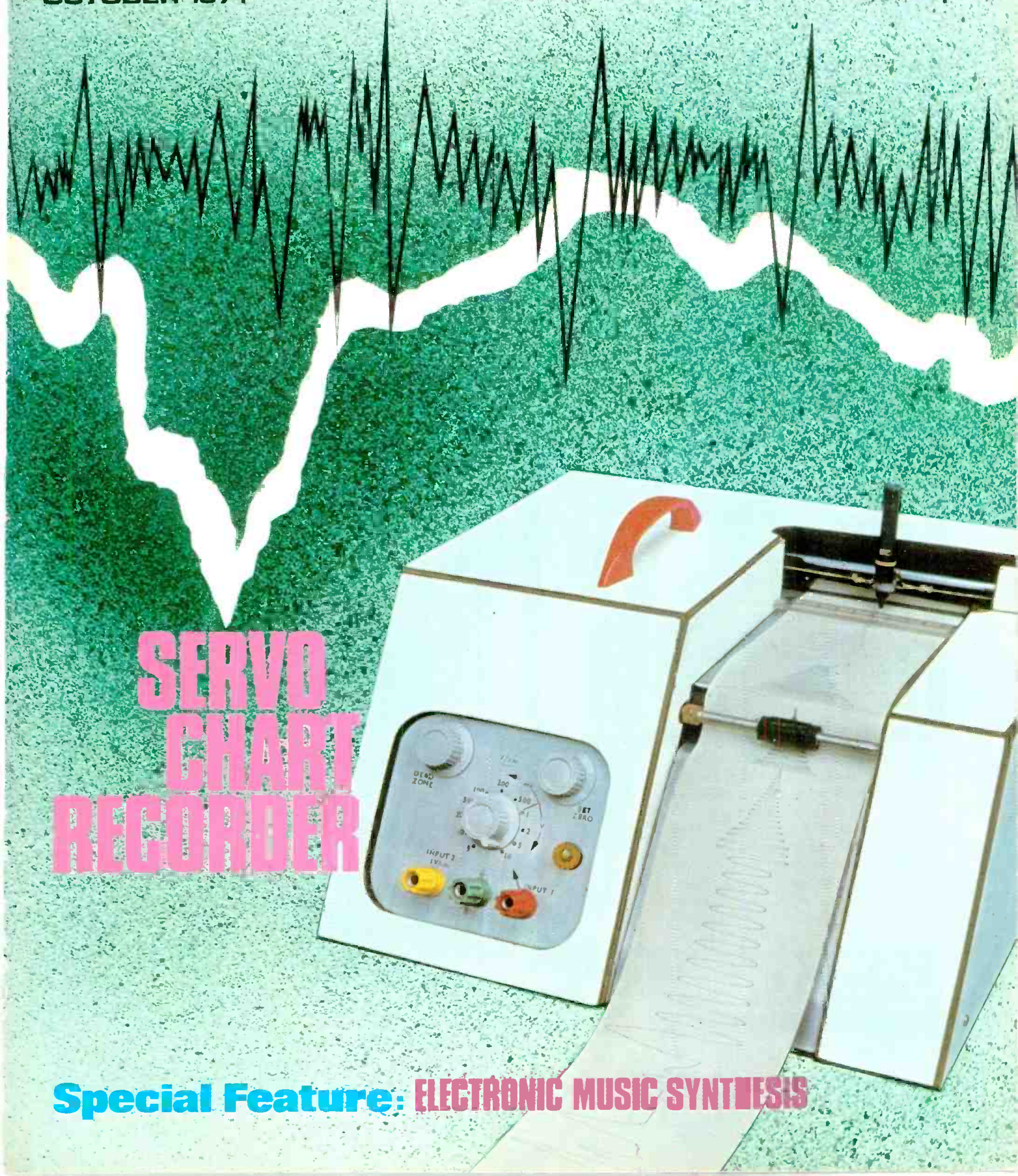
PRACTICAL

ELECTRONICS

OCTOBER 1971

20p



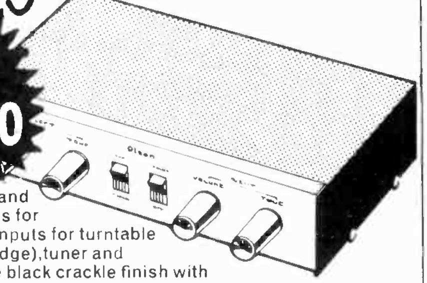
SERVO CHART RECORDER

Special Feature: ELECTRONIC MUSIC SYNTHESIS

JUST BEGINNING?

Then try out

8-Watt, 10-Transistor Stereo Amplifier R.137



ROC price £10.50

Separate tone and volume controls for each channel, inputs for turntable (ceramic cartridge), tuner and tape. Attractive black crackle finish with brushed aluminium front. Frequency response: 70-20,000 Hz ± 3dB. Output: 4 watts per channel @ 8 ohms. Inputs: Phono 80mV; tuner/aux 80mV.

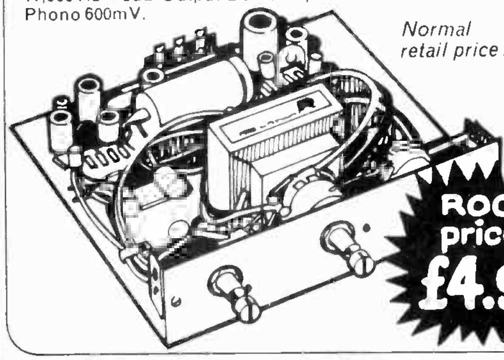
Normal retail price: £14·70

FIRST STEP TO STEREO!

5-Watt Transistor Stereo Amplifier Chassis R.123

Completely self-contained, fully transistorised, mains-powered (240vAC) amplifier, needing only cabinet and knobs. Ideal for adapting mono players to stereo. Frequency response: 40-17,000 Hz ± 3dB. Output: 2·5 watts per channel @ 8 ohms. Input: Phono 600mV.

Normal retail price: £7·30



ROC price £4.95

SOUNDS SENSATIONAL

AM/FM/MPX Stereo Tuner Amplifier R.124

A top quality amplifier with facility for receiving stereo broadcasts. Separate bass and treble controls, automatic frequency response, stereo headphone socket, output power: 8 watts. FM frequency range 88-108 M Hz; AM frequency range 535-1605 K Hz. Inputs for turntable (ceramic cartridge) and tape. Frequency response: 50-10,000 Hz ± 3dB. Output: 4 watts per channel @ 8 ohms. Inputs: Phono 200mV, tape 100mV. FM: Sensitivity 20μV, stereo separation 26dB, image rejection 55dB. AM: Sensitivity 300μV.

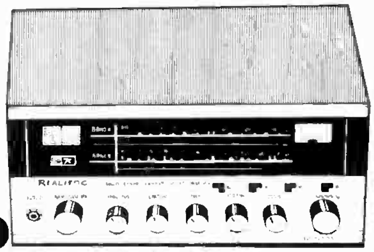
Normal retail price: £42·00 **ROC price: £29.95**

World wide reception

Professional Solid-state, Four-band Communications Receiver R.135

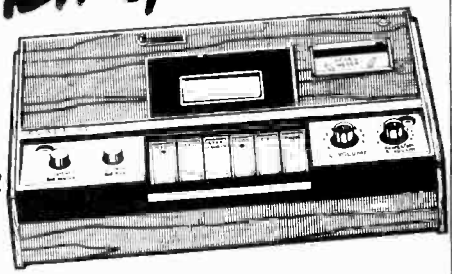
Fully transistorised with continuous coverage from 555K Hz to 30 M Hz in four bands (with illuminated bandspread for 160-10 metres). Incorporates internal speaker, automatic noise limiter, SSB/AM/CW switch, AVC switch, S Meter, Receive and Standby switch, external socket for headphone or speaker, bandspread control, BFO control, on/off/AF gain, band selector, antenna trimmer and RF gain. Runs off 240 v AC, batteries or any 12 v DC negative ground source. Frequency ranges (in mHz): Band A, 535-1·6; B, 1·55-4·5; C, 4·5-13; D, 13-30. Sensitivity: 0·5μV @ 30mHz. Bandspread: 10-160 metres.

Normal retail price: £65·00



ROC price: £45.00

AMAZING OFFER!



Stereo Cassette Tape Unit R.142

Complete stereo record and playback unit with line and microphone inputs. Fitted with tape counter, separate pause control, recording level metres for each channel, pop-up cassette ejection. Supplied complete with two pencil microphones. Wow & flutter better than 0·3%, frequency response 100-10,000 Hz. Tape speed: 1⅞ IPS, 4·75 CMS. Rewind time: Better than 60 sec (C.60 cassette).

Normal retail price: £65·00

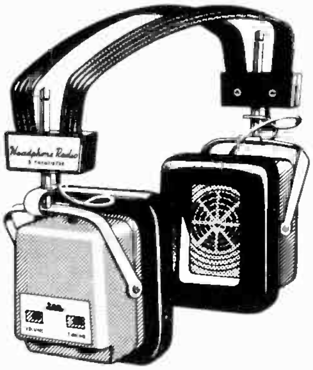
ROC price £49.50

We don't want you to

Every piece of electronic or audio-equipment we sell is built to our specifications. It comes complete with a Guarantee. And it's tested before it leaves us.

We bend over backwards in our advertising to make sure everything we say is factually accurate. But, buying mail-order, even though you're buying from us, we accept you could still end up with a piece of equipment that's not exactly what you wanted. And we think that's unfair.

FANTASTIC BARGAIN



Headphone Radio R.143

For completely private listening without the distortion of the ordinary earphone adaptor. Battery operated; PP3. Fully transistorised. Frequency range: 535-1600 K Hz, Medium Wave Band. Maximum output: 300mW.

ROC price £6.90

Normal retail price: £9·40

STEREO headphones

only £2.40

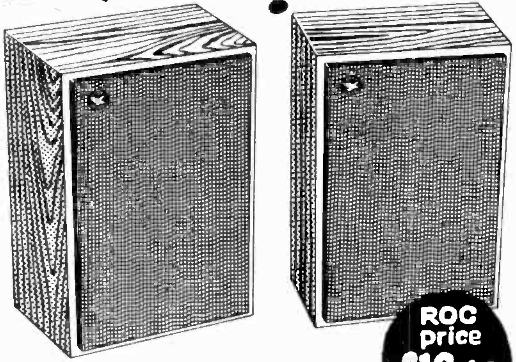
Stereo Headphones R.328

Light and comfortable, with a frequency response of 30-15,000 Hz for real listening pleasure. Complete with jack plug. Impedance 8-16 ohms.

Normal retail price: £2·95

2 for the price of one!

Matched Stereo Speakers R.446



ROC price £16.40

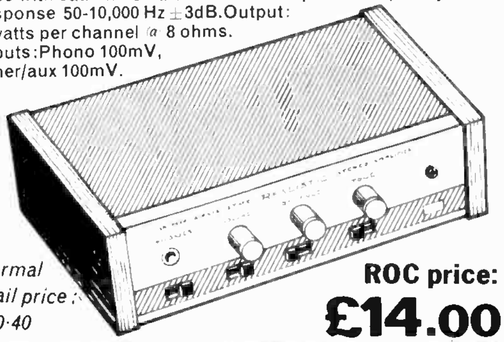
Heavily lagged teak finish cabinets each with large dual cone base unit and separate tweeter. Power handling: 10 watts peak; frequency range: 40-18,000 Hz, impedance: 8 ohms. Size: 14 x 8¾ x 6¼.

Normal retail price: £19·60

Don't read this!

10-watt Transistor Stereo Amplifier R.136

Ganged volume, balance and tone controls. Inputs for turntable (ceramic cartridge), tuner (see R.134) or tape. Oiled walnut case with satin finish aluminium front panel. Frequency response 50-10,000 Hz ±3dB. Output: 5 watts per channel @ 8 ohms. Inputs: Phono 100mV, tuner/aux 100mV.



Normal retail price: £20·40

ROC price: £14.00

The Perfect match!

AM/FM/MPX Stereo Tuner R.134

Matching unit to the R.136 amplifier. Covers AM and FM tuning bands with automatic stereo signal light. FM frequency range: 88-108mHz; AM frequency range: 535-1605kHz. FM: Sensitivity 5μV, stereo separation 25dB@1kHz, image rejection 50dB. AM: Sensitivity 250μV.

Normal retail price: £28·60

ROC price £22

pay for your mistakes

So we've got a proposition for you.
If you buy a piece of Roc equipment, and it's not quite what you expected, send it back within seven days, and as long as it's as good as new we'll give you your money back. O.K?

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NEW "SEW" DESIGNS!

CLEAR PLASTIC METERS — TYPE SW. 100, 100 x 80 mm

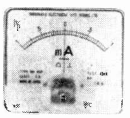
50μA	£3·47½	500μA	£3·12½
50-0-50μA	£3·37½	1mA	£2·97½
100μA	£3·37½	20V d.c. ..	£2·97½
100-0-100μA	£3·25	50V d.c. ..	£2·97½
		300V d.c.	£2·97½
		1A d.c. ..	£2·97½
		5A d.c. ..	£2·97½
		300V a.c.	£2·97½
		VU Meter	£3·75

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

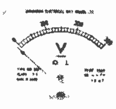
Type MR.52P. 2½in square fronts.

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 1mA ..	£2·10
5mA	£2·00	VU Meter	£3·10
10mA	£2·00	1A a.c.* ..	£2·00
50mA	£2·00	5A a.c.* ..	£2·00
100mA ..	£2·00	10A a.c.*	£2·00
500mA ..	£2·00	20A a.c.*	£2·00
1A........	£2·00	30A a.c.*	£2·00
5A	£2·00		
10V d.c. .	£2·00		

Type MR.65P. 3½in 3½in 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 1mA ..	£2·37½
50mA	£2·10	VU meter	£3·37½
100mA ..	£2·10	50mA a.c.*	£2·10
500mA ..	£2·10	100mA a.c.*	£2·10
1A........	£2·10	200mA a.c.*	£2·10
5A........	£2·10	500mA a.c.*	£2·10
10A	£2·10	1A a.c.* ..	£2·10
15A	£2·10	5A a.c.* ..	£2·10
20A	£2·10	10A a.c.*	£2·10
30A	£2·10	20A a.c.*	£2·10
50A	£2·37½	30A a.c.*	£2·10
5V d.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 ..	£1·87½
1mA	£1·50	VU Meter	£2·25
5mA	£1·50	1A a.c.* ..	£1·50
10mA	£1·50	5A a.c.* ..	£1·50
50mA	£1·50	10A a.c.*	£1·50
100mA ..	£1·50	20A a.c.*	£1·50
500mA ..	£1·50	30A a.c.*	£1·50
1A........	£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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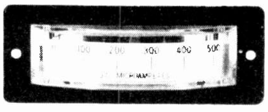
Type ED.107. Size overall 100mm × 90mm × 108mm. A new range of high quality moving coil instruments ideal for school experiments and other bench applications. 3" mirror scale. The meter movement is easily accessible to demonstrate internal working. Available in the following ranges:

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/5Ad.c.	£4·25
1A d.c.	£3·97	5V/50V d.c.	£4·25
5A d.c.	£3·97		
10V d.c. ..	£3·97		

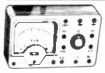
EDGWISE METERS



PE.70 3 17/32in 1 15/32in 2½in 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!

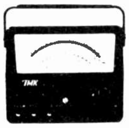


TECH PT-34. 1,000 O.P.V. 0/10/50/250/500/1,000V a.c. and d.c. 0/1/100/500mA. d.c. 0/100K. **£1·97½**. P. & P. 12½p.

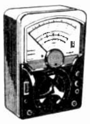
MODEL TE-200. 20,000 O.P.V. Mirror scale, overload protection. 0/5/25/125/1,000V d.c. 0/10/50/250/1,000V a.c. 0/50μA/250MA. 0/60K/6 meg. −20 to +62dB. **£3·75.** P. & P. 15p.

MODEL TE-70. 30,000 O.P.V. 0/3/15/60/300/600/1,200V d.c. 0/6/30/120/600/1,200V a.c. 0/30μA/3/30/300mA. 0/16K/160K/1·6M/16 meg. **£5·50.** P. & P. 15p.

MODEL TE12. 20,000 O.P.V. 0/0·6/30/120/600. 1,200 / 3,000 / 6,000V d.c. 1/6/30/120/600/1,200V a.c. 0 / 60μA / 6 / 60 / 600MA/0 / 6K / 600K / 6meg./60. Megohm 50PF. 2 MFD **£5·97½**. P. & P. 17½p.

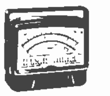


MODEL PL436. 20k Ω/Volt d.c. 8k Ω/Volt a.c. Mirror scale. 0·6/3/12/30/120/600V d.c. 3/30/120/600V a.c. 50/600μA/60/600mA. 10/100K/1 Meg/10 meg Ω. −20 to +46dB. **£6·97½**. P. & P. 12½p.



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.

270° WIDE ANGLE 1mA METERS

MW1-6 60mm square **£3·97½**. MW1-8 80mm square **£4·97½**. P. & P. extra.

T.E.40 HIGH SENSITIVITY A.C. VOLTMETER

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.

TE-65 VALVE VOLTMETER

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.

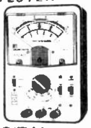
SKYWOOD SW-500

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.

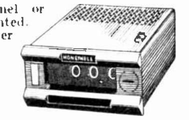
TE-900 20,000 Ω/VOLT GIANT MULTIMETER. Mirror scale and overload protection. 6in full view meter. 2 colour scale. 0/2·5 / 10 / 250 / 1,000 / 5,000V a.c. 0/25/12·5/10/50/250/1,000/5,000V d.c. 0/50μA/110/100/500mA/10A d.c. 02K/200K/20 meg. ohm. **£15.** P. & P. 25p.

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.

HONEYWELL DIGITAL VOLTMETER VT.100



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.
Specification:—
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.
Overall size: 5¼in. × 2 13/16in. × 8 3/16in
AVAILABLE BRAND NEW AND FULLY GUARANTEED AT APPROX. HALF PRICE
£49·97½ Carr. 50p

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Also see next two pages

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2N697	15p
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2N706A	11p
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
2N1303	17p
2N1304	22p
2N1305	22p
2N1306	24p
2N1307	24p
2N1308	25p
2N1309	24p
2N1507	17p
2N1613	21p
2N1631	35p
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2N1638	27p
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2N2147	72p
2N2160	57p
2N2193	40p
2N2193A	42p
2N2194	27p
2N2194A	30p
2N2217	27p
2N2218	20p
2N2219	20p
2N2220	25p
2N2221	25p
2N2222	20p
2N2222A	25p
2N2297	30p
2N2368	15p
2N2369	17p
2N2369A	17p
2N2410	42p
2N2483	27p
2N2484	32p
2N2539	22p
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2N2906A	25p
2N2907	23p
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2N3415	22p
2N3416	27p
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2N3439	130p
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2N3564	17p
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2N3566	22p
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2N3569	25p
2N3570	125
2N3572	97p
2N3605	27p
2N3606	27p
2N3607	22p
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2N5367	57p
2N5457	34p

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ACY39	47p
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ASY54	25p
ASY67	45p
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BD116	112p
BD121	65p
BD123	80p
BD124	75p
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BD132	85p
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BF159	57p
BF163	35p
BF167	25p
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BF225	20p
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BFW89	20p

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C450	15p
GET102	30p
GET113	20p
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GET889	22p
GET890	22p
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MAT120	25p
MAT121	30p
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MJ420	112p
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MJ430	102p
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NKT781	30p
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ORP12	50p
ORP60	40p
ORP61	42p
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XC141	35p
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CA3020A	160p
CA3021	156p
CA3022	130p
CA3023	126p
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FCH161	50p
FCH171	105p
FCH181	105p
FCH191	105p
FCH201	130p
FCH211	130p
FCH221	130p
FCH231	150p
FCJ101	160p
FCJ111	150p
FCJ121	275p
FCJ131	275p
FCJ141	525p
FCJ201	100p
FCJ211	275p
FCK101	430p
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
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TAA310	125p
TAA320	72p
TAA350	175p
TAA435	147p
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4003 200PIV	10p	12p	22p
4004 400PIV	10p	12p	25p
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30PL14	80p
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E180F	95p
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EAF42	35p
EB91	20p
EBC41	55p
EBC81	30p
EBF80	40p
EBF83	40p
EBF89	35p
EBL21	60p
EC86	60p
EC88	60p
ECC40	60p
ECC84	30p
ECC85	30p
ECC88	40p
ECF80	35p
ECF82	35p
ECF86	65p
ECH21	57p
ECH35	60p
ECH42	70p
ECH81	30p
ECH83	40p
ECL80	40p
ECL82	35p
ECL83	65p
ECL86	40p
EF37A	60p
EF39	40p
EF40	50p
EF41	65p
EF42	75p
EF80	25p
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PCF800	80p
PCF801	50p
PCF802	50p
PCF805	75p
PCF806	70p
PCF808	75p
PCL82	35p
PCL83	65p
PCL84	45p
PCL85	40p
PCL86	45p
PFL200	70p
PL36	55p
PL81	50p
PL82	45p
PL83	45p
PL84	40p
PL500	75p
PL504	80p
PY32	55p
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PY80	35p
PY81	30p
PY82	30p
PY83	38p
PY88	40p
PY800	50p
PY801	50p
U25	75p
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U50	32p
U52	33p
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U282	40p
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UCF80	55p
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UCL82	35p
UCL83	60p
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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
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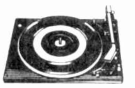

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Low cost high performance stereo headphones. Foam rubber ear cups. Adjustable headband. 8 ohm impedance. 25–18,000Hz. With lead and stereo jack plug.
ONLY **£1·97½**. P. & P. 12½p.

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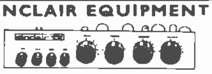

Project 60. Package offers. 2 × Z30 amplifier, stereo 60 pre-amp, PZ5 power supply, **£16·75**, Carr 37½p. Or with PZ6 power supply, **£18·85**. Carr. 37½p. 2 × Z50 amplifier, stereo 60 pre-amp, PZ8 power supply, **£20·25**. Carr. 37½p. Transformer for PZ8, **£2·97½** extra. Add to any of the above **£4·87½** for active filter unit and **£16** for a pair of Q16 speakers. Project 60 FM Tuner **£20·25**. Carr. 37½p.
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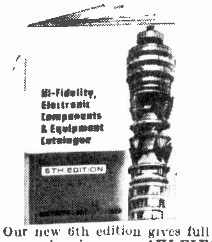

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Latest exciting release. Beautifully styled with walnut case. 6 + 6 watts r.m.s. Switched inputs for Mag, Xtal, aux, tape. Incorporates volume, bass, treble, sliding balance, scratch filter and loudness controls. Rec. List £32·50. Our price **£18·50**. Carr. 37p.

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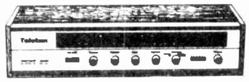

Probably the most popular budget Tuner/Amp. and now offered at a ridiculous low price. 5 watts r.m.s. per channel. Tape/Cer phono inputs. AFC/Built-in MPX. List £51. **OUR PRICE £32·50**. Carr. 50p.

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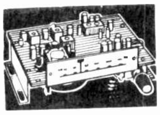
F.2000, Garrard 2025T/C Changer fitted stereo cartridge, with plinth and cover and pair of G.W.S. 3 way Speakers. Total Rec. Price £97·73½. **OUR PRICE £56·40**. Carr. £1.

★ TRANSISTORISED FM TUNER ★



6 TRANSISTOR HIGH QUALITY TUNER, SIZE ONLY 6 · 4 × 2½in. 3 I.F. stages. Double tuned discriminator. Ample output to feed most amplifiers. Operates on 9V battery. Coverage 88-108 MHz. Ready built ready for use. Fantastic value for money. **£6·37½**, P. & P. 12½p.
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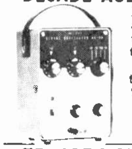
RUSSIAN CI-16 DOUBLE BEAM OSCILLOSCOPES

5MHz Pass Band. Separate Y1, Y2 amplifiers. Calibrated triggered sweep from 0·2μsec to 100msec/cm.
Supplied complete with all accessories and instructions, **£87**, Carr. paid.

BELCO DA-20 SOLID STATE DECADE AUDIO OSCILLATOR



New high quality portable instrument. Sine 1Hz to 100kHz. Square 20Hz to 20kHz. Output max. +10dB (10kΩ). Operation 220/240V a.c. Size 215mm 150mm 120mm.
Price **£27·50**. Carr. 25p.

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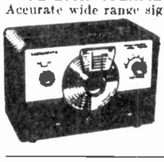
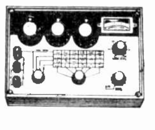
Accurate wide range signal generator covering 120 kc/s-260 Mc/s on 6 bands. Directly calibrated variable R.F. attenuator. Operation 200/240V a.c. Brand new with instructions. **£15**. P. & P. 37½p. S.A.E. for details.



BELCO AF-5A SOLID STATE SINE SQUARE WAVE C.R. OSCILLATOR

Sine 18–200,000Hz; Square 18–50,000Hz. Output max +10dB (10kΩ). Operation internal batteries.
Attractive two-tone case 7½in × 5in 2in. Price **£17·50**. Carr. 17½p.

TRANSISTORISED L.C.R. A.C. MEASURING BRIDGE



A new portable bridge offering excellent range and accuracy at low cost. Ranges: R. 1Ω–11·1 megΩ 6 Ranges ±1%. L.1 μH – 111 HENRYS 6 Ranges –2%. C. 10pF ±1110mFd. 6 Ranges ±2%. TURNS RATIO 1:1/1000–1:11100. 6 Ranges ±1%. Bridge voltage at 1,000 cps. Operated from 9 volts. 100μA. Meter indication. Attractive 2 tone metal case. Size 7¼ × 5 × 2in. **£20**, P. & P. 25p.

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2pF–2,000 mfd 2 ohms–200 megohms. Also checks impedance, turns ratio, insulation, 200/250V a.c.
Brand New £17·50. Carr. 37½.

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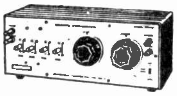
OUR PRICE £5·97 P. & P. 25p

TE111. DECADE RESISTANCE ATTENUATOR



Variable range 0–111dB. Connections. Unbalanced T and Bridge T. Impedance 600Ω range (0·1dB × 10) + (1dB × 10) + 10 + 20 + 30 + 40dB. Frequency: d.c. to 200kHz (—3dB). Accuracy: 0·05dB. + indication dB × 0·01. Maximum input less than 4W (50V). Built in 600Ω load resistance with internal/external switch. Brand new **£27·50**, P. & P. 25p.

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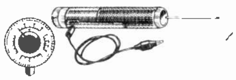


Completely portable, simple to use pocket sized tester. Ranges 0/3/30/300V a.c. and d.c. at 2,000 o.p.v. Resistance 0–20kΩ.
ONLY **£1·97**. P. & P. 13p.

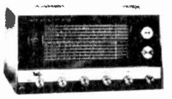
UR-1A SOLID STATE COMMUNICATION RECEIVER

4 Bands covering 55KHz-30MHz. FET, S Meter, Variable BFO for SSB. Built in Speaker, Bandspread, Sensitivity Control. 220/240V a.c. or 12V d.c. 12½in × 4½in × 7in. Brand new with instructions. **£25**. Carr. 37½p.

UNR-30 RECEIVER

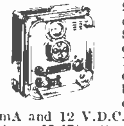
4 Bands covering 550KHz-30MHz. B.F.O. Built in Speaker 220/240V a.c. Brand new with instructions. **£15·75**. Carr. 37½p.

LAFAYETTE HA-600 RECEIVER



General coverage 150–400KHz, 550KHz–30MHz. FET front end, 2 mech. filters, product detector, variable B.F.O., noise limiter, S Meter, Bandspread. RF Gain. 15in × 9½in × 8½in. 18lb. 220/240V a.c. or 12V d.c. Brand new with instructions **£45**. Carr. 50p.

CRYSTAL CALIBRATORS No. 10



Small portable crystal controlled wavemeter. Size 7" × 7½" × 4". Frequency range 500 Kc/s. 10 Mc/s (up to 30 Mc/s on harmonics). Calibrated dial. Power requirements 300 V.D.C. 15mA and 12 V.D.C. 0.3A. Excellent condition. **£3·47½**. Carr. 37½p.

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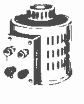
Excellent quality . Low price . Immediate delivery

S-260 General Purpose Bench Mounting



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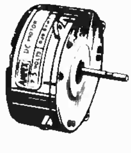

AMPEX 7·5v. **D.C. MOTOR.** This is an ultra-precision tape motor designed for use in the AMPEX model AG20 portable recorder. Torque 450GM/CM. Stall load at 500ma. Draws 60 ma on run. 600rpm +5% speed adjustment, internal AF/RF suppression ⅛" dia. 1" spindle, motor 3" dia. 1¾". Original cost £16·50. **Our price £4·25.** P. & P. 25p. Mu-metal enclosure available **75p** each.

SYNCHRONOUS MOTORS. 220/380 v. 50/60 Hz. 250-300 rpm. **75p** each.

MYCALEX MAINS. Shaded pole, 1425 rpm, 3/16" spindle. 2 for **£1·25.** Carriage Paid.

MAINS INDUCTION MOTOR. Open frame, 3/16" spindle, weight ¾ lb. Powerful. **88p** each. P. & P. 12p.

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MYCALEX. Open frame, shaded pole motors, 240v, 50 Hz. 7 rpm. 28 lb. in. 80 rpm. 12 lb. in, **£2.25** each. P. & P. 25p.

"CROUZET" TYPE 965. 115/240v. 50 Hz. 47/68 watts. 50 rpm. Stoutly constructed. Size: 2 1/16" dia. x 3¼" long plus spindle 1" x ¼" dia. Anti-clock. **£2·75.** P. & P. 25p.

TYPE 955. Same as above, but 3 rpm. **£3·00.** P. & P. 25p.

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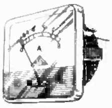

A.C./D.C. M/IRON AMMETERS. 0-5 amps or 0-8 amps (suitable battery chargers etc.). Perspex front. Size: 1⅞" x 1⅞". Any 2 for **£1·10.** Carr. Paid.

ERNEST TURNER 800μa METER. 160Ω movement, 2" case eliptic, plastic front, Green-Red-Green uncalibrated scale **£1·50** each. Carriage paid.

PAINTON BOURNS TRIMPOTS. 1k, 2k, 2·5k, 5k, 10k, 20k, 50k, 500k. Other Trimmer pots in stock. RIL 10k. MORGANITE 1k. MEC 200 Ω (tubular) 50Ω. Any 3 for **£1·10** carr. paid.

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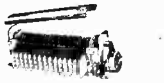
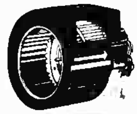
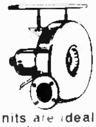
A bank of 15 micro-switches are each independently operated by 15 pairs of cams which in turn are individually adjustable to give switching periods of zero to 12 seconds with infinitely variable combinations. A mains synchronous motor drives the cam shaft at 1 rev. per 12 seconds (5 R.P.M.). Originally cost **£15·00** plus. Many applications such as lighting effects etc. New in original makers cartons. First class value at **£5·75** plus 25p. P. & P.



PRECISION FAN CO. (SMITHS INDUSTRIES) DOUBLE ENTRY CENTRIFUGAL FAN/BLOWER. This is a beautifully balanced particularly quiet running unit giving approx. 90 cubic ft./min. The motor is a 2 pole shaded pole Mycalex, drawing only 240ma on run. Weight 2¼ lbs. Sizes: case dia. 3·1 ins. width (case only) 3·125 ins. Width overall (inc. 5·25 ins. Aperture 3·125 ins x 1·85 ins. Offered well below makers price at **£2·95.** P. & P. 25p.





Brand New "DISCUS" Centrifugal Blower by Watkins & Watson. 240v. 50 Hz. Powered by A.E.I. continuous rating 2850 rpm motor. Cowl diameter 10". Outlet flange 2" I.D. Coupling flange supplied. These superb precision units are ideally suited for **Organ construction.** Offered at approx. half makers price **£12·50.** Carriage £1·50.

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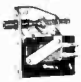

"HONEYWELL" TYPE 23AC-NE.—15 amp. change-over micro switch is fitted on angled metal mount with spring-loaded plastic rod operating cam. **50p.** each.

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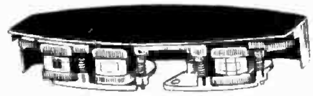

"BENSON BROS." 12v. D.C. HEAVY DUTY SOLENOID. Size: 3" overall x 1¼" x 1". Very powerful, with secondary low current hold coil, Cont. rated **£1·00** each. P. & P. 15p.

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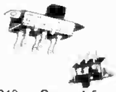

SLIDER SWITCHES. 3 amp. type D.P.D.T. 1" x 3/16" x ¾" deep. 1 amp. type 3 P.D.T. ⅞" x 7/16" x 1/16" deep. **£1·25** per doz. Either type or mixed as required. Carr. Paid.

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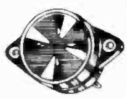

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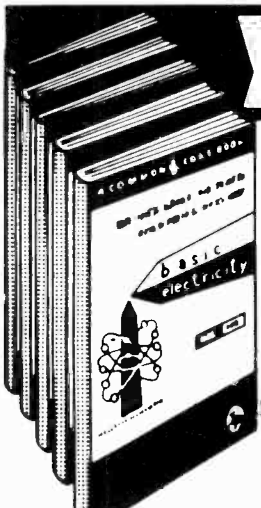

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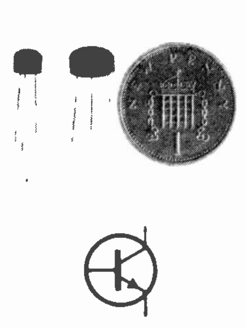
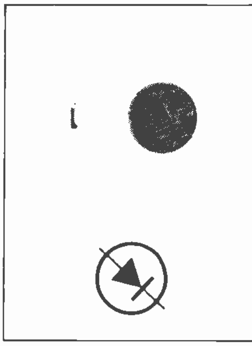


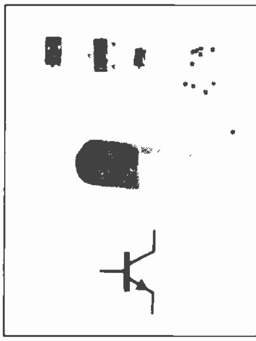
PLASTIC TRANSISTORS

A wide range of plastic transistors with code numbers identifiable with the related metal-can industrial types e.g. PN70/71/72 (=BCY 70/71/72) PN 107/8/9 (=BC 107/8/9), PN 918 (=2N 918), PN 1613/1711 (=2N 1613/1711), PN 2904-7 (= 2N 2904-7), PN 3054 (3A NPN "tab" power). Send for Information Bulletin VP



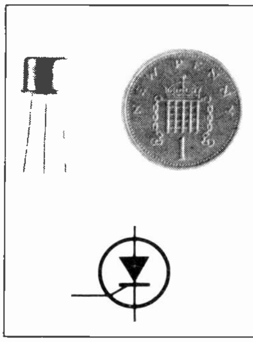
RECTIFIERS

Small flying lead rectifiers with ½ and 1A current ratings at voltages from 100 to 1000V in industry standard package. Apart from such standards as the 1N4001-4007 series, NKT provides special selections on characteristics such as leakage or forward voltage drop. Send for Information Bulletin VR



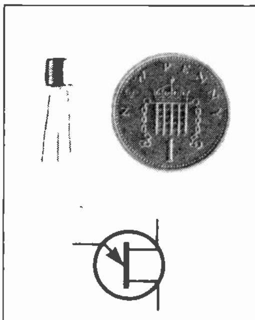
MICRO DEVICES

As manufacturers of thick film hybrid circuits, NKT specialises in the supply of microminiature semiconductor active devices for attachment to film circuits—the range includes unencapsulated chips, leadless inverted devices (LID's), microtab and flexible lead types. Send for Information Bulletin VS



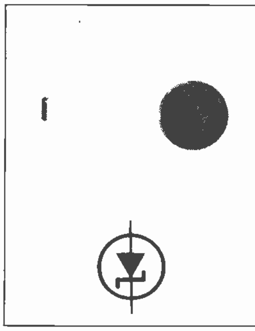
THYRISTORS

NKT specialises in the area of low current (up to 1A) thyristors in industrial metal can and economical plastic packages. The range stretches from the plastic NTS 311 (30V, 0.6A) to the T05 metal can NTS 1500 (500V, 1A) via the T018 NTS 0660 (60V, 0.6A). Send for Information Bulletin VT



UNIJUNCTIONS

In unijunctions, NKT has available the well tried industry-standard metal-can 2N 2646/7 and 2N 1671B, as well as economical plastic devices for less onerous applications where cost is the overriding factor. Send for Information Bulletin VU



ZENER DIODES

Completing the array of standard non-transistor devices, NKT provides a useful range of zener diodes. As well as the industry standard 400mW "work horse" (BZY 88/3.3-30V), the range features an economical 1W zener range, the NKT 10C-V-(11-30V). Send for Information Bulletin VZ

Distributors

For further details contact one of the distributors listed below. (In the case of large scale requirements you can save time by referring direct to Newmarket).

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Hounslow, Middlesex.
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S.D.S. (Portsmouth) Ltd.,
Hilsea Industrial Estate,
Portsmouth PO3 5JW Hampshire.
Tel: 0715/65311
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I.T.T. Electronic Services Ltd.,
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L.S.T. Electronic Components Ltd.,
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Tel: Brentwood 226470
Telex: 99443

G.S.P.K. (Sales) Ltd.,
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Yorkshire.
Tel: Harrogate 86258
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Hird—Brown Electronics Ltd.,
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Bolton BL3 6BJ
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Total	£59	

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Garrard SP25 Mk. III with MAG. cartridge, plinth and cover	£23 + £1·50	P.&P.
Total	£77	

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SYSTEM 3

Viscount III R100 Amplifier	£17 + 90p	P.&P.
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Duo Type III Size 23½in × 11½in × 9½in. Drive unit 13½in × 8¼in with H.F. speaker. Max. power 20W at 3 ohms. Frequency range 20Hz to 20kHz. Teak veneer cabinet. **£32 pair** + £3 P. & P.

SPECIFICATION R100/101

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 250mW per channel. *Tone controls and filter characteristics.* Bass: +12dB to —17dB @ 60Hz. Bass filter: 6dB per octave cut. Treble control: treble +12dB to —12dB @ 15kHz. Treble filter: 12dB per octave. *Signal to noise ratio:* (all controls at max.) R101—P.U.1. and radio—65dB. P.U.2—58dB. **R100** same as R101 but P.U.2 (for crystal cartridges) 450mV into 3 Meg. *Cross talk* better than —35dB on all inputs. *Overload characteristics* better than 26dB on all inputs. Size 13¾ × 9in × 3¾in.

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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
1200	—	0·33	—	0·33	0·57	0·75	—

TRIACS

VBOM	2A TO-1 £p	6A TO-66 £p	10A TO-88 £p
100	0·50	0·63	1·00
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10-Amp 3-K.V. (3000 P.I.V.) Stud Type with Flying Leads, **80p each.**

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T5	8 2G382T	OC82
T6	8 2G344A	OC44
T7	8 2G345A	OC45
T8	8 2G378	OC78
T9	8 2G399A	2N1302
T10	8 2G417	AF117

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U4	40 Germanium transistors like OC81, AC128	0·50
U5	60 200mA sub-min. Sil. diodes	0·50
U6	30 Silicon planar transistors NPN sim. BSY95A, 2N706	0·50
U7	16 Silicon rectifiers Top-Hat 750mA up to 1,000V	0·50
U8	50 Sil. planar diodes 250mA, OA/200/202	0·50
U9	20 Mixed volts 1 watt Zener diodes	0·50
U11	30 PNP silicon planar transistors TO-5 sim. 2N1132	0·50
U13	30 PNP-NPN sil. transistors OC200 & 2S104	0·50
U14	150 Mixed silicon and germanium diodes	0·50
U15	25 NPN Silicon planar transistors TO-5 sim. 2N697	0·50
U16	10 3-Amp silicon rectifiers stud type up to 1000 PIV	0·50
U17	30 Germanium PNP AF transistors TO-5 like ACY 17-22	0·50
U18	8 6-Amp silicon rectifiers BYZ13 type up to 600 PIV	0·50
U19	25 Silicon NPN transistors like BC108	0·50
U20	12 1·5-Amp silicon rectifiers Top-Hat up to 1,000 PIV	0·50
U21	30 A.F. germanium alloy transistors 2G300 series & OC71	0·50
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U24	20 Germanium 1-Amp rectifiers GJM up to 300 PIV	0·50
U25	25 300Mc/s NPN silicon transistors 2N708, BSY27	0·50
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U31	20 Sil. Planar NPN trans. low noise amp 2N3707	0·50
U32	25 Zener diodes 400mW D07 case mixed volts, 3–18	0·50
U33	15 Plastic case 1 amp silicon rectifiers IN4000 series	0·50
U34	30 Sil. PNP alloy trans. TO-5 BCY26, 2S302/4	0·50
U35	25 Sil. planar trans. PNP TO-18 2N2906	0·50
U36	25 Sil. planar NPN trans. TO-5 BFY50/51/52	0·50
U37	30 Sil. alloy trans. SO-2 PNP, OC200 2S322	0·50
U38	20 Fast switching sil. trans. NPN, 400Mc/s 2N3011	0·50
U39	30 RF germ. PNP trans. 2N1303/5 TO-5	0·50
U40	10 Dual trans. 6 lead TO-5 2N2060	0·50
U41	25 RF germ. trans. TO-1 OC45 NKT72	0·50
U42	10 VHF germ. PNP trans. TO-1 NKT667 AF117	0·50

Code Nos. mentioned above are given as a guide to the type of device in the Pak. The devices themselves are normally unmarked.

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Q5	4 OC75 transistors	0·50
Q6	4 OC72 transistors	0·50
Q7	4 AC128 trans. PNP high gain	0·50
Q8	4 AC126 trans. PNP	0·50
Q9	7 OC81 type trans.	0·50
Q10	7 OC71 type trans.	0·50
Q11	2 AC127/128 comp. pairs PNP/NPN	0·50
Q12	3 AF116 type trans.	0·50
Q13	3 AF117 type trans.	0·50
Q14	3 OC171 H.F. type trans.	0·50
Q15	5 2N2926 sil. epoxy trans.	0·50
Q16	2 GET880 low noise germ. trans.	0·50
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Q18	4 Madt's 2 MAT 100 & 2 MAT 120	0·50
Q19	3 Madt's 2 MAT 101 & 1 MAT 121	0·50
Q20	4 OC44 germ. trans. A.F.	0·50
Q21	3 AC127 NPN germ. trans.	0·50
Q22	20 NKT trans. A.F. R.F. coded	0·50
Q23	10 OA202 sil. diodes sub-min.	0·50
Q24	8 OA81 diodes	0·50
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Q28	2 Sil. power rects. BYZ13	0·50
Q29	4 Sil. trans. 2 × 2N696, 1 × 2N697, 1 × 2N698	0·50
Q30	7 Sil. switch trans. 2N706 NPN	0·50
Q31	6 Sil. switch trans. 2N708 NPN	0·50
Q32	3 PNP sil. trans. 2 × 2N1131, 1 × 2N1132	0·50
Q33	3 Sil. NPN trans. 2N1711	0·50
Q34	7 Sil. NPN trans. 2N2369, 500MHZ	0·50
Q35	3 Sil. PNP TO-5 2 × 2N2904 & 1 × 2905	0·50
Q36	7 2N3646 TO-18 plastic 300MHZ NPN	0·50
Q37	3 2N3053 NPN sil. trans.	0·50
Q38	7 PNP trans. 4×2N3703, 3×2N3702	0·50
Q39	7 NPN trans. 4×2N3704, 3×2N3705	0·50
Q40	7 NPN amp. 4×2N3707, 3×3N3708	0·50
Q41	3 Plastic NPN TO-18 2N3904	0·50
Q42	6 NPN trans. 2N5172	0·50
Q43	7 BC107 NPN trans.	0·50
Q44	7 NPN trans. 4×BC108, 3×BC109	0·50
Q45	3 BC113 NPN TO-18 trans.	0·50
Q46	3 BC115 NPN TO-5 trans.	0·50
Q47	6 NPN high gain 3×BC167, 3×BC168	0·50
Q48	4 BCY70 NPN trans. TO-18	0·50
Q49	4 NPN trans. 2×BFY51, 2×BFY52	0·50
Q50	7 BSY28 NPN switch TO-18	0·50
Q51	7 BSY95A NPN trans. 300MHZ	0·50
Q52	8 BY100 type sil. rect.	1·00
Q53	25 Sil. & germ. trans. mixed all marked new	1·50

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SPECIFICATION
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GENERAL PURPOSE SILICON NPN POWER TRANSISTORS

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TSO 14 pin type	30p	27p	25p
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74 series T.T.L. I.C's

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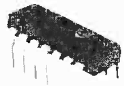

Check our 74 Series List before you buy any I.C's. **Our prices are the lowest possible.** All devices ex-stock.
Full spec. guaranteed.

BI-PAK Order No.	Similar Types to:—Description	Price and qty. prices 1–24 £p	25–99 £p	100 up £p
BP00 = 7400	Quad 2-input NAND gate	0·15	0·14	0·12
BP01 = 7401	Quad 2-input pos. NAND gate (with open collector output)	0·15	0·14	0·12
BP02 = 7402	Quad 2-input pos. NOR gates	0·15	0·14	0·12
BP03 = 7403	Quad 2-input pos. NAND gates (with open collector output)	0·15	0·14	0·12
BP04 = 7404	Hex Inverters	0·15	0·14	0·12
BP05 = 7405	Hex Inverter (with open-collector output)	0·15	0·14	0·12
BP10 = 7410	Triple 3-input pos. NAND gates	0·15	0·14	0·12
BP13 = 7413	Dual 4-input Schmitt trigger	0·29	0·26	0·24
BP20 = 7420	Dual 4-input pos. NAND gates	0·15	0·14	0·12
BP30 = 7430	8-input pos. NAND gates	0·15	0·14	0·12
BP40 = 7440	Dual 4-input pos. NAND buffers	0·15	0·14	0·12
BP41 = 7441	BCD to decimal nixie driver	0·67	0·64	0·58
BP42 = 7442	BCD to decimal decoder (4–10 lines, 1 of 10)	0·67	0·64	0·58
BP46 = 7446	BCD-to-seven-segment decoder/driver	2·00	1·75	1·50
BP47 = 7447	BCD-seven-segment decoder/drivers (15V outputs)	0·97	0·94	0·88
BP48 = 7448	BCD-to-seven-segment decoder/driver	0·97	0·94	0·88
BP50 = 7450	Expandable dual 2-input and-or-invert	0·15	0·14	0·12
BP51 = 7451	Dual 2-wide 2-input and-or-invert gates	0·15	0·14	0·12
BP53 = 7453	Quad 2-input expandable and-or-invert	0·15	0·14	0·12
BP54 = 7454	4-wide 2-input and-or-invert gates	0·15	0·14	0·12
BP60 = 7460	Dual 4-input expander	0·15	0·14	0·12
BP70 = 7470	Single-phase J-K flip-flop	0·29	0·26	0·24
BP72 = 7472	Master slave J-K flip-flop	0·29	0·26	0·24
BP73 = 7473	Dual Master slave J-K flip-flop	0·37	0·35	0·32
BP74 = 7474	Dual D type flip-flop	0·37	0·35	0·32
BP75 = 7475	Quad latch	0·47	0·45	0·42
BP76 = 7476	Dual J-K with pre-set and clear	0·43	0·40	0·38
BP80 = 7480	Gated full adders	0·67	0·64	0·58
BP81 = 7481	16-bit read/write memory	0·97	0·94	0·88
BP82 = 7482	2-bit binary full adders	0·97	0·94	0·88
BP83 = 7483	Quad full adder	1·10	1·05	0·95
BP86 = 7486	Quad 2-input exclusive NOR gates	0·32	0·30	0·28
BP90 = 7490	BCD decade counter	0·67	0·64	0·58
BP91 = 7491	8-bit shift registers	0·87	0·84	0·78
BP92 = 7492	Divide-by-twelve counters	0·67	0·64	0·58
BP93 = 7493	4-bit binary counters	0·67	0·64	0·58
BP94 = 7494	Dual entry 4-bit shift register	0·77	0·74	0·68
BP95 = 7495	4-bit up-down shift register	0·77	0·74	0·68
BP96 = 7496	5-bit parallel in parallel out shift-register	0·77	0·74	0·68
BP100 = 74100	8-bit bistable latches	1·75	1·65	1·55
BP104 = 74104	Single J-K flip-flop equivalent 9000 series	0·97	9·94	0·88
BP105 = 74105	Single J-K flip flop equivalent 9001 series	0·97	0·94	0·88
BP107 = 74107	Dual Master slave flip-flops	0·40	0·38	0·36
BP110 = 74110	Gates master-slave flip-flops	0·55	0·53	0·50
BP111 = 74111	Dual data lock-out flip-flop	1·25	1·15	1·00
BP118 = 74118	Hex set-reset latches	1·00	0·95	0·90
BP119 = 74119	Hex set-reset latches. 24-pin	1·35	1·25	1·10
BP121 = 74121	Monostable multivibrators	0·67	0·64	0·58
BP141 = 74141	BCD-to-decimal decoder/driver	0·67	0·64	0·58
BP145 = 74145	BCD-to-decimal decoder/driver O/C	1·50	1·40	1·30
BP150 = 74150	16-bit data selector	1·80	1·70	1·60
BP151 = 74151	8-bit data selectors (with strobe)	1·00	0·95	0·90
BP153 = 74153	Dual 4-line-to-1-line data	1·20	1·10	0·95
BP154 = 74154	4- to 16-line decoder	1·80	1·70	1·60
BP155 = 74155	Dual 2- to 4-line decoder	1·40	1·30	1·20
BP156 = 74156	Dual 2- to 4-line decoder O/C	1·40	1·30	1·20
BP160 = 74160	Sync. decade counter	1·80	1·70	1·60
BP161 = 74161	Sync. 4-bit binary counter	1·80	1·70	1·60
BP190 = 74190	Sync. up-down BCD counter	3·50	3·25	3·00
BP191 = 74191	Sync. binary up-down counter (single clock line)	3·50	3·25	3·00
BP192 = 74192	Sync. up-down decade counter	2·10	1·95	1·75
BP193 = 74193	Sync. binary up-down counter (tow clock lines)	2·10	1·95	1·75
BP196 = 74196	Pre-setable 50MHz decade counter	1·80	1·70	1·60
BP197 = 74197	Pre-setable 50MHz binary counter	1·80	1·70	1·60
BP198 = 74198	8-bit parallel L-R shift register	5·50	5·00	4·00
BP199 = 74199	8-bit parallel access shift register	5·50	5·00	4·00

Devices may be mixed to qualify for quantity price. Larger quantities—prices on application (TTL 74 Series only).
Data is available for the above series of I.C's in booklet form. Price **13p**.

TTL INTEGRATED CIRCUITS

Manufacturers' "Fall outs"—out of spec. devices including functional units and part function but classed as out of spec. from the manufacturers' very rigid specifications. Ideal for learning about I.C's and experimental work.

PAK No.		PAK No.		PAK No.	
UIC00 = 12 × 7400N	50p	UIC42 = 5 × 7450N	50p	UIC80 = 5 × 7480N	50p
UIC01 = 12 × 7401N	50p	UIC50 = 12 × 7450N	50p	UIC82 = 5 × 7482N	50p
UIC02 = 12 × 7402N	50p	UIC51 = 12 × 7451N	50p	UIC83 = 5 × 7483N	50p
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
UIC20 = 12 × 7420N	50p	UIC74 = 8 × 7474N	50p	UIC94 = 5 × 7494N	50p
UIC40 = 12 × 7440N	50p	UIC75 = 8 × 7475N	50p	UIC95 = 5 × 7495N	50p
UIC41 = 5 × 7441AN	50p	UIC76 = 8 × 7476N	50p	UIC96 = 5 × 7496N	50p

UICX1 = 25 × Asst'd 74's £1·50

Paks cannot be split but 20 assorted pieces (our mix) is available as PAK UICX1
Every PAK carries out BI-PAK Satisfaction or money back GUARANTEE.

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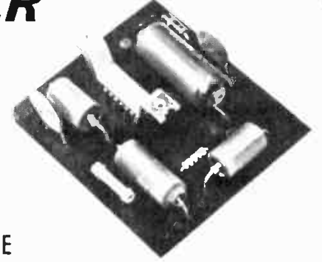

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- **Sensitivity 40 mV for 1 watt VOLTAGE GAIN 40dB but can be varied up to 73dB for some applications.**
- **Signal to Noise Ratio 86dB.**
- **Frequency response better than 50 Hz to 25 KHz for −3dB.**
- **Normal supply Voltage 9-24V.**
- **Suitable for 8-16 OHM Loads.**
- **Overall Size 2″ × 3″ × ¾″.**
- **Typical Total Harmonic distortion at 1 watt less than 1%.**

Supply voltage (Vs) = 24V 15ohm load.

Module Tested and Guaranteed

Quantity	1-9	10-25
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Larger quantities quoted on request

Full hook-up diagrams and complete technical data supplied free with each module or available separately at 10p each.

ROCK BOTTOM PRICES—CAN'T BE BEATEN!

LOGIC — DTL 930 SERIES — IC's

Type No.	Function	Price 1–24	25–99	100 up
BP930	Expandable dual 4-input NAND	12p	11p	10p
BP932	Expandable dual 4-input NAND buffer	13p	12p	11p
BP933	Dual 4-input expander	13p	12p	11p
BP935	Expandable Hex Inverter	13p	12p	11p
BP936	Hex Inverter	13p	12p	11p
BP944	Dual 4-input NAND expandable buffer without pull-up	13p	12p	11p
BP945	Master-slave JK or RS	25p	24p	22p
BP946	Quad, 2-input NAND	12p	11p	10p
BP948	Master-slave JK or RS	25p	24p	22p
BP951	Monostable	65p	60p	55p
BP962	Triple 3-input NAND	12p	11p	10p
BP9093	Dual Master-slave JK with separate clock	40p	38p	35p
BP9094	Dual Master-slave JK with separate clock	40p	38p	35p
BP9097	Dual Master-slave JK with Common Clock	40p	38p	35p
BP9099	Dual Master-slave JK Common Clock	40p	38p	35p

Devices may be mixed to qualify for quantity price. Larger quantity prices on application. (DTL 930 Series only).

BRAND NEW LINEAR I.C's—FULL SPEC.

Type No.	Case	Leads	Description	Price 1–24	25–99	100 up
BP 201C—SL201C	TO-5	8	G.P. Amp	63p	53p	45p
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
TAA 293—	TO-74	10	G.P. Amp	90p	75p	70p

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VOL. 7 No. 10
October 1971

PRACTICAL ELECTRONICS

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NON-PERMISSIVE

EVEN in this permissive age editors have certain censorial duties to perform in the interests of their readers. One of these is to apply the blue pencil and expunge from the printed page any words having dubious meanings or likely to encourage the adoption of undesirable practices.

In respect of the latter hazard, this magazine has a particularly onerous responsibility; in matters appertaining to circuit design and construction, we mean. It follows that we should have our little list of disfavoured words and expressions; although some of them may be frequently used in the vernacular without so much as an eyebrow being raised.

Yet, as we have implied, there are lines to be drawn, and altogether in our readers' own interest. Not to keep anyone in suspense any longer, let us reveal one of these disfavoured terms. It is "junk box". As alert readers will have already surmised, it is our normal policy to remove any reference to this peculiar, though fascinating, source of supply from contributors' manuscripts before they are presented to the public eye.

We recognise the partiality of many amateur designers for a dip into this traditional repository for temporarily abandoned components. But the advantages the junk box offers are strictly personal and local. The contents of some boxes would defy identification, let alone duplication, anywhere. That's for sure.

Obviously we cannot allow component oddities procured in this way to remain in the specification of any project offered to constructors at large. A suitable substitute, currently available, has to be found, and the design modified where necessary. (All would-be contributors kindly note.)

Checking with our little list again, there is the somewhat allied expression "cannibalisation". This goes hand in glove with those deliberate wrecking operations know variously as "breaking up" (or "down") and "stripping down". The fruits of these labours often go to swell the contents of the junk box and to make the collection even more varied and mysterious.

Not that we are opposed to the junk box as such. Every constructor will accumulate one in the fullness of time. Actually there's nothing you can do about it; it just grows, and grows. And what strange practices are perpetrated in private workshops is not our business. But the supply of designs for other constructors to execute is.

So have no fear about our "censorship". We wield our blue pencil solely in the cause of good, sound design, and this is in the best interests of all who construct.

F.E.B.

THIS MONTH

CONSTRUCTIONAL PROJECTS

SPECIAL SERIES

GENERAL FEATURES

NEWS AND COMMENT

Our November issue will be published on Friday, October 15

Engine Temperature CONTROLLER

By M. A. HARRIS

Thermostatically controlled fan for your car

MOST internal combustion engines in cars are overcooled, the manufacturers having to take into account all types of driving conditions that might be encountered. For the majority of the time, engines tend to run on the cool side, and the belt-driven fan on the water pump boss can be removed but, of course, it is inconvenient to do so en route.

With the mechanical fan removed permanently some auxiliary form of controlled cooling is necessary for those occasions when the forward motion of the vehicle does not force enough air through the radiator, for example, in traffic jams or when climbing a steep hill.

There are on the market various devices to increase the air flow; some fans "feather" according to temperature and/or engine speed. The one disadvantage these have is that they tend to be somewhat on the expensive side and are still wasteful of engine power. The controlled electric fan to be described, on the other hand, is inexpensive, only operates according to engine temperature, and takes no power from the engine.

AUXILIARY FANS

The two fans in use on the author's vehicle were mounted on a metal plate in front of the radiator and behind the radiator grill, so that they draw air through the grill and push it through the radiator. Initially, they were wired up to a pair of relay contacts controlled by a switch on the dashboard—in the final version this became the manual override to an electronic switch. See Fig. 1. The fans must obviously be mounted the right way round to force air through the radiator, or to suck it out through the radiator in the case of transverse engine cars.

The circuit is basically very similar in either polarity version. Fig. 2 shows the negative earth version. For positive earth operation, all that is needed is to change the transistors from *pnp* types to equivalent *npn* and reverse C2.

LONG-TAILED PAIR

The control circuit is a "long-tailed pair", the base of TR3 being fixed while the emitter determines how the temperature sensor (thermistor TH1) is

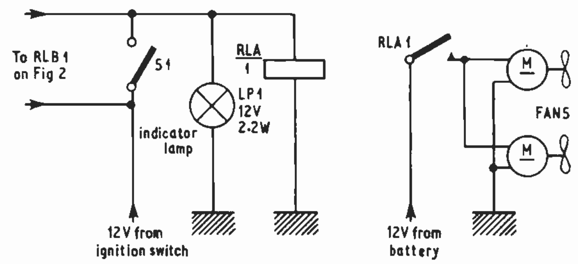


Fig. 1. The two auxiliary fans controlled by a 12V relay (RLA), switched on by RLB or S1. LP1 provides visual indication of motor operation and should be fitted to the dash panel

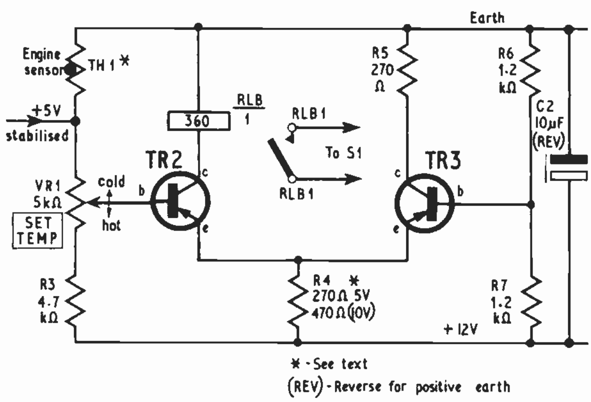
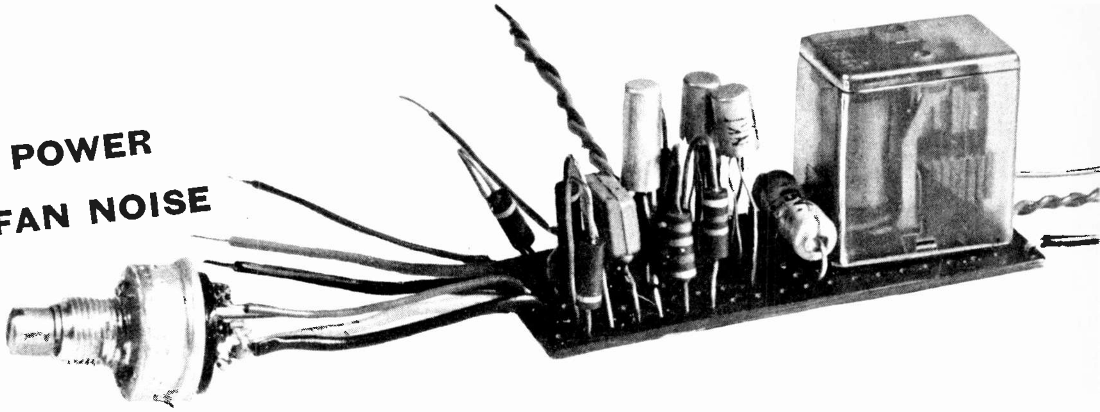


Fig. 2. Negative earth version of the electronic control circuit. For positive earth cars, change the transistors and reverse the connections of C2

★ MORE POWER

★ LESS FAN NOISE



★ BETTER HEATER EFFICIENCY ★ QUICKER WARM UP

COMPONENTS...

Resistors
- R1 1kΩ (560Ω for 10V system)
- R2 220Ω
- R3 4·7kΩ
- R4 270Ω (470Ω for 10V system)
- R5 270Ω
- R6 1·2kΩ
- R7 1·2kΩ
- All ¼W ±10% carbon

Potentiometer
- VR1 5kΩ carbon linear

Capacitors
- C1 0·1μF 600V
- C2 10μF elect. 25V

Transistors

	POSITIVE EARTH	NEGATIVE EARTH
TR1	OC35 or OC22	2N3055 or BD124
TR2	AC127 or NKT713	AC128 or OC81
TR3	AC127 or NKT713	AC128 or OC81

Zener Diode
- D1 Approximately 6·3V 250mW selected from tests (see text)

Relays
- RLA 12V with single pole normally open heavy duty contacts (see text)
- RLB 6V approximately 350 ohms with single pole normally open contacts (see text)

Miscellaneous
- LP1 12V 2·2W indicator lamp and holder
- S1 Single pole on/off toggle switch
- Veroboard 0·15 inch matrix 3in × 1⅛in
- Fan (see text)
- Diecast box 4¼in × 2½in × 1in
- Sheet steel for fan mounting 1/16in painted or p.v.c. coated
- Metal brackets (see text)
- Clips to hold fan motors
- Grommets, wire and bolts

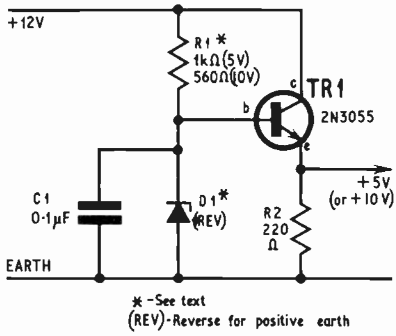


Fig. 3. Circuit of the stabilised 5V supply for cars with 12V negative earth. For positive earth, change TR1 and reverse D1

going to operate relay RLB via TR2. The thermistor is the variable element, whose resistance changes inversely with temperature. It is usually fitted into the engine block and wired up to the temperature gauge on the dashboard.

The relay RLB in the collector circuit is a small one, capable of switching a heavy duty relay to turn on the cooling fans. The relay contacts RLB1 are wired across the manual override switch S1 in Fig. 1.

In the prototype there were two changeover contacts, and two make contacts. To reduce the mechanical load of all these contacts on the relay armature, the two changeover contacts were removed. This way the relay would operate at around 4V.

STABILISED LINE

It was originally intended that the stabilised 5V line was derived from the car's instrument circuit. But on investigation the stabilised 5V was found to be a pulsed 12V, the average value of which was 5V. Hence a stabiliser (Fig. 3) was constructed to replace the original unit. For positive earth the stabiliser transistor is changed and the polarity of D1 reversed.

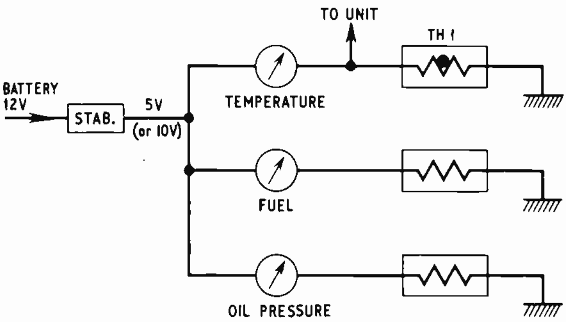


Fig. 4. Connection of the electronic stabiliser (Fig. 3) into the car instrument system (5V or 10V positive or negative earth). Also shown is the connection for the controller unit.

This system can be used for 5V (Ford) or 10V (BLMC and others) instrument systems, by alteration of R4 (Fig. 2) and R1 (Fig. 3). The power transistor TR1 has been chosen to be able to supply the current for up to three gauges as shown in Fig. 4.

If an electric temperature gauge is not fitted, or the instruments are not stabilised but fed directly from the 12V line then it is possible to construct the unit using a temperature gauge thermistor screwed into the block or a VA 1026 thermistor mounted, by epoxy resin, to the outside of the radiator just above the core and near the top hose. This thermistor then becomes TH1 in the circuit and the stabiliser output is connected directly to the junction of TH1 and VR1. The VA 1026 thermistor must not be placed in water for calibration purposes unless it has been covered in epoxy resin.

The power transistor (TR1 in Fig. 3) is required, in the worst case of full fuel tank, boiling engine, and high oil pressure, to carry approximately 0·75 A. So the maximum dissipation could be 0·75(14−5) watts, which is approximately 7 watts.

SUPPRESSION

Due to the tasks expected of a car electrical system, the occurrence of high voltage "spikes" from the ignition and charging circuit are bound to effect the supply to the controller and the Zener diode and transistors must be protected from such "spikes". The 10μF capacitor C2 across the supply line suppresses voltage spikes so preventing damage to the semiconductors. Which way round it is connected depends on the earth polarity as mentioned earlier. A 0·1μF capacitor C1 is likewise connected across the Zener diode.

THERMISTOR

If the resistance of the thermistor is not known at extreme temperatures it can be found by adopting the following course. Release the pressure of the coolant by slowly unscrewing the radiator cap and then replace the cap. Remove the sensor unit from the engine block, and plug the hole with a cork, or rag. Place the sensor in a pan of warm water and heat it up gently to boiling point. Leave the water boiling for a few minutes to allow the sensor to reach the same temperature.

Now measure the resistance of the sensor (in the prototype this was 22 ohms) and the temperature of the water, which will be around 212 degrees F (or 100 degrees C). The sensor is now replaced in the block and allowed to cool. It is quite a good idea to leave it out until the following day. The reasoning behind this is that when cold, the sensor has a resistance of approximately 450 ohms, and to give the temperature gauge the impression of a hot engine, all that is needed is to bridge the sensor with a 22 ohm resistor.

If this is done, and the temperature gauge observed, the Zener diode voltage can be chosen to give the required voltage from the stabiliser and the appropriate water temperature reference on the meter scale. In the prototype, a 6·3V Zener was used, but different cars may require different types. Some experimentation might be necessary.

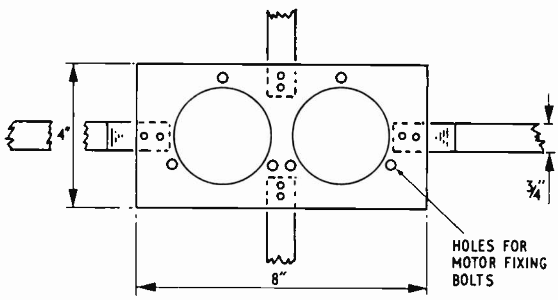


Fig. 5. The fans are mounted on a protected steel plate

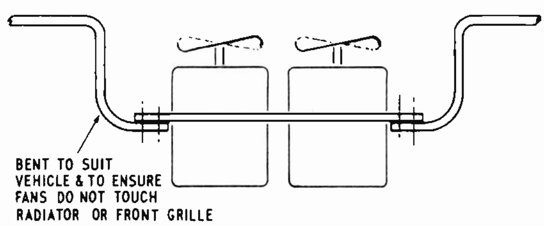


Fig. 6. Side view of the fan plate showing brackets

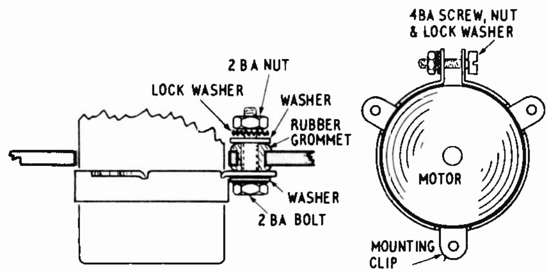


Fig. 7. Detail of mounting the motor with vibration absorbers

RELAYS

For TR1, any appropriate polarity transistor would do, provided that (a) it can carry at least 600mA collector current (that is for cars with two gauges). For vehicles with an electric oil pressure gauge as well as fuel and temperature gauges, 1A collector current should be allowed. (b) it can dissipate 10 watts or more (assuming the worst case).

The main relay RLA that switches the fans on is driven from the 12V supply. It can be a common car 12 V relay as used elsewhere in car wiring, or any other 12V relay provided that the contacts are heavy duty types and are rated at 5A continuous at 12V. Do not wire this relay directly into the transistor circuit in place of RLB or transistor damage may result.

FANS

The fans suitable for this particular application can be obtained from surplus equipment suppliers. They would be 12V 1·5A motors with 3inch or 5inch radius fan blades to fit on the shaft. Alternatively, an old car heater motor can be obtained from a breaker's yard. The centrifugal type is the most powerful.

A 5inch blade was tried on one fan, but it did not give as much air flow as the 3inch due to the motor running a lot slower, trying to push a greater volume of air. Also, the current rose to something in the order of 2·5A. Consequently, two 3inch fans were used in order to get a reasonable airflow through the radiator. These motors were circular with multi-bladed fans, the motor body diameter was 2¼inches and the overall depth was 3inches excluding the fan blades.

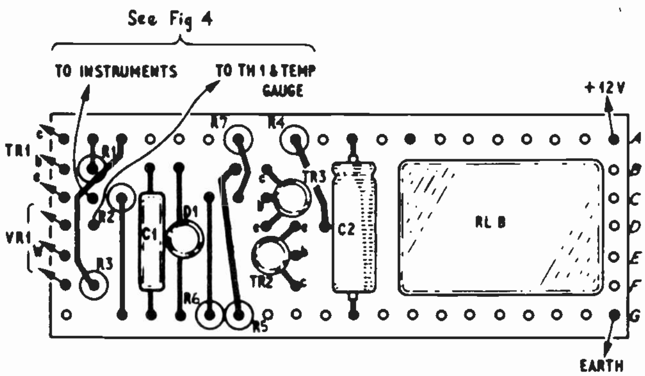
They were mounted on a piece of $\frac{1}{16}$inch steel sheet approximately 8inches by 4inches (Fig. 5). Two holes were cut to take the motors and the sheet painted and attached to the car with brackets. (Sheet steel already coated with p.v.c. is excellent for this job and does not need painting.) These brackets will differ in length, and how they are bent, depending on the vehicle to which they are fitted (Fig. 6).

The fans were attached to the plate with circular metal straps or clips fitted to the steel sheet. Rubber mountings are recommended to absorb vibrations. See Fig. 7 for details. It will be noted that the fans can slide in their mounting. This helps a great deal in positioning them clear of the radiator. Further details on fitting electric fans can be found in the July and August 1971 issues of *Practical Motorist*.

COMPONENT BOX

The electronic circuit is built into a diecast box of approximate dimensions 4¼in × 2¼in × 1in. This box can be bolted to the underside of the dashboard housing or in a glove compartment.

Although the box is robust it is not a good idea to mount it where damp and heat can get at it (such as under the bonnet) unless suitable protection is given to it. In these circumstances the box should be well painted and the joint of the lid waterproofed. A matt black finish is ideal, since this will aid any heat dissipation from TR1. Silicon grease smeared on both sides of the mica washer of TR1 will also protect from damp as well as assisting with insulation and heat transference. Similar treatment can be given to the cable entry hole when finished.



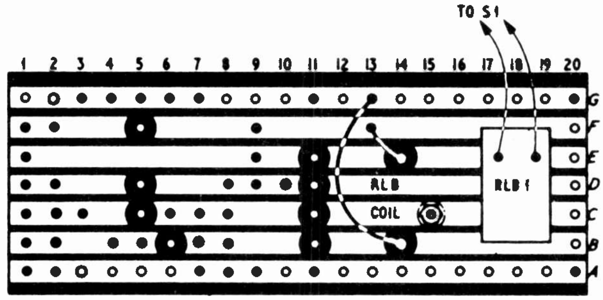


Fig. 8a. Layout of components on Veroboard

Fig. 8b. Underside view of board showing the cut out for the relay and cuts in the copper strips

The circuit board is shown in Fig. 8. Most of the components are mounted on this board, the exceptions being the thermistor TH1, transistor TR1, VR1 and RLA. The copper strips on the underside need to be cut as shown in Fig. 8b.

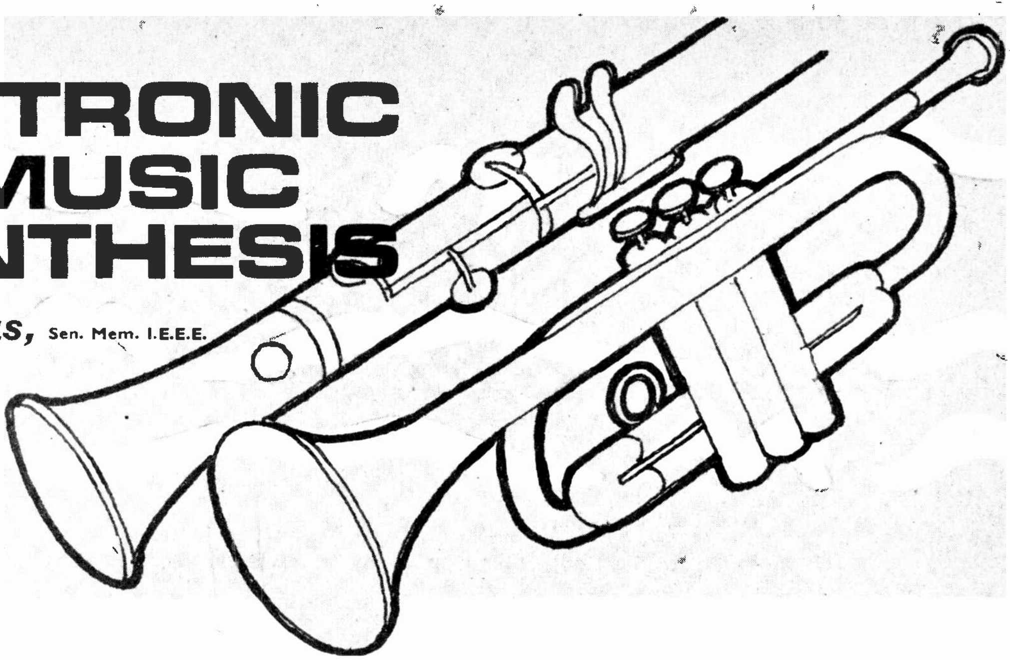
The components board was mounted on spacers and fitted to the box with screws, leaving sufficient space to mount the power transistor TR1 on the lid beside the potentiometer VR1. A mica washer must be fitted between the lid and TR1 to ensure insulation, as the case of TR1 will be connected to the collector. A smear of silicon grease is recommended on both sides of the washer. Nylon fixing screws or insulation bushes must also be used. A soldering tag should be fitted under the head of one of these screws to facilitate connection to the collector.

WIRING AND SETTING UP

When finished, the board, potentiometer and transistor TR1 are all mounted in the box and connected up. The wiring to RLA, the manual override switch S1 and indicator lamp LP1 is carried out as in Fig. 1. The feed labelled on the diagram as "12V from battery" can conveniently be taken from the starter solenoid, one ammeter terminal, or the fusebox, whichever seems to be the most convenient point.

Potentiometer VR1 can now be adjusted so that the fans just come on and finally, the resistor across TH1 removed and the thermistor replaced in the engine. A few trial runs in the car will soon show any alterations necessary in the setting of VR1. Keep a watchful eye on the temperature gauge and indicator lamp during these trial runs and try leaving the car ticking over for 10 minutes when it is hot.★

ELECTRONIC MUSIC SYNTHESIS



By A. Douglas, Sen. Mem. I.E.E.E.

A survey of the development of electronic synthesisers which provide new dimensions in tonal colouration

MUSIC is basically dependent on three factors only: pitch or frequency; loudness or intensity; and duration or time. However, other attributes are required to complete a satisfying musical sound. Firstly we must distinguish between music and noise.

Noise is a transient system having a high degree of randomness and usually consists of groups of frequencies unrelated as to pitch and power. As these transients increase in periodicity and become more symmetrical, the elements of a tone are formed. If the shape of the waveform assumes a regular character and lies within prescribed loudness and frequency limits, we have a sound which we call musical.

THE TONE DEFINED

But to establish pitch alone creates no interest; the sound must have character. It obtains this from two important attributes, the harmonic content and the shape of the wave envelope. Other desirable components appear in complex sounds, so to form a complete musical tone we require:

1. A pitch or frequency,
2. A rate at which the sound starts,
3. A length of time for which it persists,
4. A rate at which it decays,
5. A loudness level, not necessarily fixed,
6. Harmonics or partials,
7. Probably noise due to the mechanics of producing the sound,
8. Possibly vibrato or other modulation.

If any of these components is removed, the sound will be unreal, although it may be agreeable. For example, a flute or diapason-like sound on an electronic organ will probably have no "wind" noise but it can be very pleasant. However, take the corresponding organ pipe and blow it, and the synthesis is at once apparent. All of these things we, as listeners, take for granted, because we have always been brought up with them. But consider the composer for a moment.

He is in a unique position, for he requires the mental ability to create melody, harmony and rhythm (to somewhat simplify matters); yet he must thoroughly understand the capabilities of the instruments on which this music will be performed. So the music is in the end dependent on two factors; the composition, and the means to interpret that composition.

INSTRUMENT LIMITATIONS

Now instruments of the orchestra have not changed for many years. If we look at these, two things are at once apparent; some have fixed wind valves, like the oboe, clarinet, saxophone, etc; some have fixed keys, like the organ, piano, celeste, etc. But some have infinite gradations of frequency, like the string family (violin, viola, 'cello, base viol) and the slide trombone. These differences in construction mean that the composer of Western music is tied to the semitone scale, because this is the smallest frequency interval between successive notes which is possible with keyed instruments.

Further, consider the pitch and power range. Few orchestral instruments cover more than three octaves. Extensions up or down require additional instruments, for instance, the bassoon has to be extended downwards by the contra bassoon; the flute upwards by the piccolo. The whole range of notes required cannot be incorporated in one instrument. It is just the same with the violin, viola, etc.

As to power, well this is extremely limited for all instruments; even the trombone will only deliver just over half a watt of acoustic power. So, for more power we need more instruments. All these foregoing factors are limitations on the composer.

It is true that we have rubbed along for several hundred years with the existing conditions, but this is not to say that composers were satisfied. Far from it, nearly 70 years ago Busoni attempted to introduce another musical form, followed by Webern and others.

In those days when communications were limited and there was no general dissemination of concerts,

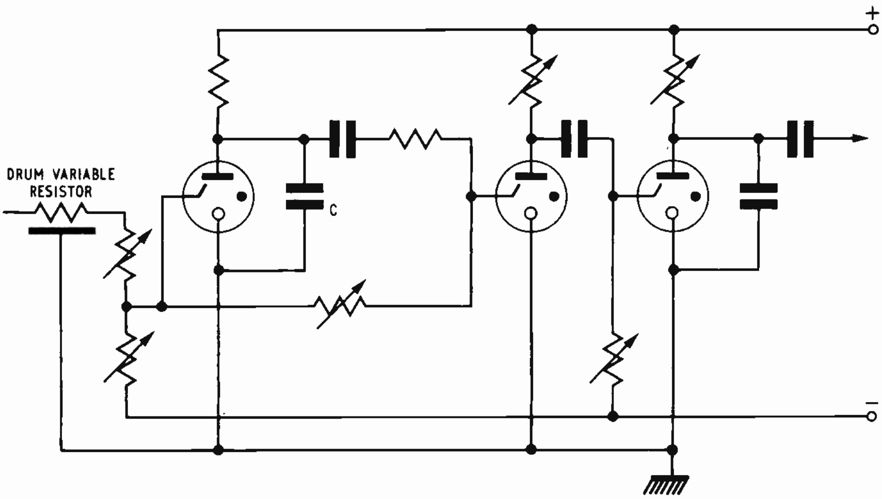


Fig. 1(a). Circuit of Trautonium with frequency divider; (b) the manual drum resistor is in a flexible form, so proportioned that the frequency of oscillation is proportional to the strip in use. Playing the "keyboard" consists of pressing the tubular cover enclosing the resistance contact strip at the point required to produce the correct pitch note

convention outlawed such revolutionary ideas. And of course at that time, all sound patterns had to be produced acoustically, there being no transducers, amplifiers or loudspeakers. Such limitations defeat the boldest spirits.

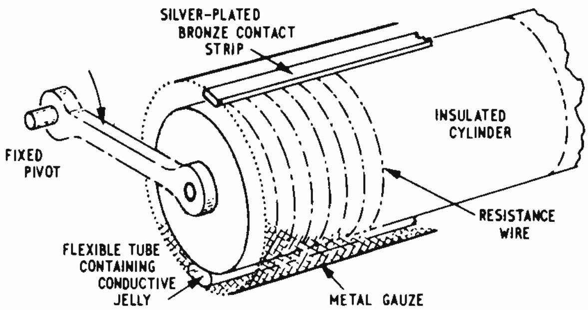
CHANGES AND THE FIRST SYNTHESISER

Most musical performances in those days were sponsored by a patron, who usually financed the composer. As times changed, especially with the introduction of gramophone records and broadcasting, the role of the patron diminished and the financial arrangements altered. Clearly this produced an atmosphere which discouraged serious composition, for the decline in status of the composer increased as the public tastes changed owing to the ease of communication. But, as always, there comes a time when old threads are picked up again in a new guise, this time by organisations instead of individuals.

The use of the valve had become commonplace after the 1914 war, but stability was unheard of and it was not until gas tubes became highly developed in Germany that successful synthetic musical instruments were produced; for it became clear that electrical methods would have to be used to overcome the limitations of all existing physical instruments.

THE TRAUTONIUM

Professor Friederich Trautwein designed the first, and still one of the most useful, synthesising devices, the Trautonium, in 1928. With this two keyboard instrument, instead of the conventional 12 notes to the octave, it is possible to obtain 1,200! Strangely enough, the Trautonium was for some years regarded as a device for examining the tonal spectrum of existing instruments, and for use as a solo instrument with orchestra—as Oskar Sala uses it. Its powers as a composing device were not really recognised until the North West German broadcasting authority set up a school of electronic music research into musical tone, form and composition.



By this time, tape recorders were readily available, as were good quality microphones and reverberation systems. It was the tape recorder which set the seal on the ability to construct music from the basic parameters mentioned, and without which electronic music is not possible, unless it be very elementary in form.

The circuit of the Trautonium is shown in Fig. 1a as an early example of voltage control, so often hailed as a new development. But in fact, voltage to frequency converters, variable gain circuits, vibrato and envelope shaping circuits all depending on voltage control are very old. Note the ingenious way of getting small increments of grid bias control by means of a variable resistance drum, Fig. 1b.

Dummy rubber keys were in fact mounted over the top "keyboard" to give an approximate indication of note positions.

This important instrument was extensively used all over Germany until the coming of the semiconductor. Of course, Helmholtz, Hermann Smith, Dayton Miller and especially Maurice Martenot had devised synthesisers, some purely mechanical, before this.

MACHINE COMPOSITION ADVANTAGES

But now we must revert to more recent problems, and there are several; but most have the composer, rather than the performer, in mind, although all composing machines can play back the composition.

In the past, a composer could put pen to paper and draft a piece of music for, say, ten players. But how could he make sure he was getting the best intended effect without employing ten musicians to play his score? This is both costly and inconvenient, and calls for a suitable acoustic environment. How much better if he could convey the musical information to a device which could play it for him. He could then listen to it in private and make any corrections thought desirable.

This was the idea behind the RCA and Oramic sound systems. Both of these enable a musician to prepare the "score" with his own hands and play it at once—no matter how long it is. The information imparted to the system can be called back and replayed again and again, and alterations made. This can only be done for very short periods of time with synthesisers of the Moog or EMS types unless they incorporate a computer and even then, the playing time per realisation is quite short—perhaps 30seconds.

THE RCA SYNTHESISER

Let us then have a quick look at the RCA machine. This is a complete studio, and not intended to be portable, a typical installation being in a college of music or a university. No matter what the system, it must be capable of providing the eight basic parameters mentioned earlier, as a minimum. Of course, there may be extensions and there is great flexibility for each of these.

The apparatus is contained in ten standard racks, each 6ft high, see Fig. 2. It comprises a range of tuning fork oscillators, frequency multipliers and dividers, means for producing any overtone or harmonic structure, duration or decay characteristic, vibrato and "glide" circuits, loudness or level controls, relay trees for operating the foregoing from the information source, and other devices to produce deviations from the above for special effects.

All the above circuitry is duplicated so that two simultaneous channels are available. The whole of this is controlled from the keyboard perforator.

PERFORATED ROLLS

Most readers remember the perforated paper roll used in player pianos. The information required to operate the correct notes took the form of perforations in the paper. As this was unwound from its reel by a motor, the roll passed over a perforated metal bar—there being as many apertures as there were notes on the piano.

A vacuum was created in a bellows system, and when a perforation in the roll coincided with an aperture in the tracker bar, as the perforated rod was called, air would be sucked in to the appropriate hole and this energised a small pneumatic device which actuated the correct hammer.

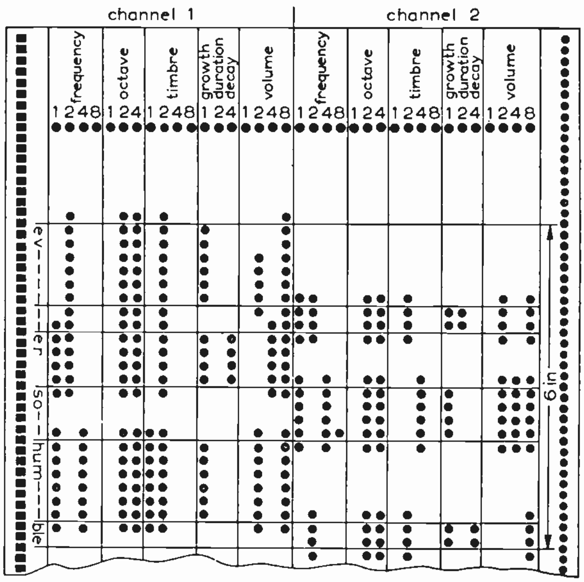


Fig. 3. Part of RCA punched roll

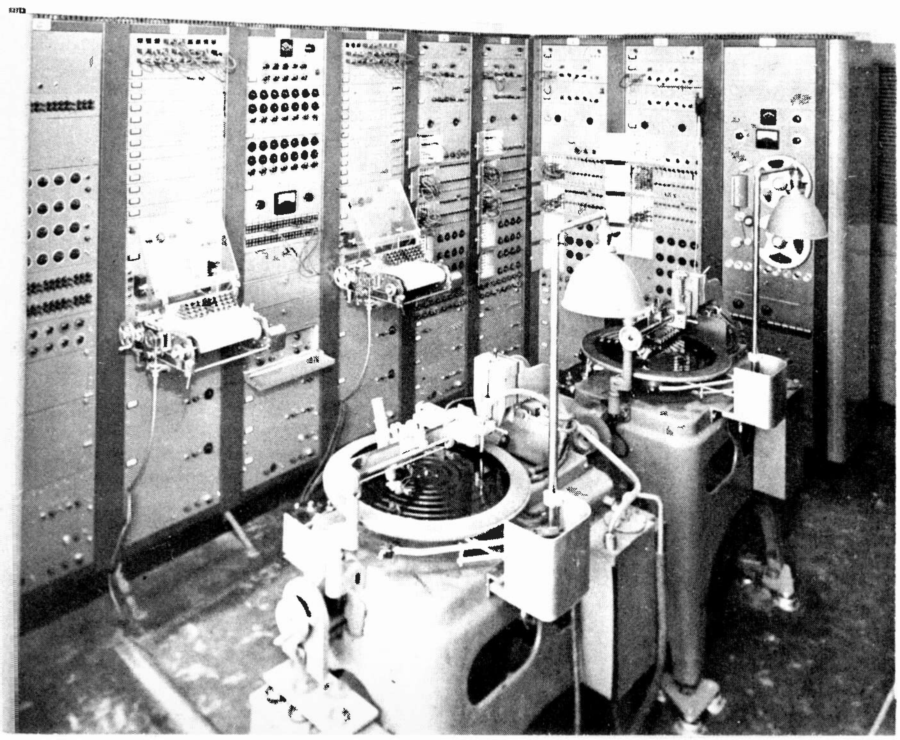


Fig. 2. RCA Synthesiser at Columbia University

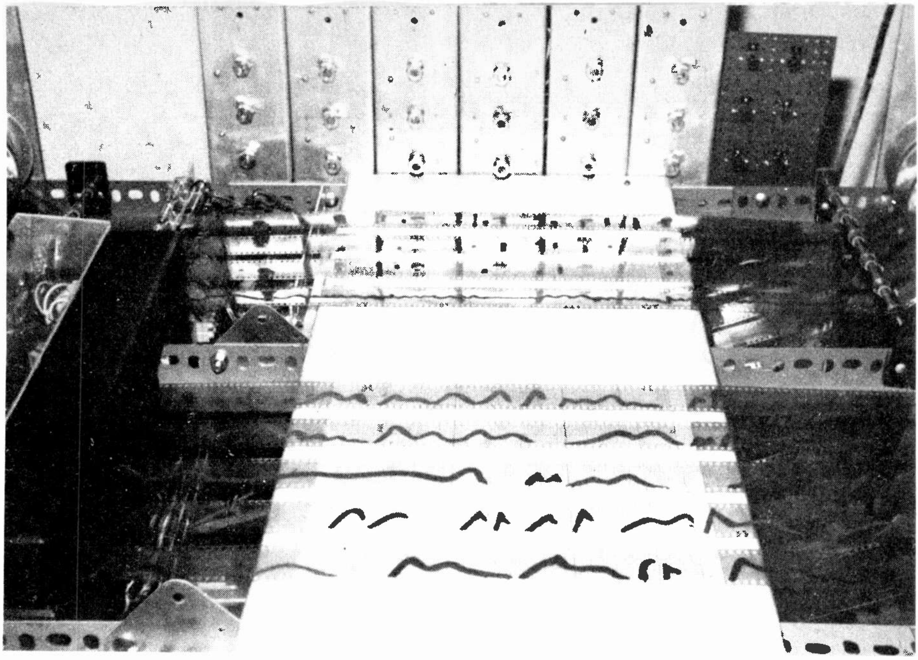


Fig. 4. Digital and analogue information on film for the Oramic Sound System

To produce a sustained note, a slot was cut in the roll, thus the hammer did not return until the end of the slot arrived, and the damper was so kept off the strings.

The same idea is used by RCA to convey the information, but as the paper roll is wider, slots make it liable to stretch and therefore a series of closely spaced holes is used for a sustained note. The little microswitches which "feel" a hole are so arranged that they will not close again if two holes immediately follow one another; in this way, sustained notes are possible.

An alternative method is to paint dots or bars for the duration of the required parameter, and then scan them photoelectrically. By this means excessive perforations in the paper are avoided. An example of the prepared roll is given in Fig. 3.

DISC AND TAPE LINKS

The two perforators are mechanically linked to either disc or tape recorders, so that after the completion of a composition, the substance can be recorded and either played back or stored.

Although only two channels are provided, re-recording is resorted to, and with modern materials quite elaborate compositions can be realised and performed. But one of the prime objects is to help the composer; he can come along with a theme, punch out the parts with quite arbitrary tone colours, listen to his harmonies at once, and correct anything which he does not like. Armed with the final information, he can write out the score in completed form—and all without employing a single live musician!

It is often thought that gliding tones, percussion sounds, "wah-wah", etc. are recent ideas. This is not at all true; all of these effects have been known and used for over 40 years; it is just that until the coming of the semiconductor, the apparatus to produce the effects was too bulky to be convenient.

Today, it is hard to realise that the free cone moving coil loudspeaker is nearly 50 years old and the rigid diaphragm moving coil speaker is nearly 80 years old.

Now it is clear that the RCA system closely approaches a stepless method, for by having many perforations and restricting the frequency or other coverage per paper section, one can produce intervals smaller than a semitone and these can be bridged by the portamento (or gliding) system. Nevertheless, the fact that the holes are discrete and represent time intervals does limit the synthesiser in some ways. When all the parameters are on the one roll, it is not possible to separate them or, for example, to change their relative positions or phase relationships.

THE ORAMIC SOUND SYSTEM

To have complete control over all the factors involved, a system such as the Oramics graphic device offers unlimited flexibility. The essential part, which provides the information, is shown in Fig. 4.

Basically, the idea of drawing a waveshape or control element is far from new; it has been extensively tried in Canada, Germany, France and this country for electronic organ generators, for example, as well as for motion picture film. But all these investigators tried to produce the fully-finished and complete complex waveform at one time, just as if it were a photographic sound film track. For composing or musical synthesis, this would be useless; no variation is possible once the track is drawn.

The Oramic system builds up a sound picture from its basic elements, related to each other only in time. Observe that there are a number of independent tracks, each consisting of a length of transparent 35mm motion picture film. These are contained on spools and are drawn up by sprockets keyed to a common shaft. Thus, however many sprockets there are, all must rotate in synchronism. Now the film passes over a large metal plate, which is the writing table and is again picked up by similar sprockets on another shaft; this is coupled by a chain to the first shaft, so they must turn together and cannot slip.

INFORMATION TRACKS

Information is imparted to the film tracks in the manner shown in Fig. 5. For example, the top four

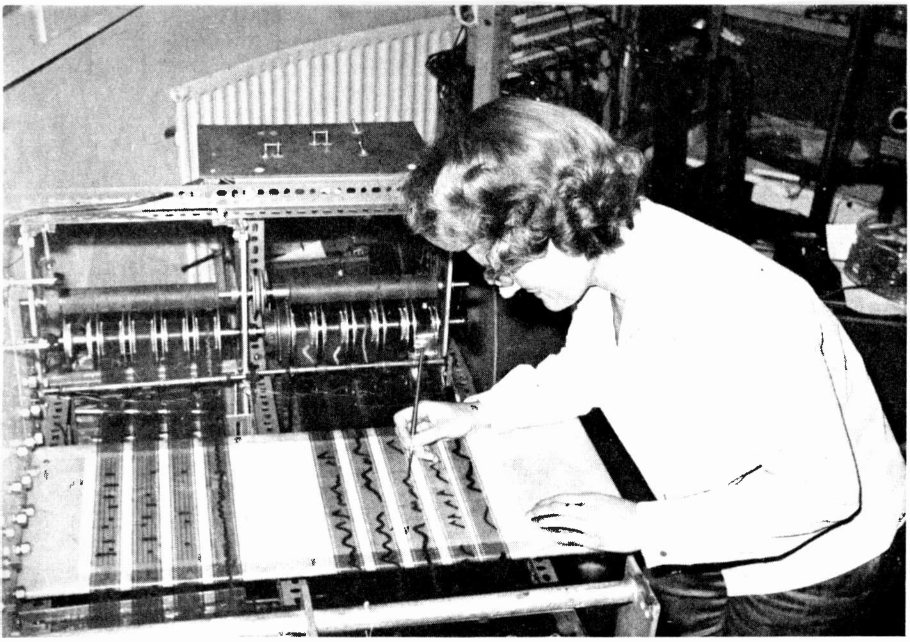


Fig. 5. Printing information on film tracks

tracks could be frequency tracks, the fifth could be noise; then the sixth could be a gating track, to initiate the signal, the seventh could be envelope control (rise time, duration, decay) and the eighth track could be vibrato. Of course, there is no limit to the number of tracks possible.

The information is painted or drawn in opaque ink, or it could be strips of adhesive tape cut to shape and stuck on (easier to alter). When the shafts are rotated, the films pass from right to left over photoscanners with suitable exciter lamps. These scanners control the different sections of the synthesiser, in much the same way as do the microswitches of RCA, but of course in a smoother and much more accurate way. Additional harmonic control is imparted by drawn masks scanned by a cathode ray tube, and these are instantly changeable. Much more complex harmonic patterns can thus be produced than by any switching system.

The tracks are ferried back and forth until the composer is satisfied that he has the effect he wants. Then the next "bars" can be worked on and so on, because in this system there is virtually no limit to the length of the composition.

An electric motor drives the sprocket assemblies at a constant speed when the hand control is not being used, and of course the composition is recorded on tape. Even so, this need not be the end of the process; if each signal track is recorded separately on a multi-track machine, further after-treatment is possible before combining the tracks in final form.

This machine, by the way, is an excellent teaching device, since the effect of altering each parameter can not only be seen, but heard. The real meaning of a musical waveform is thus clearly brought home to the student.

SOLID STATE VERSATILITY

We might again stress that however simple or however complex the apparatus, it must have the basic facilities mentioned at the outset and it need have no more; but it can have elaboration of each channel and more channels. Today then we find that because of the compactness and light weight of solid state circuits, there are portable or semi-portable synthesisers of formidable capabilities. The purpose of all these devices is the same, but some have facilities for taking in existing sounds (e.g. a microphone) and processing this in some special way.

The versatility of the transistor synthesiser is largely due to the use of voltage control. As already pointed out, this is far from new, but it is more readily applicable to semiconductors. Broadly it confers the advantage of noiseless gain control, the ability to use very long signal leads, and abolition of difficulties associated with impedance matching.

R. A. Moog appears to have been the first to apply these techniques commercially and in order to draw attention to the method, he made the well-known "Switched on Bach" record. This is indeed a combination of the old and the new, and one feels that Dr Moog was very wise not to rely on any modern composition for processing. Systems like this have no storage time, therefore only a small amount of synthesis is possible without resetting. Consequently such recordings take a long time to complete —it may run into months.

THE SYNTHI-100

These devices contain the facilities required to form any kind of musical or non-musical sound. Later developments have abolished the cumbersome patch cord, which gets in the way and is easily broken, so we show in Fig. 6 an example of the most up-to-date studio in existence, that of the Synthi-100 made by Electronic Music Studios of London.

Readers will of course have seen the advertisements for the VCS-3 in this journal, and the author has one of these, with keyboard. But the Synthi-100 is something far in advance of anything else, not only because of its facilities and long-term stability (which has always been poor with solid state synthesisers) but because for the first time it includes a small special purpose digital computer, complete with converters from analogue to digital and vice versa.

The storage capacity of this device is 10,240 bits, and the start of each event can be controlled to an accuracy of 1 part in 1,024; thus, if the clock is set to a rate of, say, 100 pulses per second, each event

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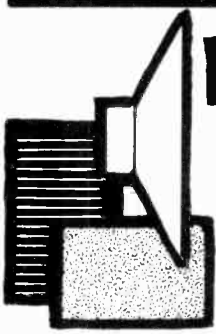

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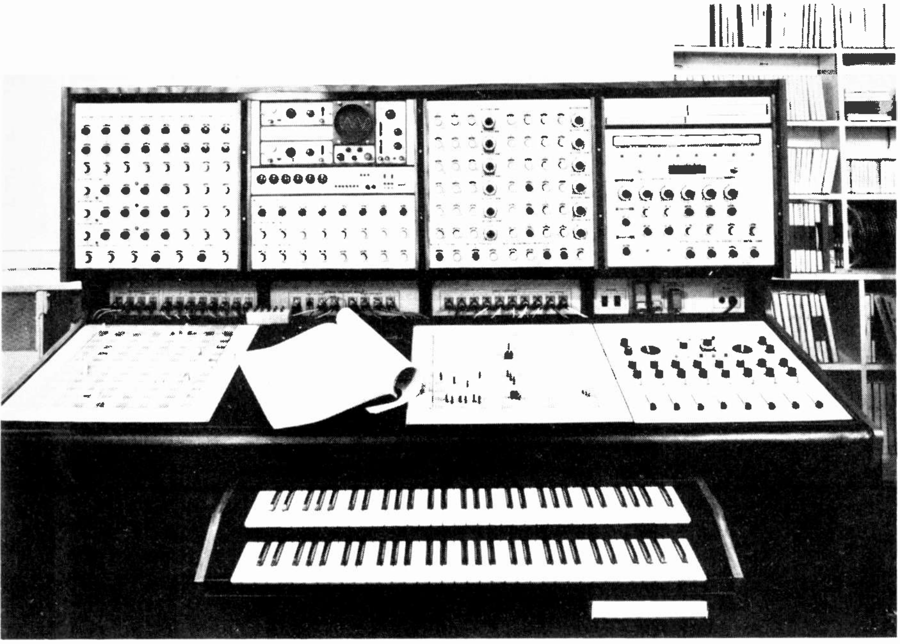


Fig. 6. EMS Synthi-100 studio

may be adjusted backwards or forwards in increments of one hundredth of a second. The total sequence length would be 10 seconds.

The many signal and processing circuits can be controlled from two 5 octave dynamically proportional keyboards. These operate the studio in real time, on six tracks, with the sequencer (the computer) remembering what is played.

This performance can be played backwards or forwards, at any speed, and edited to any degree of precision, prior to recording on magnetic tape. It is as if an infinite number of pianola rolls could be made instantly, but for any parameter.

SIGNAL AND PROCESS CIRCUITS

Briefly, this ingenious device contains voltage controlled slew limiters, a frequency to voltage converter and a two-output random staircase generator with controllable time and amplitude variations. Twelve drift-free oscillators, from 20kHz to 40 seconds per cycle; eight dynamic filters and three transformerless ring modulators, which in fact can be cascaded to give double or even triple modulation —a fearsome thought!

Also there are eight voltage controlled output channels, eight input amplifiers, two joystick controllers, three envelope shapers and followers, a noise generator and reverberation units. All of these, and many other functions, are controlled by two cordless 60 by 60 way patchboards, a total of 7,200 pin locations.

It is not surprising that the BBC bought this unit in preference to all others, although it has VCS-3's as well.

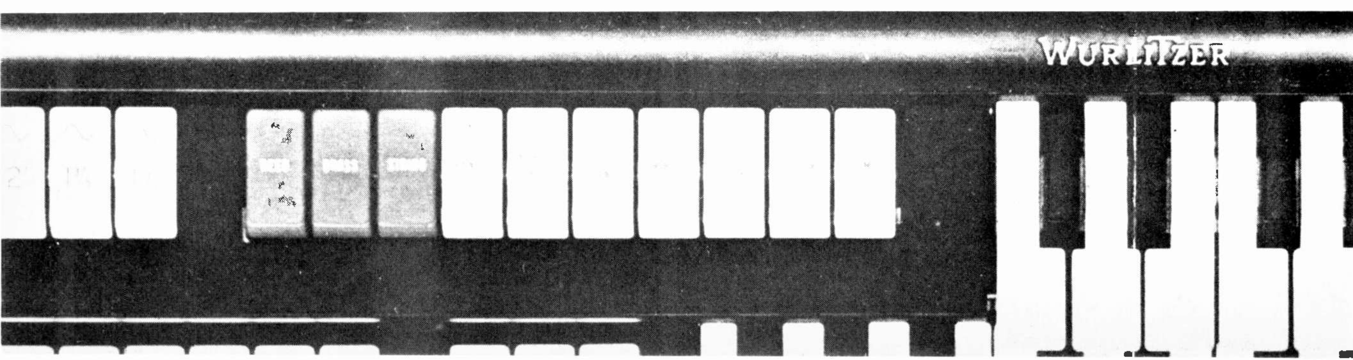
We cannot, of course, give any examples of sounds created by such systems, because a sound cannot be written down and even if this were possible, it would mean different things to different people. But we can say that it can produce musical effects of surpassing beauty, and at the other extreme, noises of an alarming nature. One could never exhaust the versatility of the Synthi-100.

And so to computers. Of course, any system feeding in digital information—like the RCA roll—is a kind of computer. But the description implies a logic device. It further suggests ownership of a computer, and this limits the field to those so equipped and with the time to spare. Consequently it is not surprising that most of the work along these lines has been carried out by the Bell Telephone Laboratories. Nevertheless, one of the most modern computer studios in the world is in London.

SYNTHESIS BY COMPUTER

Frequency and any function which can be specified numerically requires digital treatment; duration, envelope control and other factors involving time need analogue circuitry; but various compromises are necessary because of the enormous amount of detail required.

Fig. 7. Showing the short manual of the new Wurlitzer 4037 organ. This controls the Orbit III Synthesiser which adds a new realism to conventional stops. The controls to the right provide a whole new repertoire of totally new sounds for the performer. This means that the scope of the total instrument is almost limitless



Numbers stored in a computer represent the desired sound waves to be generated. These numbers are converted to pulses of constant width but of amplitudes corresponding to numbers; for example, twelve is twice as "loud" as six. These pulses are then smoothed to produce a sound. Frequencies from 0Hz to nHz can be generated by 2n pulses per second, so we require 10,000 per second to obtain 5kHz at the loudspeaker.

But this is far too tedious a process for any length of time, so simplifications have been made by grouping frequency bands and other parameters into blocks or "instruments" as they are called, so that the number of operations to release or call up a complex event is reduced. Modifying parameters are introduced by the composer, and the computer reads a line from the instrument signals and inserts the chosen modifiers at the correct time, thus activating the instrument with generated numbers equivalent to the duration of the note.

This process can also be made self-repetitive in a random manner, so that the same effect is never repeated twice; it is then rather like throwing a number of dice into a bowl and then shaking them out, in the hope that a certain total number will appear!

THE HUMAN ELEMENT

All in all, and from such recorded computer music as is available, it is irrefutable that if one wants music agreeable to our ears at this time, it is impossible to dispense with the human composer, although it is true that some sort of form can emerge from a process based on an order of probability.

Work has been done on the songs of Stephen Foster, so well known to all. All Foster's works have some resemblance to each other, so that it is possible to analyse them and establish an order of recurrence for all the notes used. If suitable deductions are made from these figures, and the result fed into a computer, sounds will emerge which, in their fundamental structure, bear a resemblance to Foster's compositions but do not sound like any of them. However, here we have a simple case, involving not more than 12 notes in all, because these are folk tunes.

PERFORMANCE DEFICIENCIES

A disadvantage of the conventional computer is that the composer is unlikely to be able to re-cast his thinking into suitable "language" acceptable to the computer; hence he may have to work through a programmer, and this may very well upset his musical judgement and certainly any spontaneity.

There are some simplifications of the computer system, notably the serial structure method, but there is no doubt that when the machine takes charge, the warmth of character and the nuances of expression disappear completely, however "clever" the result may appear to be.

Therefore we can assume that no machine is likely to supplant the human brain, any more than an electronic synthesiser is likely to take the place of a member of the orchestra. But certainly it can augment and extend his facilities and of course, can produce special effects as we all know. This would seem to be a likely exploitation of musical electronics in the future.

LINKING ORGAN AND SYNTHESISER

Readers have no doubt grasped that time is required to set up effects on any synthesiser, but if this range is limited, or complex mixing is not required, some of the facilities can be made available very quickly. We therefore see, in the new Wurlitzer 4037 organ, a simple Orbit III synthesiser built into the console and playable from a short compass third manual.

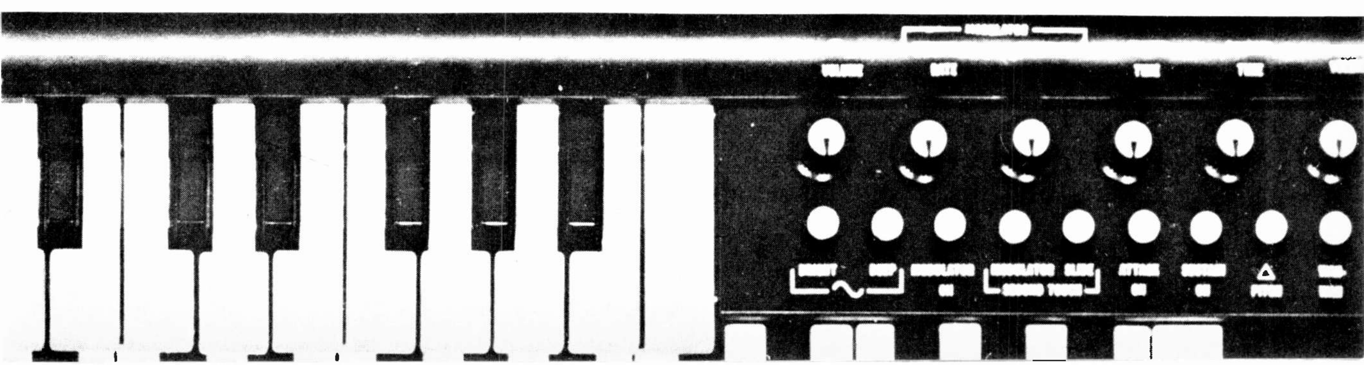
A vast number of extra effects came from this circuit, which has double touch keys so that yet further circuits can be brought into action. Because of the variable pitch characteristics of the Orbit III section, it must be on a keyboard separate from the main organ. Fig. 7 shows the lay-out.

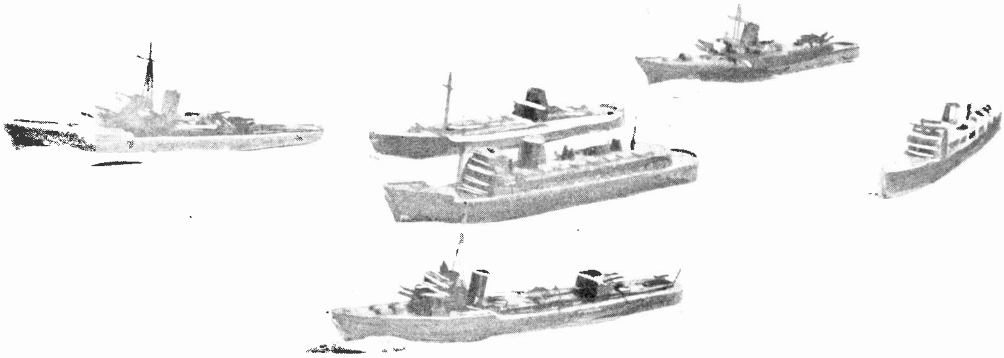
TRENDS FOR THE FUTURE

Finally, one must appreciate that the performer-audience relationship might change so far as the concert hall is concerned. Since the advent of multi-track recording for cinema films, loudspeakers have been used above and behind an audience as well as behind the screen. The listener can be immersed in the sound field, and this produces strong psychological reactions in many people and is a powerful factor in estimating the effect of sound.

Because of the increasing use of magnetic tapes and the excellence of reproduction now obtainable, recorded sound can be as realistic as the original except for the dynamic or loudness range. It is therefore altogether possible that some synthetic music, alone or combined with recorded conventional music, may be played before audiences in halls designed acoustically so as to favour the loudspeaker and no other kind of sound source.

This could already be so in the cinema, were it not required to be so heavily damped because of the speaking voice. We await the developments of the next few years with great interest. ★





WAR GAMES COMPUTER

PART THREE By D. R. Daines

THE basic concept of the War Games Computer has been described together with the constructional information required to build up to the Third Stage (Fig. 3). The remaining stages convert the computer for fair assessment of any "damage" sustained during battle. Additionally this next stage will provide various types of target.

STAGE FOUR—PANEL 'B'

Panel B (Figs. 12 and 13) and switch S11 begin to open up the real potential of the computer, for this panel adds up the energy of the incoming pulses and gives us an indication when a preset amount has been received, or when a ship is sunk (Fig. 12).

Incoming pulses of various amplitudes are amplified by TR10. This is not to say that the previous stage has been a wasted effort, for all pulses are amplified– the strong and the weak. Capacitor C2 blocks d.c. and leaves only pulses swinging about zero volts, which any high impedance voltmeter or oscilloscope will show. In order to charge the storage capacitor C12, however, only negative-going pulses are required and this is achieved by the diode clamp D9 and R77. The exact value of R77 will depend on the characteristics of the particular diode used. Adjust this until the positive swing of the pulses is exactly zero volts.

SCHMITT TRIGGER

The Schmitt trigger formed by TR11 and TR12 will fire briefly when the voltage at the base of TR11 reaches 2 volts, which it does when C12 is charged through R78. Switch 59a is a cancel switch to discharge C12 completely; C13 is an anti-surge capacitor to prevent the Schmitt from firing when the switch is snapped open.

The brief outgoing pulse passes through diode D10 and a flying lead (k) to (j) on D11 routes it to switch S11. Resistor R85 provides a convenient method of adjusting the energy available to the much larger storage capacitors C14 to C23, while diodes D10 and D11 prevent leakage of charge already on the selected capacitor. If constructors have no intention of going beyond this stage of construction, one of the Schmitt triggers (Trigger 1) can be omitted, the output from R78 going direct to D11 via points (h) and (j) on Fig. 12.

The storage capacitors C14 to C23 can be of any desired capacitance; those shown in the components list are for guidance only.

No accurate work has been done on the exponential curve comparing with size of ship, but the above component values have worked very well in dozens of games. (N.C. is no connection.)

EXTERNAL STORAGE CAPACITORS

Switch S11 is a single-pole twelve-way wafer switch fitted with a skirted knob, which has the figures 0-10 on the skirt plus a blank space. In the 0 position no capacitor (n.c.) at all is fixed, which is a useful facility when checking the correct functioning of the circuit, while in the blank position a single wire leads to a socket which also has a chassis contact. In this way external storage capacitors C14a to C23a may be switched in. Such external additions might be temporary, or favourite values permanently soldered to the tags of a switch and housed in a little box. Notice that the positive side of all capacitors must be returned to computer chassis.

From point (l) two wires are taken off—one to S10a and one back to panel B at TR13 base. (Fire bistable line is mentioned later). When the charge across the capacitor selected by S11 reaches two volts, Schmitt trigger 2 fires. The resulting brief pulse passes through C25 to Bistable 2 which switches to its second stable condition with TR15 hard on and TR16 fully off. The voltage TR16 collector rises, switching on TR17 and TR18, which are arranged in a super-alpha pair.

Since R100 carries considerable current it generates some heat. For this reason it is better to keep it away from where the increase in temperature may affect the working characteristics of transistors or even destroy them. It is used for final adjustment of lamp voltage for LP2, after some 20 V has been dropped across R16 in the power supply.

The lamp itself is mounted behind a plastic lens and marked "Magazine", the return wire being connected to chassis (Fig. 10b).

Switch S10 is a double pole on/off which discharges the capacitors on switch S11 (S10a) and also earths the base of TR15, thereby switching it off (S10b) and extinguishing the lamp. Resistor R101 is a low value discharge load for the capacitors on S11; the value should be found to be sufficiently low not to interfere with the circuit operation (about 22 ohms). Although not shown in the wiring diagram (Fig. 10b) R101 can be inserted between S10a and Trigger 2 input (l).

USE OF STAGE FOUR

The knob-skirt numbers correspond to numbers assigned to ships and as long as players remember to turn to the correct target number each time, they may happily bang away at each other confident in the knowledge that the lamp will glow when any ship has been at the receiving end of sufficient computed damage. Fuller details will be given later.

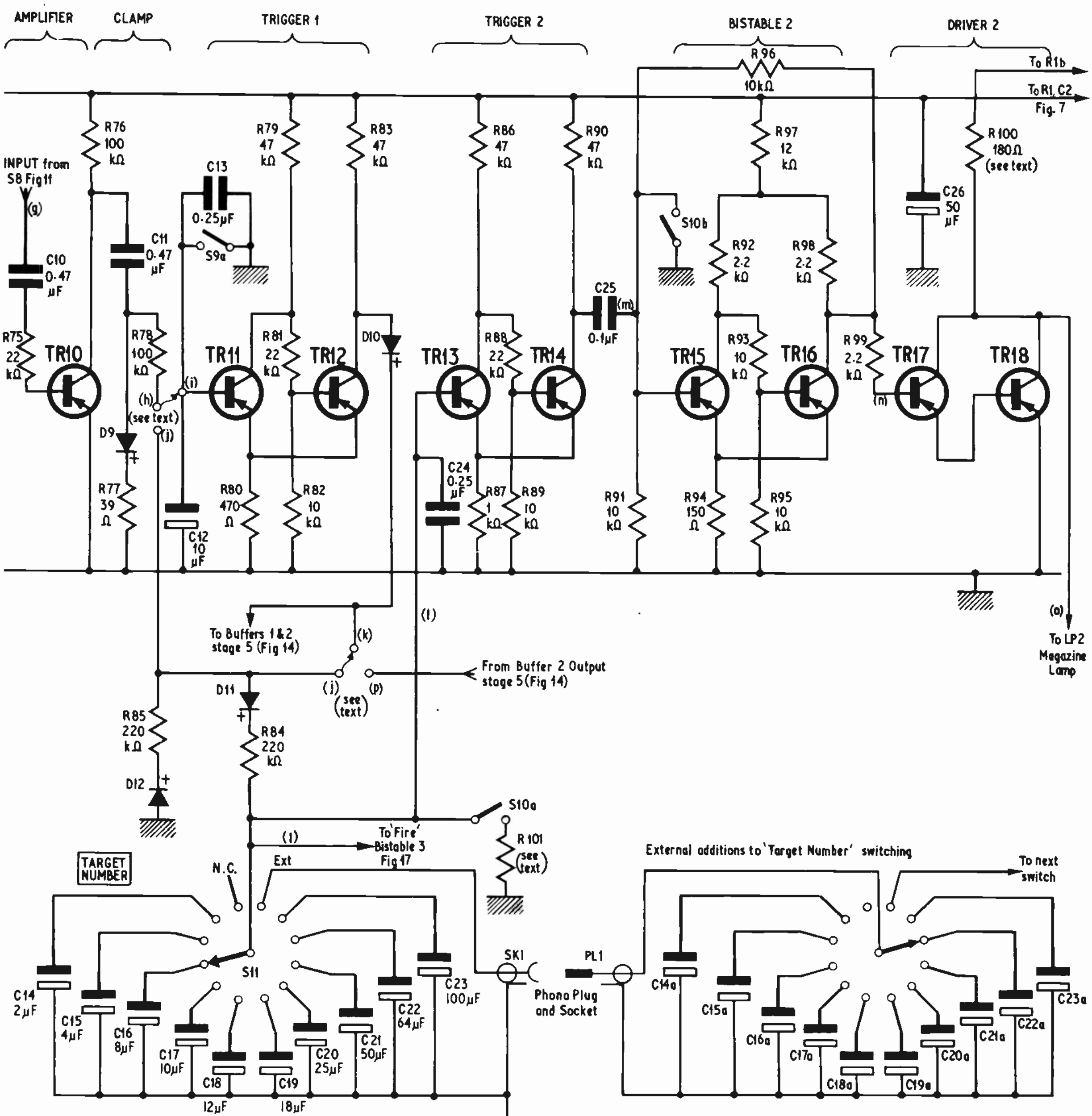
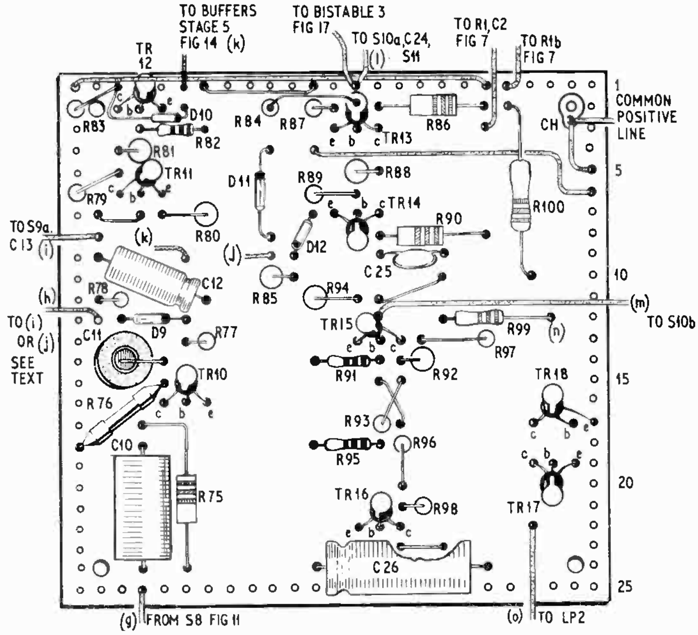
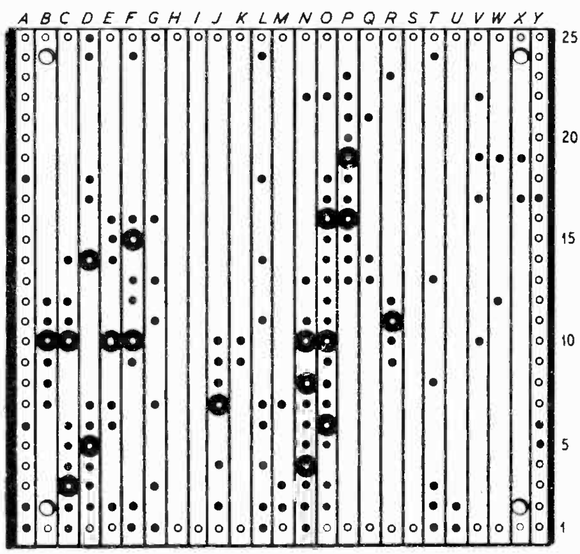


Fig. 12. Circuit diagram of Panel B (stage four). Incoming pulses are passed to the selected storage capacitor (C14-C23); trigger 2 fires when this capacitor is fully charged, bistable 2 operates, and driver 2 switches on LP2





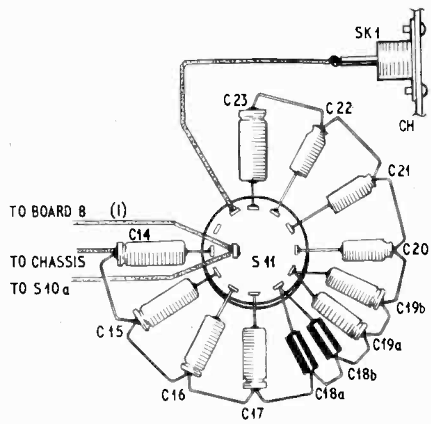


Fig. 13a. Layout of components on Panel B with underside view showing the breaks in the copper strip

Fig. 13b. Wiring details for target number switch S11 and the storage capacitors

Components . . .

STAGE FOUR (Panel B Figs. 12 and 13)

Resistors

R75	22k Ω	R84	220k Ω	R93	10k Ω
R76	100k Ω	R85	220k Ω	R94	150 Ω
R77	39 Ω	R86	47k Ω	R95	10k Ω
R78	100k Ω	R87	1k Ω	R96	10k Ω
R79	47k Ω	R88	22k Ω	R97	12k Ω
R80	470 Ω	R89	10k Ω	R98	2·2k Ω
R81	22k Ω	R90	47k Ω	R99	2·2k Ω
R82	10k Ω	R91	10k Ω	R100	180 Ω 1W
R83	47k Ω	R92	2·2k Ω	R101	22 Ω 1W (see text)

All ±10% ¼W carbon except where shown

Capacitors

C10	0·47μF polyester 125V (or 0·5μF)
C11	0·47μF polyester 125V (or 0·5μF)
C12	10μF elect. 50V
C13	0·22μF polyester 125V (or 0·25μF)
C14	2μF elect. 15V
C15	4μF elect. 15V
C16	8μF elect. 15V
C17	10μF elect. 15V
C18a	8μF } 12μF elect. 15V
C18b	4μF }
C19a	8μF elect. 15V
C19b	10μF elect. 15V
C20	25μF elect. 15V
C21	50μF elect. 15V
C22	64μF elect. 10V
C23	100μF elect. 15V
C24	0·22μF polyester 125V (or 0·25μF)
C25	0·1μF polyester 125V
C26	50μF elect. 50V

Transistors and Diodes

TR10 to TR18 OC71 or similar pnp germanium type
D9 to D12 OA91 or similar germanium type

Switches

S9	Double-pole, on/off or changeover toggle
S10	Double-pole, on off or changeover toggle
S11	Single-bank, single-pole, 12-way wafer

Miscellaneous

LP2 6V 0·06A m.e.s. lamp and holder SK1, PL1 Phono or coaxial socket and plug Veroboard 0·15in in matrix 3¾in × 3⅞in with copper strips.

STAGE FIVE—PANEL 'C'

One criticism of the computer to date is that ships blaze away at each other unabated until the sudden moment of oblivion. This is hardly realistic. A much more interesting and exciting game results when damage occurs bit by bit, affecting the fighting qualities in various ways. Panel C does that.

First, the lead (k) is disconnected from point (j) (Figures 12 and 13) and instead the damage pulses are passed equally from (k) to two buffers TR19 and TR20 (Fig. 14). These are arranged in emitter follower mode, and are designed so that the two halves of the readout section do not interfere with each other. From TR19 the output is taken through C27 and then reconnected to point (j) via (p) as in Fig. 12. The output from TR20 is taken through R108 and C30 to switch over the bistable formed by TR21 and TR22 and so drive lamp LP3 in the now familiar way through TR5 and TR6 and point (s).

TESTING AND USING

Lamp LP3 will now glow every time there is a pulse from Trigger 1 and may be extinguished by the use of S9. The number of times that this may be done before lamp LP2 glows depends entirely upon the size of storage capacitor selected by S11.

In use a dice may be rolled each time a unit of damage occurs, in order to see where it is. A six for instance might indicate the captain killed and the conning tower in flames; a one might indicate an aircraft catapult destroyed. Further examples will be given later.

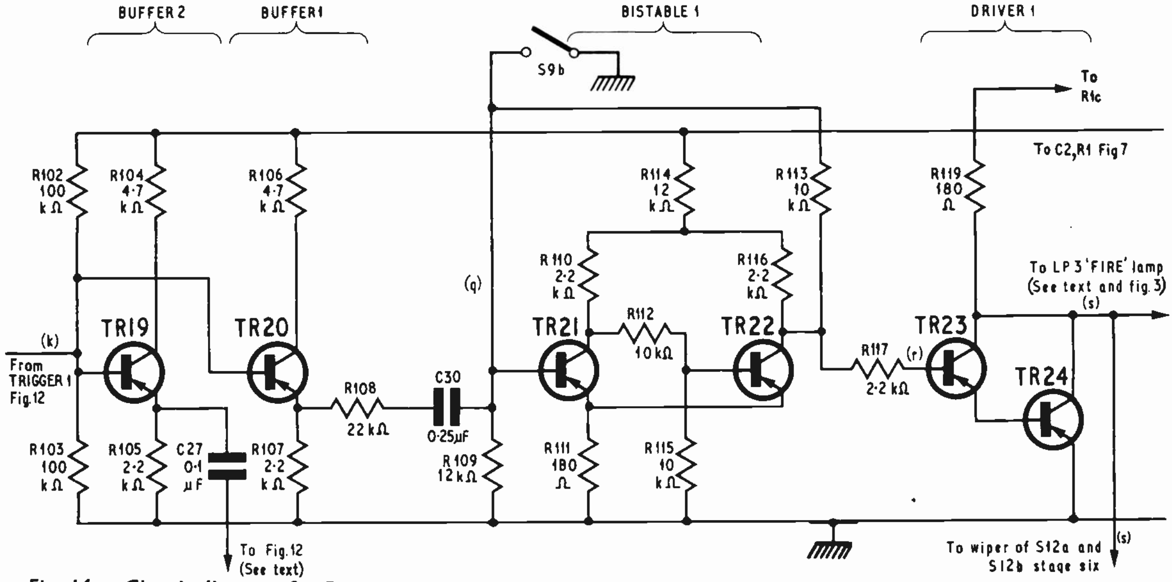


Fig. 14a. Circuit diagram for Panel C (stage five). This adds a further hazard in the form of "fire" (lamp LP3)

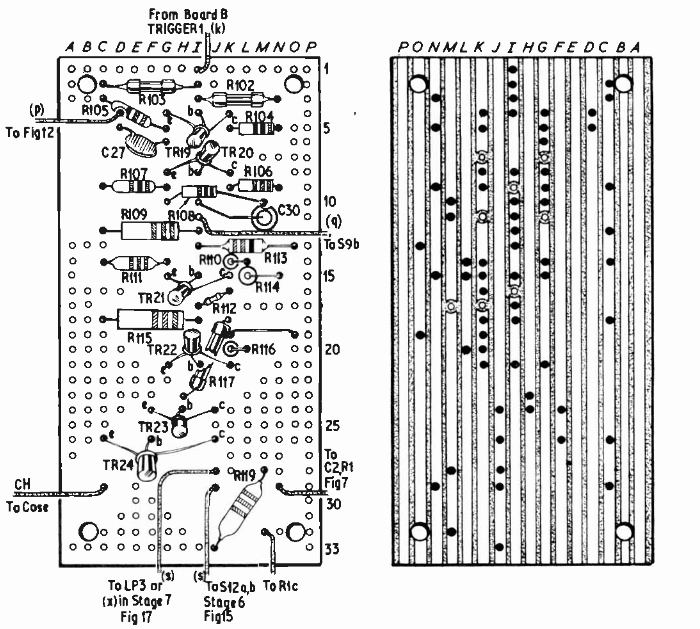


Fig. 14b. Layout of components on Panel C with underside view showing the breaks in the copper strips

Components . . .

STAGE FIVE (Panel C Fig. 14)

Resistors

R102	100k Ω	R111	180 Ω
R103	100k Ω	R112	10k Ω
R104	4·7k Ω	R113	10k Ω
R105	2·2k Ω	R114	12k Ω
R106	4·7k Ω	R115	10k Ω
R107	2·2k Ω	R116	2·2k Ω
R108	22k Ω	R117	2·2k Ω
R109	12k Ω	R119	180Ω 1W
R110	2·2k Ω		

All ±10% ¼W carbon except where shown

Capacitors
C27 0·1μF polyester 125V
C30 0·25μF polyester 125V

Transistors
TR19 to TR24 OC71 or similar germanium pnp type

Miscellaneous
LP3 6V 0·06A m.e.s. lamp and lampholder
Veroboard 0·15in matrix 5in × 2½in with copper strips

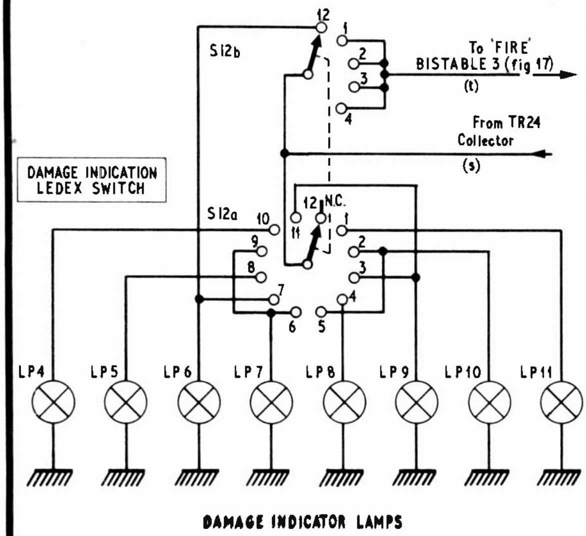


Fig. 15. "Random damage" selection circuit (stage six) using a Ledex switch

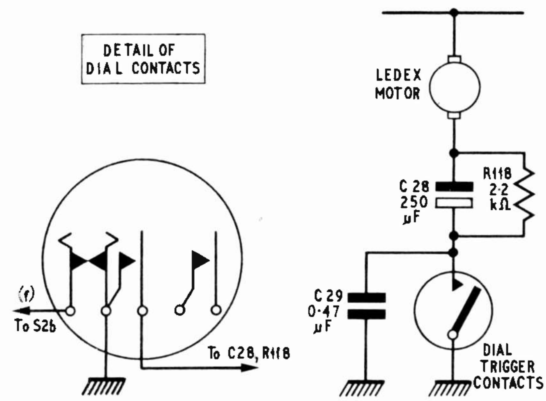


Fig. 16. Circuit details of the Ledex motor

Components . . .

STAGE SIX (Ledex switching Figs. 15 and 16)

Resistor
R118 2·2kΩ ± 10% ½W carbon

Capacitors
C28 250µF elect. 64V
C29 0·47µF polyester 125V

Switch and motor
S12a Single-pole, 12-way wafer
S12b Single-pole, 5-way wafer
Both wafers assembled on a miniature Ledex rotor and ratchet mechanism available from suppliers of surplus Post Office equipment and components. (Manufacturer is N.S.F.) Alternative suggestions see text.

Lamps
LP4 to LP11 6V 0·06A m.e.s. lamps and lampholders

STAGE SIX—AUTOMATIC INDICATION

Actually attempting to compute just where damage should occur would be impossible and quite beyond the needs of a game. What is required is a random selection, with some types of damage occurring more often than others. One method of doing this would be by a twisted-ring counter in conjunction with gates—a method rather lavish in its use of semiconductors. Another more simple method would be to spin a twelve-way switch with the click-stop mechanism removed. No doubt other methods will occur to readers. The system used in the prototype was to move a Ledex motor-driven rotary switch of the double-pole twelve-way type or a uniselector switch one space each time the dial was operated. The wiring of the wafers will be seen in Fig. 15. The output of the driver is thus routed to any one of eight lamps, with four having twice the chances of the other four created by S12b. It should be noticed that one of the second wafer tags covers the n.c. condition of the first wafer.) The lamps are labelled as follows:

Single chance
Lamp 4 Conning tower
Lamp 5 Hull
Lamp 6 Aircraft or torpedo tubes
Lamp 7 ¼ sub. armament

Double chance
Lamp 8 Engine room
Lamp 9 Rear turret
Lamp 10 Forward turret
Lamp 11 Rudder

The lamps may be arranged in any order for viewing, but it is difficult in the excitement of a game to keep track of what the next indication will be, particularly as threequarters of diallings will produce no visible effect. Moreover, no player could do anything to affect the outcome, even if he did remember the sequence.

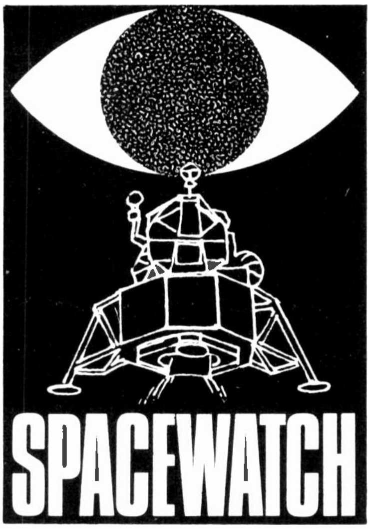
DRIVING THE LEDEX

The Ledex coil requires 48 volts (24 volt versions are available) and draws a heavy current. It was required to keep everything as automatic as possible and so the telephone dial was used again. There is a pair of contacts that makes when the dial is drawn back, and remain closed until the dial is again at rest. Fig. 16 shows how this contact is used.

Resistor R118 passes insufficient current to pull the armature when the dial contacts are closed. However, C28 is very large and the surge of current charging it plus the small amount going through R118 is enough to activate the coil. It is only momentary; C28 is soon charged and the current passing through R118 is insufficient to hold the coil. The armature drops back and now the current used by the circuit is limited to the tiny amount through R118. Capacitor C29 is a surge suppressor to prevent supply line variations triggering Schmitts.

When dialling is completed, the dial trigger contact opens and C28 slowly discharges through R118. This takes about three seconds and if dialling is attempted before C28 completely discharges, the Ledex coil may not operate satisfactorily. In game conditions this is of no moment.

Next Month : Stage seven "fire" switching from Ledex. Further notes regarding how to get the best out of the computer.



BY FRANK W. HYDE

RADIATION FROM JUPITER

New light on the variations of the radiation from Jupiter has been offered by a team from Meudon Observatory. Recent observations carried out by Messrs. L. Consiel, Y. Leblanc, G. Antonini and D. Quemada has led them to the conclusion that Jupiter has a plasmasphere similar to that of the earth. It must also be concluded that this plasmasphere is very strongly affected by the solar wind, even though Jupiter is some five times as far away from the sun as the earth.

The difference between the earth's plasmasphere and Jupiter's plasmasphere is the size. The magnetosphere (the boundary across which the solar wind cannot go) is determined by the magnetic field. It is not regular in shape and in fact can be and is very much distorted by the pressure of the solar wind and its interaction at the boundary. In the case of the earth it is pushed back on the sunward side and causes the whole boundary to swell up in size as it were on the lee side, see Fig. 1.

The normal radius of the magnetosphere of Jupiter is some 50 times that of the planet. This boundary is determined by the electrical effects in the plasma around Jupiter. The co-rotating plasma has an upper limit which depends on the interaction between the rotating electric field and the solar wind. This limit in the case of Jupiter is only about eight times the radius of Jupiter.

EFFECTS OF SATELLITE IO

This fact has led the Meudon observers to suggest that the effects known to be made on the Jupiter radiations by this planet's No. 1 satellite named IO, is the direct result of changes of level in the plasmasphere.

The effects of IO, first suggested by Bigg in 1964 were observed before this by the writer and the team led by C. H. Barrow under a NASA contract with Florida State University.

There are other considerations to be taken into account, for example, the effect of the next two satellites. Although the effect of these was slight it was detectable. As the writer predicted in 1966, Amalthea the innermost satellite was also a factor in modifying radiations as was confirmed a few years later. Still another effect has to be remembered, and that is that not all the radiation that has been observed in the decametre region is effected by IO. Some remains continuous whatever the position of IO.

THE PLASMAPAUSE

Basically the theory put forward by the French observers does add an important viewpoint. The mechanism they are suggesting works as follows. The solar wind velocity was compared with the radiation activity time and the position of IO. The results were then correlated. It seems clear that the radiation received did occur when IO crossed the upper boundary of the plasmasphere. This boundary is called the plasmapause.

During the quiet sun it would appear that the plasmasphere is able to extend outwards from its normal position, but when the sun is active it is forced downwards to a much lower level. This places the boundary within the orbit of IO, and the bursts of radiation appear when the satellite crosses the boundary.

This is of course valuable additional data but there are still a number of anomalies. Moreover in the first study undertaken by the writer in co-operation with the team previously mentioned a direct correlation between solar activity and Jupiter activity could not be found, as was reported in "Nature". However, it was always considered that the sun was a cause as the writer has always held. This new work confirms the validity of the supposition and it is now only necessary to pursue the French work further to find a satisfactory answer.

There are two prime questions which are not satisfied as yet. The first is, why is there so much difference in the level of the radiation in the northern and southern hemispheres and why is the radiation frequency selective at different stations?

This last question is a very important one since it is quite often the case that two or three stations working on the same frequency do not simultaneously receive the radiations and where the stations are working on say three frequencies, station 'A' may receive radiation at say 18MHz, station 'B' at 20MHz, and station 'C' at 22MHz at a particular time, but in each case the other operating frequencies show no results.

JUPITER'S ATMOSPHERE

Attempts to measure the depths or even the existence of atmosphere on planets and satellites use observation in the visual spectrum as well as the radio spectrum. The usual visual method is the observation of an occultation. In the case of Jupiter which is one of the brightest objects in the sky it eclipsed the bright star Beta Scorpii. This is the first time this century that this has happened.

Naturally full advantage was taken of this by astronomers. A team from the University of Texas led by Prof. David Evans and Dr. William Hubbard observed the occultation from observatories in India, Australia, South Africa and the Virgin Islands. Specially designed scanning photometers were used since it was necessary to make very quick determinations of the star's light curves.

New information as to the temperature of the planets reveals that instead of the previous figure of 100 degrees K for the outer atmosphere the observers all agree on a figure between 150 degrees and 200 degrees K. The atmospheric gradient also turned out to be less steep than had been thought.

A bonus on this observation was the fortuitous occultation of the star by IO, which proved that the satellite was larger than the earth's moon with a negligible atmosphere. The observations have enabled a more precise position for Jupiter's orbit to be determined and new information on the weight of the gases in its atmosphere.

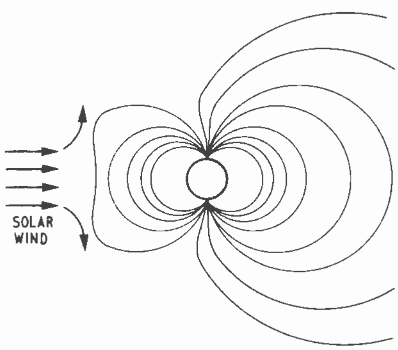


Fig. 1. A section through the magnetosphere at noon. The solar wind has pushed the sunward side of the magnetic field away to form a tail which at times is so long that a tadpole shape appears

RAIN & WATER LEVEL ALARM

By H. MOORSHEAD

THE unit to be described will act as a tireless sentry, sounding off as soon as water level rises or, perhaps more practically for most of us, will give you early warning of rain or snow so that washing left in the garden can be quickly brought in.

The unit can be left switched on for months on end as the quiescent current is in the order of nanoamps. Assuming that the alarm is not left on for hours on end, the battery will decay of old age rather than run down and for the specified type the life is at least a year.

CIRCUIT ACTION

To understand the circuit consider the block diagram in Fig. 1. The unijunction relaxation oscillator TR2 has a highly sensitive electronic switch, triggered by water or damp, in its positive supply—TR1 acts as the switch.

The output of the oscillator is insufficient for a practical alarm system so it is coupled to TR3 which switches on and off in sympathy with TR2 and passes the alarm signal to the loudspeaker.

Referring to the actual circuit in Fig. 2 it will be seen that in the "on" state (assuming the sensors are inoperative) the only current drawn will be the leakage of TR1 and TR3 since the base of TR1 is floating and the base of TR3 is held at negative potential.

When the sensors are shorted out, R1 applies bias to TR1 turning it on and although there is a volts drop across it, this is small and not enough to affect the operation of TR2.

The resistor R2 charges up C1 when TR1 allows current to pass; this raises the potential at the emitter of TR2 and because of the mode of operation of the unijunction transistor, when a certain level has been reached the device passes current which discharges C1 and this turns TR2 off. The oscillatory cycle then starts all over again.

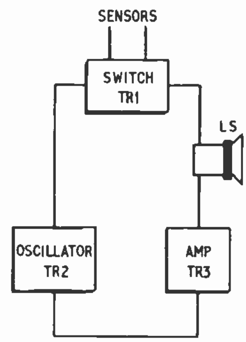


Fig. 1. Block diagram of alarm

COMPONENTS . . .

Resistors
R1 100kΩ
R2 2·7kΩ
R3 330Ω
All 10% ¼ watt carbon

Capacitors
C1 0·5μF Polyester

Transistors
TR1, TR3 2N2926 (G) 2 off
TR2 2N2646

Loudspeaker
LS1 8 ohm 2¼in dia.

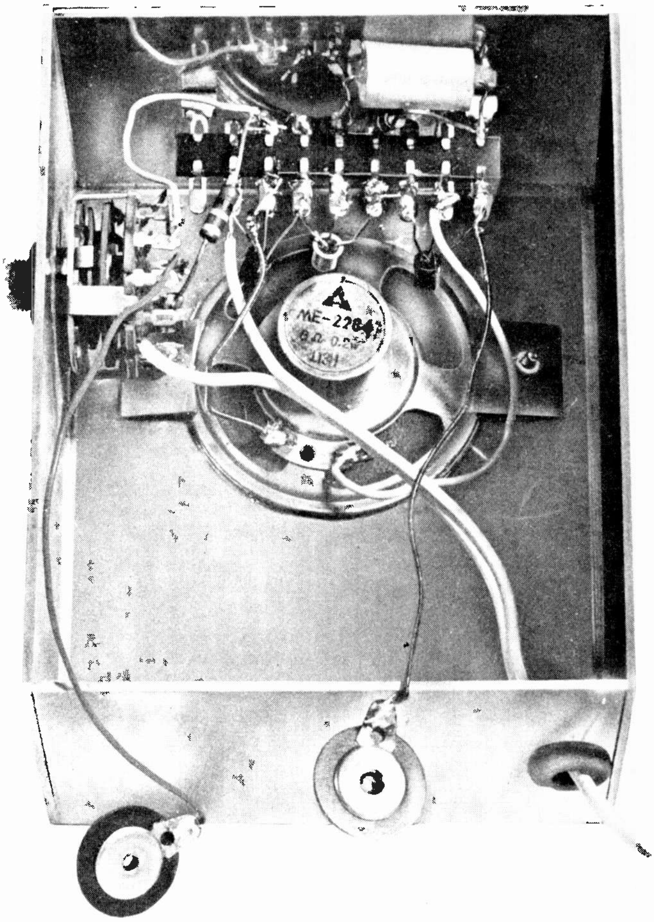
Miscellaneous
Tagstrip, 5in × 4in × 2½in aluminium chassis, S1—2 pole, 3 way rotary switch, 9V battery (PP9).

LOUDSPEAKER DRIVER

When TR2 is on, a potential is developed across R3 and this switches on TR3. What we get in effect is most of the battery potential being applied across the loudspeaker in a series of rapid pulses which together form a note.

The pitch of the alarm note is controlled by the ratio of R2/C1 and it can be changed by altering either. Greater effective output can be achieved by selecting the note so that it corresponds to the resonant frequency of the speaker which, with miniature types, is quite high.

The frequency will alter very slightly depending on the resistance between the sensors. In operation the alarm will sound if any resistance between zero and five megohms is connected between the sensors.



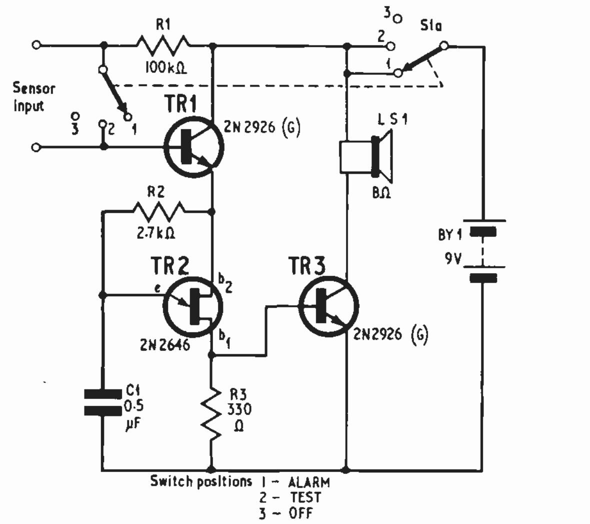


Fig. 2. Circuit diagram of alarm

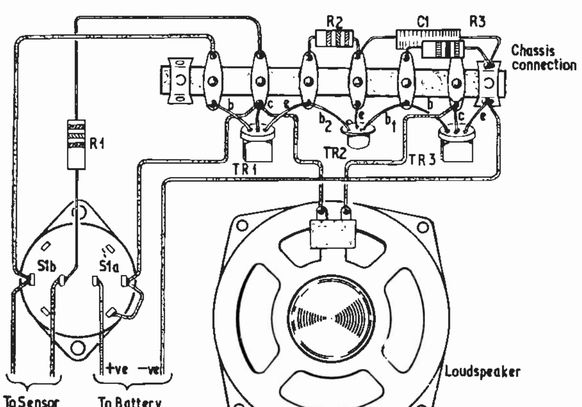


Fig. 3. Interwiring details for alarm components

SWITCH POSITIONS

Three positions can be selected by the switch. In position "1" the unit is on standby. In position "2" the sensors are shorted out setting the alarm in operation for testing. This is necessary because after about a year the battery will eventually run down and if it has not been operated, some check is needed on the battery condition.

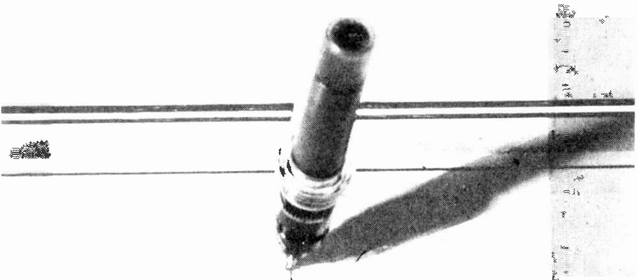
Position "3" is used once the alarm has been noted and is no longer required. If a mains power supply is used instead of batteries this could be wired to a bulb whose other connection runs to chassis giving a visual indication that the alarm is not set. A warning bulb can of course be used with battery operation but battery life will be greatly reduced.

CONSTRUCTION

All components, except of course the sensors are mounted into an aluminium chassis 5 in × 4 in × 2½ in; this makes for a neat wall mounted unit.

A series of holes should be drilled for the loudspeaker vents and others for the switch spindle, the sensor wires and the tag-strip mounting screws.

The three transistors are fixed to an 8-way tag-strip, the two extreme tags being chassis connections. Both this, the loudspeaker and the switch are wired up as shown in Fig. 3. *continued on page 829*



SERVO CHART RECORDER

By D. BOLLEN

SPECIFICATION

Pen span	10·5 cm
Slewing rate	Approx. 15cm per second
Input resistance	20kΩ per full span volt + 6kΩ
Dead zone	Less than 0·5mm (0·5%)
Accuracy	Typically ± 2%
Set zero	Anywhere on paper
Inputs (1)	Eleven attenuator settings covering 5mV/cm–10V/cm
(2)	1V/cm for timing pulses
Frequency response	D.C.–1Hz at 5cm peak to peak

THE rate of change of some electrical signals is too slow for convenient measurement with ordinary test instruments. Examples of such signals are; the charge-discharge characteristics of large batteries and capacitors, long-term drift voltages in electronic circuits, outputs from light, pressure and temperature sensors, biological impulses and waveforms, long period earthquake waves, and radio astronomy reception.

Recorders for handling very slow electrical events are expensive to buy, and some will consume hundreds of feet of specially sensitised film or paper each week when running continuously. The recorder design offered here can be built for as little as £15–£20 and draws a linear ink trace on cheap rolls of adding and accounting machine paper. Rolls cut from decorator's lining paper can also be used.

It is a simple matter to take measurements from unruled paper with the aid of a transparent graticule, similar to that employed with oscilloscope screens, and the instrument is conveniently calibrated in terms of volts per centimetre of pen deflection.

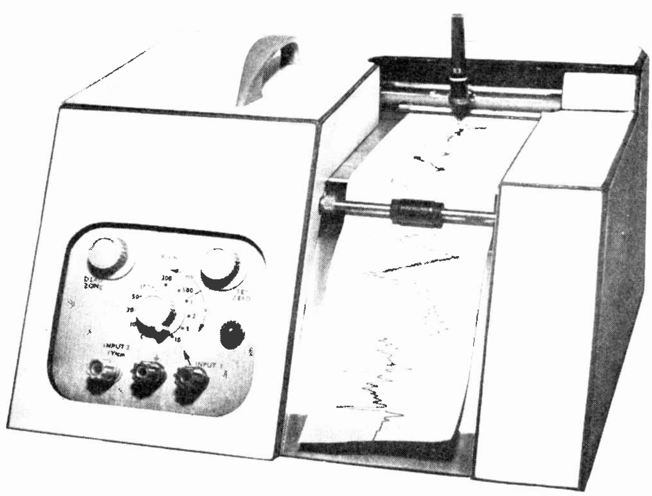
Although no attempt was made to exploit the high accuracy possible with a servo recorder, the accuracy achieved with standard components is equal to, or better than, that offered by most quality testmeters. The recorder pen mechanism is made up from radio dial cord drive parts, and a model boat motor supplies the necessary motivating force.

DESIGN CONSIDERATIONS

A simple, uncorrected servo system would drive the recorder pen in a most erratic manner. The pen could oscillate, overshoot the mark, undershoot, or take a long time to traverse the paper. As with audio amplifier testing, servo faults really come to light when the system is subjected to a step or square wave input, see Fig. 1a.

Of course, we are concerned here with a very low frequency square wave test signal, say 0·01Hz, as there is a limit to how fast a heavy pen can be made to respond. Most servo recorders have a frequency response extending to not more than a few Hertz at most.

Yet another fault, as shown in Fig. 1b, is where the pen moves in a series of jerks or steps when the input signal varies very slowly.



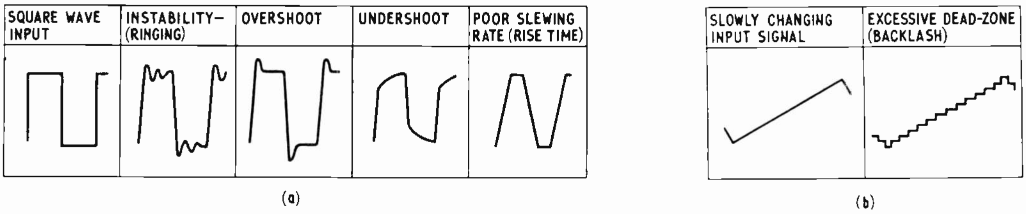


Fig. 1 (a) Oscillograms indicating various faulty recorder responses for a test square wave input. (b) ramp distortion oscillogram, the result of a jerky pen action.

BASIC CIRCUIT

The basic circuit of the chart recorder is given in Fig. 2. A high gain operational amplifier, ICI is arranged to compare two voltages at its inverting input, one via R1 from the slider of VR1, and the other an output voltage via R2. VR1 is mechanically linked to the pen drive, and has a reference voltage V_B across its track.

Because of its very high gain, ICI can be thought of as a switch which is off when both inputs are equal and of opposite polarity. If one input is slightly different to the other, the output will switch hard on in a positive or negative direction, depending on the relative polarities of the inputs.

With the servo motor at rest, there is zero volts relative to earth at the operational amplifier output, and the voltage from VR1 exactly cancels the input voltage, assuming that R1 equals R2.

Suppose now that the input increases by positive 30 millivolts; this small change of input is amplified and causes the output to switch hard on and place something like negative 6 volts across the motor brushes. The motor now rotates in a direction dictated by output polarity and moves VR1 slider to a new position where the slider output has increased by a negative 30 millivolts, thus cancelling the change of input voltage, and reducing the voltage across the motor to zero again.

The distance travelled by VR1 slider during the above operation is equivalent to the positive 30 millivolt input change.

When R1 equals R2, the full pen deflection, or span, will represent an input voltage equal to V_B, and if R2 is halved in value the span will be equivalent to half V_B. All that is necessary, therefore, to provide a choice of calibrated inputs, is single switched values of R2.

OVERCOMING INSTABILITY

The servo system shown in Fig. 2 would be unstable if the dotted components C1 and R_f were omitted. There are two forms of instability at work here, the first caused by too much amplifier gain, and the second by the delaying action of the servo motor, or electro-mechanical integrator effect. The inclusion of a feedback resistor R_f serves to reduce amplifier gain to a manageable level, but if it is made too small in value there will be a large unwanted dead zone, giving a result similar to Fig. 1b.

The function of C1 is to supply a differentiating action which almost exactly cancels servo motor integration. Without it there would be instability and overshoot resulting from a sudden change of input voltage.

If, however, C1 is too large in value, over correction leading to undershoot will be the result. It follows that C1 and R_f should be made adjustable to cater for individual variations of motor speed and amplifier gain.

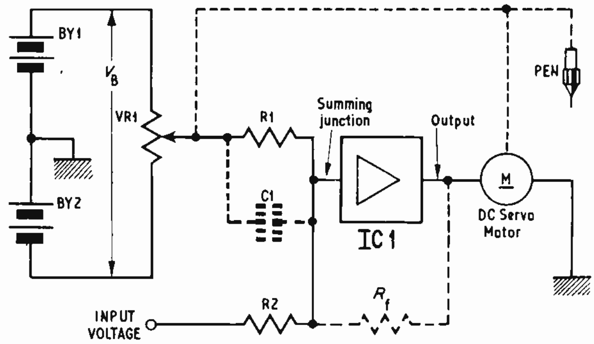


Fig. 2. Basic chart recorder circuit

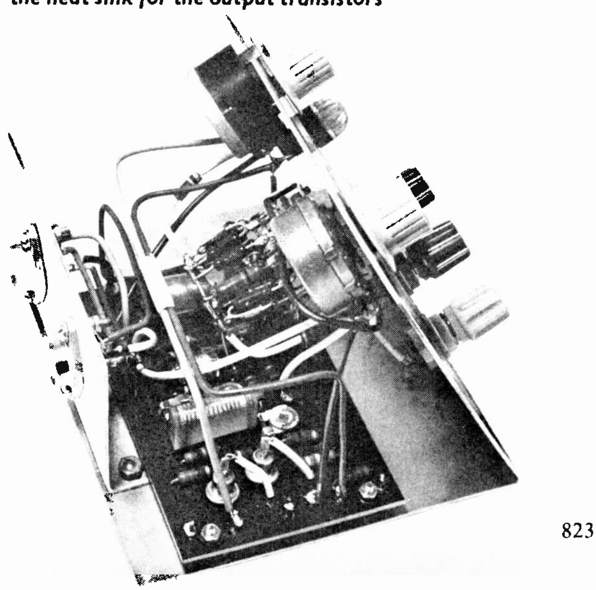
The remaining factor of a poor slewing rate is largely determined by the power of the motor and gear reduction used.

PAPER FEED PROBLEMS

A few problems can occur with the chart paper feed. Usual faults are short-term speed discrepancies, and lateral shifting, or wobble of the paper.

The former is quite difficult to cure, even when the paper has sprocket holes, and is due to paper imperfections, etc. A timing pulse fed to the pen at regular intervals will, however, serve to calibrate paper speed. Lateral shift can be prevented by correct design of the paper feed mechanism.

Controls are mounted on a single piece of aluminium which also forms a chassis for the amplifier panel. Note the heat sink for the output transistors



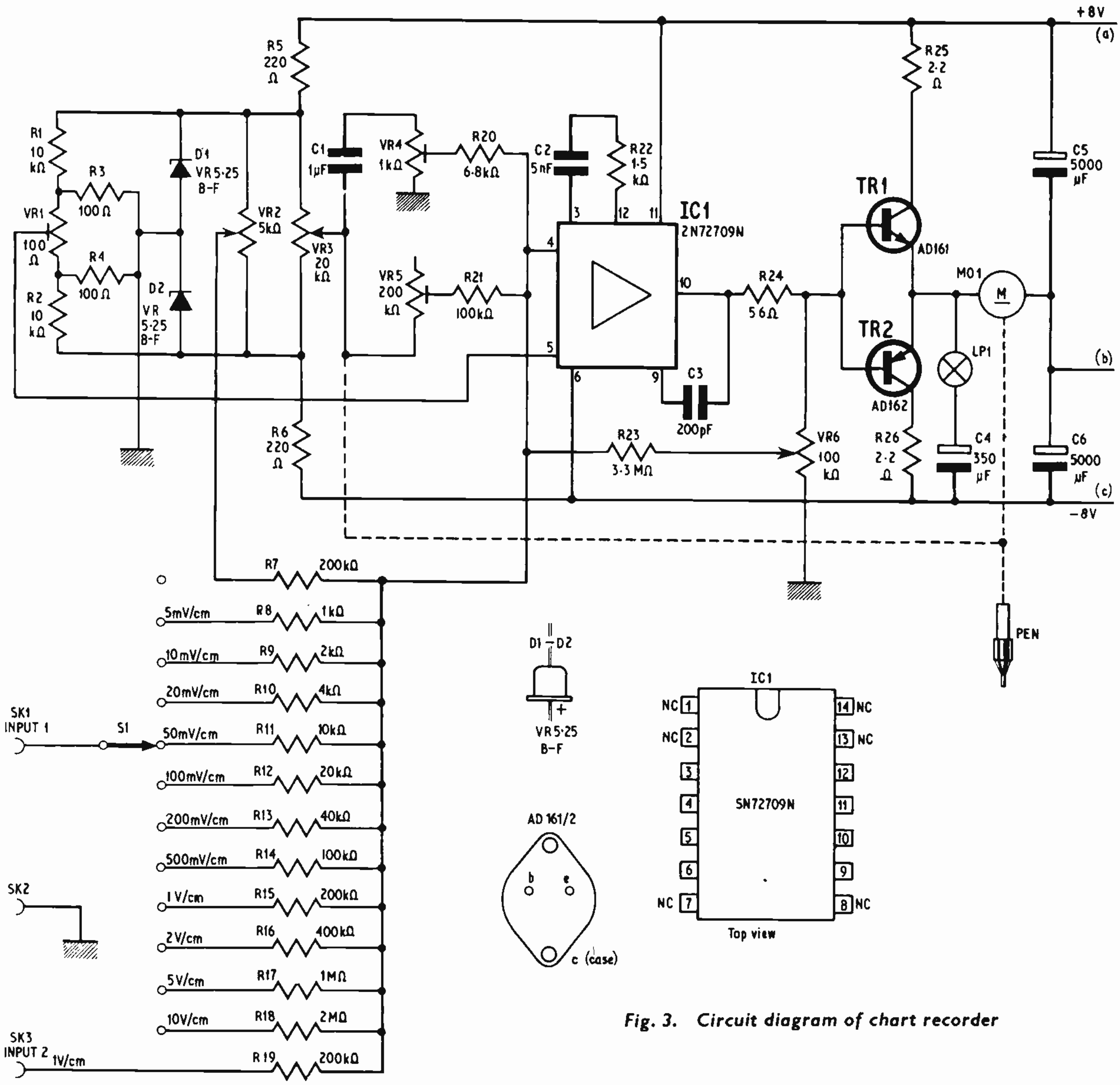


Fig. 3. Circuit diagram of chart recorder

CHART RECORDER CIRCUIT

The complete circuit of the chart recorder is given in Fig. 3. A brief comparison with the circuit of Fig. 2 will help to identify the main component functions.

VR3 in Fig. 3 is the mechanically driven potentiometer equivalent to VR1 in Fig. 2. VR5 and R21 are equivalent to R1, pin 4 of the i.c. package is the inverting input, inputs R8 to R18 are switched values for R2, diodes D1 and D2 provide the reference voltage VRB, VR4 gives a variable output from differentiating capacitor C1, and VR6 acts as an adjustable dead zone or R_f value.

Now looking at Fig. 3 in more detail, VR1 ensures that the chart recorder will maintain its zero setting with the input terminal open or short circuited, by supplying a small offset compensating voltage to the amplifier non-inverting input, pin 5. VR2 allows the pen to be set anywhere on the chart paper (centre zero, or zero either side) by injecting a large offset voltage to the summing junction via R7.

VR5 is for initial calibration of the instrument.

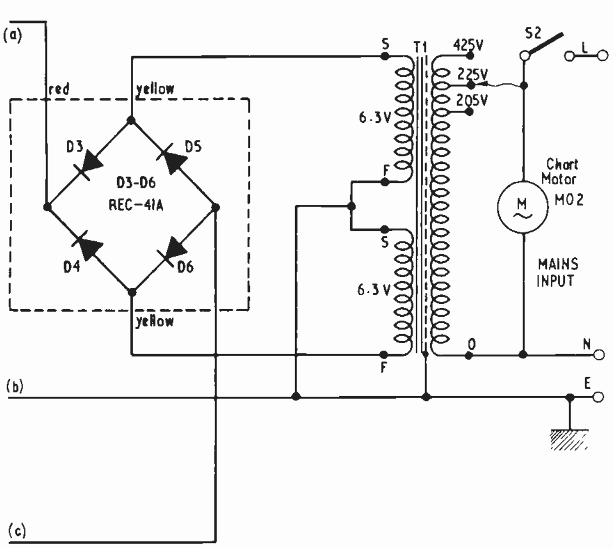
Attenuator steps (resistors R8 to R18) are in a 1, 2, 5 sequence, from 5mV/cm up to 10V/cm, plus an additional input for timing pulse calibration of chart speed.

The motor specified for use with the recorder has a stall current of 500mA at 6V d.c., far in excess of the output capability of an i.c. operational amplifier.

Complementary emitter followers TR1 and TR2 serve to boost the amplifier output current to a maximum of 1A, thus allowing other motors of heavier consumption to be substituted.

HUM INDICATOR

If mains hum or other higher frequencies are present at the recorder input they could be amplified and fed to the motor as a.c. power, thus causing it to overheat. There is no visible response from the servo to input frequencies above about 15Hz, so some method of indicating these unwanted inputs must be devised.



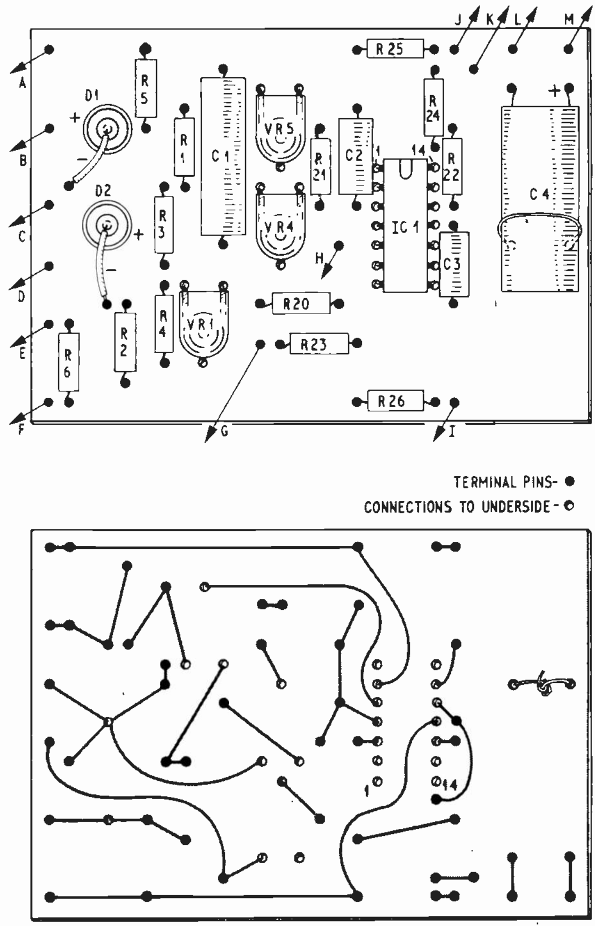


Fig. 4. Component assembly and wiring details of amplifier panel

COMPONENTS . . .

Resistors

R1	10kΩ	R10	4kΩ 1%	R19	200kΩ 2%
R2	10kΩ	R11	10kΩ 1%	R20	6·8kΩ
R3	100Ω	R12	20kΩ 1%	R21	100kΩ
R4	100Ω	R13	40kΩ 1%	R22	1·5kΩ
R5	220Ω	R14	100kΩ 1%	R23	3·3MΩ
R6	220Ω	R15	200kΩ 1%	R24	56Ω
R7	200kΩ	R16	400kΩ 1%	R25	2·2Ω 1W
R8	1kΩ 1%	R17	1MΩ 1%	R26	2·2Ω 1W
R9	2kΩ 1%	R18	2MΩ 1%		

All ±10%, ½ watt carbon except where stated.

Potentiometers
VR1 100Ω miniature horizontal mounting pre-set
VR2 5kΩ linear carbon
VR3 20kΩ wirewound or linear carbon (see text)
VR4 1kΩ miniature horizontal pre-set
VR5 200kΩ miniature horizontal pre-set
VR6 100kΩ linear carbon potentiometer

Capacitors

C1	1μF polyester	C4	350μF elect. 15V
C2	5nF polystyrene	C5	5,000μF elect. 12V
C3	200pF polystyrene	C6	5,000μF elect. 12V

Integrated Circuit
IC1 SN 72709N, BP 709 or 709 OPA

Transistors
TR1 AD161 TR2 AD162

Diodes
D1, D2 VR5·25B-F 5·25V 2W Zener (2 off)

Rectifier
D3–D6 Rec-41A

Transformer
T1 Filament transformer, secondaries 6·3V 1·8A; 6·3V 1·8A (Radiospares "Hygrade")

Switches
S1 Single pole 12 way wafer
S2 Single pole mains on/off

Lamp
LP1 6V 0·36W

Miscellaneous
4¼in × 2½in 0·1in matrix s.r.b.p. or copper laminate board, 16 s.w.g. sheet aluminium, knobs, terminals, lampholder, TO-66 mica washers with insulating bushes. For mechanical components see text. SK1-SK3 Miniature sockets with plugs. M01, M02 (see text).

It might be thought a simple matter to just filter out all frequencies above 15Hz, but this could upset the servo compensation and caüse undershoot and instability. Instead, a lamp LP1 and capacitor C4 are included to give a visual warning of hum.

Recorder accuracy is mainly determined by the track linearity of VR3 and the tolerance of input resistors R8-R18.

GENERAL CONSTRUCTION

The layout of individual chart recorders may differ from the prototype, to suit individual preferences and mechanical components to hand. Some readers may wish, for example, to increase the pen span and paper width to, say, 10 inches, or merely tailor the instrument to fit an existing box.

To facilitate custom building, the recorder is broken down into the following sub-units: amplifier panel, power pack, TR1 and TR2 heat sink, control panel, pen drive, and chart drive. The chassis frame to which the pen drive and chart drive are mounted can be fashioned from brass or alloy angle, sheet aluminium, or Meccano parts.

AMPLIFIER PANEL CONSTRUCTION

Fig. 4 shows the amplifier panel layout. As there are no wiring crossovers, components can either be assembled on a 0·1 inch matrix, punched s.r.b.p. board or a printed circuit. In the latter case it is advisable to use a 14 way dual-in-line socket for the i.c. package owing to the difficulty of desoldering in the event of a failure.

Panel leads are labelled A to M for quick identification during final wiring of the chart recorder.

POWER PACK CONSTRUCTION

With only four components, the power pack can be quickly assembled on a suitable piece of aluminium sheet, with clips for the capacitors. The sheet acts as a heat sink for the rectifier bridge assembly.

Yellow rectifier pins are wired to the transformer output, and the connection to C5 is the red pin. Finally, ensure that the finish of one transformer 6·3V winding is connected to the start of the other winding when forming the centre tap. See Fig. 5.

HEAT SINK AND CONTROL PANEL CONSTRUCTION

TR1 and TR2 should be provided with a heat sink equivalent to at least 16 square inches of 16 s.w.g. aluminium sheet. If the control panel is bent to form a chassis for the amplifier panel, this will act as an auxiliary heat sink. The power transistors must be mounted with insulating washers, and it is advisable to check this insulation with a testmeter during construction.

PEN DRIVE UNIT

Details of the pen drive are given in Fig. 6. The pen boom can be made of a section of chromed tubing taken from an old portable radio or television telescopic aerial, or just plain brass tubing.

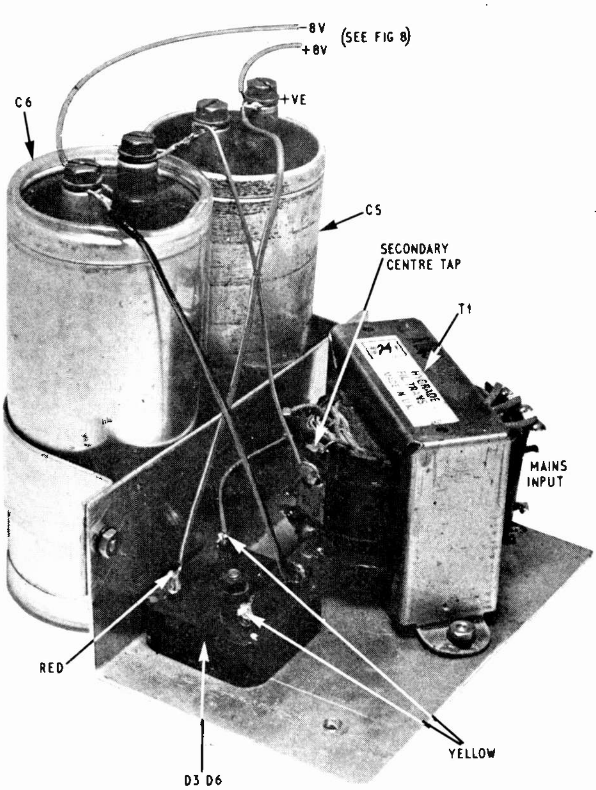


Fig. 5. Modular assembly of power pack on aluminium sheet

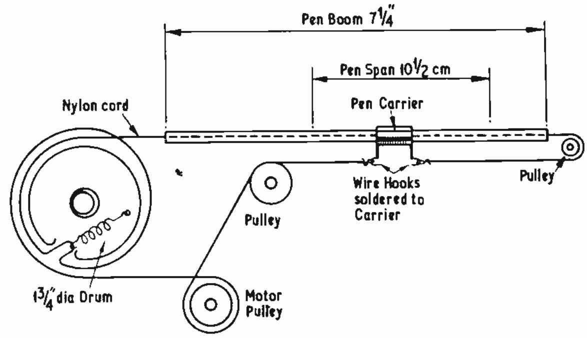


Fig. 6. Details of the pen drive assembly

The short piece of brass tubing which acts as a pen carrier should be a snug sliding fit on the boom. A compass attachment is securely glued to the carrier with epoxy resin to accept a range of tubular nib drawing pens of the Varient type.

VR3 is an ordinary wirewound or linear carbon one to three watt potentiometer, which is easy to obtain and cheap to replace when worn out. If the user wishes to extract the best possible slewing rate from his recorder, it should be specially selected or treated for minimum spindle torque.

It is possible to lighten the action of many wirewound pots by taking the back off and removing any thick protective grease with switch cleaner.

If the component used for VR3 is later found to have a linearity error of more than 1 per cent, this can often be improved by wiring a 1 Megohm preset resistor between the slider and one end of the track. The linearity error of general purpose potentiometers is seldom quoted by manufacturers, but those with values above 10 kilohms can be surprisingly good. If in any doubt, a precision potentiometer with low torque and a linearity error of less than 0·5 per cent can be purchased.

D.C. MOTOR

The d.c. motor (M01) employed for the recorder must have carbon brushes, a stall current of less than 1A, and be fitted with a gear reduction in the region of 16 : 1.

A motor with a multi-speed gearbox is preferable as it allows the reduction ratio to be adjusted to suit the frictional loading of the cord drive for optimum slewing rate.

The motor pulley is a brass or plastics bush mounted on the gearbox spindle with a tight fit p.v.c. grommet. Rubber grommets are useless in this application and will wear out quickly. Conventional brass or plastics pulleys, on the other hand, are prone to slipping. It is advisable to support the free end of the gearbox spindle with some form of bush bearing.

After assembly, check the pen drive for smooth action by connecting a 1½-3V battery to the motor. It may be necessary to alter the tension of the drum spring and remove high spots from the boom tube with glasspaper.

If a longer pen span is required, this can be achieved by fitting an extended boom tube and a larger diameter drum. The diameter of drum needed for a given span is equal to the span in centimetres divided by 5·97, assuming that VR3 has a 270 degree effective rotation.

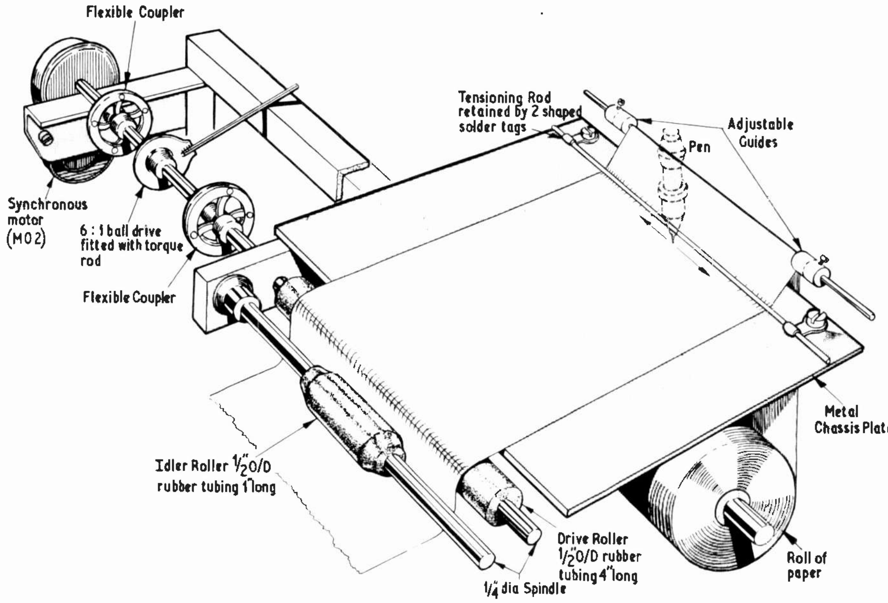


Fig. 7. Details of the chart drive unit

CHART DRIVE UNIT

The drive mechanism shown in Fig. 7 accepts any width of paper, up to the full pen span, without lateral shifting. The paper moves from the roll, through adjustable guides, and under a tensioning rod; this rod, in conjunction with the short idler roller, maintains a stable feed. Smooth, seam free rubber tubing is glued to the drive spindles to form the rollers.

Ball reduction drives are used to give a selection of speeds from one chart motor. For example, a one r.p.m. motor with three cascaded 6 : 1 ball drives gives the following speeds with a ½ inch diameter drive roller: 4cm/min, 40cm/hr, 6·6cm/hr, and 1·1cm/hr.

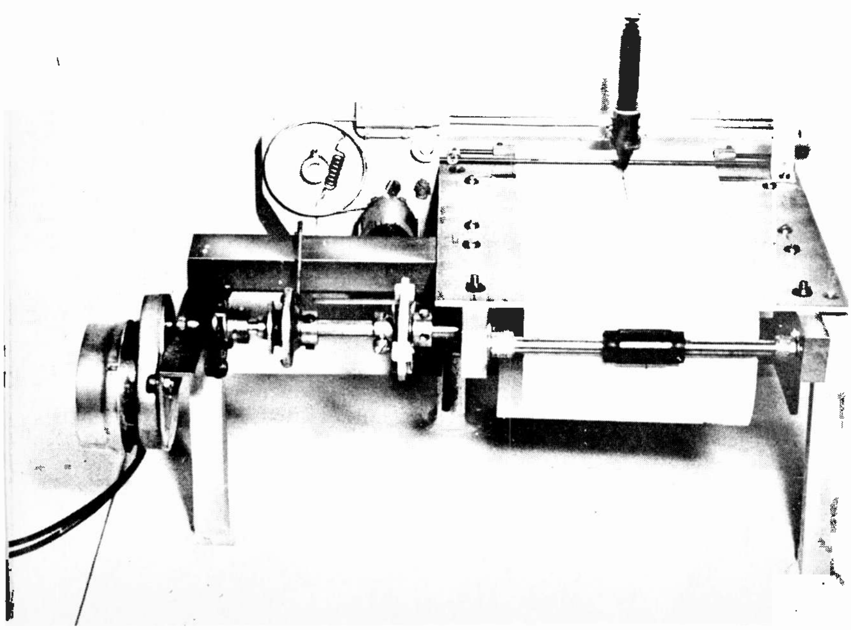
When a reduction drive is not needed it can be replaced by a flexible coupler or short length of ¼ inch spindle.

The prototype chart drive employed roller spindles mounted in thick brass bearers, but this was later found to be too robust and difficult to adjust. A much simpler form of construction would be with spindles revolving in bearings made from old potentiometer bushes, which are bolted to angle or sheet aluminium.

MECHANICAL COMPONENTS

A Mini-Richard motor with six speed gearbox can be ordered from most model shops and is imported by Ripmax, 80 Highgate Road, London, N.W.5. A Variant pen with 0·2mm nib, and a compass attachment is available from large stationers. Electronic Brokers Ltd., of 49–53 Pancras Road, London, N.W.1. can supply MA23 chart motors with fixed speeds ranging from 20 r.p.m. to 1/240th r.p.m.

Silver steel ¼ inch diameter spindles are stocked by ironmongers, and the dial drum, flexible couplers, and reduction drives by the usual electronic component suppliers.



Chassis frame with pen and chart drive unit

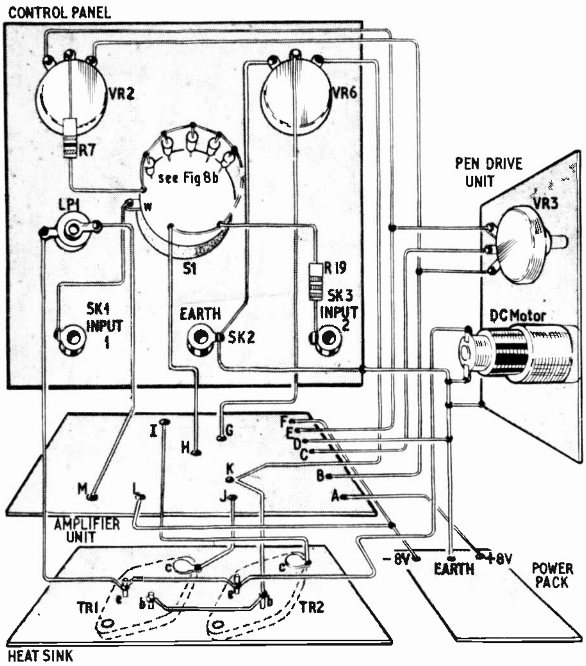


Fig. 8a. Interwiring diagram of chart recorder sub-assemblies

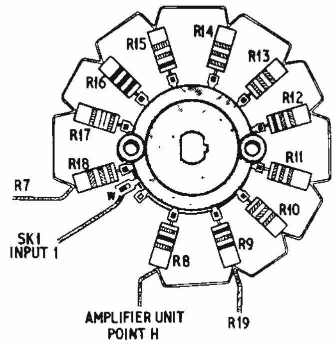


Fig. 8b. Wiring of switch S1

FINAL ASSEMBLY AND SETTING UP

Chart recorder sub-units are wired together as shown in Figs. 8a, b. The following points should be borne in mind before testing the recorder, and during final assembly.

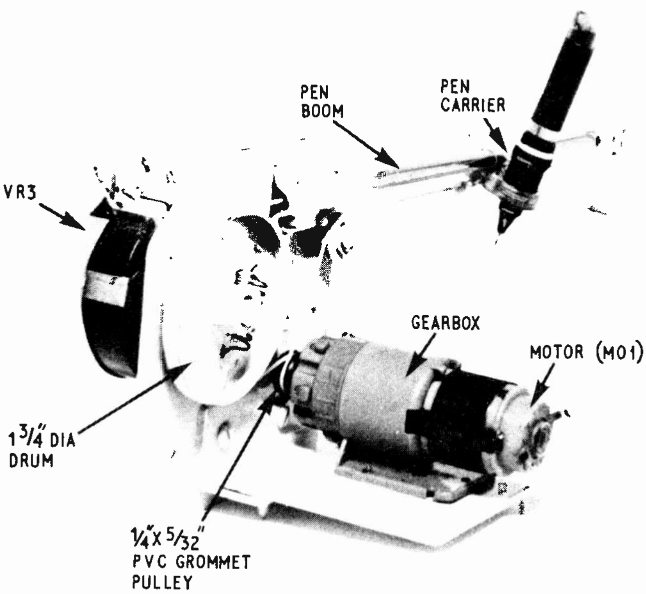
Connections to the track of VR3 may need to be reversed to give the desired direction of pen travel for a positive input voltage. If the leads to the d.c. motor are out of "sense" with VR3 rotation the pen will move hard over to one side of the paper and will not respond to an input signal. A peculiarity of the Mini-Richard gearbox is that it changes its direction of rotation for each step change of gear ratio, thus necessitating reversal of motor leads when changing gear.

To set up and calibrate the recorder, all pre-sets and VR2 and VR6 should first be placed in the mid-track position. Stick a 0–10cm scale (cut from an exercise book or a thin plastics ruler) under the pen and switch the recorder on. The pen should move to somewhere near the 5cm mark and stop. If the pen oscillates, increase the VR6 dead zone setting. Position the pen at exactly 5cm with VR2.

If the input attenuator is set to 5mV/cm, and input 1 is shorted to earth, the pen will be seen to shift to a new position. Bring the pen back to the 5cm mark with VR1 while the input is still shorted. There should be no movement of the pen when the input is open or short circuited. Now set the attenuator to 1V/cm and inject a known d.c. voltage into input 1. Calibrate the pen deflection by adjustment of VR5.

To check for over or undershoot, have the chart paper moving at maximum speed and switch a fixed input voltage on and off, this should trace a rough square wave. Adjust VR4 and VR6 for best square wave response, with reference to Fig. 1a.

As a final test for smooth pen travel in response to a slowly changing signal (Fig. 1b), charge a 1,000μF capacitor to about 10V and connect it across input 1 and earth with the attenuator set to 2V/cm. The pen will trace the discharge curve of the capacitor and if it moves in a series of jerks or steps, try increasing the gearbox reduction ratio or use a smaller dead zone. The recorder should now be ready for use.

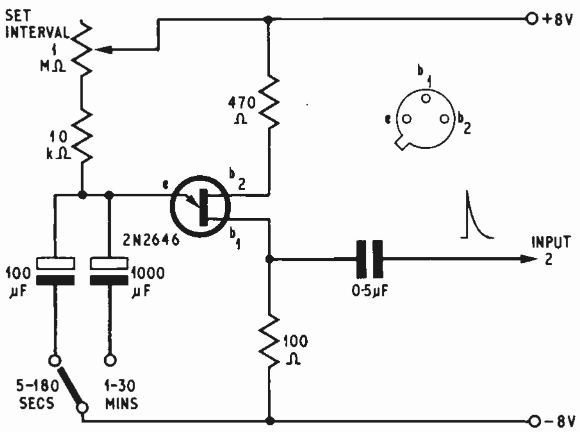


Pen drive unit

USING THE RECORDER

Normal precautions should be taken to avoid input hum when connecting the recorder to other equipment, in some cases it will be necessary to increase the dead zone setting to extinguish LP1. If desired, limit switches can be fitted, to open circuit trace, try another brand of ink, or water down the ink.

Ensure that the servo motor does not remain stalled for long periods with the pen at span limits. If desired, limit switches can be fitted, to open circuit the collector of TR1 or TR2. Alternatively, the pen drive cord tension can be carefully adjusted so that the motor pulley slips when the pen reaches the end of its travel.



(a)

(b)

Fig. 9(a). Simple u.j.t. oscillator circuit that can be built for calibrating chart speeds. (b) Showing timing pulses superimposed on trace

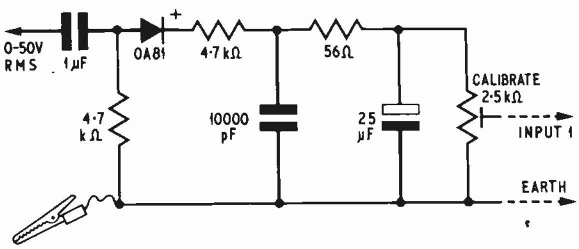


Fig. 10. Circuit diagram for a divide by ten probe. This extends the measurement capability of the recorder to higher frequencies

The circuit of Fig. 9 shows a simple pulse generator for calibrating chart speeds. A pulse output is obtained at intervals ranging from 5 seconds to 30 minutes by switch selection of two capacitors and adjustment of a 1 megohm potentiometer. An example of timing pulses superimposed on a trace is given in Fig. 9b.

As it stands, the recorder will display an undistorted sine wave of 1Hz at more than 5 cm peak to peak, and 5Hz at 1cm peak to peak. It is possible to measure and record the average level of higher frequencies by using a radio frequency probe, such as that shown in Fig. 10.

The probe has a frequency response extending from 100Hz to tens of megahertz, and with its division ratio of ten will offer 0–10V r.m.s. when the recorder attenuator is set to 100mV/cm, 0–20V r.m.s. at 200mV/cm, and 0–50V r.m.s. at 500mV/cm. If the probe is used with attenuator settings below 100mV/cm it will need to be recalibrated because of resistive loading, and linearity will be poor.

The servo chart recorder is well suited for use with the Seismograph described last month, and with Radio Astronomy receivers. ★

RAIN & WATER LEVEL ALARM

continued from page 821

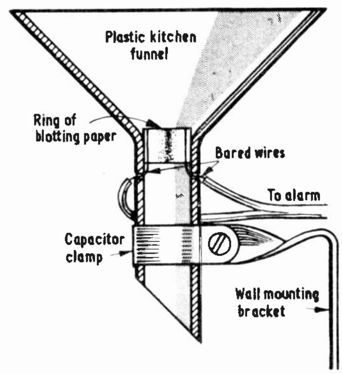


Fig. 4. Funnel arranged as a sensor for rain or snow

SENSORS

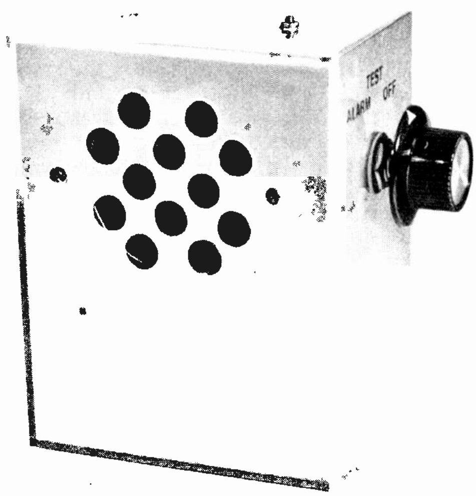
The sensors can take two forms. For water level warning two brass rods should be spaced about an inch apart and positioned above the water surface at the required level.

For rain or snow a plastic kitchen funnel can be used as seen in Fig. 4. Here two copper wires are fitted through small drilled holes at the top of the neck and a circle of blotting paper is slipped in so that it touches both. By using this arrangement snow, which may not soak into the blotting paper, will also build up until it bridges the sensors. Very light rain will tend to stick to the sides of the funnel and run down, soaking into the paper. A simple bracket should grasp the neck of the funnel for mounting to an outside wall or post.

Very long lengths of wire can be run between the sensors and the alarm because of the sensitivity of the unit.

LDR CUT-OUT

A simple refinement to the circuit can make sure that you are not disturbed by the alarm at night—after all if used as a rain alarm you usually couldn't care less if it pours after dark. Simply insert a light dependent resistor such as the ORP 12, in the collector supply to TR1. The resistance will stop operation of the whole unit except during daylight. Obviously this l.d.r. will have to be mounted outside. ★



The North American Nebula (N.G.C. 7,000). The shape of this nebula shows how it became so named. It is about 3 degrees east of α Cygni.

RADIO ASTRONOMY TECHNIQUES

BY F. W. HYDE

PART 5

THE previous article dealt with the setting up of the aerial system and the construction of a suitable corner reflector. This article deals with the pre-amplifier, the converter, the receiver, and the recording system.

PRE-AMPLIFIER

Although a general specification has been laid down for the pre-amplifier, some latitude is permissible provided that certain of the important parameters are kept in mind. For example, the desired gain has been stated as not less than 16dB. There is no reason why this should not be greater, provided that the unit is stable and the noise level at a reasonable figure.

More than one unit could be used up to a maximum overall gain of 100dB. Again, it is the stability and noise factor which will be important. If the noise level is too high the latter stages of the amplifiers may be overloaded, not forgetting the receiver. The result in such a case would be useless. The pre-amplifier gain must be consistent with low noise and real amplification of signal.

It is preferable to have a pre-amplifier at the aerial itself, and if two units or more are available then the first can be mounted on the aerial and the others located nearer the receiver. It will be clear that the screening and earthing of high gain units will need care. The interconnecting coaxial leads will have to be routed and be cut so that nodes do not appear on the screening. This is best accomplished by avoiding multiples of one -half wavelength when cutting to size.

POWER SUPPLY ARRANGEMENTS

The pre-amplifier can be a standard commercial type, built round either valves or transistors. Where the aerial is at the observation position the power supply offers no problem whether valve units or transistor units are employed. However where the aerial is some distance away there can be problems.

If valve units are decided upon, and provided the distance is not excessive, mains leads may be run. If this is the case it is recommended that they are laid in the ground, since this will generally avoid any local interference being picked up and conveyed to the amplifier.

An alternative arrangement is to use low voltage transmission by means of a step-down, step-up system at the ends. Since this will require rather larger cable it could be more costly than the simple system.

If the units are transistorised then the power can be taken via the aerial lead with suitable filter networks at each end. Alternatively the power pack may be an integral part of the unit, and normal mains leads taken to the point of use.

It is not recommended that dry batteries be used. Wet (secondary) batteries are a possibility if they happen to be available. On the whole it is perhaps best to use the mains feed for this will provide a point for appliances that may be used when working on or modifying the aerial or ancillary systems.

A watertight case or box should be provided to house the unit since exposure to the weather will cause serious problems. It is also a wise precaution to tape up the coaxial connection points.

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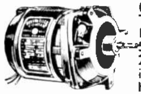

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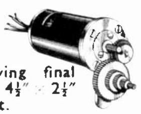

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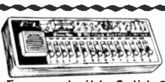

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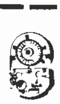

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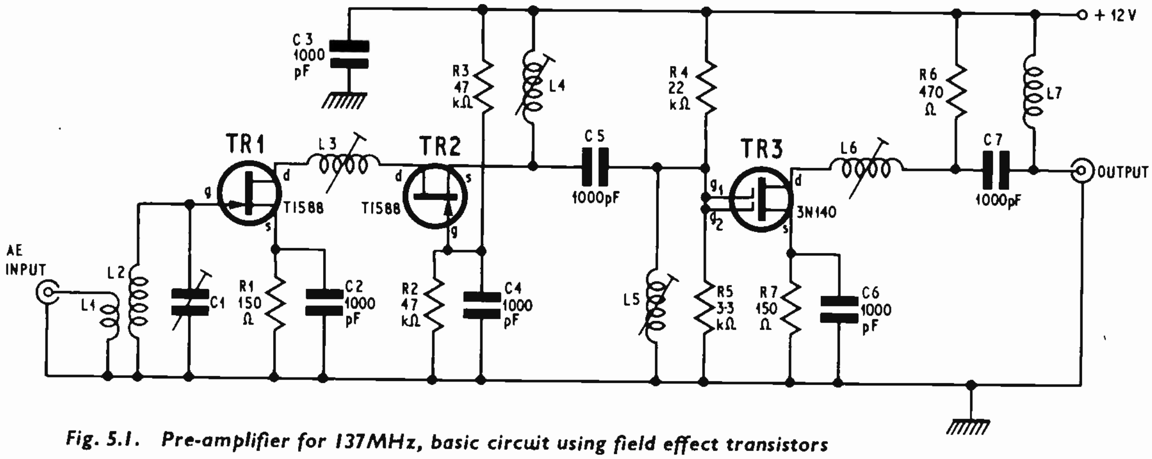

Fig. 5.1. Pre-amplifier for 137MHz, basic circuit using field effect transistors

PRE-AMPLIFIER CIRCUITS

The choice of pre-amplifier circuitry is a wide one, and some examples for the home constructor are given in Figs. 5.1 and 5.2.

Commercial units can be purchased from a number of suppliers. Among these commercial units will be found some specially designed for the 144MHz amateur band. It should be a simple matter to modify these for the chosen frequency of 137MHz. This can be done in such a way that the pre-amplifier may be used for both purposes.

THE CONVERTER

Considering the converter, it is better in some ways to use a commercial product since all the "bugs" will have been dealt with in the course of development. However, if the urge to start from scratch is strong, then there are commercial units that can be modified or entirely new units may be designed and made up.

To cover this aspect two circuits have been drawn as a guide and are shown in Figs. 5.3 and 5.4. Commercial television converters can be modified for the purpose and both valve and transistor types are available. Alternatively, local radio service dealers may have suitable turrets available from obsolete television sets.

One particular example which the writer used was a turret from a Murphy Television receiver which was manufactured as a unit by Sidney Bird Ltd. Some of these are likely to be still around. The coils on these units were easily accessible and gave no difficulty when it came to modification.

As in the case of the pre-amplifier, there are some commercial converter units built for the exact frequency band required and others that are available for the amateur band of 144MHz. Generally, these latter are easily modified, but if crystal controlled the latitude on such units as regards tuning coverage would be too narrow. In such cases, the crystal will need to be deleted and the necessary circuit modifications made.

Another point to bear in mind is that some of the converters that may be available on the surplus market have an intermediate frequency which is above 30MHz. Here, unless the communication receiver to be used has a range above 30MHz, additional modification would be required.

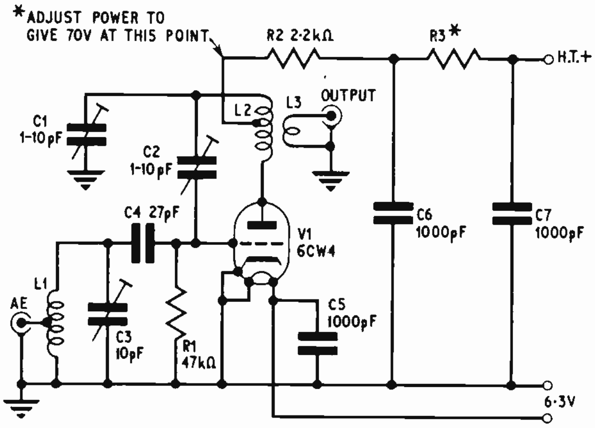

Fig. 5.2. Pre-amplifier for 137MHz, basic circuit using triode valve

A final point that must be emphasised is that the converter must be adequately bonded to the receiver. The i.f. output of the converter will come to the aerial terminal of the receiver, but it will not be sufficient to rely on the earthing provided by the coaxial lead. The chassis of the converter and the chassis of the receiver must be properly electrically bonded together.

THE COMMUNICATIONS RECEIVER

In the case of the receiver, if there is the need to acquire one, there are two groups to choose from: the current range of commercial receivers, and those which appear on the surplus market.

There are many well known brand names that come to mind, and some of these receivers may already be in the possession of readers who propose to attempt this radio astronomy project. Some of the "surplus" types have increased in price over the last year or so. This usually means that they are almost in mint condition. The most important point to be made in regard to the older types of communications receivers is the availability of spare valves.

RADIO ASTRONOMY continued

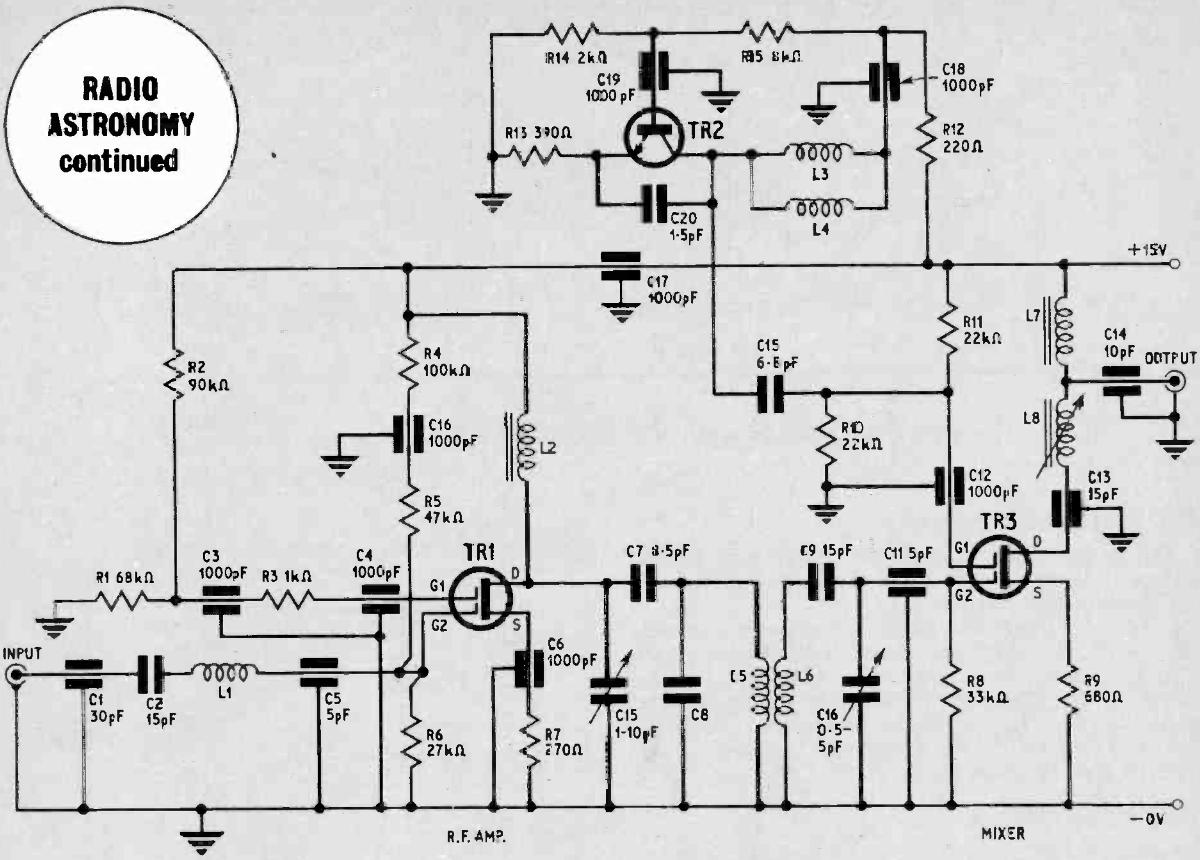

Fig. 5.3. Converter circuit, using field effect transistors

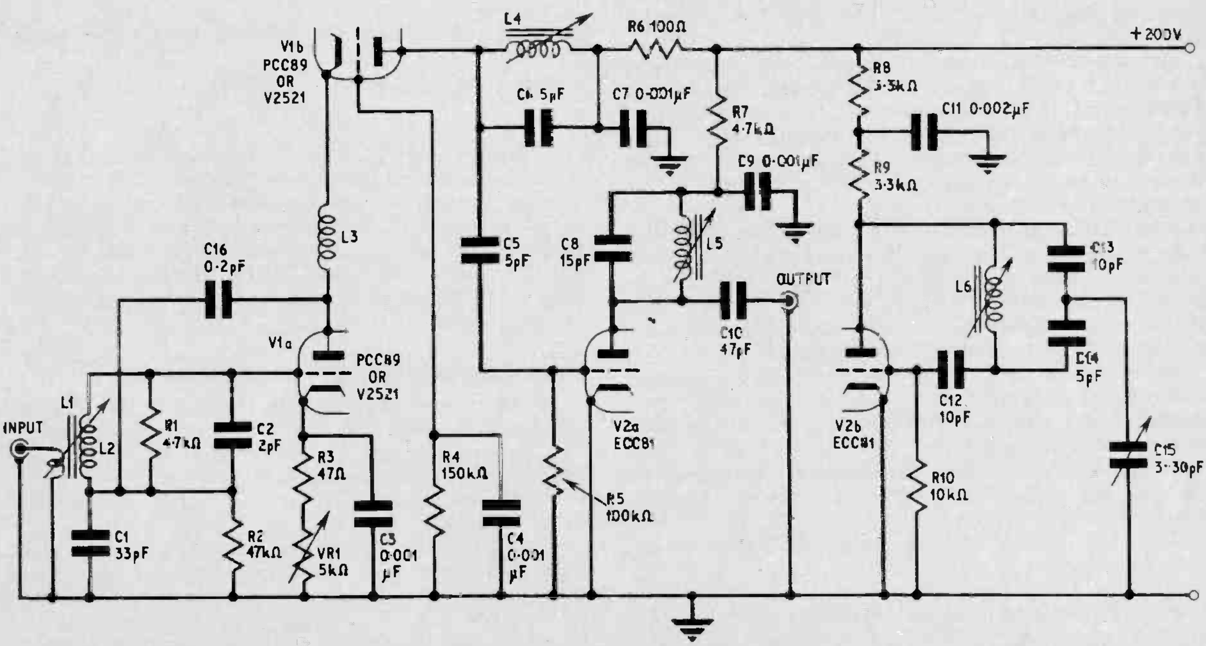

Fig. 5.4. Converter circuit, using valves

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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		
2N2484	42p	2N4284	15p	BC125	15p	BFX29	31p	ZTX502	25p
2N2646	47p	2N4286	15p	BC126	22p	BFX84	25p	ZTX503	22p
2N2904A	42p	2N4289	15p	BC147	10p	BFX85	52p	ZTX504	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.

ZENER DIODES 5% full range E24 values: 400mW: 2·7V to 30V, **15p each**; 1W: 6·8V to 82V, **27p each**; 1·5W: 4·7V to 75V, **60p each.**
Clip to increase 1·5W rating to 3 watts (type 266F), **4p.**

CARBON TRACK POTENTIOMETERS, long spindles. Double wiper ensures minimum noise level.
Single gang linear 100Ω to 2·2MΩ, **12p**; Single gang log, 4·7KΩ to 2·2MΩ, **12p**; **Dual gang** linear 4·7KΩ to 2·2MΩ, **42p**; Dual gang log, 4·7KΩ to 2·2MΩ, **42p**; Log/antilog, 10K, 47K, 1MΩ only **42p**; Dual antilog, 10K only, **42p**. Any type with ½A D.P. mains switch, **12p** extra.
Only decades of 10, 22 and 47 available in ranges quoted.

CARBON SKELETON PRE-SETS
Small high quality, type PR, linear only: 100Ω, 220Ω, 470Ω, 1K, 2K2, 4K7, 10K, 22K, 47K, 100K, 220K, 470K, 1M, 2M2, 4M7, 10MΩ. Vertical or horizontal mounting, **5p each.**

COLVERN 3 watt Wire-wound Potentiometers. 10Ω, 15Ω, 25Ω, 50Ω, 100Ω, 150Ω 250Ω, 500Ω, 1K, 1·5K, 2·5K, 5K, 10K, 15K, 25K, 50K, **32p each.**

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

MULLARD polyester C280 series
250V 20%: 0·01, 0·022, 0·033, 0·047 **3p each**; 0·068, 0·1, **4p each**; 0·15, **4p**; 0·22, **5p.** 10%: 0·33, **7p**; 0·47, **8p**; 0·68, **11p**; 1μF, **14p**; 1·5μF, **21p**; 2·2μF, **24p.**

MULLARD SUB-MIN. ELECTROLYTICS
C246 range, axial lead .. .. .. 6p each
Values (μF/V): 0·64/64; 1/40; 1·6/25; 2·5/16; 2·5/64; 4/10; 4/40; 5/64; 6·4/6·4; 6·4/25; 8/4; 8/40; 10/2·5; 10/16; 10/64; 12·5/25; 16/40; 20/16; 20/64; 25/6·4; 25/25; 32/4; 32/10; 32/40; 32/64; 40/16; 40/2·5; 50/6·4; 50/25; 50/40; 64/4; 64/10; 80/2·5; 80/16; 80/25; 100/6·4; 125/4; 125/10; 125/16; 160/2·5; 200/6·4; 200/10; 250/4; 320/2·5; 320/6·4; 400/4; 500/2·5.

LARGE CAPACITORS
High ripple current types: 1000/25, **28p**; 1000/50, **41p**; 1000/100, **82p**; 2000/25, **37p**; 2000/50, **57p**; 2000/100, **£1·44**; 2500/64, **77p**; 2500/70, **98p**; 5000/25, **62p**; 5000/50, **£1·10**; 5000/100, **£2·91**; 10000/50, **£2·40.**

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Accessory prices increased by approx. 20% (pp. 51-53 in our catalogue). Guide prices unchanged.

INDICATOR LAMPS
NEON chrome bezel, round red NR/R, **24p**; chrome bezel, round amber NR/A, **24p**; chrome bezel, round clear NR/C, **24p.** Neon, square red type LS5C/R, **18p**; amber type LS5C/A, **18p**; clear type LS5C/C, **18p.** All above are for 240V mains operation. **Filament types:** 6V, 0·04A square red type LS5C/R-6V, **30p**; 6V, 0·04A amber type LS5C/A-6V, **30p**; 6V 0·04A clear type LS5C/C-6V, **30p**; 6V 0·04A green type LS5C/G-6V, **30p**; 12V 0·04A LS5C/R-12V, **34p**; 34V 0·04A LS5C/R-28V, **45p.**

SIEMENS 5% TOLERANCE POLYCARBONATE CAPACITORS

250V up to 0·1mF: 100V 0·1mF and above
0·01, 0·012, 0·015, 0·018, 0·022, 0·027 .. .. **5p**
0·033, 0·039, 0·047, 0·056, 0·068, 0·082, 0·1, 0·12, 0·15, 0·18, 0·22 .. .. **6p**
0·27, **7p**; 0·33, **9p**; 0·39, **9p**; 0·47, **10p**; 0·56, **13p**; 0·68, **15p.**

DIN CONNECTORS

			plug	*socket*
Loudspeaker	..	2-pole	12p	10p
Audio	.. ..	3-pole	13p	10p
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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Of the many newer types of communications receivers available there are reconditioned models and some commercial firms specialise in such equipment.

ESSENTIAL FEATURES

There are one or two points that need emphasising in regard to the receiver specification. An r.f. gain control is desirable. It would be an advantage if the a.g.c. can be switched. It would be useful if a noise limiter is fitted. Last but not least is the importance of stability of the power supply; on cheaper types of receiver this is unlikely to be good enough, so to the price of the receiver must be added something for the provision of stabilisation.

In spite of what has been said above, it need not prevent any one "having a go". Even if the results are not all that is to be desired the thrill of getting some results will be the greatest urge to improve the equipment.

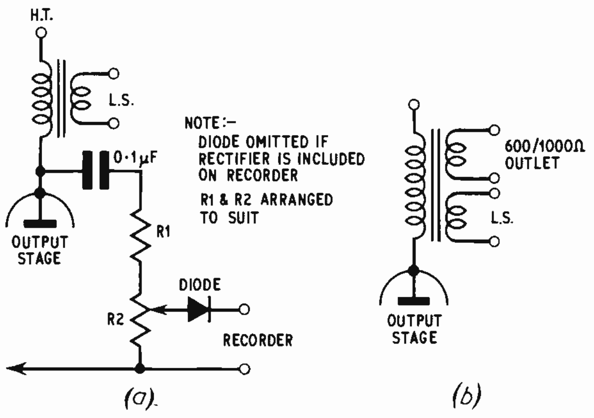


Fig. 5.5 a, b. Alternative arrangements for connecting recorder to receiver output stage

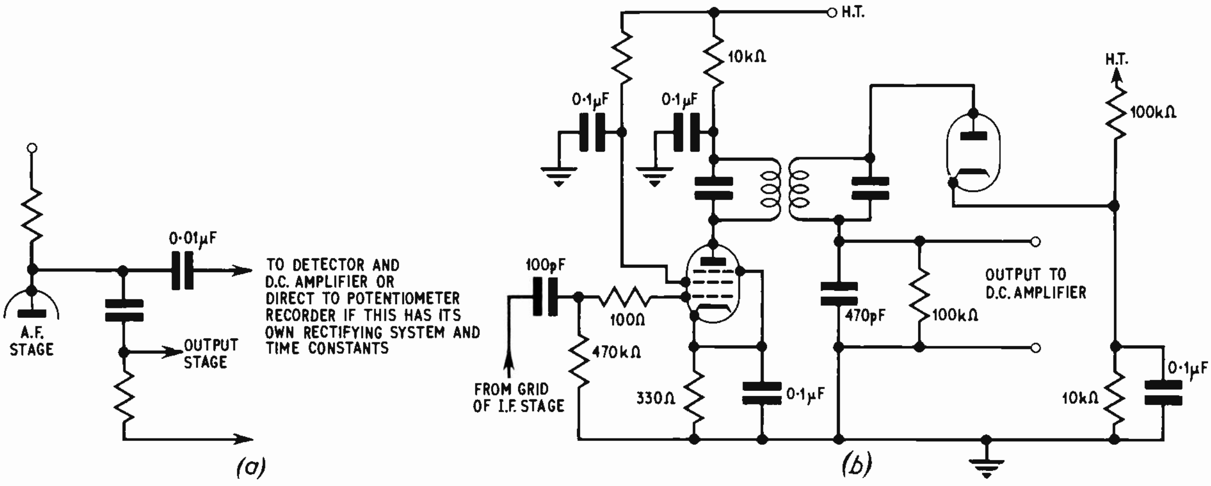


Fig. 5.6 a, b. Arrangements for connecting recorder to receiver via d.c. amplifier

RECORDING UNITS

The most basic recording system will be the pen recorder connected to the output of the receiver. If the recorder is of the low resistance coil type it can be connected directly to the output transformer at the speaker terminals via a diode or metal rectifier. Some recorders are fitted with the alternative terminal board arrangements for a.c. or d.c. operation. Where the coil is of high resistance then the output can be taken off the anode of the output section via a suitable network. Alternative systems are shown in the diagrams in Fig. 5.5 a, b.

There are other alternatives for the connection of the recorder when the coil resistance is high or the recorder is of the potentiometer type. A modification has to be made to the receiver circuitry in this case. The actual modification detail will naturally depend on the type of receiver in use, however the basic requirements for this modification are indicated in the examples of circuitry given in Fig. 5.6 a, b.

TYPES OF RECORDER

At this point it will be useful to describe the various types of recorder and the principles of operation. The simplest form is the moving coil system which is a "giant" version of the ordinary moving coil meter as used for measuring current and voltage. It consists of a magnet within which a coil is suspended between bearings. There is an arm attached to the coil which is a capillary tube type of pen, one end submerged in an ink reservoir and the other in the form of tube resting on the paper. The pen moves across the paper leaving an ink trace. The paper itself is driven by a clock of high precision or a synchronous motor. Provision is made for the speed to be changed by the use of gears.

Another type of recorder is generally known as the "potentiometer" form. This consists basically of an amplifier into which the signal is fed and the output drives a motor system which carries the pen across the paper. There are a number of forms of this but the basic principle is the same. The main difference between this type and the pen motor type is that the potentiometer version has a system of mechanical or electrical means of "chopping" the input signal so that it can be amplified sufficiently to drive the motor to which the pen is attached.

There are also a number of variations in the way the paper is marked. The ink method has been mentioned so far, but there are other ways such as hot stylus on a waxed paper, a current conveyed through

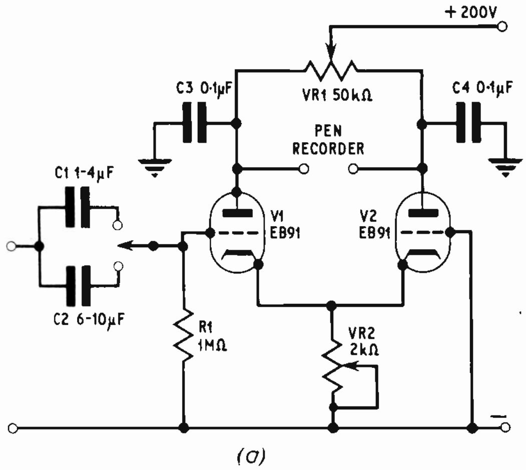


Fig. 5.7 a, b. D.C. amplifier circuits

a sensitive paper which in effect colours the paper, or maybe a system where the pen is pulled down on to the paper and the result is a series of dots. Whatever the system used the end result is a visible trace on some form of paper.

(A potentiometer recorder which will be ideal for this project appears in this month's issue.)

D.C. AMPLIFIERS

Two examples of d.c. amplifiers for recorders are shown in Fig. 5.7 a, b. Each has time constant circuits incorporated, these are necessary to record a clearer trace. If the normal time constant in the receiver were used then all the random noise received will obscure the solar noise proper. The length of the time constant is made variable so that there is a choice when looking for special effects.

For example, certain solar bursts are short in duration and therefore the best results will be obtained with a short time constant. Other phenomena is slow acting and this is better detected when using a longer time constant.

TAPE RECORDING

It is very useful to keep a tape recording of all observations since this provides an additional catalogue of events even when a pen recorder is used. For those who are unable to use a pen recorder at the beginning it may be possible for them to arrange for the tape recording to be transferred to paper at a later date.

When using the tape recorder for the observations the time of the observation must be recorded accurately, preferably on the tape as well as in the log. It would be an advantage to have a timing device that could superimpose a "time tick" on the track, but for this particular project it is not essential.

SOLAR PHENOMENA

The project being described is directed primarily to the study of certain solar phenomena. A brief survey of this phenomena will now be made so that when all the equipment is ready for operation, some idea of what the recordings will mean is understood by the observer.

The sun is one of a hundred million similar stars in the Galaxy. It is a yellow star classified as a "G" type. Though it is quite insignificant as a star in the Galaxy, it is nevertheless the most important unit in the solar system since the earth and its people could not exist without it. It is the source of energy necessary to life.

The sun has a peculiarity so far as astronomers are concerned, and that is that it is a variable star. Because this is so a great deal can be learned about processes which cannot be reproduced on earth but which enable important deductions to be made about some of the fundamental principles of the universe.

The sun is a vast sphere of highly compressed gas some 864,000 miles in diameter. It is visible as a bright disc which is called the photosphere. It has a well defined edge because there is a sharp boundary where the temperature of the main body and the chromosphere and corona suddenly changes.

The actual temperature of the photosphere is of the order of 6,000 degrees K (degrees Kelvin = degrees Centigrade + 273 degrees). Temperature measured in degrees Kelvin is known as the Absolute Temperature. From the size and the mass of the sun it can be deduced that the temperature at the centre must be of the order of 15 million to 20 million degrees. About half the mass of the sun is hydrogen and a large part of the remainder helium.

This mass of gas can be likened to a vast reactor where the energy is radiated from the centre outwards from the central core to the surface of the photosphere. From the surface it then escapes in various forms over the whole of the electromagnetic spectrum. The sun consumes some 4,000 tons of its own mass each second.

THE CHROMOSPHERE

The chromosphere, or coloursphere, is so named because of its pinkish appearance. The chromosphere is about 12,000 miles thick. It has certain special characteristics one of which is the "reversing layer" which exists at the lower levels and is about 600 miles deep. This area contains many ionised atoms, that is atoms which have lost one electron.

Under such conditions visible light can be absorbed by these atoms. Such is the activity in this area that electrons are continually jumping from one level to another. In the process intense ultraviolet radiation is produced. This extends toward the earth and causes the ionosphere layer round the earth.

TABLE 5.1
TYPES OF SOLAR EMISSION

TYPE	DURATION	POLARISATION	MECHANISM	TEMP K°
Quiet Sun	Constant	Random	Thermal	10^6
Slowly varying component	Days or months	Generally random but circular at cm wavelength	Thermal	$<2 \times 10^6$
Rapidly varying components (after flare)				
Initial phase				
Type III	Seconds	Random	Plasma	$>10^{11}$
Type V	Minutes	Usually random	Synchrotron	10^{11}
Second phase				
Type II	Minutes	Random	Plasma	$<10^{11}$
Type IV	Hours	Varies random to circular	Synchrotron	10^{11}
Type I	Hours	Random to circular	?	10^9

THE CORONA

The corona is an extension of a more tenuous part of the sun and is normally seen only at the time of an eclipse. It extends out in an irregular manner dependent upon the magnetic field of the sun.

Over a period of about 11.2 years there is a variation of the coronal activity which depends upon the number of sun spots that occur during this period. This cycle, which is regular in its rhythm but varies in maximum intensity, has many effects on the solar system.

OTHER SOLAR ACTIVITIES

In addition to the sunspots themselves there is considerable other activity. When the photosphere is examined closely it is found to be granular in appearance. These granules are of various sizes varying between 150 and 800 miles in length. There is a slightly different temperature between the darker granules and photosphere proper. This difference is something of the order of 200 degrees.

The surface is however constantly changing and great spouts of gas are thrown off to enormous heights, areas flare up and there is a constant stream of plasma which is radiated into space and known as the solar wind. Each of these activities have certain effects and these will be dealt with in more detail when the work on the project begins. In the meanwhile a list is given in Table 5.1 which summarises the various types of activity and their effects on the earth's environment.

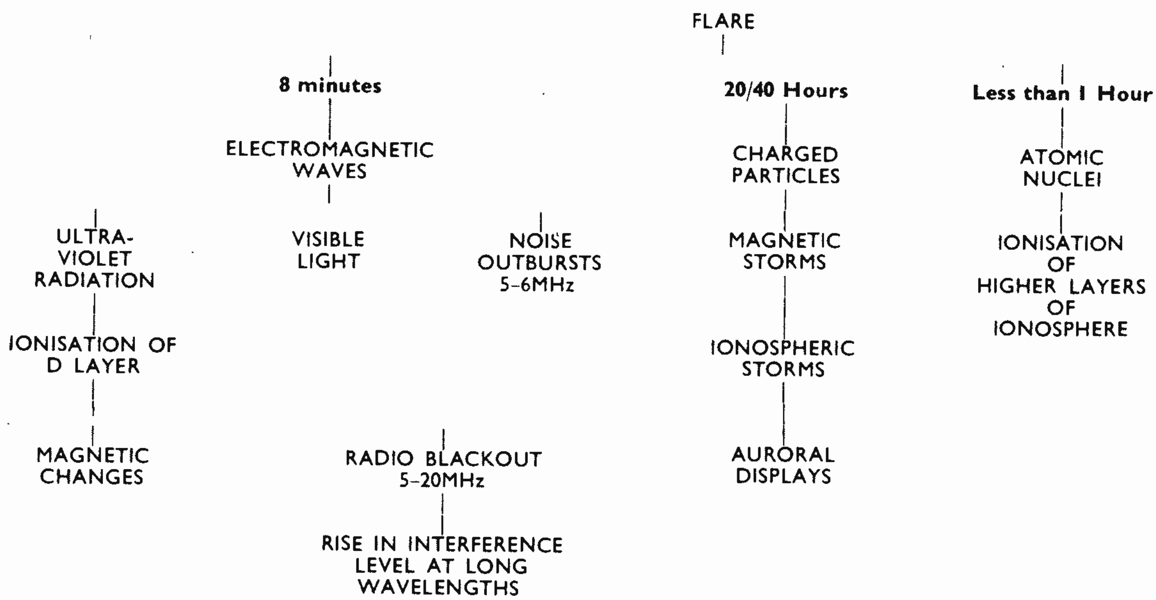
THE RADIO SUN

The radio sun is very much greater in extent than the visible corona would suggest. The radio sun is invisible and extends to something like an ellipse which is 80 solar radii in one direction and 110 solar radii in the other. This was established during the period of activity that existed in 1960 by O. B. Slee in Sydney, Australia. More will be said about this again in another project using the interferometer.

The effects of a flare are shown in Table 5.2.

The next article will describe the setting up and testing of the telescope units and the commencement of the first observations.

TABLE 5.2
THE RESULTING EFFECTS OF A SOLAR FLARE



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.

AUDIOPHILE

It is not often that **Ferrograph** find it desirable to make technical changes to their professional quality tape recorders, but when they do it is usually carefully noted by other manufacturers.

The latest modification to their Series 7 range of recorders is claimed to make them the only hi fi, domestic use, tape recorders incorporating the Dolby "B" noise reduction system on the market at the moment.

The type "B" system for use in the home recorder is based upon, and works on the same principles as, the Dolby "A" type professional noise reduction system. The "B" system eliminates the background noise once considered inevitable when recording wide-frequency-range sounds at the low speeds generally associated with domestic tape recorders. At low speeds tape hiss is usually the primary barrier to satisfactory quality, and this system was designed to reduce such hiss.

The high quality of the Ferrograph tape transport, heads, and electronics are such that when any inherent noise resulting from low recording speeds is reduced (a claimed 10dB) through use of the Dolby system; the overall quality of recordings made at $1\frac{7}{8}$ in/sec is claimed to be comparable to that produced at $7\frac{1}{2}$ in/sec without this system.

Available direct from Ferrograph Co. Ltd. at The Hyde, Edgware Road, London, N.W.9, or through selected dealers, the Ferrograph recorders with the Dolby system start at £187 for a monaural recorder, and go to £263 for a high speed, high performance stereo recorder. Purchase tax is not included.

COMPACT STEREO

Since manufacturers realised that people wanted a good performance amplifier incorporated in the compact type record player/amplifier units, they are now generally accepted and gaining increasing popularity.

Now most manufacturers produce excellent amplifiers for these units and the **Permic** 6-6 stereo amplifier/player is one such unit.

The amplifier has a claimed output of 6 watts r.m.s. per channel, measured at 1kHz continuous sine wave into 8 ohm loads. Distortion is in the order of 0.3 per cent. The frequency response at 1 watt r.m.s. with tone circuits flat is 20Hz to 20kHz $\pm$2dB.

Inputs are provided for record, tape and radio and the input sensitivity is claimed to be better than 100mV into 3 megohm for a rated output at 1kHz.

An output socket on the front panel is provided for low impedance stereo headphone listening.

The price of the Permic 6-6 is £39, which does not include the price of speakers. All models are fitted with a Garrard turntable, and a Sonotone 9. TAHC or KS41C cartridge with a diamond stylus.

Full details of the Permic 6-6 stereo amplifier and other models can be obtained from Permic Ltd. 17 Upland Road, Bexleyheath, Kent.

Permic also run a special customer service for those who wish to have the amplifiers installed in their own favourite piece of furniture.

HEADPHONE LISTENING

For those who prefer to listen to their favourite programme or piece of music without any outside distractions, then the new Ravensbrook senior professional stereo headphones from **Rogers Developments Ltd.,** 4–14 Barmeston Road, London, SE6 3BN, should be most popular.

The headphones, although intended primarily for their own amplifiers, are compatible with other high quality amplifiers. Particular features include a twin moving coil system, individual volume controls integral with each earpiece and excellent bass response, claimed to be above average.

The recommended U.K. retail price for the Ravensbrook Stereo Headphones is £18·50.

BENCH LIGHT

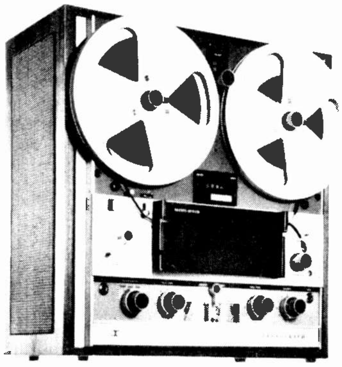
Designed primarily to aid operators and inspectors engaged on assembly or inspection work of an intricate nature, the Allen A90 4 and 6 tube bench floodlights would be a handy luxury to have in the workshop.

Costing from £24 to £55 there are two models available with either four or six 8 watt 12 inch (300mm) fluorescent tubes providing illumination levels of 11,000 and 16,000 Lux respectively 4 inches (100mm) distant from the lamps. Precise positioning is provided by a spring-balanced support arm and ball-joint mechanism.

It is claimed that the large area light source obviates distracting shadows from tools or hands, even when located very close to the work area. The maximum reach of the arm is 26 inches (640mm).

In addition to the screwdown base for bench mounting, two other alternative mountings are available: a bench clamp and a wall bracket.

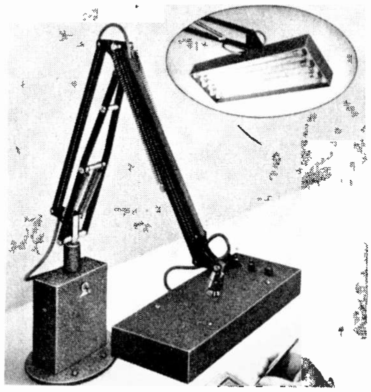
Applications advice, and an illustrated leaflet is available from the manufacturers, **P. W. Allen & Co.,** 253 Liverpool Road, London, N1 1NA.



Ferrograph Dolby "B" Recorder

Rogers Ravensbrook stereo headphones

Allen A90 benchlight



Permic stereo 6-6 amplifier/player

A selection of readers' suggested circuits. It should be emphasised that these designs have not been proven by us. They will at any rate stimulate further thought.
This is YOUR page and any idea published will be awarded payment according to its merit.

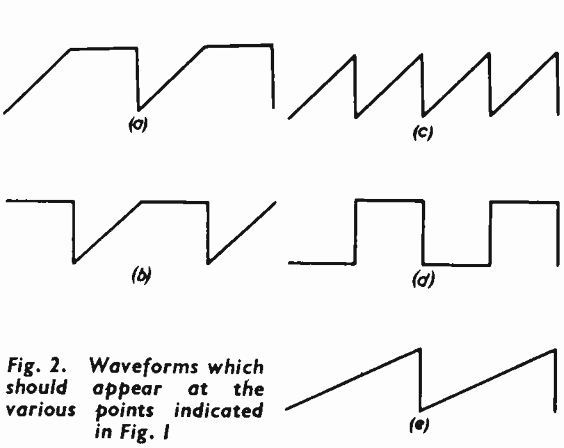


Fig. 2. Waveforms which should appear at the various points indicated in Fig. 1

ORGAN DIVIDER CIRCUIT

Tone generators of frequency divider type electronic organs are usually either driven by bistable multivibrators or synchronised blocking oscillators.

Substantial cost saving can be accomplished by using a multivibrator chain with each multivibrator cycling at one-quarter (normally half) of the frequency of the previous, and each multivibrator providing two outputs, one being twice the frequency of the other. The blocking oscillator transformers are dispensed with and only half the number of multivibrators are required.

The circuit diagram in Fig. 1 shows a circuit that has been tested and works well. Fig. 2a and 2b show the waveforms on the bases of TR1 and TR2. By combining the two, the waveform in Fig. 2c results. This is one of the outputs and has a frequency twice that of the multivibrator.

The waveform in Fig. 2d is taken from the collector of TR1. When combined with the waveform of 2c and reduced to half the magnitude the resultant effect is shown in Fig. 2e. This has the same frequency as the multivibrator and is the second output.

The values of the capacitors have, of course, to be scaled proportionately to the frequency of each multivibrator.

The synchronising output to the next multivibrator contains some of the input sychronising pulse. If desired, to make the synchronising easier an r.c. filter may be introduced between each stage to reduce this unwanted signal.

Each output is connected to the switching resistors for the various footages.

The amplifier following the keyboard switching should be biased so that the d.c. potential of the input is the same as the d.c. potential of the earth side of the keyboard switches.

J. H. Asbery,
Wembley.

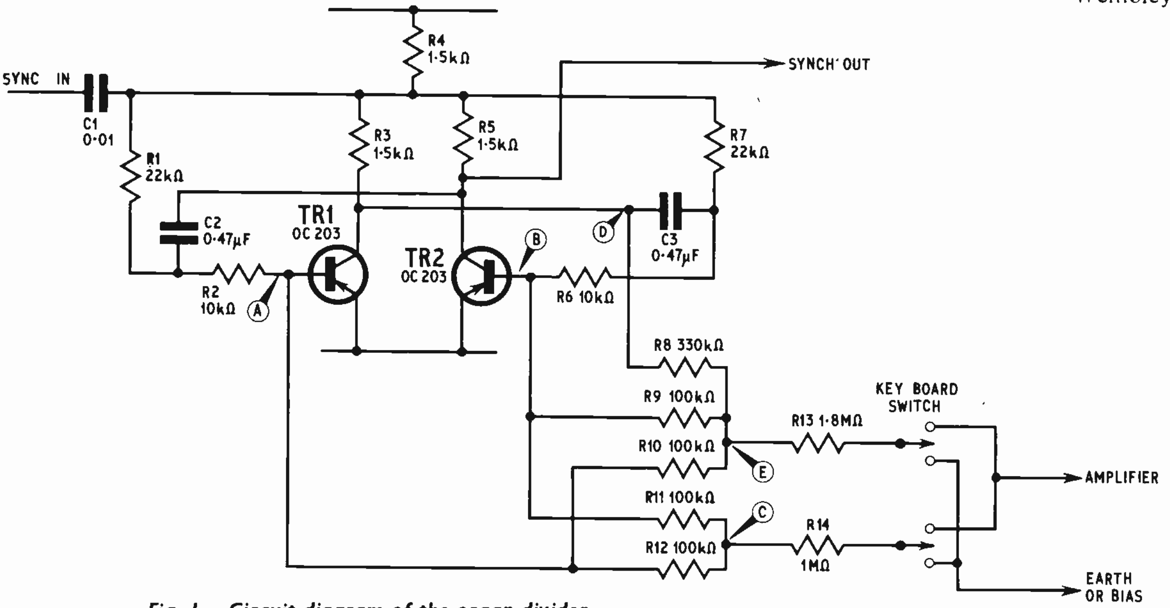


Fig. 1. Circuit diagram of the organ divider

TIME SWITCH

Some of your readers might be interested in the circuit shown in Fig. 1 that I have designed. Basically it is a monostable with a high power output and a very long time delay, approximately 10 minutes.

I am using the circuit to ring a bell for 10 minutes after a light beam is broken, but there are obviously many other ingenious applications that readers could experiment with.

An input pulse turns the thyristor SCR1 "on" and rings the bell. The resistor R1 passes more than the required holding current, while diode D1 kills any back e.m.f. The capacitor C2 charges via R3 and capacitor C4 charges via R4, D2 and SCR1. After 10 minutes TR1 fires and capacitor C4 discharges via R6 and D3. A pulse across R6 fires SCR2 via capacitor C3 and capacitor C2 switches SCR1 "off", stopping the bell ringing.

Capacitor C4 and resistor R4 determine the delay time and may be altered over a wide range, remembering that R4 should be greater than 3 kilohms. If C4 is larger than specified the value of R6 should be increased. Capacitor C5 smooths out any spikes on the supply rail, which could upset the operation of the thyristors. Resistors R2 and R5 stop any misfiring.

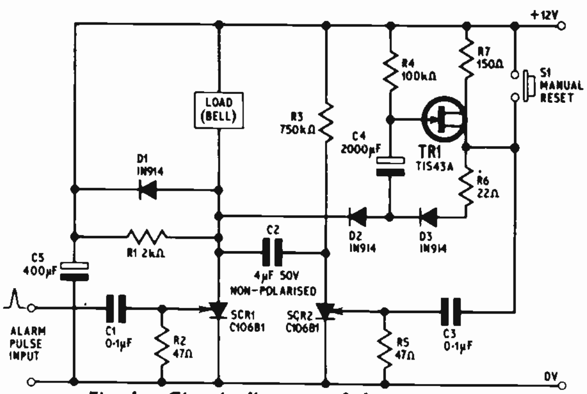


Fig. 1. Circuit diagram of the time switch

Thyristor SCR1 can handle 1A easily (12 watts load); for larger loads the thyristor must be uprated and C2 and R3 changed to ensure reliable turn-off of the SCR.

This circuit has been built and works perfectly. However, would-be constructors should note that if different thyristors are used then resistor R3 should be chosen to pass less holding current, but be low enough to charge C2 in approximately five minutes.

L. Cook,
Prescot, Lancashire.

CRYSTAL OSCILLATOR FOR CLOCK

The "Digi-Clock" published in the December 1970 to March 1971 issues of P.E. relies for its accuracy on the stability of the mains voltage frequency used to power the clock. This may be accurate enough for most people but for high accuracy, a crystal oscillator unit is the answer.

The frequency of the mains supply varies slightly during the day, and it can cause a clock to be 8 seconds slow in any one day. It is true that at sometime after midnight this error is eliminated by increasing the frequency of the mains supply to cancel any error. Also, at times during the winter months, just prior to voltage reductions, the frequency is reduced by a few per cent.

For readers who require an accurate clock, instead of one with an alarm, the enclosed circuit could be included in the original design using approximately the same number of components and occupy the same amount of area as the alarm.

The circuit of the crystal oscillator is shown in Fig. 1. The 100kHz crystal operates in the parallel mode and the 60pF trimming capacitor in series with the crystal is adjusted to give exactly 100kHz. A convenient frequency standard for this adjustment is the B.B.C. Radio 2 carrier frequency of 200kHz.

An oscilloscope is triggered from the 100kHz crystal oscillator and the 200kHz waveform is displayed on the screen. The 60pF trimmer is then adjusted for minimum horizontal shift of the waveform.

The oscillator is followed by seven divider stages where the frequency of pulses is reduced to one every minute, see Fig. 2. The first six of these dividers are decade counters in the form of integrated circuits and the seventh stage is a divide by 6 integrated circuit.

For setting the clock to exactly the correct time, the Greenwich time signal can be used. On the last of the six "pips" the clock can be switched on and adjusted to read the correct time. If a clock with seconds indication has been constructed, then the output from IC5, which has a frequency of 1Hz, can be fed to the input neglecting IC6 and 7.

The actual accuracy obtained with the prototype was the loss of only 1 second per week. After running for a month in a room in which the ambient temperature varied by about 10°C, the clock was found to be only 4 seconds fast.

J. A. Wise,
Watford.

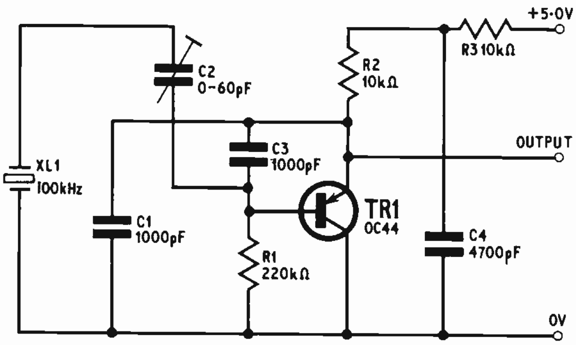


Fig. 1. Circuit diagram of the crystal oscillator

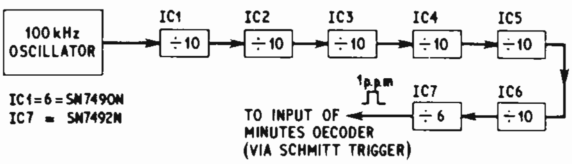


Fig. 2. Block diagram showing arrangement of oscillator and divider stages

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AF186	0·50	2N1302-3	0·20
AF139	0·37	2N1304-5	0·25
BC154	0·25	2N1306-7	0·30
BC171 = BC107	0·13	2N1308-9	0·35
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BF194	0·15		
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BSY25	0·57	OC20	0·50
BSY26	0·13	OC23	0·30
BSY27	0·13	OC25	0·25
BSY28	0·13	OC26	0·25
BSY29	0·13	OC28	0·30
BSY95A	0·15	OC35	0·25
OC41	0·13	OC36	0·37
OC44	0·13	AD149	0·30
OC45	0·13	AUY10	1·25
OC71	0·13	2S034	0·25
OC72	0·13	2N3055	0·63
OC73	0·17	**Diodes**	
OC81	0·13	AAY42	0·10
OC81D	0·13	OA95	0·10
OC83	0·20	OA79	0·09
OC139	0·13	OA81	0·09
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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.

Build or bust!

Sir—Of date I have read with interest letters from the readers of your esteemed magazine in the *Readout* section, concerning the state of "chaos" brought about by the unavailability of special components for some of the projects that are published in your magazine.

It surprises me very much that your readers "at home" (the U.K.) like the Old Mariner, keep wailing "water, water everywhere but not a drop to drink." What would some of these gentlemen do if they had to hunt for i-c's or special components in this country?

A group of us interested in such projects have evolved a way around this problem by forming a Club and when we see that we have an order to make it "well worth the while" of the various mail-order houses that advertise with your magazine, I send off an order for the required parts.

Sometimes however, we do come across a special relay or switch that cannot be supplied or is out of stock, or by writing to the manufacturer we cannot get a "one-off" job. It is here that we cannibalise parts from old equipment which have been junked, to the extent of rebuilding some of the switches to suit our needs.

It seems that your modern readers want things laid out on the table for them to go ahead and build some piece of equipment that takes their fancy. Why not improvise? If a particular transistor is not available or is obsolete, why not find an alternative? After all, we are in this hobby to enjoy ourselves, not to make a profit like the component dealers (who, must, if they want to keep their business from running into the red). What greater satisfaction in making a piece of equipment that requires something special through improvisation rather than frowning that "that damned thing isn't going to work without that thingamajig"?

Now before some keen reader bops me for saying that, I would suggest that snould your magazine wish to co-operate, and I am sure it has done all it can for its readers these past many years, is to have a Swap-Box column whereby readers could exchange parts with each other (without asking for monetary remunerations) and thus solve some of their problems if not all of them.

Keep on publishing your specialised designs. "WE SHALL BUILD THEM OR BUST".

S. M. Sharifi,
Teheran,
Iran.

American way

Sir—The amateur is very well catered for in this country. Early this year I received the latest catalogues FREE from the mail-order component houses I buy parts from on occasion.

Newark's catalogue for 1971 runs to 736 pages; Allied Radio Shack's to 460; Lafayettes to 467. It is impossible to detail their offerings which run the whole gamut from individual components of every conceivable kind through brand name kits to commercial equipment, hi-fi systems and so on, and on. I would almost say that there is no component available to the professional engineer which the amateur cannot purchase by mail. He must be prepared to pay for it though!

In Cincinnati there is also a branch of a local Ohio concern, Hughes Peters, and they have an across the counter service daily and Saturday mornings. Parts not immediately available here are ordered from their suppliers and the customer is advised by phone when they arrive. There is no extra charge for this service.

Mail orders from the other firms are processed in about fourteen days. A sign of the times, however, has been an increase in the minimum value of a mail order that these firms will handle.

Some of the firms also run their own hire-purchase plans, which cover components as well as kits and ready to use equipment.

Firms offer quantity discounts, these vary with quantity and the kind of item. Generally it pays to buy as large a number as possible, as for small items savings can be substantial.

There are also firms specialising in selling complete ready-to-assemble kits for the more sophisticated projects published in the popular magazines, and also special components that may be called for.

Supplying home experimenters is big business in the U.S.A. and why dealers in the U.K. do not try to capture this large source of revenue is something very surprising! ! Of course, dealers that do extend certain services to experimenters beyond the call of service will note that they have *a customer who chooses to deal with no one else in the long run.* I hope that some enterprising mail-order house in the U.K. finds a practical solution to this tangled problem.

I expect that the hobbiest here has more to splurge on bits than his UK counterpart and his potential business attractive to the component suppliers. Having the cash and an American philosophy he will tend to do the job right and not save pennies adapting old junk if the correct part can be purchased.

L. Huggard,
Cincinnati,
U.S.A.

New hobby

Sir—At the moment, (having just completed the first part of the "War Games Computer" successfully), I am rather keen on constructing similar projects, such as the "Operation Seasearch."

I am hoping you can give me the date of the magazines in which it appeared and where I might obtain them? Also any similar projects which might have been shown in your magazine?

I must confess that this month's is the first of your magazines I have bought, for although very interested in electronics, I have up until now mostly constructed radios.

Needless to say, from now on I shall place a regular order for PRACTICAL ELECTRONICS, which has given me a "start" on a wonderful new hobby.

Hope to hear from you soon.

N. Early,
Langport,
Somerset.

"Operation Seasearch" appeared in the December '70 issue; "Submarine Chaser" in February this year.

We regret that all back numbers of our magazine are no longer available. We can only suggest you try your local technical or reference library.

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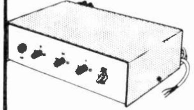

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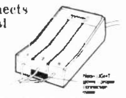

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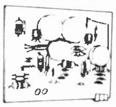

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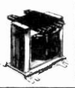

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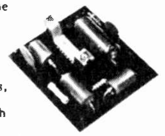

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Sub-miniature types

μF	volts
0·047	50
0·056	50
0·07	20
0·1	20
0·1	50
0·18	20
0·33	35
0·47	35
0·68	20
1·0	15
2·2	3
2·7	15
2·7	35
3·0	12
100	1·5

Miniature types

μF	volts
0·022	20
0·033	20
0·047	20
0·068	35
0·12	35
0·15	35
0·22	50
0·47	50
0·68	35
0·68	50
1·0	35
1·0	75
1·8	20
2·2	20
2·7	50
3	12
3·3	15
4	20
4·7	35
5·6	6
5·6	35
8·2	10
8·2	35
15	35
18	35
22	15
27	120
56	15
56	20
150	6

Standard

μF	volts
6·8	50
7·5	20
8·2	150
12	35
12	50
39	20
82	20
150	15
270	6

NEW! NEW! NEW! NEW!

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.

Light sensitive aerosol spray **£1**
Developer spray **50p**

G. F. MILWARD, Drayton Bassett, Tamworth, Staffs. Postage (minimum) per order 15p.

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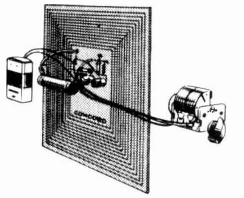
READY BUILT & TESTED

Treasure Locator Module

Only **£4·95** (99/-)



BRAND NEW FULLY TRANSISTORISED PRINTED CIRCUIT METAL DETECTOR MODULE. *Ready built and tested*—just plug in a PP3 battery and 'phones and it's working. Put it in a case, screw a handle on and **YOU HAVE A PORTABLE TREASURE LOCATOR EASILY WORTH ABOUT £20!** Extremely sensitive—penetrates through earth, sand, rock, wood, dirt, water, etc.—**EASILY LOCATES COINS, GOLD, SILVER, WATCHES, JEWELLERY, NUGGETS, METALLIC ORE, HISTORICAL RELICS, BURIED PIPES, KEYS, NAIL-IN-TREES, ETC., ETC.** Signals exact location by "beep" pitch increasing as you near buried metallic objects. **PRINTED CIRCUIT SEARCH COIL** *so stable and sensitive it will detect certain objects buried* **SEVERAL FEET BELOW GROUND! GIVES CLEAR SIGNAL ON ONE COIN!** *You could even pay for your holidays with two or three days electronic beachcombing—it's almost like having a licence to print money!* Unclaimed treasure now exceeds the combined wealth of all nations. **ORDER NOW WHILE PRESENT STOCKS LAST—TREMENDOUS DEMAND EXPECTED AT THIS REMARKABLY LOW PRICE. DEMONSTRATIONS DAILY. ORDERS DESPATCHED IN STRICT ROTATION. SEND NOW £4·95 + 30p carr.** (99/- + 6/-) etc. (High quality Danish Stethoscope headphones £2·75 (55/-) extra if required).

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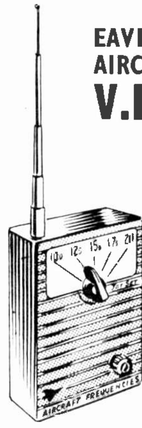
V.H.F. AIRCRAFT BAND CONVERTER

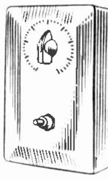


Many thousands of v.h.f. Aircraft Band Converters now selling in U.S.A. *Listen in to* **AIRLINES, PRIVATE PLANES, JETPLANES.** *Eavesdrop on exciting crosstalk between pilots, ground approach control, airport tower. Hear for yourself the disciplined voices hiding tenseness on talk downs.* Be with them when they have to take nerve rippling decisions in emergencies—Tune into the international distress frequency. Covers the aircraft frequency band including **HEATHROW, GATWICK, LUTON, RINGWAY, PRESTWICK ETC., ETC. CLEAR AS A BELL.** This fantastic fully transistorised instrument *can be built by anyone nine to ninety in under two hours.* (Our design team built four—everyone worked first time). *No knowledge of radio or electronics required.* No soldering necessary. Fully illustrated simply worded instructions take you step-by-step. Uses standard PP3 battery. Size only 4¾" x 3" x 1¼". All you do is extend rod aerial, place close to any ordinary medium-wave radio- (even tiny portables) **NO CONNECTIONS WHATEVER NEEDED.** Use indoors or outdoors. **THERE WILL BE ENORMOUS DEMAND FOR THIS NEW DESIGN, SEND NOW, ONLY £2·37** (47/6) + 23p (4/6) p. & p. for all parts, including case, nuts, screws, wire, etc., etc. (parts available separately)

ONLY **£2·37** Plus P. & P. 23p (47/6)

SOOTHE YOUR NERVES, RELAX WITH THIS AMAZING

RELAXATRON



only **£2·25** (45/-)

CUTS OUT NOISE POLLUTION—SOOTHES YOUR NERVES! Don't underestimate the uses of this fantastic new design—the **RELAXATRON** is basically a pink noise generator based on avalanche operated transistors. Besides being able to mask out extraneous unwanted sounds, it has other very interesting properties. For instance, many people find a rainstorm mysteriously relaxing, a large part of this feeling of well-being can be directly traced to the sound of falling raindrops!—a well known type of pink noise. *A group of Dentists have experimented on patients with this pink noise*—**NO ANESTHETICS WERE USED!** The noise ostensibly created a most definite reaction on these patients' nervous systems with the results that their pain systems were blocked. **IF YOU WORK IN NOISY OR DISTRACTING SURROUNDINGS, IF YOU HAVE TROUBLE CONCENTRATING, IF YOU FEEL TENSED, UNABLE TO RELAX**—then build this fantastic Relaxatron. Once used you will never want to be without it—use this amazing pink noise generator whenever you feel uneasy, can't relax or wish to concentrate. **TAKE IT ANYWHERE**, pocket sized. Uses standard PP3 batteries (current used so small that battery life is almost shelf-life) **CAN BE EASILY BUILT BY ANYONE OVER 12 YEARS OF AGE** using our unique, step-by-step, fully illustated plans. No soldering necessary. All parts including case, a pair of crystal phones, Components, Nuts, Screws, Wire, etc. etc. no soldering. **Send only £2·25 + 25p** (45/- + 5/-) p. & p. parts available separately.)

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INGENIOUS ELECTRONIC

SLEEP INDUCER

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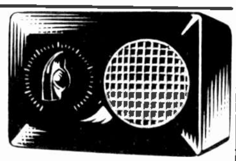
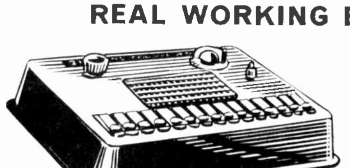


CAN'T SLEEP AT NIGHTS? DO YOU WAKE UP IN THE NIGHT AND CAN'T GET OFF TO SLEEP AGAIN? WOULD YOU LIKE TO BE GENTLY SOOTHED OFF TO SATISFYING SLEEP EVERY NIGHT? Then build this ingenious electronic sleep inducer. *It even stops by itself so you don't have to worry about it being on all night!* The loudspeaker produces soothing audio-frequency sounds, continuously repeated—but as time goes on the sounds gradually become less and less—until they eventually cease altogether, *the effect it has on people is amazingly very similar to hypnosis.* A control is provided for adjusting the length of times etc., all transistor, can be built by anyone over 12 years of age in about two hours. No knowledge of electronics or radio needed. Extremely simple, easy-to-follow, step-by-step, fully illustrated instructions included. *No soldering necessary.* Works off standard batteries—extremely economical. Size only 3" x 4¾" x 1¾"—take it anywhere. **All parts** including case, loudspeaker, components, nuts, wire, screws, etc. etc. **THERE WILL BE A GREAT DEMAND FOR THIS UNIQUE NEW DESIGN—SEND NOW £2·75 + 25p** (55/- + 5/-) p. & p. (parts available separately).

REAL WORKING ELECTRONIC ORGAN



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Don't confuse with ordinary electric organs that simply blow air over mouth-organ type reeds etc. Eight months were spent in creating and testing this superb, revolutionary electronic organ. Fully transistorized—no valves. **Proper self-contained loudspeaker.** *Fifteen separate keys span two full octaves*—play the "*Yellow Rose of Texas*", play "*Silent Night*", play "*Auld Lang Syne*", play *lots and lots of similar tunes* on this real working electronic organ. Although it's no theatre organ it's certainly no tiny thing, it measures 13¾ x 10 x 2¼". You have the thrill and excitement of building it together with the pleasure of playing a real, live, throbbing electronic organ. *Take it anywhere—play it anywhere.* **NO PREVIOUS KNOWLEDGE OF ELECTRONICS NEEDED—NONE WHATEVER.** No soldering necessary, it really is as simple as a.b.c. to make. **Anyone from nine years upwards can build it easily in one short evening** following the fully illustrated, step-by-step, simply worded instructions. **BIG DEMAND ANTICIPATED FOR THIS UNIQUE INSTRUMENT** at our low, low building price. **ONLY £2·75** (55/-) + 23p (4/6) p. & p. for all parts, including case, loudspeaker, transistors, condensers, resistors, knobs, transformer, volume control, wire, nuts, screws, simple (but full) instructions, etc. etc. Uses standard battery (parts available separately). Have all the pleasure of making it yourself, finish with an exciting gift for someone.

FIND BURIED TREASURE!

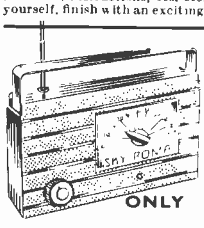
TREASURE LOCATOR TRANSISTORISED

NOW IT'S HERE AT LAST, after experimenting for four and a half months with a multitude of different circuits and carrying out actual field tests with prototypes, our design team have come up with this real winner. This fully portable transistorized metal locator detects and tracks down buried metal objects—it signals exact location with loud audible sound (no phones used)—uses any transistor radio which fits inside—no connections needed. **FINDS GOLD, SILVER, LOST COINS, JEWELLERY, KEYS, WAR SOUVENIRS, ARCHAEOLOGICAL PIECES, METALLIC ORE, NUGGETS ETC. ETC.** Outdoors or indoors. *Extremely sensitive, will signal presence of certain objects buried several feet below ground!* No knowledge of radio or electronics required. *Can be built with ease in one short evening by anybody from nine years of age upwards,* with the wonderfully clear, easy to follow, step-by-step, fully illustrated instructions—it really is easy as A.B.C. transistorized — no valves. Uses standard PP3 battery. No soldering necessary. Size of detector head 13¾" x 10" x 2¼". **Great demand expected at this remarkably low price—ORDER WHILE PRESENT STOCKS LAST.** All parts including detector head case, nuts, screws, wire, simple instructions etc. etc. **ONLY £2·37** (47/6) + 27p (5/6) p. & p. (Sectional handle as illustrated **75p** (15/- extra). Parts available separately. Made up looks worth **£15** !

ONLY **£2·37** (47/6)

SHORTWAVE TRANSISTOR RADIO

Can be built in one evening



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At last! After trying countless circuits searching for easy build, work first-time short waver. Giving advanced world-wide performance, we chose this 'Sky Roma'. Anyone from 9 years up can follow the step-by-step, easy-as-ABC, fully illustrated instructions. (We built ten prototypes and every one worked first time) no soldering necessary. 76 stations logged on rod aerial in 30 mins.—**Russia, Africa, USA, Switzerland, etc.** Experience thrills of world wide news, sport, music, etc. **Eavesdrop on unusual broadcasts.** Uses PP3 battery. Transistorised (no valves!). Size only 3" x 4¾" x 1¾". As tremendous demand anticipated price held to only **£2·25** (45/-) + 17p (3/6) p. & p. for all parts incl. Cabinet, screws, instructions etc. (Part available separately).

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ACY19	20p	C4V7	15p	NKT80212	75p	2N404	23p
ACY20	19p	C5V1	15p	NKT80213	75p	2N696	15p
ACY21	19p	C5V6	15p	NKT80214	75p	2N697	17p
ACY22	19p	C6V2	15p	NKT80215	75p	2N698	30p
ACY40	15p	C6V8	15p	NKT80216	75p	2N706	10p
ACY41	15p	C7V5	15p	OA5	20p	2N706A	12p
AD140	55p	C8V2	15p	OA10	25p	2N708	16p
AD149	57p	C9V1	15p	OA47	8p	2N711	37p
AD161	37p	C10	15p	OA70	8p	2N711A	37p
AD162	37p	C11	15p	OA73	8p	2N911	50p
AF106	24p	C12	15p	OA79	8p	2N914	20p
AF114	25p	C13	15p	OA81	8p	2N918	42p
AF115	25p	C15	15p	OA85	8p	2N1090	30p
AF116	25p	C16	15p	OA90	8p	2N1091	33p
AF117	25p	C18	15p	OA91	8p	2N1131	30p
AF118	44p	C20	15p	OA95	8p	2N1132	30p
AF124	25p	C22	15p	OA200	10p	2N1302	20p
AF126	17p	C24	15p	OA202	10p	2N1303	20p
AF139	33p	C27	15p	OC19	37p	2N1304	25p
AF186	40p	C30	15p	OC20	97p	2N1305	25p
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BC108	12p	MPF105	40p	OC41	25p	2N2160	62p
BC109	12p	NKT124	30p	OC42	30p	2N2368	17p
BC147	15p	NKT125	40p	OC44	15p	2N2369	17p
BC148	15p	NKT126	37p	OC45	15p	2N2369A	20p
BC149	15p	NKT128	25p	OC71	15p	2N2646	50p
BC158	17p	NKT135	26p	OC72	23p	2N2904	44p
BC167	11p	NKT137	32p	OC75	23p	2N2904A	49p
BC168	10p	NKT210	25p	OC76	25p	2N2905	65p
BC169	11p	NKT211	25p	OC77	40p	2N2905A	75p
BC169C	19p	NKT212	25p	OC81	23p	2N2906	44p
BC182	12p	NKT213	25p	OC81D	20p	2N2906A	54p
BC182L	10p	NKT214	23p	OC81Z	55p	2N2926 all	
BC183	9p	NKT215	21p	OC82	25p	colours	10p
BC183L	9p	NKT216	46p	OC82D	15p	2N3053	25p
BC184	15p	NKT217	50p	OC83	23p	2N3054	63p
BC184L	15p	NKT218	25p	OC84	25p	2N3055	75p
BC212	17p	NKT219	25p	OC139	25p	2N3702	11p
BC212L	12p	NKT223	27p	OC140	35p	2N3703	10p
BCY30	25p	NKT224	25p	OC170	25p	2N3704	11p
BCY31	48p	NKT225	21p	OC171	30p	2N3705	10p
BCY32	50p	NKT229	29p	OC200	37p	2N3706	9p
BCY33	20p	NKT237	31p	OC201	47p	2N3707	11p
BCY34	25p	NKT238	19p	OC202	63p	2N3708	7p
BCY38	30p	NKT239	23p	OC203	37p	2N3709	9p
BCY70	19p	NKT240	20p	OC204	40p	2N3710	9p
BCY71	37p	NKT241	21p	OC205	65p	2N3711	9p
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BF115	25p	NKT262	19p	ORP61	40p	2N4061	20p
BF163	40p	NKT264	21p	P346A	19p	2N4062	20p
BF167	25p	NKT271	18p	ST140	15p	2N4284	15p
BF173	30p	NKT272	17p	ST141	20p	2N4287	15p
BF177	25p	NKT274	18p	TD716	60p	2N4289	15p
BF178	52p	NKT275	23p	TIP31A	62p	2N4871	40p
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BF196	15p	NKT402	77p	ZTX303	18p	40250	55p
BF200	35p	NKT403	65p	ZTX304	27p	40309	33p
BFX13	25p	NKT404	60p	ZTX314	11p	40310	45p
BFX29	31p	NKT405	79p	ZTX320	30p	40312	48p
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BFX85	34p	NKT420	£1·83	ZTX500	16p	40360	43p
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BFX87	30p	NKT452	54p	ZTX502	20p	40362	58p
BFX88	25p	NKT453	50p	ZTX503	17p	40406	56p
BFY50	23p	NKT603F	30p	ZTX504	40p	40407	39p
BFY51	19p	NKT613F	30p	IN34A	20p	40408	51p
BFY52	20p	NKT674F	30p	IN60	20p	40409	54p
BFY53	16p	NKT676F	30p	IN64	20p	40468A	35p
BFY90	67p	NKT677F	28p	IN82A	47p	40600	58p
BSX19	16p	NKT713	29p	IN87A	23p	40601	55p
BSX20	16p	NKT717	44p	IN914	7p	40602	49p
BSX21	37p	NKT734	26p	IN4001	7p	40603	49p
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·22	35	4·7	16
·47	35	10	16
1	35	15	16
2·2	35	22	16
4·7	35	33	10
6·8	25	10	6·3
10	25	22	6·3
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IN4007	1000	·190	·150	·120

	p.i.v	500+	1000+
IN4001	50	·045	·040
IN4002	100	·055	·045
IN4003	200	·060	·050
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0·047	4p
0·068	4p
0·1	4p
0·15	5p
0·22	5p
0·33	7p
0·47	8p
0·68	11p
1·0	14p
1·5	20p
2·2	24p

Mullard Electrolytic C437 series

Mfd.	Volt. Wkg.	
250	16	9p
400	16	12p
640	16	15p
1,000	16	18p
160	25	9p
250	25	12p
400	25	15p
640	25	18p
100	40	9p
160	40	12p
250	40	15p
400	40	18p

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10	16	6p
20	16	6p
40	16	6p
80	16	6p
1·6	25	8p
6·4	25	6p
12·5	25	6p
25	25	6p
50	25	6p
80	25	6p
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4	40	6p
8	40	6p
16	40	6p
32	40	6p
50	40	6p

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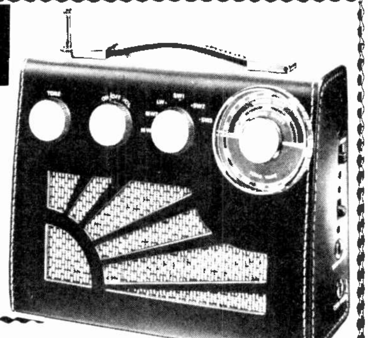

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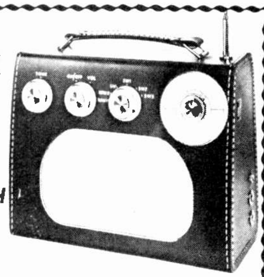

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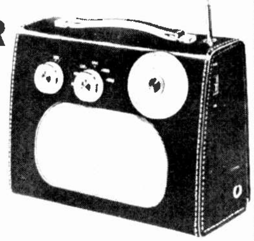

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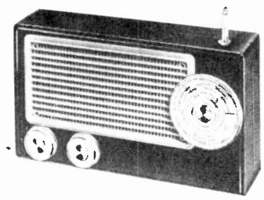
ROAMER SIX



6 TUNABLE WAVEBANDS: MW, LW, SW1, SW2, TRAWLER BAND PLUS AN EXTRA MW BAND FOR EASIER TUNING OF LUXEMBOURG, ETC. Sensitive ferrite rod aerial and telescopic aerial for short waves. 3in speaker. 8 stages—6 transistors and 2 diodes including micro-alloy R.F. transistors, etc. Attractive black case with red grille, dial and black knobs with polished metal inserts. Size 9in × 5½in × 2½in approx. Easy build plans and parts price list 15p (FREE with parts). Earpiece with plug and switched socket for private listening 30p extra.

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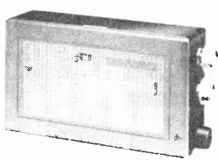
POCKET FIVE



3 TUNABLE WAVEBANDS: MW, LW, TRAWLER BAND WITH EXTENDED MW BAND FOR EASIER TUNING OF LUXEMBOURG, ETC. 7 stages—5 transistors and 2 diodes, supersensitive ferrite rod aerial, fine tone moving coil speaker. Attractive black and gold case. Size 5½in × 1½in × 3½in. Easy build plans and parts price list 10p (FREE with parts). Earpiece with plug and switched socket for private listening 30p extra.

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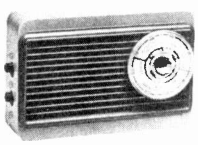
TRANSONA FIVE



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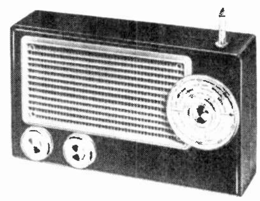

6 TUNABLE WAVEBANDS: MW, LW, SW1, SW2, SW3 AND TRAWLER BAND. Sensitive ferrite rod aerial for MW and LW. Telescopic aerial for short waves. 3in speaker. 8 improved type transistors plus 3 diodes. Attractive case in black with red grille, dial and black knobs with polished metal inserts. Size 9in × 5½in × 2½in approx. Push-pull output. Battery economiser switch for extended battery life. Ample power to drive a larger speaker. Parts price list and easy build plans 25p (FREE with parts). Earpiece with plug and switched socket for private listening 30p extra.

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UA710C	TO5	1·25	1·17	1·12
UA710C	TO5	0·70	0·65	C 60
UA716	TO5	1·87	1·75	1·70
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SN7409	0·20	0·18	SN7496	0·87	0·84
SN7410	0·20	0·18	SN7497	6·40	6·00
SN7411	0·23	0·21	SN74100	1·65	1·53
SN7412	0·48	0·46	SN74104	1·52	1·40
SN7413	0·40	0·38	SN74105	1·52	1·40
SN7416	0·84	0·78	SN74107	0·52	0·49
SN7417	0·84	0·78	SN74110	0·80	0·75
SN7420	0·20	0·18	SN74111	1·57	1·45
SN7423	0·51	0·47	SN74118	1·30	1·25
SN7425	0·48	0·45	SN74119	1·92	1·80
SN7427	0·48	0·45	SN74121	0·50	0·47
SN7428	0·80	0·75	SN74122	1·44	1·35
SN7430	0·23	0·15	SN74123	2·85	2·70
SN7432	0·48	0·42	SN74145	1·80	1·75
SN7433	0·80	0·75	SN74150	3·52	3·40
SN7437	0·64	0·60	SN74151	1·40	1·35
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SN7440	0·23	0·21	SN74154	2·20	2·10
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SN7443	2·86	2·70	SN74157	1·92	1·82
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SN7450	0·20	0·18	SN74166	4·45	4·20
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SN7454	0·20	0·18	SN74174	2·40	2·30
SN7460	0·20	0·18	SN74175	1·68	1·60
SN7470	0·40	0·38	SN74176	2·64	2·55
SN7472	0·32	0·30	SN74177	2·64	2·55
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SN7482	0·87	0·82	SN74191	1·80	1·70
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CA3002	1·80	1·60	CA3037	1·65	1·47
CA3002V1	1·80	1·60	CA3037A	2·53	2·25
CA3004	1·80	1·60	CA3038	2·53	2·25
CA3005	1·17	1·05	CA3038A	3·40	3·03
CA3006	2·80	2·50	CA3039	0·84	0·75
CA3007	2·63	2·34	CA3040	2·40	2·14
CA3008	1·80	1·60	CA3041	1·09	0·97
CA3008A	2·96	2·64	CA3042	1·09	0·97
CA3010	1·37	1·23	CA3043	1·37	1·23
CA3010A	2,53	2·25	CA3044	1·20	1·07
CA3011	0·74	0·65	CA3044V1	1·20	1·07
CA3011PRE	0·74	0·65	CA3045	1·23	1·09
			CA3046	0·69	0·60
CA3012	0·89	0·79	CA3047	1·37	1·23
CA3012V1	0·89	0·79	CA3047A	2·53	2·25
CA3013	1·05	0·94	CA3048	2·04	1·81
CA3014	1·24	1·10	CA3049	1·60	1·48
CA3014V1	1·24	1·10	CA3050	1·84	1·64
CA3015	2·09	1·86	CA3051	1·34	1·20
CA3015A	3·40	3·03	CA3052	1·65	1·47
CA3016	2·46	2·19	CA3053	0·46	0·41
CA3016A	3·73	3·33	CA3054	1·09	0·97
CA3018	0·84	0·75	CA3055	1·69	1·51
CA3018A	1·10	0·99	CA3056	1·20	1·07
CA3019	0·84	0·75	CA3056A	3·19	2·85
CA3020	1·26	1·13	CA3059	1·65	1·46
CA3020A	1·60	1·43	CA3060	4·91	4·37
CA3021	1·56	1·39	CA3062	2·55	2·27
CA3021V1	1·56	1·39	CA3064	1·20	1·07
CA3022	1·30	1·16	CA3065	1·20	1·07
CA3023	1·26	1·13	CA3066	2·11	1·88
CA3026	1·00	0·90	CA3067	2·18	1·94
CA3026PRE			CA3068	2·43	2·16
	1·00	0·90	CA3070	1·70	1·51
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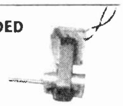

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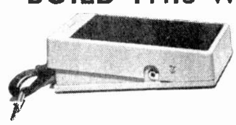

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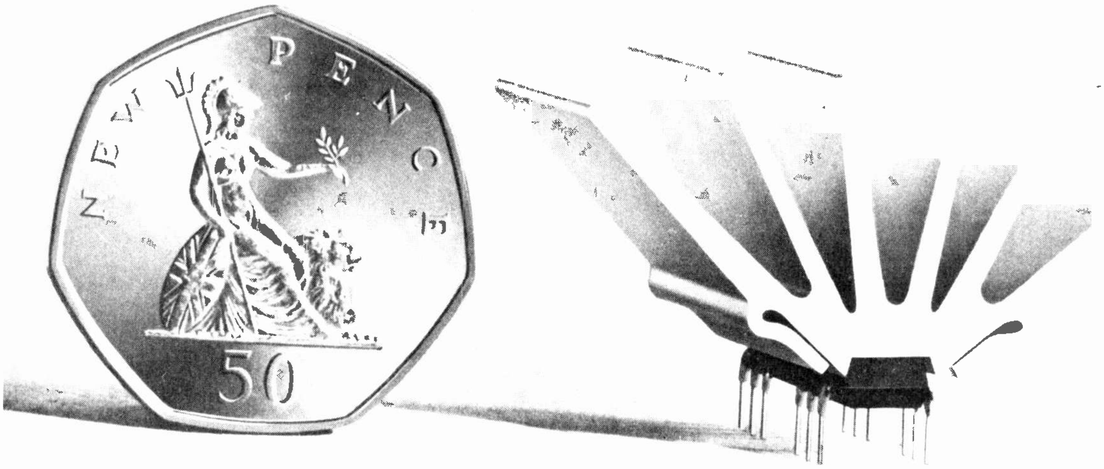

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7. Works on any voltage from 6 to 28 volts without adjustment.
8. NEW 22 transistor circuit.

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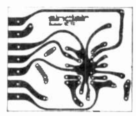

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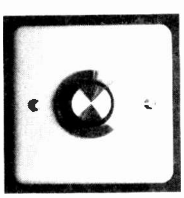

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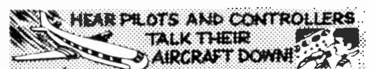

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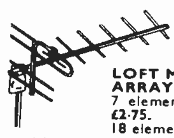

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