PRACTICAL ELECTRONICS

SEPTEMBER 1971

20p

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POWER CONTROLLER

Also inside...

TIMER with DIGITAL READOUT

IMPORTANT. THIS LATEST 1971 MODEL INCORPORATES ALL THE LATEST TECHNOLOGICAL IMPROVEMENTS AND SUPERSEDES ALL EARLIER MODELS! YES, THIS SENSATIONAL BRAND NEW VEF 204 RUSSIAN 8 WAVEBAND PORTABLE RADIO, DESIGNED FOR WORLD WIDE RECEPTION, will probably make your present radio seem like a "crystal set"! It's far better than any other 8 wave radio that even they have produced before! **It even incorporates a special MARINE WAVEBAND to receive spoken communications from ship-to-shore!** Complete with optional battery eliminator for **both** battery and mains use! **It represents the finest value we have ever offered!** We're almost **giving** them away at only **£13·97—a mere fraction of even today's Russian miracle price!** In fact we challenge you to compare the performance and value with that of £42·00 radios! *You just can't lose, we'll refund your money instantly if you are not astounded! **Purer and sweeter tone than ever! Much wider band spread than hitherto, for absolutely "pin-point" station selection!** Yes, the Russians have **really surpassed themselves this time,** proving once again their fantastic ability in the field of electronics and brilliantly reflecting their advanced micro-circuitry techniques in the field of spaceship and satellite communications. YOU GET THIS AMAZING SET FROM US AT A PRICE THAT BEARS NO RELATION TO ITS TRUE VALUE! **Yes, 8 separate wavebands, including Standard Long, Medium and Short Waves to cover the world. PLUS special "ship-to-shore" MARINE BAND! Unique side control waveband selection unit gives incredible ease of station tuning! Thousands of different transmissions, and stations at your fingertips 24 hours a day,** including ships at sea, etc. and messages from all over the world—**truly nothing is secret! The radio enthusiast can have the world** in the palm of his hand! You **must** hear it to believe it! **Superb, sweet tone**—controlled from a whisper to a roar that will fill a hall! Genuine push-pull output! Separate ON/OFF volume and Treble/Bass tone controls! **Press-button dial illumination! Take it anywhere**—runs economically on standard batteries (obtainable everywhere) or direct through battery eliminator from 220/240v AC mains supply. Internal ferrite rod aerial plus built-in telescopic aerial extending to full 31in. length. **It's also a fabulous CAR RADIO—any speed, requires no additional aerial, UNIQUE!** Elegant Black and Chrome finish case. **SIZE 11ins. × 9ins. × 3¼ins.** overall approx. Magnificently designed and superbly made to give **years of perfect service.** Complete with WRITTEN GUARANTEE, manual with simple operating instructions and circuit diagram. **ONLY £13·97** (with mains/battery eliminator £1·38 extra). **BOX, POST, ETC., 50p. Standard batteries 38p extra. Can also be used through extension amplifier, tape recorder or public address system.** Send today or call at either store, but HURRY! It's the chance of a lifetime. (Sorry—we cannot change these new radios for any earlier model already purchased.) **Send quickly or call. Refund guaranteed.**

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WORLD WIDE RECEPTION

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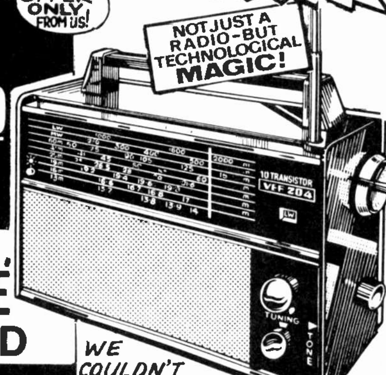
VEF 204

8 WAVEBAND

10 TRANSISTOR PLUS 2 DIODES PORTABLE RADIO



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1,000pF, 1,200pF, 1,500pF, 1,800pF, 2,200pF, **15p** per dozen (all 400V working). 0·15μF, 0·22μF, 0·27μF, **30p** per dozen (all 160V working). 25% discount for lots of 100 of any one type.

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Gross weight 2 lb. .. .. **£1** (postage 20p)
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An aerosol spray providing a convenient means of producing any number of copies of a printed circuit both simply and quickly.
Method: Spray copper laminate board with light sensitive spray. Cover with transparent film upon which circuit has been drawn. Expose to light. (No need to use ultra-violet.) Spray with developer, rinse and etch in normal manner.

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Developer spray **50p**

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No Plug	6	**50p**
2·5mm Plug	4	**50p**
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500 MICRO-AMP LEVEL METERS	1	**50p**

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IN4007 Rectifiers (1200V peak)	4	**50p**
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Stranded ditto	50yd	**50p**
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Large Selenium	2	**50p**
Small	3	**50p**
(6 cells will power a Micromatic radio)		
CRYSTAL TAPE RECORDER MIKES	1	**50p**
CRYSTAL EARPIECES 3·5mm Plug	2	**50p**
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Garrard SP25 Mk.III
Goldring G800H

Teak plinth and tinted cover. Ready wired for immediate use.

£19·50

Please add £1·15 for post and packing

TURNTABLES

Please add 50p for post and packing

*Garrard SP25 Mk. III	£10·75
*Garrard 2025TC with stereo cart.	£8·00
*Garrard 2025TC with Sonotone 9TAHC	£8·95
*Garrard 3000 with Sonotone 9TAHC	£10·25
*Garrard SL65B	£13·25
*Garrard AP76	£18·75
*Garrard SL72B	£24·00
*Garrard SL75B	£26·00
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*B.S.R. MP60	£11·50
Pioneer PL12AC	£39·00
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Goldring GL69/2	£21·50
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* *Items marked can be mounted in plinth and cover, ready wired for £4·50 extra plus 25p for post and packing*

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Please add 50p for post and packing

Armstrong	521 (cased)	£41·95
Amstrad	8000	£17·70
Europhon	10 + 10	£14·50
Leak	30 Chassis	£42·95
Leak	70 Chassis	£51·50
Leak	30 Cased	£49·00
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Metrosound	ST20	£25·25
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Pioneer	SA500	£41·50
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Rogers Ravensbrook Chassis		£36·00
Rogers Ravensbrook Cased		£41·00
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Sinclair	2000 Mk. I	£21·00
Sinclair	2000 Mk. II	£24·50
Sinclair	3000	£32·50
Sinclair	PRO60/2 × Z30/PZ5	£16·00
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Teleton	SAQ206	£18·00

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Armstrong 523 AM/FM	£41·00
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Dulci FMT7	£20·00
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Teleton GT101 MPLX	£31·50
Rogers Ravensbourne FET 2 Chassis	£47·00
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PICK-UP ARMS

Please add 35p for post and packing

SME 3009/S2	£26·00
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Please add 75p for post and packing

Armstrong 525 FM	£70·75
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Teleton CR10T with speakers	£28·25
Teleton F2300 (new product)	£39·75
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Wharfedale 100–1	£114·00

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Please add £1·25 for post and packing

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Wharfedale	Denton	£31·25
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Wharfedale	Triton	£45·75
Wharfedale	S/Linton	£40·75
Keletron	KN500	£16·50
Keletron	KN700	£19·50
Keletron	KN123/3	£31·50
Keletron	KN1000	£27·50
Keletron	KN1500	£37·00
Keletron	KN2000	£41·50
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Celestion	Ditton 10	£67·50
Ste-Ma	400	£34·00
Ste-Ma	300	£48·50
Hi-Fi 4		£78·00
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Please add 10p for post and packing

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Goldring	G800H	£5·75
Goldring	G800	£6·95
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Sonotone	9TAHC Diamond	£1·75
Shure	M3DM	£4·95
Shure	M445/7/C	£7·20
Shure	M55	£9·20
Shure	M75E	£14·50
Shure	V15 Type 2	£29·00
Shure	M44E	£8·25
Shure	M31E	£8·75
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Audio-Technica	AT66	£4·95
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SMC	101	£3·15
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Teleton TCR130	£28·75

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Send a stamped addressed envelope for a GUARANTEEO DISCOUNT PRICE.

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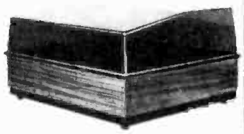
(as illustrated)



£3·25 plus 35p post and packing

Finished in real teak veneer with tinted dustcover. Ready to use (fully assembled). Suitable for Garrard SP25, 2025TC, 3000, AT60, 2000, 2500, 3500, 5100, 1025, SL65B.

Also for B.S.R. McDONALD MP60 and others

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Also finished in walnut to match Japanese equipment—no extra charge.

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Made by world famous European manufacturer

COMPLETE HI-FI STEREO SYSTEM

VHF/MEDIUM/LONG WAVE Tuner Amplifier
4 watt per channel, separate tone and balance controls. Two neat speakers with wooden slatted front. Single play deck in plinth and cover. Finished in teak. Fully guaranteed 12 months. On constant demonstration.

£38·50
plus £1·25 carriage

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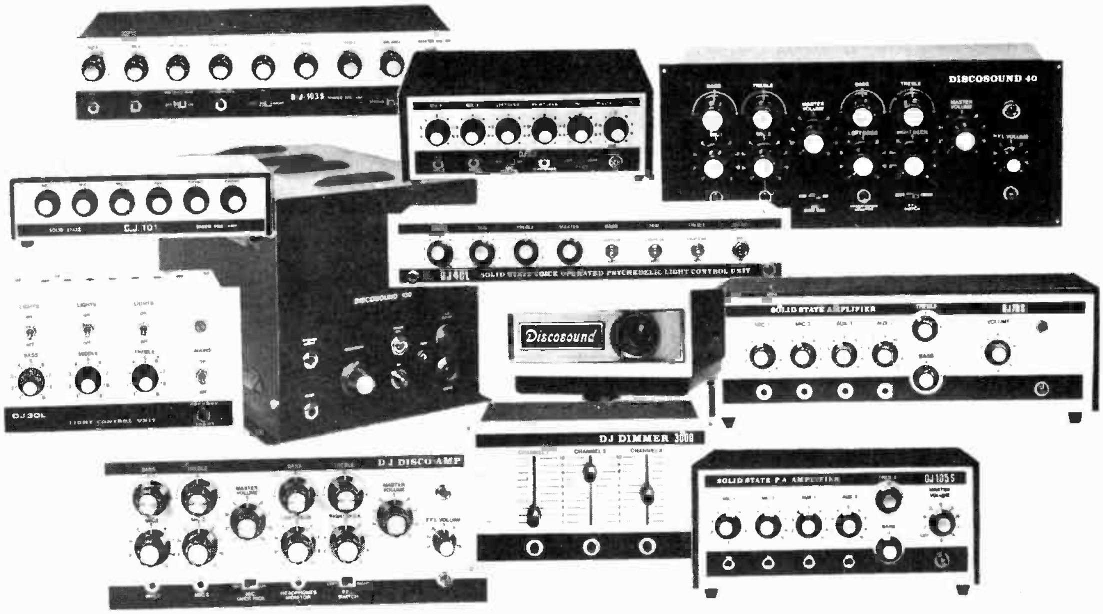
—A COMPREHENSIVE RANGE COVERING EVERY REQUIREMENT

AMPLIFIERS, MIXERS, LIGHT CONTROL UNITS.



D.J.101 Mixer Pre-Amplifier

Six inputs allow full mixing facilities for all types of equipment. 9V battery operation. Size: 10⅝in × 2⅝in × 4⅝in.
Suggested Retail Price £14

D.J.102 Discotheque Mixer Pre-Amplifier

Four inputs each with its own volume control plus master volume control, PFL monitoring and mic. override switches. Size: 10½in × 4in × 4in.
Suggested Retail Price £25

D.J.105S P.A. Amplifier

4-channel mixing facilities each with separate inputs and volume controls. 30W r.m.s. power output: a.c. mains 200/250V a.c. Size: 11¾in × 5in × 6in.
Suggested Retail Price £41

D.J.70S Integrated Mixer Amplifier

Power output 70W r.m.s. 4-channel mixer with separate inputs and volume controls, plus master volume and separate bass and treble controls. Size: 15½in × 5in × 6in.
Suggested Retail Price £63

D.J. Disco-Amp.

Designed specifically for use with discotheques. Power output 100W r.m.s. Two mic. inputs and two gram inputs, with independent volume controls plus bass and treble controls. Incorporates many exclusive features. Front panel size: 16½in × 7in.
Suggested Retail Price £85

Discosound 40 Discotheque Pre-Amplifier

Features independent inputs and volume controls for two microphones and two turntables plus separate bass, treble and master volume controls. Self-powered and ideal for use with Discosound 100 Power Amplifier (is capable of running 10 of these power amplifiers—total 1,000W). Front panel size: 16½in × 7in.
Suggested Retail Price £40

Discosound 100 Power Amplifier

100W r.m.s. power amplifier (at 8 ohms) utilising all silicon transistors and features full automatic overload against short or open circuits. Frequency response 20–20,000Hz ±3dB. Distortion less than 1% at 70W r.m.s. ±1dB. Size: 10½in × 8in × 7in.
Suggested Retail Price £49·50

D.J.103S Stereo Pre-Amplifier

A high quality stereo discotheque pre-amp unit. Incorporating two microphone and two turntable inputs each with independent volume control, plus bass, treble, balance and master volume control. Offers full mixing and monitoring facilities. Front panel size: 16½in × 3½in.
Suggested Retail Price £49·50

D.J.30L Psychedelic Light Control Unit

3-channel light unit enabling bass, middle and treble frequencies from the amplifier to be operated individually. Handles 1,000W per channel. Front panel size: 10in × 6in.
Suggested Retail Price £37·50

D.J.40L Sound Operated 3-channel light unit

Features built-in microphone which eliminates the need for connections to any amplifier or sound source. Handles 1,000W per channel. Front panel size: 16½in × 3in.
Suggested Retail Price £56·25

D.J. DIMMER 3000

3-channel light dimmer unit offered in two versions: Dimmer 3000—a straight 3-channel dimmer unit with mains input and three light outputs. Dimmer 3000S—for use in conjunction with D.J.30L Light Control unit only and has three mains inputs and three light outputs. Front Panel size: 10in × 6in.
Suggested Retail Price £32·50

Discosound Disco-Wheel

A projector designed to project a range of liquid wheels and colour change wheels for special lighting effects, adding colour and variety to any form of entertainment. Size: 7½in × 10½in × 5½in.
Suggested Retail Price £50

A range of complete Discotheques with matching Speakers also available.

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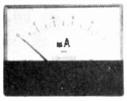
● LOW COST ● QUICK DELIVERY ● OVER 200 RANGES IN STOCK ● OTHER RANGES TO ORDER

NEW "SEW" DESIGNS!

CLEAR PLASTIC METERS

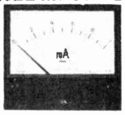
TYPE SW. 100
100 x 80 mm



50μA	£3·47½	500μA	£3·12½
50-0-50μA	£3·37½	1mA	£2·97½
100μA	£3·37½	20V d.c.	£2·97½
100-0-100μA	£3·25	50V d.c.	£2·97½
		300V d.c.	£2·97½
		1A d.c.	£2·97½
		5A d.c.	£2·97½
		300V a.c.	£2·97½
		VU Meter	£3·75

BAKELITE PANEL METERS

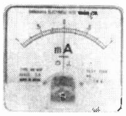
TYPE S-80
80 mm square fronts



50μA	£3·12½	1A d.c.	£2·47½
50-0-50μA	£2·97½	5A d.c.	£2·47½
100μA	£2·97½	300V a.c.	£2·62½
100-0-100μA	£2·87½	VU Meter	£3·37½
500μA	£2·62½		
1mA	£2·47½		
20V d.c.	£2·47½		
50V d.c.	£2·47½		
300V d.c.	£2·47½		

"SEW" CLEAR PLASTIC METERS

Type MR.85P. 4¼in · 4¼in fronts.



50μA	£3·60	50mA	£2·60
50-0-50μA	£3·10	100mA	£2·60
100μA	£3·10	500mA	£2·60
100-0-100μA	£3·10	1A	£2·60
200μA	£2·87½	5A	£2·60
500μA	£2·75	15A	£2·60
500-0-500μA	£2·60	30A	£2·60
1mA	£2·60	20V d.c.	£2·60
1-0-1mA	£2·60	50V d.c.	£2·60
5mA	£2·60	150V d.c.	£2·60
10mA	£2·60	300V d.c.	£2·60
		15V a.c.	£2·60
		300V a.c.	£2·60
		S Meter 1mA	£2·87½
		VU Meter	£3·60
		1A a.c.*	£2·60
		5A a.c.*	£2·60
		10A a.c.*	£2·60
		20A a.c.*	£2·60
		30A a.c.*	£2·60

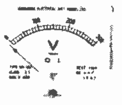
Type MR.52P. 2½in square fronts.

50μA	£3·10	20V d.c.	£2·00
50-0-50μA	£2·60	50V d.c.	£2·00
100μA	£2·60	300V d.c.	£2·00
100-0-100μA	£2·37½	15V a.c.	£2·00
500μA	£2·25	300V a.c.	£2·00
1mA	£2·00	S Meter	
5mA	£2·00	1mA	£2·10
10mA	£2·00	VU Meter	£3·10
50mA	£2·00	1A a.c.*	£2·00
100mA	£2·00	5A a.c.*	£2·00
500mA	£2·00	10A a.c.*	£2·00
1A	£2·00	20A a.c.*	£2·00
5A	£2·00	30A a.c.*	£2·00
10V d.c.	£2·00		

Type MR.65P. 3½in 3¼in fronts.

50μA	£3·37½	20V d.c.	£2·10
50-0-50μA	£2·75	50V d.c.	£2·10
100μA	£2·75	150V d.c.	£2·10
100-0-100μA	£2·60	300V d.c.	£2·10
200μA	£2·60	15V a.c.	£2·10
500μA	£2·37½	50V a.c.	£2·10
500-0-500μA	£2·10	150V a.c.	£2·10
1mA	£2·10	300V a.c.	£2·10
5mA	£2·10	500V a.c.	£2·10
10mA	£2·10	S Meter	
50mA	£2·10	1mA	£2·37½
100mA	£2·10	VU meter	£3·37½
500mA	£2·10	50mA a.c.*	£2·10
1A	£2·10	100mA a.c.*	£2·10
5A	£2·10	200mA a.c.*	£2·10
10A	£2·10	500mA a.c.*	£2·10
15A	£2·10	1A a.c.*	£2·10
20A	£2·10	5A a.c.*	£2·10
30A	£2·10	10A a.c.*	£2·10
50A	£2·37½	20A a.c.*	£2·10
5V d.c.	£2·10	30A a.c.*	£2·10
10V d.c.	£2·10		

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



50μA	£2·00	150mA	£1·37½
50-0-50μA	£1·87½	200mA	£1·37½
100μA	£1·87½	300mA	£1·37½
100-0-100μA	£1·75	500mA	£1·37½
200μA	£1·75	750mA	£1·37½
500μA	£1·50	1A	£1·37½
500-0-500μA	£1·37½	2A	£1·37½
1mA	£1·37½	5A	£1·37½
1-0-1mA	£1·37½	10A	£1·37½
2mA	£1·37½	3V d.c.	£1·37½
5mA	£1·37½	10V d.c.	£1·37½
10mA	£1·37½	15V d.c.	£1·37½
20mA	£1·37½	20V d.c.	£1·37½
50mA	£1·37½	100V d.c.	£1·37½
100mA	£1·37½	150V d.c.	£1·37½
		300V d.c.	£1·37½
		500V d.c.	£1·37½
		750V d.c.	£1·37½
		15V a.c.	£1·37½
		50V a.c.	£1·37½
		150V a.c.	£1·37½
		300V a.c.	£1·37½
		500V a.c.	£1·37½
		S Meter 1mA	£1·60
		VU meter	£2·10

Type MR.45P. 2in square fronts.

50μA	£2·25	10V d.c.	£1·50
50-0-50μA	£2·10	20V d.c.	£1·50
100μA	£2·10	50V d.c.	£1·50
100-0-100μA	£1·87½	300V d.c.	£1·50
200μA	£1·87½	15V a.c.	£1·50
500μA	£1·60	300V a.c.	£1·50
500-0-500μA	£1·50	S Meter	
1mA	£1·50	1mA	£1·87½
5mA	£1·50	VU Meter	£2·25
10mA	£1·50	1A a.c.*	£1·50
50mA	£1·50	5A a.c.*	£1·50
100mA	£1·50	10A a.c.*	£1·50
500mA	£1·50	20A a.c.*	£1·50
1A	£1·50	30A a.c.*	£1·50
5A	£1·50		

"SEW" BAKELITE PANEL METERS

Type MR.65 3½in square fronts.

25μA	£3·50	500mA	£1·75
50μA	£2·37½	1A	£1·75
50-0-50μA	£2·25	5A	£1·75
100μA	£2·25	15A	£1·75
100-0-100μA	£2·25	30A	£1·75
500μA	£2·10	50A	£1·75
1mA	£1·75	5V d.c.	£1·75
1-0-1mA	£1·75	10V d.c.	£1·75
5mA	£1·75	20V d.c.	£1·75
10mA	£1·75	50V d.c.	£1·75
50mA	£1·75	150V d.c.	£1·75
100mA	£1·75	300V d.c.	£1·75
		30V a.c.*	£1·75
		50V a.c.*	£1·75
		150V a.c.*	£1·75
		300V a.c.*	£1·75
		500mA a.c.*	£1·75
		1A a.c.*	£1·75
		5A a.c.*	£1·75
		10A a.c.*	£1·75
		20A a.c.*	£1·75
		30A a.c.*	£1·75
		50A a.c.*	£1·75
		VU meter	£3·10

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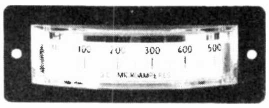
50μA	£4·50	20V d.c.	£3·97
100μA	£4·25	50V d.c.	£3·97
1mA	£3·97	300V d.c.	£3·97
50-0-50μA	£4·25	Dual range	
1-0-1mA	£3·97	500mA/5A d.c.	£4·25
1A d.c.	£3·97	5V/50V d.c.	£4·25
5A d.c.	£3·97		
10V d.c.	£3·97		

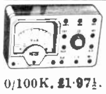
EDGWISE METERS



PE.70 3 17/32in 1 15/32in 2¼in deep.

50μA	£3·00	500μA	£2·60
50-0-50μA	£2·87½	1mA	£2·37½
100μA	£2·87½	300V a.c.	£2·37½
100-0-100μA	£2·75	VU meter	£3·25
200μA	£2·75		

MULTIMETERS for EVERY purpose!



TECH PT-34. 1,000 O.P.V. 0/10/50/250/500/1,000V a.c. and d.c. 0/1/100/500mA. d.c. 0/100K. **£1·97½**. P. & P. 12½p.

MODEL TE-200. 20,000 O.P.V. Mirror scale, overload protection. 0/5/25/125/1,000V d.c. 0/10/50/250/1,000V a.c. 0/50μA/250MA. 0/60K/6 meg. −20 to +62dB. **£3·75.** P. & P. 15p.

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MODEL PL436. 20k Ω/Volt d.c. 8k Ω/Volt a.c. Mirror scale. 0·6/3/12/30/120/600V d.c. 3/30/120/600V a.c. 50/600μA/60/600mA. 1 0/100K/1 Meg/10 meg Ω. −20 to +46dB. **£6·97½**. P. & P. 12½p.

MODEL 500. 30,000 O.P.V. with overload protection, mirror scale 0/·5/2·5/10/25/100/250/500/1,000 V d.c. 0/2·5/10/25/100/250/500/1,000 V. a.c. 0/50 μA/5/50/500 mA. 12 amp. d.c. 0/60K/6 Meg./60 Meg Ω. **£8·87½**. Post paid.

TMK MODEL TW-20CB. Features Resettable Overload Button. Sensitivity: 20K Ω/Volt d.c. 5K Ω/Volt a.c. D.c. volts: 0–0·5, 2·5, 10, 50, 250, 1,000V. A.c. volts: 0–2·5, 10, 50, 250, 1,000V. D.c. currents: 0–0·05, 0·5, 5, 50, 500mA. Resistance: 0–5K, 50K, 0–500K, 5 meg. Decibels: −20 to +52dB. **£11·50.** P. & P. 17½p.

TMK LAB TESTER. 100,000 O.P.V. 6½in scale buzzer short circuit check. Sensitivity: 100,000 OPV d.c. 5/Volt a.c. D.c. volts: 0·5, 2·5, 10, 50, 250, 1,000V. A.c. volts: 3, 10, 50, 250, 500, 1,000V. D.c. current: 10, 100μA, 10, 100, 500mA, 2·5, 10A. Resistance: 1K, 10K, 100K, 10 meg, 100 meg. Decibels: −10 to +49dB. Plastic case with carrying handle, size 7½in × 6½in × 3½in. **£18·90.** P. & P. 25p.

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10 meg. input 10 ranges: ·01 / ·003 / ·1 / ·3 / 1 / 3 / 10 / 30 / 100 / 300V. R.M.S. 4c/s.-1·2Mc/s. Decibels −40 to +50dB. Supplied brand new complete with leads and instructions. Operation 230V a.c. **£17·50.** Carr. 25p.

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High quality instrument with 28 ranges. D.c. volts 1·5–1,500V. A.c. volts 1·5–1,500V. Resistance up to 1,000 megohms. 220/240V a.c. operation. Complete with probe and instructions. **£17·50.** P. & P. 30p. Additional Probes available: R.F. **£2·12½**. H.V. **£2·50.**

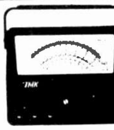
HONOR TE.10A. 20k Ω/Volt 5/25/50/250/500/2,500V d.c. 10/50/100/500/1,000V a.c. 0/50μA/2·5mA 250mA d.c. 0/6K/6 meg. ohm. −20 to +22dB. 10–0, 100 mfd. 0-100-0·1 mfd. **£3·47½**. P. & P. 15p.

MODEL TE-300. 30,000 O.P.V. Mirror scale, overload protection 0/0·6/3/15/60/300/1,200V d.c. 0/6/30/120/600/1,200V a.c. 0/30μA / 6mA / 60mA / 300mA/600mA. 0/8K/80K/800K/8 meg. −20 to +63dB. **£5·97½**. P. & P. 15p.

TMK MODEL MD.120. Mirror scale. 20k Ω/volt d.c., 10k Ω/volt a.c. 30/60/300/600/3,000V d.c. 6/120/1,200V a.c. Current 0–60μA/0–12/0–300mA. 0–60k Ω/0–6M Ω −20 to +63dB. **£4·62½**. P. & P. 15p.

MODEL TE-90. 50,000 O.P.V. Mirror scale, overload protection. 003/13/60/300/600/1,200V d.c. 0/6/30/120/300/1,200V d.c. 0·03/6/60/600mA. d.c. 16K/160K/1·6/16 meg. −20 to +63dB. **£7·50.** P. & P. 15p.

SKYWOOD SW-500



50 K Ω/Volt. Mirror scale DC Volts 0.6/3/12/30/300/600. AC Volts 3/30/300/600. DC Current 20uA/6/60/600mA. Resistance 10K/100 K/1Meg/10 Meg. Decibels −20 to +57dB. **£7·50.** P. & P. 15p.

MODEL AS-100D. 100K Ω/Volt. 5in, mirror scale. Built-in meter protection 0/3/12/60/120/300/600/1,200V d.c. 0/6/30/120/300/600V a.c. 0/10μA/6/60/300mA/12A. 0/2K/200K/2M/200M. −20 to +17dB. **£12·50.** P. & P. 17½p.

TE-900 20,000 Ω/VOLT GIANT MULTIMETER. Mirror scale and overload protection. 6in full view meter. 2 colour scale. 0/2·5 / 10 / 250 / 1,000 / 5,000V a.c. 0/25/12·5/10/50/250/1,000/5,000V d.c. 0/50μA/110/100/500mA/10A d.c. 02K/200K/20 meg. ohm. **£15.** P. & P. 25p.

FTC-401 TRANSISTOR TESTER

Full capabilities for measuring A, B and ICO, *npn* or *pnp*. Equally adaptable for checking diodes. Supplied complete with instructions, battery and leads. **£6·97½**. P. & P. 15p.

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Can be panel or bench mounted. Basic meter measures 1 volt d.c. but can be used to measure a wide range of a.c. and d.c. volt, current and ohms with optional plug-in cards.
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Accuracy: ± 0·2, ± 1 digit.
Resolution: 1mV.
No. of digits: 3 plus fourth overrange digit.
Overrange: 100% (up to 1·999)
Input impedance: 1000 Meg ohm.
Measuring cycle: 1 per second.
Adjustment: Automatic zeroing, full scale adjustment against an internal reference voltage.
Overload: to 100V d.c.
Input: Fully floating (3 poles).
Input power: 110-230V a.c. 50/60 cycles.
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2N708	15p
2N709	45p
2N718	25p
2N718A	30p
2N726	25p
2N727	25p
2N914	17p
2N916	17p
2N918	30p
2N929	22p
2N930	24p
2N937	52p
2N1090	22p
2N1091	22p
2N1131	25p
2N1132	25p
2N1302	17p
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2N1637	30p
2N1638	27p
2N1639	27p
2N1701	110p
2N1711	24p
2N1889	32p
2N1893	37p
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2N2926O	12p
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2N3394	15p
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2N5249	67p
2N5265	325p
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2N5310	42p
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2N5356	32p
2N5365	47p
2N5366	32p
2N5367	57p
2N5457	34p
2N5458	35p
2N5459	48p
2S102	25p
2S103	25p
2S104	25p
2S301	47p
2S302	47p
2S303	57p
2S304	72p
2S501	32p
2S502	35p
2S503	27p
3N83	40p
3N128	70p
3N140	77p
3N141	72p
3N142	55p
3N143	67p
3N152	87p
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40251	82p
40309	32p
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40314	37p
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40320	47p
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40347	57p
40348	52p
40360	42p
40361	47p
40362	55p
40370	32p
40406	57p
40407	40p
40408	52p
40409	55p
40410	62p
40412	50p
40467A	57p
40468A	35p
40528	72p
40600	57p
40603	50p
AC107	30p
AC126	20p
AC127	24p
AC128	20p
AC151	18p
AC152	22p
AC154	22p
AC176	22p
AC187	25p
AC188	27p
ACY17	27p
ACY18	24p
ACY19	24p
ACY20	20p
ACY21	20p
ACY22	10p
ACY28	17p
ACY39	47p
ACY40	14p
ACY41	25p
ACY44	40p
AD140	47p
AD149	47p
AD150	62p
AD161	35p
AD152	35p
AF109	45p
AF114	25p
AF115	25p
AF116	25p
AF117	20p
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AF121	30p
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AF186	39p
AF239	30p
AF279	47p
AF280	47p
AFZ11	32p
ASY26	25p
ASY27	31p
ASY28	24p
ASY29	27p
ASY50	25p
ASY51	32p
ASY54	25p
ASY67	45p
ASY86	32p
ASZ21	37p
AUY10	150p
BC107	10p
BC108	10p
BC109	10p
BC113	15p
BC114	15p
BC115	15p
BC116	15p
BC118	15p
BC119	35p
BC121	20p
BC122	20p
BC125	15p
BC126	25p
BC134	15p
BC135	15p
BC136	15p
BC137	15p
BC138	37p
BC140	35p
BC141	35p
BC147	15p
BC148	11p
BC149	15p
BC152	17p
BC153	35p
BC154	35p
BC157	15p
BC158	15p
BC159	15p
BC160	35p
BC167	15p
BC168B	14p
BC168C	15p
BC169B	14p
BC169C	15p
BC170	12p
BC171	15p
BC172	15p
BC175	22p
BC177	22p
BC178	20p
BC179	22p
BC182	12p
BC182L	10p
BC183	10p
BC183L	10p
BC184	15p
BC184L	12p
BC186	25p
BC187	27p
BC212L	12p
BC213L	12p
BC214L	15p
BCY10	27p
BCY30	24p
BCY31	30p
BCY32	50p
BCY33	20p
BCY34	25p
BCY38	30p
BCY39	60p
BCY40	50p
BCY41	15p
BCY42	15p
BCY43	15p
BCY54	32p
BCY58	22p
BCY59	22p
BCY60	97p
BCY70	15p
BCY71	20p
BCY72	15p
BCY78	30p
BCY79	30p
BCZ10	27p
BCZ11	40p
BD112	50p
BD116	112p
BD121	65p
BD123	80p
BD124	75p
BD131	75p
BD132	85p
BDY10	125p
BDY20	105p
BDY61	125p
BDY62	100p
BF115	25p
BF117	47p
BF152	28p
BF154	38p
BF158	28p
BF159	57p
BF163	35p
BF167	25p
BF170	33p
BF173	30p
BF177	30p
BF178	25p
BF179	30p
BF180	35p
BF181	35p
BF182	30p
BF184	20p
BF185	20p
BF194	17p
BF195	15p
BF196	15p
BF197	15p
BF198	42p
BF200	35p
BF224	20p
BF225	20p
BF237	22p
BF238	22p
BF244	32p
BFW61	47p
BFW87	25p
BFW88	23p
BFW89	20p
BFW90	22p
BFW91	20p
BFX12	22p
BFX13	22p
BFX29	25p
BFX30	25p
BFX37	30p
BFX44	37p
BFX68	67p
BFX84	25p
BFX85	32p
BFX86	25p
BFX87	25p
BFX88	20p
BFX89	62p
BFX93A	70p
BFY11	42p
BFY18	25p
BFY19	25p
BFY21	42p
BFY24	45p
BFY29	40p
BFY30	40p
BFY41	50p
BFY43	62p
BFY50	22p
BFY51	20p
BFY52	22p
BFY53	17p
BFY56A	57p
BFY76	42p
BFY77	57p
BFY90	65p
BSX19	17p
BSX20	17p
BSX21	20p
BSX26	45p
BSX27	47p
BSX28	32p
BSX60	82p
BSX61	62p
BSX76	15p
BSX77	20p
BSX78	25p
BSY24	15p
BSY25	15p
BSY26	17p
BSY27	17p
BSY28	17p
BSY29	17p
BSY32	25p
BSY36	25p
BSY37	25p
BSY38	20p
BSY39	22p
BSY43	50p
BSY51	32p
BSY52	32p
BSY53	37p
BSY54	40p
BSY56	90p
BSY79	45p
BSY90	57p
BSY95A	12p
C424	15p
C450	15p
GET102	30p
GET113	20p
GET114	15p
GET118	20p
GET120	25p
GET873	12p
GET880	30p
GET887	15p
GET889	22p
GET890	22p
GET896	22p
GET897	22p
GET898	22p
MAT100	25p
MAT101	30p
MAT120	25p
MAT121	30p
MJ400	107p
MJ420	112p
MJ421	112p
MJ430	102p
MJ440	95p
MJ480	97p
MJ481	125p
MJ490	100p
MJ491	137p
MJE340	62p
MJE370	95p
MJE371	87p
MJE520	87p
MJE521	87p
MPF102	42p
MPF103	35p
MPF104	37p
MPF105	37p
MPS3638	32p
NKT124	42p
NKT125	27p
NKT126	27p
NKT128	27p
NKT135	27p
NKT137	32p
NKT210	30p
NKT211	30p
NKT212	30p
NKT213	30p
NKT214	22p
NKT215	22p
NKT216	37p
NKT217	40p
NKT219	30p
NKT223	27p
NKT224	22p
NKT225	22p
NKT229	30p
NKT237	35p
NKT238	25p
NKT240	27p
NKT241	27p
NKT242	20p
NKT243	62p
NKT244	17p
NKT245	20p
NKT261	20p
NKT262	30p
NKT264	20p
NKT271	20p
NKT262	20p
NKT274	20p
NKT275	20p
NKT278	25p
NKT281	27p
NKT401	87p
NKT402	90p
NKT403	75p
NKT404	62p
NKT405	75p
NKT406	62p
NKT451	62p
NKT452	62p
NKT453	47p
NKT713	20p
NKT717	42p
NKT734	27p
NKT736	35p
NKT773	25p
NKT781	30p
OC16	50p
OC19	37p
OC20	75p
OC22	50p
OC23	60p
OC24	60p
OC25	37p
OC26	25p
OC28	60p
OC29	60p
OC35	50p
OC36	60p
OC41	22p
OC42	25p
OC44	17p
OC45	12p
OC46	15p
OC70	15p
OC71	12p
OC72	12p
OC73	30p
OC74	30p
OC75	22p
OC76	22p
OC77	30p
OC78	20p
OC81	20p
OC81D	20p
OC82	25p
OC82D	15p
OC83	25p
OC84	25p
OC159	25p
OC140	32p
OC170	25p
OC171	30p
OC200	40p
OC201	60p
OC202	75p
OC203	40p
OC204	40p
OC205	75p
OC206	90p
OC207	75p
OCP71	42p
ORP12	50p
ORP60	40p
ORP61	42p
P346A	22p
ST140	15p
ST141	20p
TI834	62p
TI843	40p
TI844	12p
TI845	12p
TI846	12p
TI847	12p
TI848	12p
TI849	12p
TI850	17p
TI851	12p
TI852	12p
TI853	22p
XB112	11p
XC141	35p
ZTX107	14p
ZTX108	11p
ZTX109	17p
ZTX300	11p
ZTX301	17p
ZTX302	18p
ZTX303	18p
ZTX304	25p
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CA3020A	160p
CA3021	156p
CA3022	180p
CA3023	126p
CA3026	100p
CA3028A	74p
CA3028B	105p
CA3029	87p
CA3029A	165p
CA3030	137p
CA3035	122p
CA3036	72p
CA3039	82p
CA3041	109p
CA3042	109p
CA3043	137p
CA3044	120p
CA3045	122p
CA3046	81p
CA3047	137p
CA3048	204p
CA3049	160p
CA3050	185p
CA3051	184p
CA3052	165p
CA3053	46p
CA3054	109p
CA3055	240p
CA3059	165p
CA3064	120p
FCH101	85p
FCH111	105p
FCH121	105p
FCH131	50p
FCH141	105p
FCH151	105p
FCH161	50p
FCH171	105p
FCH181	105p
FCH191	105p
FCH201	180p
FCH211	180p
FCH221	180p
FCH231	150p
FCJ101	160p
FCJ111	150p
FCJ121	275p
FCJ131	275p
FCJ141	525p
FCJ201	100p
FCJ211	275p
FCK101	480p
FCL101	280p
FCY101	102p
FJH101	25p
FJH111	70p
FJH121	25p
FJH131	25p
FJH141	25p
FJH151	25p
FJH161	70p
FJH171	25p
FJH181	25p
FJH221	25p
FJH231	25p
FJH241	25p
FJH251	25p
FJJ101	50p
FJJ111	50p
FJJ121	60p
FJJ131	60p
FJJ141	125p
FJJ181	75p
FJJ191	65p
FJJ211	125p
FJJ251	125p
FJL101	125p
FJY101	25p
IC10	250p
IC12	250p
L900	40p
L914	40p
L923	40p
MC724P	66p
MC780P	247p
MC788P	82p
MC790P	124p
MC792P	66p
MC799P	66p
MC1303L	262p
MC1304P	275p
MC1305P	386p
MC838P	549p
MC1435P	345p
MC1552G	461p
MC1709CG	94p
MFC4000P	112p
PA222	437p
PA230	100p
PA234	100p
PA237	185p
PA246	245p
PA424	235p
PA264	447p
PA265	497p
SL403A	187p
SL702C	147p
SN7400	23p
SN7401	23p
SN7402	23p
SN7403	23p
SN7404	23p
SN7405	23p
SN7406	80p
SN7408	23p
SN7409	23p
SN7410	23p
SN7411	23p
SN7413	35p
SN7420	23p
SN7430	23p
SN7440	23p
SN7441AN	87p
SN7442	87p
SN7446	125p
SN7447	110p
SN7448	100p
SN7450	23p
SN7451	23p
SN7453	23p
SN7454	23p
SN7460	23p
SN7472	35p
SN7473	43p
SN7474	43p
SN7475	47p
SN7476	45p
SN7483	87p
SN7486	50p
SN7490	100p
SN7492	87p
SN7493	87p
SN7495	87p
SN7496	87p
SN74107	43p
SN74153	140p
SN74154	220p
SN74160	180p
SN74161	180p
SN74164	220p
SN74165	225p
SN74192	225p
SN74193	225p
TAA241	162p
TAA242	425p
TAA243	150p
TAA263	75p
TAA293	97p
TAA300	175p
TAA310	125p
TAA320	72p
TAA350	175p
TAA435	147p
TAA521	132p
TAA522	360p
TAA530	495p
TAA811	445p
TAB101	97p
TAD100	150p
TAD110	197p
UA702A	280p
UA702C	77p
UA703C	137p
UA709C	125p
UA710C	125p
UA716	187p
UA723C	162p
UA730C	160p
UA741C	87p

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100 PIV 2A	60p	200 PIV4A	75p
200 PIV 2A	67p	400 PIV 4A	80p
400 PIV 2A	80p	50 PIV 6A	62p
		100 PIV 6A	75p
		200 PIV 6A	85p
		400 PIV 6A	£1·10

SILICON RECTIFIERS MINIATURE WIRE ENDED PLASTIC

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4002 100PIV	09p	11p	20p
4003 200PIV	10p	12p	22p
4004 400PIV	10p	12p	25p
4005 600PIV	12p	15p	26p
4006 800PIV	15p	17p	27p
4007 1000PIV	20p	20p	30p

50+less 15% 100+ less 20%

SILICON RECTIFIERS STUD MOUNTING

	6A	10A	17·5A	35A
100PIV	—	45p	50p	£1·22
200PIV	25p	50p	55p	£1·42
400PIV	30p	55p	62p	£1·77
600PIV	32p	60p	72p	£2·12
800PIV	35p	75p	87p	£2·47
1000PIV	40p	85p	£1·05	£2·77

50+less 15% 100+less 20%

ZENER DIODES

400MW	1·5 WATT	10 WATT
3·3-33 V	2·4—100	3·9—100V
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25+less 15% 100+less 20%

TRANSISTOR DISCOUNTS: 12 + 10%; 25 + 15%; 100+20% any one type Postage on all Semi-Conductors 7p extra.
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6AK6	57p	50C5	40p	PC900	48p
6AL5	20p	80	50p	PCC84	40p
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6BQ7A	40p	DF96	42p	PCF802	50p
6BR7	85p	DK91	35p	PCF805	75p
6BR8	65p	DK92	50p	PCF806	70p
6BW6	85p	DK96	42p	PCF808	75p
6BW7	70p	DL92	35p	PCL82	35p
6BZ6	35p	DL94	45p	PCL83	65p
6C4	33p	DL96	42p	PCL84	45p
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6CW4	63p	DY87	35p	PFL200	70p
6F1	62p	E88CC	65p	PL36	55p
6F6G	30p	E180F	95p	PL81	50p
6F13	33p	EABC80	35p	PL82	45p
6F14	65p	EAF42	35p	PL83	45p
6F15	65p	EB91	20p	PL84	40p
6F18	45p	EBC41	55p	PL500	75p
6F23	80p	EBC81	30p	PL504	80p
6H6	20p	EBF80	40p	PY32	55p
6J4	50p	EBF83	40p	PY33	63p
6J5	20p	EBF89	32p	PY80	35p
6J5GT	30p	EBL21	60p	PY81	30p
6J6	20p	EC86	60p	PY82	30p
6J7	45p	EC88	60p	PY83	38p
6K8G	35p	ECC40	60p	PY88	40p
6L6GT	45p	ECC84	30p	PY800	50p
6LD20	40p	ECC85	60p	PY801	50p
6Q7	40p	ECC88	40p	U25	75p
6SA7	40p	ECF80	35p	U26	75p
6SG7	35p	ECF82	35p	U50	32p
6SJ7	40p	ECF86	65p	U52	33p
6SK7	35p	ECH21	57p	U191	75p
6SL7	35p	ECH35	60p	U281	40p
6SN7	35p	ECH42	70p	U282	40p
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6X4	30p	ECL83	65p	UBC41	50p
6X5G	30p	ECL86	40p	UBC81	40p
6X5GT	27p	EF37A	60p	UBF80	40p
10C2	50p	EF39	40p	UBF89	35p
10F1	90p	EF40	50p	UCC84	49p
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10P14	£1·10	EF42	70p	UCF80	55p
12AT6	30p	EF80	25p	UCH21	60p
12AT7	30p	EF85	35p	UCH42	70p
12AU7	30p	EF86	30p	UCH81	35p
12AX7	30p	EF89	28p	UCL82	35p
12AV6	33p	EF91	33p	UCL83	60p
12BA6	35p	EF92	40p	UF41	60p
12BE6	35p	EF183	30p	UF80	35p
12BH7	40p	EF184	35p	UF85	40p
19AQ5	35p	EH90	40p	UF89	35p
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20P4	£1·10	EL84	25p	VR150/30	35p
20P5	£1·20	EL85	43p	*Add 12p in £*	
25L6	45p	EL91	32p	*for postage*	

DIODES & RECTIFIERS

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AA119	7p	BAY31	7p	OA10	22p
AA129	10p	BAY38	17p	OA9	10p
AAZ13	10p	BY100	15p	OA47	7p
AAZ15	12p	BY103	22p	OA70	7p
BA100	15p	BY122	37p	OA73	10p
BA102	22p	BY124	15p	OA79	9p
BA110	32p	BY126	15p	OA81	7p
BA111	27p	BY127	17p	OA85	7p
BA112	70p	BY164	57p	OA90	7p
BA115	7p	BY210	35p	OA91	7p
BA141	32p	BYZ11	32p	OA95	7p
BA142	32p	BYZ12	30p	OA200	7p
BA144	12p	BYZ13	25p	OA202	10p
BA145	20p	BYZ16	40p	OA210	17p

← See previous page ● G. W. SMITH & CO. (RADIO) LTD. ● See opposite page →

28watts, r.m.s. 40Hz to 40kHz ± 3dB

There are two stereo amplifiers — the RT100 for ceramic cartridges, the RT101 for magnetic. Both incorporate FETs (FIELD EFFECT TRANSISTORS), just like top-priced units. FETs give you more of the signal you want, and almost none of the background hiss you don't. Both units have a jack socket to plug in headphones and there's a separate output for tape recorder. Filters (an unusual feature in this price range) and tone controls give a wide range of bass and treble adjustment which compensate for input deficiencies and domestic acoustic conditions.

Viscount III Audio Suite complete £49

PRICES SYSTEM 1

Viscount III RT101 amplifier	£22.00 + 90p p&p
2 x Duo Type II speakers,	£14.00 + £2 p&p
Garrard SP25 Mk. III with MAG. cartridge, plinth and cover	£23.00 + £1 p&p
Total	£59.00

Available complete for only £52.00 + £3.50 p&p.

SPECIFICATION

14 watts per channel into 3 to 4 ohms. Total distortion @ 10W @ 1kHz 0.1%. *P.U.1* (for ceramic cartridges) 150mV into 3 Meg. *P.U.2* (for magnetic cartridges) 4mV @ 1kHz into 47K equalised within ± 1dB R.I.A.A. *Radio* 150mV into 220K. (Sensitivities given at full power.) Tape out facilities; headphone socket, power out 250 mW per channel. *Tone controls and filter characteristics.* Bass + 12 dB to − 17 dB @ 60 HZ. Bass filter: 6 dB per octave cut. Treble control: treble + 12 dB to − 12 dB @ 15 kHz. Treble filter: 12 dB per octave. *Signal to noise ratio:* (all controls at max) RT101 — P.U.1 and radio − 65 dB. P.U.2 − 58 dB. **RT100** same as RT101 but P.U.2 (for crystal cartridges) 450 mV into 3 Meg. *Cross talk* better than −35 dB on all inputs. *Overload characteristics* 26 dB on all inputs. Size 13¾" × 9" × 3¾"

SYSTEM 2

As System 1, but with 2 x Duo Type III speakers at pair £32.00 + £3 p&p

Available complete for £69 + £4 p&p

SYSTEM 3

Viscount III Amplifier RT100	£17.00 + 90p p&p
2 x Duo Type II speakers, pair	£14.00 + £2 p&p
Garrard SP25 Mk. III with CER. diamond cartridge, plinth and cover	£21.00 + £1 p&p
Total	£52.00

Available complete for only £49.00 + £3.50 p&p

SPEAKERS Duo Type II

Size 17" x 10½" x 6½". Drive unit 13" x 8" with parasitic tweeter. Max. power **10 watts.** 3 ohms Teak veneer cabinet. **£14 pair** + £2 p&p.

Duo Type III Size 23½" x 11½" x 9½". Drive unit 13½" x 8½" with H.F. speaker. Max. power 20 watts at 3 ohms. Frequency range 20Hz to 20kHz. Teak veneer cabinet. **£32 pair** + £3 p&p.

R+TV

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PLIERS

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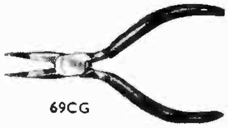

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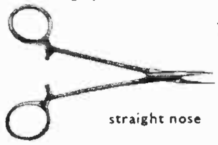

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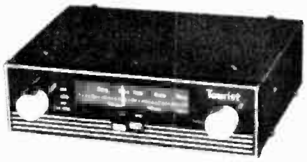

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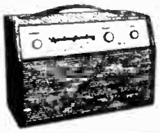

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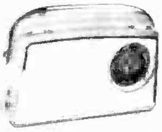

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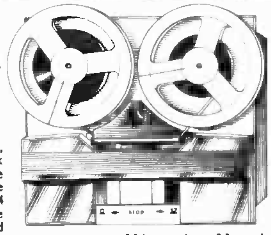

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VOL. 7 No. 9
September 1971

PRACTICAL ELECTRONICS

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ON THE ROAD

THE motor car is a wonderful vehicle for electronics. Solid state technology never had a happier hunting ground. Consider that reliable easy-to-tap d.c. supply at 12 volts: just what the transistor ordered. No wonder so many interesting and useful aids for the motorist have appeared in recent times. Many owe their origin to private electronics enthusiasts, their imagination stirred to new heights during long solo drives, no doubt; or, perhaps, during enforced idling caused by holiday season snarl-ups.

The majority of such devices represent electronics in a comparatively simple form. Whether as self-sufficient gadgets or systems, or as ancillary units for coupling to standard car accessories for control purposes, their function is to aid the motorist rather than his vehicle. Useful as they are, such appendages do not represent the limit of electronics involvement in motor cars. This is far from the case. Electronics is destined to become a vital and intrinsic part of the vehicle itself.

The increasing concern over road safety and environmental matters like atmosphere pollution, will bring about more stringent regulations. In order to meet these tough requirements the car manufacturers will have no alternative but to look beyond their own industry and traditional methods. They are already fairly familiar with the possibilities of electronics in the internal combustion engine field. For example, the advantages of electronic ignition and fuel injection have long been known. It is only the initial cost that deters car manufacturers from incorporating such systems in their mass produced models.

Coming now to more life-or-death matters, car designers in the future will have little option but to incorporate more refined and sensitive control systems. Present systems largely dependent upon electromechanical and hydraulic linkages will undergo drastic change, if not entire replacement, as electronic control systems are developed. Methods of preventing wheel slide by use of electronic sensing and computing techniques to control the brake have already been perfected. This is a foretaste of the future in motoring.

This revitalizing of the traditional vehicle is all to the good, though even the magic of electronics cannot save the internal combustion engine from ultimate extinction. Indeed, how far on the road towards fully automated driving will we have journeyed before the electric powered vehicle overtakes us? Commercial interests are very reticent about the current state of development in this exciting area, but there have been some ominous (or rather, welcome) rumblings from Detroit, of late. Perhaps the long awaited motoring revolution is nearer than we think.

F.E.B.

THIS MONTH

CONSTRUCTIONAL PROJECTS

SPECIAL SERIES

GENERAL FEATURES

NEWS AND COMMENT

Our October issue will be published on Friday, September 17

Practical Electronics, Fleetway House, Farringdon St., London, E.C.4. Phone: *Editorial* 01-634 4452; *Advertisements* 01-634 4202

THE simple control of power has for a long time been desirable, but it was not until the introduction of thyristors, or silicon controlled rectifiers that such control became convenient in the home constructor field.

The unit to be described here is capable of controlling power levels of up to 1kW and makes use of the "burst fire" system to achieve this. Any attempt to control elements in excess of this rating will result in damage to the controller.

Although the handling of greater power levels might seem to be desirable, it should be borne in mind that most heaters of a greater power output have the facility of switching in and out 1kW at a time. Thus fine control of 1kW will cover most situations; larger power handling would call for a larger unit than that described here.

In order to understand the advantages of the burst-fire system and why it is used in this controller, a brief outline of the alternative method is given. There are, of course, advantages and disadvantages in both systems, as will be seen.

PHASE SHIFT CONTROL DISADVANTAGES

The simplest form of control of power, using a thyristor, is that known as "phase shift". Fig. 1 shows a typical waveform of load current controlled in this way, where switch-on is delayed in each half-cycle, so causing the power level, averaged over a number of cycles, to be less than when no delay is included. Variation of the length of the delay varies the average power level.

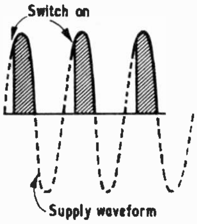
Controllers based on the phase-shift principle have been described previously in this magazine. While they are quite satisfactory in enabling the power level to be controlled, there are two disadvantages.

Since the current switch-on is sudden and is repeated at the rate of 50Hz, a large level of radio frequency is generated and careful screening and filtering are called for if interference to radio and television is to be avoided. Loads consisting of motors, such as electric drills, tend to give much lower levels of interference due to the inductance of the windings acting as a built-in filter. In general, the greater the power level being controlled, the greater level of interference generated.

Distortion of the mains supply also occurs as can be seen from Fig. 1, and large scale use of phase-shift control at high power levels—say greater than a few hundred watts—can give rise to difficulties. The Electrical Supply Authorities accordingly discourage the use of phase-shift control for space heaters.

BURST FIRE COMPARED

The burst-fire system causes very little or no interference, even without filtering, and no distortion of the supply voltage occurs. This is because complete half-cycles of current are permitted to flow to the load in controllable trains as in Fig. 2. Alteration of the ratio of "on" time to "off" time, while still maintaining complete half-cycles in the power supplied to the load, varies the average output power.



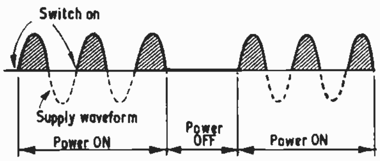


Fig. 1 (left). Phase shift control of thyristor load current. Power supplied can be varied by altering switch-on point

Fig. 2 (right). Current half cycles supplied to load with burst fire control. Note that switch-on occurs at zero point

CHOICE OF PULSE PERIODS

The actual lengths of time employed for "on" and "off" require choosing with care. Both periods should not be too short, for if, for example, the current period was to consist of two half-cycles, then only a slight change in component values, due to load or temperature changes, could alter this to either one or three half-cycles. This represents a large percentage change and smooth stable control would be impossible.

Conversely, too long a period of time in either the "on" or "off" mode would permit a heater element to alternately cool down and heat up. Continuous temperature cycling of this kind might give rise to a shorter life for the element. In any case, it is easily avoided, for with correct timing, the thermal inertia of the element overcomes this.

The unit described here has been arranged to have its output pulsed on and off once per second, that is "on" time plus "off" time is equal to about 1 second. As the ratio of "on" and "off" is varied, to effect a change in average power supplied, this time of 1 second remains virtually constant, due to the circuit configuration employed.

Control of power from 10 per cent to 90 per cent of full is possible; a by-pass switch (which may be omitted if desired) enables full power to be supplied when required.

— — — provides smooth power

APPLICATIONS FOR THE BURST FIRE CONTROLLER

From the foregoing it will readily be seen that while the Burst Fire Controller is eminently suitable for control of heaters—such as electric fires, aquaria heaters and photographic processing bath heaters—it is not suitable for the dimming of lights, nor the slowing of motor speeds.

However, as was noted earlier, phase-shift control of electric motors is appropriate; the self suppression of interference in motors and the generally lower power levels present in lamp circuits avoid the difficulties mentioned in that system.

Uses for the Burst Fire Controller involving lamps is in those cases where flashing is required. Christmas tree and similar displays are examples; perhaps a cycling period of about 5 to 10 seconds would be more suitable and possible modifications will be given later.

Having thus outlined the need for burst fire control, we can now turn to practical details.

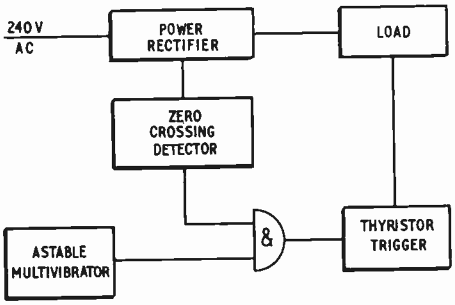


Fig. 3. Block diagram of controller

BLOCK DIAGRAM

In Fig. 3 is given the block diagram of the unit. Here the astable multivibrator has an almost constant frequency, but its on-off ratio can be altered. The output of the multivibrator, together with information from the zero crossing detector, is fed to the AND gate, the output of which turns on the thyristor, and so applies power to the load.

The incorporation of the AND gate in this way ensures that switch-on of the thyristor occurs only at the start of each mains half-cycle, so causing no high frequency radiation.

CIRCUIT ACTION

Full circuit details are given in Fig. 4. In the circuit diagram, transistors TR2 and TR3 form the astable multivibrator, which has two points of interest.

Potentiometer VR1 enables the on-off ratio of the multivibrator to be changed but with a constant repetition rate. This is because while varying amounts of resistance can be included between each base and the positive supply rail, the total amount of such resistance is constant, one base circuit having more resistance included as the other has less.

The inclusion of the diode D7 and resistor R9 to supply rail, isolates the timing capacitor C6 from the collector of TR3 so allowing the voltage at that collector to rise sharply when the transistor ceases to conduct. Consequently, a good square wave is available for passing to the AND gate comprising D8, D9 and R11.

ZERO CROSSING DETECTOR

The second input to the AND gate is derived from the zero crossing detector circuitry.

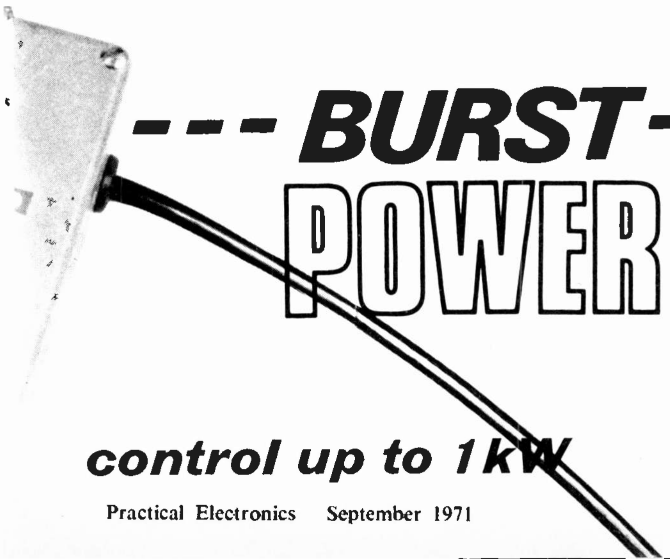
Inspection of the circuit will show that the upper side of C3 has D3 connected to negative rail; similarly, C4 has D1 connected to the positive rail. This means that the waveforms at the upper sides of C3 and C4 are 90 degrees out of phase with the waveform across D6, this acting as a positive clamp to the negative line and providing positive half-cycles, as shown in Fig. 5.

These provide positive switching of TR1, so giving positive signals, coinciding with zero mains crossing, at the emitter of TR1.

The capacitors C3 and C4 are connected to the mains, and so must withstand full mains potential. For this reason, 750 volts should be considered the minimum working voltage for these components, with 1,000 volt working desirable.

GATE CONTROL

The AND gate comprising D8 and D9 controls the switching of TR4. Suppose TR3, in one of its



--- BURST-FIRE --- POWER CONTROLLER

control up to 1kW

By J. N. Watt

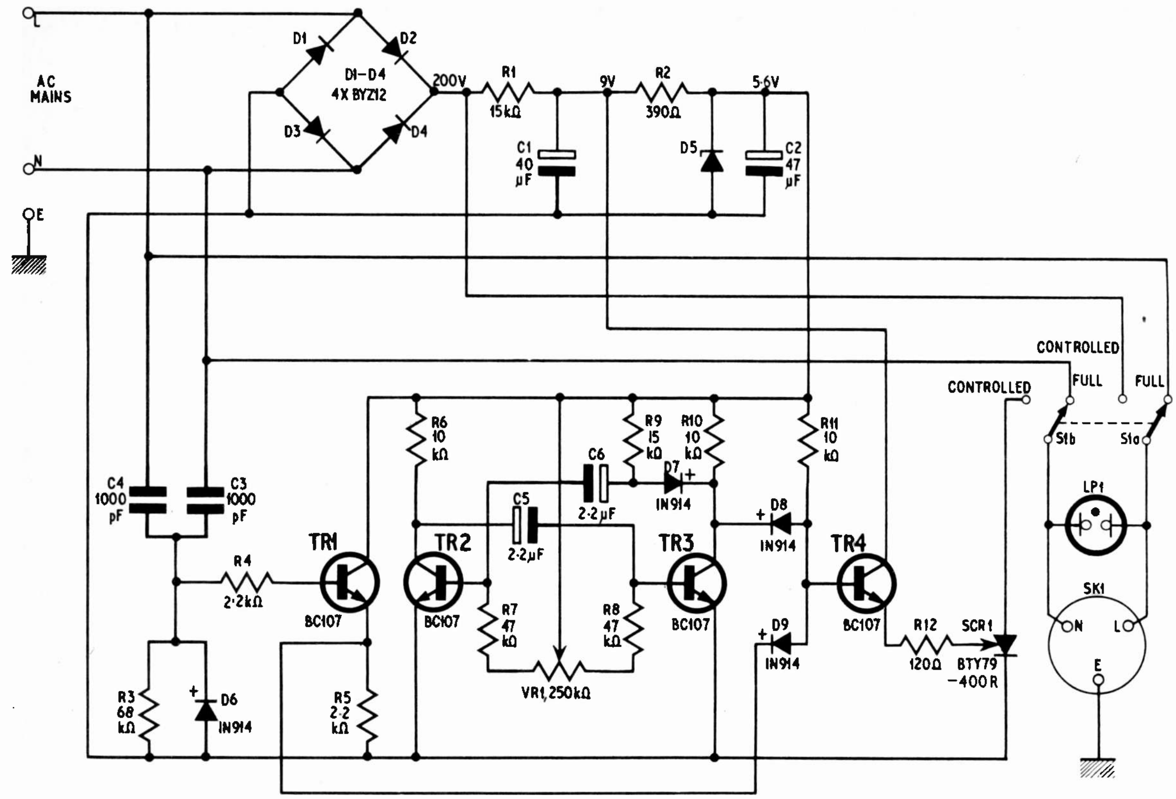


Fig. 4. Circuit diagram of controller

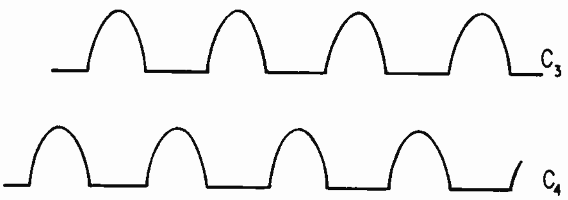


Fig. 5. Trains of voltage half-cycles that are applied to the zero crossing detector via the input capacitors

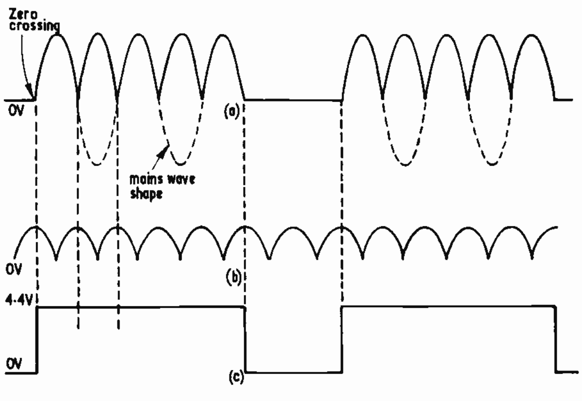


Fig. 6 (a). Unidirectional half cycles at thyristor load, (b) Rectified and much reduced voltages that appear at TR1 base. These are 90 degrees out of phase with the load voltages, (c) Voltage waveshape at TR3 collector

oscillations, is switched off, then the collector voltage goes positive as in Fig. 6c. D8 is reverse biased and does not conduct.

As stated, a train of positive voltages is being continually applied to TR1 base as in Fig. 6b. At zero volts TR1 does not conduct so that D9 is forward biased and the voltage that appears at TR4 base is insufficient to turn it on. With the base voltage at TR1 increasing to a maximum this transistor is switched on and D9 is reverse biased.

With both diodes not conducting R11 provides a direct feed to TR4 base and this transistor is switched on, so gating the thyristor at the zero crossing point of the bridge rectifier supply as in Fig. 6a. When TR3 turns on D8 conducts, and TR4 turns off and the applied burst voltage to the load is terminated.

POWER SUPPLY

A low voltage d.c. supply is required to run the control circuits and this is most conveniently done by means of the diode bridge, D1-D4, followed by a resistive dropper and Zener regulator, with capacitive smoothing.

The thyristor employed to switch power to the load can deal only with direct current so it is logical to uprate the current capacity of the bridge rectifier and use it to rectify the a.c. supply at each half-cycle, and so feed the thyristor.

It follows that unidirectional current flows in the load. This is no disadvantage with heaters and the like, but it *positively rules out any load involving a transformer.*

Heaters are the most likely load for this controller, however, and they function just as well on d.c. as on a.c.

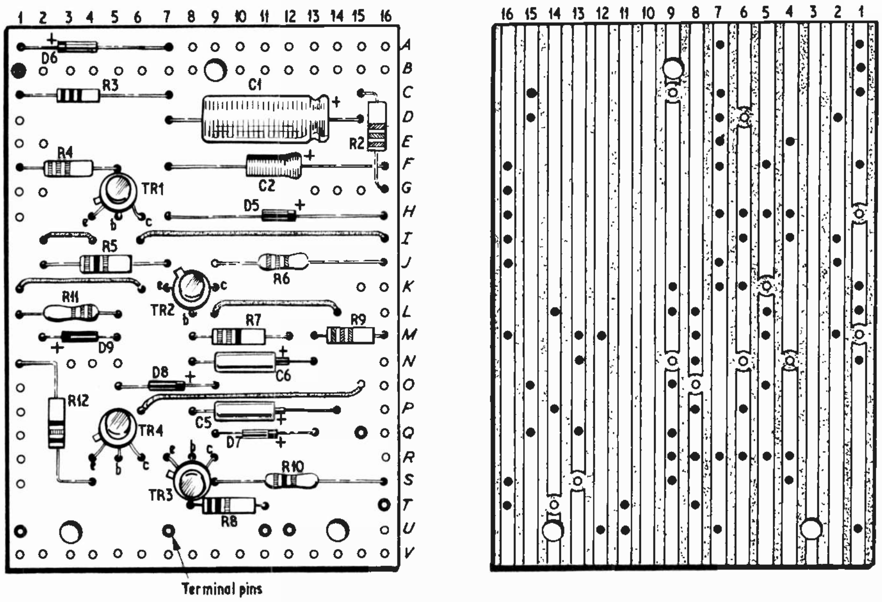


Fig. 7. Assembly and wiring layout of control board

BEWARE OF HIGH VOLTAGES

Practical construction raises some important safety points and it would be as well to mention them first.

All parts of the circuitry are at high voltage, due to direct connection to the mains and under no circumstances should any part be handled directly when live. Disconnect the unit from the mains supply by un-plugging it when making any adjustments or modifications to it.

Since most oscilloscopes are grounded via mains earth at one input terminal, it is essential that any waveform inspection is made through a 1 : 1 isolating transformer. Any direct oscilloscope connections will certainly result in considerable damage to the controller circuitry.

Where control of an electric fire is intended, avoid low mark-space ratio settings of VR1, since short period bursts of power are not sufficient to make a 1kW element glow. This could be dangerous to children with inquisitive fingers who might think the fire is off.

For insulation, the piece of Veroboard carrying most of the components in Fig. 7 is secured by means of 4B.A. nylon screws and nuts, with nylon nuts used as insulated spacers. The heat sinks themselves are earthed, although the components they carry are of course at high potential, with the appropriate insulation.

The need for care, when the cover of the box is removed and the unit is connected to the mains, cannot be too strongly emphasised. Of course, in normal use, no danger should arise.

A strong die-cast box is used to house the controller, and this should be earthed. Such boxes are readily available, easy to drill and, rather important in this case, provide good protection.

COMPONENTS . . .

Resistors

R1	15k Ω 6W wire wound		R7	47k Ω
R2	390 Ω ½ watt		R8	47k Ω
R3	68k Ω		R9	15k Ω
R4	2·2k Ω		R10	10k Ω
R5	2·2k Ω		R11	10k Ω
R6	10k Ω		R12	120 Ω

All 10% ¼ watt except where otherwise stated

Potentiometers
VR1 250k Ω carbon linear

Capacitors
C1 40μF elect. 16V
C2 47μF elect. 6V
C3, C4 1000pF 750V (2 off)
C5, C6 2·2μF elect. 6V (2 off)

Transistors
TR1—TR4 BC107 (4 off)

Diodes
D1–D4 BYZ12 (4 off)
D6–D9 IN914 (4 off)
D5 5·6V 400mW Zener

Thyristor
SCR1 BTY79–400R

Switch
S1 D.P.D.T. 5A contact rating

Miscellaneous
LP1-Mains neon, heat sinks and insulating mica for rectifiers, nylon screws and nuts (4 B.A.). Eight way insulated tag strip, 13A mains socket, Die-cast box 7½in × 4¾in × 2¼in.

A high degree of polish can be imparted to the box by rubbing with successively finer grades of emery paper, followed by toothpaste (in lieu of jewellers' rouge) and then metal polish. Alternatively, a painted finish, obtained by making use of one of the many spray aerosols on the market, enables a choice of colour to be made.

MOUNTING THE RECTIFIERS

The four power rectifiers, D1 to D4, and the thyristor are mounted on heat sinks as shown in the wiring diagram of Fig. 8.

These sinks are earthed, and this can be done because mica washers, with insulating bushes, are employed on the diode and thyristor mounting studs as in Fig. 9.

Each of the sinks is painted matt black, to assist with heat dissipation, as are the inside surfaces of the box. A light smear of silicon grease, if available, should be applied to the surfaces of the sinks that joint with the box.

When fitting the washers, ensure that no burrs are present that could puncture the mica insulation. After fixing, check that the mica washers are still insulating, with an ohmmeter.

FULL POWER SWITCHING

A mains voltage neon lamp across the load indicates when power is actually being applied to it, while the double pole change-over switch S1 enables full power to be applied direct to the load when required.

This switch must be capable of handling the full load current, and for this reason has a rating of 5A or greater.

When wiring up, remember that all leads passing load current can be called upon to carry 4A, so use

CONTROLLER INTERWIRING

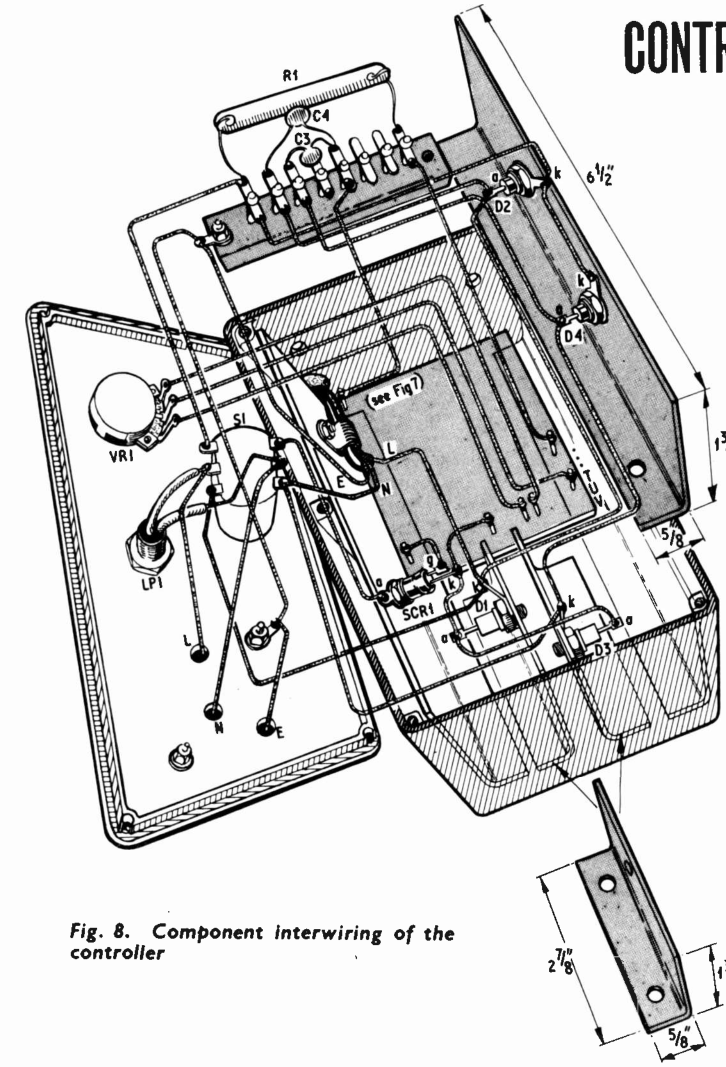


Fig. 8. Component interwiring of the controller

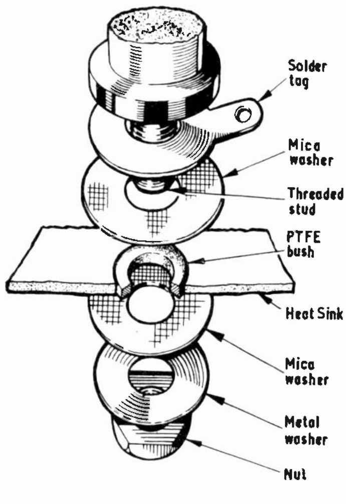


Fig. 9. Insulator details for mains rectifiers and thyristor

wire of an appropriate rating. Leads such as those running to the Veroboard can be of a lighter gauge.

When it has been ensured that all components and connections have been made correctly, power can be applied.

CHECK OUT

A voltmeter should be used to monitor the d.c. voltages present—those given in Fig. 4 are with respect to the thyristor cathode. At the collector of TR3 the voltage will change as the multivibrator oscillates, it depending on the setting of VR1.

A 100 watt lamp is a good load to check the operation of the unit; it will easily be seen that variation of the setting of VR1 results in a short flash at intervals of about one per second at one end of the range, with almost continuous light, punctuated by short term extinguishing of the lamp, at the other end. Settings of VR1 in between give smooth control of average power.

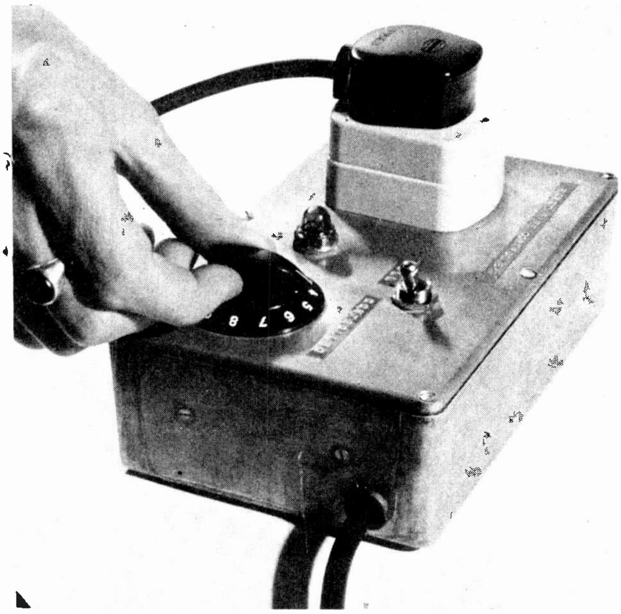
After a few minutes, withdraw the plug of the unit from the mains, and test the running temperature of the diodes and thyristor. With the 100 watt load suggested, they should not be in any way warm to the touch.

At this stage, it would be as well to ensure that the zero crossing circuits and AND gate are working correctly. To do this, disconnect one end of C3. The lamp should continue to flash, but at reduced brilliance. Disconnection of C4 also will give no output at all.

The explanation for this is that with C3 removed, only alternate half-cycles of the mains can be switched through to the load. Removal of both C3 and C4 means that no pulses are fed to TR1 and, with the AND gate working correctly, the output of the multivibrator is unable to switch on the thyristor.

NO INTERFERENCE

Correct functioning of this part of the circuit is essential if no interference is to be caused, for if the thyristor could apply voltage to the load starting at any time but zero crossing, the resultant sudden flow of a large current would generate considerable r.f. energy.



Switch off of load current at zero crossing is automatic, for the current through the thyristor falls to zero at the end of each half-cycle.

With C3 and C4 replaced and a larger load connected, such as a 1kW fire, there will be a warming of the heat sinks and the box at the higher power settings. This is quite in order. It should be borne in mind that about 30 watts is to be dissipated at the highest setting, and in case this seems excessive, remember that it is only 3 per cent of the total power controlled.

At lower power settings, only slight warming should occur.

Depending on the relative values of the capacitors employed for C5 and C6—remember that electrolytics have a wide tolerance—it will be found that average power levels of from 10 per cent to 90 per cent of full power can be delivered.

SUBSTITUTE COMPONENTS

The question of substitute components will no doubt arise in connection with the Burst Fire Controller.

The transistors specified are BC107, but in fact unmarked *npn* transistors, quoted as being "similar to BC107" worked well, provided those found to be leaky or of low gain were not used.

As for the diodes D6 to D9, germanium or silicon devices can be used, although D8 and D9 should be of a similar type.

The thyristor employed in the prototype was a Mullard BTY79-400R; a BT102-500R also functioned satisfactorily. Unmarked thyristors, of a sufficiently high current rating may require more gate current than this circuit can generate and consequently may not prove to be suitable.

The power diodes are type BYZ12, with cathode stud. Alternatives, provided that they are at least of 400 volt 4A rating, but preferably of a somewhat higher current carrying capability, can be employed.

FLASHING DISPLAYS

As already described, the repetition rate is about one burst per second. An increase in the value of C5 and C6 to say, 4·7μF, or 6·8μF will slow down the rate of flashing to a suitable rate, while unequal values of these capacitors will enable the relative lengths of "on" and "off" time to be varied over a very wide range, particularly useful for lamp flashing displays.

Should the use of the Burst Fire Controller be confined to such uses, with upper power limits of, say, 200 watts, then some economies in the construction can be made. A 3A thyristor, on a smaller heat sink, and 1A wire ended rectifiers should enable the unit to be constructed in a smaller die-cast box, so making a very compact unit.

Apart from the obvious use of controlling room heaters, constructors may find the Controller useful to run a soldering iron, when on stand-by, at a reduced temperature, with switching to full power for actual soldering. These will increase the life of the iron bit. Other uses will doubtless occur to the home experimenter. ★

Microwave semiconductors

By M. FLETCHER (Mullard Ltd)

MICROWAVE frequencies occupy that part of the spectrum where the circuitry used is comparable in size to the wavelength. In practice this usually means frequencies from 1GHz to 100GHz or possibly higher. Originally exploited for radar at the beginning of World War II, microwaves now have a multitude of applications.

The wide bandwidths possible are utilised in communications, both overland and by satellite. Microwaves form a valuable research tool for performing various physical measurements and the use of high power microwaves is now being applied to cooking.

Until comparatively recent times microwave electronics has been largely the domain of thermionic devices. Within the last decade however a host of microwave semiconductor components have become available. Many of these, because of their simplicity and low power consumption compared to thermionic devices, are stimulating new applications for microwaves not previously considered practical.

POINT CONTACT

In the early development work on radar principles, a sensitive detector was required for the receiver to respond to the high frequencies being used. The technique adopted was to use a point contact diode either as a detector or as a mixer in a superhet receiver.

The diodes used were really a refined form of the simple cat's whisker semiconductor rectifier used in early radio receivers. The form of construction is shown in Fig. 1. The noise figures obtained were poor by modern standards but sufficed for the purpose. No basic change in technology took place for many years although a steady improvement in materials and techniques brought about improvements in noise performance (Fig. 2).

Although still widely used today the point contact diode remained the only semiconductor element available to microwave engineers for nearly two decades. In the early 1960s, however, the gathering pace of semiconductor technology began to have application in the microwave area. One of the first of these devices was the variable capacitance diode or varactor.

VARACTOR DIODES

The varactor diode depends on the phenomenon of capacitance change under varying reverse bias due to the variation in the width of the depletion region in a *pn* junction. See Fig. 3.

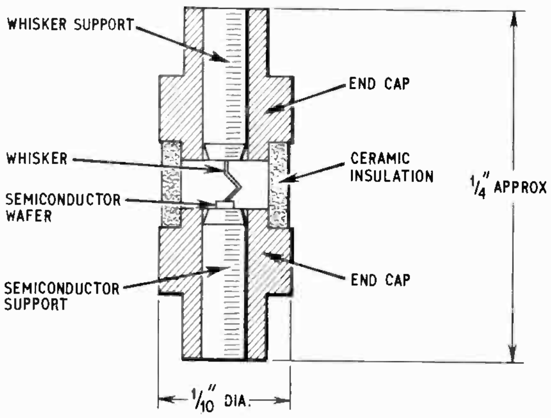


Fig. 1. Construction of a modern point contact mixer diode

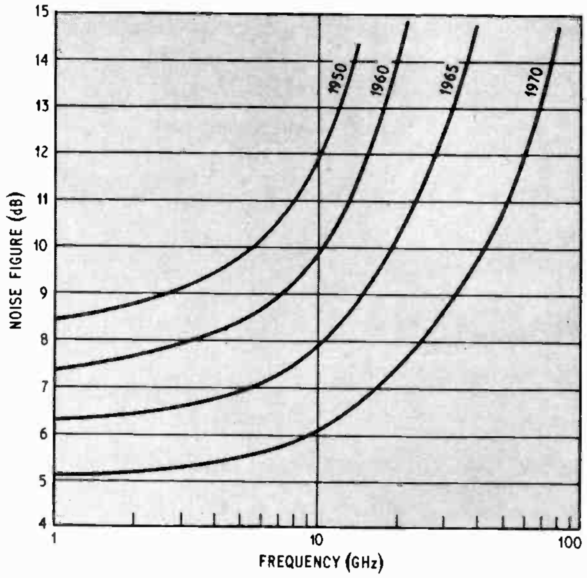


Fig. 2. Improvement in the noise figures of mixer diodes

The capacitance voltage relationship is $C \propto V^{-n}$ The value of n depends on the impurity profiles in the *pn* junction. It is typically 0·5 (as shown in Fig. 3) but the important point is that the relationship is non-linear.

The junction capacitance of a microwave varactor is normally specified at $V = 6V$ and might be from 0·2pF to 20pF, depending on the application. Various methods are used for fabricating *pn* junction varactors, two important ones being shown in Fig. 4.

The diodes are usually made with silicon although gallium arsenide is used for some special applications. The manufacturing problem is to define the required area of diffused *pn* junction since this affects the capacitance value.

In the case of the mesa diode this is done by etching away the unwanted area. In the case of the planar diode areas are defined by making holes in the oxide window of required size prior to diffusion. The holes are made by photolithography and the whole process is similar to that used for making planar transistors.

The advantage with planar construction is that a large number of diodes may be fabricated with one series of operations. When the varactor chip is made it must be mounted in an envelope suitable for use at microwave frequencies.

The varactor diode has numerous applications, not all of them confined to microwaves. Clearly it may be used as a circuit tuning element which is voltage controlled. In this respect it is used for tuning microwave oscillators, T.V. tuners, automatic frequency control systems and so on.

The other applications of the varactor depend on the fact that it is a non-linear circuit element whose response to a large signal differs from that of a small one. The change of impedance at high signal levels may be applied to limiter type circuits.

Under conditions of high signal level the varactor will generate harmonics. If resonant circuits are coupled, tuned to the harmonic frequencies, substántial amounts of power may be extracted at the higher frequency. Using the second or third harmonic, a chain of varactor multipliers may be built up capable of giving powers in the order of 1-2 watts at 8GHz (see Fig. 5).

Of course, losses are present in this system both in the circuits and the varactors and a great deal more power must be supplied at the lower frequencies from, say, power transistors. However it is a useful technique for generating power with solid state devices and is widely used in communications transmitters. Obtainable output powers are shown in Fig. 6.

SCHOTTKY BARRIER DIODES

Another new type of microwave diode to appear in recent years is the Schottky barrier diode. Basically a Schottky barrier is a junction diode with the junction formed between the semiconductor and a metal contact rather than between dissimilar semiconductor materials, as in the case of an ordinary *pn* diode.

The construction of a Schottky diode is shown in Fig. 7. The manufacturing processes used are very similar to those for planar diodes and many of the same advantages accrue, for example the uniformity arising from making a large number of diodes with a single process.

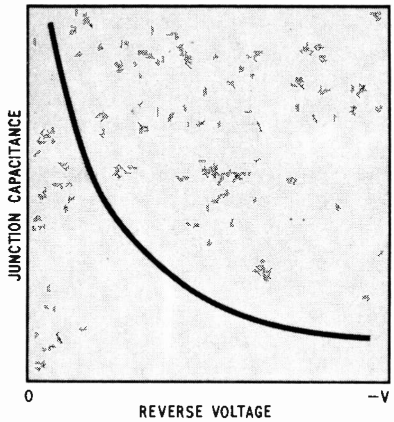


Fig. 3. Relationship of capacitance with voltage $C \propto V^{-n}$

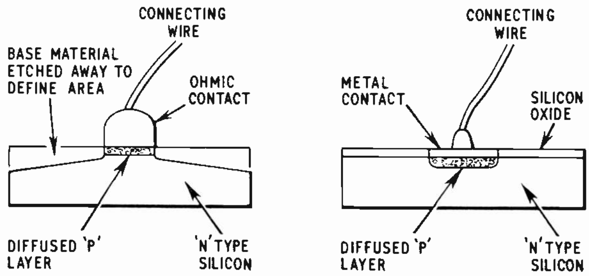


Fig. 4. Construction of (left) Mesa and (right) planar pn diodes. The chips are typically 0·25mm × 0·25mm

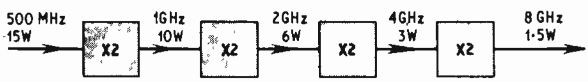


Fig. 5. Chain of varactor doublers producing 1·5W at 8GHz

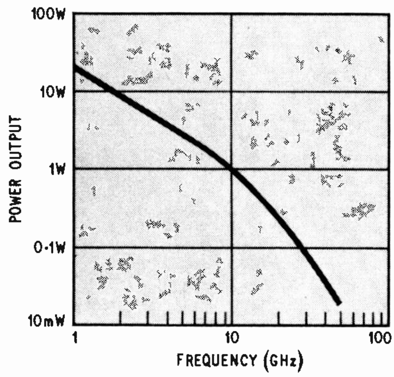


Fig. 6. Output power obtainable from vacactor chains

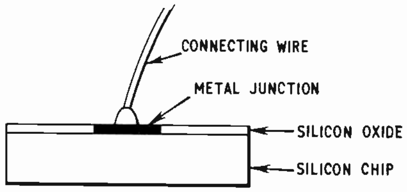


Fig. 7. Construction of Schottky barrier diode. The metal junction may be as small as 0·01mm across

The Schottky diode has the advantage that minority carrier storage effects (present in normal *pn* junction diodes) cannot take place. These limit the switching speed and hence rectification efficiency and are the main reason why *pn* diodes are not suitable for detection or mixing of microwave frequencies.

Thus Schottky diodes are finding application as microwave mixer diodes and have noise figures equal to the best point contact diodes. They are also

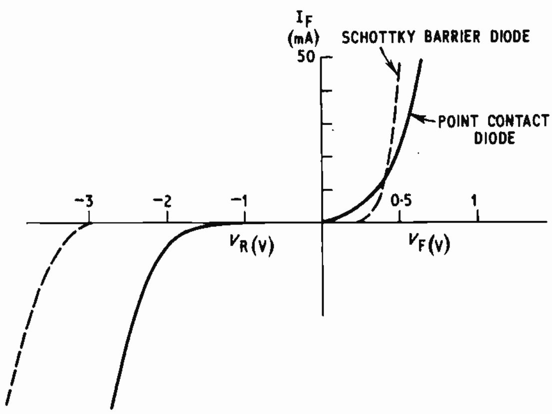


Fig. 8. Voltage/current characteristic of the Schottky barrier diode (dotted) compared with that of a point contact diode

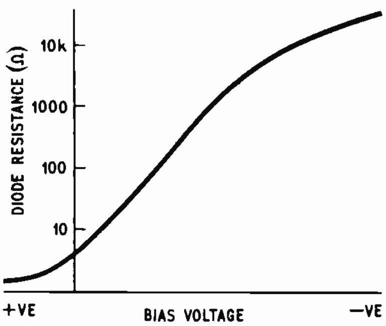


Fig. 9. Variable resistance characteristic of a pin diode

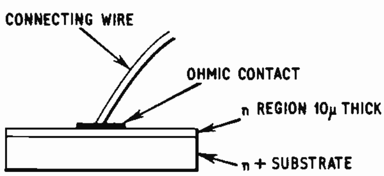


Fig. 10. Construction of a Gunn diode

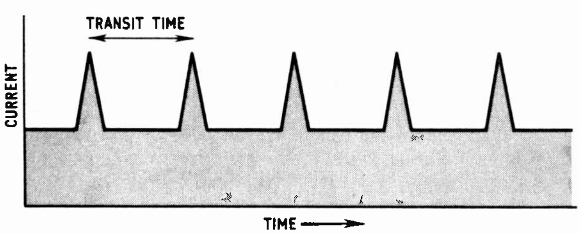


Fig. 11. Current/time waveform in a Gunn diode

mechanically more robust and have several other advantages so that in time they are likely to displace the long standing point contact microwave diode. The absence of minority carrier storage also makes the Schottky diode useful in high speed switching circuitry. The d.c. characteristics of silicon point contact and Schottky diodes are compared in Fig. 8.

THE *PIN* DIODE

Another new and very useful device is the *pin* diode. These consist of a *pn* silicon junction with a layer of intrinsic or high sensitivity silicon between the *p* and *n* regions. When forward biased the *pin* diode behaves as a resistance from d.c. to microwave frequences. The value of the resistance depends on the forward current (see Fig. 9). Under reverse bias the resistance is very high.

Thus the *pin* diode may be used as an electrically variable resistance or attenuator. It uses at microwave frequencies are for switching and modulating microwave signals as well as an electrically variable attenuator. It can perform switching in a few nanoseconds and handle peak powers of hundreds of watts.

GUNN DIODE

The Gunn diode is one of the most important forms of a new family of microwave semiconductors which are used for directly generating microwave power from d.c. In view of their simplicity of operation and simple power supply requirements, Gunn diodes present an attractive alternative to the klystron valve.

The Gunn diode requires a power supply of a few volts d.c. which can be obtained from a battery as opposed to the reflex klystron which requires (typically) −150V d.c. for the reflector, +300V for the resonator, and 6·3V for the heater. At present Gunn diodes are rather expensive but already a Gunn diode transmitter with its battery can cost less than a klystron with its special power supply. Gunn diodes are available which can give up to 100mW of output power.

Gunn diodes are already being used in "mini-radar" systems for small boats, in burglar alarms, for counting, for measuring the speed of road traffic, and for many other applications where small size, simplicity of design and portability are important. Although simple in operation the mechanism of the Gunn diode requires some explanation.

The device is named after J. B. Gunn who discovered the phenomenon now called the "Gunn Effect" at the Watson Research Centre of I.B.M. in 1963.

GUNN DIODE CONSTRUCTION

Gunn diodes contain a tiny wafer of *n*-type gallium arsenide of thickness about 100µm mounted in a standard microwave diode encapsulation. The faces of the wafer constitute the two electrodes of the device, Fig. 10.

The wafer consists of a thin active layer of *n*-type gallium arsenide grown on a low resistivity substrate of the same material. The substrate is bonded to the anode terminal of the encapsulation and the other face of the wafer has an evaporated cathode contact connected by a bonded gold wire.

The Gunn diode has two terminals called the cathode and the anode. However, it is misleading to

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Voltage Gain: at 1KHz 30 dB.

Frequency Response: 5Hz to 60 KHz ± 1dB.

Total Distortion: less than 1% (typical 0·1%) at all output powers.

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TO3 Heat Sink. Suitable for most power transistors OC26, etc. This is aluminium, anodised black for maximum heat dissipation. Supplied complete with mica disc and insulation bushes. Price **10p** each or 10 for **90p**. Size approx. 2¾ × 2¾in.

12 Volt 500 M.A. Mains Transformers. Miniature type now available, price **55p** each or 10 for **£5**.

3 Core Flex, New Colours. (Brown for live, blue for neutral, yellow/green for earth.) This is completely p.v.c. covered and ribbed, virtually non-kinkable. Suitable for washing machines (without heaters) and all portable tools, lawn mowers, etc. Conductor size 23/36. **£1** per dozen yards or **£10** per 100yd coil.

MOTOR by A.E.I. 1/20 hp, 1,275 r.p.m. Self-starting for normal a.c. mains, a well made enclosed motor with standard 5/16in dia. shaft 1in long. Suitable for light power operation. Continuous rating. **£1·50** plus 20p post.

Instrument Motor by Evershed. Hysteresis motor—makers type No. FEX25-CG30—this is a capacitor start motor for 110V a.c. working double ended shaft—**£3·50** plus 20p post and insurance.

Cut and Prepared 3 Core Leads. 2yds long, p.v.c. covered and ribbed, virtually non-kinkable 23/36 conductors. Old colour scheme, **8p** each, 10 for **70p**. New colour scheme **15p** each or 10 for **£1·35**.

Hearing Aid Amplifiers (Ex behind ear deaf aids). 3 transistors on tiny P.C. board with volume control—whole thing about only half as big as Oxo cube. **£1·75** or with sub-miniature microphone and L.S. attached **£3·50**.

Totally Enclosed Mains Transformers with Primary for normal 230/240 50Hz mains and secondary rated at 4A 80V tapped at 75V and 70V. This is a very well made transformer totally enclosed in metal case. Size 4½in × 5¼in × 6½in high. Made to be mounted above chassis with terminations all on bottom. **£3·50** each plus 65p post.

8 AMP Variacs. 0–260V—panel mounting type—ex-unused equipment, fully guaranteed. **£10** each. Carriage: England £1; Wales and Scotland: £1·50.

Wafer Switches. Standard Size (1½ wafer) built to Post Office spec. good contacts and generally very reliable. 9 pole 3-way on 3 wafers, **45p**—10 for **£4**. ditto 2 pole 3-way, **20p**—10 for **£1·80**.

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Pointer Knobs. Bulgin brass insert type ref. No. K.357, black with white line down pointer grub screw fixing, **5p** each—10 for **45p**.

Jack-Socket Bulgin. Catalogue No. J14. This is a standard size panel mounting jack, with two leaf contact circuit switches incorporated. Makers recommended price 41p. Our price **30p** or 10 for **£2·70**.

Miniature Wafer Switch, 1 Pole 8-Way. This has a short spindle and is therefore suitable only for mounting through a metal panel. Price **12p** or 10 for **£1·08**.

24-Way Rotary Switch. Single pole, **£1·25**; double pole, **£1·95**.

Double pole, Double Throw Toggle Switch. Suitable for mains voltage and up to 10A. **15p** or 10 for **£1·35**.

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Fits in place of cigarette lighter. Useful method for making a quick connection into the car electrical system. **38p** each or 10 for **£3·42**.

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13A self-fixing into an oblong hole, size approximately 1in × ¾in **6p** each, 10 for **54p**.

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Single pole	**25p** each	10 for **£2·25**
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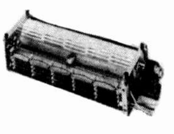
(A 15A Switch) Just the thing if you want to come home to a warm house without it costing you a fortune. You can delay the swtch on time of your electric fires, etc., up to 14 hours from setting time or you can use the switch to give a boost period of up to 3 hours. Equally suitable to control processing. Regular price probably around £5. Special snip price **£1·50**, p. & ins. 23p.

OUT OF SEASON BARGAIN
TANGENTIAL HEATERS



Once again we are able to make a special bargain offer of these very popular heating units. Tangential heaters although brought out a few years ago are still the latest and best type as nothing has yet been made which could be called an improvement on them. The Tangential unit is still the only one used in good quality heaters made by Hoover, G.E.C. and all the famous names. The unit comprises quiet running a.c. induction motor with special bearings, the tangential impeller and a 2 section heater element which allows switching half and full heat in the case of the 2 kW and one-third—two-thirds and full heat in the case of the 3 kW. These heaters are also fitted with a safety cutout to cut the heaters should the impeller stop or the air flow be impeded. They are free standing and need only the simplest of cases, even a wooden cabinet is suitable or the plinth of the kitchen cabinet. Lots of customers missed our special Summer offer of these heaters last year so order early. 200/240 2 kW model **£2·50**. 200/240 3 kW model **£3·50**. Control switch heaters only **25p** or two-heat, cold-blow and off **35p**. Postage and insurance 33p on heaters.

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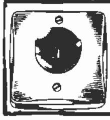
LIGHT DIMMER



For any lamp up to 200W. Mounted on switch plate to fit in place of standard switch. Virtually no radio interference. Price **£1·99** plus 20p post & ins.

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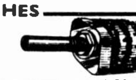
STANDARD WAFER SWITCHES

Standard size 1½ 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	40p	40p	40p	40p	40p	40p	40p	40p	40p
2 poles	40p	40p	40p	40p	40p	40p	40p	70p	70p
3 poles	40p	40p	40p	40p	70p	70p	70p	95p	95p
4 poles	40p	40p	40p	70p	70p	70p	70p	£1·20	£1·20
5 poles	40p	40p	70p	70p	95p	95p	95p	£1·45	£1·45
6 poles	40p	70p	70p	70p	95p	95p	95p	£1·70	£1·70
7 poles	70p	70p	70p	95p	£1·20	£1·20	£1·20	£1·95	£1·95
8 poles	70p	70p	70p	95p	£1·20	£1·20	£1·20	£2·20	£2·20
9 poles	70p	70p	95p	95p	£1·20	£1·45	£1·45	£2·45	£2·45
10 poles	70p	70p	95p	£1·20	£1·45	£1·45	£1·45	£2·70	£2·70
11 poles	70p	95p	95p	£1·20	£1·70	£1·70	£1·70	£2·95	£2·95
12 poles	70p	95p	95p	£1·20	£1·70	£1·70	£1·70	£3·20	£3·20

INSTRUMENT SWITCHES

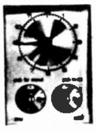


Precision made with diecast indexing mechanism Full length ¼in spindle 5A and silver plated contacts. Range except for 9 way is as standard wafer switches. Prices obviously higher. For 40p read **60p**, for 70p read **£1**, for 95p read **£1·40**, for £1·20 read **£1·80**, for £1·45 read **£2·20**. Note also 2 way types available up to 36 poles, 3 way 30 poles, 4 way 24 poles, 5 way 19 poles, but 10 and 12 way only available up to 6 poles.

3 STAGE PERMEABILITY TUNER

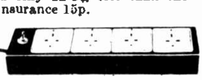
This Tuner is a precision instrument made for the famous Radiomobile Car Radio. It is a medium wave tuner (but set of longwave coils available as an extra if required with a frequency coverage 1620kHz–525kHz and intended to operate with an I.F. value of 470kHz. Extremely compact (size only 2¾ × 2 × ¾in thick) with reduction gear for fine tuning. With circuit of front end suitable for car radio or as a general purpose tuner for use with Amplifier. **65p.**

ELECTRIC CLOCK WITH 25 AMP SWITCH



Made by Smith's, these units are as fitted to many top quality cookers to control the oven. The clock is mains driven and frequency controlled so it is extremely accurate. The two small dials enable switch on and off times to be accurately set. Ideal for switching on tape recorders. Offered at only a fraction of the regular price—new and unused only **£2·50**, less than the value of the clock alone—post and insurance 15p.

DISTRIBUTION PANELS



Just what you need for work bench or lab. 4 × 13A sockets in metal box to take standard 13A fused plugs and on/off switch with neon warning light. Supplied complete with 7ft of heavy cable. Wired up ready to work. **£2·25** less plug, **£2·50** with fitted 13A plug; **£2·65** with fitted 15A plug plus **23p** P. & I.

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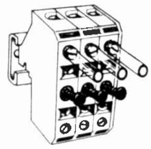
Model 772—small but powerful 1in pull—approx. size 1¼ × 1¼ × 1½in **60p.**
Model 400/1 ¾in pull. Size 2¾ × 2 × 1¾in **75p.**
Model TT10 1½in pull. Size 3 × 2¼ × 2¾in **£1·80** plus 20p post and ins.

XEE I/cs, relays and most parts available. Send for list

MAINS CONNECTOR



A quick way to connect equipment to the mains safely and firmly—L, N. and E, coded to new colour scheme; disconnection by plugs prevents accidental switching on; has sockets which allow insertion of meter without disconnection; cable inlets firmly hold one hair wire on up to four 7·029 cables. **85p** each.

MINIATURE WAFER SWITCHES

2 pole, 2 way—4 pole, 2 way—3 pole, 3 way—4 pole, 3 way—2 pole, 4 way—3 pole, 4 way—2 pole, 6 way—1 pole, 12 way. All at **18p.**

WATERPROOF HEATING ELEMENT

26 yards length 70W. Self-regulating temperature control. **50p** post free.

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2,400ft of the Best Magnetic Tape money can buy—users claim good results with Video and sound. 1in wide **£1·45** plus 33p post and insurance, with cassette. ¾in wide **£1·25** plus 30p post and insurance with cassette. ½in wide **£1** plus 25p post and insurance with cassette. Spare spools and cassettes—1in **£1**, ¾in **85p**, ½in **75p** each plus 20p post and insurance.

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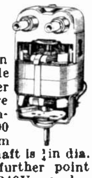

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think of it as a diode as it has no *pn* junction and cannot be used for rectification. When a few volts d.c. are applied to make the anode positive with respect to the cathode, the current which flows is d.c. with superimposed pulses as illustrated in Fig. 11.

In the case of a diode designed to work at 10GHz, the current pulses occur at 10^{-10} second intervals and can be used to induce oscillations in a cavity or waveguide resonator.

GUNN EFFECT

The Gunn effect is caused by high field regions called "domains" passing between the cathode and the anode. When the supply is connected a high field domain builds up at the cathode and drifts rapidly through the crystal to the anode. As the domain reaches the anode, a new domain forms at the cathode.

The transit time of the domains through the active layer determines the frequency of the pulses. The velocity of the domains has been measured experimentally and is known to be about $10^{11}\mu m/s$ and so a frequency of 10GHz (λ = 3cm) is obtained with a 10μm thickness.

As is well known, in the energy band diagram for semiconductor materials the valence and conduction bands are separated by an energy gap called the "forbidden gap". Electrons can be excited from the valence band to the conduction band by the application of energy, for example by heating the crystal or by the addition of donor atoms. However, this well-known concept does not explain the Gunn effect.

To explain the effect we must look more closely at the conduction band. This can in fact be divided into two regions—the normal conduction band and a higher energy "satellite" band. In the satellite band the effective mass of the electrons is higher and their mobility lower than in the normal conduction band, Fig. 12.

In *n*-type gallium arsenide the majority of the conduction band electrons can be excited into the satellite band by the application of a field of about 350V/mm. As this critical field is reached the electrons in the crystal become heavier and slow down.

This reduction in average velocity results in a negative resistance characteristic. For this phenomenon to occur, the energy gap between the normal conduction and satellite bands must be considerably smaller than the forbidden gap between valence and conduction bands, otherwise the application of the critical field would result in the transfer of electrons across the forbidden gap, and an increase rather than a decrease in the average velocity would result. Only a few known materials, notably gallium arsenide and gallium phosphide, have a suitable band structure.

ELECTRON MOBILITY

In an ordinary conductor under normal conditions the electron velocity increases linearly with the applied field (Ohm's law). In *n*-type gallium arsenide, however, the average velocity increases at first linearly with the field, Fig. 13 A to B and then, as the critical field of 350V/mm is reached and electrons begin to move into the low mobility satellite band, the average velocity begins to fall (point B). Eventually, as the field continues to increase and all the available electrons have moved into the satellite band, the velocity increases linearly again (C to D).

Clearly the region BC is one of negative resistance. However, the result of applying such a bias field to the wafer is not the same as for conventional negative resistance devices.

In practice the wafer is biased in the negative differential resistance region above the threshold value of 350V/mm. Many of the electrons coming into the crystal at the cathode are excited to the lower mobility satellite band and slow down. The situation where two types of carrier exist simultaneously is unstable and the lighter electrons flow away leaving a concentration of heavy ones behind.

It follows that there is a local increase in the field since, in the negative resistance region BC, a fall in average velocity is associated with an increase in field. Moreover the effect is cumulative since an increase in the field causes a further decrease in average velocity.

Hence a high field E_H builds up at the cathode whereas the field throughout the rest of the crystal falls to a low value E_L. The high field domain (E_H) drifts rapidly across the wafer to the anode.

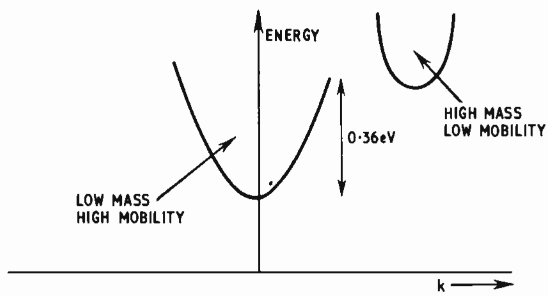


Fig. 12. Energy band diagram for gallium arsenide

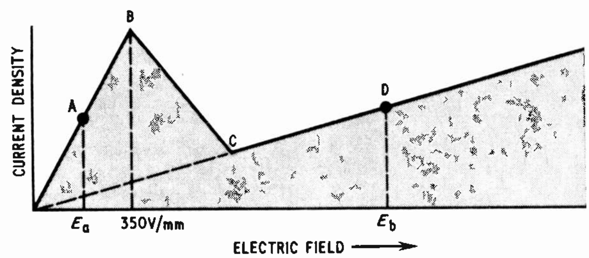


Fig. 13. Current density/electric field characteristic of an n-type gallium arsenide diode

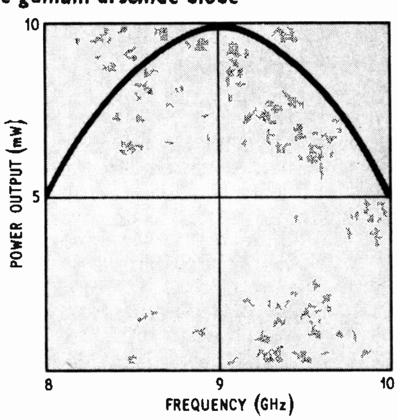


Fig. 14. Tuning characteristic for a Gunn oscillator

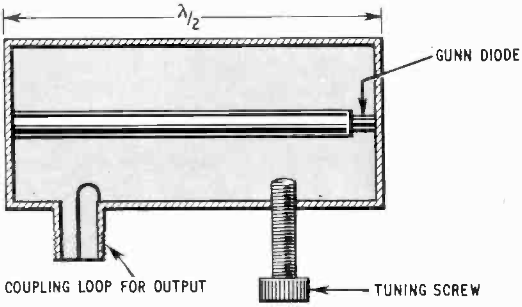


Fig. 15. Sectional view of a coaxial cavity Gunn oscillator

As the domain reaches the anode the bias supply again causes the field at the cathode to exceed the threshold of 350V/mm and a new domain is established. The action repeats continuously.

CHARACTERISTICS OF GUNN DIODES

From the above explanation of the Gunn Effect it is apparent that the frequency of oscillation depends on the thickness of the active layer of gallium arsenide 10μm at 10GHz). Whilst this is true, the device must be used in a cavity and the effect of the r.f. voltage in the cavity is to modify the transit time of the current pulses through the diode.

In practice it is found that a Gunn diode oscillator may be tuned up to one octave by tuning the cavity. Maximum power output occurs at or near the "normal" transit time frequency however (Fig. 14). Cavities may be constructed in either coaxial or waveguide form. A simple coaxial cavity is shown in Fig. 15.

By introducing a varactor diode into the cavity electronic tuning of the Gunn oscillator is possible up to a few per cent by varying the d.c. bias applied to the varactor. Such a combination of Gunn diode, cavity and varactor form a solid state equivalent of the klystron with the inherent advantages of modest power supply requirements and solid state reliability.

Gunn diodes are now commercially available from 4GHz to nearly 40GHz with power outputs from a few milliwatts to 100 milliwatts. Apart from being used in the traditional forms of microwave equipment the Gunn diode is already opening new fields of application for microwaves as mentioned above. Although the diodes are currently somewhat expensive for amateur construction projects the possibilities are many.

FUTURE FOR MICROWAVE SEMICONDUCTORS

So much innovation has occurred in this field during the last 10 years that it seems unlikely to be repeated in the 1970s. Although other new forms of device may be introduced there is bound to be an overriding trend to lower cost microwave semiconductors stimulating new microwave applications.

One way of producing cheaper microwave circuits is to eliminate the traditional "plumbing" required and substitute a thin film circuit. Transmission line components may be deposited onto a thin film substrate and microwave semiconductors bonded to this in chip form.

Already being introduced to professional systems, this technique is likely to have considerable impact in microwave applications in the years to come. ★

THERE are many situations in both recreational pursuits and in engineering, where it is necessary to measure a time interval to one-tenth of a second without employing expensive and complex equipment. The suggested design in this article gives a direct digital reading with tenths of a second and keeps the cost to a reasonably small figure.

MEASUREMENT READOUT

In most digital timers, the designs are based on the accurate generation of a basic frequency; then, with suitable gating circuits, the counting of the number of cycles passed whilst the gate is open. The accuracy of these timers is therefore mainly dependent on the frequency generator.

Although some of the cost is determined by the frequency generator accuracy, the major proportion of the cost is usually involved in the readout system. An inexpensive digital readout device is the electromagnetic counter, several versions being readily available on the surplus market.

The use of this counter does place a limitation on the smallest measurable time interval and hence the number of decimal figures, since the maximum speed of operation is 10Hz. Accepting this limitation allows an inexpensive design based on a minimum time measurement of 0·1 second to be constructed.

Fig. 1 shows the system block diagram. A simple astable or multivibrator circuit generates a square wave of 10Hz. When the gate is opened this square wave supply drives the counter at the same speed. If the gate is held open for 10·8 seconds, the counter will have counted 10 units for each second, i.e. a reading of 108. Marking in the decimal point gives a direct readout of 10·8 seconds.

DRIVE CIRCUIT

The multivibrator circuit is given in Fig. 2. The transistors can be any germanium types such as OC71 or OC72. Potentiometer VR1 controls the frequency of oscillation, and the square wave generated may be taken from the collector of either TR1 or TR2.

Fig. 3 shows a suitable drive circuit for the counter. The additional relay is necessary since the majority of low voltage counters available on the surplus market take currents that are too high for the OC72.

If it is required to eliminate the additional counter battery and relay, then it is often possible to remove the counter coil and replace it with a more suitable coil taken from a Post Office 600 type relay, as was done in the prototype.

CALIBRATION

The unit should be calibrated with the multivibrator driving the counter, so that any loading presented by the relay/counter unit is accounted for. This may be achieved by comparing the collector voltage waveform with that of a signal generator, producing a signal of 10Hz, on a double beam oscilloscope, or a direct reading frequency meter.

An alternative method is to measure the time taken for the counter reading to change from, say 0 to 3,000 (which should take five minutes) with a stop watch. In this case an accuracy of at least 6 counts in 3,000, i.e. 0·2% or better should be obtainable.

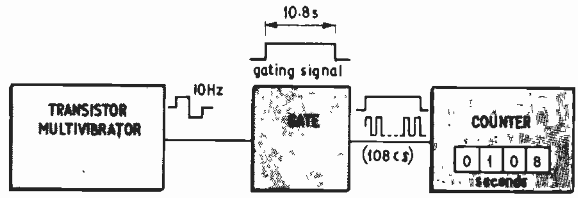


Fig. 1. Block diagram of the basic timing system

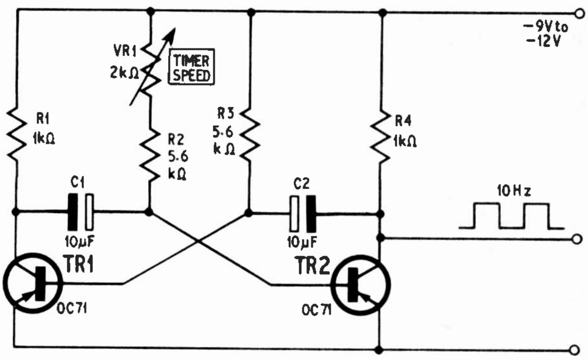


Fig. 2. Multivibrator oscillator used for providing clock pulses

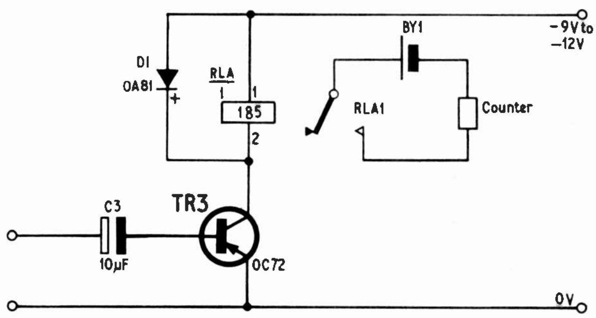
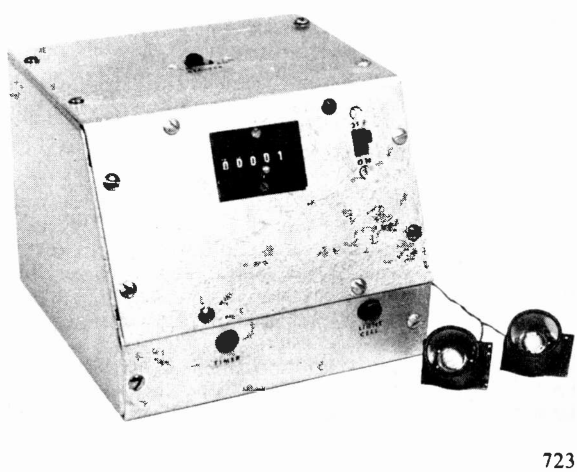
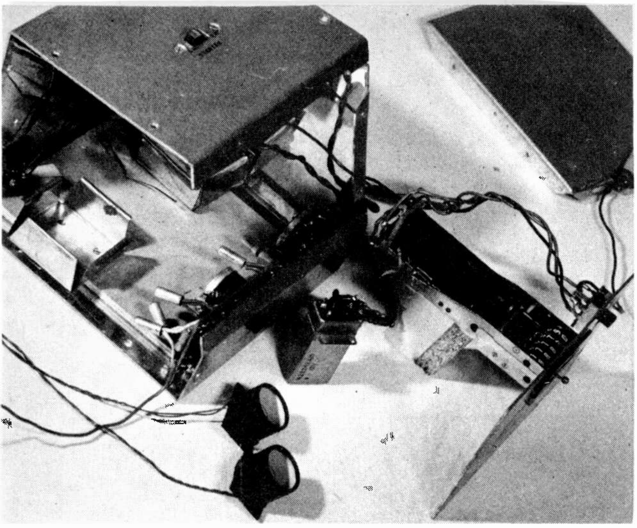
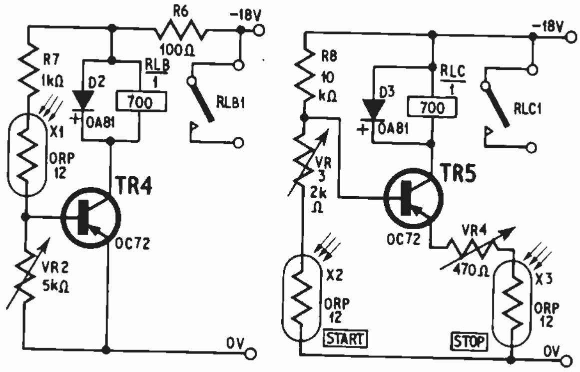


Fig. 3. Relay driver for operating the counter readout







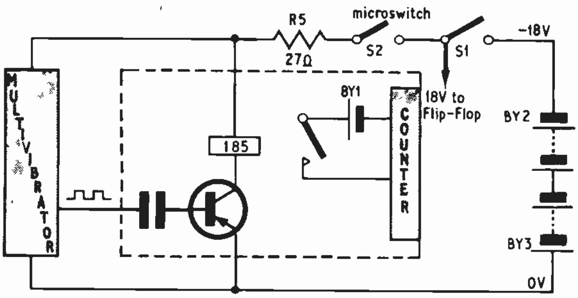


Fig. 4a. Multivibrator system using a microswitch to gate the clock pulses to the driver. The circuit for the multivibrator is in Fig. 2 and the relay driver in Fig. 3

COMPONENTS . . .

MULTIVIBRATOR AND RELAY DRIVER (Fig. 4a)

Resistors
- R1 1kΩ
- R2 5·6kΩ
- R3 5·6kΩ
- R4 1kΩ
- R5 27Ω
- All ±10%, ¼W carbon

Potentiometer
- VR1 2kΩ linear preset spindle type

Capacitors
- C1, C2, C3 10μF elect. 15V (3 off)

Transistors
- TR1, TR2 OC71 (2 off)
- TR3 OC72

Diode
- D1 OA81

Relay
- RLA 185Ω, 6V operate

Batteries
- BY1 Battery to operate counter
- BY2, BY3 9V type PP9 (2 off)

Switches
- S1 Single pole on/off toggle switch
- S2 Single pole on/off microswitch

Miscellaneous
- Digital Counter (ex-G.P.O. telephone charge meter) (see text)
- Veroboard, 0·15in matrix, 12 copper strips by 38 holes for whole project

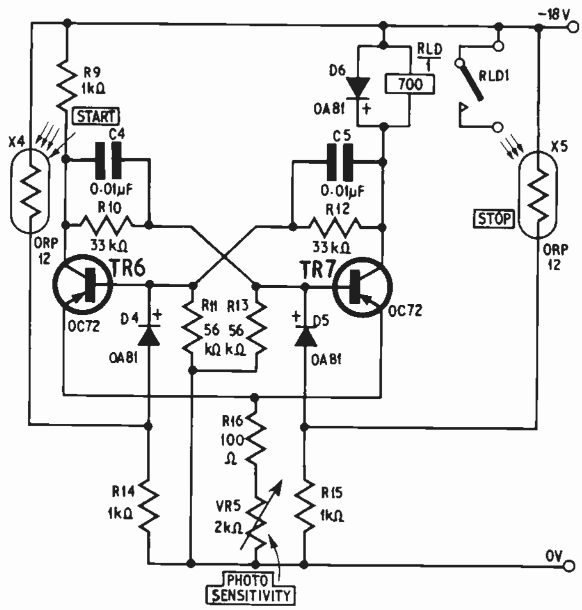


Fig. 4d. An improved stop start light sensitive circuit in the form of a flip-flop. Reloy RLD1 is used in ploce of S2 in Fig. 4o

COMPONENTS . . .

LIGHT-SENSITIVE FLIP-FLOP (Fig. 4d)

Resistors

R9	1kΩ	R13	56kΩ
R10	33kΩ	R14	1kΩ
R11	56kΩ	R15	1kΩ
R12	33kΩ	R16	100Ω

All ± 10%, ¼W carbon

Potentiometer
- VR5 2kΩ linear preset spindle type

Capacitors
- C4, C5 0·01μF

Transistors
- TR6, TR7 OC72 (2 off)

Diodes
- D4, D5, D6 OA81 (3 off)

Relay
- RLD 700Ω, 12V operate

Light sensitive cells
- X4, X5 ORP12 light dependent resistors 2 off)

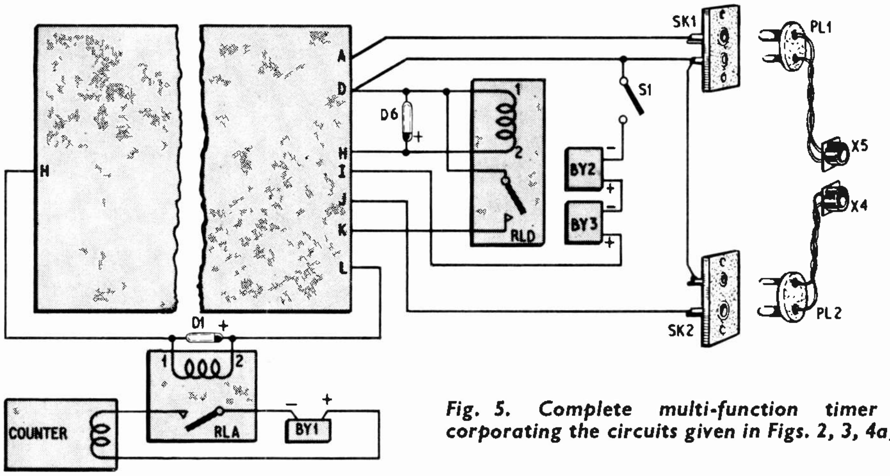


Fig. 5. Complete multi-function timer incorporating the circuits given in Figs. 2, 3, 4a, 4d

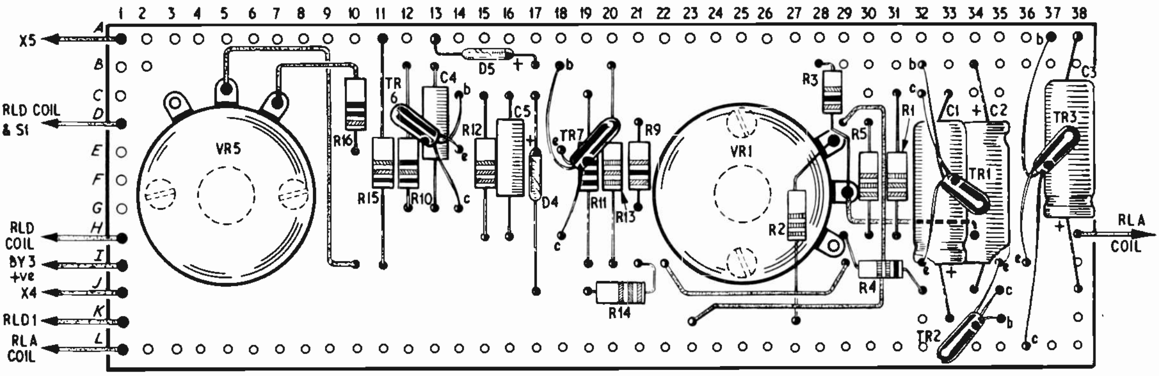


Fig. 6. Layout of components on Veroboard of system shown in Fig. 5. The copper strips must be cut at holes 25A, 25B, 25C, 24D, 25D, 25H, 24I, 25I, 25J, 25K

GATING CIRCUITS

To gate the unit, several methods are possible depending on the application of the timer. Basically, two alternatives are available: firstly, the d.c. supply line to the oscillator may be interrupted; secondly the output from the multi-vibrator may be interrupted. Both methods may have particular advantages, but in the prototype design the negative supply line was switched on and off by a relay.

Four possible gating methods are shown in Fig. 4. The first method (Fig. 4a) is the simplest, and is a single pole on/off switch such as a microswitch. This circuit could be employed for measuring the time taken for a moving object to pass a given point, so that the microswitch is held closed by the object. Alternatively, the switch could be held closed manually when the time for the object to pass between two points could be measured.

Fig. 4b indicates a photoresistor operated gate for a similar situation to that outlined above, the contacts on the relay replace the microswitch contacts. These methods could be used for sports events, photographic processing, machine speed measurement, batch counting and so on.

Fig. 4c shows a circuit whereby the passage of an object in front of the first cell X2 starts the timer, and the passage of an object in front of the second cell X3 stops the timer. This method was found to be satisfactory with the first model constructed, but the setting of VR3 and VR4 was found to be very critical.

Because of this, the more conventional bistable circuit (Fig. 4d) was adopted. Due to the additional transistor, diodes and other components, the circuit is more expensive, but the added reliability justifies its use in the majority of applications.

RESET CONTROL

An improvement may be to use a counter with a reset control, so that all the time reading will commence from zero readout. Unfortunately these units are much more costly, and some applications may not justify this additional expenditure. Resettable counters are obtainable but can cost a few pounds to buy. Further accuracy is possible by modifying the multivibrator to operate at 50Hz and to utilise a high speed counter.

CONSTRUCTION

A complete operational system using the basic system shown in Fig. 4a employs the following circuits for reliability, and the construction of the timer is based on these three: the multivibrator (Fig. 2); a gate unit (Fig. 4d); the drive unit (Fig. 3).

A Veroboard layout for this system is given in Fig. 6 and uses a board that has twelve copper strips each 38 holes long. The preset-potentiometers are fitted directly to the board, so that the only components not attached are the relays, with their associated diodes, the counter and miscellaneous

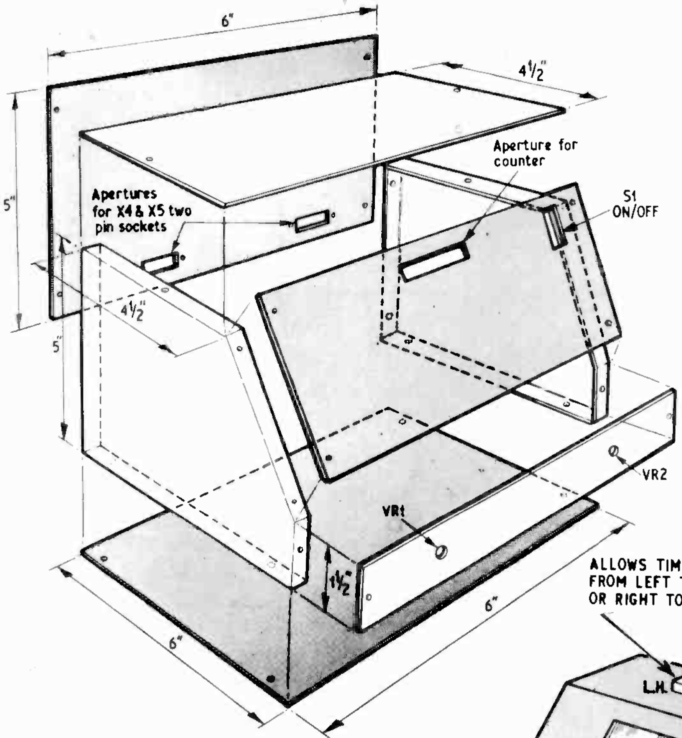
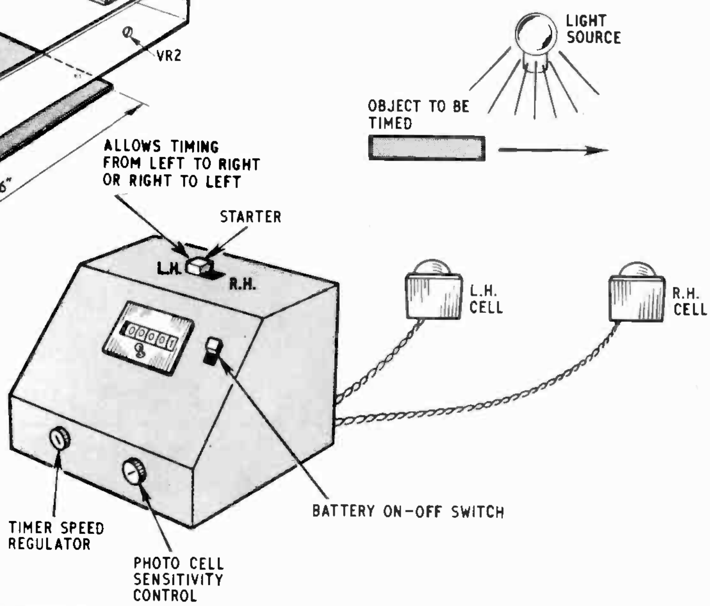


Fig. 7. Exploded view of the case showing drilling and assembly details

Fig. 8. Set-up of timer with two light sensitive cells for timing a moving object



hardwear such as switches, batteries, plugs and sockets. The use of "skeleton" or miniature potentiometers would enable a shorter length of Veroboard to be used.

The inter-unit wiring diagram is given in Fig. 5. This assumes that the counter requires the additional relay in the drive unit, and the extra battery. The counter used in the prototype had a coil which took only a few milliamperes, so that this directly replaced the relay RLA.

One suitable form of case (Fig. 7) is constructed from 18 s.w.g. or 20 s.w.g. aluminium sheet. Two end pieces are folded as indicated, and the flat top panel, rear, base, lower front and instrument panels fastened to the end pieces with self tapping screws. Alternatively, if bending proves too difficult, the end pieces may be cut from ⅜in thick plywood, and the panels screwed to them.

A slide switch S1 is used to isolate the batteries when the timer is not in use. One refinement on the prototype was to use a two-pole, two-way slide switch in conjunction with the two cells, so that the triggering sequence of the cells could be reversed. For example, switch position 1: cell 1 starts the timer, cell 2 stops the timer; switch position 2 reverses the operation. See Fig. 8.

LIGHT SENSORS

Each l.d.r. is soldered to a small piece of Veroboard. Light shields for these may be made from small cardboard tubes (such as is found for containing sweets) and glued to the cells, to keep out unwanted stray light. The leads are fitted with miniature two-pin plugs to fit the sockets on the rear panel of the case.

Penlight torches are used as light projectors for the cells, as they produce a narrow concentrated beam of light, and are easily fitted in the required positions with adhesive tape.

OPERATION

Connect the two photo-sensitive l.d.r.s into the sockets on the rear of the case. Place the cells in bright daylight or average (not brilliant) artificial lighting. Switch on the supply. With the "starter" switch selecting "L.H.", and the right-hand cell covered with the hand or a piece of card, the counter should stop. If it does not, adjust the sensitivity control until it does. This should now be set for normal operation. Normally, when the L.H. cell is covered the timer should start; when covering the R.H. cell it should stop. Moving the "starter" switch to R.H. will reverse the cell effects. ★

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2N1306	25p
2N1307	25p
2N1308	25p
2N1309	25p
2N1613	22p
2N1711	25p
2N2147	75p
2N2160	60p
2N2218	20p
2N2219	20p
2N2222	20p
2N2222A	25p
2N2369	20p
2N2484	35p
2N2646	50p
2N2904	20p
2N2904A	25p
2N2905	25p
2N2906	20p
2N2906A	25p
2N2907	23p
2N2926	10p
2N3011	25p
2N3053	20p
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2N4061	15p
2N5457	35p
2N5458	37p
2N5459	50p
2S301	50p
2S302	50p
2S303	60p
2S304	75p
40250	50p
40361	50p
40362	55p
AAY30	10p
AAY42	15p
AAZ13	12p
AAZ17	10p
AC107	37p
AC126	25p
AC127	25p
AC128	25p
AC176	25p
AC187	30p
AC188	30p
ACY17	30p
ACY18	25p
ACY19	25p
ACY20	20p
ACY21	20p
ACY22	16p
ACY39	50p
ACY40	15p
AD140	50p
AD149	50p
AD161	37p
AD162	37p
AF114	25p
AF115	25p
AF116	25p
AF117	25p
AF118	62p
AF124	25p
AF125	20p
AF126	17p
AF127	17p
AF139	30p
AF178	47p
AF179	65p
AF180	52p
AF181	42p
AF186	40p
AF239	40p
ASY26	25p
ASY27	32p
ASY28	25p
ASY29	30p
ASY67	47p
ASZ21	42p
BA115	7p
BA164	10p
BAX13	6p
BAX16	7p
BAY31	7p
BAY38	17p

BC107	12p
BC108	12p
BC109	12p
BC113	15p
BC114	25p
BC115	20p
BC116	25p
BC116A	30p
BC118	25p
BC119	35p
BC134	25p
BC135	20p
BC136	22p
BC137	25p
BC138	25p
BC147	17p
BC148	12p
BC149	20p
BC154	37p
BC157	20p
BC158	17p
BC159	20p
BC169C	15p
BC177	25p
BC178	25p
BC179	27p
BC182L	12p
BC183L	12p
BC184L	15p
BC212	12p
BCY30	25p
BCY31	30p
BCY32	50p
BCY33	25p
BCY34	30p
BCY38	40p
BCY39	85p
BCY40	50p
BCY58	25p
BCY59	25p
BCY70	15p
BCY71	20p
BCY72	15p
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BFX86	25p
BFX87	25p
BFX88	20p
BFY18	30p
BFY50	22p
BFY51	20p
BFY52	22p
BFY53	17p
BFY90	65p
BSX20	17p
BSX21	20p
BSX76	15p
BSY95	15p
BSY95A	15p
BY100	15p
BY126	15p
BY127	20p
BY182	85p
BYZ10	40p
BYZ11	35p
BYZ12	30p

BYZ13	25p
BYZ15	£1·00
GET880	37p
MAT100	25p
MAT101	30p
MAT120	25p
MAT121	30p
MJ2801	£1·37
MJ2901	£2·25
MJE370	97p
MJE520	87p
MJE2955	£1·37
MJE3055	87p
MPF102	42p
MPF103	35p
MPF104	37p
MPF105	40p
NKT217	40p
NKT277	20p
NKT403	75p
NKT404	62p
OA5	20p
OA9	10p
OA10	25p
OA47	10p
OA70	10p
OA73	10p
OA79	10p
OA81	10p
OA85	12p
OA90	10p
OA91	7p
OA95	7p
OA200	7p
OA202	10p
OC16	50p
OC20	97p
OC22	50p
OC23	60p
OC24	60p
OC25	37p
OC26	25p
OC28	60p
OC29	60p
OC35	50p
OC36	60p
OC41	25p
OC42	30p
OC43	40p
OC44	17p
OC45	15p
OC70	12p
OC71	15p
OC72	25p
OC73	30p
OC74	30p
OC75	25p
OC76	25p
OC77	40p
OC81	25p
OC82	25p
OC83	25p
OC84	25p
OC139	25p
OC140	37p
OC141	62p
OC170	25p
OC171	30p
OC200	40p
OC201	70p
OC202	80p
OC203	40p
OC204	40p
OC205	75p
OC206	90p
OC207	90p
OCP71	97p
ORP12	50p
ORP60	40p
ORP61	42p
TIP29A	50p
TIP30A	60p
TIP31A	62p
TIP32A	75p
TIP33A	£1·00
TIP34A	£2·00
TIS43	40p
TIS60	22p
TIS61	25p
TIS62	27p
ZTX107	15p
ZTX108	15p
ZTX300	12p
ZTX301	15p
ZTX302	20p
ZTX303	20p
ZTX304	25p
ZTX500	20p
ZTX501	25p
ZTX502	25p
ZTX503	20p
ZTX504	40p
ZTX531	30p

DISCOUNTS
10% 12+
15% 25+
20% 100+
Any one type

HENRY'S LOW COST INTEGRATED CIRCUITS

WE OFFER FROM STOCK AN EXCLUSIVE RANGE OF BRAND NEW FULL SPECIFICATION LOW COST TTL 7400 RANGE OF INTEGRATED CIRCUITS

Part No.	Ceramic Description	1-24	25-99	100	250+
7400	Quadruple 2-input NAND Gate	23p	20p	15p	13p
7401	Quadruple 2-input Positive NAND Gate (with open collector output)	23p	20p	15p	13p
7402	Quadruple 2-input Positive NOR Gates	23p	20p	15p	13p
7403	Quadruple 2-input Positive NAND Gates (with open collector output)	23p	20p	15p	13p
7404	Hex Inverters	23p	20p	15p	13p
7405	Hex Inverter with open collector	23p	20p	15p	13p
7410	Triple 3-input Positive NAND Gates	23p	20p	15p	13p
7413	Dual 4-input Schmitt Trigger	35p	32p	29p	25p
7420	Dual 4-input Positive NAND Gates	23p	20p	15p	13p
7430	8-input Positive NAND Gates	23p	20p	15p	13p
7440	Dual 4-input Positive NAND Buffers	23p	20p	15p	13p
7441	BCD to decimal nixie driver	87p	77p	66p	60p
7442	BCD to decimal decoder (4-10 lines, 1 of 10)	87p	77p	67p	60p
7447	BCD-Seven-Segment Decoder/Drivers (15-V Outputs)	£1·40	£1·30	£1·20	£1·05
7450	Expandable dual 2-input AND-OR-INVERT	23p	20p	15p	13p
7451	Dual 2-wide 2-input AND-OR-INVERT GATES	23p	20p	15p	13p
7453	Quad 2-input Expandable AND-OR-INVERT	23p	20p	15p	13p
7454	4-wide 2-input AND-OR-INVERT Gates	23p	20p	15p	12p
7460	Dual 4-input Expander	23p	20p	15p	13p
7470	Single-phase J-K Flip-Flop	35p	32p	29p	25p
7472	Master-slave J-K Flip-Flop	35p	32p	29p	25p
7473	Dual Master slave J-K Flip-Flop	43p	40p	37p	33p
7474	Dual O tyoe Flip-Flop	43p	40p	37p	33p
7475	Quad latch	47p	45p	43p	40p
7476	Dual J-K with pre-set and clear	47p	45p	43p	40p
7480	Gated Full Adders	87p	77p	67p	60p
7481	16-bit read/write memory	£1·35	£1·25	£1·15	£1·00
7482	2-bit Binary Full Adders	£1·30	£1·20	£1·00	85p
7483	Quad Full Adder	87p	77p	67p	60p
7486	Quad 2 input Exclusive OR Gates	80p	70p	60p	50p
7490	BCD decade counter	87p	77p	67p	60p
7491	8-bit Shift Registers	£1·21	£1·00	87p	75p
7492	Divide-by-Twelve Counters	87p	77p	67p	60p
7493	4-bit Binary Counters	87p	77p	67p	60p
7494	Dual entry 4-bit shift register	87p	77p	67p	60p
7495	4-bit up-down shift register	87p	77p	67p	60p
7496	5-bit Parallel in parallel out Shift Register	87p	77p	67p	60p
74100	8-bit Bistable Latches	£1·75	£1·65	£1·65	£1·35
74118	Hex Set-Reset Latches	£1·30	£1·20	£1·00	85p
74121	Monostable Multivibrators	87p	77p	67p	60p
74141	BCD-to-Decimal Decoder/Driver	87p	77p	67p	60p
74145	BCD-to-Decimal Decoder/Drivers	£1·80	£1·70	£1·60	£1·50
74151	8-bit Data Selectors (with Strobe)	£1·40	£1·30	£1·20	£1·05
74153	Dual 4-Line-to-1-Line Data Selectors/Multiplexers	£1·40	£1·30	£1·20	£1·05
74191	Binary Counter reversible	£3·50	£3·25	£3·00	£2·50

Price and Qty.

Devices may be mixed to qualify for quantity price.
Data available for above series in booklet form, price **10p.** (*Ref No.* 30).
Larger quantity prices Extn. 4. Dual Inline 14 Pin Socket 30p each 16 Pin 35p each.

SILICON RECTIFIERS

1 AMP MINIATURE WIRE ENDED PLASTIC RECTIFIERS

Type	P.I.V.	1-49	50+	100+	500+	1000+
IN4001	50	8p	7p	6p	5p	4p
IN4002	100	9p	8p	7p	5½p	4½p
IN4003	200	10p	9p	7½p	6p	5p
IN4004	400	10p	9p	8p	7p	6p
IN4005	600	12p	10p	9p	7p	7p
IN4006	800	15p	14p	12p	11p	9p
IN4007	1000	20p	16p	13p	12p	10p

1.5 AMP MINIATURE WIRE ENDED PLASTIC RECTIFIERS

Type	P.I.V.	1-49	50+	100+	500+	1000+
PL4001	50	10p	9p	8p	7p	6p
PL4002	100	11p	10p	9p	8p	7p
PL4003	200	12p	11p	10p	9p	8p
PL4004	400	12p	11p	10p	9p	8p
PL4005	600	15p	13p	11p	10p	9p
PL4006	800	17p	15p	13p	12p	10p
PL4007	1000	20p	17p	15p	13p	11p

3 AMP PLASTIC WIRE ENDED RECTIFIERS

Type	P.I.V.	1-49	50+	100+	500+	1000+
PL7001	50	20p	18p	17p	16p	14p
PL7002	100	20p	19p	18p	17p	15p
PL7003	200	22p	20p	19p	18p	16p
PL7004	400	25p	23p	21p	20p	18p
PL7005	600	26p	24p	23p	22p	20p
PL7006	800	27p	25p	24p	23p	21p
PL7007	1000	30p	28p	26p	24p	22p

POTTED BRIDGE RECTIFIERS (SILICON) SIZE ½ x ½ x ¾ins.

Type	P.I.V.	Current	1-49	50+	100+	500+
1002	100	2 amps	60p	55p	50p	45p
2002	200	2 amps	70p	65p	60p	55p
4002	400	2 amps	80p	75p	70p	65p
1004	100	4 amps	70p	60p	55p	50p
2004	200	4 amps	75p	70p	65p	60p
4004	400	4 amps	80p	75p	70p	65p
6002	600	2 amps	90p	80p	75p	70p
6004	600	4 amps	90p	80p	75p	70p
1006	100	6 amps	75p	70p	65p	60p
2006	200	6 amps	80p	75p	70p	65p
4006	400	6 amps	£1·10	£1·00	90p	80p
6006	600	6 amps	£1·25	£1·10	£1·00	90p

INTEGRATED CIRCUITS

MCFC4000P	£1·12	LA709C	65p
I.C. 12	£2·75	MC1304	£2·75
PA246	£2·45	MC724P	60p
TAA263	75p	741c (T05)	85p
TAD100	£1·97	741c (DIL)	85p
TAD110	£1·97	709c (T05)	65p
MC1303	£2·60	709c (DIL)	65p
UL900	40p	Toshiba 20 watt Amp	£4·47
UL914	40p	Toshiba PreAmp	£1·50
UL923	40p		

ZENER DIODES

400 M/W 5% Miniature
BZY 88 Range. All voltages 3·3–33 Volt. **15p** each.
25+ 12p; 100+ 10p; 500+ 8p; 1000+ 6p. Any one type.
1½ Watt 5% Metal case. Wire Ends.
6·8V. all voltages to 100V. **25p** each.
25+ 22p; 100+ 19p; 500+ 17p; 1000+ 15p. Any one type.
3 Watt Plastic Wire Ends 5%
All voltages 6·8–100V. **30p** each.
25+ 27p; 100+ 25p; 500+ 23p; 1000+ 21p. Any one type.
10 Watt Stud Mounting 5%
All voltages 5·1–100V. **40p** each.
25+ 37p; 100+ 35p. Any one type.

TRIACS

(All stud mounting)

Type	P.I. Volts	Current	1-49	50+	100+
SC35A	100	3 amps	90p	75p	65p
SC35B	200	3 amps	95p	80p	70p
SC35D	400	3 amps	£1·00	85p	75p
SC40A	100	6 amps	£1·00	85p	75p
SC40B	200	6 amps	£1·20	£1·00	85p
SC40D	400	6 amps	£1·25	£1·10	£1·00
SC45A	100	10 amps	£1·25	£1·10	£1·00
SC45B	200	10 amps	£1·35	£1·20	£1·10
SC45D	400	10 amps	£1·50	£1·35	£1·20
SC50A	100	15 amps	£1·65	£1·50	£1·35
SC50B	200	15 amps	£1·75	£1·60	£1·45
SC50D	400	15 amps	£2·00	£1·75	£1·60
SC40E	500	6 amps	£1·50	£1·25	£1·10
SC45E	500	10 amps	£1·75	£1·50	£1·35
SC50E	500	15 amps	£2·25	£2·00	£1·75

DIAC ST2 20p
Larger quantity prices Extn. 4

SEMI-CONDUCTORS

LOOK AT THESE PRICES FOR QUANTITIES FROM STOCK

AF114 Mullard **25p**
25 + 20p
100 + 17p
500 + 15p

AF115 Mullard **25p**
25 + 20p
100 + 17p
500 + 15p

AF116 Mullard **25p**
25 + 20p
100 + 17p
500 + 15p

AF117 Mullard **25p**
25 + 20p
100 + 17p
500 + 15p

2N3055 75p
Mullard 115watt Silicon Power
25 + 65p
100 + 50p

2N3819 Texas **35p**
25 + 30p
100 + 25p
500 + 20p
1000 + 18p

BFY90 65p
1000 MC/S
25 + 60p
100 + 55p
500 + 50p

2N2646 40p
Motorola Unijunction
25 + 35p
100 + 30p
500 + 25p

AF139 30p
Siemens V.H.F.
25 + 25p
100 + 22p
500 + 19p

AF186 40p
Mullard V.H.F.
25 + 35p
100 + 30p
500 + 25p

OC170 Mullard **25p**
25 + 21p
100 + 17p
500 + 15p

BYZ13 25p
Mullard 6a 200v
25 + 20p
100 + 17p
500 + 15p

OC171 Mullard **30p**
25 + 27p
100 + 22p

BC107, BC108, BC109 12p each
I.T.T. Planars
25 + 11p
100 + 10p
500 + 8p

BY127 Mullard **20p**
1000v 1 amp Plastic
25 + 17p
100 + 15p
500 + 13p

OCP71 97p
Mullard Photo
25 + 85p
100 + 80p
500 + 75p

BC113 SGS **15p**
25 + 13p
100 + 11p
500 + 9p

OA202 10p
SILICON Diodes
25 + 8p
100 + 6p
500 + 5p
1000 + 4p

OC28 62p
Mullard Power
25 + 55p
100 + 50p
500 + 42p

OC42 Mullard **30p**
25 + 25p
100 + 23p
500 + 21p
1000 + 18p

OC71 Mullard **15p**
25 + 12p
100 + 10p
500 + 8p

OC45 Mullard **15p**
25 + 13p
100 + 12p
500 + 10p
1000 + 8p

ORP12 Mullard **50p**
25 + 45p
100 + 42p
500 + 40p

OC75 Mullard **25p**
25 + 21p
100 + 17p
500 + 15p
1000 + 13p

2N930 25p
25 + 23p
100 + 20p
500 + 17p
1000 + 15p

OC20 97p
Mullard 100v
25 + 85p
100 + 80p
500 + 75p

OC72 Mullard **25p**
25 + 20p
100 + 17p
500 + 15p
1000 + 13p

OC44 Mullard **17p**
25 + 15p
100 + 13p
500 + 11p
1000 + 10p

OC83 25p
25 + 20p
100 + 17p
500 + 15p
1000 + 13p

OC139 Mullard **25p**
25 + 20p
100 + 17p
500 + 15p

OC84 25p
25 + 20p
100 + 17p
500 + 15p
1000 + 13p

OC81 Mullard **25p**
25 + 20p
100 + 17p
500 + 15p

AF239 42p
25 + 35p
100 + 30p
500 + 25p
1000 + 20p

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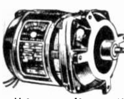
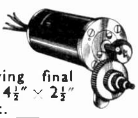
VARIABLE VOLTAGE TRANSFORMERS

BODINE TYPE N.C.I. GEARED MOTOR



(Type 1) 71 r.p.m. Torque 10lb. inch. Reversible. 1/70th h.p., 50 cycle, 0·38 amp. (Type 2) 28 r.p.m. Torque 20lb. inch. Reversible. 1/80th h.p., 50 cycle, 0·28 amp. "As new" condition. Input voltage of motor 115V a.c. Supplied complete with transformer for 230/240V a.c. input. Price, either type £3·15 plus 35p P. & P. or less transformer £2·13 plus 27p P. & P.

12 VOLT DC MOTOR



Powerful 1 amp. REVERSIBLE motor. Speed 3,750 RPM complete with external gear train (removable) giving final speed of 125 RPM. Size: 4½" × 2½" dia. Price 95p inc. post.

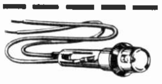
230V/240V COMPACT SYNCHRONOUS GEARED MOTORS

Manufactured by either Sangamo, Haydon or Smith. Built-in gearbox.
1 rev. per hour. Clockwise rotation.
1 rev. per hour. Anti-clockwise rotation.
2 revs. per hour. Clockwise rotation.
3 revs. per hour. Anti-clockwise rotation.
5 revs. per hour. Anti-clockwise rotation.
60 revs. per hour. Clockwise rotation.
Fraction of makers' price. All at 75p incl. P.&P.

ALARM BELL

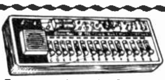
Mfg. by GENTS. 6 inch bell, 3/6 volt D.C. operation. As NEW. Only £1·50 plus 45p P. & P.

200-250V A.C. NEON INDICATOR



Available in red or amber at 20p each. Or in green at 32p each. Minimum order 3 units. P. & P. 5p.

ELECTRONIC ORGAN KIT



Easy to build, Solid State. Two full octave (less sharps and flats). Fitted hardwood case. Powered by two penlite 1½V batteries. Complete set of parts including speaker, etc., together with full instructions and 10 tunes. Price £3·00. P. & P. 22p.

50 in 1 ELECTRONIC PROJECT KIT

50 easy to build Projects. No soldering, no special tools required. The kit includes Speaker, Meter, Relay, Transformer, plus a host of other components and a 56-page instruction leaflet. Some examples of the 50 possible Projects are: Sound Level Meter, 2 Transistor Radio, Amplifier, etc. Price £7·75. P. & P. 30p.

CRYSTAL RADIO KIT

Complete set of parts, including: Crystal Diode, Ferrite Aerial, Drilled Chassis, and Personal Ear Piece. No soldering, easy to build, full step by step instructions. £1·75 inc. post.

230v AC SOLENOID

Extremely powerful with approx. 14lb. pull, 1" travel. Fitted with mounting feet. Size: 4" long, 2¼" wide, 3" high. £2·00 incl. P. & P.

230-250V SOLENOID

Mfg. by Westool, approx. 1½lb pull (similar in appearance to above illustration). Size of feet 1½" × 1$\frac{3}{16}$". Price 85p incl. Post.

VENNER Electric Time Switch

200/250V Ex. GPO. Tested. Manually set 2 on, 2 off every 24h. Override switch: 10A £2·75, 15A £3·25, 20A £3·75. P. & P. 20p. Also available with solar dial ON dusk, OFF dawn. Price as above.

INPUT 230/240V a.c. 50/60 OUTPUT VARIABLE 0-260V.
All Types (and Spares) from ½ to 50 amp from stock.

SHROUDED TYPE
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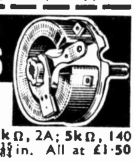
5 amp, £9.75. 8 amp, £14·50.
10 amp, £18·50. 12amp, £21·00
15 amp, £25·00. 20 amp, £37·00. 37·5 amp, £72·00. 50 amp, £92·00. Carr. extra.

2·5 AMP

OPEN TYPE (Panel Mounting) ½ amp, £3·93.
1 amp, £5·50. 2½ amp, £6·63. Carr. 40p on open types.

Superior Quality Precision Made NEW POWER RHEOSTATS



100 WATT. 1 ohm, 10A; 5 ohm, 4·7A; 10 ohm, 3A; 25 ohm, 2A; 50 ohm, 1·4A; 100 ohm, 1A; 250 ohm, 0·7A; 500 ohm, 0·45A; 1 kΩ, 280 mA; 1·5 kΩ, 230 mA; 2·5 kΩ, 2A; 5kΩ, 140 mA. Diameter 3½in Shaft length ⅝in, dia. $\frac{13}{32}$in. All at £1·50 each. P. & P. 5p.

50 WATT. 1/5/10/25/50/100/250/500/1/1·5/2·5/5kΩ. All at £1·12 each. P. & P. 11p.

25 WATT. 10/25/50/100/250/500/1/1·5/2·5/5kΩ. All at 78p each. P. & P. 15p.

STROBE! STROBE! STROBE!

Build a Strobe Unit, using the latest type Xenon white light flash tube. Solid state timing and triggering circuit. 230/250V a.c. operation.

EXPERIMENTERS' ECONOMY KIT
Speed adjustable 1 to 36 Flash per sec. All electronic components including Veroboard S.C.R. Unijunction Xenon Tube and instructions £6·30 plus 25p P. & P.

NEW INDUSTRIAL KIT
Ideally suitable for schools, laboratories, etc. Roller tin printed circuit. New trigger coil, plastic thyristor. Speed adjustable 1–80 f.p.s. Price £10·50. P. & P. 50p.

HY-LYGHT STROBE MK III
This strobe has been designed and produced for use in large rooms, halls and the photographic field, and utilizes a silica plug-in tube for longer life expectancy, printed circuit for easy assembly, also a special trigger coil and output capacitor. Speed adjustable 0–30 f.p.s. Light output approx. 4 joules. Price £12·00. P. & P. 50p.

AND NOW! THE 'SUPER' HY-LYGHT KIT

Approx. four times the light output of our well proven Hy-Lyght strobe.
incorporating:
- Heavy duty power supply.
- Variable speed from 1–23 flash per sec.
- Fantastic Octal based tube with massive electrodes.
- Reactor control circuit producing an intense white light.

The brilliant light output of the "SUPER" HY-LYGHT gives fabulous effects with colour filters.
Never before a Strobe Kit with so HIGH an output at so LOW a price. ONLY £20 plus 75p P. & P.

7-inch POLISHED REFLECTOR
Ideally suited for above Strobe kits. Price 53p. P. & P. 13p or post paid with kits.

RELAYS SIEMENS, PLESSEY, Etc.

MINIATURE RELAYS · COMPETITIVE PRICES

1	2	3	4	1	2	3	4
45	6–9	2 HD M	50p	700	12–24	2 c/o	63p*
185	6–12	2 c/o	63p*	700	15–35	2 c/o HD	73p*
185	6–12	4 c/o	73p*	700	16–24	6M	63p*
230	9–12	4 c/o	78p*	1,250	24–36	4 c/o	63p*
280	9–12	2 c/o	73p*	2,500	36–45	6M	63p*
600	18–32	4 c/o	78p*	2,400	30–48	4 c/o	50p
700	16–24	4M 2B	63p*	5,800	40–70	4 c/o	63p*
700	16–24	4 c/o	78p*	9,000	40–70	2 c/o	50p*
				15k	85–110	6M	50p*

(1) Coil ohms; (2) Working d.c. volts; (3) Contacts; (4) Price
(HD) Heavy Duty. All Post Paid. *Including Base.

MAINS RELAY
230V a.c. coil 3 c/o. 10 amp a.c. contacts, 50p plus 8p P. & P.

MOTOROLA MAC 11/6 PLASTIC TRIAC 400 PIV, 8 AMP

Now available EX STOCK. Supplied with full data and applications sheet. Price £1·05. P. & P. 7p.
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BOOK REVIEWS

A DICTIONARY OF ELECTRONICS—Third Edition

Compiled by S. Handel
Published by Penguin Reference Books
413 pages, $6\frac{1}{8}$in × $4\frac{3}{8}$in. Price 45p

To COMPILE a dictionary of any kind is no small task and of those currently available in the electronics field, this Penguin paperback gives by far the best value for money. To add to the data given above, there are 185 designated diagrams plus numerous "thumb-nail" drawings of circuit symbols against appropriate references. All the descriptions and diagrams are concise and easy to understand; cross-references are also given to related expressions in a distinctive type face.

Whilst Mr Handel readily admits in the Preface that omissions are inevitable due either to oversight or the need for avoiding over complication, one must give full credit for keeping up-to-date with such a useful work. Since the second edition was first published five years ago, a great many changes in electronics have brought to light several new entries.

On the subject of acronyms, many have had to be left out; the author feels that he needs a RED PENCIL—a Reliable Electronic Device for Printing Every Name Composed of Initial Letters.

M.A.C.

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THREE titles in a series of revision texts designed to cover a first degree course in electrical engineering and HNC, HND and CEI examinations. The books are based on a series of question and answer tests which have appeared over a period of years in *Wireless World*.

The first in the series deals with electron physics and poses questions on electron dynamics, atomic theory and spectra, semiconductor physics electron emission and valves. It concludes with sections on gas discharge processes, devices and lasers and masers.

The second book, probably more pertinent for readers of this magazine, covers rectifiers and regulator diodes, load lines, small signal amplifiers, feedback, power amplifiers, oscillator, switching theory and waveshaping.

The final volume in Telecommunications includes principles, Fourier analysis, noise, two part networks, transmission lines, waveguides, radio propagation, aerials and modulation theory.

In each of the books the questions are set on each right hand page with the solutions overleaf. This certainly speeds the learning process.

Since most of the questions require calculations, to work through these texts will undoubtedly reinforce any weaknesses or knowledge of specific matter for examination purposes.

G.G.

INTEGRATED CIRCUIT SYSTEMS

By D. J. Walter, B.Sc.(Eng.), C.Eng.
Published by Iliffe Books (Butterworth Group)
228 pages, 9in × 6in. Price £3·50

FIRST of all let me qualify this title a little because first impressions might assume a complete dossier on all types of integrated circuit. The primary aim of the book is to assist students in the final stages of HND or degree courses in engineering and computer science. The emphasis is on logic systems using monolithic integrated circuits, although operational amplifiers and d-to-a and a-to-d converters are brought in at the end to relate the arithmetic logic to real time and on-line applications.

Having established these details it comes somewhat as a surprise to find Chapter 1 extolling the ins and outs of reliability assessment and statistical analysis of quality control procedures. Chapter 2 goes into manufacturing procedures, and it is not until page 59 that we start to come to terms with the theory and application of logic systems and Boolean algebra in relation to integrated circuits. This, as they say, is the meat, and the book progresses through flip flops and counting circuits to binary calculation, correction and coding in Chapter 5.

Armed with the information gained in these three chapters, the reader can then make an intelligent assessment of the advanced techniques using MOS (Chapter 6) which will undoubtedly figure more prominently in the near future.

Converters (mentioned previously) provide a means of assessing the characteristics of analogue or digital techniques and interrelating both of these to the task in hand.

Generally, this book has been carefully prepared and the author provides a great deal of useful material, assuming that the reader has some mathematical background experience.

M.A.C.

PRICES ! ! !

Due to recent Government purchase tax changes, all prices quoted in the magazine may be subject to alteration

RADIO ASTRONOMY TECHNIQUES

BY F. W. HYDE · PART 4

Image of the Sun projected by an optical telescope. First sunspots ever transmitted over BBC television

THE first project that will be undertaken will be a Simple Full Power Radio Telescope for the study of Solar Radiation. This project has been chosen because it will be possible to record the sun quite satisfactorily with a minimum of apparatus. Furthermore, it will be possible to use the system for the amateur bands and for the observation of satellites. The design of the aerial system will also be applicable to a more advanced telescope in the form of a simple interferometer and later to the near professional set-up of a complete phase-switching system. All the apparatus of the simple full power telescope will be absorbed as the project advances.

NATURAL PROGRESSION

Those who undertake this programme will be going step by step from the simplest type of radio telescope to the most advanced form that can be attempted by the private enthusiast.

There is a considerable advantage in taking this course, because in moving from the simple to the complex a better understanding of the final results will emerge. It also means that each unit that is constructed or adapted will remain in the project. There will be no redundant parts. This perhaps will be most helpful to the younger group who may have to improvise more.

In the construction of the telescope only common or garden "bits" will be essential, but of course those who wish to put their mechanical engineering skill to work can do so provided the basic parameters are kept in mind. The aerial system can normally be of wood or angle iron, whether the latter be the wrought iron type or drilled constructional angle of which there are a number of proprietary makes. The life of an aerial system constructed of wire and rough sawn timber, even unpainted, is of the order of ten years. In fact the writer has one unit which is still in operation after twelve years.

Perhaps it would be right here to set out the objects of the Project and what is required to implement them.

THE PROJECT

The purpose of this project is the study of solar radiations at a frequency of 137MHz. Time of observations:

(1) Sunrise to two hours after sunrise
(2) Two hours before noon (G.M.T.) until two hours after noon
(3) Two hours before sunset until sunset

Conditions of locality will determine whether the first and last items are practicable. It will add valuable data about the propagation of radio waves if these two periods of observation can be put into operation.

THE TELESCOPE

Aerial System

Ninety degrees Corner Reflector Steerable in azimuth and altitude, or fixed in azimuth but steerable in altitude.

Pre-Amplifier

Valve or transistor, gain preferably 16dB plus, noise level as low as possible, bandwidth about 5–10MHz.

Receiver

A standard communications receiver preceded by a convertor for the operating frequency. A two-position time constant circuit may be added.

Recording

For recording purposes a pen recorder and/or tape recorder will be required. The pen recorder should preferably have two speeds, one inch and three inches per hour. The tape recorder should have speeds sufficient to cover the period of observation and ideally this will be $\frac{15}{16}$ inches per second If the recorder can accommodate large reels then $1\frac{7}{8}$ inches per second could be used.

Power Supply

The power supply should be stabilised. The preferred form would be a stabilised mains transformer. Some of these are still available on the surplus market. If this is not possible then a voltage stabilised power pack can be employed. Many of the communications units already have in-built stabilisation.

D.C. Amplifier

This will offer a higher sensitivity than the direct recording from the output of the receiving unit. Where the pen recorder is of a low current type then this will be an advantage. If the pen recorder is of the potentiometer type it will have an in-built amplifier.

DATA RECORDING

The manner in which data recordings are stored is most important. It may take the form of an album for the pen recordings or, alternatively, the whole record may be kept on the paper roll and a simple table with spindles used to scan the paper by rolling from one spindle to the other. The advantage of this is that later scrutiny may reveal other items of règular change which may be worth a special study. This is in fact how many new sources of radiation were discovered.

Cassettes are useful to store the tape recordings.

The log book should be arranged in columns so that it contains a record of the times of starting and finishing an observation. The background level of radiation at the start of the observation period and also at the end of the period should be noted. The maximum level that was recorded should also be included. Finally, a column for special remarks which should include a note of the weather conditions at the time of observations.

AUTOMATED OPERATIONS

It should be noted here that in radio astronomy it is not always necessary for the operator to be present. This is perhaps one of its advantages over optical astronomy. Provided certain precautions are taken anyone can be taught the simple methods of setting up and switching on the equipment and merely returning to check at the time the observation ends.

If no help like this is available then the whole operation can be automated so far as the start and stop times are concerned. A time clock arranged to cut in for a sufficiently adequate time for the equipment to warm up and become stabilised, and then to cut out at the end of the observation time would work out quite well.

Such a procedure will result in a considerable saving in paper and tape, and in the general project that is being used to start the hobby, will not materially affect the results. The day to day variations of local conditions will be known since there will be a preliminary trial period of observation before starting the observations in earnest.

THE CORNER REFLECTOR AERIAL

The corner reflector has been chosen for two main reasons. Firstly, it has a front-to-back ratio which is superior to the ordinary dipole and reflector. Unwanted signals from the rear of the array are at a minimum and the best use of the forward gain can be made.

Setting the size for the lowest frequency that is to be used will allow for even greater efficiency when other projects involving higher frequencies are attempted—this is the second reason for the choice of this type of aerial.

REASON FOR HIGH GAIN

The corner reflector can be regarded as a development of the flat sheet in that it is folded so that single elements may be used for the same effective gain. An analysis of this aerial is not an easy task but some clue as to the reason for the high gain in such a simple aerial can be understood from the diagram in Fig. 4.1.

Angles other than 90 degrees may be used but each has certain individual characteristics. For example, had 60 deg. been chosen instead of 90 deg. there would have been a greater reduction in bandwidth for little advantage in forward gain.

If the diagram in Fig. 4.1 is studied it will be seen that there are three images of the dipole in addition to the dipole itself. The nett result of this configuration is to provide a forward gain of some 10dB over a single dipole. It can be viewed as though the images reinforce the real dipole and add to the gain.

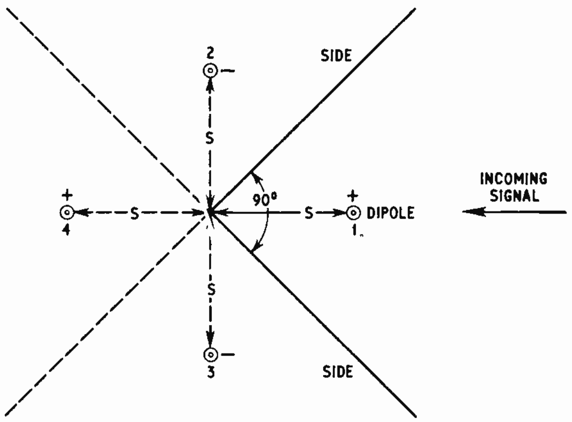


Fig. 4.1. The corner reflector aerial: an analysis diagram showing the reflections of the real dipole. If the reflector was not present the configuration would behave as though there were four separate dipoles. The presence of the reflector can be regarded as the means by which the gain is increased over a half-wave dipole in free space. The result is an increased gain in the forward direction

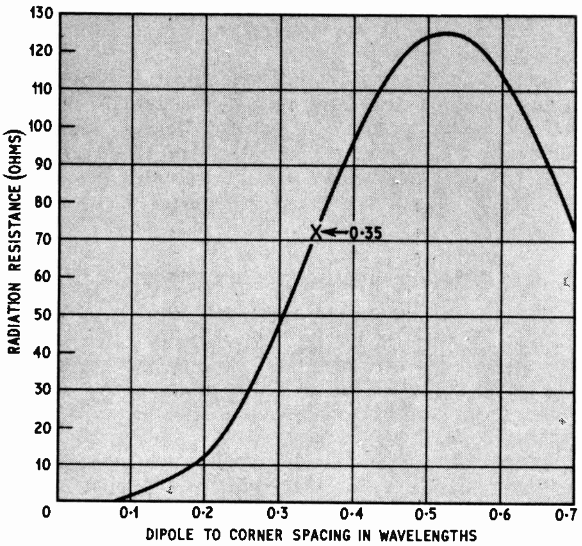


Fig. 4.2. Chart of terminal radiation resistance of a half wavelength dipole in relation to the distance of the dipole from the apex of a 90 degree corner reflector

It is possible to set up an extensive mathematical analysis of the corner reflector but no useful purpose would be served at this time by doing this. The empirical measurements which have been made of this type of aerial yield consistent results and these data will be used for the purpose of this design. The system is quite tolerant in that the gain over a reasonable variation of dimensions remains constant.

AERIAL IMPEDANCE

The chart in Fig. 4.2 shows the variation of the impedance of the dipole at various distances from the apex of the reflector. It will be seen that the optimum value is a spacing from the apex to the centre of 0·35 wavelengths for an impedance of 72 ohms.

If a single dipole is used then standard 75 ohm coaxial cable will be suitable for conveying the signals from the aerial to the receiving system.

PRACTICAL DIMENSIONS

Having chosen a frequency of 137MHz for the project the practical aerial will need to conform to the following dimensions.

The frequency of 137MHz is a wavelength of approximately 2·2 metres. This is about 7ft 2in. The length of the reflector according to the dimensions laid down in Part 1 should not be less than 1·5 wavelengths at the lowest frequency to be used. At the frequency chosen this will be 10ft 9in, but for convenience this can be rounded up to 11ft.

The width of the side of the reflector was given as not less than 0·7 of a wavelength. This works out at approximately 5ft, but as it would be beneficial to exceed this dimension this will be rounded up to 6ft.

With these dimensions it will be possible to use two half-wavelength dipoles in the reflector with the benefit of gain increase by a factor of 2.

AERIAL CONSTRUCTION

The diagrams in Fig. 4.3 show the constructional details for the aerial reflector assembly.

Work begins with the construction of the reflector. This consists of two frames each 11ft by 6ft, see "A". These should be finished with a coat of aluminium paint. Next the reflecting surface is added to each frame. This can consist of either wire mesh or single wires.

WIRE MESH REFLECTOR

If mesh is to be used, then it must be of good quality with a mesh size of not less than one inch. This refers to the normal twisted galvanised wire type. There is another popular type of welded mesh and this is better than the ordinary type previously mentioned. Both types of mesh do however, suffer from certain mechanical drawbacks. This particular type of reflector requires to be pulled very tightly up on the frames and it is doubtful if a really flat surface will be achieved with mesh. A certain amount of buckling is tolerable—say up to one and a half inches—however, it does not look very elegant though the performance of this aerial will not be impaired.

SINGLE WIRES

A more simple and easy method of making the reflector is to use single wires. This can result in a successful unit which is also of satisfying appearance. The single wires may be of standard insulated telephone wire or fencing wire (16 s.w.g.) which should be "half-hard" to hold tension.

The wires should be arranged in parallel rows at one inch spacing. They will run longitudinally and be secured at each end of the frame. If insulated wire is used then on the wooden frames ordinary staples should be used.

Starting at one end the wire is made off with two turns round the staple and a tail of 2 inches or so left, see inset diagram "A". The staple is then driven home tightly. The other end of the wire is dealt with in the same way after tensioning. The intermediate fixings are made with staples driven in far enough to hold the wire but leaving room for movement to take care of expansion and contraction.

If bare wire is used then it would be better to use insulated staples for the intermediate positions since movement in the wire in the supporting staples may give rise to unwanted noise in the aerial system.

CONNECTING THE TAILS

After a frame is completed the tails should be soldered so that there is a continuous connection between all elements of the reflector. It is not good enough to merely twist the ends together for there will be corrosion which could also add to noise in the aerial. The rule again here as with wiring connections is use *no flux other than resin.*

Fig. 4.3a shows how the two frames are bolted together. The accompanying photograph of one type of corner unit shows some of the details of construction. (The supports at the sides of the particular unit shown in this photograph will help to give some alternative ideas for use in cases where the aerial is to be fixed in azimuth.)

The reflector itself has side members bolted on, see "B". The centre strut serves to support the dipole units and also provide the suspension points for the reflector on the main frame support.

It will be necessary to check the centre of gravity of the completed unit so that it is balanced. This will ensure easy adjustment of position in altitude.

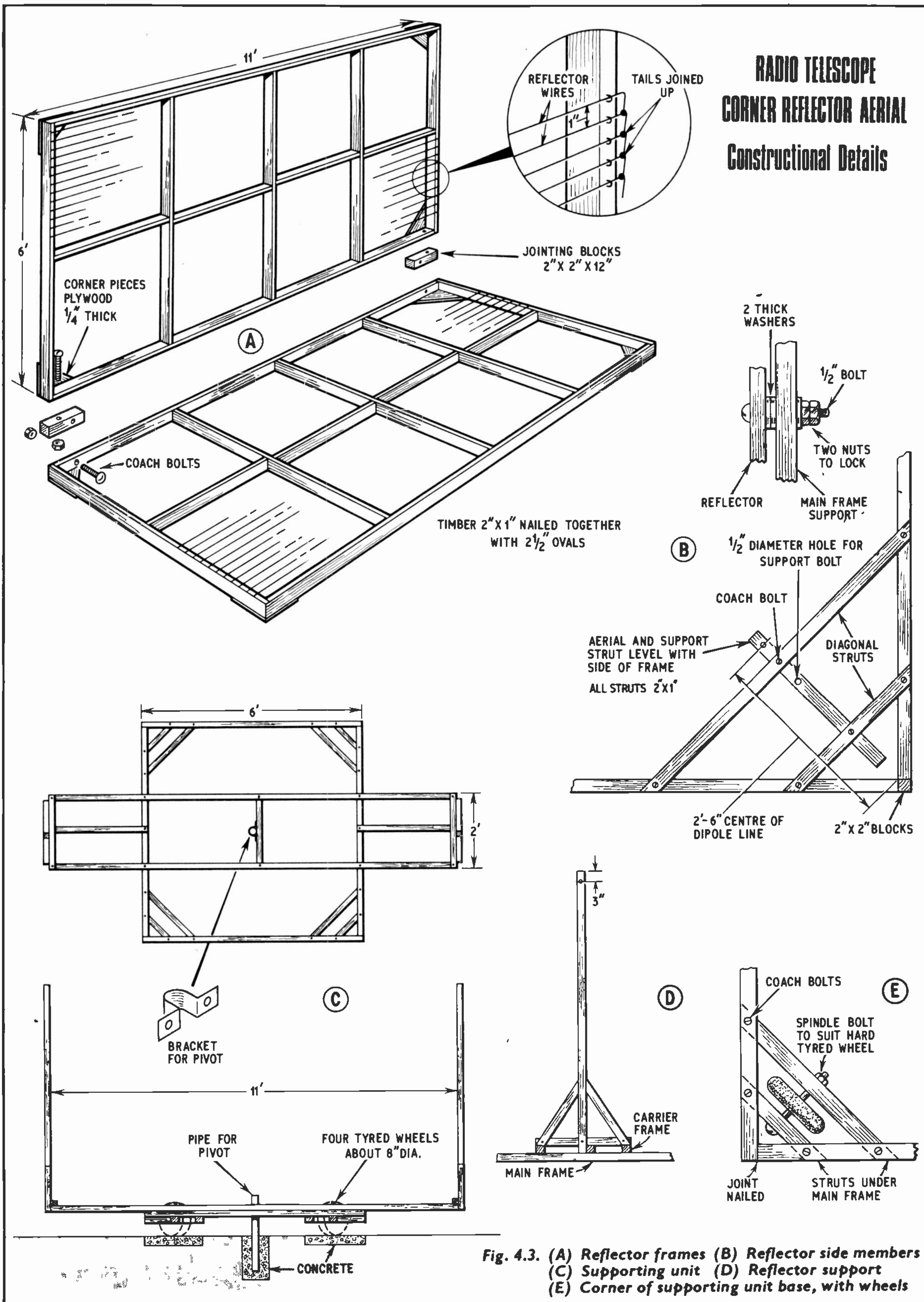


Fig. 4.3. (A) Reflector frames (B) Reflector side members (C) Supporting unit (D) Reflector support (E) Corner of supporting unit base, with wheels

SUPPORTING UNIT

The next task is to make the supporting unit which can be made in either of two forms—fixed or steerable. The basic construction is the same in both cases and is shown in "C". The material used is 2in by 2in timber and the assembly consists of a base and frame-support system. The base is made 6ft by 6ft with corner diagonal members which will serve as supports for the wheels (see "E") as well as providing rigidity for the base frame. If the unit is not to be steerable in azimuth then the wheels can be omitted.

On this base is mounted the aerial support system which is a sub-frame with vertical supports for the reflector, see "D". Again the material used is 2in by 2in timber. Detailed measurements are given in the diagrams.

For main assembly work coach bolts are used as far as possible since these will weather well, make for easy assembly, or if necessary allow easy dismantling for future modification.

If the aerial is to be steerable it is preferable that the wheels should run on a solid surface. Ideally this would be of concrete about 2in thick or, alternatively, concrete paving units could be used provided the base on which they are laid is carefully prepared, see "C". Cost-wise concrete would be the better choice.

If it is decided to make a permanent base and the project is to be carried through to the later developments of the interferometer where a second aerial unit will be required, then place the first unit on the east-to-west base line at one end of the line.

An alternative method of mounting the reflector, which again can be fixed or steerable, is shown in the photograph on page 467 (Part 1 of this series). This arrangement will provide scope for those who prefer to work in materials other than wood. The foundation for the steerable unit is much simpler than for the four wheel system of the first design, described above.

FOLDED DIPOLES

The frequency chosen will enable two dipoles to be used and in order to make the system as efficient as possible folded dipoles will be used. It was stated that the optimum distance from the apex would be 0·35 wavelengths and that this would give an impedance of 72 ohms. As two aerials are to be used it will be better to make these folded dipoles to take advantage of the increase in impedance that these will provide. By doing this the system can be properly matched and balanced.

A dipole is naturally a balanced system, and the use of coaxial cable to make connections makes it unbalanced. It might be thought that because it is common practice to use coaxial cable for connection between the television aerial and the receiver, that this is also a satisfactory arrangement for radio astronomy. This is not so because the level of signal that is available for television is much greater than that which is received from extra terrestrial sources.

BALUN TRANSFORMER

It is however possible to use coaxial cable for part of the system. In order to do this a balance to unbalance transformer known as a "balun" is used to connect an unbalanced system to a balanced system and vice versa.

To connect the folded dipole to standard 75 ohm cable the "balun" shown in diagramatic form in Fig. 4.4 will be used. This is a 4-1 step down in impedance and provides a balanced connection at the dipole. Details of the construction are given in Fig. 4.5. The centre core of the coaxial feeder is connected to a half-wave length of cable in a special way. The outer braid of the cable ends are all connected together as closely as possible.

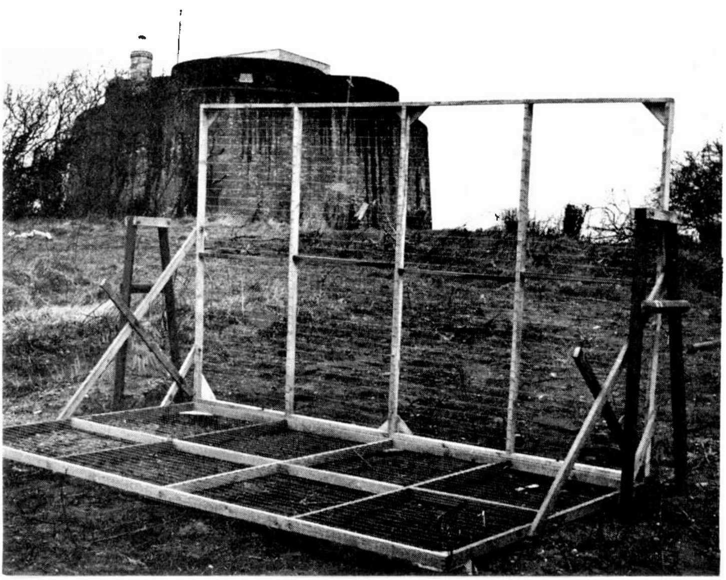
The inner of the main cable and inner of the nearest end of the half-wave section are connected together and to one side of the dipole. The inner of the other end of the half-way section is connected to the other side of the dipole. No connection is required to the outer of the coaxial cable at the dipole end of the system. The other end of the main coaxial lead matches the unbalanced termination at 75 ohms.

CONNECTING THE DIPOLES

The dipoles can be either of the following types. They can be made up from copper wire of about 14 s.w.g. The wire should be hard drawn copper, or cadmium copper. This is necessary because there will be considerable strain on the dipoles if they are to remain in the focal line of the reflector without sagging.

Alternatively, the standard commercial folded dipole as used for television can be employed. In this case the dipole can be supported by an aluminium tube of about 0·5in diameter, from the apex of the reflector.

The "balun" on each dipole and the coaxial lead should go straight to the apex of the reflector and the lead taken through without touching the wires of the reflector screen. The free ends of the two cables will be matched to the 50 ohm quarter-wave section which will, in turn, be plugged into the preamplifier. See Fig. 4.6.



A corner reflector aerial built by the author. Note that the side supports are of a different style to those in the described design

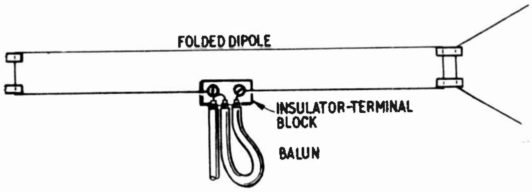
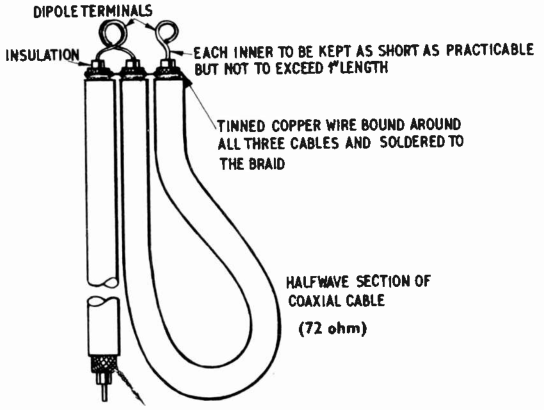


Fig. 4.4. A balance to unbalance transformer or " balun " connected to a dipole



NOTE: The length of the halfwave section will depend on the type of cable insulation :

$$\text{Solid polythene} = \frac{\text{wavelength} \times 0{\cdot}65}{2}$$

$$\text{Cellular polythene} = \frac{\text{wavelength} \times 0{\cdot}86}{2}$$

$$\text{Air-spaced} = \frac{\text{wavelength} \times 0{\cdot}9}{2}$$

Fig. 4.5. Constructional details of the balun

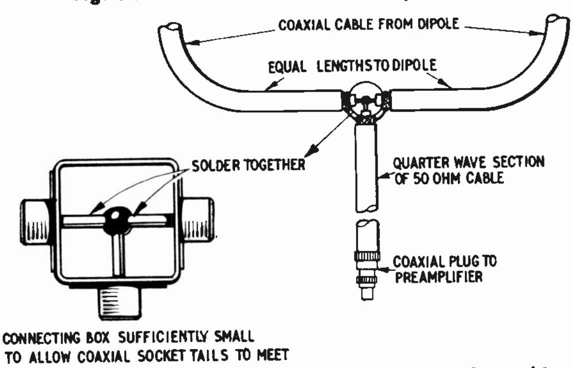


Fig. 4.6. Connector of two dipoles to the 50 ohm cable

If wire dipoles are used then a wood support reaching nearly to the dipoles will help to support the balun and cable. The dipoles themselves are supported in the reflector framework between the diagonal struts by means of nylon cords. The assembly of the two dipoles is shown in Fig. 4.7.

If the commercial type of dipole is used then balun and cable can be taped to the tube support.

ASTRONOMICAL TERMS

During this article the terms azimuth and altitude have been used. Though no doubt many will be familiar with these terms it may be of interest to give a short summary of the use of them. They are the coordinates by which the position of a celestial object may be indicated. A diagram of the system is shown in Fig. 4.8.

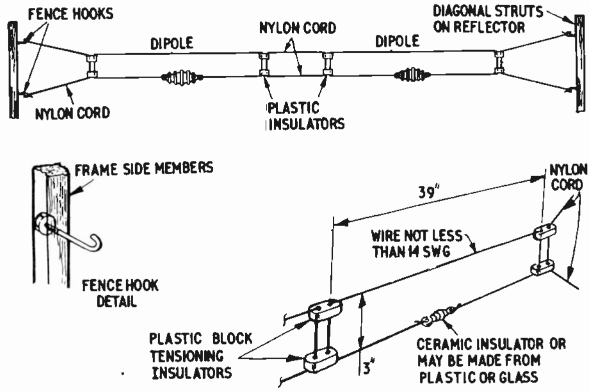


Fig. 4.7. Details of the dipole assembly and mounting

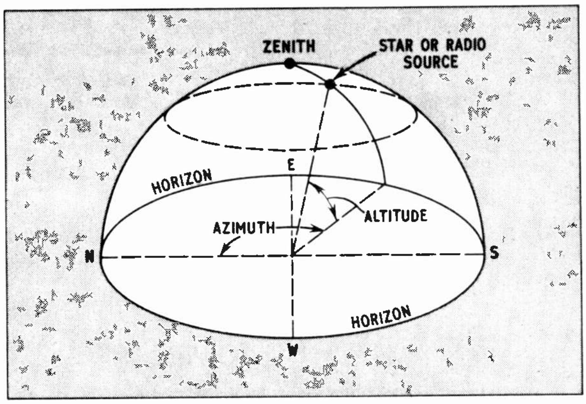


Fig. 4.8. Illustrating the meaning of the terms Azimuth and Altitude

AZIMUTH

This is the distance measured on a horizontal circle which coincides with the visible horizon. It is measured usually from North in degrees through East (90°), South (180°), West (270°), thence up to North again (360°). The logging of a position, for example, would read "Azimuth 202°."

ALTITUDE

This is the distance from the horizon up to the position of the object observed. The greatest altitude is 90° therefore the logging in this case might be "Altitude 52°". This greatest altitude is called the Zenith.

The altazimuth system is known as the Horizon System of Coordinates. It is used where the aerial system in radioastronomy is steerable in these terms and the position so obtained is translated into other celestial coordinates such as equatorial or galactic. Where large radio telescopes are involved it is usual to have direct computerised conversion of altazimuth to the other system of equatorial coordinates, in order that the telescope is kept continuously pointing to the correct position.

Altazimuth coordinates are used mostly for the location of artificial satellites where it is necessary to follow their path.

Next month: The receiver set-up and recording methods will be described, and some elementary Solar Astronomy will be discussed.

PART TWO

SEISMOGRAPH

BY D.BOLLEN

An instrument for the detection and graphing of earth tremors

THIS month constructional details for a 1Hz vertical seismograph are given together with installation and operating instructions.

A 1Hz VERTICAL SEISMOMETER

The spring pendulum seismometer of Fig. 9 is based on a welded mild steel frame. It might be possible to persuade a garage proprietor to weld the frame and also tap threaded holes in the baseplate, but if not, the frame could be built of well seasoned oak. Compared with many other seismometers, the spring pendulum type is one of the easiest to set up and operate.

Any old spring will not do for the seismometer as it must be near zero length. If the turns of a zero length spring were without thickness it would shrink to nothing when untensioned. Of course, an actual spring will only contract to the position where the wire turns touch. Some springs can have a theoretical negative length, depending on how they are wound.

To determine the spring length, tension it with various weights, measure the extension given by each weight, and then plot weight against extension on a graph. When the resulting straight line is projected it should pass through, or close to, the zero co-ordinates.

A spring of the dimensions specified in Fig. 9 can be obtained from most large ironmongers, but it is advised that several should be purchased so that one may be selected which has a zero or negative length.

A negative length spring can be converted to zero length by altering the spring adjuster.

Magnets for the transducer are taken from dismantled loudspeakers. The small bar magnet taped to the seismometer boom, above the calibrating coil, will impart a small force to the boom when the calibrating coil is energised by a 1Hz sine wave input. Approximately 1 millivolt r.m.s. in the coil will produce a zero-peak deflection of 50 nanometers.

The thin leads from the transducer coils are threaded through the hollow boom, and can be terminated by soldering them to a tag strip mounted on the upright section of the frame. Coil the transducer wires so that they do not interfere with the free movement of the seismometer boom.

To make up the seismometer mass, obtain a length of 2in inside diameter cardboard tube and glue this to a cardboard base. Insert and glue in position a dowel of the same diameter as the boom tube, then melt down 2lb of lead and pour this into the mould.

WINDING TRANSDUCER AND CALIBRATING COILS

A bobbin for the transducer coil, shown in Fig. 10, is made up from two 2½in square thin sheets of s.r.b.p., and a 1in × 1in × ¼in plywood former. Make sure that the corners of the former are rounded off, and edges smoothed, before glueing on the s.r.b.p. sides.

Drill a hole in the centre of the bobbin for mounting on a mandril in the chuck of a hand drill. With a sharp spike, make a hole in one s.r.b.p. side to admit L1 start lead. Solder some thin red insulated wire to the 40 s.w.g. enamelled wire and push through the spiked hole. Secure and insulate the joint with a layer of plastics insulating tape.

Wind on 2,000 turns of 40 s.w.g. wire for L1 then make another spiked hole and terminate this winding with a short length of green insulated wire. Insert the wire through the hole and insulate and secure with plastics tape.

A similar procedure is followed for the L2 winding, except that this consists of 500 turns of 40 s.w.g. wire, and has a blue start lead and a green finish lead. Finally, use more plastics tape to protect the windings and transducer bobbin.

A piece of s.r.b.p. or gummed paper tube is glued to one edge of the transducer bobbin to make a push fit mount on the end of the seismometer boom. A hole is drilled to admit the transducer leads.

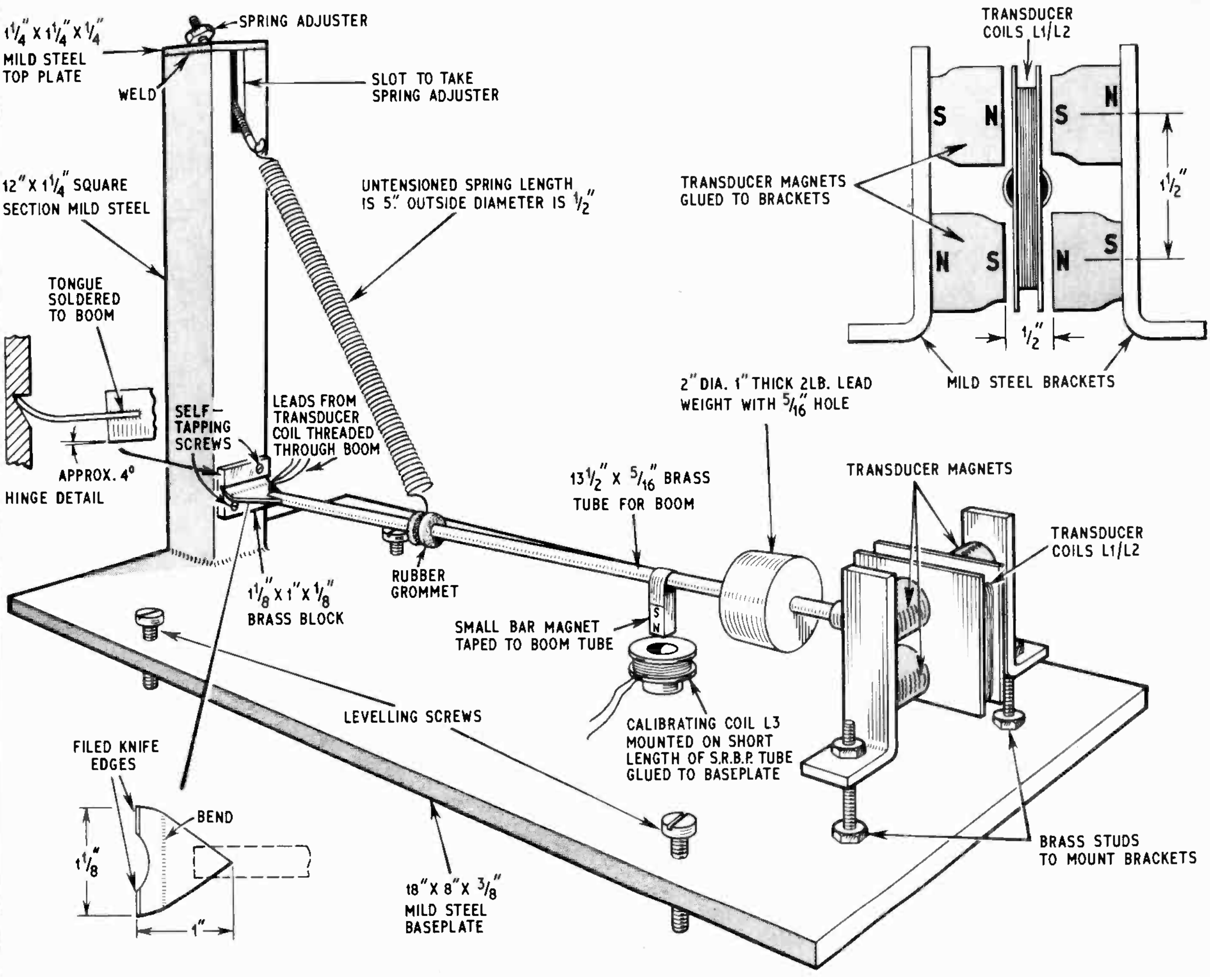


Fig. 9. Constructional details of 1Hz vertical seismometer

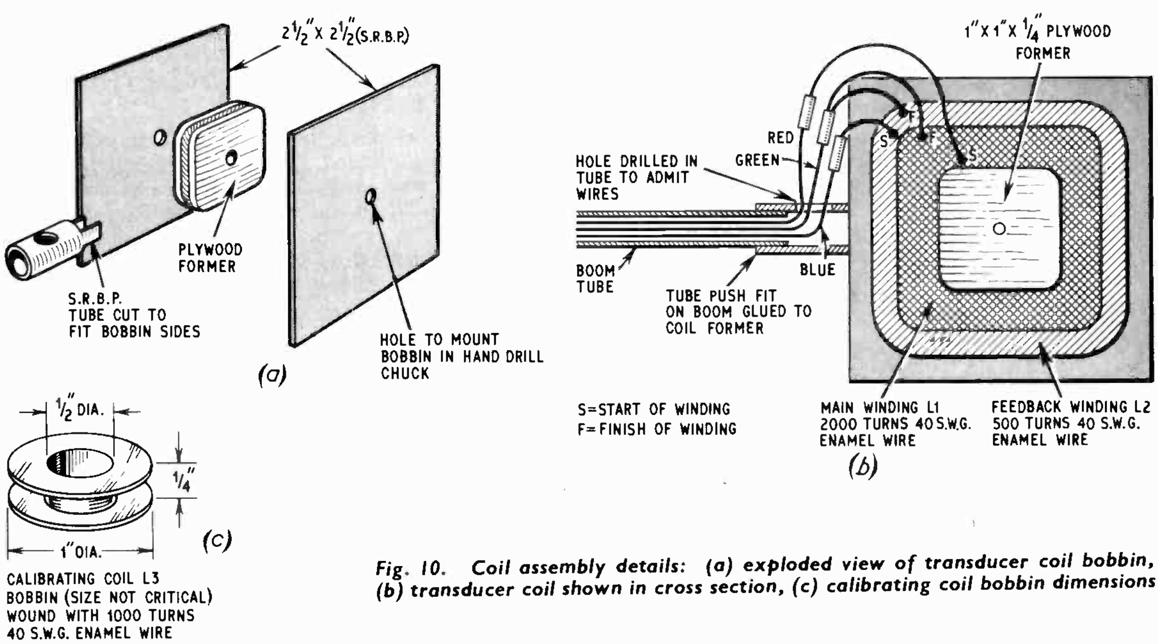
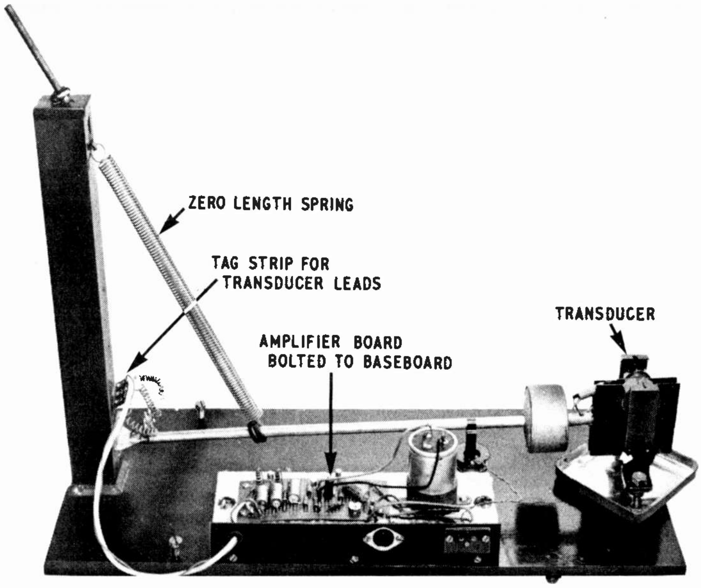


Fig. 10. Coil assembly details: (a) exploded view of transducer coil bobbin, (b) transducer coil shown in cross section, (c) calibrating coil bobbin dimensions



The calibrating coil dimensions are not critical, and the small bar magnet does not have to enter the hole in the centre of the calibrating coil. An LA5 pot core bobbin, or a former of approximately the same shape and size, can be wound with approximately 1,000 turns of 40 s.w.g. enamelled wire to make the transducer coil L3.

CONSTRUCTING THE SEISMOMETER AMPLIFIER

For the seismometer amplifier, prepare a piece of 0·1in matrix Veroboard 19 holes wide by 43 holes long, with copper strips running parallel to the longest side. Drill holes to take panel mounting screws, enlarge the holes for VR1 tabs, and make breaks in the copper strips, see caption Fig. 11.

Insert and solder all terminal pins and proceed with mounting all components, except R2. Take particular care not to overheat transistors TR1 and TR2.

TESTING

To test the seismometer amplifier module for wiring or component faults, solder a 470 ohm resistor temporarily across the terminal pins to which the red and green leads from the transducer coil will later be attached.

Connect the orange and black leads to the module panel as in Fig. 11, and ignore the remaining terminal pins.

Wire the orange lead to the positive terminal of a 12V battery, and the black lead to the negative terminal.

Check the potential between the collector and emitter of TR1 using a 20 kilohm/volt meter. If significantly lower than 0·9V, disconnect the battery and add resistor R2; this should increase the TR1 collector emitter voltage to near the required value. If necessary experiment with the value of R2.

Where the TR1 voltage is found to be much higher than 0·9V, when R2 is absent, the transistor may be faulty.

Now check the voltage between the collector of TR2 and the negative battery terminal. Any serious departure from five volts will probably indicate either a faulty transistor, a wiring error, or abnormally high leakage in C3.

PEN AMPLIFIER CONSTRUCTION AND TESTING

The pen amplifier module is based on a 0·1in matrix Veroboard 19 holes wide by 57 holes long, with copper strips running parallel to the longest side. Drill holes to take the panel mounting screws,

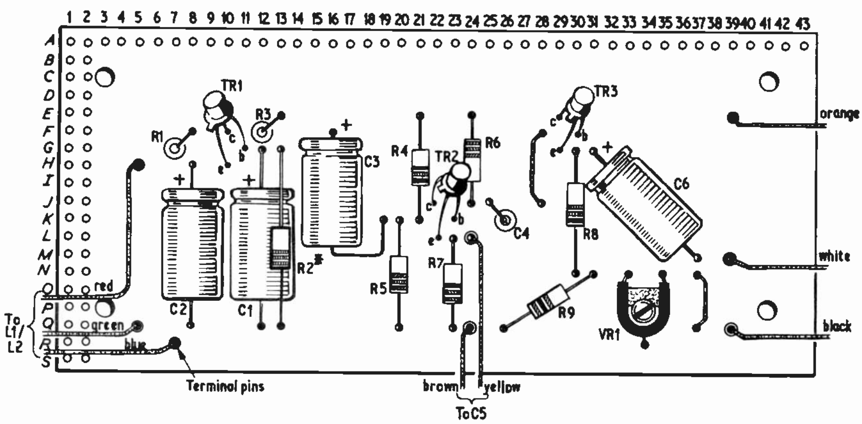


Fig. 11. Assembly and wiring details of seismometer amplifier. Cut copper strips at the following: B4; B40; C4; C40; D4; D40; F18; G14; H14; N34; O5; O40; P5; P40; R5; R40

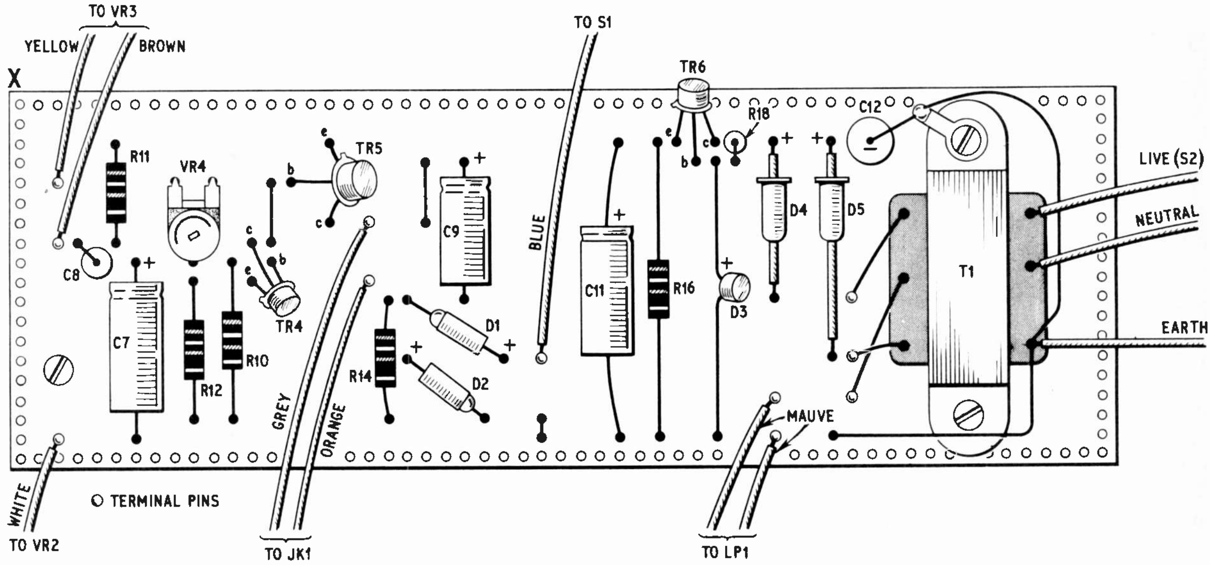


Fig. 12. Assembly and wiring details of pen amplifier. Cut copper strip at following holes: B48; C36; C48; D27; D48; E10; E11; E48; K27; M6; N6; N30; O6; O48; P6; P48; Q48; R9; R48

the miniature mains transformer mounting screws, and enlarge holes for VR4 tabs.

Make breaks in the copper strips as listed in the caption of Fig. 12, and insert all terminal pins before wiring up other components.

Make a preliminary check on the pen amplifier module as follows. Temporarily wire a six volt, 60mA bulb across the terminal pins identified by mauve leads in Fig. 12. Connect a mains lead to the appropriate pins on the miniature mains transformer T1.

Solder a one kilohm resistor across the grey and orange lead terminal pins, and connect a shorting link across the brown and yellow lead terminal pins.

When the mains input to T1 is switched on, look for a dull red glow from the lamp LP1. With the testmeter, check that the voltage across C11 is between 11V and 12V.

Apply the positive voltmeter lead to the grey wire terminal pin, and the negative lead to module earth. Adjust VR4 for a reading of around 6V.

If it is impossible to obtain a reading of 6V, there may be a wiring fault, or something wrong with TR4 or TR5.

INSTALLING THE SEISMOMETER AMPLIFIER

Although insensitive to slow changes of ambient temperature, the seismometer amplifier should be screened against thermal variations which lie within the frequency range of the seismograph, otherwise there will be an addition to the apparent overall noise level. Draughts can similarly produce spurious noise.

Thermal screening is achieved by placing the amplifier module inside a draught proof box which is lined with expanded polystyrene. In Fig. 13, board mounting and interwiring details are shown. Here the aluminium base plate provides a support for the polystyrene lined s.r.b.p. cover. Only the socket panel is shown. SK1 and SK2 are mounted by means of an 8in × 1½in s.r.b.p. panel attached to the side of the 8in × 3in × 1½in aluminium chassis.

A layer of expanded polystyrene is interposed between the top of the chassis, and the amplifier module and C5, to minimise thermal gradients. Leads from the seismometer transducer are taken through a grommet in the s.r.b.p. panel, to appropriate terminal pins on the module panel.

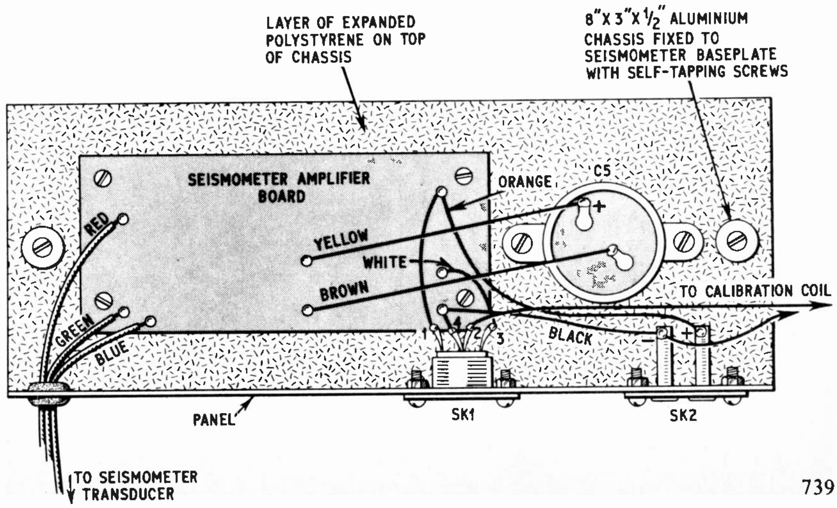
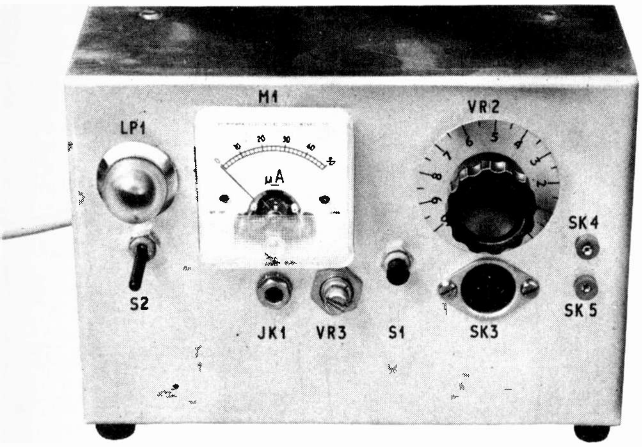


Fig. 13. Seismometer amplifier unit. After assembling the unit should be enclosed in hardboard lined with polythene to exclude draughts, and short term temperature changes



There is sufficient room on the baseplate of the seismometer to accommodate the complete seismometer amplifier and batteries on either side of the boom. The amplifier unit chassis can be fixed with two self-tapping screws. If desired, a battery box can be made up for BY1 and BY2.

CONTROL UNIT CONSTRUCTION

A 6in × 4in × 2¼in aluminium chassis placed on its side will serve as a box for the control unit components, and can house the pen amplifier module.

After drilling the box front to take those components shown in Fig. 14, drill holes in the sides of the box to accept the pen amplifier module mounting screws, and mains lead grommet. Install all controls, sockets, and the amplifier module, then proceed with wiring up as shown.

CONSTRUCTING A DISC RECORDER

A prototype disc recorder which incorporates a bell warning circuit and a pen vibrator is shown in Figs. 15a and b. Disc recorder layout will depend on the types of turn-table motor used and on additional facilities.

A start can be made by selecting a suitable motor for one revolution per 24 hour operation. It is essential to have a slipping clutch drive of the type found in mechanisms taken from alarm clocks, electric wall clocks, or time switches.

Most time switches have a spindle with a threaded hole which can be easily adapted to take a turntable, but in the case of a converted clock, a threaded bush must be soldered to the hour hand cog as in Fig. 16a. If difficulty is experienced in making a suitable turntable and fixing it to the motor, try using an old gramophone turntable with a friction drive on the rim; this will also allow a bigger paper disc to be employed, and will give greater trace detail.

Mount the turntable assembly on a baseboard made of plywood or thick s.r.b.p., with space to spare for the pen relay RLA, and RLB and RLC if used see Fig. 8).

RELAYS

All relays specified for the disc recorder are of the G.P.O. type 3000, with 1,000 ohm windings, operating on 6–12V. Modification details for RLA are given in Fig. 16b.

The pen arm is soldered to a 4B.A. solder tag which is held against the armature by a small pressure spring. The arm is free to move up and down, with the pen counterbalanced by a lead weight, but is driven horizontally by the movement of the armature; in this way the pen is free to follow surface irregularities of the paper and maintains a constant but light contact.

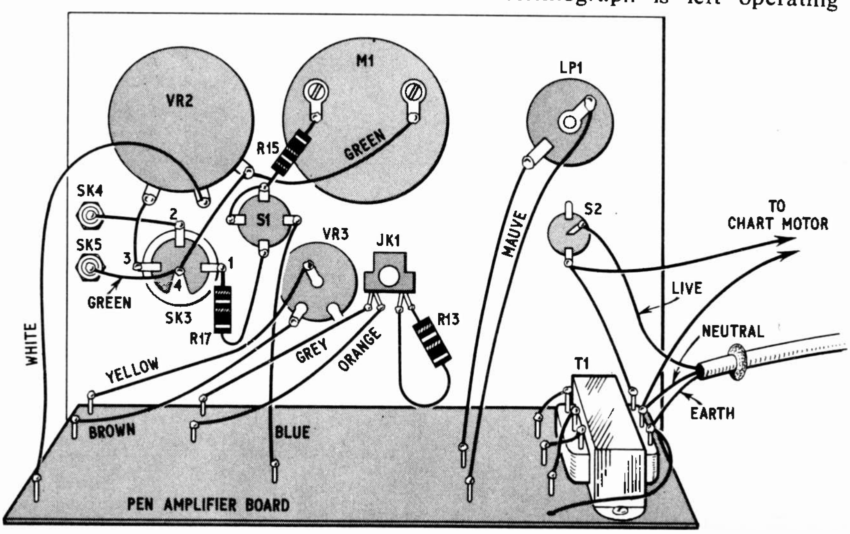
Remove RLA armature and glue two small squares of foam plastic, approximately ¼in × ¼in × ⅛in thick, to the relay frame and polepiece, then replace the armature and mount the pen arm. If necessary, bend the relay contacts so that they are just open when the armature is naturally biased by the foam inserts.

Fix RLA to the baseboard beside the turntable and bend the pen arm until the resulting ink trace is in line with the turntable radius. The disc recorder in its basic form will now be ready for use.

EXTRA FACILITIES

It is useful to have some warning of the onset of a tremor when the seismograph is left operating

Fig. 14. Interwiring of control unit



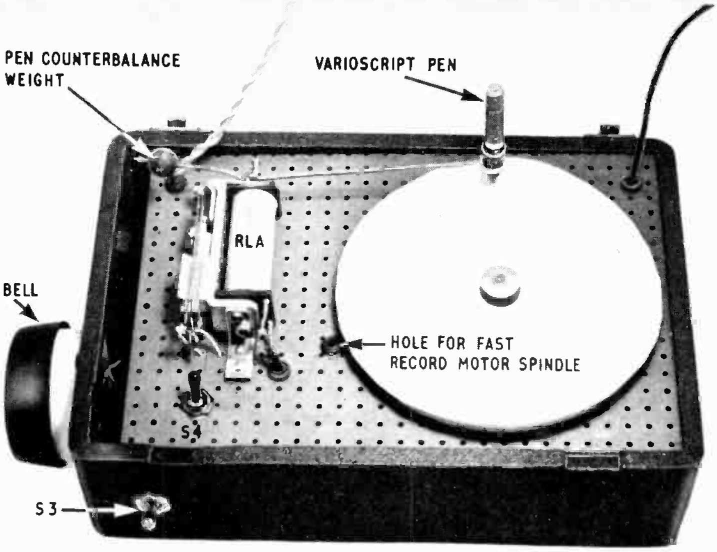


Fig. 15a. Top view of prototype disc recorder

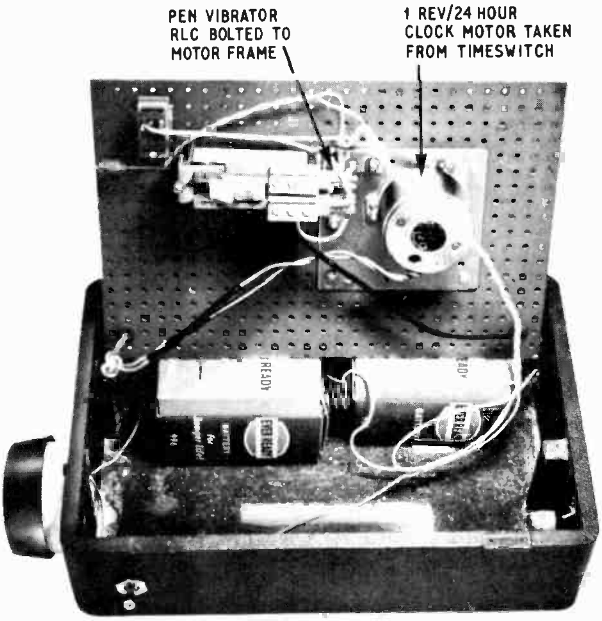
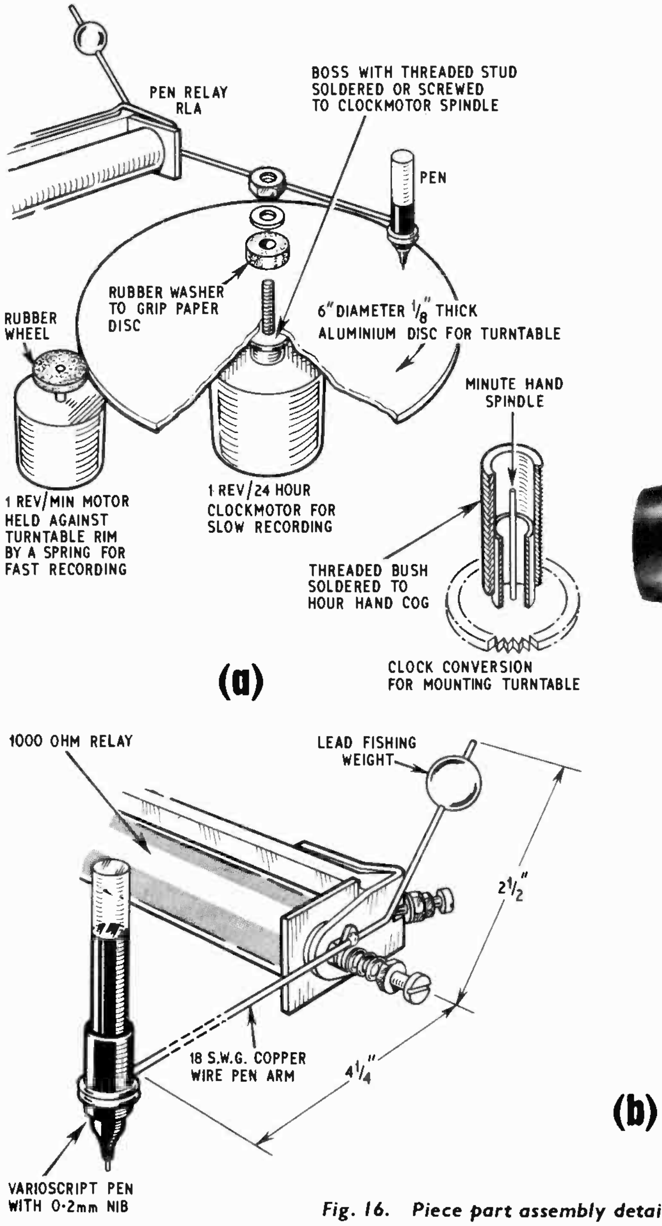


Fig. 15b. Underside of motor board



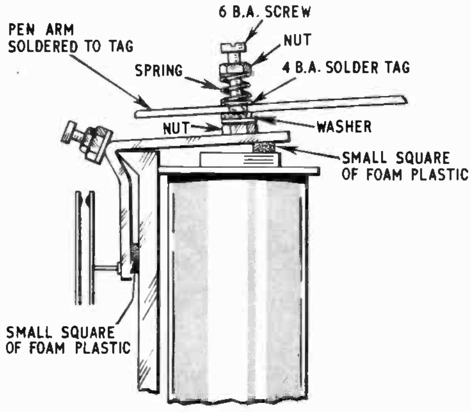


Fig. 16. Piece part assembly details for disc recorder

unattended, perhaps in a separate room. The simple bell circuit wired to the relay RLA contacts as in Fig. 8 can be quickly added to the basic recorder.

One of the bugbears of most pen recorders is unreliable inking. There is nothing more infuriating than finding that the pen has dried up just before the onset of an interesting event. To improve matters, the pen can be filled with watered down ink, but this gives a grey trace.

Further improvement results if the detachable nib is cleaned at the end of each 24 hour recording period, but this is a nuisance, and uses up valuable recording time.

The remedy is to employ a vibrator to keep the point of the nib bouncing up and down on the paper, and maintain a tiny pool of wet ink under the nib, without appreciably thickening the trace. A description of the vibrator has already been given, see also Fig. 8 and Fig. 15.

For triggered, expanded trace recording, a one revolution per minute synchronous motor can be arranged to rim drive the turntable approximately one revolution in every 36 minutes by means of a spring loaded ½in diameter rubber wheel.

A choice of motor speeds and friction wheel sizes will allow a wide range of recording speeds to be covered.

INSTALLING THE SEISMOMETER

An ideal seismometer site would be a deep pit excavated down to bedrock, somewhere in the middle of a large, unpopulated area of open countryside, devoid of trees, and at least one hundred miles from the nearest seashore. Of course, the ideal site is not available in the United Kingdom, and the best use must be made of available terrain.

In the centre of large towns built on chalk or clay, the "cultural" noise level will almost certainly mask all but the strongest tremors from distant events, but advantage can be taken of reduced human activity in the early hours of the morning. The seismograph will anyway be left running for 24 hours under normal circumstances.

The seismometer can be placed on a large concrete block which is let into the floor of a cellar, as this serves to couple it efficiently to the ground.

A suburban site could be based on a pit—or seismometer "vault" to use the correct term—dug in a garden. See that the pit is either well drained, or rendered completely waterproof with a lining of impervious concrete.

Although rural seismometer sites are obviously the best, the presence of trees can multiply the micro-seismic background noise at least three or four times when a high wind is blowing, and quarry shots have a perverse habit of turning up right in the middle of an interesting recording.

Training areas for the Armed Services are also sited in rural areas. Guns, bombs, depth charges, and sonic booms are all recorded faithfully by the seismograph.

Having decided upon and prepared a seismometer site, the instrument is installed and levelled with the aid of a spirit gauge. Make sure that the transducer coil is correctly aligned, completely free to move, and cannot touch the magnets.

A sharp increase in resonant frequency can be caused by minute whiskers of ferrous metal bridging the gap between magnets and coil. The remedy is to clean the magnets by wiping them with a piece of foam plastic.

A tin can placed over the transducer assembly, with a cut-away to clear the seismometer boom, will prevent dirt collecting on the magnets. It is advisable to protect and shield the seismometer with a heavy box cover of wood or metal, which is in turn covered by an old blanket to keep out drafts and loud noises.

TESTING THE SEISMOGRAPH

Connect the seismometer amplifier to the control unit. Adjust VR1 for minimum damping (slider earthed, and plug in the batteries. With gain control CR2 at zero, switch on the control unit, and wait for a minute or two for the circuits to settle down.

Advance VR2 while watching the zero-peak meter; the pointer should be seen to rise and fall rhythmically at the resonant frequency of the seismometer. If instead the pointer persistently goes to full scale, at low settings of VR2, and the panel lamp LP1 flashes, this will indicate instability.

The instability might have been caused by switch-on surges, in which case a 1·5V d.c. voltage injected into SK4 sockets should kill the unwanted oscillation, and return the seismometer amplifier to normal working.

To check the amplifier noise level, set VR2 to zero and clamp the seismometer transducer by inserting a thickness of cardboard between the coil and the magnets. Turn VR2 to maximum gain and observe the peak meter deflection, this should not exceed 4μA on the existing meter scale.

CALIBRATION

The seismologist is not necessarily concerned with the accurate measurement of ground motion amplitudes. Often it is enough to time the tremors, and merely compare relative trace amplitudes. Nevertheless, it is instructive to see how the seismometer responds to a well defined mechanical displacement and there are several methods of attempting this.

Perhaps the best technique is to place the seismometer on a special "shaking table", a precision engineered platform capable of being moved with great accuracy through small distances.

A simpler alternative more suited to the amateur is to impart a small motion to the seismometer boom by applying a known electromagnetic force.

An item of equipment needed for calibration is a sub-audio oscillator, tunable from about 0·5Hz–5Hz, with an output of at least 10V r.m.s., and having a switched attenuator covering 100dB or more.

An ordinary audio signal generator can sometimes be converted for sub-audio use by adding extra large capacitors to the frequency determining network, while at the same time increasing the value of all coupling, de-coupling, and smoothing capacitors to prevent distortion and loss of output at the lowest attainable frequencies.

The Heathkit AG-9U, for example, will work down to 0·1Hz after suitable modification.

To calibrate the 1Hz spring pendulum seismometer, attach a small pointer to the seismometer mass, arranged so that it moves up and down a millimetre scale. Temporarily short-circuit the red and green leads from the transducer coil L1 at the seismometer amplifier input, and make sure that the supply is disconnected.

Inject a 1Hz sinusoidal signal of about 5V r.m.s. into the calibration coil L3, via sockets SK4 and SK5 on the control unit front panel.

With the help of another person, tune the oscillator for maximum deflection of the seismometer boom, and then adjust the oscillator output voltage until the seismometer mass is swinging through a vertical distance of 1 millimetre. Carefully note the exact oscillator voltage required to give the above deflection, then switch off the oscillator.

Remove the short circuit from the transducer leads and re-connect the supply. Advance VR2 to make sure that the seismometer is now responding correctly to microseisms, with VR1 set for minimum damping.

With VR2 turned down low, attenuate the previous oscillator output voltage by 80dB and inject this signal into SK5. Adjust the oscillator frequency control for maximum deflection of the zero-peak meter; this is because the seismometer may not have the same point of resonance for very large and very small displacements. Since the original deflection was 1 millimetre peak-to-peak, or 0·5 millimetre zero-peak, the new seismometer deflection should be 0·5mm $\times$ 10^{-4}, or 50 nanometres.

Adjust VR2 for a full scale deflection of 50μA on the zero-peak meter, and make a note of the VR2 setting for future reference. The calibration obtained will be dependent on the amount of damping applied.

For other settings of VR1, re-calibrate, or prepare a response graph similar to Fig. 2 so that known settings of VR1 can be related to amplitude.

Another factor to be taken into account is that the calibration will only apply at the particular frequency used to deflect the seismometer boom, because the transducer is of the velocity type. It is a reasonable assumption that output will be related to amplitude in the undamped mode when the seismometer can only respond to a narrow band of frequencies centred at resonance.

OBTAINING RECORDINGS

Set VR2 to zero and insert the disc recorder jack plug into socket JK1 on the control unit front panel. Wait for a few minutes for the pen amplifier to settle down, and then adjust VR4 to position the armature of relay RLA at the mid-point of its travel.

Set up the pen, paper disc, and turntable rotation. Advance VR2 until the pen just moves in response to microseisms, and gives a slightly thickened trace. If necessary, re-adjust the pen zero by means of fine control VR3.

Leave the disc recorder running for several hours to check for reliable inking and pen deflection. At the same time, try injecting a range of frequencies from the test oscillator via SK5, to see how the complete seismograph responds to displacements of the seismometer mass.

SEISMOGRAMS

Four seismograms obtained with a simple disc recorder are given in Fig. 17.

A tremor from an epicentre a few hundred miles from the seismograph is depicted in Fig. 17a, recorded at a speed of one revolution every 24 hours. Seismogram Fig. 17b is the result of a rapid succession of small quarry shots at a distance of 6 miles (also clearly audible at the recording station); turntable speed one revolution every 36 minutes.

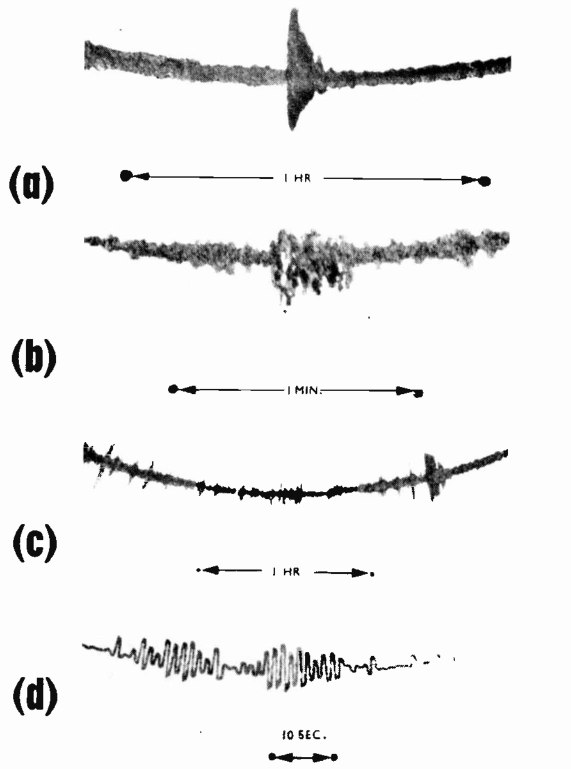


Fig. 17. Specimen seismograms obtained with a simple disc recorder: (a) a near earth tremor, (b) quarry blasting six miles from recording station, (c) storm microseisms, (d) speeded up trace showing microseisms

An approaching area of low pressure, accompanied by high winds produced the seismogram of Fig. 17c; the large amplitude deflections were caused by trees in the vicinity of the seismometer. The recording speed for this was the same as for Fig. 17a seismogram.

Finally, in Fig. 17d, a turntable rate of one revolution per minute gives a detailed record of microseisms, and shows the modulation effect which is sometimes referred to as "string of sausages".

Although not certain, the modulation may be caused by long period oscillations from the continental shelf being added to more local microseisms.

If a strip or helical chart recorder is available, having paper speeds of 10sec/cm or more, it can be connected to the seismograph control unit as shown in Fig. 18, to obtain more detailed recordings.

Serious seismological work demands the use of fast paper speeds with precise timing marks, to fix the arrival times of subsidiary waves reflected from crustal layers.

STRIP CHART RECORDINGS

The two seismograms in Fig. 19 are representative of traces given by a strip chart servo recorder.

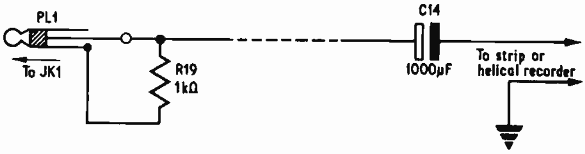


Fig. 18. Circuit for feeding output from pen amplifier into an advanced recorder

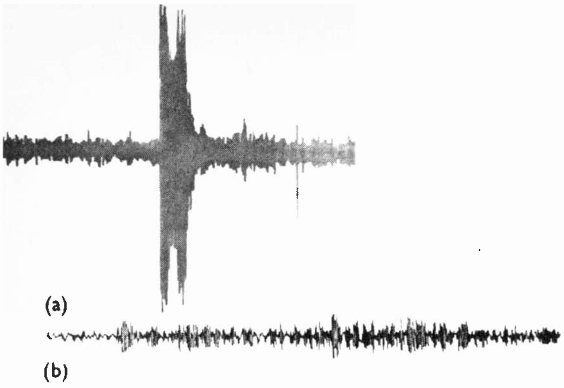


Fig. 19. Seismograms obtained with a strip recorder, (a) earthquake in the North Atlantic Ocean, (b) depth charge recorded at a distance of 250 miles

Fig. 19a is of a confirmed earthquake centred under the North Atlantic ridge, with minimum damping applied to the seismometer, and a fairly slow paper speed of 5·5min/cm.

Clearly shown here are the two peaks produced by the difference in arrival times of major P and S waves.

Fig. 19b gives a good general impression of seismograph sensitivity, and also shows the increase in detail resulting from a faster paper speed of 10sec/cm. To obtain this seismogram, frequencies below 1Hz were filtered out by reducing the value of C14 coupling capacitor (Fig. 18) to one microfarad. The input impedance of the chart recorder was ten kilohms

For this, the response of the seismometer was set to wide-band with near maximum damping, and the major recorded frequencies were in the region of 5Hz.

FILTERING

The seismograph response characteristic can, of course, be tailored to suit a particular situation.

If the main interest is the recording of teleseisms, that is events occurring some thousands of miles away, integrating capacitor C10 in Fig. 7 can be added to attenuate signals above 1Hz; this also partly corrects the inherent transducer response to yield an output more nearly related to amplitude over the full frequency range of the instrument, instead of velocity.

Quarry shots and other explosions can form a study in themselves, as seismic signals revealing something of the structure of the Earth's crust.

For all but explosions approaching nuclear magnitude, the frequencies generally encountered will lie above 1Hz. It will pay, therefore, to improve the signal to microseismic noise ratio by attenuating unwanted frequencies below 1Hz; simply achieved by reducing the value of C14, as was done for seismogram Fig. 19b.

To conclude this short introduction to the subject, the serious experimenter can find plenty of opportunity in the field of seismology for circuit development. Good sub-audio amplifiers, filters, and oscillators are scarce items. Equally, there are few seismological stations run by amateurs in the British Isles, despite the new impetus given to the subject by nuclear explosion detection and Moon quake recording. ★

NEWS BRIEFS

Sub Trainer

A NEW era in the training of Royal Naval submarine crews was signalled by the recent opening of a computer-based Submarine Command Team Trainer (SCTT) at HMS Neptune, the R.N. training establishment.

The SCTT system was developed jointly by the Ministry of Defence and the Electronic & Display Equipment Division of Ferranti Ltd. in Manchester, and is based on two Ferranti Argus computers.

The equipment is designed to train the submarine command team and crew in tactics and operations, and the various degrees of training available in the simulator system range from simple operator training to complex tactical exercises involving a number of target and escort vessels. Realistic simulations of sonar, radar, periscope, fire control and navigation systems are provided.

Lucas Looks Ahead

WITH the formation of an Electronics Product Group under Dr. John E. Maund, Lucas Electrical Limited intend to marry their undisputed engineering skill in automative electrical systems with the more recent electronics and semiconductor technology and production capacity of their former Semiconductor Division.

This move was considered desirable in the face of a rapidly changing electronics market where integration in both i.c. and hybrid module form are foreseen as major expansion areas, and in particular the acceleration of automotive electronics technology, an area in which Lucas has made a significant contribution. This company sees a greatly expanded market in the future since electronic-based systems will become essential parts of modern cars as a move to meet the new safety and environmental requirements.

Apart from the automotive market, Lucas intends to increase its activities in other areas, including consumer electronics. To this end their recent distributor agreements with two large U.S. component manufacturers, Centralab Semiconductor and Quantrol Electronics, are significant. The optoelectronics market in particular is seen as a major expansion area in the future.

It is of interest to note that the entry of Lucas into the field of semiconductor manufacture started originally in 1955 when, faced with the difficulty of obtaining silicon semiconductors, they decided to develop and manufacture their own.

They achieved fame as the creators of the world's first 500V transistor.

MARKET PLACE

Items mentioned in this feature are usually available from electronic equipment and component retailers advertising in this magazine. However, where a full address is given, enquiries and orders should then be made direct to the firm concerned.

INSTRUMENT CASES

Keeping up with the range of instrument cases available on the market is becoming increasingly difficult for the designer and constructor of equipment.

Adding to this large selection of instrument cases available at present are three new ranges from **West Hyde Developments, Vero Electronics** and **McArdle and Brainsby.**

With the increase in popularity of anodised aluminium finishes, West Hyde have developed the "Brightcase" instrument case which can be either free standing or rack mounting. The external construction is of aluminium with the exception of the top and bottom panels which are made of black PVC coated steel.

The anodised side panels are held with button head socket screws, which can also be used to carry the rack mounting brackets.

All units come complete with front and back panels in anodised aluminium in either full, half or quarter width. These panels are held by stainless steel Pozidriv screws on to the anodised main rails. Inside there are four aluminium slides on which the equipment can rest.

Details of case sizes and prices can be obtained from West Hyde Developments Ltd., Ryefield Crescent, Northwood Hills, Northwood, Middx. HA6 1NN.

As an addition to their "D" series instrument cases Vero Electronics introduce a 17½in deep series. The cases accept standard 19in front panels or frames and incorporate flush fitting side handles, for ease of carrying.

The cases incorporate all the usual features of the "D" series, such as tilt feet, front trim, and handles and a vinyl paint finish. Ventilation is provided by slots in the bottom and rear panels which are both detachable for easy access to the interior.

Further details of all the Vero cases are available from Vero Electronics Ltd., Chandlers Ford, Hampshire, SO5 3ZR.

The Impex range of cases from McArdle and Brainsby covers 36 different sizes. The case bodies are made from 20 s.w.g. steel coated with stove enamel in green hammer finish.

The detachable front and back panels are 18 s.w.g. satin anodised aluminium and the base is made from 18 s.w.g. passivated zinc plated steel.

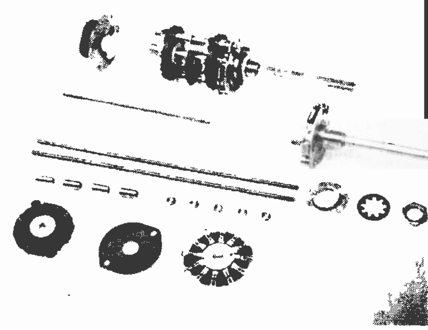
Further information on the Impex range of cases is obtainable from McArdle and Brainsby (Import and Export) Ltd., P.O. Box 2BB, Newcastle-upon-Tyne, NE99 2BB.

SWITCH KIT

Constructors will be delighted to learn that a contender to the famous Maka Switch, which many readers seem to have difficulty in obtaining, is now being marketed through **Home Radio (Components) Ltd.,** by **A.B. Electronic Components Ltd.**

The switch is available in kit form and practically any multiple arrangement of rotary switching can be set-up. The switch consists of a shafting unit with a 6in shaft, wafers, screens, spacers, studding and a mains switch.

Addresses of local stockists and details of wafers available can be obtained from A.B. Electronic Components Ltd., Sutherland House, 5/6 Argyll Street, London, W1V 1AD.



Switch kit made by A.B. Electronics Components

TREASURE HUNTER

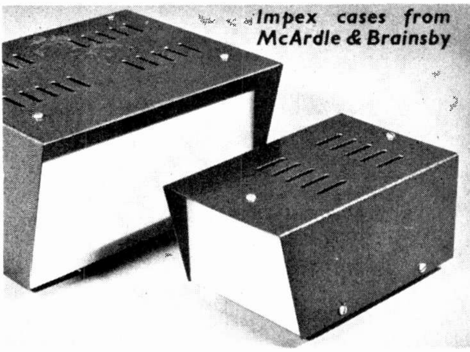
Hunting for buried treasure appears to be one of the popular outdoor pastimes, and the electronic metal detector is an essential part of the equipage of every serious treasure hunter.

A useful little handbook "A Fortune Under Your Feet" by Edward Fletcher has been brought to our attention. Its value is in the lesser known facts it contains about where and how to search. One chapter gives a broad outline of metal locators and suggests the kind of performance one should look for. Available from **Joan Allen & Co.,** Biggin Hill, Kent, price 45p plus 6p post and packing.

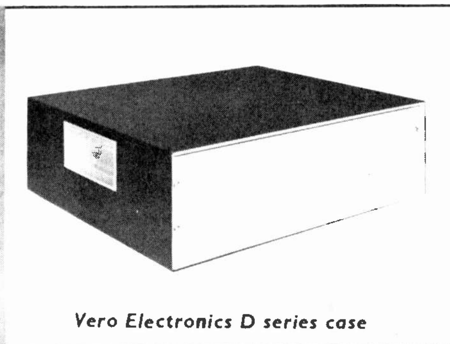
METALS TO ORDER

Happy to meet even the smallest order and advise which metal is best suited for a particular job, **Henry Righton & Co. Ltd.,** of Brookvale Road, Witton, Birmingham 6, have opened a "Cash & Carry" counter for the do-it-yourself enthusiast and model builders in the Birmingham area.

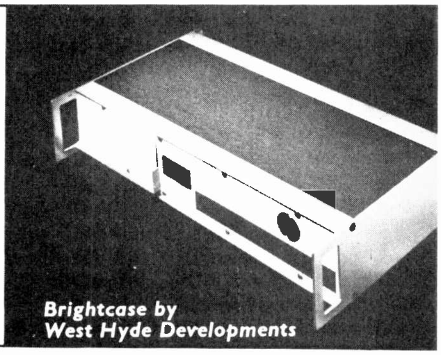
The counter, open from 9.0 a.m. to 5.0 p.m. and 8.30 a.m. to 12 noon Saturdays, is able to supply aluminium, brass, copper, bronze and stainless steel in rod, bar tube, sheet or strips cut to any size, shape or length.



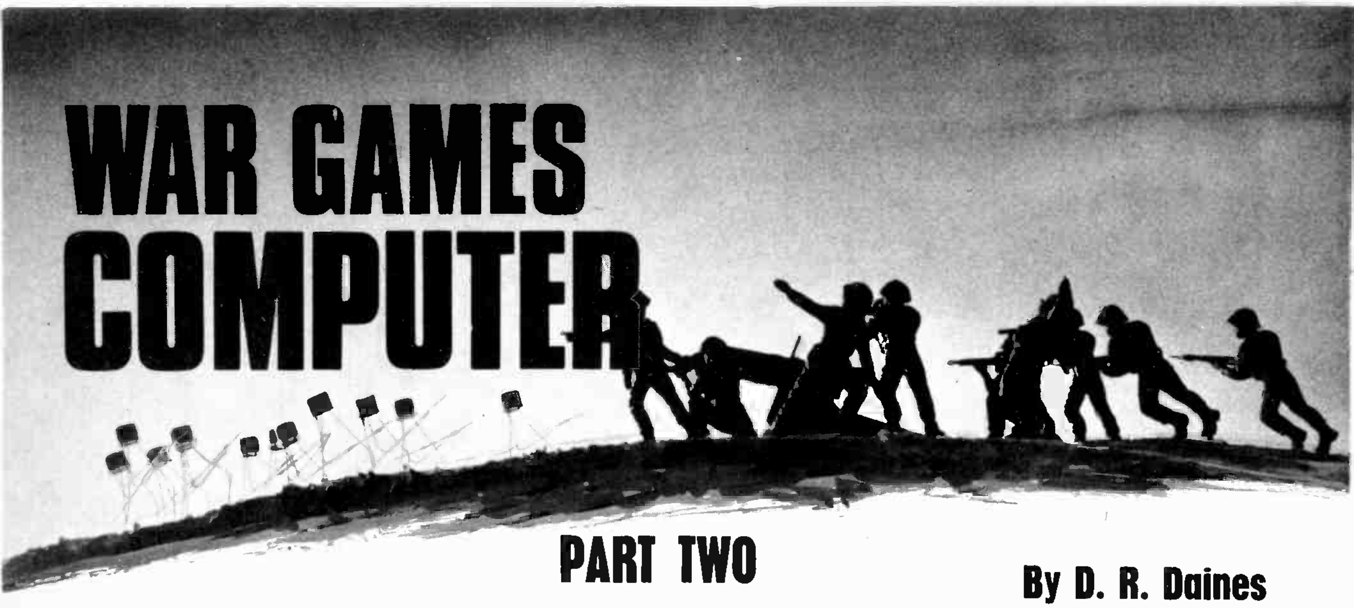
Impex cases from McArdle & Brainsby



Vero Electronics D series case



Brightcase by West Hyde Developments



WAR GAMES COMPUTER

PART TWO

By D. R. Daines

IT SHOULD have been possible with last month's article to play in a very limited game using the primary parameter controls in Fig. 8. The SPEED controls would be "slowest" at the higher voltage end of the potentiometers VR4 and VR5; while TARGET SIZE would be smallest when S4 is switched to (d) line and largest on R22, although the labels for these switch positions have no direct importance to circuit function—only to strategy.

SECOND STAGE—PANEL 'A'

Panel A contains the three multivbrators and the gate. The circuit is shown in Fig. 9. TR1 and TR2 form the first "CHANCE" multivibrator, with TR3 added to speed up the rise time.

The frequency of a multivibrator can be changed by altering the voltage applied to the bases of the transistors, which is what is done here. VR1 alters the voltage, while VR2 alters the distribution of that voltage between TR1 and TR2, thereby altering the mark/space ratio (Fig. 8). The large CR combinations result in a slow change-over rate, and can be as low as once in every six or seven seconds.

The RATE OF FIRE multivibrator is formed by TR4 and TR5, with TR6 speeding up the output. Applying a variable voltage to the base of both transistors TR4 and TR5 would result in a varying frequency, but the mark/space ratio would remain the same; what is required is a fixed time pulse output with a variable delay between pulses. To this end TR4 is provided with a fixed base bias, but the voltage to TR5 is varied.

Exactly the same configuration is applied to the PROBABILITY multivibrator formed by TR7 and TR8, but the components are chosen to give a repetition rate somewhere between those of MV1 and MV2. TR9 speeds up the output. In practice TR6 provides a very good square wave, but because of the slow repetition rates of MV1 and MV3, TR3 and TR9 switch on and off very slowly, but the result is good enough for our purpose.

The outputs of the three multivibrators are applied to the gate formed by D5, D6, D7 and R41 (D8 is described later). Any small glass diodes will do for this purpose. If an oscilloscope is available, R41 may be adjusted to give the best output, but a meter may

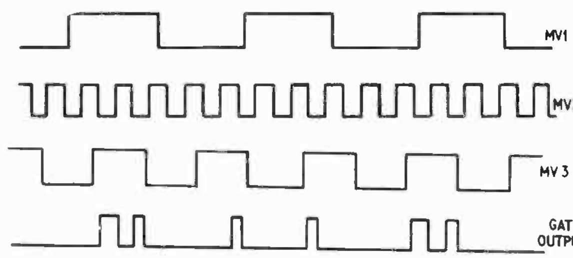


Fig. 9a. The waveforms into each gate diode D5, D6, D7 and the gate output waveform

COMPONENTS . . .

STAGE TWO (Panel "A" Fig. 9)

Resistors

R23	56kΩ	R30	100kΩ	R37	1MΩ
R24	1kΩ	R31	1MΩ	R38	22kΩ
R25	1kΩ	R32	470kΩ	R39	330kΩ
R26	22kΩ	R33	22kΩ	R40	56kΩ
R27	10kΩ	R34	330kΩ	R41	100kΩ (see text)
R28	56kΩ	R35	56kΩ		
R29	22kΩ	R36	22kΩ		

All ±10%, ¼W carbon

Capacitors

- C3 25μF elect. 50V
- C4 50μF elect. 50V
- C5 0·05μF polyester
- C6 0·05μF polyester
- C7 4μF elect. 50V
- C8 10μF elect. 50V
- C9 0·25μF polyester

Transistors and Diodes

- TR1 to TR9 any general purpose germanium types (e.g. OC71) all same (9 off)
- D4 to D8 any general purpose diodes (e.g. OA81) all same (4 off)

Miscellaneous

- Copper strip Veroboard 8in × 3¾in
- Dial (ex-P.O. type) with all contacts or components for Alternative Firing Element (Fig. 10)

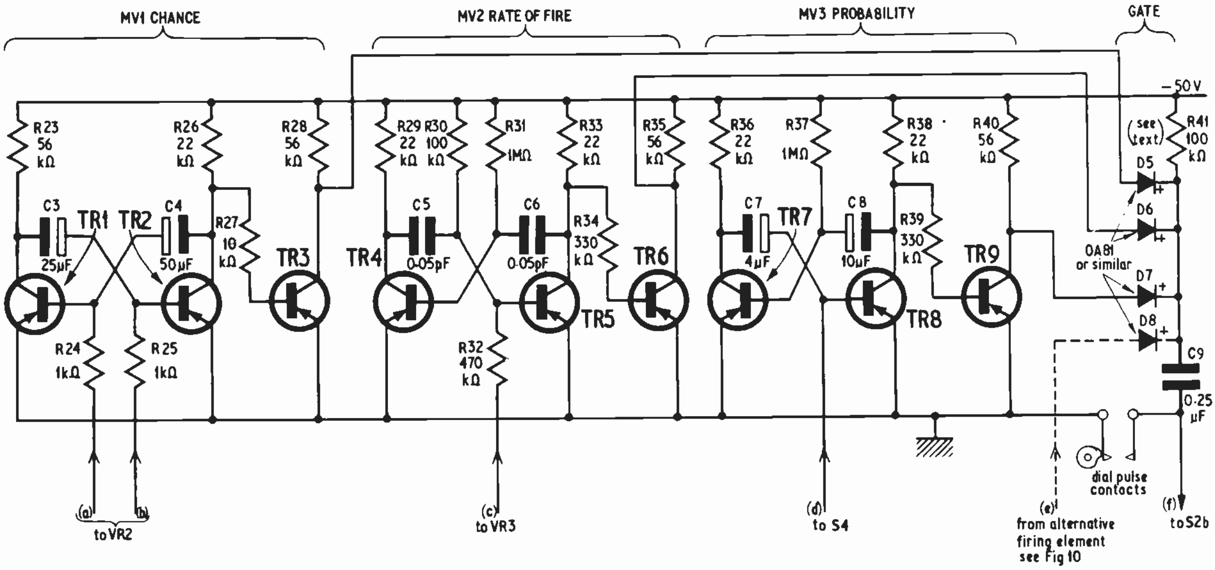


Fig. 9b. Circuit diagram of the multivibrators and gate (stage one) with waveforms (Fig. 9a) showing how coincidence gating is achieved

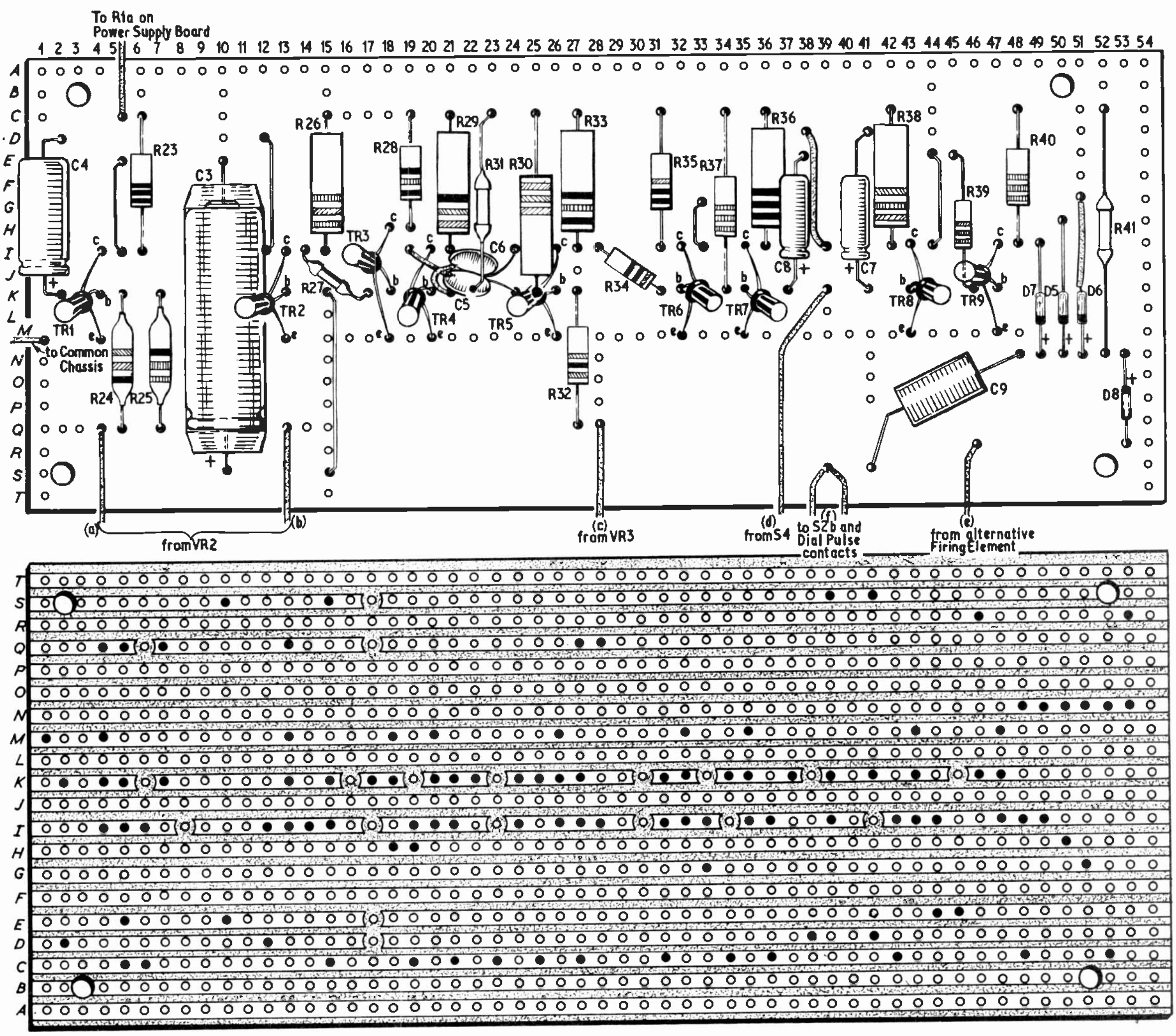


Fig. 9c. Layout of components on Panel A with underside view showing the breaks in the copper strips

be used as well. C9 prevents any back e.m.f. from damaging the transistors.

TESTING AND USING

Apply an oscilloscope to the collector of TR3, TR6 and TR9 in turn and ensure that all three multivibrators respond to their associated controls in a satisfactory manner.

All multivibrators have a free-running frequency and unless the controls allow sufficient current to pass to the bases of the transistors, the multivibrators will assume their own free-running condition. There must be a variation of response throughout the entire sweep of associated controls.

Earthing resistors such as R2 in Fig. 8, may be increased or decreased and it may be necessary to have recourse to padding resistors between the various controls and the negative rail.

When all is satisfactory, apply the 'scope to the gate output (f), observing the appearance and disappearance of pulses singly or in bursts. After a while a definite sequence will be discerned; the adjustment of any control will affect this sequence. Connect the output (f) to one of the pulsing contacts on the telephone dial and the other one to chassis.

In the best conditions of the controls, dialling a 1 will produce a pulse or pulses 99% of the time, whereas in the worst conditions it may be necessary to dial ten times ten before observing pulses out.

The circuit so far may be used with a simple voltmeter attached as before, but this time any deflection of the needle will indicate hits and damage. A dice may then be thrown to determine where the damage is, or the extent of that damage. If necessary, a simple one-transistor amplifier stage can be used.

FIRING BUTTON

Some constructors may prefer pressing a firing button to dialling (see Fig. 10). TR10 may be considered as part of a bistable with TR11 and part of a monostable with TR12. Switches S5a and S5b are

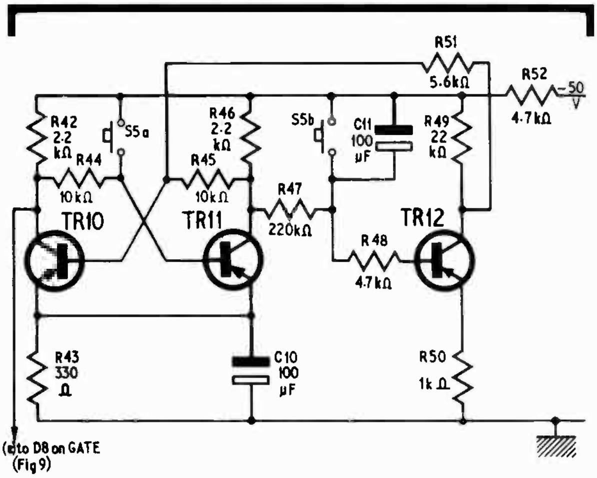


Fig. 10a. Circuit diagram of the alternative firing element and firing button S5, shown with dotted connections in Fig. 3

COMPONENTS . . .

ALTERNATIVE FIRING ELEMENT (Fig. 10a)

Resistors

R42	2·2kΩ	R46	2·2kΩ	R50	1kΩ
R43	330Ω	R47	220kΩ	R51	5·6kΩ
R44	10kΩ	R48	4·7kΩ	R52	4·7kΩ
R45	10kΩ	R49	22kΩ		

Capacitors
C10, C11 100µF elect. 50V (2 off)

Transistors
TR10–TR12 any general purpose germanium types (e.g. OC71) all same (3 off)

Miscellaneous
S5 Double-pole, on/off toggle switch, Veroboard

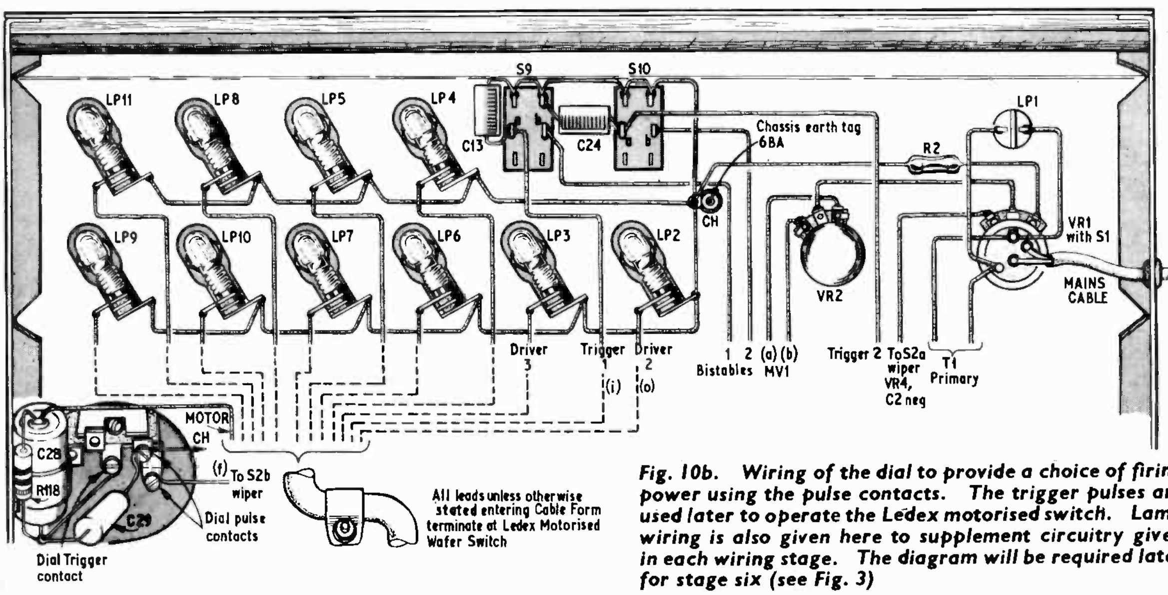


Fig. 10b. Wiring of the dial to provide a choice of firing power using the pulse contacts. The trigger pulses are used later to operate the Ledex motorised switch. Lamp wiring is also given here to supplement circuitry given in each wiring stage. The diagram will be required later for stage six (see Fig. 3)

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40362	68p	2N2905A	47p	2N4292	15p	BC149	10p	BFX88	26p
2N696	17p	2N2924	20p	AC107	46p	BC153	19p	BFY50	23p
2N697	18p	2N2925	22p	AC126	20p	BC154	20p	BFY51	20p
2N706	12p	2N2926	11p	AC127	20p	BC157	12p	BFY52	23p
2N930	29p	2N3053	27p	AC128	20p	BC158	11p	BSX20	16p
2N1131	29p	2N3055	60p	AC153K	22p	BC159	12p	C407	17p
2N1132	29p	2N3702	13p	AC176	16p	BC167	11p	MC140	25p
2N1302	19p	2N3703	13p	ACY20	20p	BC168	10p	MPS6531	35p
2N1303	19p	2N3704	13p	ACY22	16p	BC169	11p	MPS6534	30p
2N1304	26p	2N3705	13p	AD140	63p	BC177	14p	NKT211	25p
2N1305	26p	2N3706	13p	AD142	50p	BC178	13p	NKT212	25p
2N1306	33p	2N3707	13p	AD149	58p	BC179	14p	NKT214	23p
2N1307	33p	2N3708	10p	AD161	33p	BC182L	11p	NKT274	18p
2N1308	36p	2N3709	11p	AD162	36p	BC183L	10p	NKT403	65p
2N1309	36p	2N3710	13p	AF114	24p	BC184L	11p	NKT405	79p
2N1613	23p	2N3711	13p	AF115	24p	BC212L	16p	OC71	38p
2N1711	26p	2N3819	23p	AF117	22p	BC213L	16p	OC81	25p
2N1893	54p	2N3904	35p	AF124	24p	BC214L	16p	OC81D	25p
2N2147	95p	2N3906	35p	AF127	22p	BCY70	18p	ZTX300	14p
2N2218	34p	2N4058	13p	AF139	33p	BCY71	33p	ZTX301	16p
2N2218A	44p	2N4059	10p	AF239	36p	BCY72	15p	ZTX302	22p
2N2219	38p	2N4060	11p	ASY26	27p	BF115	23p	ZTX303	22p
2N2219A	53p	2N4061	11p	ASY28	27p	BF167	18p	ZTX304	27p
2N2270	62p	2N4062	12p	BC107	12p	BF173	19p	ZTX500	18p
2N2369A	19p	2N4124	18p	BC108	11p	BF194	14p	ZTX501	21p
2N2483	35p	2N4126	27p	BC109	12p	BF195	15p	ZTX502	25p
2N2484	42p	2N4284	15p	BC125	15p	BFX29	31p	ZTX503	22p
2N2646	47p	2N4286	15p	BC126	22p	BFX84	25p	ZTX504	52p
2N2904A	42p	2N4289	15p	BC147	10p	BFX85	52p		

RESISTORS

Code	Power	Tolerance	Range	Values available	1 to 9	10 to 99 (see note below)	100 up
C	1/20W	5%	82Ω–220KΩ	E12	9	8	7
C	1/8W	5%	4·7Ω–470KΩ	E24	1	0·8	0·7
C	1/4W	10%	4·7Ω–10MΩ	E12	1	0·8	0·7
C	1/2W	5%	4·7Ω–10MΩ	E24	1·2	1	0·9
C	1W	10%	4·7Ω–10MΩ	E12	2·5	2	1·9
MO	1/2W	2%	10Ω–1MΩ	E24	4	3·5	3
WW	1W	10% ± 1/20Ω	0·22Ω–3·9Ω	E12	7	7	6
WW	3W	5%	12Ω–10KΩ	E12	7	7	6
WW	7W	5%	12Ω–10KΩ	E12	9	9	8

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

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

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.

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Handbook of transistor equivalent and substitutes, 40p. (Postage 3p if ordered alone).

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Audio	4-pole	**14p**	**12p**
Audio	5-pole 180deg.	**15p**	**12p**
Audio	5-pole 240deg.	**15p**	**12p**
Audio	6-pole	**15p**	**13p**

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OCTOBER 71

SERVO CHART RECORDER

The rate of change of some electrical signals is often too slow to provide convenient monitoring with a test meter. This Chart Recorder makes a continuous assessment in graphical form on slow moving paper of such changing signals. Suitable for use with currently running P.E. Radio Telescope project and other applications involving long-term observation and monitoring.

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The fan used in the motor car is unnecessarily wasteful when driven from the engine. This controller operates a fan independently from engine drive according to the temperature of the water in the radiator.

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A simple audible alarm is triggered when rain falls or when the level of water in a vessel reaches a set point.

PRACTICAL ELECTRONICS

ON SALE SEPTEMBER 17

two poles of a pushbutton. It should be red and marked "Firing". Depressing the button discharges C11 completely and at the same time turns TR10 off and TR11 on.

The collector of TR11 becomes approximately 3 volts negative with respect to earth, and 6 volts with respect to the negative rail. C11 begins to charge through R47 and as it charges the base of TR12 lowers.

There comes a point (after about five seconds) when TR12 switches off. The voltage at the collector rises towards the negative rail, and this rise is transmitted through R51 to turn TR10 on. TR10 and TR11 together form a bistable and they now assume a stable state in which TR10 is on and TR11 off. The cycle cannot resume until S5 is again depressed, hence the whole circuit is a five-second timer, determined by R47, R48, R50, R51 and C11.

While TR10 is in the off position during the cycling process, the voltage at the collector rises to the negative rail and this is taken out to prime the gate via D8 (Fig. 9a). Since nothing can pass the gate until all inputs have a 1 (positive), no rate of fire pulses can go forward until the firing button is pressed.

This substitution for the dial would leave the constructor no method of feeding the computer with information regarding the number of guns firing and so it would be necessary to introduce another VR arranged as a voltage divider, and it may be necessary to adjust the gate resistor.

Fig. 10b shows the connections to the dial and lamps on the upper part of the control panel.

THIRD STAGE WIRING

Pulses are now routed and attenuated according to the positions of the remaining controls, S6, S7 and S8 (Fig. 11). Notice that first they go through the second wafer of the CALIBRE switch, S2b. Heaviest calibre pulses pass unattenuated, while others pass through voltage divider networks, for example that formed by R48 and R49.

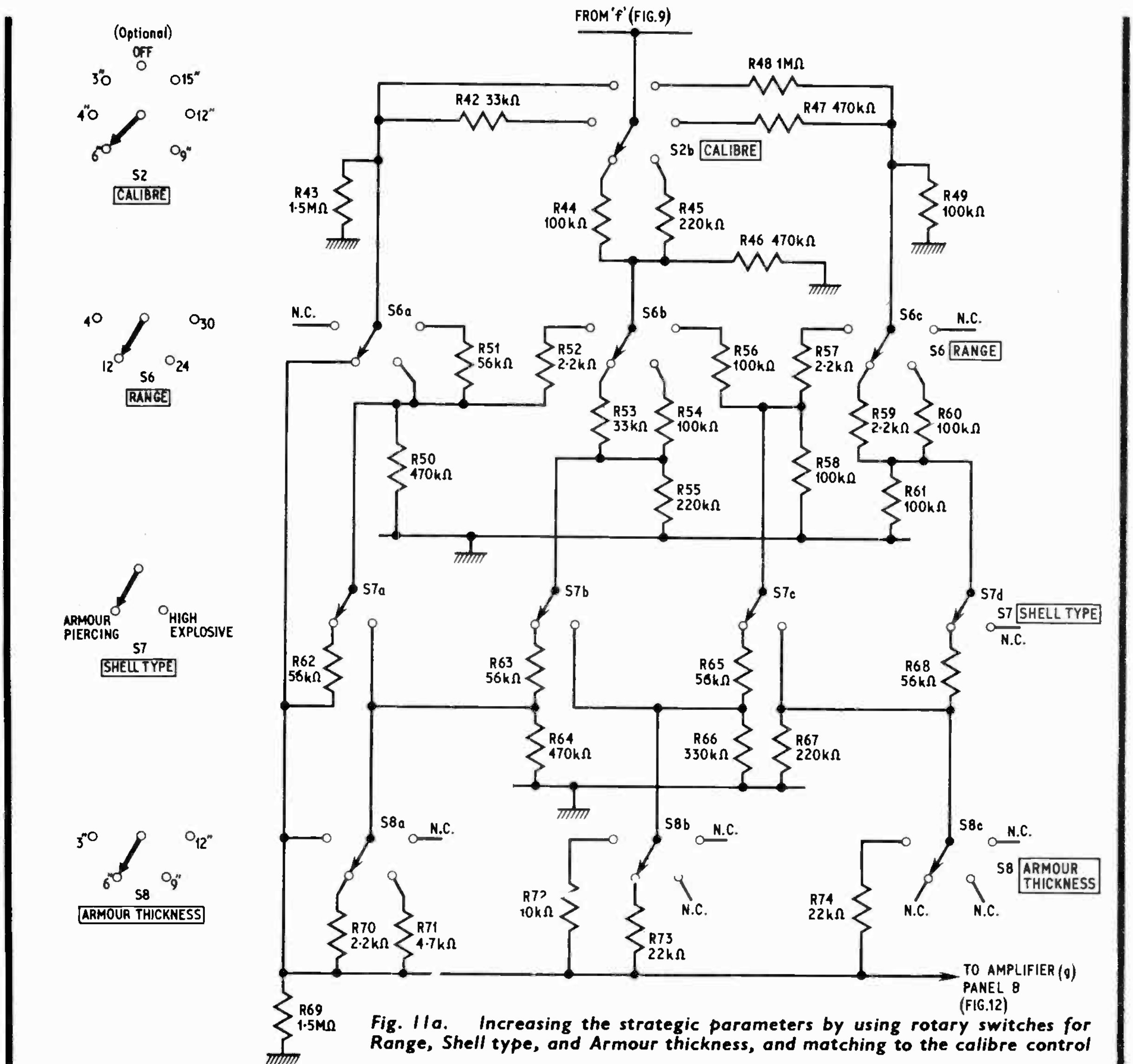


Fig. 11a. Increasing the strategic parameters by using rotary switches for Range, Shell type, and Armour thickness, and matching to the calibre control

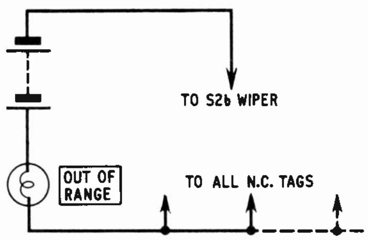


Fig. 11b. How to use n.c. positions to indicate "out of range"

COMPONENTS . . .

STAGE THREE (Fig. 11)

Resistors

R42	33kΩ	R53	33kΩ	R64	470kΩ
R43	1·5MΩ	R54	100kΩ	R65	56kΩ
R44	100kΩ	R55	220kΩ	R66	330kΩ
R45	220kΩ	R56	100kΩ	R67	220kΩ
R46	470kΩ	R57	2·2kΩ	R68	56kΩ
R47	470kΩ	R58	100kΩ	R69	1·5MΩ
R48	1MΩ	R59	2·2kΩ	R70	2·2kΩ
R49	100kΩ	R60	100kΩ	R71	4·7kΩ
R50	470kΩ	R61	100kΩ	R72	10kΩ
R51	56kΩ	R62	56kΩ	R73	22kΩ
R52	2·2kΩ	R63	56kΩ	R74	22kΩ

Switches
S6 3-pole, 4-way rotary wafer
S7 6-pole, 2-way rotary wafer (only 4 poles are used)
S8 3-pole, 4-way rotary wafer

Optional (see Fig. 11b and text)
Lamp and battery (any voltage) to show "out of range"

The other dividers will readily be discerned. At S6, the RANGE control, lightest calibres are blocked at long range, while heaviest calibres are blocked at short range, it being assumed that such guns will fire over their targets.

If desired, the outputs marked N.C. (no connection) may be taken to illuminate an out-of-range bulb (Fig. 11b). A separate supply will be necessary; four 1·5 volt batteries in series would feed a six volt bulb for months, at the rate of use found here.

The SHELL TYPE switch S7 is unusual in that the player is required to make a conscious choice that is not governed by conditions on the playing board. There are two positions, marked "Armour piercing" and "High explosive", the point being that AP shells pierce thicker armour, but HE shells do more damage.

On the AP side the pulses pass through a divider network such as R63 and R64, but are routed to the left of the diagram to pierce thicker armour, whereas HE pulses pass unattenuated to the right.

The ARMOUR switch S8 is set for armour thickness and again the pulses are blocked if the shells that they represent cannot pierce that thickness at that range. Others are attenuated by voltage dividers as before. Notice that R69 may form a divider with R62 as well as R70 to R74. The clear unattenuated signal path down the left of the diagram means that at optimum range the very heaviest shells whether HE or AP can pierce any armour. At a little longer range the heaviest AP can do so.

TESTING AND USING

Disconnect the chassis wire from the telephone dial (Figs. 9b and 10b), allowing pulses to pass unrestricted, and apply an oscilloscope to the output. There should be a very wide variation in the amplitude and frequency of pulses, and since we now have 12 controls (without the dial), the total number of combinations becomes $6^3 \times 10^3 \times 12 \times 4^2 \times 3 \times 2$—which is over 60 million combinations. It is obviously impossible to check all these and it becomes necessary to sample in order to satisfy ourselves that all is well.

First repeat the tests of the second stage, ensuring that the sequence pattern alters with the movement of the previous controls. Then set the RANGE switch to position two (short) and ARMOUR to minimum. Under these conditions all calibre settings will produce pulses.

Check that heavy calibres produce large amplitude pulses, and not vice-versa. Switching RANGE to position 1 should block the two heaviest calibres, while switching to position 4 will block the lightest.

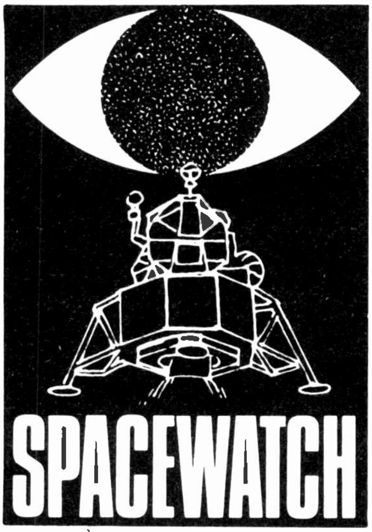
Check that pulses are progressively attenuated with range, also in the AP position. Check the progressive blocking of lighter calibres as armour is thickened.

It is really a matter of checking step by step, keeping a clear idea of the principles involved. When all is satisfactory, replace the chassis lead to the dial.

The computer can be used with a voltmeter as before, if necessary with an amplifier stage. Deflection of the needle indicates damage, but it is difficult, to be any more precise about this without becoming complicated. The amount of deflection is not a very good guide to the amount of damage because of the time lag in meter response.

A single heavy pulse of short duration may pass unnoticed by the observer, whereas a longer train of weaker pulses would produce a deflection proportionate to their amplitude and frequency. It is much better at this stage to say that if there is a needle deflection there is damage and to roll a dice to ascertain the extent of the damage.

Next month: Stage four—the start of showing how much damage is made to equipment.



BY FRANK W. HYDE

SOVIET PROBE TO MARS

One of the experiments being carried out on the Soviet probe to Mars, which began with the launching of the Russian *Mars 3* on May 28, indicates extensive Russo-Franco co-operation. This is the first time that a Western European country has been able to "thumb a lift" on an interplanetary probe.

The originators of the new experiment J. L. Steinberg and C. Caroubalos of the Observatoire de Meudon are studying solar bursts at metre wavelengths.

The particular study of sudden bursts of radiation from the sun is being carried out because the mechanism of their appearance is not fully understood. The bursts which may last from a few milliseconds to a few seconds are not adequately explained by the thermal motions of electrons. There must be some additional mechanism involving energetic electrons interacting with the magnetic field, and the plasma in the corona.

SOLAR RADIATIONS

Solar radiations are classified into different type groups. The two types involved in this study are Type 1 which last for less than half a second and are strongly polarised, indicating interaction with the coronal field; and Type 3 which are indicated by solar flares, terrestrial magnetic disturbances and auroral effects.

Type 3 bursts last for seconds and the particles that are involved move at very high speeds through the corona. Typically the velocity of the particles may be as high as 100,000 km/second. Type 3 bursts are confined to a cone of direction with an axis that lines up with direction of maximum variation of electron density.

From the earth these can be studied only in two dimensions but with the instrumentation on a probe it will be possible to obtain simultaneous observations from earth and a position in distant space. A partial 3D effect can then be secured. For this reason the French have called this a "stereo experiment". It is hoped that the experiment will reveal how the energy of the bursts is distributed in space and also the total amount of energy that is radiated.

The earth based station will be installed at Nancay in France where the 1,500 metre long radio heliograph is in operation. This radio telescope can provide 50 high resolution radio images of the Sun every second.

On *Mars 3* there is a radio telescope mounted on the solar panels of the spacecraft so that it is always pointing at the Sun. Two identical receivers will be in operation, one on *Mars 3* and one connected to the aerials at Nancay. From the probe data will be telemetered to the USSR where it will be processed and then passed on to France for comparison with their data.

MARINER NINE

The ninth of the *Mariner* series on its way to Mars alone, since *Mariner 8* aborted on May 8 for the reasons given in August *SPACEWATCH*, has been modified to give a compromise survey of the planet. It will go into a 65 degree orbit with periapais at 750 miles.

Under the new scheme less than 70 per cent of the planet will be mapped but with the same resolution as was originally intended. The slant range will be greater for some of the photography and some loss of detail will ensue.

Instead of the original plan of looking at six selected areas every five days it will look at several small areas once every seventeen days. Also, two tapes of data per day will be relayed back to earth instead of three as would have been the case with both vehicles operating. The scheduled programme remains the same at 90 days.

INTERSTELLAR MOLECULES

Using the 300 foot radio telescope at Kitt Peak to observe the emission lines in the millimetre-wave spectrum of the object Sgr B2, which is near the galactic centre, Dr. L. E. Snyder and Dr. D. Buhl have identified the molecules methylacetylene (CH_3C_2H) and isocyanic acid (HNCO).

They also found another line in the spectra of two other galactic sources W51 and DR21 though identification was difficult. It is thought that the molecule is isocyanide (HNC) but this opinion is based on laboratory work.

Dr. Snyder is from The University of Virginia and Dr. Buhl from the National Radio Astronomy Observatory.

ARTIFICIAL MARS CHAMBER

At the Institute of Microbiology in Moscow a chamber has been set up to simulate Martian conditions in order to examine the behaviour of different types of microorganisms. The chamber with a pressure of 7mm of mercury and sharp temperature variations ranging from minus 60 degrees to plus 30 degrees Centigrade, with a minimum amount of moisture, represents the conditions that are as near to that which exists on the planet.

Soil bacteria from the Pamirs, the Kara-Kum desert and Dixon Island in the Arctic Ocean was obtained for the experiment. During the experiments it turned out that microbes and bacteria from Dixon Island had the highest survival factor.

It is thought that the main reason for the survival of terrestrial forms in a Martian environment was the low humidity. Also, it turned out that coloured organisms were able to endure the conditions better.

It seems that pigment is a good protection against the effect of ultra violet rays. There are some workers who think that the changing colour observed on Mars is linked with the activity of micro-organisms.

If there is life on Mars then the cycle involving micro-organisms is a necessary part of any organic process.

TELESCOPES IN SATELLITES

The object of the design of telescopes to be carried by satellites above the turbulent and murkx parts of the earth's atmosphere is to obtain improved viewing.

Such instruments are costly and tend to be of relatively large size if they are to exceed the performance of the 200 inch reflector at Mount Palomar. Hopes of any unit of suitable size being put into space seemed to be linked to the advent of the space shuttle since the greatest single weight unit is the mirror.

A solution to the problem has been offered by J. Wilczynski of IBM. He suggests that two mirrors 20 inches in diameter could be put into orbit in such a way that the resolution of the 200 inch telescope could be achieved.

The new telescope would consist of two mirrors arranged to have a common focus by mounting them on a common arm which could be rotated with great precision. The image through the two mirrors would be photographed and the position changed. This would continue until the whole area was covered. By this means any point on any picture would be mathematically related to any other.

Readout—
A SELECTION FROM OUR POSTBAG

Correspondents wishing to have a reply must enclose a stamped addressed envelope. We regret we are unable to guarantee a reply on matters not relating to articles published in the magazine. Technical queries cannot be dealt with on the telephone.

Prior notice please!

Sir—Referring to the correspondence published in your July issue, one of the answers to the general problem of constructors being unable to obtain components, is for the authors of the articles in your magazine and others, to ensure that all components are currently obtainable at the time of issue. The name of the manufacturer of specialised components, including semiconductors should be mentioned, as also sources of supply.

In agreement with Mr P. F. Clarke, prior notice to suppliers would ensure that specialised components could be available within a reasonable time from the date of publication of a constructional article.

My firm is able to supply any component manufactured by Mullard Ltd., on a one-off basis, and this covers many thousands of individual items.

For Mr A. J. Sanders, the components he requires in the way of ferrites and associated hardware, can be supplied off the shelf.

I sympathise with Mr H. Boys of Weedon regarding the Mullard LA 2103 which is obsolete, the number having been changed twice since 1968.

I cannot understand Mr Easterfield's difficulties in obtaining Radiospares components, as all items in their catalogue (available to the trade only) can be supplied to retailers generally throughout the country on the day after an order is placed.

A. F. Trinder,
Gurney's (Radio) Ltd.

Reckless design

Sir—We agree that the points you have raised constitute real problems to the amateur constructor. We would, however, like to make the following comments:

Amateurs often obtain components for their circuits from unusual sources, i.e. cannibalising surplus equipment and by buying from surplus dealers. This means that very often the manufacturer is approached for components which are either obsolete or have been made for a specific purpose against a specific contract.

We as a company are in the process of appointing distributors for our components and would suggest that prior to publishing circuits the designer contacts either ourselves or one of our distributors so as to ascertain the availability.

We would mention that we would expect our distributors to deal not only with industrial customers but with amateur customers as well. It is probable, however, that there would be minimum order charges.

If this kind of liaison could be built up, it should in theory then be possible to arrange for our distributors to hold stocks of particular items, and in fact we see no reason why there should not be some reference at the end of the article as to where the components could be obtained.

We are sympathetic towards amateurs as very often amateur designed circuits eventually become professional circuits, but we do consider that some amateurs are reckless in the extreme by designing circuits without having made sure that the components are available.

The other point we would like to make, is that as manufacturers it is really not a practical proposition for us to deal direct with amateurs, as they only usually require very small quantities and the cost of processing their orders costs more than the goods. This of course emphasises the need for distributors.

J. N. Shipton,
Siemens (United Kingdom) Ltd.

Inadequate details

Sir—I refer to the letter published in the May issue concerning the supply of components to electronic enthusiasts.

In my experience the main problems encountered when dealing with private individuals are exactly those outlined by Mr Hughes. Firstly, ascertaining the exact component required and secondly arranging payment. Often orders give inadequate details and describe the application instead of the component which, rather than enter into correspondence, we tend to reject.

The remedy is for anyone requiring our components to detail accurately the unit required, preferably the type number, but if this is unknown, the value, working voltage, tolerance, size, etc., and; if the price is also unknown to request a Pro Forma Invoice.

On receiving an order in this form, our Distributor Division will be pleased to supply anyone subject to the following conditions which are necessary to cover the cost of non-standard clerical routines and to protect against the unfavourable economics of special small quantity manufacture:—

1. The order has a minimum value of £3.
2. The component required is in stock or available from Work-in-Progress.

Our Distributor Division carries a broad selection of Erie products, manufactured both in the U.K. and overseas, including ceramic, monolithic and trimmer capacitors, r.f.i. suppression filters, semiconductors and integrated circuits, and is able to provide on request full details of its stock programme.

While appreciating that we can only satisfy in part the demand for specialised, new or non-standard items, we can, if given a business-like order, extend considerably the variety of Erie products previously available to the enthusiast.

R. D. Hurrell,
Distribution Manager,
Erie Electronics Ltd.

Good relations

Sir—I hope I am not too late in replying to your editorial in Practical Electronics May issue, which at the same time was related to a letter in *Readout* from M. J. Hughes.

On behalf of our company we would be very pleased to help those electronic enthusiasts who are having trouble in obtaining semiconductors. As stockists for many components we may well be able to offer some of those rather special parts which people need from time to time.

In Worcester we have already served a number of amateur radio enthusiasts with their "ones and twos" requirements and we see no reason why this should not be extended to those other branches of electronics which need similar parts.

As a licensed "ham" I appreciate the feelings of those unable to complete a project for the want of a small part. If readers care to send us their "wants lists", particularly for all types of semiconductors, integrated circuits, capacitors, miniature transformers and so on, we should be glad to do our best to help. What we value most is a satisfied customer whether he buys one part or one thousand, and we have no minimum order charge on those goods we actually hold in stock.

R. C. Evans, G3LQC,
Thorp Electronic Components Ltd.

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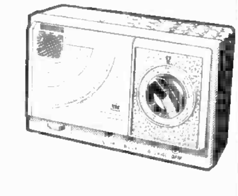
Miniaturised version of Model C-1052 employing similar ultra compact slimline impact resistant cabinet. Features—large easy to read 1¼in meter with mirror scale, D'Arsonval movement. Overload protection circuit. Fine calibration gives extremely high standard of accuracy on all ranges. Ohms zero adjustment. Click-stop range selection switch. Colour coded scales.



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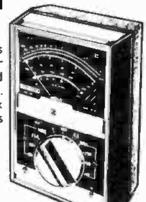

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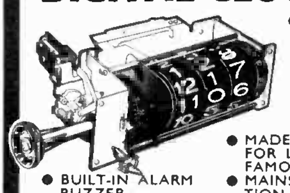

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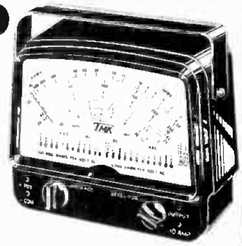

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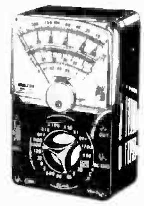

Specification
20,000 P.O.V. Multimeter. Features 24 measurement ranges with mirror scale accuracy. DC/V and current: 2%. A.c.:V: 3%. Resistance 3%. Special 0–6V DC range for transistor circuit measurements.

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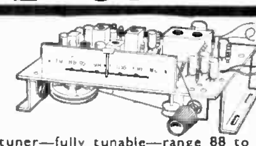

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AC141K	17p	AF127	20p	BC149	17p	BCZ11	20p	BFX29	27p	MPF105	43p	V410A	45p
AC142K	17p	AF139	33p	BC150	17p	BD121	85p	BFX84	20p	OC19	30p	2G301	19p
AC151	15p	AF178	50p	BC151	20p	BD123	85p	BFX85	27p	OC20	50p	2G302	19p
AC154	15p	AF179	50p	BC152	17p	BD124	75p	BFX86	22p	OC22	30p	2G303	19p
AC155	17p	AF180	50p	BC153	27p	BD131	80p	BFX87	25p	OC23	33p	2G304	20p
AC156	17p	AF191	50p	BC154	30p	BD132	80p	BFX88	22p	OC24	45p	2G306	35p
AC157	17p	AF186	45p	BC157	20p	BDY20	£1	BFY50	20p	OC25	25p	2G308	35p
AC165	17p	AF239	37p	BC158	17p	BF115	22p	BFY51	20p	OC26	25p	2G309	35p
AC166	17p	AFZ11	37p	BC159	20p	BF117	45p	BFY52	20p	OC28	40p	2G339	17p
AC167	20p	AFZ12	45p	BC167	13p	BF118	60p	BFY53	17p	OC29	40p	2G339A	15p
AC168	20p	AL102	85p	BC168	13p	BF119	70p	BSX19	15p	OC35	33p	2G344	15p
AC169	14p	AL103	85p	BC169	13p	BF152	35p	BSX20	15p	OC36	40p	2G345	15p
AC176	23p	ASY26	25p	BC170	12p	BF153	35p	BSY25	15p	OC41	20p	2G371	13p
AC177	20p	ASY27	30p	BC171	13p	BF154	35p	BSY26	15p	OC42	22p	2G371B	10p
AC187	30p	ASY28	25p	BC172	13p	BF157	45p	BSY27	15p	OC44	15p	2G374	17p
AC188	30p	ASY29	25p	BC173	13p	BF158	25p	BSY28	15p	OC45	12p	2G377	27p
ACY17	25p	ASY50	25p	BC174	13p	BF159	30p	BSY29	15p	OC70	15p	2G378	15p
ACY18	20p	ASY51	25p	BC175	22p	BF160	30p	BSY38	15p	OC71	9p	2G382	15p
ACY19	22p	ASY52	25p	BC177	17p	BF162	30p	BSY39	15p	OC72	12p	2G401	30p
ACY20	20p	ASY54	25p	BC178	17p	BF163	35p	BSY40	30p	OC74	12p	2G414	30p
ACY21	20p	ASY55	25p	BC179	17p	BF164	35p	BSY41	35p	OC75	15p	2G417	25p
ACY22	19p	ASY56	25p	BC180	20p	BF165	35p	BSY95	12p	OC76	15p	2N388	30p
ACY27	18p	ASY57	25p	BC181	22p	BF167	22p	BSY95A	12p	OC77	25p	2N388A	50p
ACY28	19p	ASY58	25p	BC182	10p	BF173	22p	BU105	£3·90	OC81	15p	2N404	22p
ACY29	30p	ASY58	25p	BC182L	10p	BF176	35p	C111E	60p	OC81D	15p	2N404A	30p
ACY30	25p	ASZ21	40p	BC183	10p	BF177	35p	C400	30p	OC82	15p	2N524	55p
ACY31	25p	BC107	10p	BC183L	10p	BF178	45p	C407	25p	OC82D	15p	2N527	60p
ACY34	18p	BC108	10p	BC184	13p	BF179	50p	C424	17p	OC83	20p	2N696	12p
ACY35	18p	BC109	11p	BC184L	13p	BF180	30p	C425	40p	OC84	20p	2N697	15p
ACY36	30p	BC113	25p	BC186	27p	BF181	30p	C426	30p	OC139	15p	2N698	24p
ACY40	15p	BC114	30p	BC187	27p	BF182	30p	C428	20p	OC140	17p	2N699	55p
ACY41	18p	BC115	30p	BC207	11p	BF183	30p	C441	27p	OC170	15p	2N706	7p
ACY44	35p	BC116	35p	BC209	11p	BF184	25p	C442	35p	OC171	15p	2N706A	8p
AD140	40p	BC117	35p	BC209	11p	BF185	30p	C444	37p	OC200	25p	2N708	12p
AD142	40p	BC118	25p	BC212L	11p	BF188	30p	C450	17p	OC201	27p	1N709	45p
AD149	43p	BC119	45p	BC213L	11p	BF194	23p	C720	12p	OC202	27p	2N711	40p
AD161	35p	BC125	35p	BC213L	11p	BF195	24p	C722	25p	OC203	25p	2N717	42p
AD162	35p	BC126	35p	BC214L	12p	BF196	30p	C740	25p	OC204	25p	2N718	24p
AD161/		BC132	25p	BC225	25p	BF197	35p	C742	17p	OC205	35p	2N718A	50p
162(MP)	63p	BC134	30p	BC226	35p	BF200	45p	C744	17p	OC309	35p	2N726	27p
ADT140	50p	BC135	30p	BC317	12p	BF222	80p	C760	17p	P346A	17p	2N727	27p
ADZ11	£2	BC136	30p	BC318	12p	BF257	35p	C762	17p	P397	45p	2N743	17p
ADZ12	£2·10	BC137	35p	BC319	12p	BF270	25p	C764	60p	OCP71	43p	2N744	17p
AF114	17p	BC139	45p	BCY30	20p	BF271	17p	EC401	15p	ORP12	43p	2N914	17p

2N918	30p	2N2714	25p	2N3704	15p
2N929	22p	2N2904	25p	2N3705	12p
2N930	25p	2N2904A	30p	2N3706	12p
2N1131	20p	2N2905	25p	2N3707	13p
2N1132	22p	2N2905A	30p	2N3708	8p
2N1302	17p	2N2906	25p	2N3709	8p
2N1303	17p	2N2906A	27p	2N3710	10p
2N1304	20p	2N2907	25p	2N3711	10p
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2N1308	27p	2N2925	13p	2N3904	27p
2N1309	27p	2N2926		2N3905	25p
2N1613	17p	(G)	12p	2N3906	27p
2N1711	20p	2N2926(Y)	11p	2N4058	15p
2N1889	35p	2N2926		2N4059	10p
2N1890	45p	(O)	10p	2N4060	12p
2N1893	37p	2N3010	80p	2N4061	12p
2N2160	60p	2N3011	20p	2N4062	12p
2N2147	75p	2N3053	20p	2N5172	12p
2N2148	60p	2N3054	50p	2N5459	43p
2N2192	30p	2N3055	63p	2S034	75p
2N2193	30p	2N3391	17p	2S301	50p
2N2194	27p	2N3391A	20p	2S302A	45p
2N2217	20p	2N3392	17p	2S302	45p
2N2218	25p	2N3393	15p	2S303	60p
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BY101	12p	BYZ18	30p	OA200	6p
BY105	15p	BYZ19	25p	OA202	7p
BY114	12p	OA5	17p	SO10	4p
BY126	15p	OA10	22p	SO19	4p
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Duty bound

Sir—I am following with considerable interest the correspondence and your remarks in P.E. relating to supplies of special electronic components to the amateur.

It may be of interest to your readers to know that the British Amateur Electronics Club appears to anticipate the demand by amateurs in some cases. This is probably because we are an amateur organisation, and the problems relating to minimum economical orders do not apply.

As an example, when the British Amateur Electronics Club started in 1966, silicon controlled rectifiers available in this country were very expensive. However, the B.A.E.C. was able to obtain good quality SCR's in America at very low prices, even after paying duty and additional postage.

Members of the B.A.E.C. are able to obtain specialised electronic components either at cost or, if they are required for experimental purposes and the member undertakes to write an article on his experiments for the B.A.E.C. Newsletter, they are provided free of charge.

The B.A.E.C. has recently been able to obtain very cheap but perfect voltage regulator integrated circuits and also inexpensive infra-red and visible-light semiconductor generators (L.E.D.) and receivers (photo-transistors).

These, as you know, are available in this country at relatively high prices, but I think that if any supplier in this country, who is interested in the amateur market, were to study the advertisements in amateur electronic magazines published in America, they, too, would be able to supply sophisticated and up-to-date electronic devices at reasonable prices to the amateur.

However, this does not apply to the well-known SN74 TTL integrated circuits which are in fact cheaper in this country than in America.

C. Bogod,
British Amateur Electronics Club

Opposite view

Sir—Having been a home constructor for a number of years, I would like to present the opposite view in your correspondence on the subject of components, and their availability.

I have rarely, if ever, experienced difficulty in obtaining components I require, even by mail order. Having lived in an area close to the majority of component retailers, I received, with few exceptions, courteous assistance and good service during personal buying of parts.

As I am no longer able to shop personally, due to a change of residence to another area of the country, I have, for the past year been buying by mail. Parcels received have been well packed, again with few exceptions, and refunds for out of stock items cheerfully and promptly given. In the case of the exceptions, a simple, well worded letter of complaint direct to the sales manager has usually cleared matters in a fortnight or less.

Considering the amount of business done by mail order, it is surprising that the service of most retailers is as good as it is, indeed, it could be far worse.

While I would also concur with the view that "one-offs" and highly specialised components are a loss maker for the firm who are prepared to deal with them, I would express surprise that the people who complain about being unable to obtain them, while deeming themselves capable of constructing, testing and setting to work a piece of often complex equipment, are unable to write to suppliers for their catalogues and find a replacement.

The one possible exception to the last paragraph is the amateur radio enthusiast, who, following the demise of the only manufacturer (Electroniques) in the country supplying r.f. coils to tune the amateur bands, has the dubious choice between bodging commercially available coils or winding his own.

To conclude, if components cannot be bought, begged or borrowed for the special project, there is a solution—set up in business and supply your own components!

P. J. Brent,
Helensburgh,
Scotland.

Final tip

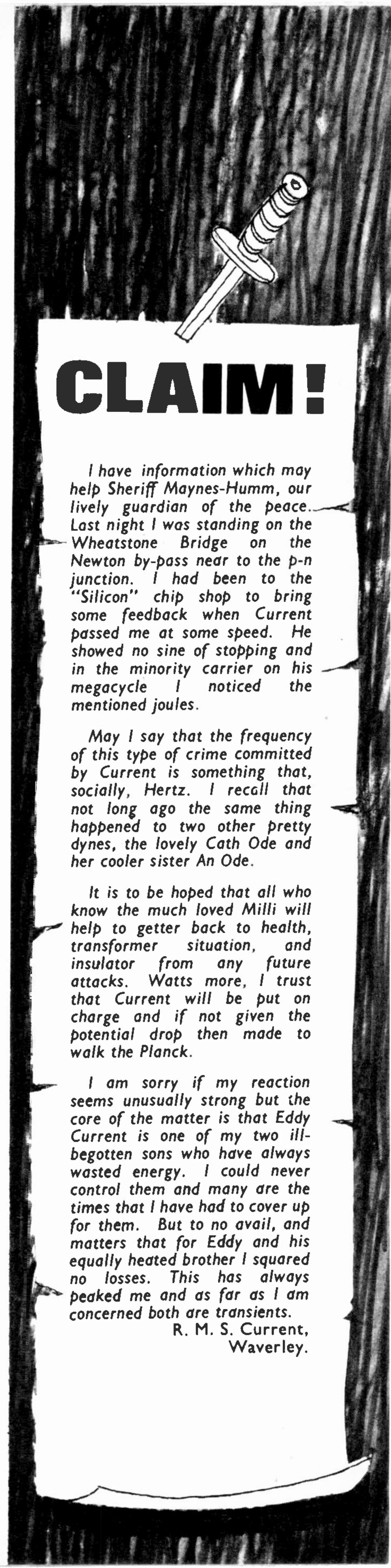
Sir—I have just received PRACTICAL ELECTRONICS magazine July issue, and after reading *Readout* I cannot understand why a number of your readers have such a problem trying to obtain parts for various circuits.

For instance, a 6-pole 5-way switch (letter on page 585), an advertisement for this appears on the opposite page 584, I think that a lot of readers do not take enough trouble to read the various advertisement pages for items wanted.

I have always found most manufacturing companies or large distributors very helpful regarding where to obtain special parts providing you keep your request brief, enclose an s.a.e. and make sure that your letter can be read.

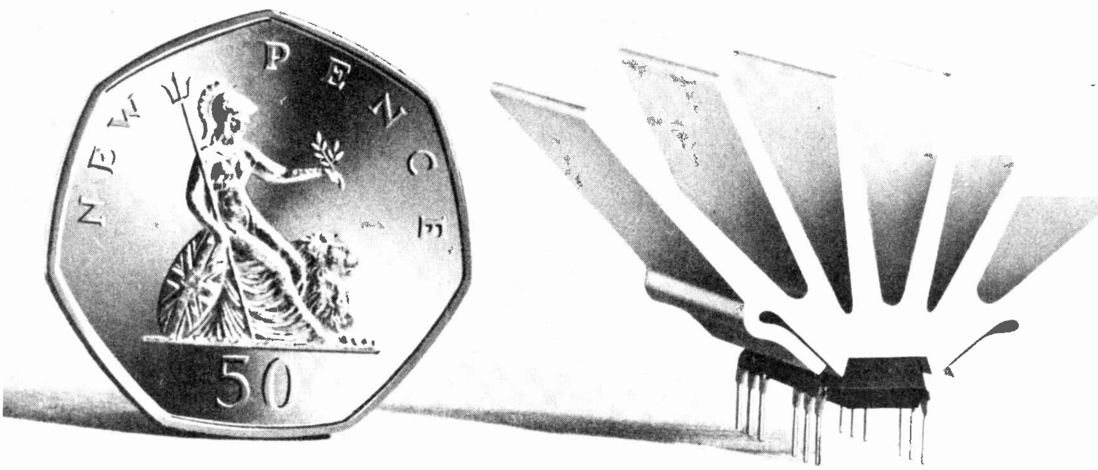
A final tip, always keep by your side a number of catalogues from various companies, this can make life a lot easier.

D. J. Brown,
Coventry.



new

Super IC-12



High fidelity Monolithic Integrated Circuit Amplifier

Two years ago Sinclair Radionics announced the World's first monolithic integrated circuit Hi-Fi amplifier, the IC.10. Now we are delighted to be able to introduce its successor, the Super IC.12. This 22 transistor unit has all the virtues of the original IC.10 plus the following advantages:

1. Higher power.
2. Fewer external components.
3. Lower quiescent consumption.
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5. Specially designed built-in heat sink. No other heat sink needed.
6. Full output into 3, 4, 5 or 8 ohms.
7. Works on any voltage from 6 to 28 volts without adjustment.
8. NEW 22 transistor circuit.

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Total Harmonic Distortion Less than 1%. (Typical 0.1%) at all output powers and all frequencies in the audio band.

Load Impedance 3 to 15 ohms.

Power Gain 90dB (1,000,000,000 times) after feedback.

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Size 22 x 45 x 28 mm including pins and heat sink.

Input Impedance 250 Kohms nominal.

Quiescent current 8mA at 28 volts.

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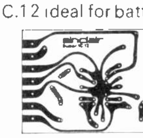

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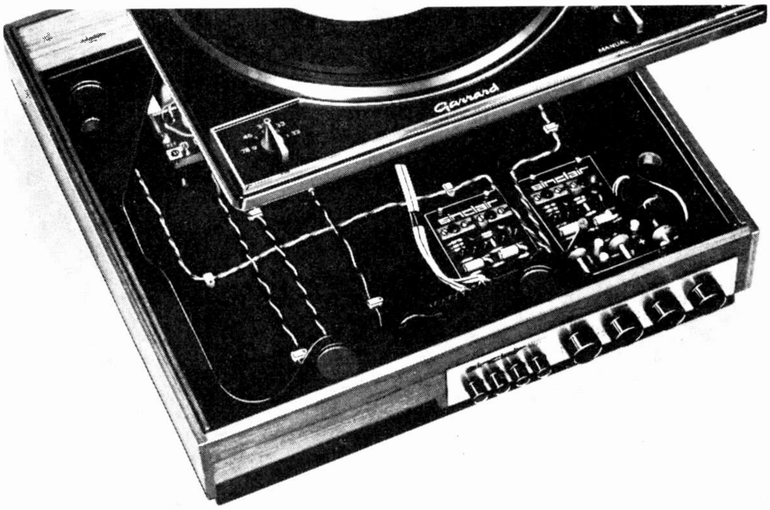
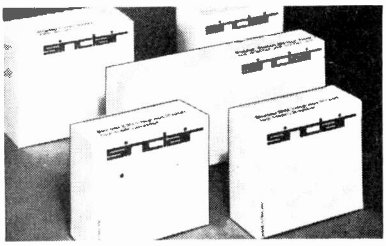
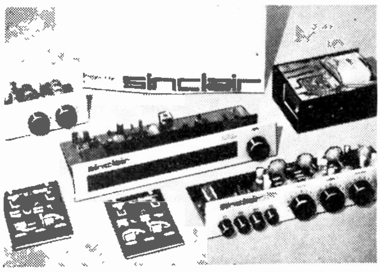
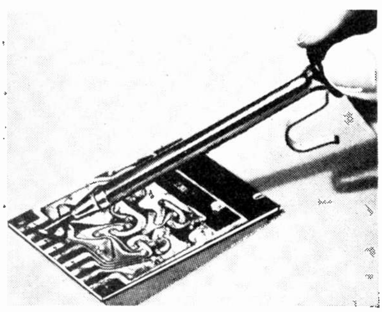
Sinclair Project 60

The World's leading range of high fidelity modules









Project 60 offers more advantage to the constructor and user of high fidelity equipment than any other system in the world.
Performance characteristics are so good they hold their own with any other available system irrespective of price or size.
Project 60 modules are more versatile – using them you can have anything from a simple record player or car radio amplifier to a sophisticated and powerful stereo tuner-amplifier. Either power amplifier can be used in a wide variety of applications as well as high fidelity. The Stereo 60 pre-amplifier control unit may also be used with any other power amplifier system, as can the AFU filter unit. The stereo FM tuner operates on the unique phase lock loop principle to provide the best ever standards of sensitivity and audio quality. Project 60 modules are very easily connected together by following the 48 page manual supplied free with all Project 60 equipment. The modules are great space savers too and are sold individually boxed in distinctive white and black cartons. With all these wonderful advantages, there remains the most attractive of all – price. When you choose Project 60 you know you are going to get the best high fidelity in the world, yet thanks to Sinclair's vast manufacturing resources (the largest in Europe) prices are fantastically low and everything you buy is covered by the famous Sinclair guarantee of reliability and satisfaction.

Typical Project 60 applications

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20 + 20 W. stereo amplifier with high performance spkrs.	**2 x Z.30s, Stereo 60, PZ.6**	High quality ceramic or magnetic P.U., F.M. Tuner, Tape Deck, etc.	**£26.90**
40 + 40 W. R.M.S. de-luxe stereo amplifier	**2 x Z.50s, Stereo 60 PZ.8, mains trsfrmr**	As above	**£34.88**
Indoor P.A.	**Z.50, PZ.8, mains transformer**	Mic., guitar, speakers, etc., controls	**£19.43**

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200	0·35	0·37	0·57	0·61	0·75	1·60
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200	0·05	0·09	0·06	0·14	0·20	0·24	1·00
400	0·06	0·13	0·07	0·20	0·27	0·37	1·25
600	0·07	0·16	0·10	0·23	0·34	0·45	1·85
800	0·10	0·17	0·13	0·25	0·37	0·55	2·00
1000	0·11	0·25	0·15	0·30	0·46	0·63	2·50
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BP03 = 7403	Quadruple 2-input positive NAND gates (with open-collector output)	0·23	0·20	0·15
BP04 = 7404	Hex Inverters	0·23	0·20	0·15
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BP20 = 7420	Dual 4-input positive NAND gates	0·23	0·20	0·15
BP30 = 7430	8-input positive NAND gates	0·23	0·20	0·15
BP40 = 7440	Dual 4-input positive NAND buffers	0·23	0·20	0·15
BP41 = 7441	BCD to decimal nixie driver	0·87	0·77	0·67
BP42 = 7442	BCD to decimal decoder (4–10 lines, 1 of 10)	0·87	0·77	0·67
BP47 = 7447	BCD-seven-segment decoder/drivers (15V outputs)	1·40	1·30	1·20
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BP53 = 7453	Quad 2-input expandable and-or-invert	0·23	0·20	0·15
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UIC03 = 12 × 7403N	50p	UIC60 = 12 × 7460N	50p	UIC86 = 5 × 7486N	50p
UIC04 = 12 × 7404N	50p	UIC70 = 8 × 7470N	50p	UIC90 = 5 × 7490N	50p
UIC05 = 12 × 7495N	50p	UIC72 = 8 × 7472N	50p	UIC92 = 5 × 7492N	50p
UIC10 = 12 × 7410N	50p	UIC73 = 8 × 7473N	50p	UIC93 = 5 × 7493N	50p
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BP 701C—SL701C	TO-5	8	OP Amp	63p	50p	45p
BP 702C—SL702C	TO-5	8	OP Amp Direct OP	63p	50p	45p
BP 702 —72702	D.I.L.	14	G.P. OP Amp (Wide Band)	53p	45p	40p
BP 709 —72709	D.I.L.	14	High OP Amp	53p	45p	40p
BP 709P—μA709C	TO-5	8	High Gain OP Amp	53p	45p	40p
BP 711—μA711	TO-5	10	Dual comparator	58p	50p	45p
BP 741 —72741	D.I.L.	14	High Gain OP Amp (Protected)	75p	60p	50p
μA 703C—μA703C	TO-5	6	R.F.–I.F. Amp	43p	35p	27p
TAA 263—	TO-72	4	A.F. Amp	70p	60p	55p
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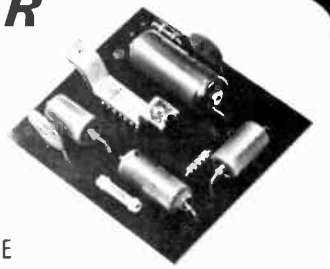

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BP933	Dual 4-input expander	25p	23p	20p
BP935	Expandable Hex Inverter	25p	23p	20p
BP936	Hex Inverter	25p	23p	20p
BP944	Dual 4-input NAND expandable buffer without pull-up	25p	23p	20p
BP945	Master-slave JK or RS	35p	32p	29p
BP946	Quad, 2-input NAND	23p	20p	15p
BP948	Master-slave JK or RS	35p	32p	29p
BP954	Monostable	90p	85p	80p
BP962	Triple 3-input NAND	23p	20p	15p
BP9093	Dual Master-slave JK with separate clock	80p	75p	70p
BP9094	Dual Master-slave JK with separate clock	80p	75p	70p
BP9097	Dual Master-slave JK with Common Clock	80p	75p	70p
BP9099	Dual Master-slave JK Common Clock	80p	75p	70p

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UIC933 = 12 × μA 933	50p	UIC961 = 12 × μA 961	50p
UIC935 = 12 × μA 935	50p	UIC9093 = 5 × μA 9093	50p
UIC936 = 12 × μA 936	50p	UIC9094 = 5 × μA 9094	50p
UIC944 = 12 × μA 944	50p	UIC9097 = 5 × μA 9907	50p
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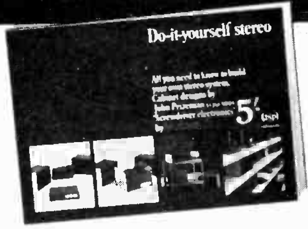

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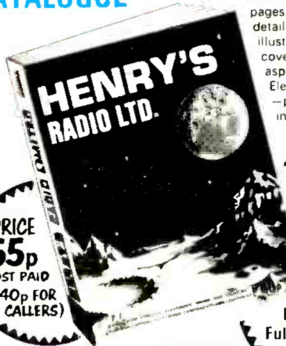

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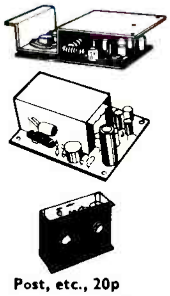

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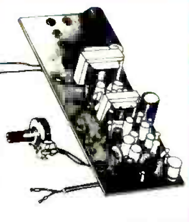

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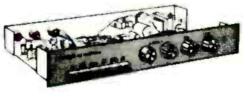

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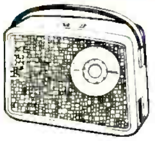

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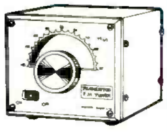

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