual random variations to be found in any army. However, the battle simulator must be balanced so that should an identical situation occur, neither side has a better chance of winning. The four variable resistors VR1 to VR4 are used to balance the circuit.

Starting with the multivibrators temporarily solder a 4·7kΩ resistor to each biasing network at 1 and 2 in turn, using 1 per cent or 5 per cent resistor if possible. Using a voltmeter across R4 or R13, count the number of oscillations in a ten second interval. Using the variable resistors, VR1 or VR4 alter the frequencies until they are, as nearly as possible, equal.

To balance the score counters, temporarily solder two 2·2MΩ resistors across points XX′ and YY′. Switch on the simulator and note which lamp goes out permanently first. Alter VR2 and VR3 until only a small change in each preset changes the lamp which goes out. In between each try, it will be necessary to switch off and discharge C4 and C5.

THE PLAYING BOARD

The playing board circuit is shown in Fig. 4 together with details of switch connections. The 64 sockets are arranged in an 8 × 8 array on a hardboard mounting which forms the top of the circuit cabinet and the playing board. The four single-pole, eight-way switches are mounted two at each end, the press on, press off mains switch, the lamps and phono sockets can be mounted in any convenient position. The line and interconnecting resistors are suspended in the wiring. The wiring can be tied into looms and attached to the inside of the wooden sides with wiring clips. The sockets can be attached with Araldite.

The sides and ends of the cabinet are fastened to the hardboard top with glue and panel pins. The bottom, another piece of hardboard, is secured to the sides with a few screws so that it can be removed for servicing. Dimensions have not been given since size and proportions will vary with the constructor.

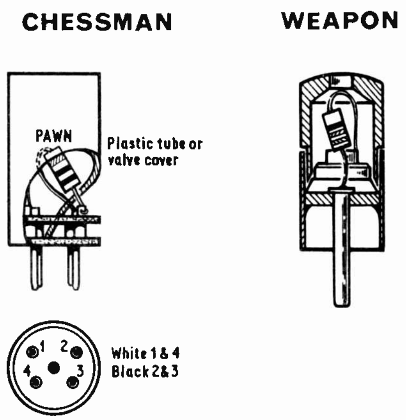


Fig. 5. A suggested form of chessman and weapon

CHESSMEN

Resistors	
King	0 Ω (link)
Queen	330 Ω
Knight	1·2k Ω
Bishop	2·7k Ω
Rook (Castle)	5·6k Ω
Pawn	8·2k Ω
Miscellaneous	
Holders	32 four-way plug bases

WEAPONS

Resistors	
Sword	2·2M Ω
Dagger	5M Ω
Mace	22M Ω
Miscellaneous	
Plugs	Phono plugs in quantity to suit

CHESSMEN AND WEAPONS

In the present example the chessmen are constructed on the four-way plug bases by soldering the correct resistors between the requisite pins as in Fig. 5 and Aralditing a length of plastic tube onto the base. The tube length may be varied to indicate the power of the piece; say three inches for a King reducing to one inch for a pawn. The name of the chessmen should be marked on the outside of the tube. The weapons are constructed similarly, using the phono plugs. Remember the Queening rule for pawns which successfully reach the opposite side of the board and make two Queens for each side.

The more ambitious might wish to mount genuine chessmen on the bases or perhaps even make pieces of their own devising. There are plenty of techniques available today to do this.

FINAL TESTING

When all the wiring is complete and the circuit board secured inside with small brackets, the complete unit may be tested. Switch both sets of co-ordinate switches to Rank 1, File 8 and place a pawn from each side at this position. Switch on the simulator and observe the rate at which the lights flash. Switch off and move the pawns to square: Rank 8, File 1 and switch on; the lights should now flash more slowly. Try the same tests with Kings; the same thing should happen except that the rate of flashing will be higher in both cases. Sometime during these tests a win will be indicated; when this happens, switch off and wait for the score capacitors to discharge, or alternatively discharge by shorting while switched off.

Try adding other pieces to the board in different positions and note the different flashing frequencies of each combination. In some cases the difference will be hard to distinguish since the alteration will be small.

RULES OF PLAY

The chessmen move as for conventional chess and for the same distances.

When one player wishes to take an opposing piece and gain the occupied square, the attacking player must verbally challenge the other. Attacking and defending chessmen should be indicated and the defender cannot retreat from the challenge.

Rank and File co-ordinates are set on the switches to indicate the squares holding each piece. Weapons may be selected at any time and plugged into the phono sockets. The battle simulator is now switched on and the two lamps will flash alternately for, typically, 20 or 30 seconds. The light which remains on after the flashing has ceased indicates the winner who can now occupy the disputed square. The loser is removed from the game and the winner confiscates the loser's weapons for his own arsenal.

TACTICS

The interaction of Player/Chessman/Position/Weapons/Morale alters the probability of any particular piece winning and if two roughly equal chessmen are opposed it is virtually impossible to predict a duel's outcome. The tactics used in Battle Chess can be effective in placing a player in a stronger position.

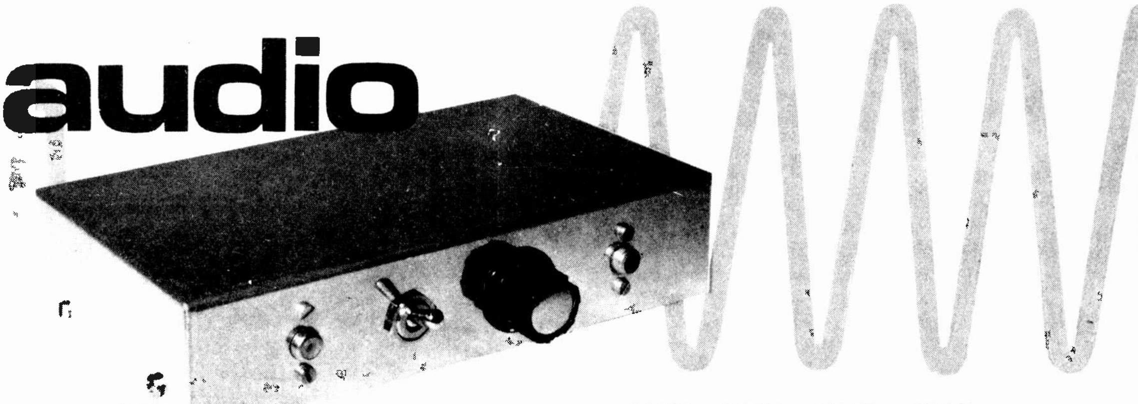
For example, wherever possible arrange to do battle as near as possible to your own King's square or try to arrange that your own combatant is close to a number of friendly pieces—the more powerful, the better.

Force battles to take place within 5 or 10 minutes of a previously successful battle or fight a delaying action for a similar time if a battle has just been lost. This avoids or uses the morale charge on the capacitor.

Of course there are the obvious comments like "don't throw pieces away in needless battles, they may be useful for support if not for combat" and finally always remember, you may win a battle but lose the war.

NOTES

Although the rules of play suggested follow the rules of conventional chess, the equipment can be used to simulate modern battle conditions quite successfully. The playing board may be marked out with a map, and infantry, tanks, missiles can be substituted for pawns, knights, rooks, etc. In this case, the constructor is left to formulate his own rules. ★



audio compressor

By R. A. Penfold

AN AUDIO compressor is an audio amplifier which is designed to provide a constant output level, from a wide variety of input levels. Thus it is sometimes referred to as a constant volume amplifier. It merely consists of an audio amplifier which is fitted with some form of automatic gain control.

AUDIO COMPRESSION

Reasons for using audio compression vary, as it can be used in several applications. It is often used in tape recording when something such as a debate is to be recorded, and only one microphone is to be used.

The use of compression obviates the need to re-adjust the recording level each time a different person speaks, as, once the level is set for one speaker, the correct modulation depth will be obtained for all the others. This is of course providing that all the speakers are close enough to the microphone, to provide a sufficient output to operate the compressor. This technique also removes the possibility of overmodulation at unexpectedly high volume levels.

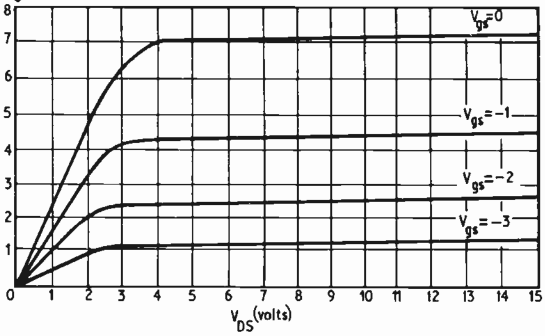


Fig. 1. Drain current plotted against drain to source voltage for a typical *n*-channel f.e.t.

Speech compression is used in some amateur transmitters in order to maintain a high average modulation level, without running the risk of overmodulating an a.m. transmitter, or exceeding the maximum power rating of the power amplifier of an S.S.B. transmitter.

Simple peak clipping circuits are sometimes used instead, but these introduce a comparatively high degreee of distortion, and are not as effective.

USING AN F.E.T.

When subject to a low voltage between the drain, and source terminals, an f.e.t. exhibits the characteristic of an ordinary resistor. This is illustrated in Fig. 1, which shows typical transfer characteristics of an *n*-channel f.e.t., at various gate voltages.

It will be seen that the value of the resistor formed by the f.e.t. can be varied by altering the gate bias voltage. It can be varied from a few hundred ohms to many megohms.

THE CIRCUIT

A circuit diagram of an audio compressor utilising an f.e.t. in a voltage controlled attenuator is shown in Fig. 2. The input impedance to the unit is high (typically 2·5 megohm), and is suitable for use with a crystal microphone. The output is at a low impedance, and will drive virtually any amplifier. For low level inputs (i.e. below the level at which compression begins) a voltage gain of about 275 is available with the gain control at maximum.

In order to obtain the required high input impedance, the input transistor, TR1, is operated in the emitter follower mode. This is direct coupled to TR2, which is a common emitter amplifier.

For TR1 to produce a very high input impedance it must have a fairly high impedance in its emitter circuit. R4 is therefore used to raise the input impedance to TR2, in order to achieve this.

The bootstrapping technique has been employed in order to virtually eliminate the shunting effect the biasing resistors, R1, R2, and R3 would otherwise have on the input impedance. C3 is the bootstrapping capacitor.

Transistors TR1 and TR2 are used mainly as a buffer amplifier, and provide only a small voltage gain.

VOLTAGE CONTROLLED ATTENUATOR

The output from TR2 is fed via C4 to the voltage controlled attenuator. R7 and R8 form a tap on the main supply rail, and produce a suitably low supply voltage for the f.e.t. TR3. The drain to source impedance of TR3, and R9 form an attenuator.

With no negative bias at TR3 gate, the drain to source impedance is very low, and the attenuation factor of the circuit is very low. By giving a negative bias at TR3 gate, the drain to source impedance can be greatly increased, and the attenuation factor of the circuit thus also greatly increased. A voltage controlled attenuator is thus formed.

The output from the attenuator is fed via C5 to the input of a very high gain common emitter amplifier, TR4, which is followed by an emitter follower stage, tens of ohms. This will have a negligible effect upon the attenuation factor of the circuit.

Raising the input level slightly will increase the bias voltage, and due to the logarithmic relationship between bias voltage, and drain to source resistance, this will cause a much larger increase in this resistance, say a few hundred ohms. This will result in a noticeable, although still only small increase in the attenuation factor of TR3 and R9.

INPUT LEVEL

It is at this point that raising the input level will begin to have a very noticeable effect on the voltage controlled attenuator, as only a very small change in bias is required to cause an increase of several kilohms in the drain to source resistance of TR3. Thus an increase in the input level causes the gain of the amplifier to drop considerably, and so reduce the output level. The output level will therefore tend to remain almost constant, even though the input level may vary considerably, providing the

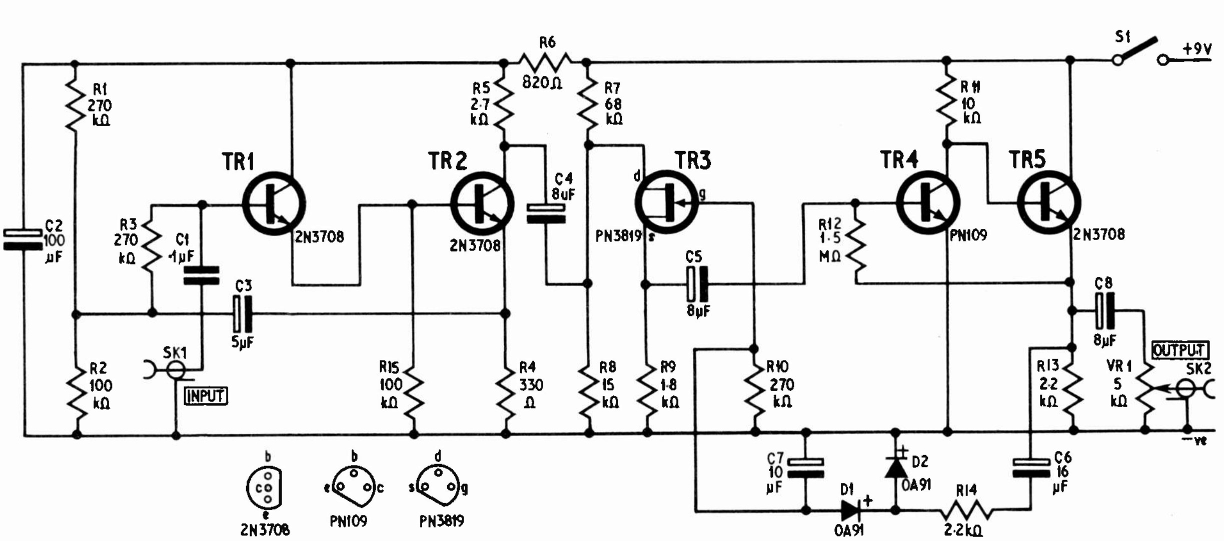


Fig. 2. Circuit diagram of the complete Audio Compressor

TR5. From the emitter of TR5, some of the signal is fed via C8 to the volume control, VR1, and then to the output socket. The remainder of the signal is used to produce the biasing voltage for the attenuator.

RECTIFYING CIRCUIT

It is fed via C6, and R14 to a rectifying circuit, consisting of D1 and D2. This arrangement is used as it provides a fast attack speed, but with a long decay. C7 smoothes the a.f. half cycles to a d.c. negative bias, which is then fed to the gate terminal of the f.e.t.

There is not a linear relationship between the gate bias voltage, and the drain to source resistance of the f.e.t. With a low level input, only a small bias voltage will be produced, and this will only alter the value of the resistor formed by TR3 by a few

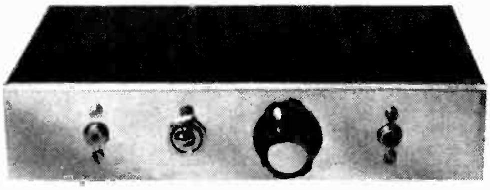
input is above the level at which compression commences.

Even with quite high input levels (up to about 0·25V r.m.s.) there will be only a small degree of distortion in the circuit. The use of modern silicon transistors in the input stage ensures a low noise level.

TIME CONSTANT

The attack of the a.g.c. circuit is very fast, being virtually instantaneous, but the time constant capacitor, C7, produces a fairly long decay time (about two seconds). For most applications this is very desirable, as it prevents the gain from rising during brief pauses in the signal, and the noise which would subsequently accompany this.

However, the decay time can be altered to suit individual requirements by altering the value of C7, the larger its value, the longer the decay time.



audio compressor

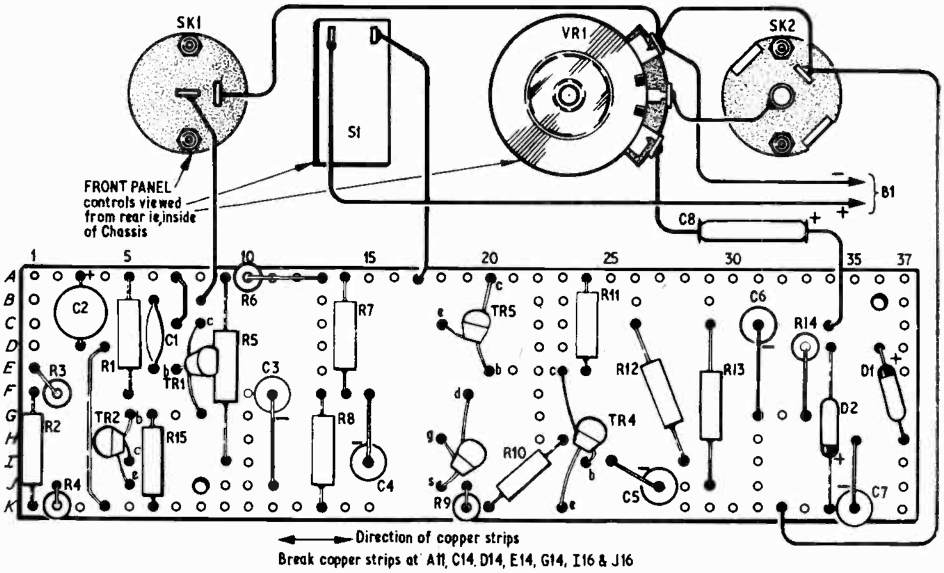


Fig. 3. Layout of the components on the Veroboard panel and interconnections to the other components. Note breaks in copper strips

COMPONENTS . . .

Resistors

R1	270k Ω	R8	15k Ω
R2	100k Ω	R9	1·8k Ω
R3	270k Ω	R10	270k Ω
R4	330 Ω	R11	10k Ω
R5	2·7k Ω	R12	1·5M Ω
R6	820 Ω	R13	2·2k Ω
R7	68k Ω	R14	2·2k Ω
		R15	100k Ω

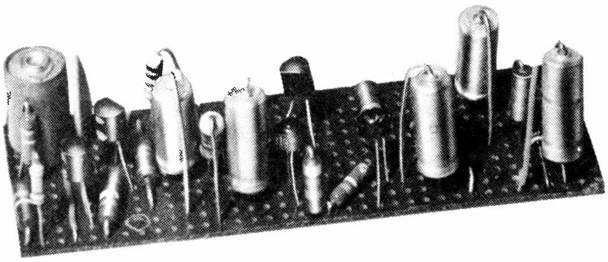
Miniature ¼W, ±10%

Potentiometer
VR1 5k Ω logarithmic

Semiconductors
TR1, TR2, TR5 2N3708 (3 off)
TR3 PN3819 }(Arrow Electronics Ltd.)
TR4 PN109 }(Arrow Electronics Ltd.)
D1, D2 OA91 or similar (2 off)

Capacitors
C1 0·1μF disc ceramic
C2 100μF
C3 5μF
C4 8μF
C5 8μF
C6 16μF
C7 10μF
C8 8μF
All 10V electrolytic except C1

Miscellaneous
S1 S.P.S.T. toggle switch.
Vero board panel, 0·1in matric 7in × 4in × 1½in
Aluminium chassis with base plate (H. L. Smith and Co.)
SK1, SK2 phono sockets (2 off)
Control knob, 9V PP6 battery and clips to suit, hardware



CONSTRUCTION

Constructional requirements will vary widely, as some constructors may wish to build the unit as an integral part of some piece of equipment, while others may wish to build it as a self-contained unit, as was the prototype. In either case the Veroboard layout shown in Fig. 3 can be used. 0·1in matrix board is used, and the copper strips run lengthwise. These are cut at a number of points as detailed in the diagram.

A 7in × 4in × 1·5in aluminium chassis fitted with a base plate is used as a case for the prototype. The Veroboard panel is mounted on stand-off insulators in order to hold it a little way clear of the metal case. A PP6 battery is used to power the unit, this particular type being a good fit in the case, and has virtually its shelf life with normal use.

Phono sockets were use for SK1, and SK2 on the prototype, but almost any type of two way socket is of course suitable. Due to the high input impedance of the unit it is essential that the input lead is screened, in order to avoid unwanted noise pick up.

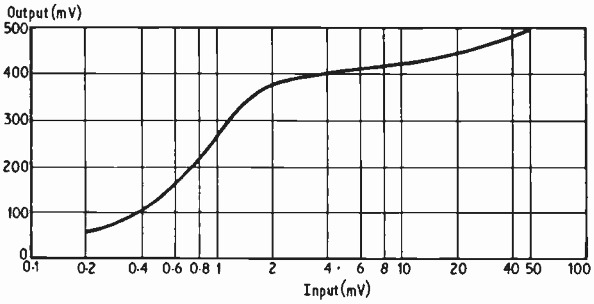


Fig. 4. Graph showing the relationship between the input and output voltages of the Audio Compressor. It can be seen that while the input changes from 2 to 50 millivolts the output only changes by 25 per cent

RESULTS

A graph of the results obtained on the prototype compressor is shown in Fig. 4. This shows input voltage versus output voltage. With an input of 1mV or less the gain is fairly constant at about 275, or a little less. Above this the gain decreases slightly as the input voltage is raised, until it reaches about 2·6mV, and increasing the input voltage above this level has very little effect upon the output. ★

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. This is YOUR page and any idea published will be awarded payment according to its merits.

LIGHT-OPERATED POWER CONTROLLER

THE circuit shown in Fig. 1 will control the a.c. power delivered to a mains load according to the level of light incident on a light-dependent resistor PCC1. An advantage of this circuit is its extreme simplicity and consequent ease of construction.

As the mains voltage rises the capacitor C1 is charged via the potentiometer formed by R1 and PCC1. When the voltage across C1 rises sufficiently, the bi-directional trigger diode D1 breaks down and C1 is discharged into the gate of the triac CSR1, switching it into its low resistance state. The combination of a 0·1μF capacitor and the breakover voltage of the diac of around ±30V gives a sufficient pulse to ensure the triggering of most commonly available triacs. The diac also ensures that the maximum voltage rating of the LDR is not exceeded. Since the triac and the diac are bi-directional this situation occurs on both positive and negative-going half-cycles of the mains supply, the triac returning to its high resistance state at each zero point in the cycle.

The point in each half-cycle at which the triac is fired is determined by the incident light on PCC1, full power being delivered to the load when this point occurs very early in the cycle—i.e. with the LDR in

REED RELAY CURRENT TRIP

A SIMPLE over current protection device for a series regulated power suppply can be made using a thyristor and a reed relay. The circuit diagram is shown in Fig. 1.

When a fault current appears across VR1 and R1, R2, diode D1 conducts a positive going signal to the gate of the thyristor CSR1 which triggers it on. The reed relay then closes applying a negative voltage to the base of TR1 cutting it off and reducing the output voltage to zero.

The action of this cutout is much faster than a fuse thus protecting the sensitive semiconductors in the circuit being supplied. The lamp LP1 will show a fault condition until the SCR is shorted by S1. If the fault is still present the thyristor will fire cutting off the supply again.

The trip current is set by VR1. The reed relay is a miniature type about an inch long with 250 turns of 32 s.w.g. enamelled copper wire wound onto the reed relay body.

G. Daddy,
Hull.

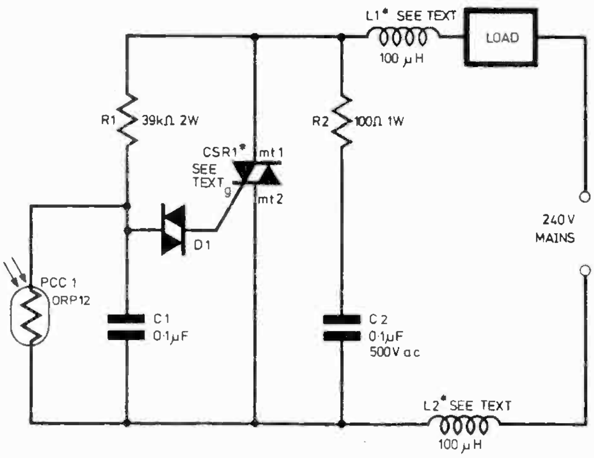
darkness. The power that can be controlled by the circuit depends only on the ratings of the triac and on the adequacy of its heat sink.

Components L1, L2, C2, R2 provide suppression of the radio interference generated by the switching of the triac and also protect the triac against mains-borne transients to which these devices are highly susceptible. Note that R2 is necessary to limit the discharge current of C2 which might otherwise exceed the peak surge current of the triac when it fires, and destroy it.

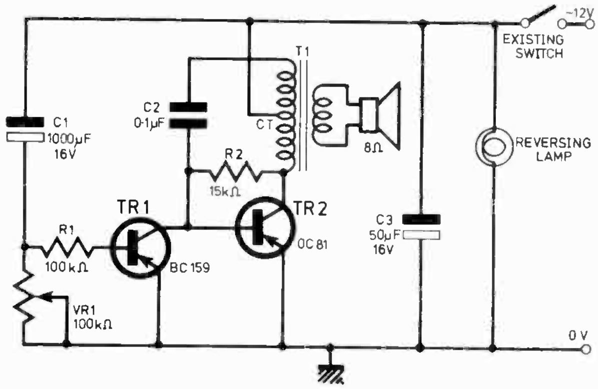
Owing to the triac's low tolerance to over-voltage transients, this circuit can not be recommended for use with motor loads without the incorporation of additional protection. If circuit values are altered, to change the light threshold or the operating range of the unit for example, care should be taken not to exceed the current/power ratings of the LDR, the diac and the triac gate.

Circuit values are such that incident daylight will result in no power being applied to the load, while the level of light around dusk will give full power.

I. Page,
London, S.W.13.



REVERSING LIGHT WARNING



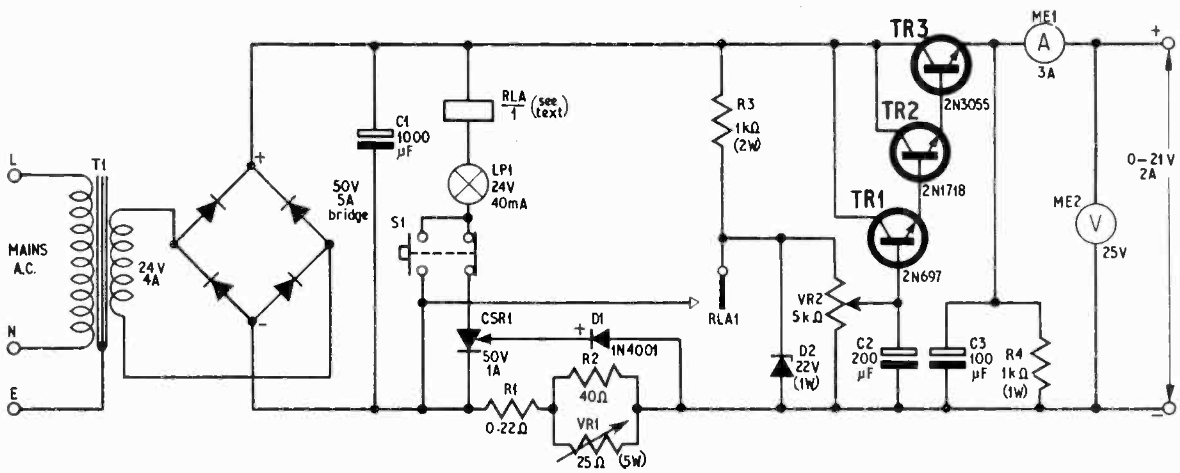
Many cars have reversing lights fitted which are operated by a switch on the dash; this must by law be illuminated, but I have found it quite easy to leave the switch on accidentally for periods during the daytime.

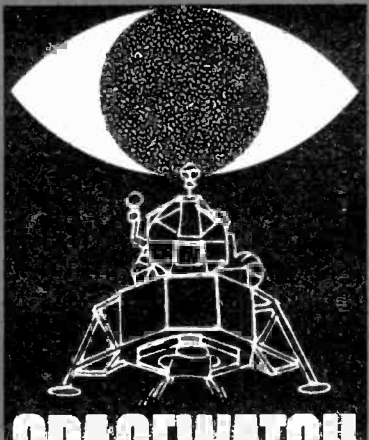
I therefore devised the circuit shown in Fig. 1. This is wired in parallel with the reversing light(s), and sounds a warning if left on for more than about a minute. When power is applied, C1 slowly charges up through VR1 and TR1, the latter remaining switched on until C1 is almost fully charged. TR2 is a conventional oscillator, but cannot operate until TR1 turns off, when it produces a fairly loud tone in the speaker.

Components are not critical. TR1 can be any silicon *pnp* transistor, and any of the OC72/75/81/82 range will work as TR2. Transformer T1 is a small audio output transformer out of an old transistor radio.

The circuit was made up on a small piece of tag-board, and mounted behind the dashboard.

D. L. Atkin.
Sheffield.





SPACEWATCH

BY FRANK W. HYDE

SUN JOLTS THE EARTH

Solar storms release an enormous amount of energy which can affect the spin of the earth on its axis. Some ten years ago the French astronomer, A. Danjon, announced that the very large solar flare of 1959, significantly affected the length of the day. At that time he was not very well supported by colleagues.

However, the very energetic solar storm which occurred in August 1972 showed an even greater effect on the earth. A change of more than 10 milliseconds was recorded. This particular solar storm is the greatest that has been recorded during the 370 years that observations have been made.

The storm, which began on August 2, started with very pronounced sun spot activity and continued for a week. At that time there were probes orbiting the earth and sun and the *Pioneer 10* spacecraft was on its way towards Jupiter. It was thus a time when an enormous amount of data was to hand to record the solar activity.

The recorded cosmic rays and the ejected plasma measurements have enabled an estimate to be made of the manner in which the magnetosphere is affected. The storm also gave a clue to the mechanism involved. There is always a short interval between the time of storm and the jolt that the earth receives. The theory is that the particles and the plasma disturb the atmospheric circulation, thereby affecting the earth's spin.

CHANDLER WOBBLE

That the length of day is increasing has been known for a long time since it can be determined by observation. The main effect is from the tidal action between the sun-earth-moon system. Another condition that affects the length of day is the Chandler wobble.

Named after its discoverer, the poles of the earth wobble against the star background in a regular way over a period of fourteen months. The effect is by no means well understood but it is thought to be due to the fluidic centre core of the earth. The wobble effect on the slowing down of the earth's rotation is superimposed on the main tidal variation.

In addition to the Chandler wobble there is still another effect and that is the seasonal variation of the large scale atmospheric movements. Here again the actual mechanism is not fully understood though it is noted that this effect is on the same scale as that of the solar activity.

CHINOOK WINDS

The strong winds which blow on the eastern slopes of the Rocky Mountains are known as the Chinook winds and in some areas do much damage as there has been no way in which to predict when these winds will come. It is thought that the winds are related to the temperature inversion layer of the atmosphere on the windward side of the Continental Divide.

It is now thought that the Chinook wind of the Northern Plains is produced because the weight of the air causes a compression which in turn raises the temperature. While this is helpfully welcomed in some places it is not in others.

EARLY WARNING

To provide some means of prediction, audio methods are being tried out and powerful audio pulses are being directed at the atmosphere. These pulses transmitted vertically upwards every twenty seconds, at a frequency of 1,000Hz, are reflected by the inversion layers. High power is required because some of the temperature inversion layers are as high as 7,000ft.

By using a doppler sounder it is hoped to measure the profiles of the winds. The very obvious advantage of this, in addition to warning, is the possible effects of pollution carried by air. Siting factories and other process plants could be predetermined and a possible reduction of pollution effects controlled.

ASTEROIDS

The earth seems to have a wider influence in the solar system than was first thought. There are from time to time reports that certain asteroids come close to the earth and but for the grace of cosmic law the home planet would be exposed to a catastrophe. It has now been established that certain of the asteroids are specifically involved.

The asteroids which have been the subject of special study are the Apollo group consisting of Toro and Geographos, which cross the earth's orbit, and three of the Amor group, Eros, Amor and Ivar, which cross Mars' orbit. These asteroids all have orbits round the sun but are perturbed in these orbits by the influence of the planets.

Of the five asteroids named Geographos is perturbed only at random. The others have regular periodical perturbations in respect of the earth's orbital period. The way in which this occurs is rather complex for there is libration in the sense that the whole pattern of the orbit rocks about the earth-sun line. Libration or rocking implies a periodic variation in the orbital period but the period can oscillate without libration.

ORBITAL PERIODS

The periods that emerge are in the ratio five earth periods to eight Toro which would result in a period of 150 years were it not complicated by a relation with Venus. This ratio of 5 Venus periods to 13 Toro gives a 180 year period. The Toro orbit is therefore an unstable one and it is expected that this may change after 2200 A.D.

The complicated nature of these variations of one body relative to another is further indicated by the fact that the earth perturbs Eros once every seven years and also the asteroid Amor is involved. In the case of Ivar two perturbations take place in each 28 years. This has a libration of 300 years and is the most stable of the orbits.

TAILPIECE

It seems that there is to be a further revival of the Velikovsky theories. Claims are being made as to confirmation of such events as the Jupiter radiations and the magnetic remanence in the older moon rocks with a suggestion that the main craters and valleys are no more than 300 years old.

At any rate no one can say that the astronomical world and that of space is dull.

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NPN: BC107 **13p**, BC108 **12p**, BC109 **13p**, BC167 **11p**, BC168 **10p**, BC169 **11p**.

PNP: BC177 **21p**, BC178 **19p**, BC179 **21p**, BC257 **12p**, BC258 **11p**, BC259 **13p**.
Standard groupings available.

BD135 *npn* medium power	**37p**
BD136 *pnp* medium power	**38p**

DIODES

OA90, OA91, OA95, **6p** each; OA200, **9p**; OA202, **10p**.

Other semiconductors: AC128, **17p**; AF117, **32p**; BFY51, **19p**. Full lists and technical data will be found in Catalogue No. 6. See also amendments list.

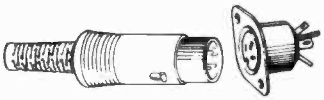
SIEMENS' THYRISTORS

0·8A 400V **56p**, 600V **70p**.
3A 400V **60p**, 600V **88p**.

ZENER DIODES full range E24 values: 400mW: 2·7V to 36V, **14p** each; 1W: 6·8V to 82V, **21p** each; 1·5W: 4·7V to 75V, **48p** each. Clip to increase 1·5W rating to 3 watts (type 266F) **4p**.

DIN PLUGS AND SOCKETS

by Hirshmann, 4A rating

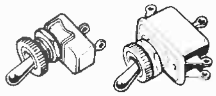


2 way LS —socket **10p**, plug **12p**
3 way scr.—socket **10p**, plug **12p**
5 way scr.—socket **11p**, plug **15p**

TRANSISTOR ACCESSORIES

TO3 cover, **7p**; Heat sinks 1°C/W, type 6W1, undrilled, **60p**.

SWITCHES

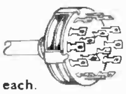


1011 SPST toggle, **20p**; 409 DPDT toggle, **29p** (these are chrome plated, 2·5A rating); 7201 sub-miniature DPDT 250V a.c./2A, **48p**.

ROTARY SWITCHES

Radiospares Miniature Maka-switch (in assembly kit form). Shaft, **48p**. Wafers, MBB-2P5W, 1P11W; BBM1P12W, 2P6W, 3P4W, 4P3W, 6P2W, **32p** each.

WAVECHANGE SWITCHES



1P12W, 2P6W, 3P4W, 4I3W, **24p** each.

ELECTROLYTIC CAPACITORS AXIAL LEAD

Rated voltage: Capacity µF	3V	6·3V	10V	16V	25V	40V	63V	100V
0·47	—	—	—	—	—	—	10p	7p
1·0	—	—	—	—	—	10p	—	7p
2·2	—	—	—	—	10p	—	7p	8p
4·7	—	—	—	10p	—	7p	8p	7p
10	—	—	—	—	7p	8p	7p	8p
22	—	—	7p	7p	—	7p	7p	9p
47	7p	—	8p	8p	8p	7p	9p	12p
100	8p	7p	7p	7p	7p	9p	11p	19p
220	7p	8p	8p	8p	9p	10p	17p	27p
470	8p	9p	9p	10p	12p	17p	24p	43p
1,000	10p	12p	12p	17p	20p	24p	40p	—
2,200	14p	17p	22p	25p	36p	40p	—	—
4,700	25p	28p	37p	41p	54p	—	—	—
10,000	40p	43p	—	—	—	—	—	—

Prices subject to amendment by the manufacturer.

POLYCARBONATE—5% TOLERANCE

250V up to 0·1µF: 100V, 0·1µF and above.
0·01; 0·012; 0·015; 0·018; 0·022; 0·027; 0·033; 0·047; 0·056; **4p** each. 0·068; 0·082; 0·1; 0·12; 0·15; **4p** each. 0·18; 0·22; **5p** each. 0·27; 0·33; **6p.** 0·39 **7p.** 0·47 **8p.** 0·56 **10p.** 0·68 **11p.** 1µF **13p.** *Prices subject to amendment by the manufacturer.*

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Type 3015F. Seven Filament segment indicators to make 0-9 + decimal point. Compatible with standard logic modules, nett **£2.** Decoder driver type FLL 121T nett **£1·36.** DIL socket, nett **£2.**

RESISTORS – 10%, 5%, 2%

Code	Power	Tolerance	Range	Values available	1 to 9	10 to 99 (see note below)	100 up
C	1/20W	5%	82 Ω–220K Ω	E12	**9**	**8**	**7·5**
C	1/8W	5%	4·7 Ω–470K Ω	E24	**1**	**0·9**	**0.75 nett**
C	1/4W	5%	4·7 Ω–10M Ω	E12	**1**	**0·9**	**0·75 nett**
C	1/2W	5%	4·7 Ω–10M Ω	E24	**1·2**	**1**	**0·95 nett**
C	1W	5%	4·7 Ω–10M Ω	E12	**2·5**	**2**	**1.6 nett**
MO	1/2W	2%	10 Ω–1M Ω	E24	**4**	**3**	**2 nett**
WW	1W	10% ± 1/20 Ω	0·22 Ω–3·9 Ω	E12	**7**	**7**	**6**
WW	3W	5%	1 Ω–10K Ω	E12	**7**	**7**	**6**
WW	7W	5%	1 Ω–10K Ω	E12	**9**	**9**	**8**

Codes: C = carbon film, high stability, low noise.
MO = metal oxide, Electrosil TR5, ultra low noise.
WW = wire wound, Plessey.
Values:
E12 denotes series: 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82 and their decades.
E24 denotes series: as E12 plus 11, 13, 16, 20, 24, 30, 36, 43, 51 62, 75, 91 and their decades.

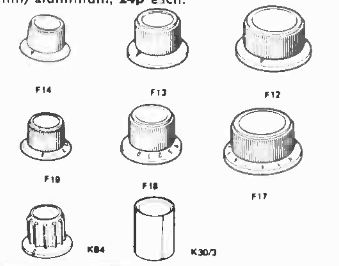
Prices are in pence each for quantities of the same ohmic value and power rating. NOT mixed values. (Ignore fractions of one penny on total value of resistor order.)

Send S.A.E. for latest supplement of additional lines and price amendments to our No. 6 Catalogue

KNOBS

All grub screw fitting for ¼in shafts. Black. For other types —see Catalogue No. 6, p. 54.

F.14 (20mm) pack of 2, **32p**; F.13 (26mm) pack of 2, **38p**; F.12 (33mm) pack of 2, **40p**; F.19 (20mm) pack of 2, **32p**; F.18 (26mm) pack of 2, **38p**; F.17 (33mm) pack of 2, **40p**; KB.4 (20mm) pack of 4, **40p**; K30/3 (17mm) aluminium, **24p** each.



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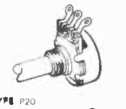

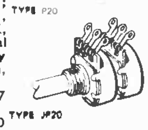

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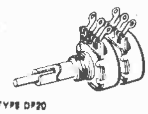

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Strictly

by K. Lenton-Smith

THE piano, without which no home was complete several decades ago, is now becoming a rarity because of lack of living room space and other home entertainment attractions. This could be one of the reasons that the guitar is often the choice of younger members of the household.

For those wishing to take up a keyboard instrument, the Electric Piano is ideal as it occupies very little room.

ELECTRIC PIANO

The majority of these instruments suffer from only one disadvantage musically in that the keyboard is usually a standard five octave (organ) manual, against the seven octaves of a conventional piano. Nevertheless, five octaves are probably sufficient for performing many piano pieces. The cost of a compact electric piano may be well under £200 and, with pre-amplified output, it is small enough to be easily carried in one hand.

The percussive attack of a conventional piano will readily penetrate a semi-detached house's party wall: the volume of its electronic counterpart may be closely controlled. Earphones may be used for practising late in the evening. The electric piano allows changes of timbre, such as harpsicord, honky-tonk, etc.

Like the majority of commercial electronic organs, the generated waveform is square. The usual arrangement is a Hartley (sine wave) oscillator, followed by a series of Eccles-Jordan frequency dividers (square wave) for each of the 12 chromatic notes of the scale. The dividers are invariably integrated circuits as these are cheaper and smaller than discrete components and there is a saving in labour costs.

Piano tuners introduce small frequency variations to give an ordinary piano added brilliance: from middle "*C*", notes above are progressively sharpened slightly, those below flattened. A system of electronic frequency division—where tuning must be mathematically accurate—would thus not appear to be ideal. In practice, however, this discrepancy is not noticeable and, given a good amplification system (which could well be the domestic hi-fi), a most realistic piano results.

KEYING METHODS

Diode-keying is normally used in electric pianos as this keying method can produce the attack/decay characteristics of a piano fairly closely. Keying transients are practically eliminated by diode-keying and precious metal keyswitches are not vital.

Some instruments employ a changeover keyswitch where a capacitor is kept charged while the key is at rest, depression of the key connecting the charged capacitor to the gating circuit. Filtering is required to round up the square waveform somewhat, usually in the form of a passive low pass filter for "piano" tone.

The keyboard may be split by a special control so that a "walking bass" may be played without drowning the melody line. The Italian-made "Instapiano" is an attractive example, retailing at about £160 before VAT. It measures approximately 48in × 10in × 4in.

PLAYING TECHNIQUE

The electric piano has a number of advantages, not least that there is plenty of published piano music available. Though it may take a little getting used to, pianists have no difficulty in accustoming themselves to the electric piano.

Where two manuals and a pedal clavier are concerned, printed music is not so readily available—unless the player particularly likes Bach and Handel.

The pianist who turns to the organ has some formidable problems: as long as a note is held it will sound, unlike the automatic decay of the piano/electric piano. Thus, attempting to play piano scores on an organ results in disaster—and what does one do with the pedals except "double" the left hand part?

Any constructional project is a challenge to get the beast working! Those who build musical instruments have a further challenge: they have to master the keyboard, and organists who like lighter music will find three-stave scores few and far between.

CHORD SYMBOL BASIS

A number of readers will have built the P.E. Organ, or have access to an organ, and may have experienced difficulty buying music. The usual light music score includes the piano part, guitar symbols, vocal line and chord symbols; the last two are the important items for the organist. With practice, it is possible to play both manuals and pedals using this information only, on sight.

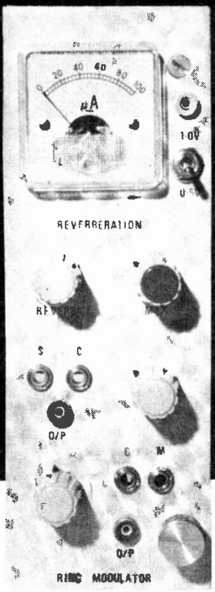
Memorising what each chord symbol involves might, at first, appear to be a mammoth task. Relatively few key signatures are used in popular music as the publishers have to bear in mind the transposing instruments (normally *B* flat and *E* flat) which may be involved. The same chords appear frequently and can be memorised as easily as the resistor colour code! But it must be admitted that the "bridge" often moves into a strange key and demands quick thinking.

The right hand part (melody) should be registered in a way that makes the tune fairly incisive; single notes are often sufficient and, where chords are used, the melody should still stand out.

The left hand part is the problem and should be considered along with the pedals; accompaniment registration should be quieter and less clear cut than the upper manual. The root of the chord symbol can be used for the pedal on the downbeats, at least for a start, alternating with the fifth (i.e., *C* — *G*) except where a diminished chord is indicated. The left hand plays the notes indicated by the chord symbol, according to the time signature and rhythm, using an "anchor note" if possible.

PE Sound Synthesiser 7
REVERBERATION AMPLIFIER RING MODULATOR PEAK LEVEL METER

By G.D.SHAW



THIS month the Ring Modulator, Peak Level Meter circuit and Reverberation Amplifier will be described.

THE RING MODULATOR

With the ring modulator the combination of tones follows a complex inter-relationship in which each frequency is continuously compared with and modified by the other. The resultant output provides a tone which consists of the sum and difference of the two constituent frequencies appearing at the same time and irrespective of the phase angle relationship. A typical output waveform is illustrated in Fig. 7.1.

A simplified version of a transistorised ring modulator manufactured in integrated circuit form by Silicon General, the SG3402N, is shown in Fig. 7.2 and it will be seen that the device consists essentially of a pair of cross-coupled differential pairs jointly controlled by a third. Two inputs—carrier and modulator—are required and it is important to differentiate between them since the input characteristics are dissimilar. Application of equal amplitude signals to both inputs will provide an output showing about 3dB voltage gain over either input. Removal of the modulator with the carrier still applied will result in attenuation of the output signal by about 50dB but if the input situation is reversed the output attenuation is only about 35dB.

Although designed primarily for communications work the SG3402N is capable of working satisfactorily at quite low audio frequencies by the simple expedient of increasing the value of the input and decoupling capacitors.

The frequency response of the prototype Ring Modulator is shown in Fig. 7.3 and will be seen to be effectively flat over most of the audio frequency spectrum. The theoretical circuit is shown in Fig. 7.4.

The maximum input signal to the SG3402N should not normally exceed 50mV and thus resistive attenuators are employed to raise the signal level, at the input sockets, to one more compatible with the signal level normally routed around the Synthesiser. With the value of resistors employed in the attenuators the maximum input signal at the sockets is thus 500mV.

IC2 serves to amplify the output to about 1·5V at the rated input levels and measured at an input frequency to both channels of 1kHz. The ring modulator shares a circuit board with the peak level meter and the board layout is shown in Fig. 7.5.

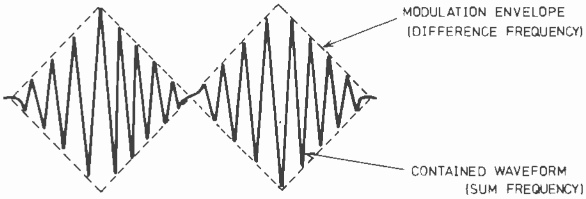


Fig. 7.1. Typical output waveform of the Ring Modulator

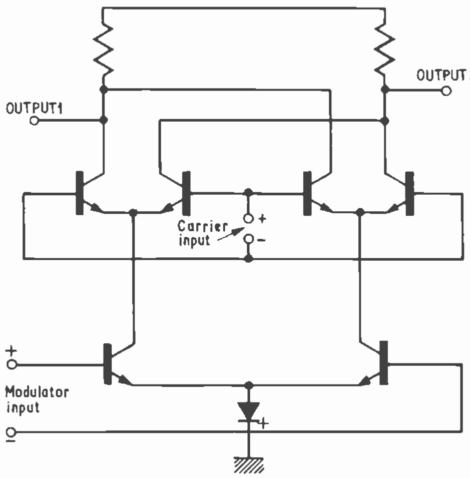


Fig. 7.2. Schematic of a transistorised Ring Modulator

RANGE OF SOUNDS PRODUCED

The type of modulation produced by the ring modulator is wholly unique and thus also is the range of sounds which can be achieved. If two pure tones are modulated together and one of them is reduced in frequency the resultant output would follow the pattern shown in the table below which relates the sum and difference output frequencies with the carrier and modulator input frequencies.

	Frequency (Hz)						
Carrier	700	600	500	400	300	200	100
Modulator	400	400	400	400	400	400	400
Sum	1100	1000	900	800	700	600	500
Difference	300	200	100	0	100	200	300

It can be seen that, whereas the resultant sum reduces in frequency at the same rate as the carrier, the frequency reduces until it reaches zero (carrier and modulator frequencies equal) and then, as the carrier continues to fall to a frequency lower than that of the modulator, the difference frequency begins to increase at a proportional rate.

When the inputs to the Ring Modulator carry harmonics in addition to the pure tones then further series of frequency relationships are established for each of the component harmonics relative to one another and to the respective fundamentals.

When the inputs to the Ring Modulator are of symmetrical triangular waveform, such as those generated by the v.c.o., an extremely complex set of frequency relationships is established due to the fact that, in common with the square wave, the triangular waveform consists of a long series of odd harmonics.

SOUNDS PRODUCED

The Ring Modulator may be used in many fascinating ways from the creation of truly "out of this world" sounds, the transposition of tones, bell-like sounds, Dalek voices and so on.

In the transposition of tones the only stipulation is that the modulating frequency should be higher than the carrier (this latter input consisting of the signal for treatment). For any range of carrier frequencies the modulator frequency has to be calculated or determined empirically, to provide the best overall effect.

An interesting experiment can be carried out by cascading two Ring Modulators. The first uses the v.c.o. output to drive carrier and modulator inputs so that the output is the octave, or second harmonic, of the v.c.o. frequency. The output of the first Ring Modulator is used to drive the modulator input of the second whilst the carrier input is derived direct from the v.c.o. Thus the difference frequency of the second Ring Modulator will follow, exactly, the performance of the v.c.o. while the sum frequency will approximate to a quarter-tone accompaniment about $1\frac{1}{2}$ octaves higher. There are very wide possibilities for further experiment in this kind of mode.

A true bell tone is very complex and is difficult to imitate with exactitude. A fairly close approximation may be achieved by adjusting two v.c.o.s to a mid-range frequency, say 4kHz, such that there is a slow beat between them. One v.c.o. then drives the carrier and the other v.c.o. the modulator input of the Ring Modulator. A very important characteristic of the bell-like sound lies in its envelope presentation and this will be dealt with in detail in next month's article.

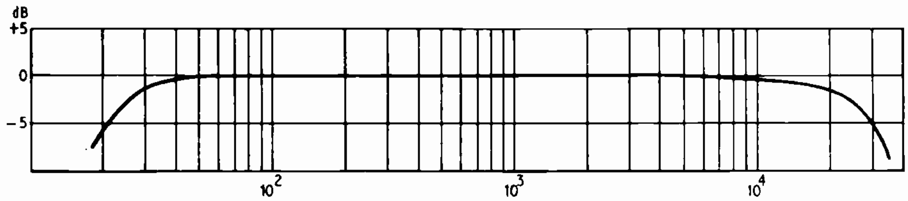


Fig. 7.3. Frequency response of prototype Ring Modulator

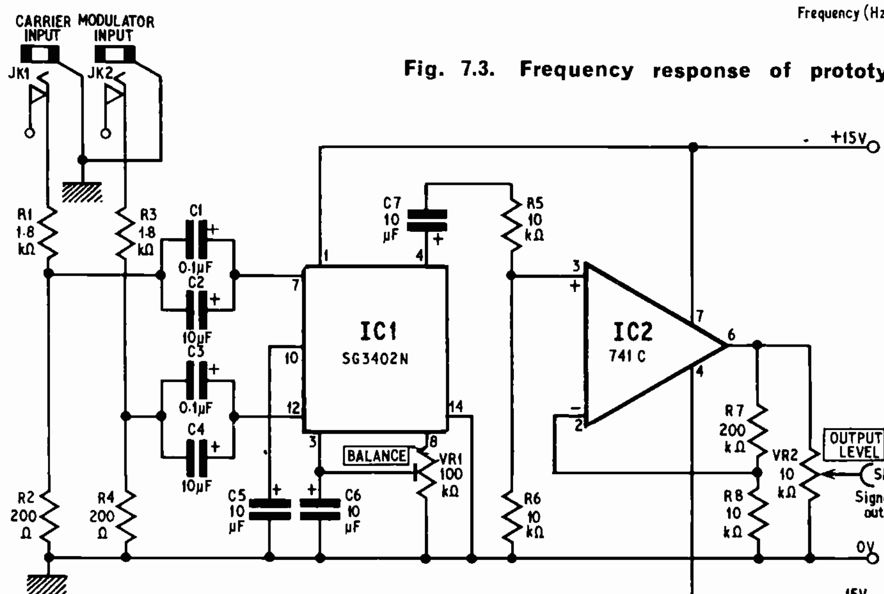


Fig. 7.4. Ring Modulator circuit

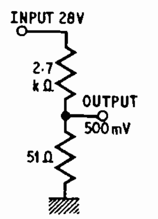


Fig. 7.5. Simple resistive attenuator for use with the Ring Modulator

PEAK LEVEL METER

RING MODULATOR

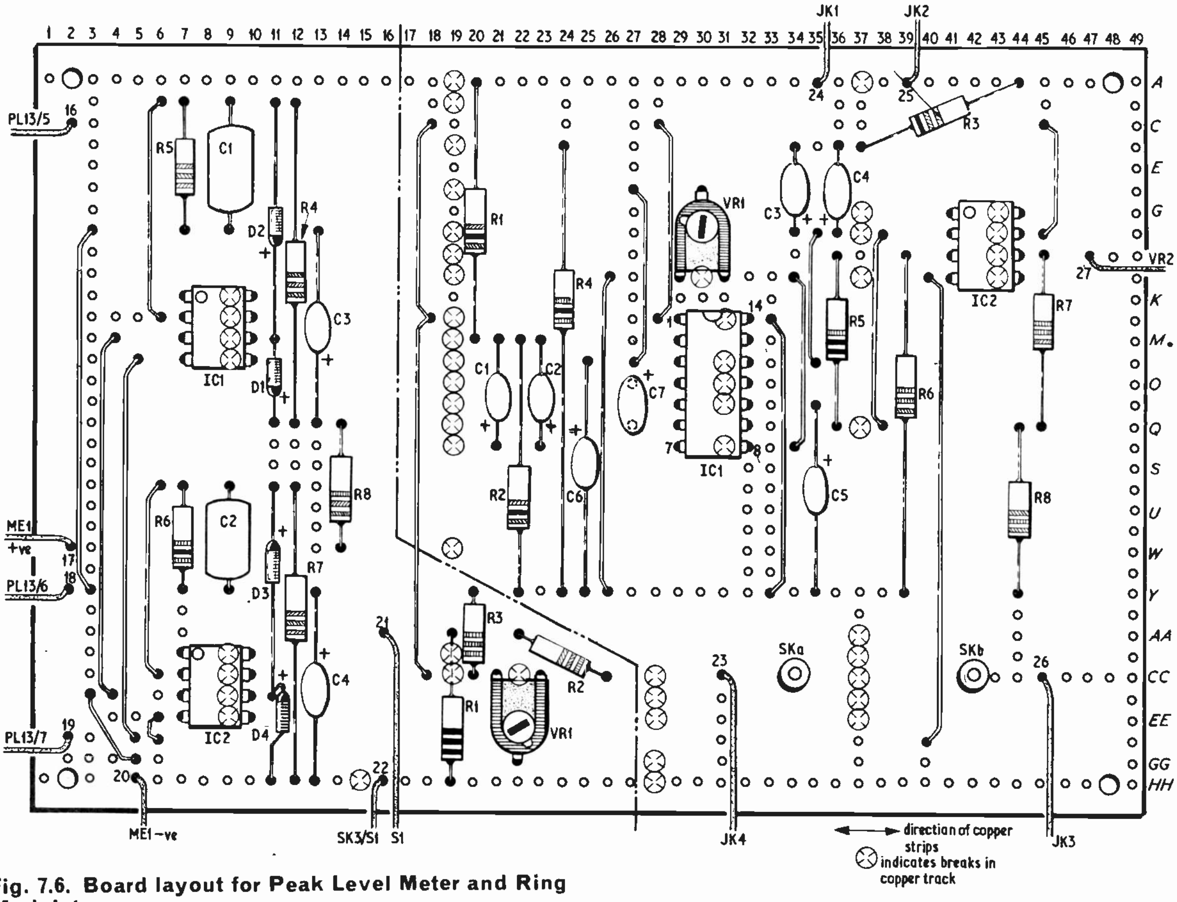


Fig. 7.6. Board layout for Peak Level Meter and Ring Modulator

COMPONENTS . . .

PEAK LEVEL METER CIRCUIT

Resistors

R1 91k Ω
R2–R3 20k Ω (2 off)
R4 91k Ω
R5–R6 3·3k Ω (2 off)
R7 91k Ω
R8 110k Ω
All 5% ½ watt carbon

Capacitors

C1–C2 1,500pF (2 off)
C3–C4 22μF 16V tantalum

Potentiometers

VR1 50k Ω carbon preset

Diodes

D1–D4 IN914 (4 off)

Integrated Circuits

IC1-IC2 741C (2 off)

Miscellaneous

ME1 MR38P SEW panel meter (G. W. Smith Ltd.)
SK3 2mm miniature socket

RING MODULATOR

Resistors

R1 1·8k Ω
R2 200 Ω
R3 1·8k Ω
R4 200 Ω
R5 10k Ω
R6 10k Ω
R7 200k Ω
R8 10k Ω

All 5% ½ watt carbon

Capacitors

C1 0·1μF 35V
C2 10μF 16V
C3 0·1μF 35V
C4–C7 10μF 16V (4 off)

All tantalum

Potentiometers

VR1 100k Ω carbon preset
VR2 10k Ω miniature moulded carbon

Integrated Circuits

IC1 SG3402N
IC2 741C

Miscellaneous

JK1, JK2 3·5mm miniature jack sockets (2 off), SK1 2mm miniature socket, Veroboard as required

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BA154	13p	BY126	15p	IN4006	12p
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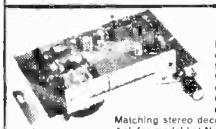

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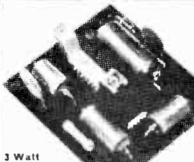

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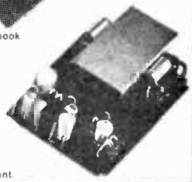

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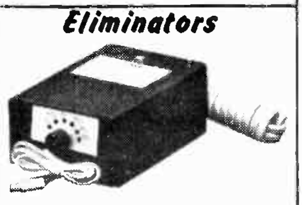

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033µF	3p	22µF	5p	1 5µF	20p
047µF	3p	·33µF	6½p	2·2µF	24p

metallised polyester 400V (C281)

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·015µF	4½p	·068µF	6p	33µF	14p
·022µF	4½p	·1µF	7p	47µF	15p
·033µF	5½p	·15µF	8p		

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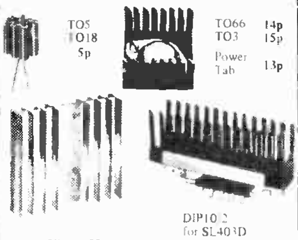

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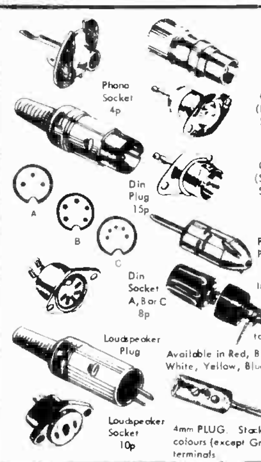
AC187	25p	BC159	12p	BRY39	36p	ZTX108	12p	2N3054	50p	LO36T1	£1.50
AC187K	25p	BC169	15p	BSX21	26p	ZTX109	15p	2N3055	49p	LO37T1	£1.50
AC188	25p	BC268	15p	BSY95A	14p	ZTX300	12p	2N3702	12p	MC1303L	£1 75
AC188K	25p	BD115	67p	BU105/02	£1.75	ZTX301	15p	2N3703	12p	MC1330	80p
ACY20	20p	BD131	70p	MJE340	67p	ZTX302	20p	2N3704	10p	MC1350	75p
AD140	40p	BD132	70p	MPF102	40p	ZTX303	20p	2N3705	10p	MC1351	£1.00
AD149	40p	BD131/2M.P.		MPF103	37p	ZTX304	25p	2N3706	10p	MC1352	£1.00
AD161 / AD162	60p		149p	MPF104	37p	ZTX341	20p	2N3707	12p	MFC4000B	49p
		BF160	21p	MPF105	40p	ZTX500	15p	2N3708	12p	MFC4010A	55p
AF114	18p	BF167	20p	MPF106	45p	ZTX501	15p	2N3709	12p	LM380	£1.45
AF115	18p	BF173	20p	OC28	40p	ZTX502	20p	2N3710	12p	SL403D	£1.50
AF116	18p	BF180	25p	OC35	40p	ZTX503	17p	2N3711	12p	TAD100	£1.50
AF117	18p	BF181	30p	OC44	15p	ZTX504	50p	2N3819	35p	FILTER LP1175	£1.50
AF139	28p	BF184	25p	OC45	15p	ZTX531	25p	2N3903	15p	µA709C	34p
BC107	10p	BF185	25p	OC71	11p	2N697	18p	2N3904	17p	µA710	45p
BC108	10p	BF194	15p	OC72	17p	2N706	12p	2N3905	21p	µA723C	95p
BC109	10p	BF195	15p	OC76	15p	2N708	15p	2N3906	12p	µA741C	47p



Coax Plug 8p
Phono Socket 4p
Coax (Flush) Socket 8p
Coax (Surface Socket 8p
Din Plug 15p
A B C
Din Socket A, B or C 8p
Phono Plug 5p
Insulated TERMINALS 13p each takes 4mm plug
Available in Red, Black, Green, White, Yellow, Blue and Grey
Loudspeaker Plug
8p each
Loudspeaker Socket 10p
4mm PLUG. Stackable same colours (except Grey) as terminals

ADCOLA INVADER

L706 ⅛" £1 70 p.& p. 10p
L646 3/16" £1 85 p.& p. 10p

Savbit Solder Dispenser. Contains 12 ft. of coiled 18 s.w.g. Ersin Multi-core Savbit Alloy
18p each

ROTARY MAINS 25p

SINGLE WAFER ROTARY 25p

1 pole	12 way
3 pole	4 way
4 pole	2 way
4 pole	3 way

SLIDE D P D T 17p
TOGGLE S P S T 250V 1A 18p
TOGGLE D P D T 250V 1A 20p

mixed dielectric 1000V

1000pf	6p	6800pf	9p	·1µF	12p
2200pf	6p	01µF	9p	·22µF	22p
3300pf	6p	·022µF	9p	47µF	30p
4700pf	6p	·047µF	12p		

Ceramic

12KV.d.c		8KV.d.c.		HI-K 750V.	
10pf	9p	200pf	9o	1000pf	5p
15pf	9p	220pf	9p	1500pf	5p
22pf	9p	250pf	9p	2000pf	5p
68pf	9p	270pf	9p	3000pf	5p
82pf	9p	300pf	9p	5000pf	5p
100pf	9p	750V DISC		10.000pf	5p
120pf	9p	470pf	5p	feed-through	
140pf	9p	1000pf	5p		
150pf	9p	5000pf	5p		
180pf	9p	10.000pf	5p	1000pf	5p

Mullard & Siemens Electrolytics

CAP µF	VOLTAGE 4	6.3	10	16	25	40	63
1	—	—	—	—	—	—	6p
1·5	—	—	—	—	—	—	6p
2·2	—	—	—	—	—	—	6p
3·3	—	—	—	—	—	—	6p
4·7	—	—	—	—	—	—	6p
6·8	—	—	—	—	—	6p	6p
10	—	—	—	—	6p	—	6p
15	—	—	—	6p	—	6p	6p
22	—	—	6p	—	6p	—	6p
33	—	6p	—	6p	—	6p	—
47	6p	—	6p	—	6p	6p	6p
68	—	6p	—	6p	—	—	10p
100	6p	—	6p	—	6p	6p	12p
150	—	6p	—	6p	6p	10p	12p
220	6p	—	6p	6p	10p	12p	18p
330	6p	—	6p	10p	—	—	21p
470	—	6p	10p	—	12p	18p	40p
680	—	10p	—	12p	18p	21p	—
1000	10p	—	12p	18p	21p	40p	60p
1500	—	12p	18p	21p	—	—	—
2200	—	18p	21p	40p	45p	55p	93p
3300	—	21p	—	—	—	—	—
4700	21p	—	—	60p	75p	93p	—

CAP µF	VOLTAGE 16	25	40	64
500			33p	40p
1250			50p	—
1600			—	75p
2000	40p	50p	—	—
2500	—	—	75p	93p
3200	50p	—	—	—
4000		75p	93p	—
6400	75p	93p	—	—

Quantity Prices on application

Hi~Volt Electrolytics

1, 2, 4, 8µF	450V	14p	32µF	450V	20p
16µF	450V	15p	50µF	350V	20p
8 + 8µF	450 V W	18p	32 + 32µF	350 V.W	25p
8 + 16µF	450 V.W	20p	32 + 32µF	450 V W	43p
16 + 16µF	450 V.W	25p	50 + 50µF	350 V.W	35p

Dalek voices are produced by modulating a modified speech waveform at about 15-20Hz. Speech, and certain types of music waveforms, can present a very peaky characteristic. The peaks are multiplied and added to in the Ring Modulator and thus, if the signal is remodulated several times, or if the initial frequency is high enough, the final output contains a large proportion of sound which bears a remarkable resemblance to white noise. The cure for this problem is to limit the dynamic range of the signal.

Although exact details for such a procedure lie outside the scope of this series a passable method is to feed the offending signal to one of the input amplifiers and, observing the output on the oscilloscope, adjust the gain of the amplifier so that a large proportion of the peaks are suitably clipped. If insufficient gain is available to allow an adequate degree of clipping the input amplifiers may be cascaded. The achievement of clipping means, of course, that the amplifier output signals are swinging between the positive and negative saturation levels and it will be necessary to attenuate the signal quite considerably. Fig. 7.5 shows a simple resistive attenuator which will give a signal of about 500mV from a 28V source.

CONSTRUCTION

Construction of the Ring Modulator is quite straightforward and the only critical requirement lies with the observation of polarity of the tantalum capacitors. Reversal of any of the capacitors will result in noisy operation and, in the case of the output capacitor, no operation at all. Tantalum capacitors have been specified in order to conserve space and there is no reason why 10V electrolytics should not be used with an alternative layout.

SETTING UP

Setting up the Ring Modulator consists only of providing a modulation balance. Set VR1 to its mid position and apply a common sine wave signal to both inputs. The output of the ring modulator will be a sine wave which is twice the frequency of the applied signal. If the modulation is out of balance alternate peaks of the output signal will be at different amplitudes. VR1 should be adjusted to bring the peaks into line at which point the modulation is balanced.

It is a wise precaution to repeat this measurement from time to time to adjust for settling down changes in the circuit.

THE PEAK LEVEL METER

In the prototype Synthesiser the meter circuit was based on a precision rectifier built around a pair of operational amplifiers arranged in such a way as to eliminate the effect of the diode forward voltage drop. Although the circuit proved to be very responsive it was found, in practice, to present a number of disadvantages. In the case of a.c. signals the meter would read only the r.m.s. value and although it was possible to determine the actual peak-to-peak value by application of a form factor for known wave shapes the determination of peak-to-peak values for complex waveforms proved to be a very hit and miss affair.

In a similar manner, when endeavouring to set up reasonably accurate programming voltage levels, the rapid response of the meter frequently made it difficult to establish the peak value with any certainty.

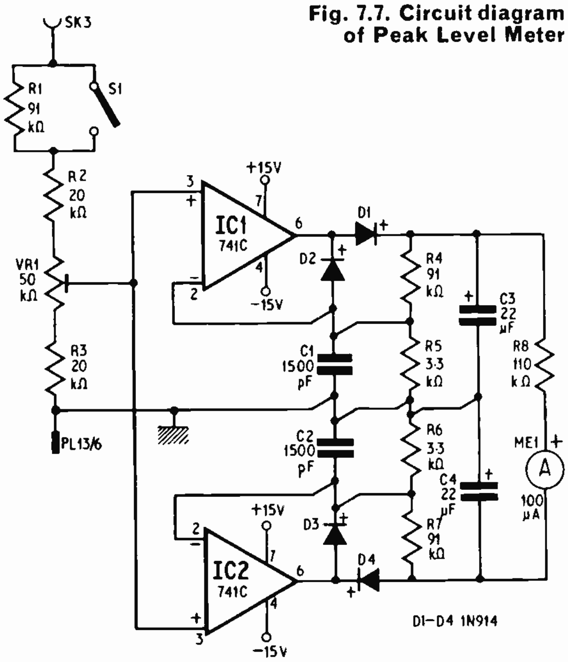


Fig. 7.7. Circuit diagram of Peak Level Meter

In consequence it was decided to redesign the meter circuit to provide a peak reading facility which would be independent of waveform configuration and which would have a reasonably long decay time to ease the establishment of transient level readings. The final circuit is shown in Fig. 7.7. IC1 and its associated circuitry is used to read the positive going peaks while IC2 deals with the negative side of the signal. The operation of the circuit is as follows.

CIRCUIT OPERATION

The input sensitivity of the circuit at the i.c. is about 200mV for full scale deflection of the meter. A positive going peak of this value appearing at the input of IC1 will swing the output positive to a level determined by the values of R4 and R5, about 6·2V with the values shown, and capacitor C3 will charge at a rate determined essentially by the effective current output of the i.c. The charging time for C3 is thus rather less than 2mS.

If, after the capacitor is charged, the 200mV peak is replaced by a lower amplitude peak the tendency would be for the i.c. to swing hard negative due to the effect of the positive voltage from the capacitor appearing at the inverting input via R4. This tendency is prevented by D2 which limits the negative excursion of the output to about 700mV.

Capacitor C3 discharges through R4 + R5 in parallel with R8 + R (meter) and with the values shown takes about 1 second. C1 serves to decouple a.c. from the feedback loop and thus effectively extends the accurate range of the meter to about 15kHz.

The negative reading side of the circuit around IC2 operates in the same way. The circuit is adjusted to give full scale deflection with inputs of 1·0V and 0·5V by means of the attenuator R1, 2, 3 and VR1.

In using the meter it should be borne in mind that the peak values recorded represent only half the total peak to peak value of the signal being measured and this applies whether the signal is symmetrical or assymmetrical about zero. When measuring low frequency programming signals of greater than 1Hz the minimum reading of the meter between peaks does not represent the lowest level of programming signal.

This particular meter circuit can be used to measure the peak level of single transients of not less than 2mS duration.

ADVANTAGES

In tape recording the peak level meter scores heavily over the more conventionally employed v.u. meter. This latter meter will record what is essentially the mean value of signal presented to the recording amplifier and if, as is generally the practice, the mean level is kept to about −3dB transient peaks are likely to be clipped or otherwise distorted. The use of a peak level meter, on the other hand, enables the peaks to be kept within the limits imposed by the recording amplifier and thus enhances the overall quality of the recording.

THE REVERBERATION AMPLIFIER

Reverberation, or re-echo, in varying degrees is a characteristic observed in the majority of large halls, public buildings, cathedrals and so on. In a properly designed and proportioned hall the inherent reverberation characteristic can provide a high degree of enhancement to the sounds occurring therein.

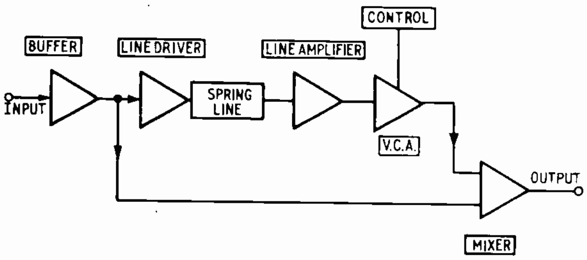


Fig. 7.8. Block diagram of Reverberation Amplifier

COMPONENTS . . .

REVERBERATION AMPLIFIER

Resistors

R1	10k Ω	R15	3·9k Ω
R2	270k Ω	R16	110k Ω
R3	39k Ω	R17	13k Ω
R4–R5	10k Ω	R18	13k Ω
R6	47k Ω	R19	0·5 Ω } 3W wire-wound
R7	10k Ω	R20	0·5 Ω } 3W wire-wound
R8	6·8k Ω	R21	56 Ω } 3W wire-wound
R9	390 Ω	R22	10k Ω
R10	10k Ω	R23	10k Ω
R11	20k Ω	R24	120k Ω
R12	10k Ω	R25	10k Ω
R13	10k Ω	R26	See text
R14	10k Ω		

All 5% ½ watt carbon unless otherwise stated

Capacitors

C1, C2	0·1μF ceramic
C3	620pF silver mica
C4	4μF 15V elect.
C5	0·1μF ceramic
C6	0·1μF ceramic
C7, C8	10μF 16V tantalum
C9	0·003μF ceramic
C10	See text
C11, C12	100μF elect. 22V

Transistors and Diodes

TR1	2N2905	TR3	BC209C
TR2	2N2219	D1, D2	IN914

Potentiometers

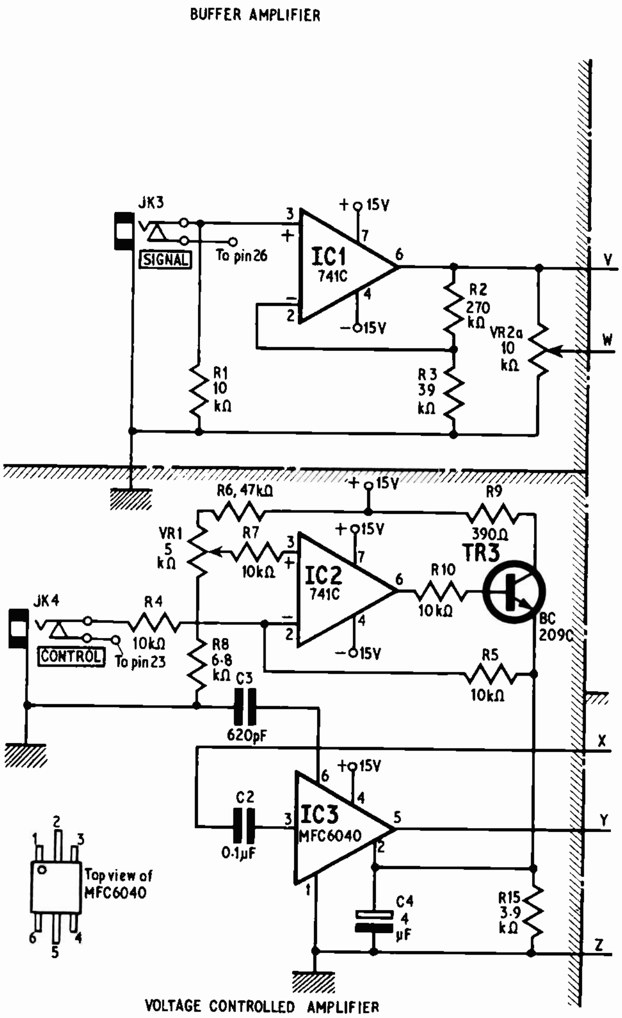
VR1	5k Ω lin.
VR2a/b	10k Ω lin. (two ganged)
VR3	10k Ω lin.

Integrated Circuits

IC1, IC2	741C
IC3	MFC6040
IC4, IC5, IC6	741C

Miscellaneous

Spring line type HR42 (Henry's Radio), JK3, JK4 3·5mm jack sockets (2 off), SK2 2mm miniature socket



There are a number of ways in which a reverberation characteristic may be simulated and for the Synthesiser the spring line has been adopted. The spring line consists essentially of a coiled wire, usually steel, which is supported at each end in a compliant mounting. At the supported ends of the wire are fitted electro-magnetic transducers. The line driving transducer is excited by an electrical signal and the varying field produced causes mechanical wave motion to be set up in the spring line. When the wave motion reaches the far end of the line it sets up an electrical disturbance in the line output transducer which is, in turn, amplified and added to the original signal.

Part of the original mechanical wave motion is reflected back down the spring line where it serves to modify further on-coming waves.

Because a mechanical wave motion travels much more slowly than its electrical counterpart the signals received by the line output transducer are delayed in relation to their source, such delay being a function of the length of wire used in the spring line. Thus the mixing of the mechanically routed signal with the source signal constitutes the addition of an echo. However, since the wave motion, once initiated, travels back and forth along the line until its amplitude becomes negligible, multiple echoes are received and added to the original signal.

The spring provides a further useful feature having its origin in the fundamental resonance of the system. When the driving signal passes through the frequency at which the system resonates the output is characterised by a sudden increase in amplitude which can be as much as three times the value of the normal mean signal. Similarly when the input signal passes through any of the harmonics of the resonant frequency there is an increase in output signal amplitude, and this despite the fact that the useful range of the HR42 spring line, specified for this project, is limited at its upper end to about 4kHz. In the prototype unit quite high resonant peaks were occurring at up to 25kHz.

The combination of multiple echoes and varying amplitude imparts a very useful "singing" quality to an otherwise uninteresting sound.

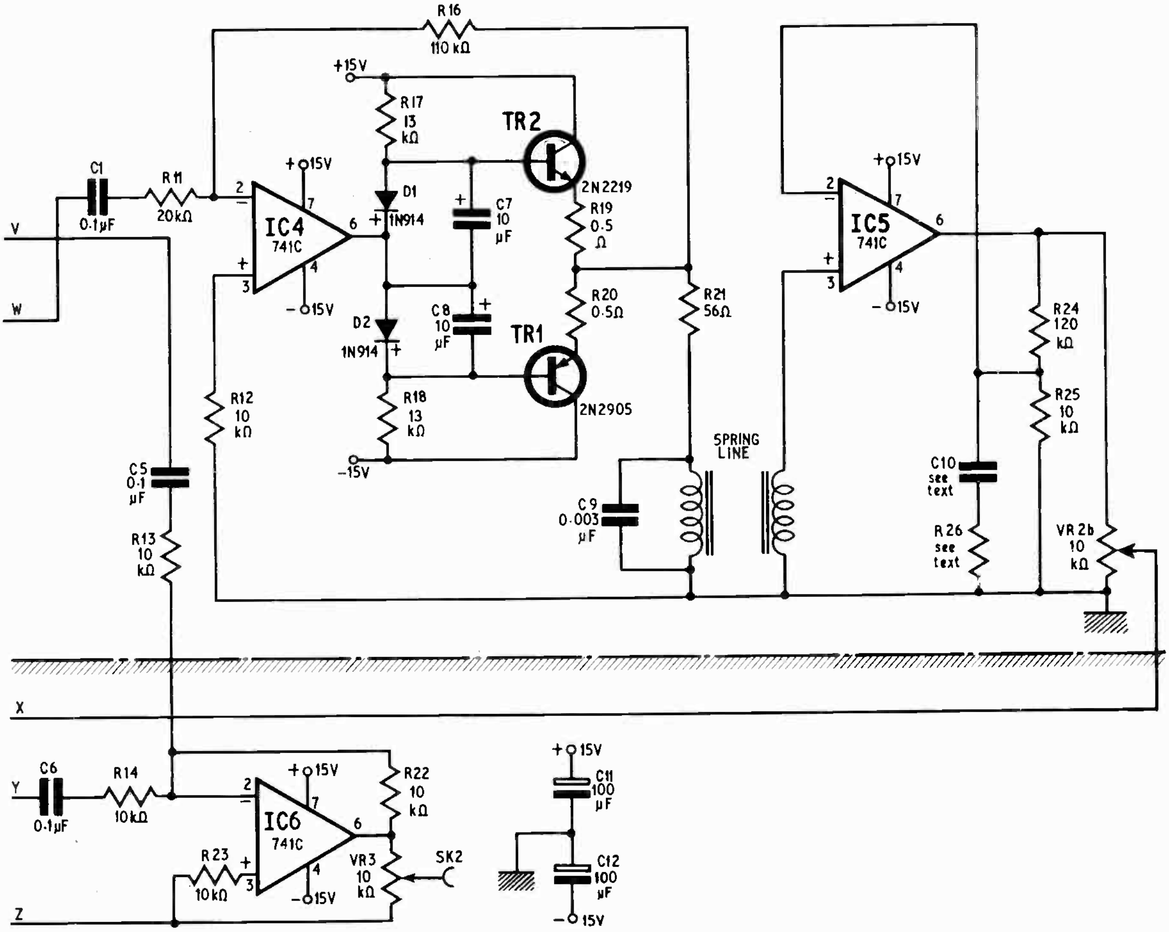
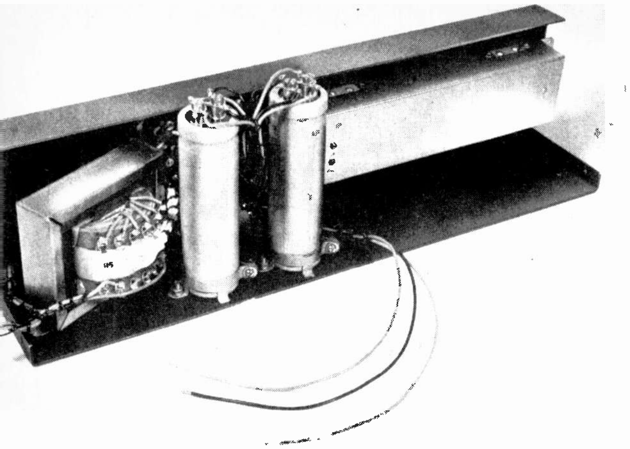


Fig. 7.9. Circuit diagram of Reverberation Amplifier



The spring line unit is attached to the p.s.u. sub-frame

DESIGN CONSIDERATIONS

In the prototype the line driving amplifier employed a single transistor operating in what was effectively Class A. The current consumption was thus quite high even in the quiescent state and small variations in the power supply rails gave rise to noise in the system which was apparent when the line was not being driven hard. For the modular version of the Synthesiser therefore the Reverberation Amplifier was redesigned to reduce current consumption, reduce hum and noise to negligible proportions and to enable a complete divorcing of the voltage controlled part of the system so that the amplifier may be built as a separate unit outside the Synthesiser project altogether.

A fortuitous advantage of the re-design provides sufficient power capability to drive two HR42 or one HR42 and one HR162 spring lines in series. It is also theoretically possible to drive up to four of the above spring lines in any combination although this latter method has not been tested.

The advantage in using more than one spring line in the system lies in the fact that it is rare for two units to have identical resonances and delays and thus two or more units can only improve the overall reverberation characteristic.

CIRCUIT ACTION

The Reverberation Amplifier is shown in block form in Fig. 7.8 and the circuit diagram in Fig. 7.9. The input signal is led to a buffer stage, which has a gain of about six, and the output is divided to drive the line amplifier and output mixer. The line driving amplifier consists of a pre-amplifier built around a 741 and having a gain of about five which, in turn, provides drive to a complementary pair of output transistors having a current gain of about a hundred and arranged in what may be described as a modified form of Class B. The output from this latter stage provides drive direct to the spring line through a current limiting resistor.

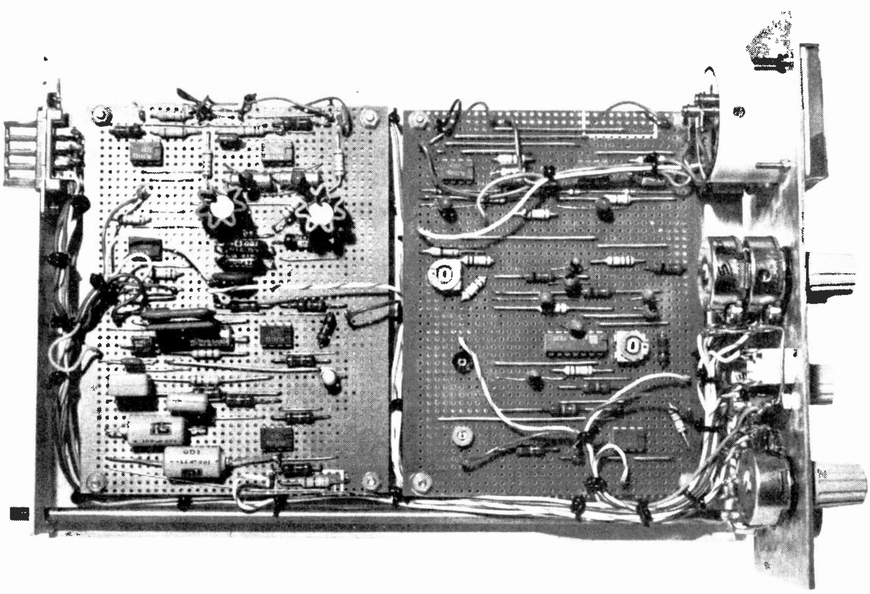
The output from the spring line is amplified by another 741 having a gain of about nine and then led to the input of the voltage controlled amplifier based on the Motorola MFC6040. This latter device has a maximum gain of 13dB and a maximum attenuation of about 77dB relative to the input signal which should not normally exceed 500mV r.m.s. The overall gain of the spring line route is thus arranged so that when the line is being driven hard at a non-resonant frequency, and with the v.c.a. at maximum gain, the output of the v.c.a. is equal to the output of the buffer stage and thus the mixer is receiving equal components of reverberated and non-reverberated signal.

The choice of component values for C10 and R26 may be arrived at by experiment on the basis of the measured response of individual spring lines. To limit the gain to 6dB a value of 2·5 kilohms for R26 will suffice.

The value of C10 is calculated on the basis of the frequency at which the 6dB gain is required. For a frequency of 15kHz the value of C10 is 1nF.

The v.c.a. is controlled by a separate 741 arranged in the differential mode. The non-inverting

Photograph of the assembled module



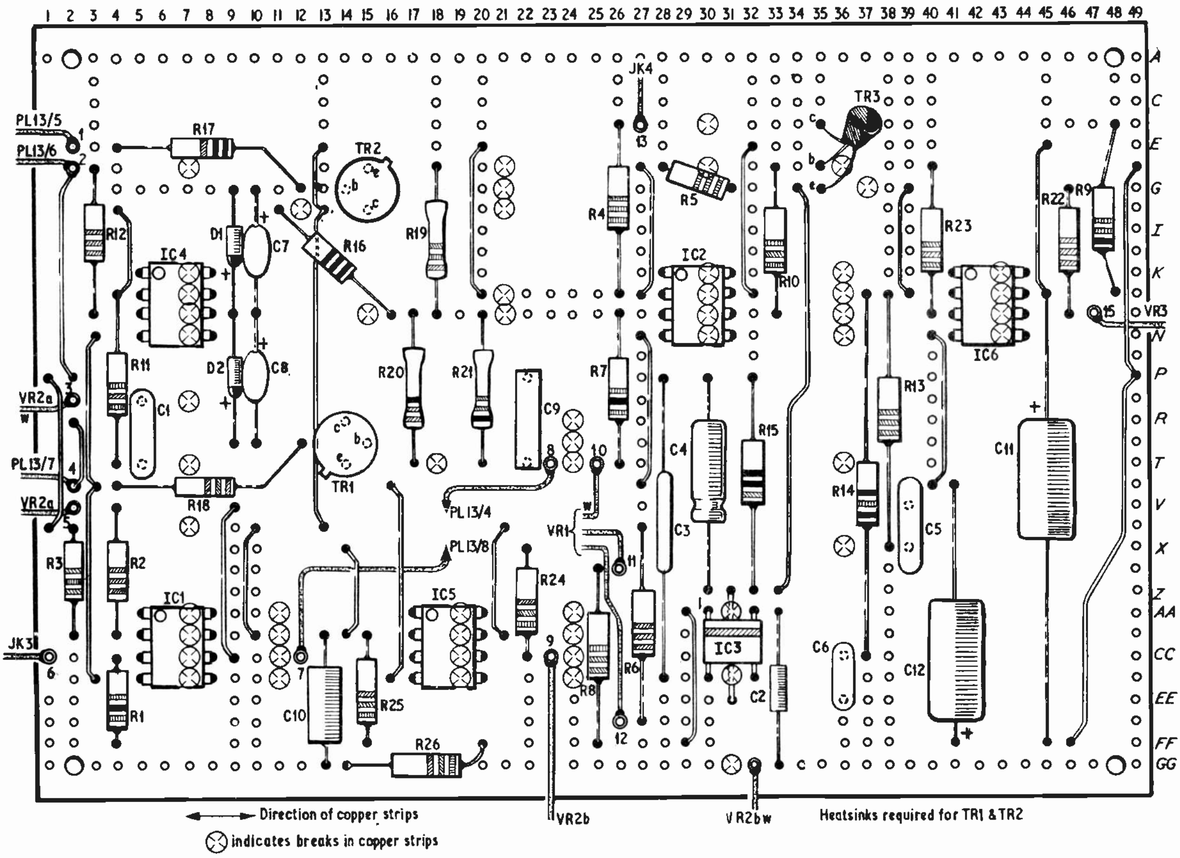


Fig. 7.10. Board assembly of Reverberation Amplifier

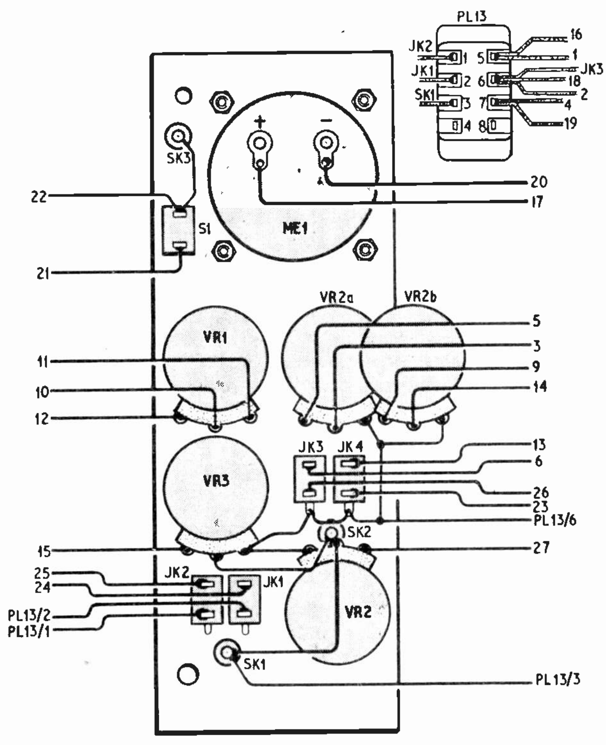


Fig. 7.11. Front Panel Wiring

input is driven by a positive voltage derived from the divider R6, R8, and VR1. The high and low ends of VR1 are thus at 3·0V and 1·75V respectively. The inverting input of the 741 is driven by a control voltage which should have a swing of 2·5V maximum.

With VR1 at its minimum setting a control voltage swinging from zero to −2·5V will have the effect of attenuating the output of the MFC6040. With VR1 at its maximum setting a control voltage swinging from zero to +2·5V will have the effect of amplifying the output of the MFC6040 from −77dB to +13dB relative to its input signal. The inverting input of the 741 acting as control amplifier is prewired to a ramp generator which will, of course, provide the first mode of v.c.a. operation described due to its negative going output.

If external automatic control of reverberation is not required it is essential that a grounded jack plug be inserted into the control socket otherwise the output of the control amplifier will be insufficient to swing the MFC6040 through its full range.

The current sink at the control input of the MFC6040 is specified as being 2mA but on several

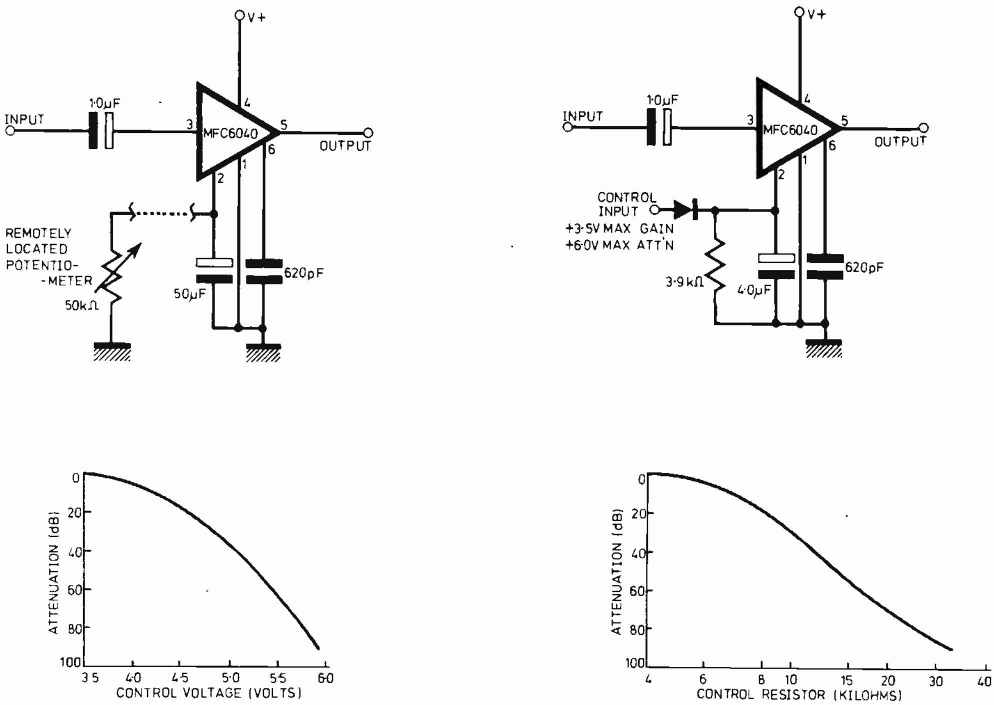


Fig.7.12. Two methods of providing external control using a potentiometer and voltage control input. The relevant response curves are located below each circuit. Here the 0dB reference equals a 13dB gain

tested in this mode of operation quite a wide variation in current sink was noted, the highest being 25mA. Consequently it is prudent to provide a series transistor on the output of the control amplifier, with overall feedback, in order that the 741 is not overloaded. The effect of overload will not necessarily damage the 741 but it could result in a reduction of the output voltage swing which would, in turn, affect the operation of the 6040.

OMITTING THE V.C.A.

For some possible applications the use of voltage control will not be required and, in these instances, the MFC6040 and associated control amplifier may be omitted from the circuit entirely. In these circumstances the gain of the line output amplifier, IC5, will have to be increased by a factor of 0·33 if equal reverberated and non-reverberated components are required at the mixer. The output of IC5 is, of course, led direct to C6 on the mixer in these latter circumstances.

CONSTRUCTION

Fig. 7.10 illustrates the recommended circuit board layout. Construction is quite straightforward and the only setting up required lies in checking the signal levels at the outputs of the buffer, line driver and line output amplifiers to ensure that equal signal components from both sources are presented at the mixer when the line is being driven hard at a suitable non-resonant frequency.

Adjustment of the gain of the line output amplifier may be necessary and is dependent upon the mechanical attenuation of the line which may differ unit to unit.

Overall construction of the module should generally follow the pattern previously described and the wiring of the components on the front panel and McMurdo plug are shown in Fig. 7.11.

In this module the McMurdo plug has insufficient ways to carry all the necessary signals and two extra leads are required to carry the control and audio signals to the reverberation amplifier. Reference to the block diagram in the first part of the series will show that the control signal is derived from RG2 while the audio signal is derived from the right channel of the output amplifiers yet to be described. Suitable leads should be run from the respective McMurdo sockets on these latter modules to a point immediately adjacent the left hand Vero endplate and secured to the connector mounting rail by a tie of lacing cord. From this point they should run along the end plate and be trimmed so that they protrude about three inches beyond the front face of the mainframe. Terminated in 1mm miniature plugs, they can be mated with their respective sockets on the Ring Modulator circuit board when the finished module is being inserted into the mainframe.

A fully comprehensive revision of all module interconnections will appear in part nine of the current series.

For the benefit of constructors who may wish to explore the possibilities of the MFC6040, Fig. 7.12 shows two possible methods of providing external control with the resistance attenuation curve and the control voltage attenuation curve of this very versatile device.

In Part 3, VRZ is 100Ω.

Next month: The Envelope Shaper will be described.

RECMF Component Show '73

DESPITE the recent adoption of the title International London Electronic Components Show, the RECMF of old seems still to be so called both on the official catalogue and by many of the exhibitors and visitors. However, this year it bears little resemblance to the Radio Show of old. Perhaps the word "subdued" would describe the feeling best.

In size the 1973 event was not much more than half its previous size, a factor with very mixed blessings. Obviously less to see but, to the footsore visitor, the possibility of seeing most of what was there without total self destruction. And, with less stands, the opportunity to see around, particularly from the gallery which of recent years has tended to become rather crowded.

The last three years have left their mark on the industry very clearly, as the drop in the number of exhibitors showed and it is a shame that some of the more famous semiconductor manufacturers chose not to attend. In fact the usual bustle, not just of visitors, but of new products looking for markets seemed to be muted almost out of existence.

Generally the atmosphere was one of trading rather than of displaying goods, many of the stands were totally bereft of components or equipment and, in this sense were a sad disappointment to the engineer looking for new "toys". However, the current world shortage situation in many component areas probably goes a long way to explaining this.

RADIO RECEIVER I.C.s

Perhaps one thing which stands out from the show is the advances being made in integrated circuits. It is almost possible to build anything using i.c. techniques these days and several of the manufacturers are trying to prove just that.

Fairchild displayed a set of interesting chips which can make up an a.m. or f.m. radio with stereo facilities. These included their 720 single chip a.m. receiver, the 753 f.m. gain block, the 758 phase-lock loop stereo decoder, the 3075 f.m. i.f. amplifier and limiter, detector and audio pre-amplifier, and the 706 audio power amplifier with a 5W capacity.

Both mono and stereo were demonstrated using either one or two of the power amplifier chips and considering the nature of the halls at Olympia, reception was very impressive.

To an extent of course, this type of display is really more of an application demonstration than a display of new concepts since the basics of such systems have been around for some time. However, it does illustrate the way in which we can expect developments to go as more and more roles are taken over by the chip.

FILTERS USING I.C.s

Take the case of Siliconix of Swansea, well known in the semiconductor market. They are investigating the ability of multi-amplifier chips to provide variable filters, of great value in audio control and generation applications.

They have already developed some prototype circuits using their L114 triple operational amplifier and have established that it is possible to obtain a tuning range from 0 to 10kHz, that high Qs up to 400 can be obtained, that high and low bandpass is simultaneously possible and that both gain and Q are easily programmable.

Indeed, they have even developed a digitally programmed filter using one of their own DG 507 chips to do the logic control.

With all this compression of componentry on to chips one almost wonders where the discrete component went. But one only has to look at any circuit board to see the still tremendous need for power rail droppers, couplers and so on.

MULTI-PURPOSE INSTRUMENT

On the more constructional side there were a number of interesting items. For the portable instrument constructor there was the Pakit kit multi-purpose instrument. An analogue display and movement is available to fit a moulded plastic case which has ample room for circuitry and components. Available from Elcometer Instruments Ltd., the Pakit can be bought complete with a rechargeable power supply, self-designed front panel, leather carrying case and printed circuit.

The basic unit with case will probably market for something under £20.

CASES AND PACKAGING

For the inveterate casemaker there was a display of coated aluminium panel material from Bakelite Xylonite Ltd., which provides both strong covering, attractive colours and, as an added bonus fairly high electrical insulation by virtue of the plastic coating material.

For the man who is always losing components on the bench there was an interesting adaption of the plastic packaging market. Dunlavin Converters have developed their Ducon Carripallet system for packaging delicate materials to the point where it can be used for other applications.

Thus the Carripallet is a multicavity foam plastic pad measuring 400 × 400 × 50mm and with 25 cells. Laid on its back, which is a cardboard support layer, it can be used as a multi-compartment tray. As the material is flexible foam plastic it will not damage delicate parts and indeed components can be stuck upright in it if required.

Normally items of this type are sold in large quantity only, but we understand that single sheets are available and will probably cost about £1 each.

Weller were at the show with their latest low voltage temperature-controlled soldering pencils (no longer irons we see), the W-MCP available with a variety of tip shapes.

PANEL METERS

On the meter front several so-called panel meters were on display including the Dinline 50, the first such product to come from the Avo stable. The name is based on the rectangular styling which follows the DIN (IEC 51) specification.

A digital panel meter is something that, only a short while ago, would have been regarded as an instrument rather than a component. By miniaturisation and recent price reductions in digital i.c.s, Analogic are able to offer a versatile 3-digit digital panel meter at only £25 in quantity. Designated the 2530, this unit can measure, display and transmit voltages and currents of either polarity. The 2530 has fully floating inputs just like any analogue meter so that measurements with respect to any arbitrary level in a circuit can be made.

A filament readout is used for good readability and low cost. This meter can be incorporated in many types of instrument giving a really competitive alternative to analogue measuring instruments.

West Hyde displayed their Contil digital panel meter card with three digit display in Atron tubes and costing less than £25.

Integrated Photomatrix showed their digital panel meter kit using a MOS LSI chip and l.e.d. display which is available for £36·75. Of course the IPL unit is considerably smaller than many other displays on show.

LARGE SCALE INTEGRATION

One of the fastest-growing areas of semiconductor technology must be the MOS large scale integration (LSI) field. All the major companies appear to be competing to see who can cram the most MOSTS into a single 24-pin package.

One of the latest contenders in this competition is the Motorola MCM6571L character general i.c. It contains a read only memory of 8,192 bits which can produce 128 different characters, including upper and lower case and Greek symbols, each character being formed by a matrix of seven horizontal and nine vertical dots. As well as the stored characters themselves there are 128 bits which are used to automatically control each character position so that the "tails" of letters such as p, q, and j come below the base line as in normal typewritten material.

Another piece of news in the MOS LSI field comes from General Instrument Microelectronics who announced that slashing price reductions have been made on their C500 calculator i.c. Its new price of £13·70 (1 off) represents an £18 drop from its previous value. G.I. hope that this new low price will encourage designers to regard the calculator i.c. as just another component for use in many types of instrument where arithmetic operations are to be carried out. For instance, they could be used in a weighing scales which automatically displays the price of the goods after the price per pound is typed in.

NEW LOW-PRICE FOR L.E.D. DISPLAYS

While MOS manufacturers are aiming at miniaturisation, the display device manufacturers are aiming at bigger and brighter components. One of the innovators of l.e.d. displays, Monsanto, announced new low prices for their displays.

Single l.e.d.s can now be bought for 5p in large quantities making it possible for manufacturers to use them in such applications as diagnostic lamps on printed circuit boards, panel lamps, and battery "low" indicators.

On the numeric display side the MAN5, a green seven-segment device is down to £3·99 from £9 (1 off) and the MAN64A, a 0·4in numeric display down to £4·27 from £7·85.

NEW TIMER INTEGRATED CIRCUIT

Another example of large scale integration, but this time combining digital and analogue functions was on show at the Elremco stand. Designated the LR171E, this i.c. has an enormous range of applications because of its inherent flexibility.

It uses a digital counter so that timing ranges of seconds, hours or even weeks can easily be obtained. A digital-to-analogue converter is used to give a current output which means that a cheap meter can be used to give an indication of time elapsed.

It has eight operational modes, delayed on, delay interval etc., and has three digital outputs which give indications at ⅛, ¼ and ½ of a preset time period.

The i.c. is TTL compatible and has integral output drivers for a triac or SCR. Price is £12 for one off.

RUSSIAN COMPONENTS

Many manufacturers are finding difficulty obtaining such ubiquitous components as resistors and capacitors and so it is not really surprising to see more and more imported components creeping into instruments such as calculators.

Z & I Aero Services are importers of Russian resistors and capacitors and supply both to industry and non-professional users. The components are cheap, clearly marked with their values (not colour coded) and readily obtainable.

NOVEL BREADBOARDING AID

A novel breadboarding system which has great potential in the amateur field was shown by Critchley Bros. Ltd. Manufactured by the German firm of Christel Wainwright, the system is called "Mini-Mounts." Each Mini-Mount is a small rigid board with a copper pattern on one side and adhesive on the other. Components are soldered onto the boards which are then positioned anywhere on a convenient baseboard (which could be copper-plated to give a good ground plane), and stuck in place.

This system has many advantages over other similar systems: no holes need be drilled; the adhesive holds the Mini-Mounts firmly in place yet they can be moved if the circuit requires; components and Mini-Mounts can be re-used if care is taken.

Mini-Mounts to take DIL i.c.s, and other such components are available so the system gives great scope to the designer.

NEW SHAPE FOR LAMINATIONS

Though by no means a spectacular breakthrough, the new design for transformer laminations by Kent Insulations shows how old and tested designs can be improved with a little ingenuity. Instead of the usual "E" shape the new type has a tapered centre arm so that excellent mechanical and magnetic contact is made when the two halves are fitted together.

MULTI-MEMORY MACHINE

On the Advance Electronics stand and in fact using the same case as the Advance calculators was a new accounting aid from Phytron. Called the Analysis 14 this calculator incorporates 13 accumulating memories each of which can be debited or credited at any time simply by selecting the required store with one of thirteen keys. Only credit and debit (i.e. addition and subtraction) are available, the manufacturers suggesting that this instrument is to complement, rather than replace, the normal desk calculator which can multiply and divide.

At £210 this calculator cannot really be termed inexpensive by modern standards and one wonders whether a machine without a print-out is really useful in accounting, where mistakes cost money.

CONCLUSIONS

One wonders why a star attraction like the actual *Apollo* capsule "Charlie Brown" which circled the moon four years ago, which was on show on the Livinstone Hire stand together with a piece of moonrock, received so little publicity. This could have attracted great crowds, was this what the organisers were afraid of?

At a time when electronics is developing so fast, the show was not up to expectations and one can only hope that the companies will stop hiding their lights under bushels and give us some really interesting shows in the future. ★

25 YEARS OF SEMICONDUCTORS

PART 2

By M. J. Rose (MULLARD LTD.)

POWER DEVICES, PHOTO DEVICES AND INTEGRATED CIRCUITS

THE first article described the types of transistor and small-signal diode available. This article considers power devices, photo devices using, or emitting light, and the most revolutionary semiconductor device of all—the integrated circuit.

POWER DIODES

The amount of power that can be handled by a semiconductor diode is limited by the junction temperature. Provided the heat dissipated within the device can be conducted away so that the maximum permissible junction temperature is not exceeded, the diode will operate satisfactorily. Therefore a power diode should have as large a junction area as possible, and a low thermal resistance to the case. The cooling area can be increased by mounting the diode on a suitably shaped heatsink.

Germanium power diodes were developed using these techniques, and could carry currents of approximately 10A and withstand peak inverse voltages of up to 600V. The introduction of silicon, however, led to their replacement during the 1960's by silicon diodes with junctions alloyed or diffused with aluminium.

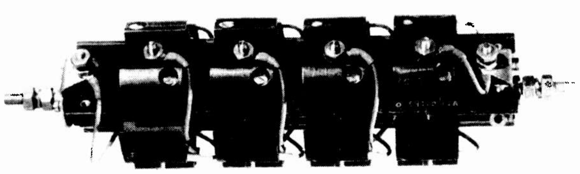
AVALANCHE DIODES

As the reverse voltage across a junction diode is increased, a voltage is reached where avalanche breakdown occurs, marked by a sudden increase of current. Provided the diode can withstand the current at breakdown, it will recover when the reverse voltage is decreased below the breakdown value. Avalanche diodes are designed to withstand such breakdown currents, and so can be used safely in applications where voltage transients are likely to be encountered.

By the end of the 1960's other protection devices such as high-speed fuses had been developed so that semiconductor-diode rectifier systems were firmly established in such applications as battery chargers, electroplating and electrolysis processes, and electric furnace supplies. These semiconductor systems occupied less space than the existing systems, had a higher rectifier efficiency, and for the first time presented power engineers with a device that had no wear-out effects.

A high-voltage rectifier stack is shown in the photograph of Fig. 8. Diodes are mounted on heatsinks around a central fixing stud. Such stacks can be cooled by natural convection, or for higher currents by forced-air cooling or immersion in an oil bath.

Fig. 8 High-voltage rectifier stack operating at 12kV and 5A with natural convection cooling (length approximately 10in)



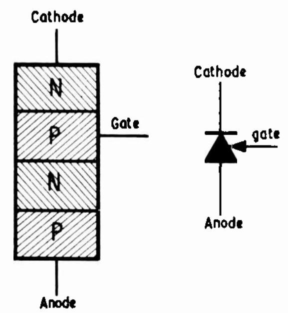


Fig. 9 Structure and circuit symbol of thyristor

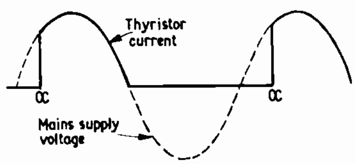


Fig. 10 Phase control using thyristor

THYRISTORS

The thyristor or controlled silicon rectifier was developed for power control in parallel with the silicon rectifier diode. The rectifier action of the thyristor allows a current to flow in one direction only, but in addition current can only flow when the thyristor has been triggered.

In form, the thyristor is a four-layer *pnpn* device, as shown in Fig. 9. The circuit symbol is also shown in this figure. If the anode is positive with respect to the cathode, and a positive voltage is applied to the gate, the thyristor conducts. Once conduction has been established, the gate voltage can be removed.

Therefore the thyristor can be triggered by a pulse provided the duration is sufficient to allow the current to be established. The thyristor is made non-conducting by reducing the current to below a holding value.

The method of power control with thyristors is shown by the waveforms in Fig. 10. By varying the trigger angle within the half-cycle (α), the amplitude of the current pulses passed by the thyristor, and hence the power delivered to the load, can be varied. This control technique is called phase control.

A second method of control is burst triggering, used for loads with a high thermal inertia such as furnaces. In this method, complete half-cycles of the mains supply are passed by the thyristor, the ratio of half-cycles passed to those blocked determining the power to the load.

TRIACS

Another device for power control similar to the thyristor is the triac or bidirectional thyristor. This device is equivalent to two thyristors connected in inverse-parallel with a common gate connection. The circuit symbol for a triac is shown in Fig. 11. A current will flow through the device when the gate is sufficiently positive or negative with respect to terminal mt1, the direction of current flow depending on the relative polarities of mt1 and mt2.

The currents that could be handled by thyristors, and the inverse voltages they could withstand, increased during the 1960's as the manufacturing techniques were improved. Present-day thyristors can handle currents up to 1000A and withstand inverse voltages of over 2kV. Protection devices have been developed as with rectifier diodes to ensure reliable operation under practical conditions.

A typical thyristor stack with thyristors connected in a bridge configuration for the control of power to a load is shown in Fig. 12. The thyristors are mounted on heatsinks.

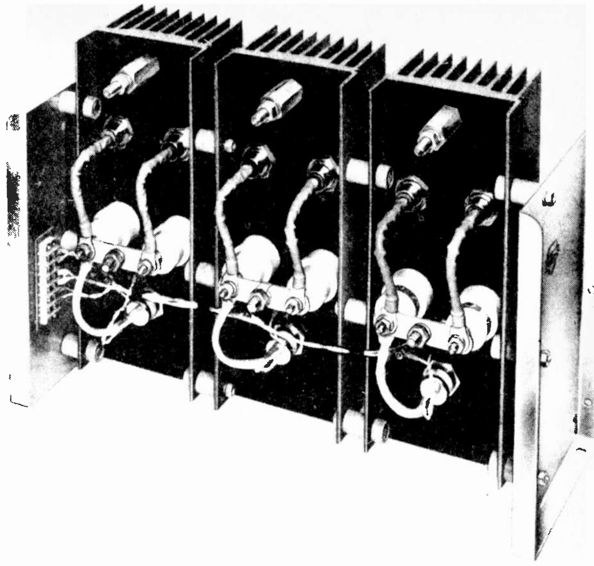


Fig. 12 Thyristor stack for operation on 440V three-phase mains to control 110A per phase

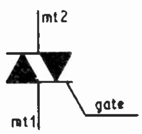


Fig. 11 Circuit symbol for triac

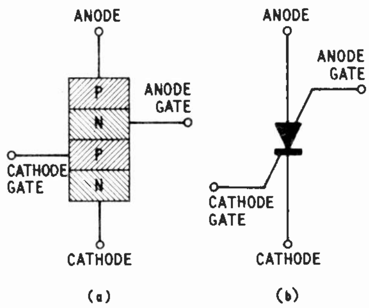


Fig. 14 Structure and circuit symbol for silicon controlled switch

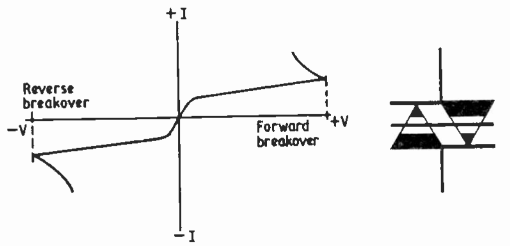


Fig. 13 Breakdown characteristic and circuit symbol for diac

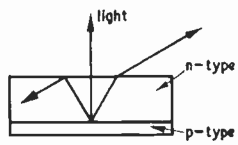


Fig. 15 Diagram showing construction of a typical light emitting diode

THE DIAC

The diac, or bidirectional diode thyristor, is a useful trigger device for thyristors and triacs. It uses avalanche breakdown, but as the characteristic in Fig. 13 shows, the voltage decreases after breakdown so that the gate circuit is not overloaded on triggering.

SILICON CONTROLLED SWITCH

Another four-layer *pnpn* device is the silicon controlled switch or SCS. Unlike the thyristor and triac, both intermediate layers of the SCS are accessible making it a four-terminal device. The structure and circuit symbol are shown in Fig. 14.

The SCS (like the thyristor) has two stable states: conducting and non-conducting. The SCS can be used in two circuit configurations. In one, the load is connected in the anode gate circuit so that the SCS operates as a four-terminal device. In the other, the load is in the anode circuit and the anode gate is not connected. The SCS then acts as a low-power thyristor or three-terminal device.

PHOTOTRANSISTORS AND PHOTODIODES

Light falling on a junction in a semiconductor diode or transistor affects the current through the device. The energy of the light dislodges electrons and so increases the number of carriers available at the junction.

Constructive use of this effect is made in photodiodes and phototransistors where the change in current with light can be used in such applications as light meters and alarm systems.

Other semiconductor materials exhibit a change of resistance with light, and this effect is used in photoconductive cells (or light-dependent resistors). The choice of semiconductor material determines which part of the spectrum the device responds to, for example cadmium sulphide responds to visible light while lead sulphide is used for infrared detectors.

LIGHT EMITTING DIODES

Another type of photodevice is the electroluminescent or light-emitting diode (Fig. 15). This device is made from gallium arsenide or gallium arsenide phosphide, and when a sufficiently high current (a few milliamperes) is passed through, light is emitted. Such diodes can be used as indicator lights directly coupled into, for example, computing systems.

INTEGRATED CIRCUITS

Of all the semiconductor devices that followed the invention of the transistor, the most revolutionary both in reducing the size of equipment and improving reliability is the integrated circuit.

The problems of manufacturing different circuit elements on the same silicon chip were overcome so that integrated circuits that were both practicable and economic became available by the mid-1960's.

Today two types of integrated circuit (i.c.) are available, the bipolar and MOS, each with their advantages and disadvantages for particular applications.

BIPOLAR I.C.

The bipolar i.c., as the name implies, uses bipolar transistors manufactured by the planar process. Diodes are formed by a single diffusion, capacitors by using a reverse-biased diode junction, and resistors by a single diffusion like a stretched-out diode with connections at both ends. The main problem with the manufacture of bipolar i.c.s is isolation between components.

MOS INTEGRATED CIRCUITS

The transistor used in MOS i.c.s is a field-effect transistor, the MOSFET or MOST. Because MOS i.c.s are almost exclusively used in digital applications, an MOST can form the load for another MOST, the transistors are directly coupled, and the capacitances on which information is stored are formed by the gate capacitances of the MOSTs themselves. Thus only transistors and connections need to be formed on the chip.

One advantage of MOS i.c.s over the bipolar type already mentioned, is the fact that no isolating diffusion is needed on the chip. In addition, an MOST is smaller than the equivalent bipolar transistor. Both these reasons lead to a higher packing density being achieved with MOS i.c.s. On the other hand, bipolar i.c.s have a higher operating speed, and can drive higher current and capacitive loads which MOS i.c.s cannot do without interface circuits.

Thus the choice of MOS or bipolar i.c. may well depend on the requirements of the application rather than any clear-cut advantage of a particular type.

In general, it can be said that small scale integration (SSI) is rarely economical with MOS i.c.s so that gate packs and flip-flops will use bipolar i.c.s.

Large scale integration (LSI) for such devices as random-access memories (RAMs) and read-only memories (ROMs) will use MOS i.c.s. The choice for medium scale integration (MSI) will depend on the application.

COMPLEMENTARY MOS

A limitation on the use of MOS i.c.s occurs through the use of field-effect transistors. The current-carrying channel for the transistor is formed in the substrate, and so normally only *p*-channel or *n*-channel devices but not both can be formed on any one i.c.

To overcome this, a technique called complementary symmetry MOS or CMOS has been developed. Areas of *p*-material are diffused into an *n*-type substrate so that both *n*-channel and *p*-channel MOSTs can be formed.

More diffusions are required for CMOS than with normal MOS i.c.s, and a lower packing density results. On the other hand, there are considerable advantages for the user, particularly higher operating speeds and lower dissipation.

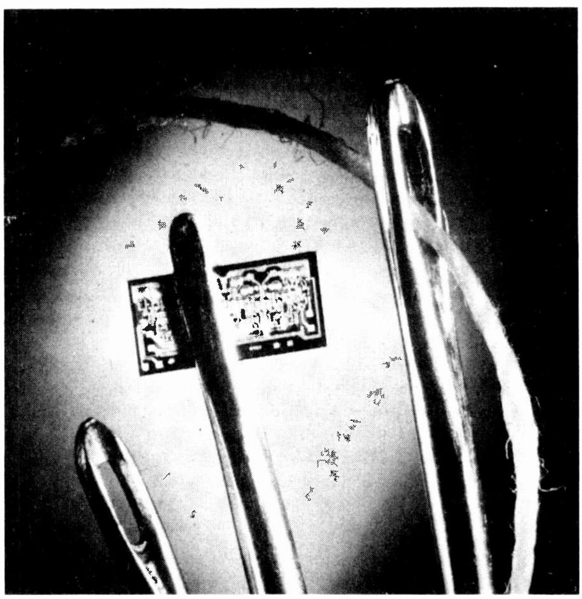
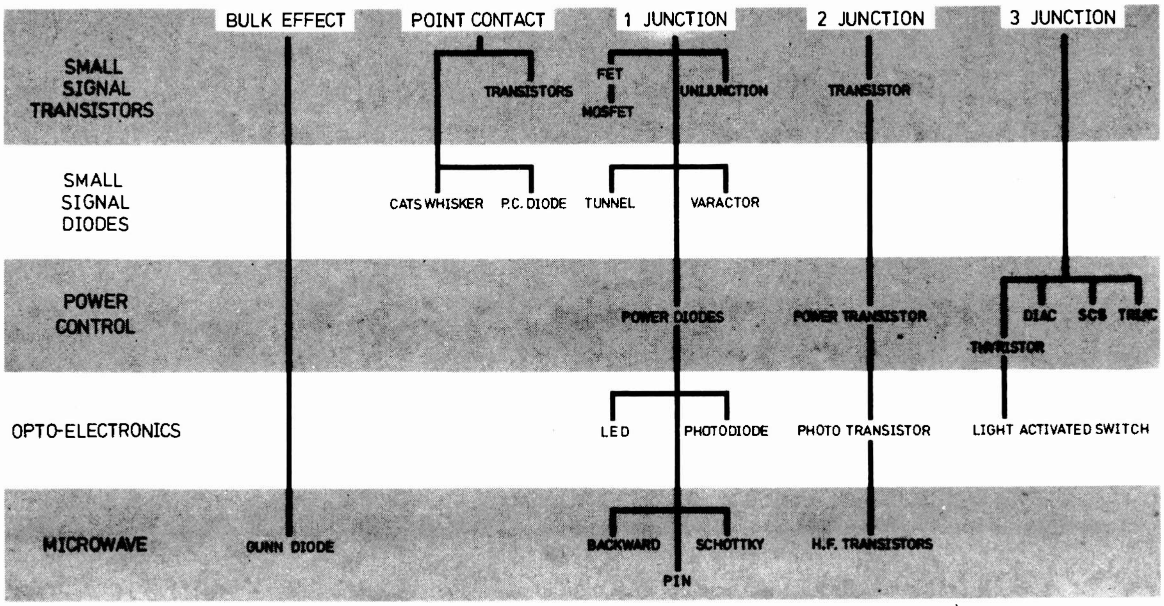


Fig. 16 Integrated circuit chip compared with ordinary sewing needle, the chip being 1·5 × 3mm



FAMILY TREE OF SEMICONDUCTOR DEVICES

LINEAR I.C.s

The i.c.s described above are digital circuits. Later in the 1960's linear i.c.s were developed. In terms of the number of devices contained, these i.c.s are more complex than the equivalent discrete stages they replace, although cheaper and with better performance. Today a wide range of linear i.c.s is available covering r.f. and i.f. amplifiers, operational amplifiers, TV signal-processing circuits and audio amplifiers with output powers up to several watts.

The reduction in size possible with an i.c. is impressive, typified by such photographs as that in Fig. 16 showing a silicon chip containing over 120 devices passing through the eye of an ordinary sewing needle.

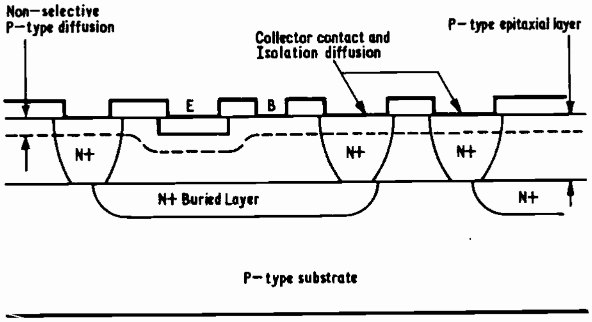


Fig. 17 Structure of a CDI transistor (*Ferranti*)

COLLECTOR DIFFUSION ISOLATION

Another process which overcomes many of the disadvantages of conventional bipolar i.c.s has been developed by Ferranti from an American idea. Known as the collector diffusion isolation (CDI) process, it makes use of thin epitaxial layers but needs only five masking processes making it comparable to MOS technology in simplicity.

Fig. 17 shows the structure of a CDI transistor. The process uses a *p*-type substrate into which buried low resistivity $n+$ areas are diffused where each resistor, transistor or diode is to be formed. A thin epitaxial *p*-type layer is then diffused. The collector diffusion is then made producing low resistivity $n+$ channels round each component. This diffusion serves three purposes: to make contact with the buried $n+$ area which forms the collector; to provide isolation between components; and to define base and resistor areas.

A shallow *p*-type layer is diffused over the whole slice to define resistor values. A shallow emitter diffusion then follows.

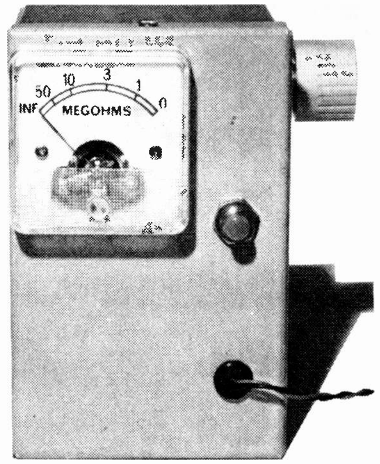
The CDI process reduces transistor areas by up to a third and also enables digital and linear circuits to be combined on one slice. The main disadvantage is that there is no *pnp* transistor available, though a *p*-channel f.e.t. under development should overcome this difficulty.

CONCLUSIONS

From the original low-power low-frequency transistor have developed transistors capable of operating high in the radio frequencies, transistors handling powers of over 100W, transistors capable of switching wave-forms with rise times of 1ns. Signal diodes operating in the microwave frequencies have been developed, and diodes and thyristors capable of operating on high-voltage supplies controlling powers measured in megawatts. Devices reacting to and producing light are available, and devices containing a complete computer processing system on a chip only 3·5mm square.

Although the transistor was the fore-runner, the most revolutionary device may well be the integrated circuit which has brought a new concept into electronic circuit design. The thermionic valve (apart from its more specialised forms such as klystrons and magnetrons) had a commercial life of about 35 years. It may well be that the discrete transistor apart from more specialised forms like photodevices will have a shorter life. ★

550 VOLT MEGOHMMETER



by B. V. Lamb

THE PAST few years have seen more and more householders tackling home wiring installation work. When the work is completed and before the mains can be permanently connected certain safety checks have to be made. This article and project deal with a very useful instrument that will measure the insulation resistance of the wiring.

Poor insulation causes current to flow between the line and earth or neutral. This current in turn will generate heat in the wiring, which if of sufficient temperature could cause fuse blowing or, more seriously, a fire.

Unfortunately, most do-it-yourself wiring enthusiasts do not possess the means for measuring leakage currents at high voltage. Commercially available instruments are expensive and secondhand units are not cheap either. The traditional instrument consists of a hand driven generator that causes a high voltage to appear across a lead terminating in a couple of croc clips, a meter registers the insulation resistance. More recently, electronic testers have tended to replace the hand driven types.

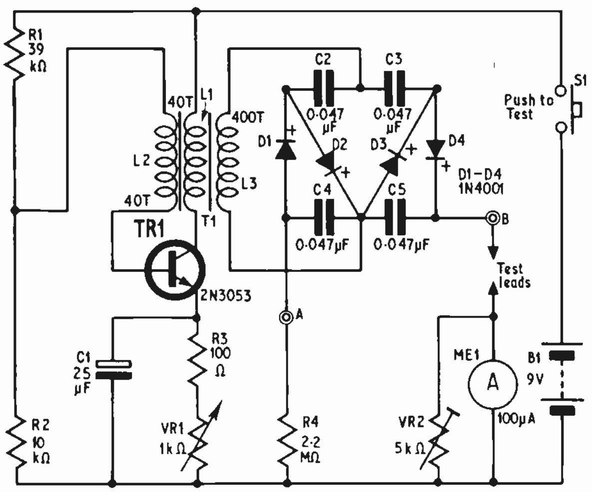


Fig. 1. Circuit diagram of the Megohmmeter

DESIGN CONSIDERATIONS

The a.c. voltage in the United Kingdom is 240 volts r.m.s.. Since we are interested in peak voltage, and $V_{peak} = V_{r.m.s.} \times 1{\cdot}414$ the test voltage generator will need to be at least 340 volts. In practice, however, regulations require that a minimum of 500 volts be used.

The 550 volt megohmmeter here described satisfies the twin requirements of the home electrican; it is easy to build and the price is low compared to commercially available units. Push button operation is employed as this prevents inadvertent battery run down due to a switch being left on. All of the components are readily available.

As to the choice of a suitable transistor high voltage generator; the demands made by the Megohmmeter dictate that a sine wave oscillator type d.c. convertor be used. There are three broad types of d.c. convertor that could be used, namely: ringing choke, multivibrator and sine wave.

Each of these circuits produce an oscillating voltage that is stepped up to a higher voltage by means of a transformer and then rectified to give a d.c. voltage at the required level.

Although the least efficient of the three, the sine wave oscillator is the first choice in favour of the ringing choke method when it comes to ease of starting. In economy of components it beats the multivibrator circuit. Since the Megohmmeter does not need to produce more than about 170 microamps under short circuit conditions, a low efficiency high voltage generator does not matter in the least.

CIRCUIT OPERATION

Transformer T1, TR1 and the associated circuitry form a sine wave oscillator whose period of oscillation is determined by the inductance and self capacitance of T1 (Fig. 1).

The feedback winding of T1 sustains the oscillation and is connected to the junction of R1 and R2 which together with R3 and VR1 set the d.c. bias for TR1. C1 prevents a.c. degeneration. VR1 allows for variation in voltage developed across the collector winding of T1.

The diodes, D1, D2, D3 and D4 plus the capacitors, C2, C3, C4 and C5 comprise a voltage quadrupler circuit. This circuit rectifies the a.c. voltage appearing across L3 and multiplies by four its equivalent d.c. value.

By varying VR1 over its whole range the open circuit output at the test leads can be varied from approximately 300 to 650 volts. In practice however, the voltage will be set at 550 for normal use. The wide range does allow for increased versatility and the constructor will be able to make use of this from time to time.

CONSTRUCTION

Dismantle the Ferroxcube core and carefully mount the bobbin on a suitable arbor — the author used a wheelbrace which had a gear ratio of 3·75 : 1 clamped in a bench vice and a 2BA screw as the arbor.

Strip a 2in length of thin pliable plastic sleeve from some spare wire and thread this onto some 41 s.w.g. enamelled copper wire (L3).

Carefully wind 400 turns and finish off L3 by insulating with one turn of Scotch Tape.

Next wind 40 turns of 41 s.w.g. for L2 and similarly insulate. Finally wind 40 turns of 28 s.w.g. for L1 and complete the transformer with a layer of tape.

The rest of the construction is quite straightforward (Fig. 2). The only caution is that building the circuit on inferior leaky tagboard is bound to cause difficulty in getting an infinity reading since leakage current will cause a standing error. The ideal case is plastic although metal can be used if care is taken with insulation.

SETTING UP

Once the circuit has been built, it is first of all necessary to establish the working of the oscillator.

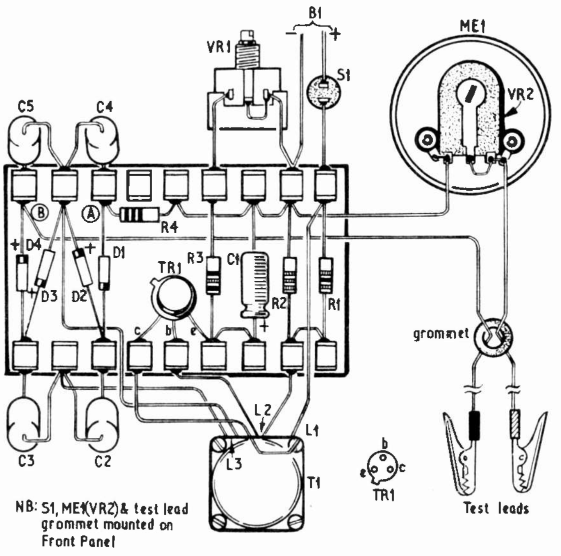


Fig. 2. Layout of the components on the tagboard and interconnections to the transformer, potentiometer, pushbutton and meter.

COMPONENTS . . .

Resistors
R1 39k Ω
R2 10k Ω
R3 100 Ω
R4 2·2M Ω
All ¼W 10% carbon

Potentiometers
VR1 1k Ω
VR2 5k Ω preset

Capacitors
C1 25μF 6·4V electrolytic
C2, 3, 4, 5 0·047μF 400V polyester (4 off)

Semiconductors
TR1 2N3053
D1, 2, 3, 4 1N4004 *or* any 400 p.i.v. low current diode (4 off)

Miscellaneous
S1 Miniature pushbutton
ME1 100μA f.s.d.
T1 Ferroxcube core type LA1 *or* equivalent
9 way Tagboard
Crocodile Clips (2 off)
9V Battery. PP7 or similar
Metal case 4in × 2½in × 2in
41 and 28 s.w.g. enamelled copper wire

Short the test clips together and the meter should indicate some value. If no movement is seen the oscillator feedback winding (L2) has to be reversed. Once the circuit is working, the output should be set to 550 volts.

Connect a high resistance voltmeter between points A and B then adjust VR1 for 550 volts. During this operation the test clips must of course be open circuited. The meter can now be calibrated in terms of megohms.

Remove the meter from its case and place it on the working surface having previously cleaned up and dusted down. Carefully remove the scaleplate and paint the reverse side matt white with emulsion paint.

When dry place the scaleplate — with its original markings uppermost—on a piece of cardboard. With a compass find the radius of the scale line and the maximum and minimum positions. Transfer these lines to the blank side. Screw the scaleplate back on the meter.

Short out the test clips and mark the scale with a soft pencil at this point. Now connect 1, 3, 10 and 50 megohm resistors and mark these equivalent points in. A professional job can be done by using plastic film ink for the scale lines and Letraset for the letters and numbers.

CONCLUSION

The 550 volt insulation tester that has been described should prove to be a valuable addition to the electricians tool kit. There are of course other uses to which it can be put, insulation tests for the electronic engineer being one example.

By making a simple twin pointed probe, relative dampness in wood and plaster can be measured. ★

INDUSTRY NOTEBOOK

By Nexus

UPTURN

Yesteryear's sobs and groans from industry salesmen were conspicuously absent at the London Electronic Components Show. Nobody seemed to care that the show was smaller than before and, from first reports, less well attended. Those who came were buyers and that was the important thing.

But it wasn't all smiles and sunshine. The spectre of empty order books may have retreated but only to make way for another spectre to give top management some sleepless nights. What is haunting the industry to-day is how to get components made fast enough to meet the demand. Those major companies which had spare capacity have none today. An even worse fear looming up is a shortage of raw materials.

But, on the whole, things look pretty good. Quipped one exhibitor, "If you can't make a few bucks in these conditions you never will."

This year's Chairman of RECMF, Ronald Bulgin, wore one of the biggest smiles at the show. His publicly quoted family business is still a profit leader in the industry and he will preside as the component industry Chairman in a boom period. What could be better?

Wearing his chairman's hat rather than his company's, he put out a public plea for rationalisation of the exhibition calendar. And he was quite right to do so. In the past six months we have had Electronica in Munich, the Paris Salon and the British show at Olympia. What the industry needs is one big international show a year in Europe with London, Paris and Munich in rotation so that each of the three electronics "capitals" puts on a show every three years.

A sensible idea but unlikely to be accepted by exhibition organisers while they still make huge profits from the present spate of shows. The only hope is that the economic forces of the market place will do what exhortation won't. If enough would-be exhibitors opted out, the exhibition organisers would have to adjust their ideas.

ROYAL SPOKESMAN

His Royal Highness The Duke of Kent is tipped to succeed Admiral of the Fleet Earl Mountbatten of Burma as an important independent commentator on electronic industry affairs.

As yet, The Duke admits to being "a complete amateur, hardly knowing the difference between R and C." But having heard him speak on the subject I find him well-informed. Naturally, he is briefed in advance of public utterances but I am reliably told that his interest in electronics borders on the enthusiastic and that he is eager to expand his knowledge of the industry not only in its technology but also in its commercial and social impact.

If knowledge is born of experience he should be learning fast. He is a member of the National Electronics Council and opened the London Electronic Components Show and, more recently, Microwave '73 at Brighton.

THE OLD AND THE NEW

This is a good year for anniversaries. Sperry Gyroscope has just celebrated 60 years in the U.K. with an exhibition opened by Prince Philip, Duke of Edinburgh, at the company's Bracknell HQ. Then there's AVO Ltd., celebrating fifty years in coil winding equipment and instruments (the millionth Avometer left the works as long ago as 1965!).

But what about companies yet unborn? There are plenty on the way to swell the ranks of industry. Expect announcements soon that Jim Griffith, boss of Plastronics, is setting up a manufacturing plant in Germany and that Maurice Hatter, a co-founder of Keyswitch Relays (subsequently sold to Thorn), is moving back into relay manufacture in a plant in Italy. Two new British Euro-babies for the Common Market.

HI-FI

Cosmocord is looking to hi-fi as a logical expansion based on its long history in pick-up cartridges, audio instruments and, more recently, head sets and ear protectors. For a start, the company has won the sole U.K. franchise for quality speakers built by Martin in the USA. There is a complete range from about £30 per pair up to £200 for a single 100W multiple speaker unit.

Cosmocord tell me that there is a possibility of making some of the Martin range in the U.K. but following the recent introduction of the ACOS "Lustre" pick-up arm (reported to be doing well), it is more likely that manufacture will be concentrated on tuners and amplifiers to complete the audio chain. Cosmocord marketing men are scanning the market with a keen eye before committing themselves, but if the Martin speakers are to come as part of a Cosmocord hi-fi package my guess is that they are looking at the top end of the market.

The company has now absorbed the Birch-Stolec thumbwheel switch business — renamed Cosmocord-Stolec—which has a turnover of some £250,000 a year. In all Cosmocord is targeted for £1·85 million turnover in the fiscal year just started.

NOT ALL HONEY

Although the electronics capital goods sector has a more healthy looking order book than last year, things are still sluggish according to the Electronic Engineering Association. Sales at £684·5 million, although marginally higher in total than in the previous year, were in real terms, showing a decline said retiring President Dr B. J. O'Kane in his "state of the industry" address at the EEA annual luncheon. Best areas in the year under review were communications and marine radar, both of which showed gains of better than 20 per cent.

Disturbing and perhaps an uncomfortable experience for Rank-Xerox, brightest and most profitable jewel in the Rank crown, is the impending Monopolies Commission probe. The British inquiry follows the threat to the U.S. parent company of anti-trust action by the U.S. Trade Commission. Curtailing of Rank-Xerox activities could have quite an effect on many of the smaller electronic companies who are engaged in sub-contract work for the company.

Even prosperous Mullard has its black spots. Forecast losses on integrated circuit manufacture this year is £700,000, following losses of nearly £3 million in the past two years. Break-even is forecast by the end of the year and profit by the end of '74, or perhaps a little earlier. Meantime, the really hot lines like colour TV tubes more than make up for the deficiency.

ELECTRONORAMA

STEPS FORWARD IN TIME . . . .

UNTIL 1970 electronic watches seemed to make very little impact on the market, probably because the manufacturers themselves seemed mostly reluctant to invest in this new technology. However three years ago the major Swiss manufacturers unveiled new electronic models incorporating quartz oscillators and it became clear that the whole industry was actively concerned with "the watch of the future".

THREE TYPES

Since that time electronics have become the major topic of interest and excitement throughout the watch world. Today there are three types of electronic watches driven by batteries. These are tuning fork, quartz and solid state.

Tuning fork watches employ an acoustic resonator (tuning fork) as a timing device and a motor driven by a transistor circuit. Because of this they do not tick but emit a slight hum. The accuracy of these watches is about one minute a month.

Quartz systems with mechanical display use a quartz crystal which oscillates under the effect of an alternating electric field. These oscillations, through a system of circuits and a motor, control the hands of the watch and provide accuracy within 5 seconds a month.

Solid state electronic models show the time in figures with a digital display instead of hands and have no moving parts. They use a quartz crystal oscillator as a timekeeper and activate a liquid crystal or diode display on the face of the watch. Again these have an accuracy of around 5 seconds a month. In addition to these, there are watches which are better described as electric rather than electronic. They employ a conventional hair spring and a balance wheel as the timing mechanism, but are powered by a battery as opposed to a main spring. Their accuracy is no more than that of a comparable conventional watch.

SIMPLE SERVICING

The advent of electronic watches offers considerable benefits as substantial improvements in accuracy and reliability can be achieved. In addition, problems of after-sales service will be reduced at a time when servicing is increasing in cost and there are fewer skilled watchmakers, because the regular cleaning and maintenance necessary for conventional watches is either considerably reduced or eliminated for electronic models.

NEW DESIGN CONCEPTS

Omega, part of SSIH (Société Suisse pour l'Industrie Horlogère SA)—the world's third largest watch manufacturer—have announced new design concepts for electronic watches, which made their international debut last month at the Swiss Industries Fair in Basle.

The three new watches are the Megaquartz 2400, the Time Computer and the Megasonic 720. The Megaquartz is a quartz watch with a mechanical display. It has a precision reaching $\pm$ one second a month in normal wear—the world's most accurate watch.

The Time Computer is a solid state electronic watch with no moving parts, which shows the time digitally. This model has an accuracy within five seconds a month.

The third new model, the Megasonic 720, is an original and entirely new development of the basic tuning fork watch, and has an accuracy reaching 10 seconds a month in normal wear.

THE MEGAQUARTZ 2400

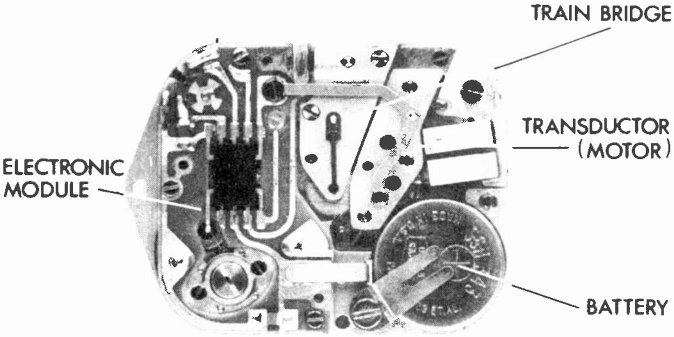
The Megaquartz 2400 heralds a new generation of quartz watches. Announced as the world's most accurate watch it only varies within one second a month. This remarkable increase in precision over earlier quartz watches (about 1 minute a year) is achieved with a crystal vibration of 2,359,296 times a second.

The first generation of quartz watches used frequencies of up to 65,536Hz. In order to achieve any further technical progress beyond this point it was necessary to increase frequency up to at least 1,000,000Hz, but microelectronic technology was not available to make this practical.

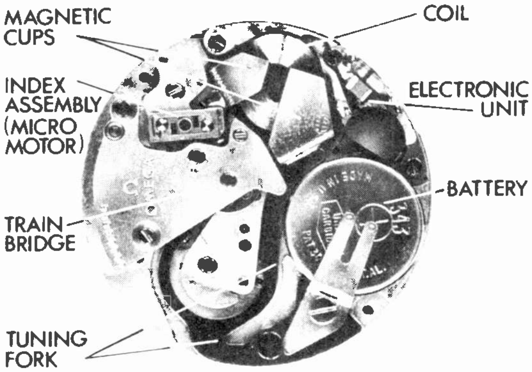
Now with the Megaquartz 2400 Omega have developed a unique electronic microcircuit. This has been achieved by using an analogue circuit dividing the quartz frequency, and by the most advanced CMOS technology in the area of integrated circuits of micropower.

One characteristic of the watch would be important to the "Jet Set", who travel between time zones. In order to maintain the accuracy of the minute and second hands the watch can be immediately adjusted by moving the hour hand alone.

Megaquartz 2400 is now in production, and it is expected that it will be available in the U.K. in 1974, at prices starting from £425.



Photograph showing the movement of the Megaquartz 2400, claimed to be the world's most accurate watch



Movement of the Megasonic 720 — the first original development on the basic tuning fork watch

The Time Computer. A solid state digital watch with no moving parts

THE TIME COMPUTER

The Time Computer is a completely solid state digital watch with no moving parts. The display is by red light emitting diodes arranged for four digits.

Time is shown "on demand" by pushing a command button which illuminates the light emitting diodes covered by a synthetic ruby face, chosen for its hardness and filtering qualities. When the command button is pressed the time in hours and minutes is shown for 1·25 seconds and is then replaced by the seconds for as long as the button remains depressed.

Another advance in this timepiece is its unique system for resetting time that allows hours or minutes to be changed independently. This is an obvious advantage for international travellers constantly flying from one time zone to another. Time is changed by inserting a tiny magnetic key into one of the two timeset recesses in the back of the watch, one linked to the minute digits, the other to the hours. To change the hour only, the magnet is placed into the hour recess, when the face lights up to show the hour digits moving forward.

The Time Computer has the equivalent of 1,238 transistors in a surface area of only 3·8 × 3·8mm. Its brain is an electronically operated quartz crystal vibrating 32,768 times a second.

The vibrations are counted and the results are fed to the driver decoder circuit, which activates the time display on demand. The watch is powered by two tiny batteries.

Because the watch has no moving parts there is no need for the oiling and cleaning advised for conventional movements.

The Omega Time Computer will be available in the shops within a few months at around £300.

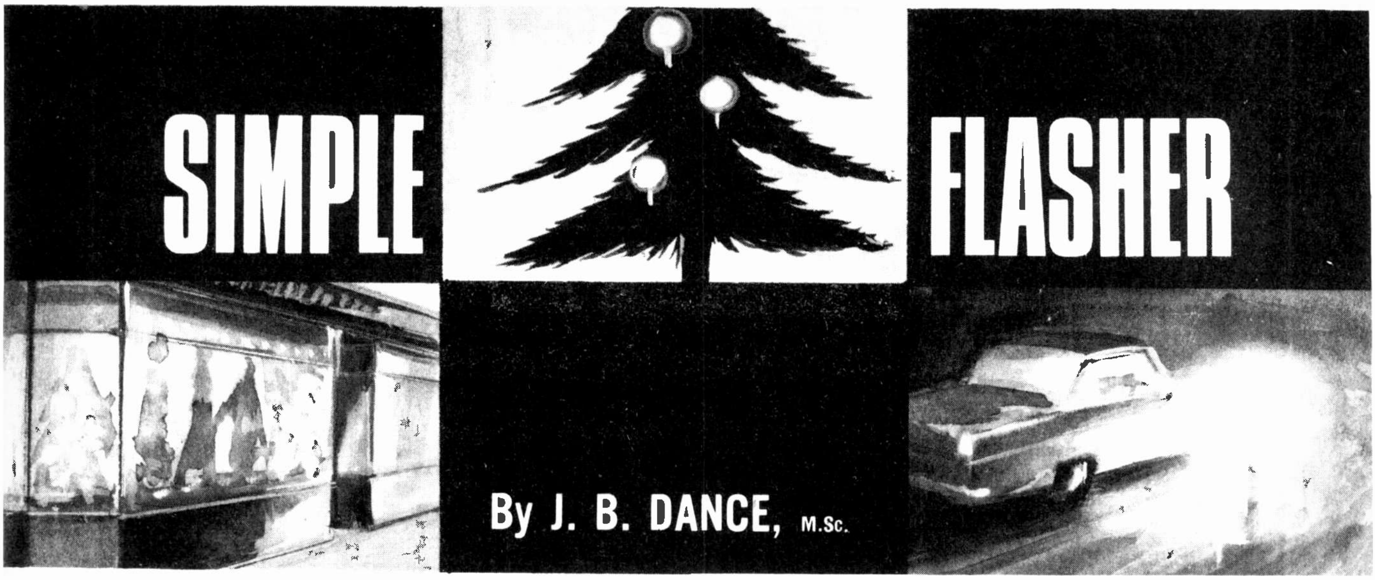
MEGASONIC 720

Electronic tuning fork (acoustic resonator) watches are well established and proven on the market. Almost all the major manufacturers offer models which are basically derived from the original invention in the 1950's by Max Hetzel.

The Megasonic 720 has distinct advantages over earlier tuning fork watches. It gives a considerable improvement in accuracy to within ±10 seconds a month in normal wear, compared with 60 seconds in similar watches. This is achieved by increasing the frequency at which the resonator vibrates to 720 hertz compared to 300/360.

The acoustic resonator is stimulated by an integrated circuit. The movement is transmitted to the train by an original micromotor. The train is driven by magnetic gear, and conventional display shows seconds, minutes, hours, day and date. A mercury battery powers the movement and guarantees it for one year's running.

Its launch is scheduled for 1974 in a new range of models styled Omega Megasonic 720. Retail prices have not yet been finalised, but are expected to be only slightly above existing models.



SIMPLE FLASHER

By J. B. DANCE, M.Sc.

In the June issue of PRACTICAL ELECTRONICS the introduction of a new integrated circuit, the 555, was discussed in detail from both the theoretical and practical point of view. Only one application as a timer suitable for photography or event control was considered as a constructional project.

Thus we now consider the application of this i.c. to the control of such items as the lights on the Christmas tree or in a window display so as to provide a flashing effect. At the instant the one set of lights is switched off, another set can be switched on if this is desired. The two sets are then illuminated alternately.

THE CIRCUIT

The type NE555V i.c. which has a dual-in-line encapsulation was used by the writer, but the NE555T in the circular TO-99 encapsulation is equally suitable. Both types have eight connecting leads and contain the equivalent of 23 transistors, two diodes and 16 resistors in a small package.

The 555 is used in the astable mode in this application. In the circuit shown in Fig. 1, the capacitor C1 alternately charges and discharges so that the potential across it varies between $V_{cc}/3$ and $2V_{cc}/3$. Each time the voltage across C1 falls to $V_{cc}/3$, the 555 is automatically re-triggered by means of the connection to the trigger pin 2; the capacitor then commences to charge again.

TIMING

The charging current flows through both R1 and R2. It can be shown that the time for charging from $V_{cc}/3$ to $2V_{cc}/3$ is $0{\cdot}693(R_1 + R_2)C_1$ seconds where R_1 and R_2 are expressed in ohms and C_1 is expressed in farads. During discharge the current from C1 flows through R2 only; thus discharging takes the shorter time $0{\cdot}693R_2C_1$. The frequency of oscillation is $1{\cdot}44/(R_1 + 2R_2)C_1$. The charging time cannot be made shorter than the discharging time.

If one uses the values for R1, R2 and C1 shown in the circuit, one can calculate that the charging time is 4·8 seconds and the discharging time 3·3 seconds. This should be suitable for the automatic switching of lights in a shop window or on a Christmas tree.

In practice the times will not be exactly equal to the calculated values since the values of the three components will differ somewhat from their marked values. In particular, electrolytic capacitors have very wide tolerances.

The component values can be altered to obtain the desired switching times. However, for applications of this type one does not need to adjust the values critically. One may require shorter times for use in a flashing toy; for example, C1 may be reduced to 2μF of 1μF. The value of the power supply voltage, V_{cc}, does not affect the switching times appreciably.

THE RELAY

The relay remains open whilst the capacitor is charging, but closes during the discharging time. A diode must be placed in parallel with the relay in order to suppress the transient back e.m.f.; the latter is generated across the inductive relay coil when the current ceases to flow through it. If the transient voltage is not suppressed with a diode, it could damage the integrated circuit.

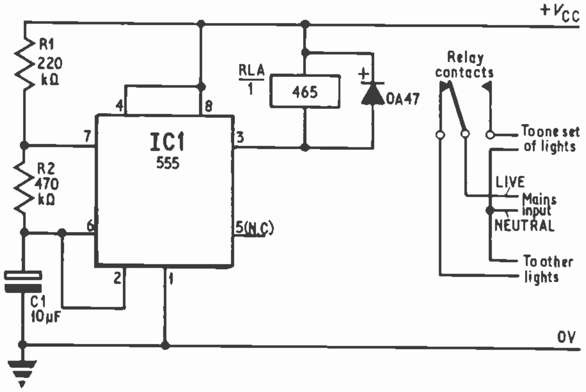


Fig. 1. Circuit diagram for the simple i.c. flasher

The writer used an economical microswitch relay type MS1B designed for printed circuit board mounting. It is readily available (through retailers) from Keyswitch Relays Ltd. The value of the power supply voltage, V_{cc}, used must match the recommended relay operating voltage to within about 20 per cent. If V_{cc} is between five and seven volts, an MS1B with a 6V, 50mA coil rating should be employed. Alternatively V_{cc} may be between 9·5 and 15·5V, in which case the MS1B employed should have a 12V, 26mA coil rating.

The MS1B relay has a single group of change-over contacts which can switch 250V at up to 5A in a.c. circuits. This maximum power of 1·25kW is more than is likely to be required in any shop window of moderate size.

Nevertheless, a larger relay can be used in this circuit if necessary provided that it does not require a current of over 200mA to operate it. Another type of microswitch relay, the Keyswitch Relay type MS2B, has two pairs of change-over contacts each of which can control a current of up to 2A in a 250V a.c. circuit. In d.c. circuits the current ratings of relay contacts are lower (0·2A at 250V and 0·25A at 100V for both the MS1B and MS2B).

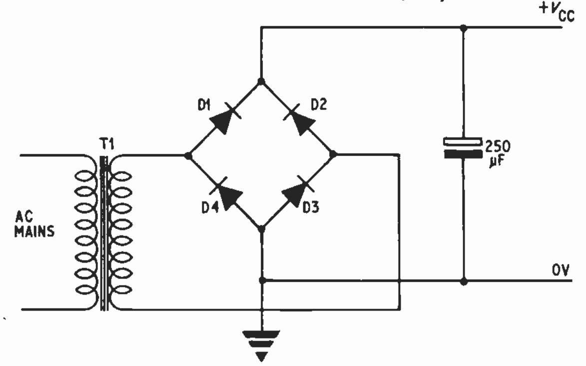


Fig. 2. Circuit diagram for a suitable power supply

POWER SUPPLY

The circuit of Fig. 1 can be operated from a small battery. Indeed, this is the most sensible source of power to use in a toy for children. The integrated circuit itself requires a current of about 3mA (maximum 6mA) when V_{cc} is 5V, but the current rises to about 10mA (maximum 15mA) when V_{cc} is 15V. The relay coil current is additional to these values.

When the circuit is used to switch 250V lamps on and off, it is normally more convenient to employ a small power pack which operates from the mains.

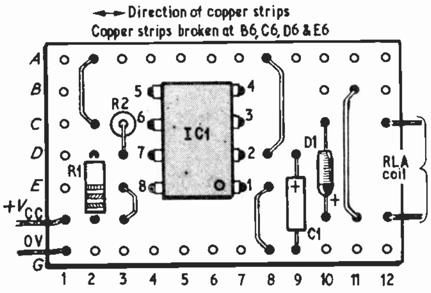


Fig. 3. Board layout for the flasher circuit

Components

Resistors
R1* 220k Ω, 1/10W, 10%
R2* 470k Ω, 1/10W, 10%

Capacitors
C1* 10µF, 15V electrolytic

Miscellaneous
NE555V (or NE555T) Signetics integrated circuit
OA47 gold bonded germanium diode.
MS1B relay, 6V or 12V coil (see text).
Mains three-way input plug if needed.
One or two two-way output connectors (depending on whether one or two sets of lights are to be switched).
Eight pin dual-in-line socket (if NE555V used).
* Values may be altered to obtain desired switching times.

POWER PACK

T1 Small mains transformer with an output of either about 5V or about 10V r.m.s., depending on the relay used (see text).
D1–4 1N4001 or similar or alternatively one bridge rectifier such as REC 41A (RS Components Ltd.).
250µF capacitor, 15V, electrolytic.

The whole system can then be operated from a supply which is switched off at a preset time at night by the normal type of time switch used for controlling the lighting in many shop windows.

A suitable power supply circuit is shown in Fig. 2. The output of the secondary winding of the transformer T1 should be chosen so that it is suitable for the coil operating voltage of the relay used. A 5V r.m.s. transformer winding is suitable for a relay with a 6V coil rating, whilst a 10V r.m.s. winding may be used with a 12V relay. However, these voltages are not very critical.

The output voltage of the transformer may be rectified by four separate diodes (D1 to D4), such as type 1N4001. Alternatively a single bridge rectifier (such as the RS Components type REC 41A) may be used instead of the four diodes.

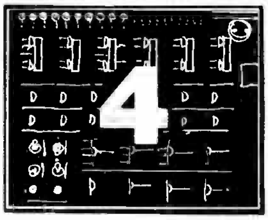
CONSTRUCTION

The whole unit, including the mains power pack, may be placed in a small die-cast metal box. One suitable box of approximate external dimensions 114 × 89 × 55mm is available from RS Components Ltd., whilst another type of approximate dimensions 119 × 93 × 52mm is available from Eddystone Radio Ltd.

The metal box should be connected to the mains earth when used with mains equipment for safety reasons. The small mains transformer can be mounted directly on the box, but the remaining components are conveniently mounted on a small circuit board. One can solder directly to the contacts of the 555 integrated circuit, but it is generally more convenient to employ an eight-pin dual-in-line socket if the NE555V is used.

In view of the simplicity of the circuitry and mechanics involved it is deemed unnecessary to discuss construction in greater depth on this project. ★

LOGIC TUTOR EXPERIMENTS.. 4



DE MORGAN'S THEOREM

FIRSTLY the answer to last month's question. There are various ways of getting the six input AND but they all use the same principle. There is an Associative rule in Boolean algebra which says that if you have a number of variables coupled by the same logical functions then the variables can be grouped together in sub-groups and combined by their function independently; the independent groups can then be coupled together with like functions to produce the final desired effect.

Thus if we want to AND together inputs A, B, C, D, E and F we can carry out the operation in three stages; firstly we AND A with B and C (as a sub-group) then D with E and F as a separate sub-group. Finally we take the outputs of each of the sub-groups and AND them together in a two input gate to give the total effect.

One form of six input AND gate using NANDS is shown in Fig. 4.1. Notice that it is necessary to use a lot of gates to carry out what is basically a very simple function. It would be much more economical—in space and cost—to use a six input NAND followed by an inverter or alternatively convert a four input NAND into a six input version using an expander before inverting.

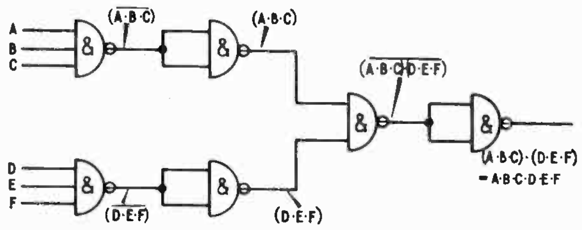


Fig. 4.1. A solution to last month's problem.

DE MORGAN'S THEOREM

Referring to the truth table for the NAND we could say that the output is 1 when A is 0 OR B is 0. Remember we are describing the same function as last month but are using a different point of view. Using the Boolean nomenclature that $\overline{A}$ represents "when A is nought" we can say that the output Q is given by $\overline{A}$ or $\overline{B}$

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

But from a different view point—last month we saw that

$$Q = \overline{A.B}$$

Therefore by normal algebraic argument we can say that

$$\overline{A} + \overline{B} = \overline{A.B}$$

This proves the first of De Morgan's Theorems which—in very simple terms—says that an inverted AND is identical to a sort of inverted OR.

There is a second theorem which is very similar (it is worth you thinking how to argue it out) which says:—

$$\overline{A}.\overline{B} = \overline{A + B}$$

Again in simple terms an inverted OR is the same as a sort of inverted AND.

Before moving on, take note of a catch that beginners sometimes fall into. $\overline{A.B}$ is *not* the same as saying $\overline{A}.\overline{B}$. This means that when writing Boolean expressions you have to be careful with the length and breaks of the negate bar over the top of the alphabetical characters. Sometimes brackets are used to make the distinction clear in complex expressions.

OR FROM NAND

De Morgan's Theorem is one of the most used in Boolean algebra because it gives a NAND gate a duality of purpose. Depending on how we want to think we can say that the output is either $\overline{A.B}$ or $\overline{A} + \overline{B}$. We have already utilised the former to give us AND from NAND. Now we can use the latter to give us basic OR.

Fig. 4.2 shows the way of producing a fundamental two input OR function. The inputs A with B become $\overline{A}$ with $\overline{B}$ at the outputs of their respective inverters. The output of the final NAND can be considered to be an OR function coupling the inverted form of its inputs. Therefore the output in this case is $\overline{\overline{A}} + \overline{\overline{B}}$. The double negates over each variable cancel and we are left with A + B.

Use the toggle switches on the Logic Tutor to provide inputs to this circuit and monitor the logic levels at the various nodes on the lamps and check these against the truth table for the circuit shown in Fig. 4.2.

As an exercise try and use the knowledge you now have of the Associative rule and the gates available on Logic Tutor to produce a six input OR. (One answer to be given next month).

by M. Hughes

Next month we shall deal with the EXCLUSIVE OR function.

This column also describes $\overline{A}+\overline{B}$

A	B	$\overline{A \cdot B}$
0	0	1
1	0	1
0	1	1
1	1	0

A	B	$\overline{A}$	$\overline{B}$	A+B
0	0	1	1	0
1	0	0	1	1
0	1	1	0	1
1	1	0	0	1

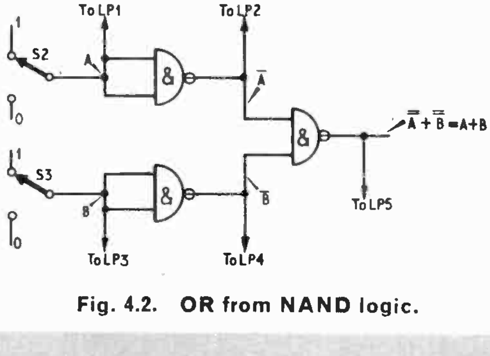


Fig. 4.2. OR from NAND logic.

NEW DEVICES ...APPLICATIONS

I.C. TRIAC CONTROL

In this section we present a selection of both new devices and applications, with news of applications developed for existing devices.

Generally only basic circuit details will be given sufficient for the experimenter to create his own equipment.

THE TRIAC is, without a doubt, one of the most convenient forms of a.c. power control yet devised. Provided one supplies it with correctly timed trigger pulses, it will control large amounts of power reliably without taking up too much space.

A variety of methods of supplying the trigger pulse have been developed but thus far these have involved discrete components. Now a new integrated circuit has been developed by Plessey specifically for triac control circuitry. Of necessity it is internally fairly complex as can be seen from the block schematic of Fig. 1.

It includes an amplifier, capacitor charge and discharge control circuitry, a comparator, a voltage stabilizer, a zero crossing detector and a triac firing circuit.

The basic function performed by this SL440 as the device is identified is in phase control circuits in which the power in the load depends on the phase angle or point on the a.c. cycle, at which the triac is fired. The extra facilities offered by the SL440 enable various circuits to be implemented with the bare minimum of external discrete components.

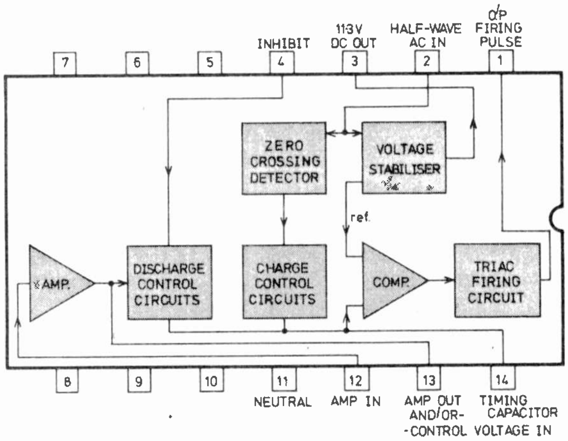


Fig. 1 Block schematic diagram of the SL440

TIMING CIRCUIT

The SL440 contains a timing circuit with a period determined by external control voltages. It is the timing circuit's period which determines exactly when in each half cycle of the mains power supply the triac is fired.

This is illustrated diagrammatically in Fig. 2. Whenever the mains power supply crosses through zero volts,

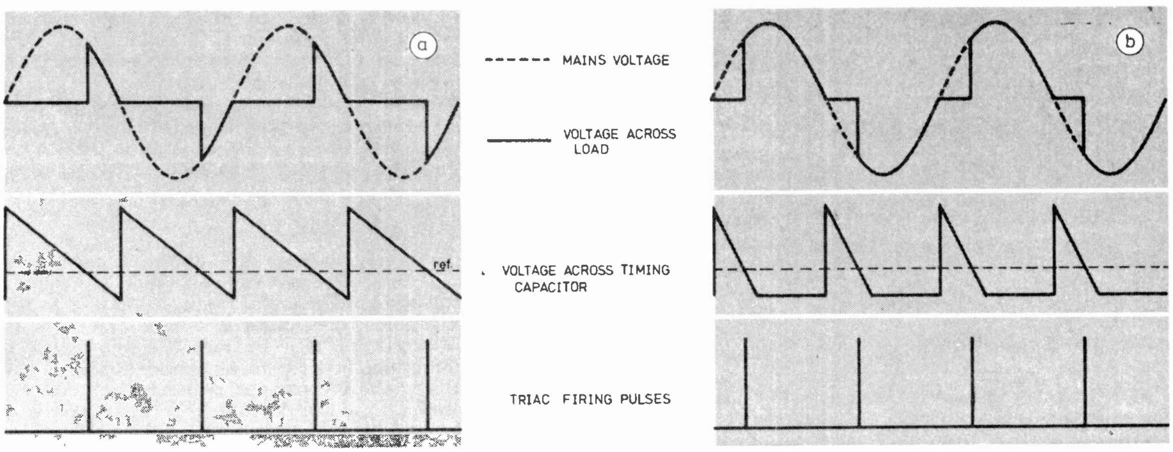


Fig. 2 (a) When the voltage across the timing capacitor falls below the on-chip reference voltage a triac firing pulse is generated. (b) When the capacitor is discharged more quickly, more power is applied to the load

either in the positive or negative direction, a capacitor external to the i.c., but connected to it, is rapidly charged.

During the following half cycle the capacitor discharges at a rate determined by an external control voltage until the voltage across the capacitor falls to a level set within the i.c. When this occurs a pulse is generated which fires the triac.

In Fig. 2a the effect of quite a long timing period is illustrated. As the mains power supply crosses through zero the timing capacitor connected to pin 14 is charged. During each half cycle the capacitor discharges at a constant rate until the voltage across it reaches the same value as the reference when a triac firing pulse is generated.

In the illustration the dotted sinewave represents the mains supply while the solid line indicates the voltage across the load.

integrator in automatic lamp dimmer circuits and the like.

VOLTAGE STABILIZER

The SL440 contains a voltage stabilizer which performs three main functions. Firstly, it provides a stabilized 11·3 V supply for the rest of the chip; it also provides the reference voltage against which the voltage across the timing capacitor is compared and, finally, it provides a stabilized 11·3 V supply for circuitry external to the chip. However, the current available for off-chip circuits is extremely limited and must not be allowed to exceed 3 mA.

MAINS INPUT

The SL440 does not require a d.c. power supply in the conventional sense. Power input is obtained directly from the mains *via* a diode and series dropping resistor. With

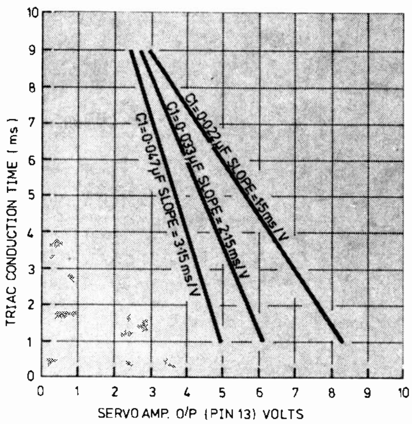


Fig. 3 Showing triac conduction time for different values of timing capacitor and different voltages at pin 13

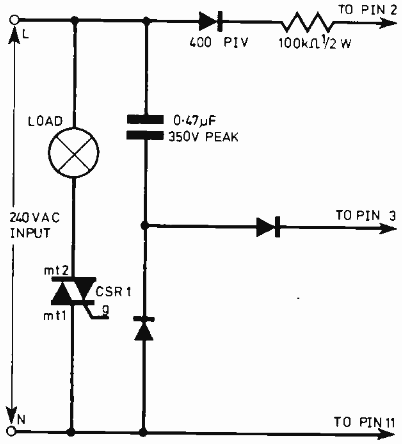


Fig. 4 A circuit to replace the heat dissipating mains dropper resistor

DISCHARGE RATE

The external control voltage setting the discharge rate would normally range from 3 to 8 V, this being sufficient to alter the power in the load from zero to full power. An inverse law applies in that the lower the control voltage the higher the power in the load. The actual power in the load for a given control voltage is also dependent on the value chosen for the timing capacitor.

The larger the capacitor's value the greater the power applied to the load for a given control voltage. These relationships can be seen in Fig. 3, which plots the control voltage against triac conduction time for three different values of timing capacitors.

ON-CHIP AMPLIFIER

The SL440 integrated circuit incorporates an amplifier, called a servo amplifier by Plessey, which can be used to produce the control voltage. It can really be looked at as a grounded emitter amplifier with a beta of about 2,000 and a 2 kΩ resistor in the emitter. It is necessary to connect a suitable external load resistor.

The amplifier is useful in motor speed control as an error voltage amplifier or it can be connected as an

the values recommended by Plessey, the half-wave rectified input has a peak value of about 60 or 70 V. The series resistor (6·8 kΩ, 5 W) can be eliminated with the circuit shown in Fig. 4.

The half-wave rectified input, as well as supplying power, also allows the chip to detect the zero crossings of the mains. Each time a zero crossing is detected the circuitry on the chip charges the external timing capacitor.

OUTPUT AND INHIBIT

When the voltage across the timing capacitor falls below that of the reference voltage supplied to the comparator from the voltage stabilizer, an output triac firing pulse is generated. This pulse is 50 µS wide and must not be allowed to exceed 60 mA. However, this will be more than sufficient for most applications.

An inhibit input is provided which, when connected to the common line (or less than 5 V), prevents any firing pulses from being generated. This input could be used in conjunction with current sensing circuits for protection purposes.

APPLICATIONS

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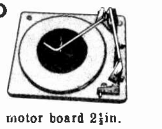

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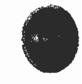

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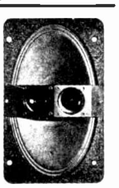

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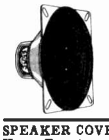

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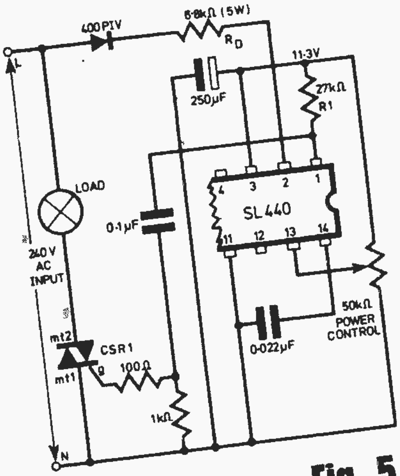

Fig. 5.

AUTO LIGHT

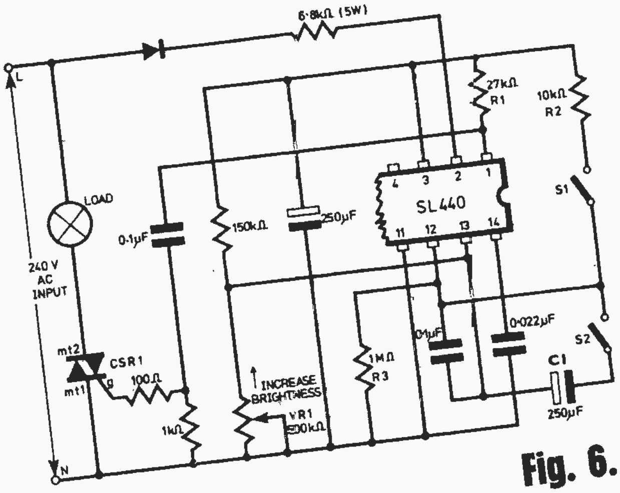

Fig. 6.

SPEED CONTROL

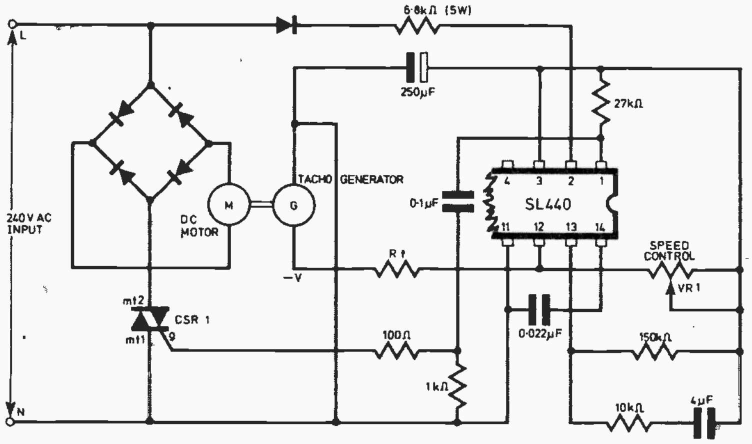

Fig. 7.

APPLICATIONS

Numerous applications for the device will have probably already suggested themselves to the reader. Plessey have developed several circuits.

Fig. 5 shows the SL440 used in a basic lamp dimmer circuit with the minimum of external components. Resistor R1 provides the triac firing circuit with its load.

The potentiometer forms a potential divider across the 11·3 V supply and varies the light output by varying the voltage at pin 13. The input impedance at this point is very high and current flow can be measured in nA. The internal amplifier is not employed in this circuit.

The automatic lamp fader circuit of Fig. 6 is a variation on the same theme, the main difference being that the internal amplifier can be switched to perform an integration of the control voltage.

When S1 is open, the brilliance of the lamp is set by RV1. When S1 is closed, the positive potential derived from the divider R2, R3 is presented to the input causing the lamp to give full output.

If now S2 is closed and S1 is opened, the lamp will gradually reduce in brightness until it reaches the brightness level corresponding to the setting of RV1. The time taken for the fade to occur will depend on the value of the integration capacitor C1. With the value shown, this will be between 20 and 30 minutes.

A motor speed control circuit is shown in Fig. 7 This is basically similar to the previous circuits except that one leg of the potential divider is formed by a tachometer generator driven by the motor.

The device is available from SDS Components Ltd., Hilsea Trading Estate, Portsmouth, Hants, at £2·08p for one-off, £1·82 for 25 off. ★

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THE TOPICAL SYNTHESISER

Sir—In answer to Mr. Baily's letter (last month)—he admits that the building of a stable, accurate log law circuit is difficult. I would tend to go further and say that for the average amateur constructor the task is almost impossible. This statement is in no way intended as a slight to the amateur but serves to highlight a situation which seems to be occurring all too often these days. Although there are many more avenues for the amateur to explore than there were a few years ago it is frequently found that exploitation of a particular circuit or function requires the possession of a bewildering array of test equipment and the technical expertise to interpret their respective readings.

This situation is very much in evidence in the case of designing and building a log law v.c.o. as Mr. Baily has testified. There is little point in publishing designs for such circuits since the problems arise, not so much in the building, but in the final setting-up and matching. Thus, from this point of view alone, there is considerable justification in the presentation of a linear v.c.o. which can be built with a minimum of test equipment and which behaves, with few limitations, in an exactly determinable manner. I would like to underline the fact that the P.E. Synthesiser is very much an experimental project which has been designed, as far as possible, to allow the widest possible licence to the individual constructor for the incorporation of modifications and/or additions to the system. In the case of the v.c.o. the overall response is determined by the response of the "front-end" as it is in most commercially available units. Thus by changing the response of the front end only the circuit can be made to obey a variety of laws to suit the whim of the constructor and this without disturbing the settings of the oscillator section at all.

With regard to Mr. Baily's specific criticisms of the linear v.c.o. the following observations apply:

1. No chording facility. This is a perfectly valid criticism and without doubt is the major disadvantage of the linear v.c.o. Octave chords can be played however and the keyboard incorporates a harmony switch for this purpose. If the Synthesiser is to be used for *musique concrete* purposes the lack of chording facility is no disadvantage since a full range of four note chords may be set up and recorded as discrete sounds.

2. No variable keyboard pitch. Not strictly true since the keyboard oscillators have their own manual frequency control with which it is possible to vary the "spread" by about an octave either way. Since the keyboard oscillators are tuned an octave apart this effectively gives a register of seven octaves although the upper and lower ends are not tightly in tune due to the "non-logarity" of the oscillators.

3. Difficulties in tuning . . . Again not entirely valid. The variation in programming voltage from end of the keyboard to the other is only about 65 millivolts (see Fig. 3.4.) consequently there are only two values of fixed resistor and one value of preset per key. The values of fixed resistor are chosen such that the majority of presets are operating within the middle 60 per cent of their rotation. There is thus not such a vast range of adjustment as Mr. Baily anticipates. Furthermore, and to the advantage of this particular system, the resistive value set-up during tuning affects only one note whereas in the series chain system used with log v.c.o.s any one resistor going unstable will affect all the others downstream in the chain.

4. Poor frequency stability. Voltage and resistance wander can scarcely be cited as being problematical in this respect since they are relatively easy to correct. The use of a well regulated power supply together with adequate decoupling and the use of high stability resistors in the frequency determining networks will largely dispose of the problem. Mr. Baily correctly pinpoints the problem of thermal drift with the linear v.c.o. circuit as published.

On test at an ambient temperature of 18°C and with the oscillator running at 256Hz rapid cycling between about 0°C (induced with a freezer aerosol) and 25°C (close proximity 100 watt lamp) resulted in a variation in frequency of between 222Hz at 0°C and 312Hz at 25°C. This approximates to −10 per cent, +20 per cent on the basic frequency. On the other hand the oscillator in its case was monitored over a 48 hour period with a digital frequency meter and normal changes in day/night ambient temperatures resulted in frequency changes within ±2 per cent. Extreme changes in ambient temperatures are unlikely under what might be termed normal operating conditions and such light changes as do occur can be adequately compensated for by adjustment of the manual frequency bias on the oscillators.

5. Uneven swing in pitch control. There is no real answer to this one since Mr. Baily is correctly citing the characteristic of the linear circuit, i.e. the requirement for a progressively increasing programming voltage in order to maintain the same rate of change of frequency as frequency increases. I feel bound to say, however, that I have never noticed this as a problem.

Two final points are worth mentioning. Mr. Baily cites the increase in power required from the use of integrated circuits as opposed to discrete components. This is undoubtedly true and while there is probably a hard core of amateur constructors who enjoy the challenge of design there is a far larger group who build for the sake of building and whose principal requirement from their hobby is results. To this latter group the integrated circuit, in its many forms, represents a release from many of the problems associated with design and allows them to enjoy their hobby more fully as a result. The increase in power required is thus surely a small price to pay?

Finally, on the subject of price, I would be very interested to have full details of the range of Dewtron modules offering the same specification as the P.E. Sound Synthesiser at under £200.

D. Shaw.

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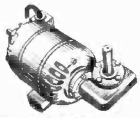
PARVALUX TYPE SD19 230/250 VOLT A.C. REVERSIBLE GEARED MOTORS
30 r.p.m. 40 lb. ins. Position of drive spindle adjustable to 3 different angles. Ex-equipment. Tested and in first-class running order. A really powerful motor offered at a fraction of makers' price. **£7·48.**



PARVALUX TYPE SD2. 200/250 VOLT A.C./D.C. HIGH SPEED MOTOR
Speed 9,000 r.p.m. approx. or 3,200 r.p.m. if used with built-in governor, or variable speed over a wide range if used in conjunction with our Dimmer Switch, illustrated below. PRICE **£2·20.**

600 WATT DIMMER SWITCH. Easily fitted. Fully guaranteed by makers. Will control up to 600W of all lights except fluorescent at mains voltage. Complete with simple instructions. **£3·30.**

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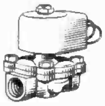
Will handle liquids or gases up to 7 p.s.i. Forged brass body, stainless steel core and spring. ½in b.s.p. inlet/outlet. Precision made, British mfg. PRICE: **£2·09.**
Special quotation for quantity.
(New in makers' carton)



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Test to I.E.E. Spec. Rugged metal construction, suitable for bench or field work, constant speed clutch. Size L.8in, W.4in, H.6in, weight 6lb. **1,000V, 1,000 megohms, £37·40. 500V, 500 megohms, £30·80.**

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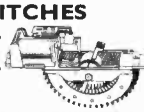
***NEW* 4 Bank 25 Way,** 24V d.c. operation. **£7·04. 6 Bank 25 Way,** 24V d.c. **£8·14. 8 Bank 25 Way,** 24V d.c. operation. **£9·46.**

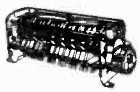


24-HOUR TIMER

Can be adjusted to give a switching delay of between 2 hrs. to 24 hrs. Driven by 200/250V A.C. synchronous motor. 15 amp c/o contacts. Mfg. Crater Controls Ltd. Supplied with scale calibrated 0-10 (2 hrs. per division). Brand New. **£2·20.**

HONEYWELL PROGRAMME TIMERS

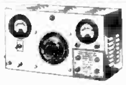
240V. A.C. 5 r.p.m. motor. Each cam operating a c/o micro switch. Cams are individually variable, allowing inumerable combinations. Ideally suited for machinery control, automation, etc. Also in the field of entertainment, for chaser lights, animated displays, etc.
15 cam model **£6·60.**
10 cam model **£5·50.**



SIMPLE 12 CAM PROGRAMMER 240V A.C. 15 RPM MOTOR with 4 adjustable cams and 8 that may be profiled to individual requirements, **£4·18.**

36V 30 AMP. A.C. or D.C.

VARIABLE L.T. SUPPLY UNIT
INPUT 220/240V a.c.
OUTPUT CONTINUOUSLY VARIABLE 0–36V



Fully isolated. Fitted in robust metal case with Voltmeter. Ammeter Panel Indicator and handles. Input and output fully fused. Ideally suited for Lab. or Industrial use. **£77.**

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Will operate four of our Hy-Lyght or Super Hy-Lyght Strobes in either 1, 2, 3, 4 sequence; 2 + 2; or all together. Thoroughly tested and reliable. Complete with full connection instructions. Price: **£20·63.**
Send S.A.E. for details.

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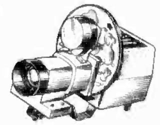

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As used for Disco lighting effects, etc. Price **£5·72.**

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Suitable for Motors, Drills, Sewing Machines, etc., etc. 5 amp. 250 volt.
Price **£1.**

ALL PRICES INCLUDE V.A.T. POSTAGE AND PACKING
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Superior Quality Precision Made NEW POWER RHEOSTATS

New ceramic construction, vitreous enamel embedded winding, heavy duty brush assembly, continuously rated.
25 WATT 10/25/50/100/250/500/1k/1·5k ohm **£1·10.**
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Black Silver Skirted knob calibrated in Nos. 1-9, 1½in. dia. brass bush. Ideal for above Rheostats, **22p** each.

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Col. 3 Contracts
Col. (4) Price
HD = Heavy duty
*Incl. Base
All prices incl. P. & P.

1	2	3	4
52	4–6	6M	66p*
52	4–6	4 c/o	88p*
150	6–12	4 c/o	88p*
185	8–12	6M	66p*
410	10–18	4 c/o	77p*
600	9–18	2 c/o	66p*
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700	16–24	4 c/o	88p*
700	15–35	2 c/o HD	77p*
700	16–24	6M	66p*
700	6–12	1 c/o HD	55p*
700	20–30	6 c/o	88p*
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2,500	36–45	6M	66p*
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9,000	40–70	2 c/o	55p*
15k	85–110	6M	55p*

12 VOLT D.C. RELAY 140 ohm coil
Type 1: Three sets c/o contacts rated at 5 amps. **88p** (Similar to illustration below.)
Type 2: 4-8 volt, 3 c/o HD, 67 ohm coil. **88p.**

SPECIAL OFFER
700 ohm 4 c/o. Ex. new equipment. **£55** per 100 incl. bases (minimum 100).

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Three sets c/o contacts rated at 5 amps. PRICE: **66p.** (100 lots) **£44.**
24 volt A.C. 3 c/o **66p.** Incl. P. & P.

MINIATURE LATCHING RELAY
Manufactured by Clare-Elliott Ltd. Type F. 2 c/o permanent latching in either direction. Coil 1150 ohm, 15-30 Volt D.C. Size ¾" high, ¾" wide, ¾" thick. Complete with 3" leads. New **77p,**

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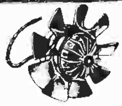
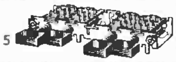
200-240 Volt A.C. Precision German built. Dynamically balanced, quiet, continuously rated, reversible motor. Consumption 60mA. Size 120 mm. dia. × 60 mm. deep. Price **£3·52.**

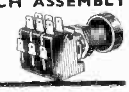


230V FAN ASSEMBLY
Continuously rated, special sealed bearing, removable aluminium blades. Price **£1·10.**

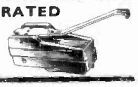
4 BANK 3c/o PUSH BUTTON ASSEMBLY
Black rectangular buttons. 5 units (min. order) **£1·10.**



"HONEYWELL" PUSH BUTTON, PANEL MOUNTING MICRO SWITCH ASSEMBLY
Each bank comprises a c/o rated at 10 amps 240V. A.C. Black knob 1 in. Fixing hole ½ in. ONE bank **33p;** TWO bank **44p;** THREE bank **61p.** Quot. for quantity.



'HONEYWELL' LEVER OPERATED MICRO SWITCH
15 amps 250 volt A.C. c/ contacts. In maker's carton.
PRICE: 10 for **£2·09.**

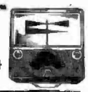


Very special offer **MICRO SWITCH**

5 amp c/o contacts. Fitted with removable metal panel assembly. Ex. P.O. 20 for **£1·10** (Min. order 20.)

METER BARGAIN

BALANCE/LEVEL METERS
100-0-100 Micro Amp. Size 1½in + 1½in + ¾in. Price only **83p.**



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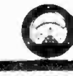

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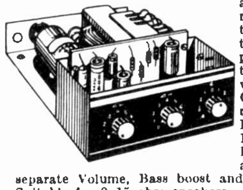

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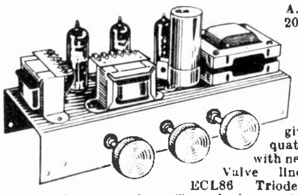

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SONOTONE 9TAHC COMPATIBLE STEREO CARTRIDGE T/O stylus. Diamond Stereo LP and Sapphire 78. ONLY **£2·30.** P. & P. 10p. Also available fitted with twin Diamond T/O stylus for Stereo LP. **£2·80.** P. & P. 10p.
LATEST RONETTE T/O Stereo Compatible Cartridge for EP/LP/Stereo/78. **£1·63.** P. & P. 10p.
LATEST RONETTE T/O Mono Compatible Cartridge for EP/LP/78 mono/stereo records on mono equipment **£1·50.** P. & P 10p.

QUALITY RECORD PLAYER AMPLIFIER MK II
A top-quality record player amplifier employing heavy duty double wound mains transformer, ECC83, EL84, and rectifier. Separate Bass, Treble and Volume controls. Complete with output transformer matched for 3 ohm speaker. Size 7in. w. × 3 d. × 6 h. Ready built and tested. PRICE **£4·40.** P. & P. 40p. ALSO AVAILABLE mounted on board with output transformer and speaker. PRICE **£5·85.** P. & P. 50p.

SPECIAL OFFER!!
HI-FI LOUDSPEAKER SYSTEM

Beautifully made teak finish enclosure with most attractive Tygan-Vynair front. Size 16in high × 10½in wide × 6in deep. Fitted with E.M.I. Ceramic Magnet 13in × 8in bass unit, two H.F. tweeter units and crossover. Max. power handling 10W. Available 3, 8 or 15 ohm impedance.

Our Price £9·25 Carr. 70p.

CABINET AVAILABLE SEPARATELY **£4·95.** Carr. 65p.
Also available in 8 ohm with EMI 13in × 8in. bass speaker with parasitic tweeter. **£7·15.** Carr. 70p.

HARVERSON'S SUPER MONO AMPLIFIER
A super quality gram amplifier using a double wound fully isolated mains transformer, rectifier and ECL82 triode pentode valve as audio amplifier and power output stage. Impedance 3 ohms. Output approx. 3·5 watts. Volume and tone controls. Chassis size only 7in. wide × 3in. deep × 6in. high overall. AC mains 200/240V. Supplied absolutely Brand New, completely wired and tested with good quality output transformer.
OUR ROCK BOTTOM BARGAIN PRICE **£3·30** P. & P. 35p

LOUDSPEAKER BARGAINS
5in 3 ohm **£1·05,** P. & P. 15p. 7 × 4in 3 ohm **£1·15,** P. & P. 20p. 10 × 6in 3 or 15 ohm **£1·90,** P. & P. 30p. E.M.I. 8 × 5in 3 ohm with high flux magnet **£1·62,** P. & P. 20p. E.M.I. 13½ × 8in with high flux ceramic magnet with parasitic tweeter 3, 8, or 15 ohm **£3·50.** P. & P. 30p. E.M.I. 13 × 8in, 3 or 8 or 15 ohm with two inbuilt tweeters and crossover network **£4·65.** P. & P. 30p.
EMI CERAMIC MAGNET HEAVY DUTY TWEETER. pprox. 3½in. Av. 3 or 8 or 15 ohms. **£1·25** plus 15p p. & p.
BRAND NEW. 12in 15w H/D Speakers, 3 or 15 ohm. Current production by well-known British maker. Now with Hiflux ceramic ferrobar magnet assembly **£7·50.** Guitar models: 25w **£7·50,** 35w **£9·35.** P. & P. 40p each.

SPECIAL OFFER!

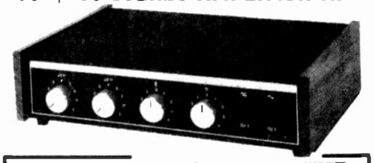
LIMITED NUMBER OF BRAND NEW ELAC 10" TWIN CONE LOUDSPEAKERS. With large ceramic magnet and plasticised cone surround. 8 ohm impedance.
£2·70. P. & P. 25p.

12in "RA" TWIN CONE LOUDSPEAKER
10 watts peak handling. 3, 8 or 15 ohm, **£2·45.** P. & P. 30p.
35 ohm SPEAKERS 3". ONLY **70p.** P. & P. 13p.
"POLY PLANAR" WAFER-TYPE, WIDE RANGE ELECTRO-DYNAMIC SPEAKER
Size 11¾in × 14 11/16in × 1 3/16in deep. Weight 19oz. Power handling 20W r.m.s. (40W peak). Impedance 8 ohm only. Response 40Hz–20kHz. Can be mounted on ceilings, walls, doors, under tables, etc., and used with or without baffle. Send S.A.E. for full details. Only **£6·55** each. P. & P. 25p.
VYNAIR & REXINE SPEAKERS & CABINET FABRICS app. 54 in. wide. **Our price 85p yd.** length. P. & P. 15p per yd. (min. 1 yd.). S.A.E. for samples.

HI-FI STEREO HEADPHONES
Adjustable headband with comfortable flexifoam earmuffs. Wired and fitted with standard stereo ¼in jack plug. Frequency response 30–15,000Hz. Matching impedance 8–16 ohms. Easily converted for mono. PRICE **£3·30.** P. & P. 15p.

HIGH IMPEDANCE CRYSTAL STICK MIKES. OUR PRICE **£1·15.** P. & P. 10p.

HARVERSONIC SUPER SOUND 10 + 10 STEREO AMPLIFIER KIT

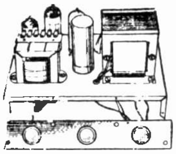


NEW FURTHER IMPROVED MODEL WITH HIGHER OUTPUT AND INCORPORATING HIGH QUALITY READY DRILLED FIBRE GLASS PRINTED CIRCUIT BOARD WITH COMPONENT IDENTIFICATION CLEARLY MARKED FOR EVEN EASIER CONSTRUCTION

A really first-class Hi-Fi Stereo Amplifier Kit. Uses 14 transistors including Silicon Transistors in the first five stages on each channel resulting in even lower noise level with improved sensitivity. Integrated pre-amp with Bass, Treble and two Volume Controls. Suitable for use with Ceramic or Crystal cartridges. (Very simple to modify to suit magnetic cartridge—instructions included). Output stage for any speakers from 5 to 15 ohms. Compact design, all parts supplied including drilled metal work, high quality ready drilled fibre glass printed circuit board, smart brushed anodised aluminium front panel with matching knobs, wire, solder, nuts, bolts—no extras to buy. Simple step by step instructions enable any constructor to build an amplifier to be proud of. Brief specification: Power output 14W r.m.s. per channel into 5 ohms. Frequency response ±3dB 12–30,000Hz. Sensitivity better than 80mV into 1MΩ. Full power bandwidth ±3dB 12–15,000Hz. Bass boost approx. to ±12dB. Treble cut approx. to −16dB. Negative feedback 18dB over main amp. Power requirements 35V at 1·0 amp. Overall size—12" wide × 8" deep × 2½" high.
Fully detailed 7-page construction manual and parts list free with kit or send 18p plus large S.A.E.

PRICES AMPLIFIER KIT,	**£11·55**	P. & P. 18p.
(Magnetic input components 33p extra)		
POWER PACK KIT,	**£3.30**	P. & P. 33p.
CABINET,	**£3·30**	P. & P 33p.

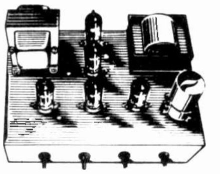
(Post Free if all units purchased at same time). Full after sales service. Also available ready built and tested, **£23·10.** Post Free.
Note: The above amplifier is suitable for feeding two mono sources into inputs (e.g. mike, radio, twin record decks, etc.) and will then provide mixing and fading facilities for medium powered Hi-Fi Discotheque use, etc.



3-VALVE AUDIO AMPLIFIER HA34 MK II
Designed for Hi-Fi reproduction of records. A.C. Mains operation. Ready built on plated heavy gauge metal chassis, size 7¾in w. × 4in. d. × 4½in. h. Incorporates ECC83, EL84, EZ80 valves. Heavy duty, double wound mains transformer and output transformer matched for 3 ohm speaker. Separate volume control and now with improved wide range tone controls giving bass and treble lift and cut. Negative feedback line. Output 4½ watts. Front panel can be detached and leads extended for remote mounting of controls. Complete with knobs, valves, etc., wired and tested for only **£5·50.** P. & P. 35p.

BRITISH MADE SOLID STATE ALL SILICON STEREO AMPLIFIER. 15 watts rms per channel output. Fre. res. 20Hz to 20KHz. Suitable for magnetic or ceramic pickup tape mic., etc., built-in switchable scratch filter, rumble filter and loudness control. 60 m/m slider controls for bass, treble and volume. 10 way push button function, selector switch. This amplifier has specification and performance usually only found in amplifiers costing twice as much. Each amplifier supplied, tested and fully guaranteed. Finished in the most attractive contemporary style teak cabinet. Size 16¾in. × 8¾in. × 4¼in. Makers' recommended price **£46·36.** incl. V.A.T. Our price (while stocks last) **£35·75** incl. V.A.T. plus 75p P. & P. Send S.A.E. for full details of specification.

10/14 WATT HI-FI AMPLIFIER KIT



A stylishly finished monaural amplifier with an output of 14 watts from 2 EL84s in push-pull. Super reproduction of both music and speech, with negligible hum. Separate inputs for mike and gram allow records and announcements to follow each other. Fully shrouded section wound output transformer to match 3–15Ω speaker and 2 independent volume controls, and separate bass and treble controls are provided giving good lift and cut. Valve line-up 2 EL84s, ECC83, EF86 and EZ80 rectifier. Simple instruction booklet **15p** plus S.A.E. (Free with parts). **All parts sold separately.** ONLY **£8·80.** P. & P. 55p. Also available ready built and tested **£12·10.** P. & P. 60p.

Open 9-5.30 Mon. to Fri. 9-5 Sat. Early closing Wed. 1p.m.

A few minutes from South Wimbledon Tube Station.

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SEND STAMPED ADDRESSED ENVELOPE WITH ALL ENQUIRIES

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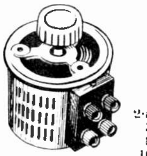
PLEASE NOTE: P. & P. CHARGES QUOTED APPLY TO U.K. ONLY. P. & P. ON OVERSEAS ORDERS CHARGED EXTRA.

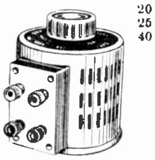
"YAMABISHI" VARIABLE VOLTAGE TRANSFORMERS

Excellent quality at low cost. All models—Input 230v. 50/60 c/s. Variable output 0-260v.



MODEL S-260 GENERAL PURPOSE BENCH MOUNTING

1 amp.	£7·00
2·5 amp.	£8·05
5 amp.	£11·75
8 amp.	£15·90
10 amp.	£22·50
12 amp.	£23·60
20 amp.	£49·00
25 amp.	£58·00
40 amp.	£82·50



MODEL S-260B

Panel mounting
·1 amp .... £7·00
2·5 amp .... £8·05

Carriage and Packing Extra

AUTO TRANSFORMERS

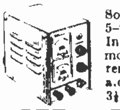
0/115/230V. Step up or step down. Fully shrouded.

80W	£2·10	P. & P. 18p
150W	£2·70	P. & P. 18p
300W	£3·60	P. & P. 23p
500W	£5·25	P. & P. 33p
1000W	£7·50	P. & P. 38p
1500W	£10·20	P. & P. 43p
2250W	£17·25	P. & P. 50p
5000W	£36·00	P. & P. £1

MCA.220 AUTOMATIC VOLTAGE STABILISER

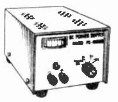
Input 88–125V a.c. or 176–250V a.c. Output 120V a.c. or 240V a.c. 200VA rating. **£11·97.** Post 50p.

PS.200 REGULATED P.S.U.



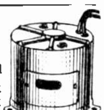
Solid state. Variable output 5–20V d.c. up to 2 amp. Independent meters to monitor voltage and current. Output 220/240V. a.c. Size 7½in. × 5½in. × 3½in. **£19·95.** Post 25p.

PS.1000B REGULATED POWER SUPPLY



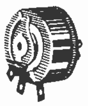
Solid state. Output 6, 9 or 12V d.c. up to 3 amps. Meter to monitor current. Input 220/240V a.c. Size 4in. × 3½in. × 6½in. **£11·97.** Post 25p.

230V/240V SMITHS SYNCHRONOUS GEARED MOTORS



Built in gearbox. All brand new and boxed. 30 RPH CW; 2 RPH CW; 20 RPH CW; 2 RPH ACW; 30 RRH CW. **50p** each, Post 12p.

POWER RHEOSTATS

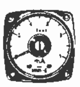


High quality ceramic construction. Windings embedded in vitreous enamel. Heavy duty brush wiper. Continuous rating. Wide range available ex-stock. Single hole fixing, ¼in dia. shafts. Bulk quantities available.

25 WATT. 10/25/50/100/250/500/1000 ohms. **95p.** P. & P. 10p.

50 WATT. 10/25/50/100/250/500/1000/2500 or 5000 ohms. **£1·35.** P. & P. 10p.

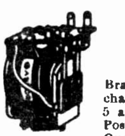
100 WATT. 1·5/10/25/50/100/250/500/1000 or 2500 ohms. **£1·95.** P. & P. 15p.



240° Wide Angle 1mA Meters

MW1·6 60mm square	£3·97
MW1·8 80mm square	£4·97

Post extra



230 VOLT A.C. 50 CYCLES RELAYS

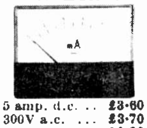
Brand new. 3 sets of changeover contacts at 5 amp. rating. **50p each.** Post 10p (100 lots **£40**) Quantities available.

SEW CLEAR PLASTIC PANEL METERS

USED EXTENSIVELY BY INDUSTRY, GOVT. DEPTS., EDUCATIONAL AUTHORITIES, ETC.

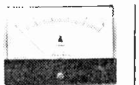
Over 200 ranges in stock—other ranges to order. Quantity discounts available. Send for fully illustrated brochure.

TYPE SW.100 100mm × 80mm Fronts



50μA	£4·15	5 amp. d.c.	£3·60
50-0-50μA	£3·95	300V a.c.	£3·70
100μA	£3·95	VU Meter	£4·30
100-0-100μA	£3·90		
500μA	£3·70		
1mA	£3·60		
20V d.c.	£3·60		
50V d.c.	£3·60		
300V d.c.	£3·60		
1 amp. d.c.	£3·60		

Type SD.830 82·5mm × 110mm Fronts



50μA	£3·40	10mA	£3·10
50-0-50μA	£3·40	50mA	£3·10
100μA	£3·35	100mA	£3·10
100-0-100μA	£3·35	500mA	£3·10
200μA	£3·30	1 amp.	£3·10
500μA	£3·15	5 amp.	£3·10
1mA	£3·10	10 amp.	£3·10
5mA	£3·10	5V d.c.	£3·10
		10V d.c.	£3·10
		20V d.c.	£3·10
		50V d.c.	£3·10
		300V d.c.	£3·10
		15V a.c.	£3·30
		300V a.c.	£3·30
		VU Meter	£3·50

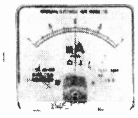
Type SD.640 63·5mm × 85mm Fronts

50μA	£3·05	500mA	£2·90
50-0-50μA	£3·05	1 amp.	£2·90
100μA	£3·00	5 amp.	£2·90
100-0-100μA	£3·00	10 amp.	£2·90
200μA	£3·00	5V d.c.	£2·90
500μA	£2·95	20V d.c.	£2·90
1mA	£2·90	50V d.c.	£2·90
5mA	£2·90	300V d.c.	£2·90
10mA	£2·90	15V a.c.	£3·00
50mA	£2·90	300V a.c.	£3·00
100mA	£2·90	VU Meter	£3·15

Type SD.460 46mm × 59·5mm Fronts

50μA	£2·80	1 amp.	£2·60
50-0-50μA	£2·80	5 amp.	£2·60
100μA	£2·75	10 amp.	£2·60
100-0-100μA	£2·75	5V d.c.	£2·60
200μA	£2·70	10V d.c.	£2·60
500μA	£2·55	20V d.c.	£2·60
1mA	£2·60	50V d.c.	£2·60
5mA	£2·60	300V d.c.	£2·60
10mA	£2·60	15V a.c.	£2·70
50mA	£2·60	300V a.c.	£2·70
100mA	£2·60	VU Meter	£2·90
500mA	£2·60		

Type MR.85P. 4¼in. × 4¼in. Fronts



		50mA	£3·90
		100mA	£3·90
		500mA	£3·90
		1 amp.	£3·90
		5 amp.	£3·90
		15 amp.	£3·90
		30 amp.	£3·95
		20V d.c.	£3·90
		50V d.c.	£3·90
50μA	£4·40	150V d.c.	£3·90
50-0-50μA	£4·25	300V d.c.	£3·90
100μA	£4·25	15V a.c.	£3·95
100-0-100μA	£4·05	300V a.c.	£3·95
200μA	£4·05	8 Meter 1mA	£3·90
500μA	£3·90	VU Meter	£4·55
5000-500μA	£3·90	1 amp. a.c.*	£3·90
1mA	£3·90	5 amp. a.c.*	£3·90
1-0-1mA	£3·90	10 amp. a.c.*	£3·90
5mA	£3·90	20 amp. a.c.*	£3·90
10mA	£3·90	30 amp. a.c.*	£3·90

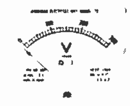
Type MR.52P. 2½in. square Fronts.

50μA	£3·50	10V d.c.	£2·50
50-0-50μA	£3·05	20V d.c.	£2·50
100μA	£3·00	50V d.c.	£2·50
100-0-100μA	£2·95	300V d.c.	£2·50
500μA	£2·65	15V a.c.	£2·60
1mA	£2·50	300V a.c.	£2·60
5mA	£2·50	8 Meter 1mA	£2·60
10mA	£2·50	VU Meter	£3·60
50mA	£2·50	1 amp. a.c.*	£2·50
100mA	£2·50	5 amp. a.c.*	£2·50
500mA	£2·50	10 amp. a.c.*	£2·50
1 amp.	£2·50	20 amp. a.c.*	£2·50
5 amp.	£2·50	30 amp. a.c.*	£2·50

Type MR.65P. 3½in. × 3½in. Fronts

50μA	£3·70	10V d.c.	£2·60
50-0-50μA	£3·15	20V d.c.	£2·60
100μA	£3·15	50V d.c.	£2·60
100-0-100μA	£3·10	150V d.c.	£2·60
200μA	£3·05	300V d.c.	£2·60
500μA	£2·75	15V a.c.	£2·80
500-0500μA	£2·60	50V a.c.	£2·80
1mA	£2·60	150V a.c.	£2·80
5mA	£2·60	300V a.c.	£2·80
10mA	£2·60	500V a.c.	£2·80
50mA	£2·60	8 Meter 1mA	£2·85
100mA	£2·60	VU Meter	£3·70
500mA	£2·60	50mA a.c.*	£2·60
1 amp.	£2·60	100mA a.c.*	£2·60
5 amp.	£2·60	200mA a.c.*	£2·60
10 amp.	£2·60	500mA a.c.*	£2·60
15 amp.	£2·60	1 amp. a.c.*	£2·60
20 amp.	£2·60	5 amp. a.c.*	£2·60
30 amp.	£2·80	10 amp. a.c.*	£2·60
50 amp.	£2·90	20 amp. a.c.*	£2·60
5V d.c.	£2·60	30 amp. a.c.*	£2·60

Type MR.38P. 1 21/32in. square Fronts.



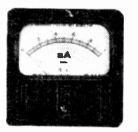
		200mA	£2·25
		300mA	£2·25
		500mA	£2·25
		750mA	£2·25
		1 amp.	£2·25
		2 amp.	£2·25
		5 amp.	£2·25
		10 amp.	£2.25
		3V d.c.	£2·25
50μA	£2·55	10V d.c.	£2·25
50-0-50μA	£2·50	15V d.c.	£2·25
100μA	£2·45	20V d.c.	£2·25
100-0-100μA	£2·40	50V d.c.	£2·25
200μA	£2·25	100V d.c.	£2·25
500μA	£2·25	150V d.c.	£2·25
500-0-500μA	£2·25	300V d.c.	£2·25
1mA	£2·25	500V d.c.	£2·25
1-0-1mA	£2·25	750V d.c.	£2·25
2mA	£2·25	15V a.c.	£2·35
5mA	£2·25	50V a.c.	£2·30
10mA	£2·25	150V a.c.	£2·30
20mA	£2·25	300V a.c.	£2·30
50mA	£2·25	500V a.c.	£2·30
100mA	£2·25	8 Meter 1mA	£2·30
150mA	£2·25	VU Meter	£2·65

Type MR.45P. 2in. square Fronts.

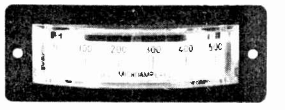
50μA	£2·70	5 amp.	£2·40
50-0-50μA	£2·65	10V d.c.	£2·40
100μA	£2·60	20V d.c.	£2·40
100-0-100μA	£2·50	50V d.c.	£2·40
200μA	£2·50	300V d.c.	£2·40
500μA	£2·45	15V d.c.	£2·40
500-0-500μA	£2·40	300V d.c.	£2·40
1mA	£2·40	8 Meter 1mA	£2·50
5mA	£2·40	VU Meter	£2·70
10mA	£2·40	1 amp. a.c.*	£2·40
50mA	£2·40	5 amp. a.c.*	£2·40
100mA	£2·40	10 amp. a.c.*	£2·40
500mA	£2·40	20 amp. a.c.*	£2·40
1 amp.	£2·40	30 amp. a.c.*	£2·40

"SEW" BAKELITE PANEL METERS

Type MR.65. 3½in. square Fronts.



		1 amp.	£2·60
		5 amp.	£2·60
		15 amp.	£2·60
		30 amp.	£2·60
		50 amp.	£2·60
		5V d.c.	£2·60
		10V d.c.	£2·60
		20V d.c.	£2·60
		50V d.c.	£2·60
		150V d.c.	£2·60
25μA	£4·60	300V d.c.	£2·60
50μA	£3·55	30V a.c.*	£2·65
50-0-50μA	£3·05	50V a.c.*	£2·65
100μA	£3·00	150V a.c.*	£2·65
100-0-100μA	£3·00	300V a.c.*	£2·65
500μA	£2·70	500mA a.c.*	£2·60
500-0-500μA	£2·70	1 amp. a.c.*	£2·60
1mA	£2·60	5 amp. a.c.*	£2·60
1-0-1mA	£2·60	10 amp. a.c.*	£2·60
5mA	£2·60	20 amp. a.c.*	£2·60
10mA	£2·60	30 amp. a.c.*	£2·60
5mA	£2·60	50 amp. a.c.*	£2·60
50mA	£2·60	VU Meter	£3·65
100mA	£2·60	50mV d.c.	£2·90
500mA	£2·60	100mV d.c.	£2·90



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200μA	£3·40		

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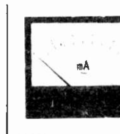
50-0-50μA	£6·40	300V d.c.	£5·95
10-0-1mA	£5·95	Dual range	
1A d.c.	£5·95	500mA/5A d.c.	£7·00
5A d.c.	£5·95	5V/50V d.c.	£7·00

Type S-80 80mm square Fronts



50μA	£3·50		
50-0-50μA	£3·40		
100μA	£3·40		
100-0-100μA	£3·30		
500μA	£3·05		
1mA	£3·00		
20V d.c.	£3·00		
50V d.c.	£3·00		
300V d.c.	£3·00		
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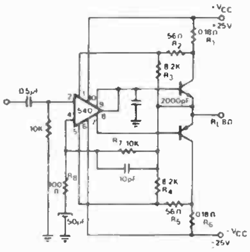
Device of the Month NE540L



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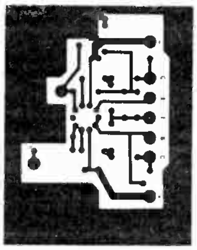
The Signetics 540 is a monolithic, class AB power audio amplifier designed specifically to drive a pair of complementary output transistors.



This device features: internal current limiting; low standby current; high output current capability; wide power bandwidth; low distortion – features which make this device ideal for use as an audio power amplifier.

Signetics power driver NE540L
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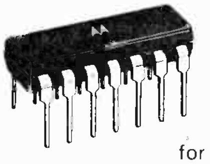
including application notes

Compatible device MC1339P



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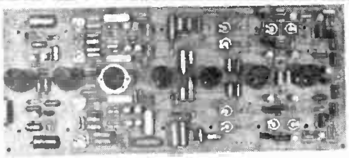
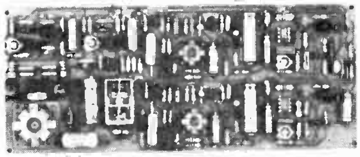


AURORA
Multichannel Sound Controlled Light (PE Apr./Aug. 71). S/c's (excl. SCRs), Rs, Cs, Pots, Cores—8 ch. **£17·75**; 4 ch. **£10·15**. Reg. PSU **£3·65**. PCB—4 ch. control (4¾in × 10½in) Mk. 2—also holds rotary or slider pots **£2·35**. PCB (4¾in × 5in) Mk. 2—for PSU, Sync Gen. 8 cores, 8 SCRs, **£1·35**. SCRs—1A, **50p**, 3A, **55p**.



HI-FI TAPE LINK
(PE Mar./Apr. 73). S/c's, i.c.'s, Rs, Cs, Relay and pc-base, Pot Cores and pc-bases, Sw's, Pots, Panel Lamp—Mono, **£11·80**; Stereo, **£18·70**. PSU, **£2·50**. PCB—Main Assy. (3¼in × 9in) (Stereo) also holds relay and cores, **£1·85**. PCB—Sub-Assy. (2¼in × 6¼in) (Stereo) holds Sw-assoc. Rs, Cs, Presets and mounts on Sw's, **80p**.

A.F. SIGNAL GENERATOR
(PE Nov. 72). S/c's, Rs, Cs, Pots, Sw's, PCB (2¼in × 4in) also holds Sw's, **£3·15**.

AUDIO MIXER
(PE Jan. 72). Rs, Cs, Pots, PCB (1¼in × 2in) (i.c. excl.), **£1·55**.

DOOR BELL YODELLER
(PE Apr. 71). S/c's, Rs, Cs, Pots, PCB (3in × 3¼in), **£5·10**. T/fmr **£1·30**. L/spkr **£1·30**.

BIOLOGICAL AMPLIFIER
(PE Jan./Feb. 73). P/A Set—S/c's, i.c.'s, Rs, Cs, Pots, PCB (1¼in × 3¾in), **£3·70**. O/P Stages (S/c's, Rs, Cs, Pots and Sw's as reqd.). Alphaphone **60p**, Cardiophone **75p**, Freq. Meter **£1·90**, Vis-Feedback **60p**. Audio Amp PC7 avail. to order **£4·75**.

ELECTRONIC PIANO
(PE Sep. 72/Jan. 73)—Details in lists

GEMINI STEREO AMPLIFIER
(PE Nov. 70/Mar. 71) Stereo Sets and PCBs. Pre-amp—S/c's **£1·85**. Rs, Cs, Pots, Mak—Sw's—with ¼W MO Rs, **£11·60**—with ¼W CF Rs, **£9·35**—with ½W CF Rs, **£8·90**. PCB (3¼in × 10½in) for sets with MO and ¼W Rs, also holds rotary or slider pots and Maka-Sw's, **£2·10**. Main Amp—Rs, Cs, Pots, **£5·40**. PCB (3¼in × 5in), **£1·40**. PSU—Rs, Cs, Pot, **£3·70**. PCB (2in × 4in), **75p**.

LOGICAL RADIO CONTROL
(PE Apr./Jun. 72)—Details in lists

GEMINI STEREO TUNER
(PE Apr./Jun. 72). Rs, Cs, Pot, **£3·80**. PCB as publ., **£1·50**.

MICROPHONE MIXER
(PE Apr. 69). S/c's, Rs, Cs, Pots, **£2·90**. PCB (3¼in × 4¼in) also holds 6 rotary or 4 slider pots, **£1·20**.

MODEL SERVO CONTROL
(PE Feb./Mar. 72)—Details in lists

8 WATT AMPLIFIER
(PW Nov./Dec. 72). Pre-amp—S/c's, Rs, Cs, Pots, Sw—Mono, **£2·50**; Stereo, **£5·20**. PCB (3¼in × 7¼in) (Stereo) also holds rotary or slider pots and Sw, **£1·50**. Main Amp—S/c's, Rs, Cs, Pot—Mono, **£3·90**; Stereo, **£7·70**. PCB (2¼in × 3in) Mono), **60p**.

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REVERBERATION UNIT
(PW Nov./Dec. 72). S/c's, Rs, Cs, Slider Pots, T/fmr, **£6·80**. PCB (2in × 11¼in) also holds sliders, **£1·20**. 9in Spring Unit avail. to order, **£3·75**.

VIBRASONIC GUITAR PRE-AMP
(PW Sept. 70). Incl. Mic P/A, 2-Guitar P/A, Trem and Tone Controls, Master Volume. S/c's, Rs, Cs, LDR, Rotary Pots, Lamp, Coupling T/fmr, **£7·75**. PSU, **£2·80**. PCB (3¼in × 10½in) Mk. 2, also holds 7 rotary or slider pots, **£2·30**.

ULTRASONIC TRANSMITTER-RECEIVER
(PE May 72). S/c's, Rs, Cs, Pot, Relay, Dual PCB (2in × 5¼in), **£3·90**. T/ducers avail. to order, **£7·30** per pair.

ALSO
PCBs as published (while stocks last) for:
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OSCILLOSCOPE P/A (PE Aug. 72), **40p**
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AND
DIGITRONIC (PW Mar. 73). Read-out PCB (1¼in × 3¼in), **60p**.

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TAPE NOISE LIMITER
(PE Feb. 72). S/c's, Rs, Cs, Pot, PCB (1¼in × 3in), **£2·20**. Reg. PSU and PCB (1¼in × 2¼in), **£3·20**.

VERSATILE LIGHT EFFECTS UNIT
Single Channel Sound Controlled Light with built-in variable strobe. (PE June 72). S/c's, Rs, Cs, Pots, T/fmrs, Keyswitch, **£8·85**. PCB (3¼in × 7¼in) Mk. 2, also holds pots, Sw, T/T7 T/fmr, **£1·50**. SCRs—1A, **50p**, 3A, **55p**.

PHOTOPRINT PROCESS CONTROL
(PE Jan./Feb. 72). Finds exposures, controls timing, stabs. mains voltage. S/c's, SCR, LDR, Rs, Cs, Pots, Relay, Keyswitch, T/fmr, **£7·60**. PCB (3¼in × 5¼in) also holds pots, Sw, relay, **£1·20**.

SOUND SYNTHESISER
(PE Current Series)
Details of PCBs and Components in list. Free mailing list service available for further information about PCBs and Sets for this project.

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1N4007	0·20
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1S130	0·18
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2N2148	0·60
2N2160	0·60
2N2218	0·20
2N2219	0·20
2N2369A	0·15
2N2444	1·99
2N2613	0·28
2N2646	0·45
2N2904	0·20
2N2904A	0·25
2N2906	0·20
2N2907	0·28
2N2924	0·23
2N2925	0·15
2N2926	0·10
2N3054	0·50
2N3055	0·75
2N3702	0·10
2N3705	0·10
2N3706	0·23
2N3707	0·12
2N3709	0·10
2N3710	0·10
2N3711	0·10
2N3819	0·35
2N5027	0·58
2N5088	0·33
2S301	0·50
2S304	0·75
2S501	0·37
2S703	0·62
AA129	0·20
AAZ12	0·30
AAZ13	0·12
AC107	0·37
AC126	0·20
AC127	0·25
AC128	0·20
AC187	0·25
AC188	0·25
ACY17	0·30
ACY18	0·25
ACY19	0·25
ACY20	0·20
ACY21	0·20
ACY22	0·10
ACY27	0·25
ACY28	0·17
ACY39	0·50
ACY40	0·15
ACY41	0·15
ACY44	0·25
AD140	0·50
AD149	0·50
AD161	0·37
AD162	0·37
AF106	0·30
AF114	0·25
AF115	0·25
AF116	0·25
AF117	0·25
AF118	0·62
AF119	0·20
AF124	0·25
AF125	0·20
AF126	0·17
AF127	0·17
AF139	0·30
AF178	0·55
AF179	0·65
AF180	0·52
AF181	0·42
AF186	0·40
AFY19	1·18
AFZ11	0·60

Type	£p
AFZ12	1·00
ASY26	0·25
ASY27	0·32
ASY28	0·25
ASY29	0·30
ASY36	0·25
ASY50	0·17
ASY51	0·40
ASY53	0·20
ASY55	0·20
ASY62	0·25
ASY86	0·33
ASZ21	0·42
ASZ23	0·75
AUY10	0·98
AU101	1·50
BC107	0·10
BC108	0·10
BC109	0·10
BC113	0·15
BC115	0·20
BC116	0·25
BC116A	0·30
BC118	0·25
BC121	0·20
BC122	0·20
BC125	0·68
BC126	0·65
BC140	0·55
BC147	0·15
BC148	0·13
BC149	0·15
BC157	0·15
BC158	0·12
BC160	0·63
BC169	0·13
BCY31	0·35
BCY32	0·55
BCY33	0·25
BCY34	0·30
BCY38	0·40
BCY39	1·00
BCY40	0·50
BCY42	0·25
BCY70	0·15
BCY71	0·20
BCZ10	0·35
BCZ11	0·50
BD121	0·65
BD123	0·80
BD124	0·75
BDY11	1·62
BF115	0·25
BF117	0·50
BF167	0·25
BF173	0·25
BF181	0·35
BF184	0·20
BF185	0·20
BF194	0·17
BF195	0·15
BF196	0·15
BF197	0·15
BF861	0·28
BF898	0·28
BFX12	0·20
BFX13	0·25
BFX29	0·25
BFX30	0·25
BFX35	0·98
BFX63	0·50
BFX84	0·25
BFX85	0·30
BFX86	0·25
BFX87	0·25
BFX88	0·20
BFY10	1·00
BFY11	1·25
BFY17	0·25
BYF18	0·25
BFY19	0·25
BFY24	0·45
BFY44	1·00
BFY50	0·22
BFY51	0·20
BFY52	0·22
BFY53	0·17
BFY64	0·42
BFY90	0·65
BSX27	0·50
BSX60	0·98
BSX76	0·15
BSY26	0·18
BSY27	0·17
BSY51	0·50
BSY95A	0·12
BSY95	0·12
BT102/500R	0·75
BTY42	0·92
BTY79/100R	0·75
BTY79/400R	1·25
BY100	0·15
BY126	0·15
BY127	0·17
BY182	0·85
BY213	0·25

Type	£p
BYZ10	0·35
BYZ11	0·32
BYZ12	0·30
BYZ13	0·25
BYZ15	1·00
BYZ16	0·62
BYZ88C3V3	0·15
C111	0·65
CRS1/05	0·25
CRS1/40	0·45
CS4B	2·50
CS10B	3·18
DD000	0·15
DD003	0·15
DD006	0·18
DD007	0·40
DD008	0·38
GD3	0·88
GD4	0·05
GD5	0·88
GD8	0·25
GD12	0·05
GET102	0·80
GET103	0·22
GET113	0·20
GET114	0·15
GET115	0·45
GET116	0·50
GET120	0·25
GET872	0·30
GET875	0·25
GET880	0·37
GET881	0·25
GET882	0·25
GET885	0·25
GEX44	0·08
GEX45/1	0·10
GEX941	0·15
GJ3M	0·25
GJ4M	0·88
GJ5M	0·25
GJ7M	0·37
HG1005	0·50
HS100A	0·20
MAT100	0·25
MAT101	0·30
MAT120	0·25
MAT121	0·30
MJE520	0·87
MJE2955	1·37
MJE3055	0·87
NKT128	0·35
NKT129	0·30
NKT211	0·25
NKT213	0·25
NKT214	0·15
NKT216	0·37
NKT217	0·35
NKT218	1·13
NKT219	0·33
NKT222	0·20
NKT224	0·22
NKT251	0·24
NKT271	0·25
NKT272	0·25
NKT273	0·15
NKT274	0·20
NKT275	0·25
NKT277	0·20
NKT278	0·25
NKT301	0·40
NKT304	0·75
NKT403	0·75
NKT404	0·55
NKT678	0·30
NKT713	0·25
NKT773	0·25
NKT777	0·38
O78B	0·38
OA6	0·12
OA47	0·10
OA70	0·10
OA71	0·10
OA73	0·10
OA74	0·10
OA79	0·10
OA81	0·08
OA85	0·12
OA86	0·15
OA90	0·08
OA91	0·07
OA95	0·07
OA200	0·07
OA202	0·10
OA210	0·25
OA211	0·30
OAZ200	0·55
OAZ201	0·50
OAZ202	0·42
OAZ203	0·42
OAZ204	0·30
OAZ205	0·42
OAZ206	0·42
OAZ207	0·47
OAZ208	0·32
OAZ209	0·32
OAZ210	0·32

Type	£p
OAZ211	0·32
OAZ222	0·45
OAZ223	0·45
OAZ224	0·45
OAZ241	0·22
OAZ242	0·23
OAZ244	0·22
OAZ246	0·23
OAZ290	0·38
OC16	0·50
OC16T	0·38
OC19	0·37
OC20	0·85
OC22	0·50
OC23	0·60
OC24	0·60
OC25	0·37
OC26	0·25
OC28	0·60
OC29	0·60
OC30	0·40
OC35	0·50
OC36	0·60
OC41	0·25
OC42	0·30
OC43	0·40
OC44	0·17
OC44M	0·17
OC45	0·12
OC45M	0·18
OC46	0·27
OC57	0·60
OC58	0·60
OC59	0·65
OC66	0·50
OC70	0·12
OC71	0·12
OC72	0·20
OC73	0·30
OC74	0·30
OC75	0·25
OC76	0·25
OC77	0·40
OC78	0·20
OC79	0·22
OC81	0·20
OC81D	0·20
OC81M	0·20
OC81DM	0·18
OC81Z	0·40
OC82	0·25
OC82D	0·20
OC83	0·25
OC84	0·25
OC114	0·38
OC122	0·60
OC123	0·65
OC139	0·25
OC140	0·35
OC141	0·60
OC169	0·20
OC170	0·25
OC171	0·30
OC200	0·40
OC201	0·70
OC202	0·80
OC203	0·40
OC204	0·40
OC205	0·75
OC206	0·90
OC207	0·90
OC460	0·20
OC470	0·80
OCP71	0·97
ORP12	0·50
ORP60	0·40
ORP61	0·42
S19T	0·30
SAC40	0·25
SFT308	0·38
ST722	0·38
ST7231	0·63
SX68	0·20
SX631	0·30
SX635	0·40
SX640	0·50
SX641	0·55
SX642	0·60
SX644	0·75
SX645	0·75
V15/30P	0·50
V30/201P	0·75
V60/201	0·50
V60/201P	0·75
XA101	0·10
XA102	0·18
XA151	0·15
XA152	0·15
XA161	0·25
XA162	0·25
XB101	0·48
XB102	0·10
XB103	0·25
XB113	0·12
XB121	0·48
ZR24	0·63

Type	£p
Z8170	0·10
Z8271	0·18
ZT21	0·25
ZT43	0·25
ZTX107	0·15
ZTX108	0·12
ZTX300	0·12
ZTX304	0·25
ZTX500	0·16
ZTX503	0·17
ZTX531	0·25
INTEGRATED CIRCUITS	
7400	0·20
7401	0·20
7402	0·20
7403	0·20
7404	0·20
7405	0·20
7406	0·30
7407	0·30
7408	0·20
7409	0·45
7410	0·20
7411	0·23
7412	0·42
7413	0·30
7416	0·30
7417	0·30
7420	0·20
7422	0·48
7423	0·48
7425	0·48
7427	0·42
7428	0·50
7430	0·20
7432	0·42
7433	0·70
7437	0·65
7438	0·65
7440	0·20
7441AN	0·75
7442	0·75
7450	0·20
7451	0·20
7453	0·20
7454	0·20
7460	0·20
7470	0·30
7472	0·30
7473	0·40
7474	0·40
7475	0·55
7476	0·45
7480	0·80
7482	0·87
7483	1·00
7484	0·90
7486	0·45
7490	0·75
7491AN	1·00
7492	0·75
7493	0·75
7494	0·80
7495	0·80
7496	1·00
7497	6·25
74100	2·50
74107	0·50
74110	0·80
74111	1·45
74118	1·00
74119	1·90
74121	0·60
74122	1·35
74123	2·70
74141	1·00
74145	1·50
74150	3·35
74151	1·10
74154	2·00
74155	1·55
74156	1·55
74157	1·80
74170	4·10
74174	2·00
74175	1·35
74176	1·60
74190	1·95
74191	1·95
74192	2·00
74193	2·00
74194	2·50
74195	1·85
74196	1·50
74197	1·50
74198	4·60
74199	4·60
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14 pin DIL	0·15
16 pin DIL	0·17

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(ACTUAL BEECHING UNITS)

MODULES LP1185/86	£9 pair
REGULATOR MFC4060	£0·78 each
DECODER MC1310P	£3·15 each
(100's in stock)	
PRINTED CIRCUIT BOARD—GLASS FIBRE	£1·87 each
READY BUILT AND TESTED BOARDS	£23 each
COMPLETED TUNERS IN TEAK CABINETS	£34 each

(BRUSH ALU. FRONT PANEL with 6 BUTTONS, MAINS + 5 STATIONS)

(ADD 25p POSTAGE TO ABOVE)

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30-14,500 cps. Double cone woofer and tweeter combination. Baker ceramic magnet assembly, flux density 145,000 gauss. BASS RESONANCE 40 cps 20 watt RMS.

MAJOR MODULE KIT £12·50

30-17,000 cps. response. Tweeter, crossover and baffle as illustrated.

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Regent 12 in. 15W	£8·80	Superb 12 in. 20W	£16·50	ALL PRICES INCLUDE V.A.T.
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NSS

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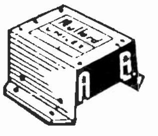
MULLARD AMP



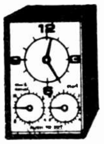
Sensational 'Once in a Life-time Offer' Unrepeatable once stocks are cleared. The amplifier is made by Mullard. Carries maker's Guarantee. In neat case. May be used for Mono or Stereo. Music or speech. Works off dry battery, car batt. or mains power pack. FREE—all who purchase we send copy of Mullard booklet DIY stereo. **£1·60**

DRILL CONTROLLER
NEW IKW MODEL

Electronically changes speed from approximately 10 revs. to maximum. Full power at all speeds by finger-tip control. Kit includes all parts, case, everything and full instructions. **£1·65.** Made up model also available. **£2·48.**

MIGHTY MIDGET

Probably the tiniest possible radio, as described in Practical Wireless, 4 January 73. All electronic parts **£2·20** post paid.



TIME SWITCH

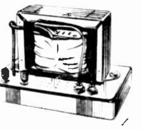
Smith's mains driven clock with 15 amp switch, also notes showing how you can wake up with music playing kettle boiling or come home to a warm house, warn off burglars, keep pets warm, halve your heating bill, etc. **£1·95.**

1 CHIP RADIO

Ferranti's latest device ZN414—gives results better than superhet. Supplied complete with technical notes and circuits. **£1·38** each. 10 for **£11·11.**

HI-Q TUNER COMPONENTS

For experimenting with the ZN414.
KIT NO. 1. Plessey Miniature Tuning Condenser with built in LW switch and 3" ferrit slab and litz wound MW coil, **72p.**
KIT NO. 2. Air spaced tuning condenser 6" ferrite rod litz wound MW and LW coils, **94p**
KIT NO. 3. Air spaced TC with slow motion drive 8" ferrite rod, with litz wound LW and MW coils, **£1·10.**
KIT NO. 4. Permeability tuner with fast and slow motion drive and LW loading coils, **45p.**



12 VOLT 1½ AMP POWER PACK

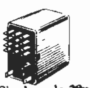
This comprises double-wound 230/240V mains transformer with full wave rectifier and 2000mF smoothing. Price **£2·20,** plus 20p post and packing.

Heavy Duty Mains Power Pack. Output voltage adjustable from 15-40V in steps—maximum load 250W—that is from 6 amp at 40V to 15amp at 15V. This really is a high power heavy duty unit with dozens of workshop uses. Output voltage adjustment is very quick—simply interchange push on leads. Silicon rectifiers and smoothing by 3,000mF. Price **£6·33** plus 65p post.

MICRO SWITCH

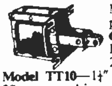
5 amp changeover contacts, **11p** each. 10 for **99p.** 15 amp Model **15p** Changeover **15p** each.

MAINS RELAY BARGAIN



Special this month are some single, double and treble pole changeover relays. Contacts rated at 15 amps. Operating coil wound for 240V A.C. Good British Make. Unused. Size approx. 1¾" × 1". Open construction.
Single pole **28p** each 10 for **£2·48.**
Treble pole **39p** each 10 for **£3·57.**

MAINS OPERATED SOLENOIDS



Model 772—small but powerful 1" pull—approx. size 1¼ × 1¼ × 1¼". **66p.**
Model 400/1—½" pull. Size 2¼" × 2 × 1¾". **83p.**
Model TT10—1½" pull. Size 3 × 2½ × 2". **£1·98** plus 20p post and insurance.

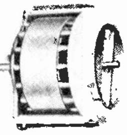
MAINS TRANSISTOR POWER PACK

Designed to operate transistor sets and amplifiers. Adjustable output 6V, 9V, 12 volts for up to 500mA (class B working). Takes the place of any of the following batteries: PP1, PP3, PP4, PP6, PP7, PP9, and others. Kit comprises: mains transformer rectifier, smoothing and load resistor condensers and instructions. Real snip at only **£1·10** plus 20p postage.

DESK TELEPHONES

Ex G.P.O. Black standard model with dialing dial but no internal bell. Supplied with connection diagram **94p** each—post etc. **40p** for single then **65p** per pair. Ditto, with bell but without dialing dial **98p** each plus 40p post for single then **65p** per pair.

PAPST MOTORS



Est. 1/40th h.p. Made for 110–120V working, but two of these work ideally together off our standard 240V mains. A really beautiful motor, extremely quiet running and reversible. **£1·65** each. Postage one 23p, two 33p. 230V model **£3·30.**

10 AMP DIMMER CONTROL

For the control of lighting on stage or in a studio or for control of portable equipment in workshops, etc. This has two 13 amp socket outlets each is controlled by a 5 amp solid state regulator. The overall length is 17in., width 3½in. and depth 1½in. In the end is fitted a master On/Off switch indicator, lamp and fuse. Price **£8·25.**

STANDARD WAFER SWITCHES

Standard size 1¼" wafer—silver-plated 5-amp contact, standard ¼" spindle 2" long—with locking washer and nut.

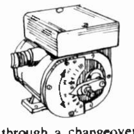
No. of Poles	2 way	3 way	4 way	5 way	6 way	8 way	9 way	10 way	12 way
1 pole	44p	44p	44p	44p	44p	44p	44p	44p	44p
2 poles	44p	44p	44p	44p	44p	44p	44p	77p	77p
3 poles	44p	44p	44p	44p	77p	77p	77p	£1·04	£1·04
4 poles	44p	44p	44p	77p	77p	77p	77p	£1·32	£1·32
5 poles	44p	44p	77p	77p	£1·04	£1·04	£1·04	£1·60	£1·60
6 poles	44p	77p	77p	77p	£1·04	£1·04	£1·04	£1·87	£1·87
7 poles	77p	77p	77p	£1·04	£1·32	£1·32	£1·32	£2·15	£2·15
8 poles	77p	77p	77p	£1·04	£1·32	£1·32	£1·32	£2·42	£2·42
9 poles	77p	77p	£1·04	£1·04	£1·60	£1·60	£1·60	£2·70	£2·70
10 poles	77p	77p	£1·04	£1·32	£1·60	£1·60	£1·70	£3·00	£3·00
11 poles	77p	£1·04	£1·04	£1·32	£1·87	£1·87	£1·87	£3·25	£3·25
12 poles	77p	£1·04	£1·04	£1·32	£1·87	£1·87	£1·87	£3·52	£3·52

CAPACITOR DISCHARGE CAR IGNITION

This system which has proved to be amazingly efficient and reliable was first described in the *Wireless World* about a year ago. We can supply kit of parts for an improved and even more efficient version (*Practical Wireless*, June). Price **£6·55** plus 20p post. When ordering please state whether for positive or negative systems. De-luxe model including printed circuit board, etc. **£7·95.**

MULLARD UNILEX

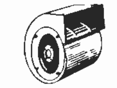
This D.I.Y. Stereo Amplifier is still available complete at **£7·00** for the four Mullard Modules, or Modules can be bought separately as follows:—4 watt amplifier module (2 required) Mullard Ref. No. E.P. 9000—**£1·60.**
Pre amp module Mullard Ref. No. E.P. 9001—**£1·98** each.
Power Module—Mullard Ref. No. E.P. 9002—**£2·53** each.
In addition and made to Mullard specification we offer:—
Standard Control Unit with escutcheon and knobs—**£3·30.**
Knobs—Set of 4—**50p.**
Special offer the complete Unilex with control panel at Pre VAT price—**£10·00** post paid.



ZPM MODULATION MOTOR

Could also be used to open ventilators, doors, valve, damper, etc. particularly suitable for remote control. Made by Satchwell. Essentially a reversible geared motor fitted with internal limit switches to stop it at the end of its travel. Size approx. 6in. × 6in. × 5½in. and weighing approx. 10 lb This is extremely powerful and would lift a heavy door or open a long line of ventilators. To operate this motor you put the 50 cycle supply through a changeover switch. For instance a thermostat with changeover contacts could automatically regulate the temperature in a growing house, chicken hatchery, etc. An indicator on the motor graduated 0–10 shows the state of open or close. Also internally fitted is a variable resistor, wires from this to a volt meter would give a remote indication of the open or close position. A very expensive motor if both direct from Satchwell, our price complete with step down Transformer is **£16·50.**

CENTRIFUGAL FAN



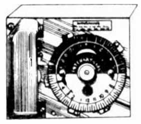
Mains operated, turbo blower type. Pressed steel housing contains motor and impeller. Motor is 1/10th h.p. giving considerable air flow but virtually no noise. Approx. dimensions 10½in. wide × 12in. dia. outlet into trunking 10½ × 4½in. **£6·55** plus £1 post and insurance.

THIS MONTH'S SNIP

TAPE PLAYBACK UNITS

Mains operated. Made by Reditune the famous "music in background people". These are complete units ready to work and we understand that they are in good going order. We have not tested them but would exchange any that do not work properly. These have a superior motor driven fly wheel to control the tape through the capstan and also an even equally useful valve amplifier with EL84 output. In a steel case with carrying handle. Two models offered, good as new **£6·50** and somewhat used at **£3·50.** 75p carriage up to 200 miles then 50p per 100 miles extra.
3-hour cassettes, already recorded light music £1·10 each extra

24-HOUR TIME SWITCH



Made by Smiths, these are A.C. mains operated, NOT CLOCKWORK. Ideal for mounting on rack or shelf or can be built into box with 13A socket. Two completely adjustable time periods per 24 hours, 5A changeover contacts will switch circuit on or off during these periods. **£2·75** post and ins. 25p. Additional time contacts **55p** pair.

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EP9001 twin channel or stereo pre amp. **£1·99.**
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NEW ITEMS THIS MONTH

MINI SEALED RELAY

American made. Our Ref: REL A1. Measures only 3" wide × ½" thick and ¾" high and it's a double change-over, we don't know the contact rating but estimate this at 3/5 amps. The coil resistance is 600 ohms and 9–12 volt will close it. Ideal for models and miniaturised equipment. It's a plug in relay but we supply complete with base. Price **28p** including base.

SUB-MINIATURE MICROSWITCH

Made by Burgess, their Ref V476—our Ref MS.A1. These measure only ¾" × ¾" × ¼" thick—have change-over contacts and tag connection. Price **16p** each or 10 for **£1·44.**

3-CORE MAINS FLEX

Metric size. 5mm which is approx. equivalent to the old 14/36 rating. Suitable therefore for mower or similar portable tools. Cores are colour coded to the new European standard. Brown—live . . . Blue—neutral . . . Yellow/Green—earth. Grey P.V.C. covered overall. 100mm coils **£5,** 50m coils **£3** and 25m coils **£1·75.** Post 40p on 100m. **25p** for 50m coils and **20p** for 25m coils.

PANIC SWITCHES

Tough enough to be foot switches and elegant enough to be panel switches. Bakelite construction with white push rod. Price **40p** less quantity discounts. Switch is rated 250V—2 amp.

20 WATT CAMPING LIGHT

Also makes good car emergency light. This uses a standard 2 foot 20 watt tube and operates from a 12V car battery drawing approx. 1A. This gives illumination per amp/hour of battery life far in excess to filament lamps and in fact to the miniature 8–13 watt camping lights often offered. Complete unit ready to operate, in strong white enamelled metal frame. These would normally sell at £6 are unused but slightly soiled and we offer these at **£3·50** plus 40p post and packing.

6 MAINS TRANSFORMERS

Our Ref: MTM1 27 volt at 8 amp. Upright mounting fully shrouded—flying leads—fully tapped primary. Price **£3·30.**
Our Ref: MTM2 12V at 1 amp. Upright mounting with fixing lugs, tag connection. 240V primary—12V 1 amp secondary Price **82p.**
Our Ref: MTM3 6·3V 2 amp upright mounting with fixing lugs, tag connections. 240V primary 6·3V 2 amp secondary. Price **77p.**
Our Ref: MTM4 18V—½ amp with thermal cut-out, upright mounting with fixing lugs—tag connections. Primary 240V—secondary 18V at ½ amp. Price **88p.**
Mains Isolation MTM5 350 watts earth shielded—flex leads—upright mounting lugs for fixing. Price **£4·40** each.

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Our Ref: REL M1. Removable clear plastic enclosed two screw fixing. Have a 6 volt D.C. operated coil but two changeover contacts, each rated to make and break 240V A.C. at 15 amps. Price **66p** each

P.O. TYPE 3000 RELAY

Our Ref: REL M2—100 ohms coil and 2 pair normally open heavy duty contacts. Price **75p** each.

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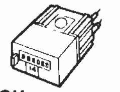
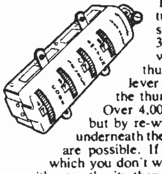
6 DIGIT COUNTER



Resettable. 440 ohm coil up to 25 impulses per second. Ex-equipment but guaranteed perfect. **£2·20** each.

COMBINATION SWITCH



This comprises of 12 miniature changeover micro switches. Joined in banks of 3 and mounted on frame with four digital numbered thumb wheels and a removable lever for locking the thumb wheel-the thumb wheel operates 3 banks. Over 4,000 combinations are possible but by re-wiring the switch connections underneath then thousands more variations are possible. If you are making equipment which you don't want switched on accidentally or without authority then this is a switch to consider—this can also be used as a coding switch for many other operations. Very neat and compact and measuring approx. 4" × 1½" × 1½" deep. Priced at **£3·03.**

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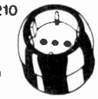

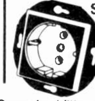

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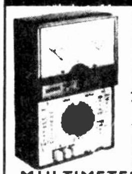

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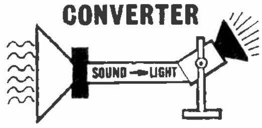

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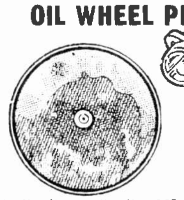

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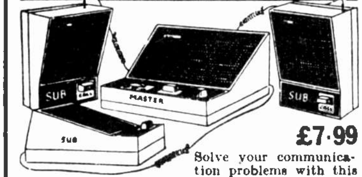

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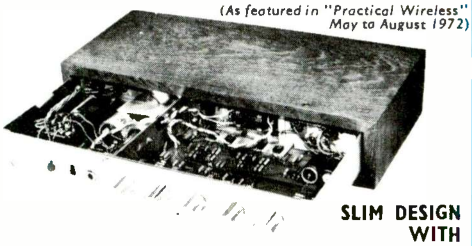

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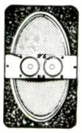

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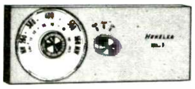

Uses Mullard Module. Slow motion tuning. Built-in battery. Ferrite aerial. Overall size 7in x 2¾in x 3¼in. TOTAL COST TO BUILD **£4·85.** Post 15p. All parts sold separately—Leaflet No. 6.

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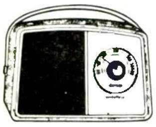

Printed circuit all transistor design using Mullard RF/IF Module. Medium and Long Wave bands plus Medium Wave Bandspread for extra selectivity. 600mW push-pull output, fibre glass PVC covered cabinet, car aerial. Attractive appearance and performance. TOTAL COST TO BUILD **£7·98,** p.p. 32p (Batt. 22p).

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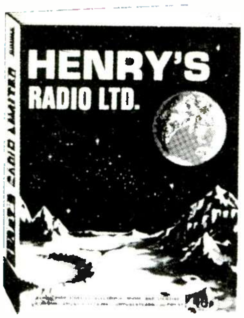

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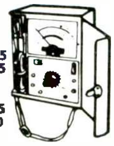

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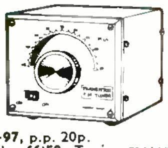

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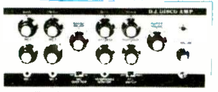

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