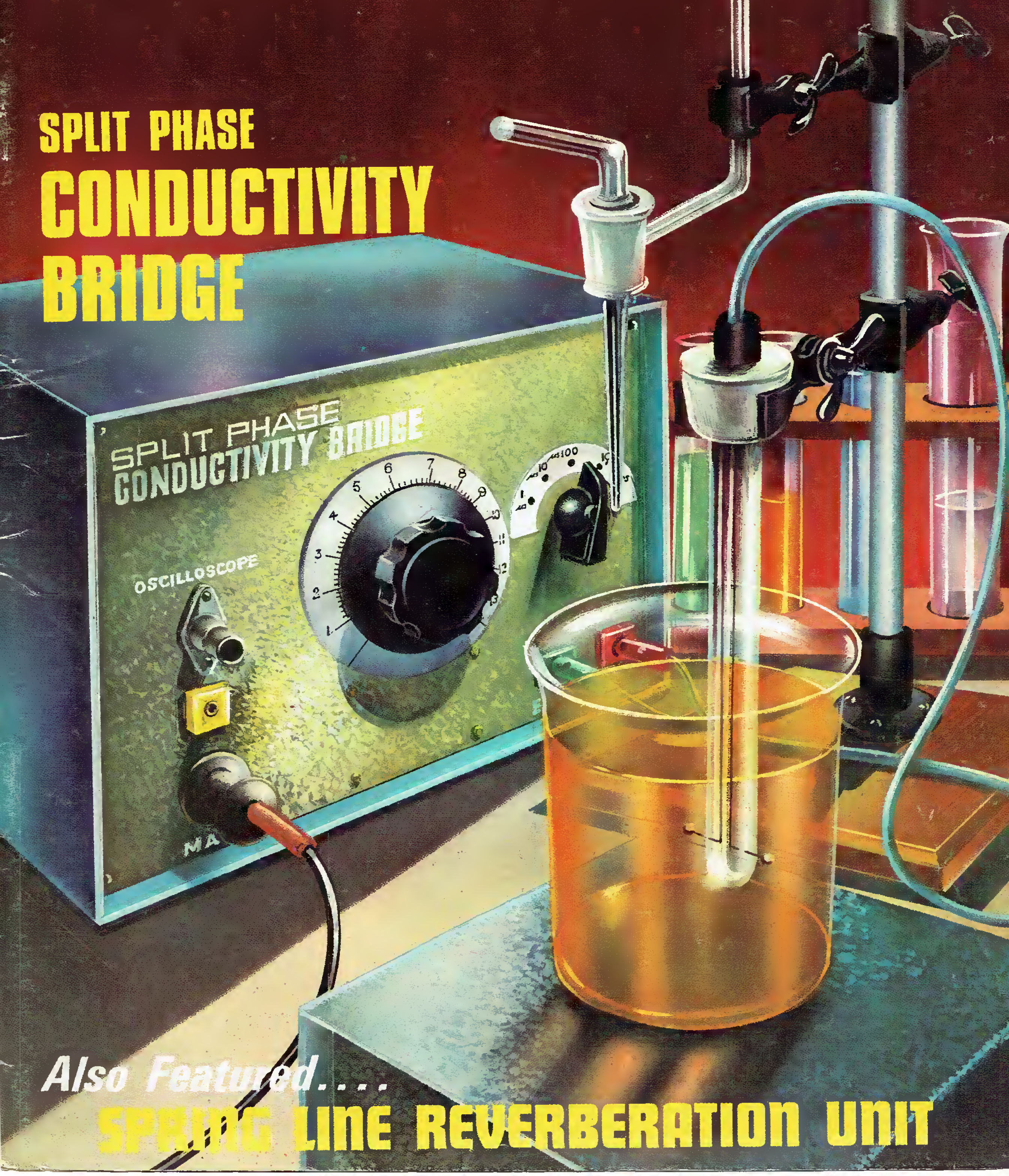
PRACTICAL
ELECTRONICS

AUGUST 1969

THREE SHILLINGS

SPLIT PHASE CONDUCTIVITY BRIDGE



Also Featured....

SPRING LINE REVERBERATION UNIT

a complete stereo system for 28 gns!

The new Duo general purpose two way speaker system is beautifully finished in polished teak veneer, with matching vynair grille. It is ideal for wall or shelf mounting either upright or horizontally. **SPECIFICATION:** Impedance 10 ohms. It incorporates Goodmans high flux 6 × 4in speaker and 2½in tweeter. Teak finish 12 × 6¾ × 5½in. **4 guineas** each, P. & P. 7/6. Garrard Changers from **£7.19.6**, P. & P. 7/6. Cover and Teak finish Plinth **£4.15.0**, P. & P. 7/6.

The Duetto — 9 GNS + 7/6 P. & P.

Integrated Transistor Stereo Amplifier

The Duetto is a good quality amplifier, attractively styled and finished. It gives superb reproduction previously associated with amplifiers costing far more. SPECIFICATION: R.M.S. power output: 3W per channel into 10 ohms speakers. **Input Sensitivity:** Suitable for medium or high output crystal cartridges and tuners. Crosstalk better than 30dB at 1Kc/s. **Controls:** 4-position selector switch (2 pos. mono and 2 pos. stereo) dual ganged volume control. **Tone Control:** Treble lift and cut. Separate on/off switch. A preset balance control.

The Classic

8½ GNS
P. & P. 7/6

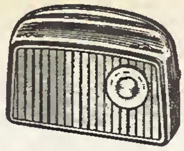
Specification: Sensitivities for 10W output at 1KHz. *Tape head:* 3mV (at 3¾ i.p.s.). *Mag. P.U.:* 2mV. *Cer. P.U.:* 80mV. *Radio:* 100mV. *Aux.:* 100mV. *Tape/Rec. output:* 100mV. Equalisation for each input is correct to within ±2dB (R.I.A.A.) from 20Hz to 20KHz. *Tone control range:* Bass ±13dB at 60Hz. Treble ±14dB at 15KHz. *Total distortion:* (for 10W output) <1·5%. *Signal noise:* < −60dB. A.C. mains 200–250V. Size 12½in long, 4½in deep, 2¾in high. Teak finished case.

The Viscount — 13½ GNS + 7/6 P. & P.

Integrated High Fidelity Transistor Stereo Amplifier

SPECIFICATIONS: Output: 10W per channel into 3 to 4 ohms speakers (20W monoral). **Input:** 6 position rotary selector switch (3 pos. mono and 3 pos. stereo). P.U., Tuner, Tape and Tape Rec. out. Sensitivities: All inputs 100mV into 1·8M ohm. **Frequency response:** 40Hz–20KHz ±2db. **Tone controls:** Separate bass and treble controls. TREBLE 13db lift and cut [at 15KHz]. BASS 15db lift and 25db cut [at 60Hz]. **Volume ontrols:** Separate for each channel. **A.C. mains input:** 200–240V. 50–60Hz. **Size:** 12½ × 6 × 2¾in in teak finished case. Built and tested. P. & P. 7/6.

THE DORSET (600mW Output)

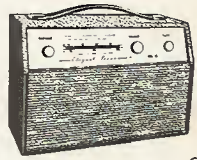


7-transistor fully tunable M.W.–L.W. superhet portable—with baby alarm facility. Set of parts. The latest modulised and pre-alignment techniques make this simple to build. Sizes: 12 × 8 × 3in. MAINS POWER PACK KIT: 9/6 extra.

Price £5.5.0
Plus 7/6 P. & P. Circuit 2/6 FREE WITH PARTS.

THE ELEGANT SEVEN Mk. III (350mW Output)

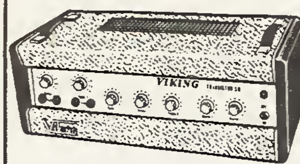
7-transistor fully tunable M.W.–L.W. portable. Set of parts. Complete with all components, including ready etched and drilled printed circuit board—back printed for foolproof construction. MAINS POWER PACK KIT: 9/6 extra.



Price **£4.9.6** + 7/6 P. & P.

Circuit 2/6 FREE WITH PARTS.

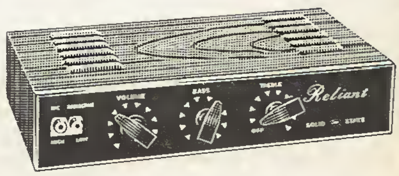
50 WATT AMPLIFIER A.C. MAINS 200-250V



An extremely reliable general purpose amplifier—with six electronically mixed inputs. Suitable for use with: mics, guitars, gram, tuner, organs, etc. Separate bass and treble controls. Output impedance 3, 8 and 15 ohms.

Price **27 GNS** + 20/- P.&P.

THE RELIANT



SOLID-STATE GENERAL PURPOSE AMPLIFIER

Specifications: *Output:* 10W R.M.S. *Output impedance:* 3 to 4 ohms. *Inputs:* 1. Xtal mic 10mV; 2. Gram/radio 250mV. *Tone controls:* Treble control range ±12dB at 10KHz; Bass control range ±13dB at 100Hz. *Frequency response* (with tone controls central): Minus 3dB points are 20Hz and 40KHz. *Signal to noise ratio:* better than −60dB. *Transistors:* 4 silicon Planar type and 3 Germanium type. *Mains input:* 220–250V a.c. *Size of chassis:* 10½in long, 4¾in wide × 2½in deep. A.c. Mains, 200–250V. For use with Std. or L.P. records, musical instruments, all makes of pick-ups and mikes. Separate bass and treble lift control. Two inputs with control for gram and mike. Built and tested. 8 × 5in speaker to suit: Price 14/6 plus 1/6 P. & P. Crystal mike to suit: 12/6 plus 1/6 P. & P. Mk. I as above, less teak case 5½ gns. + 7/6 P. & P.

RELIANT Mk. II **6½ GNS** + 7/6 P. & P. In teak-finished case

POCKET MULTI-METER

Size 3¾ × 2½ × 1¾in. Meter size 2¼ × 1¾in. Sensitivity 1,000 O.P.V. on both a.c. and d.c. volts. 0–15, 0–150, 0–1,000 d.c. current 0–150mA. Resistance 0·100kohms. Complete with test prods, battery and full instructions, 42/6. P. & P. 3/6. **FREE GIFT** for limited period only. 30W Electric Soldering Iron Value 15/- to every purchaser of the Pocket Multi-Meter.

OUR PRICE 12 for 30/-
Postage 4/6 extra

G.E.C. 13 amp surface mounting switched sockets in brown. Listed at 6/6.

12 for 21/-
Postage 4/6

W. & D. 13 amp flush sockets in green.

CYLDON 2 TRANSISTOR U.H.F. TUNER. BRAND NEW. COMPLETE WITH CIRCUIT DIAGRAM

£2.10.0 + 1/- P. & P.

B.R.S. TD2 TAPE DECK

This tape deck takes 5¾in spools complete with two-track heads. Size 13¼in long by 8¾in wide.

£8.19.6 Plus 7/6 P. & P.

THREE-IN-ONE HI-FI 10 WATT SPEAKER

A complete Loud Speaker system on one frame, combining three matched ceramic magnet speakers with a low loss cross-over network. Peak handling power 10W. Impedance 15 ohms. Flux density 11,000 gauss. Resonance 40–60c/s. Frequency range 50c/s to 20kc/s. Size 13¼in × 8⅛in × 4¼in. By famous manufacturer. List price £7. Our price 74/6 plus 5/- P. & P. Similar speaker to the above minus tweeters in 3 & 15 ohms 44/6 +5/- P. & P.

RADIO & TV COMPONENTS (ACTON) LIMITED

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RACAL RA-17

First ministry release of these world famous communication receivers. Frequency range 500 Kc/s–30 Mc/s. Available in excellent condition fully tested and guaranteed. **£150.** Carr. 40/–.

CLASS D WAVEMETERS

A crystal controlled heterodyne frequency meter covering 1·7–8 Mc/s. Operation on 6V d.c. Ideal for amateur use. Available in good used condition. **£5.19.6.** Carr. 7/6. Or brand new with accessories. **£7.19.6.** Carr. 7/6.

CLASS D WAVEMETERS No. 2

Crystal controlled. 1·2–19 Mc/s. Mains or 12V d.c. operation. Complete with calibration charts. Excellent condition. **£12.10.0.** Carr. 30/–.

MARCONI CT44/ TF956 AF ABSORPTION WATTMETER

1 μ/watt to 6 watts.

£20. Carr. 20/-.

LELAND MODEL 27 BEAT FREQUENCY OSCILLATORS

Frequency 0·20 Kc/s on 2 ranges. Output 500 Ω or 5k Ω. Operation 200/250V. A.C. Supplied in perfect order **£12/10/–.** Carr. 10/–.

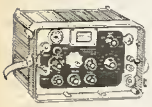
AVOMETERS

Supplied in excellent condition, fully tested and checked. Complete with prods, leads and instructions. Model 47A **£9.19.6** P. & P. 7/6.

SOLARTRON CD. 1016 OSCILLOSCOPE

Double beam. d.c. To 5 Mc/s. Excellent condition. **£55** each. Carr. 20/–.

AM/FM SIGNAL GENERATORS



Oscillator Test No. 2. A high quality precision instrument made for the ministry by Airmec. Frequency coverage 20–80Mc/s. AM/ C.W./FM. Incorporates precision dial, level meter, precision attenuator 1μV-100mV. Operation from 12V d.c. or 0/110/200/250V a.c. Size 12 × 8½ × 9in. Supplied in brand new condition complete with all connectors fully tested. **£45.** Carr. 20/-.

GEARED MAINS MOTORS

Paralux type SD19 230/250V a.c. Reversible. 30 RPM. 40 lb in. Complete with capacitor. Excellent condition. **99/6.** Carr 10/–.

SINCLAIR EQUIPMENT

Z12 12 watt amplifier, **89/6**
PZ4 Power Supply Unit **89/6**
Stereo 25 Preamp., **£9.19.6**
Q14 Speakers, **£7.19.6**
Micromatic Radio Kit, 49/6. Built **59/6**
ALL POST PAID

SPECIAL OFFER

Two **Z12** Amps., **PZ4** Power Supply, Stereo **25** Preamplifier, **£22,** or with two **Q14** speakers, **£37.**

NEW SINCLAIR 2000 SYSTEM

35 watt Integrated Amplifier **£29.** Carr. 5/- Self powered F.M. Tuner. **£25.** Carr. 5/–

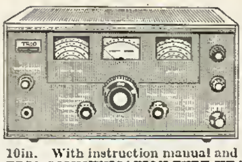
ECHO HS-606 STEREO HEADPHONES

Wonderfully comfortable. Lightweight adjustable vinyl headband. 6ft. cable and stereo jack plug. 25–17,000 cps. 8 ohm imp. **67/6** P. & P. 2/6.

UNR-30 4-BAND COMMUNICATION RECEIVER

Covering 550 Kc/s–30 Mc/s. Incorporates BFO. Built-in speaker and phone jack. Metal cabinet. Operation 220/ 240V. a.c. Supplied brand new, guaranteed with instructions. Carr. 7/6 **13 gns.**

TRIO COMMUNICATION RECEIVER MODEL 9R-59DE

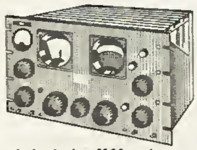


4 band receiver covering 550Kc/s to 30Mc/s. continuous and electrical bandspread on 10, 15, 20, 40 and 80 metres. 8 valve plus 7 diode circuit. 4/8 ohm output and phone jack. SSB-CW ● ANL ● Variable BFO ● S meter ● Sep. bandspread dial ● IF 445Kc/s ● Audio output 1·5W. ● Variable RF and AF gain controls. 115/250V A.C. Mains. Beautifully designed. Size: 7 × 15 × 10in. With instruction manual and service data. **£42.10.0.** carriage paid.
TRIO COMMUNICATION TYPE HEADPHONES. Normally **£5.19.6.** OUR PRICE **£3.15.0** if purchased with above receiver.

TRIO JR-500SE 10–80 METRE AMATEUR COMMUNICATION £69.10.0. Carr. Paid.

SPECIAL BONUS OFFER! TRIO SP5D Matching Speaker Mate and TRIO HS4 Communication Headphones. Normal Value £10.7.0. FREE OF CHARGE with every JR-500SE purchased.

HAMMARLUND SP600JX COMMUNICATION RECEIVER

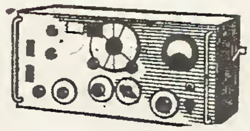


High quality professional dual conversion communication receivers. Few available again in this country at a reasonable price. Frequency range 540 Kc/s–54 Mc/s in 6 bands, variable tuning or 6 channel crystal controlled. 2·5 watt output into 600 ohms. Input 110/230V a.c. 20 valve circuit incorporating: Xtal filter, B.F.O., A.N.L., Xtal calibrator, S meter etc. Size 19 × 12 × 22in. (List £520.) Offered in excellent condition fully tested and checked. **£100** each.

LAFAYETTE LA-224T TRANSISTOR STEREO AMPLIFIER

19 transistors, 8 diodes, IHF music power, 30W at 8Ω. Response 30–20,000 ± 2dB at 1W. Distortion 1% or less. Inputs 3mV and 250mV. Output 3–16Ω. Separate L and R volume controls. Treble and bass control. Stereo phone jack. Brushed aluminium, gold anodised extruded front panel with complementary metal case. Size 10½ × 3 9/16 × 7 13/16in. Operation 115/230V. A.C. **£28.** Carriage 7/6.

MARCONI TEST EQUIPMENT



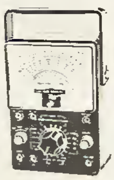
EX-MILITARY RECONDITIONED.
TF 144G STANDARD SIGNAL GENERATORS, 85Kc/s–25Mc/s, **£25,** carr. 30/–. TF.885, VIDEO OSCILLATOR. 0·5Mc/s, **£45.** Carr. 30/–. T.F. 195M. BEAT FREQUENCY OSCILLATOR 0–40Kc/s, 200/250Va.c. **£20.** carr. 30/–. TF.142E. Distortion Factor Meter, **£20.** carr. 20/-. All above offered in excellent condition fully tested and checked. TF. 1100 VALVE VOLTMETER, Brand New, **£50.** T.F. 1267 TRANSMISSION TEST SET, Brand New **£75.** TF.1371. Wide Band Millivolt Meter, **£50.**

MULTIMETERS *for EVERY purpose!*

LAFAYETTE DE-LUXE 100 KΩ/VOLT "LAB TESTER"

Giant 6½in. scale. Built-in meter protection. 0/·5/2·5/10/50/ 250/500/1,000V d.c. 0 / 3 / 10 / 50 / 250 /500 /1,000V a.c. 0/10/ 100μA /10 / 100 / 500 MA / 2·5 / 10A. 0/ 1K / 10K / 100K / 10M / 10M Ω ... –10 to 49·4dB **£18.18.0.** P. & P. 5/-.

MODEL AS-100D.



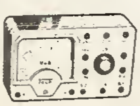
100KΩ/VOLT. 5in., mirror scale. Built-in meter protection. 0 / 3 / 12 / 60 / 120 / 300 / 600 / 1,200V d.c. 0/6/30/120/300/ 600V a.c. 0/10μA/ 6/60/300MA/12 Amp. 0/2K / 200K / 2M / 200MΩ. –20 to +17dB. **£12.10.0.** P. & P. 3 6.

MODEL TE-90 50,000 O.P.V. MIRROR SCALE OVERLOAD PROTECTION

0/3/12/60 / 300 / 600 / 1,200V d.c. 0/6/30/120/300/1,200V d.c. 0·03/6/60/600MA d.c. 16kΩ / 160kΩ / 1·6/16MΩ. –20 to +63dB. **£7.10.0.** P. & P. 3/-.

MODEL TE-70.

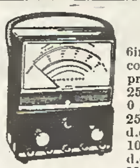
30,000 O.P.V. 0/3/15/60/300/ 600/1,200V. d.c. 0/6/ 30 / 120 / 600 / 1,200V. a.c. 0/30μA / 3/30 / 300mA. 0/16K/160K/ 1·6M / 16megohm. **£5.10.0.** P. & P. 3/-.



MODEL PT-34.

1,000 O.P.V.0/10/ 50 / 250 / 500 / 1,000V a.c. and d.c. 0/1/100/500 mA d.c. 0/100 KΩ **39/6.** P. & P. 1/6.

TE-900 20,000Ω VOLT GIANT MULTIMETER

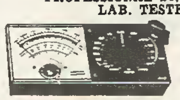


6in. full view meter. 2 colour scale, overload protection. 0/2·5/10/ 250/1,000/5,000V a.c. 0 / 25 / 12·5 / 10 / 50 / 250 / 1,000 / 5,000V d.c. 0 / 50μA / 110 / 100 / 500mA 10A d.c. 20K / 200K / 20 MΩ. **£15.** P. & P. 5/-.

LAFAYETTE

57 Range Super 50,000 O.P.V. Multimeter. D.c. Volts 125V-1,000V A.c. Volts 1·5V-1,000V D c. Current 25μA-10 Amp. Ohms. 0·15 MegΩ dB.—20 to +81dB. Overload Protection. **£12.10.0.** Carr. 3/6.

PROFESSIONAL 20,000 O.P.V. LAB. TESTER



Automatic overload protection, mirror scale. Ranges: 1/10/ 50 / 250 / 500/ 1,000 volts, d.c. and a.c 0–500μA, 10mA, 250mA. Current: 0/20K, 200K. 2 megohm. Decibels: —20 to +22dB, **£5.19.6.** P. & P. 2/6.

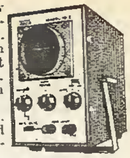
MODEL TE 80.

20,000 O.P.V. 0 / 10 / 50 / 100 / 500 / 1,000V. a.c. 0/5/25/50/ 250 / 500 / 1,000V d.c. 0·5μA. 5/50/500mA/ 0/6K/60/K/600K/6 Meg. **£4.17.6.** P. & P. 3/-.

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 **£5.19.6.** P. & P. 3/6.

TO-2 PORTABLE OSCILLOSCOPE



A general purpose low cost economy oscilloscope for everyday use. Y amp. Bandwidth 2 CPS-1 MHZ. Input imp. 2 megΩ 25 P.F. Illuminated scale. 2in tube. 115 × 180 × 230mm. Weight 8lb. 220/240V a.c. Supplied brand new with handbook **£22.10.0.** Carr. 10/-.

FIELD TELEPHONES TYPE L

Generator ringing, metal cases. Operates from two 1·5v. batteries (not supplied). Excellent condition. **£4.10.0.** per pair. Carr. 10/-.

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. **£17.10.0.** Carr. 5/-.

AUTO TRANSFORMERS

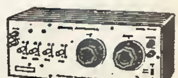
0/115/230v. Step up or step down. Fully shrouded.

150 W.	**£1.12.6,**	P. & P. 3/6
300 W.	**£2.7.6,**	P. & P. 3/6
500 W.	**£3.10.0,**	P. & P. 6/6
1,000 W.	**£5.10.0,**	P. & P. 7/6
1,500 W.	**£6.10.0,**	P. & P. 8/6
7,500 W.	**£15.10.0,**	P. & P. 20/–

TE22 SINE SQUARE WAVE AUDIO GENERATORS

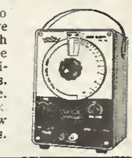
Sine: 20c/s to 200 Kc/s on 4 bands. Square: 20c/s to 30Kc/s. Output impedance 5,000 ohms. 200/250V. A.C. Supplied brand new and guaranteed with instruction manual and leads. **£16.10.0.** Carr. 7/6.

TE111. DECADE RESISTANCE ATTENUATOR



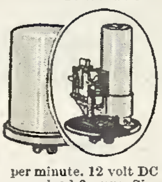
Variable range 0–111dB. Connections. Unbalanced T and Bridge T. Impedance 600Ω range (0·1dB × 10) + (1dB × 10) +10 + 20 + 30 + 40dB. Frequency: d.c. to 200kHz (–3dB). Accuracy: 0·05dB. +indication dB × 0·01. Maximum input less than 4W (50V). Built in 600Ω load resistance with internal/ external switch. Brand new **£27.10.0.** P. & P. 5/-.

TY75 AUDIO SIGNAL GENERATOR



Sine Wave 20c/s to 200kc/s. Square Wave 20c/s to 30kc/s. High and low impedance output. Output variable up to 6 volts. 220/240 volts a.c. Size 210 × 150 × 120mm. Brand new with instructions. **£16.** Carr. 7/6.

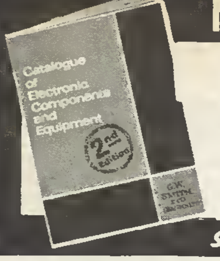
CAR LIGHT FLASHERS



Heavy duty light flasher employs a condenser discharge principle operating on electro mechanical relay. (As inset.) Housed in strong plastic case. Flashing rate between 60-120 per minute. 12 volt DC operation. Maximum load 6 amps. Size 2 11/16" dia. × 4". Supplied brand new at a fraction of original cost. **6/6** each P. & P. 2/6. (3 for **17/6** P.&P. 4/6).

Full range of all components ● Valves ● Semi-conductors ● Test equipment ● Receivers ● Hi-fi equipment ● All at discount prices.

G. W. SMITH & CO (RADIO) LTD.
Also see oppos. page



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Nearly 200 pages giving full details of a comprehensive range of COMPONENTS, TEST EQUIPMENT, COMMUNICATION EQUIPMENT AND HI-FI EQUIPMENT.
Each section greatly enlarged and fully illustrated. Thousands of items many at bargain prices.
FREE DISCOUNT COUPONS VALUE 10/-.

SEND NOW-ONLY 7/6 P&P 1/-

GARRARD

FULL CURRENT RANGE OFFERED, BRAND NEW AND GUARANTEED AT FANTASTIC SAVINGS

SRP22 Stereo	£5.19.6	*SL55	£11.19.6
*1025 Mono	£7.10.0	A70 MKII	£12.10.0
*1025 Stereo	£7.15.0	*AT60MKII	£13. 5.0
*2025 Stereo	£7.19.6	*SL65	£14.14.0
*2025T/C Mono/Stereo	£8.17.6	AP75	£17.17.0
		401	£28. 7.6
*3000 Stereo	£9.19.6	SL75	£28.10.0
SP25 MKII	£11.19.6	SL95	£35. 0.0

Carriage/insurance 7/6 extra any model. WB4 Bases £3.19.6. Perspex covers £3.10.0. *Special offer base and cover available for these models at £4.15.0. Carr. 5/-. Full range of Garrard accessories available.

TYPE 13A DOUBLE BEAM OSCILLOSCOPES

An excellent general purpose D/B oscilloscope. T.B. 2 c/s–750 kc/s. Bandwidth 5·5 Mc/s. Sensitivity 33 mV/CM. Operating voltage 0/110/200/250 V. a.c. Supplied in excellent working condition. £22.10.0. Or complete with all accessories, probe, leads, lid, etc. £25. Carriage 30/-.

ADMIRALTY B.40 RECEIVERS

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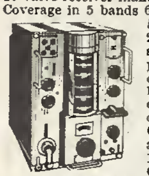

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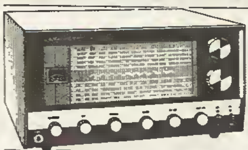

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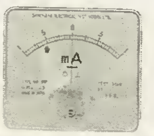

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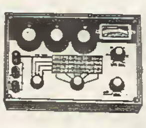

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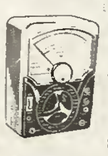

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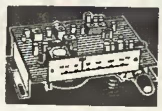

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2N706	3/-	ADT140	12/6	BSX20	3/3	OC36	13/-
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2N930	6/6	AF118	16/6	BY100	5/-	OC72	4/6
2N1131	9/6	AF124	6/-	BYX10	4/9	OC73	3/-
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2N1302	4/6	AF139	15/-	BYZ12	6/-	OC76	2/6
2N1303	4/6	AF239	12/-	BYZ13	5/-	OC77	8/8
2N1304	5/-	AF186	11/-	GET102	6/-	OC81D	3/-
2N1305	5/-	AFZ12	11/9	GET103	4/6	OC82	4/6
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2N3708	3/-	BCY33	4/8	OA70	1/6	EC401	5/-
2N3709	3/-	BCY34	6/4	OA73	1/6	EC402	4/8
2N3710	4/-	BCY38	8/-	OA79	1/6	C111E	18/-
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2N3820	23/6	BCY54	15/3	OA90	1/6	2C425	32/-
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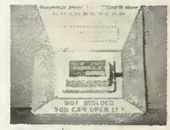

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¼ Watt 10% Tolerance—
Voltages:

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6·4V	6·4	25	50	100	200	320
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25V	1·6	6·4	12·5	25	50	80
40V	1	4	8	16	32	50
64V	0·64	2·5	5	10	20	32
Price	1/6	1/3	1/2	1/-	1/1	1/2

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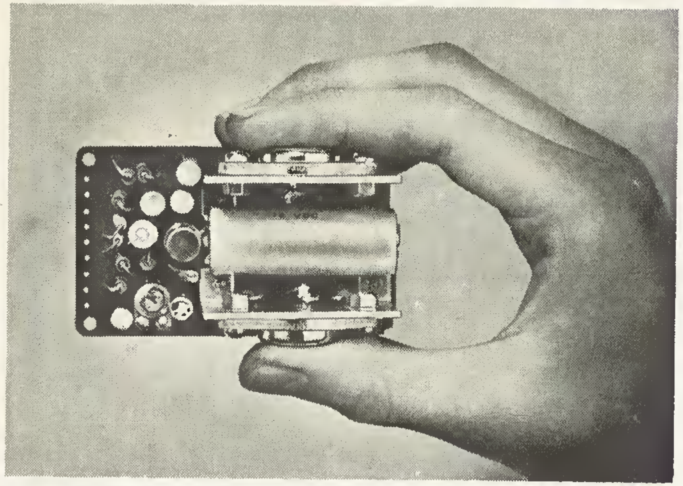

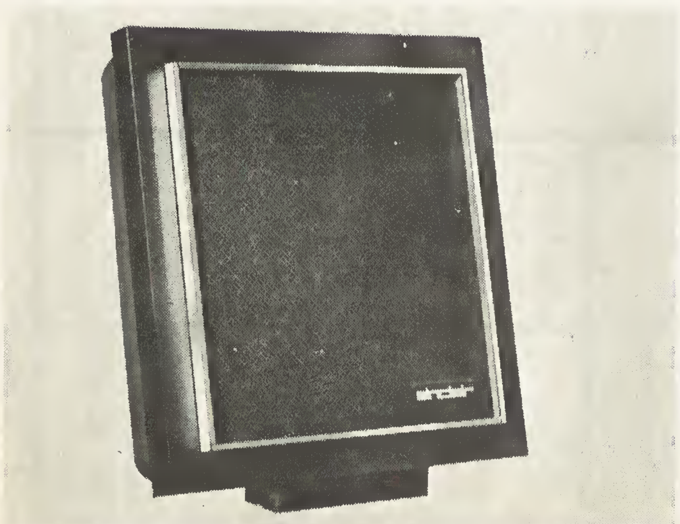

With Sinclair you can buy a total stereo assembly or choose units to add to or modify existing installations. Each of the products shown here is the result of intensive research and development, representing a new and original approach in each case to users' needs. Each product has achieved unsurpassed standards of performance, quality and value, while for individual radio listening, there is the very efficient Micromatic, which is also the world's smallest radio.

Z.12 12 WATT HIGH-FIDELITY AMPLIFIER AND INTEGRATED PRE-AMP

SPECIFICATIONS

Compact, powerful 12W high fidelity amplifier and integrated pre-amp. 8 special transistors are used. The ultra-linear Class B output is suitable for loudspeakers from 3 to 15 ohms (two 3-ohm speakers may be used in parallel) Output power—12W R.M.S. continuous sine wave (24W peak) 15W music power (30W peak). Frequency response 15-50,000Hz. ± 1dB. Input sensitivity 2mV into 2K ohms. Signal to noise ratio is better than 60dB. With power requirements from 6 to 20V d.c., the Z.12 can be run from a car battery or the PZ.4 for example. Size 3 × 1¾ × 1¼in. Supplied ready built, tested and guaranteed.

APPLICATIONS

Hi-fi system (2 required for stereo): car radio: P.A. systems: electric guitar: electronic organ: intercom system: record player: laboratory and industrial use, etc.

89/6

Q.14 HIGH FIDELITY LOUDSPEAKER

SPECIFICATIONS

Compact high-fidelity loudspeaker of outstandingly good performance and value it has smooth frequency response from 60 to 16,000Hz; loading capacity up to 14W R.M.S. Input impedance—4 ohms. With special drive unit in a sealed, seamless pressure chamber ensures excellent presence and transient response. Size—9¾in square × 4¾in deep on pedestal base; black matt finish with aluminium bar trim. It is the speaker which has won so much praise from reviewers in the technical press.

APPLICATIONS

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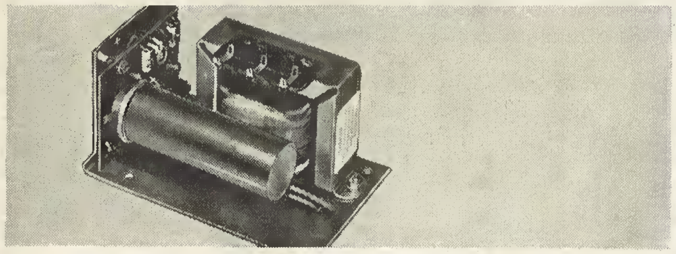
+ 2/11 P/T Surcharge



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STEREO 25 PRE-AMP AND TONE CONTROL UNIT

SPECIFICATIONS

Pre-amplifier and tone control unit with treble boost/cut from +12dB to —10dB at 10KHz, bass boost/cut from +15dB to —12dB at 100Hz. Stereo balance, volume and selector switch controls. Inputs—Mic. 2mV into 50K ohms, P.U.—3mV into 50K ohms, Radio 20mV into 20K ohms. P.U. input corrected to within ±1dB on R.I.A.A. curve from 50 to 20KHz. Front panel in brushed and polished aluminium. Size $6\frac{1}{2} \times 2\frac{1}{2} \times 2\frac{1}{2}$in plus solid aluminium knobs.

APPLICATIONS

For use with two Z.12's and PZ.4, can also be used with other good stereo amplifier systems.

£9.19.6

PZ.4 STABILISED POWER SUPPLY UNIT

SPECIFICATIONS

Stabilised mains power supply unit, delivering 17·5V d.c at 1·5 amps. Assured constant output under severest operating conditions. For a.c. mains 200/250V 50Hz.

APPLICATIONS

Systems using one or two Z.12's and Stereo 25, etc.

99/6

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Kit in fitted pack with earpiece, solder, etc.

49/6 +1Id P/T Surcharge

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Mallory Mercury Cell type RM.675 (2 required) 2/9 each

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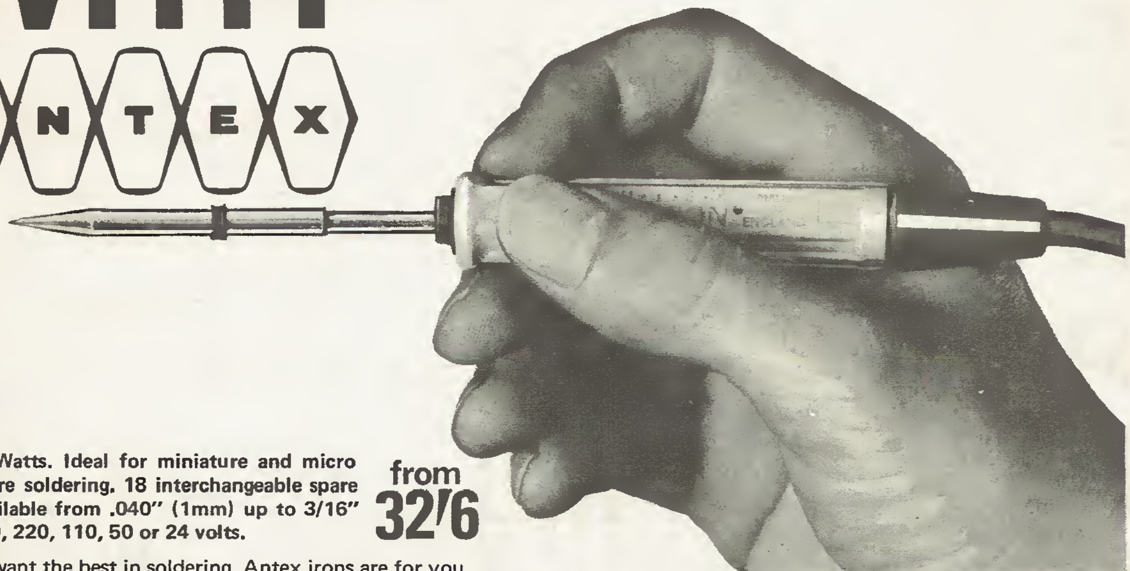

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- Felt cleaning pad
- Stand for soldering iron
- Space for stowage of lead and plug

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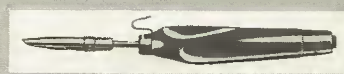
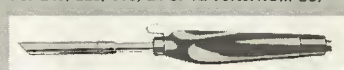


ES 25 watts. Fitted with 1/8" bit. Interchangeable bits 3/32", 3/16" and 1/4". Ideal for high speed production lines. For 240, 220, 110, 24 or 12 volts. from 35/-



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VOL. 5 No. 8
August 1969

PRACTICAL ELECTRONICS

OUT OF SPACE

THIS is the day and age of instant communication, and nowhere is this better epitomised than in space exploration. Some of the impact the imminent moon landing should have on us earth dwellers will be blunted through familiarity with previous space voyages brought right into our homes by television. It is all so matter-of-fact, or so the marvels of electronics make it seem to the viewing millions. Let us hope minds will not be too jaded to sense the magnitude of the achievement and to thrill to the momentous occasion when man sets foot on earth's own satellite, the moon, for the first time.

Yet we fear discordant voices will be heard again, even on this unique occasion. One of the charges that could be made against instant communication is the ease with which minds can be conditioned by over exposure to the television screen. So it is to be expected that a chorus of complaints will arise from some of those temporarily deprived of their favourite programme. There are those who are intolerant of any disturbance of their cosy dream world populated by fictional characters, whose performances as often as not are pre-recorded and later resuscitated from film or video tape by electronic devices. The live show going on in space has tough competition!

Communications systems are the life line of every space project, and not only manned spacecraft. The less spectacular unmanned satellites perform a variety of useful functions. The communications satellites have been much in the public eye, since they already contribute regularly to the relaying of television programmes, amongst other services. Less is generally known about the proposed remote sensing satellites.

These, it is forecast, could perform broad scale surveys of earth agricultural, forestry, and mineral resources; and gather data about ocean currents, movement of icebergs, flow rate of rivers, and so on. With their aid it would be possible to obtain data from areas of the earth not otherwise accessible to man.

A host of specially developed electronic instruments would be carried in these survey satellites. Included would be sensors operating in all parts of the electromagnetic spectrum: long waves through to microwaves, and infra-red and light waves. Neither the land regions nor the ocean depths would be able to conceal their secrets from these electronic or photographic eyes.

The vast expenditure on space is often challenged, and the value of the return in the form of commercial "spinoffs" open to question. Nevertheless it would be churlish to deny the exciting prospect of international economic betterment opened up through the use of data collecting satellites, which would have the whole globe under surveillance.

F. E. Bennett—*Editor*

THIS MONTH

CONSTRUCTIONAL PROJECTS

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GENERAL FEATURES

NEWS AND COMMENT

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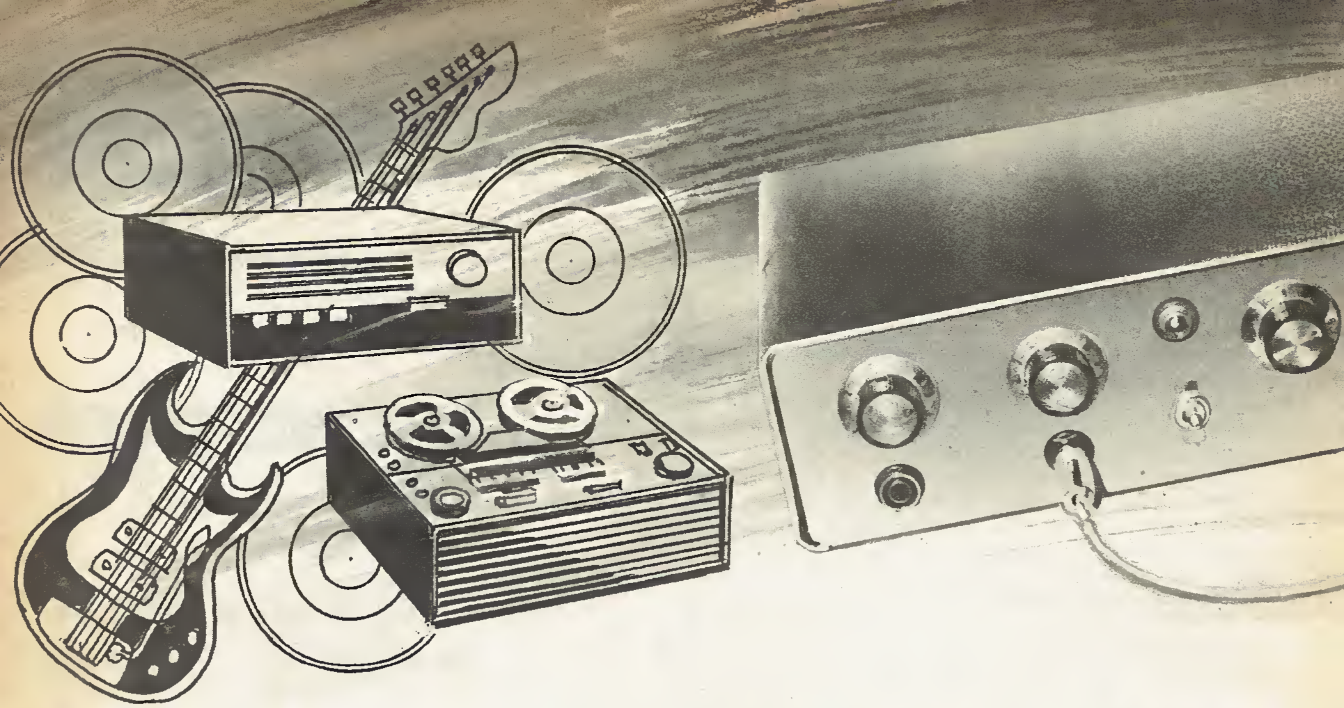


SPRING LINE REVERBERATION

THE SPEED of sound through air, water, and metal is quite slow when compared with its speed in the form of an electrical signal through wires. Good use can be made of this to create echo and reverberation, by employing an arrangement like that shown in Fig. 1. Here the direct electrical sound signal is mixed with its delayed acoustic counterpart after the latter has travelled via the loudspeaker and microphone. This is the principle of the so-called "echo chamber".

However, the real object of the system is not to create separate and distinctive echoes, like those obtained with a magnetic tape system, but rather a series of very short duration echoes gradually, but eventually, completely dying away.

This is called reverberation and is achieved by the use of hard surfaced walls which cause the sound to bounce backwards and forwards until it decays completely. A degree of reverberation varying from that of a small room to a large church hall can be produced by controlling a mixture of the reverberant and direct signals.

A rather more sophisticated but very expensive arrangement, known as metal plate reverberation, is now used by recording and broadcasting studios. The idea is similar to that of the echo chamber illustrated in Fig. 1 but employs metal instead of air as the delay medium.

The main component is a thin steel plate approximately 6ft by 3ft suspended in a tubular metal frame (see Fig. 2). The plate is excited into vibration at one end by means of a moving coil driving unit and these vibrations are picked up at the other end by special contact microphones. However, the vibrations continue to travel backwards and forwards along the plate until they die away, thus producing the "reverberation" effect previously described.

The spring line system (Fig. 3) operates in much the same way as a plate reverberator, the echo time being a few milliseconds, but the reverberation time is long—up to about two seconds. The spring line is driven by an electro-magnetic unit and the signals are picked up at the far end by another. The signals from the line output are mixed with the direct signals as in Fig. 4.

A spring line reverberator requires fairly large signals to drive it and, since the output signals are small, these must be amplified to bring them to a level approximately equal to the direct signal. A block diagram of the system is shown in Fig. 4.

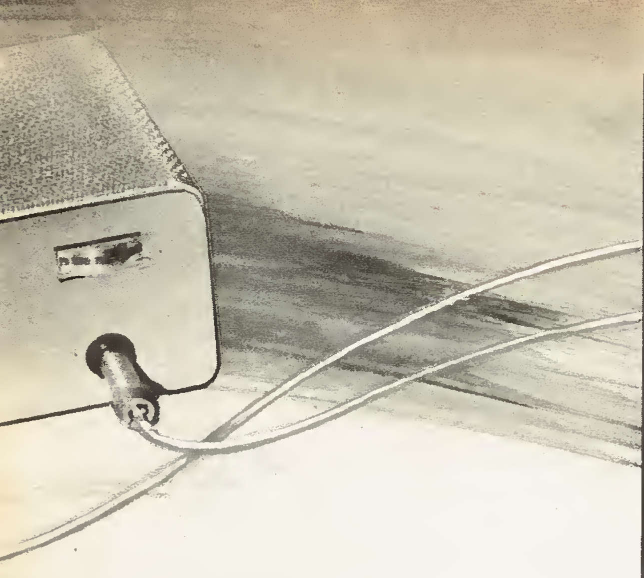
SPRING LINE REVERBERATION

The circuit given in Fig. 5 employs a spring line unit type HR42 (see components list). Reverberation times from a fraction of a second up to approximately 2·5 seconds are available and with the reverb. control off the through signals are of course "dry", i.e. no reverberation. The unit can therefore be used to simulate reverberation varying from that of a small room to a large empty hall.

Two medium impedance inputs are provided, each of which can be mixed, the input signal requirements being from about 100mV minimum up to 1 volt maximum. The input signals are first amplified by TR1 and TR2, the output from TR2 being divided through R9 to the line driver TR5 and through R10 to the output amplifier TR3 and TR4.

The output signals from the spring line unit are first amplified by TR6 and TR7 and then returned via the reverb. control VR4 and R11 to the output amplifier. The direct and reverberated signals are therefore mixed at the junction of R10 and R11.

As the signals from the spring line unit are added to the direct signals, it is quite easy to overload the output



UNIT

By F. C. JUDD

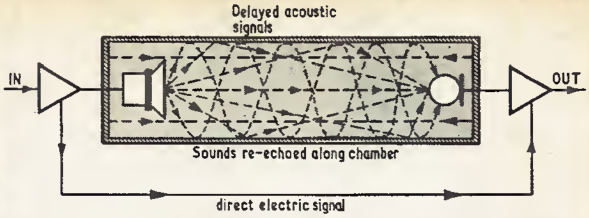


Fig. 1. The echo chamber system in diagrammatic form with the direct bypass line

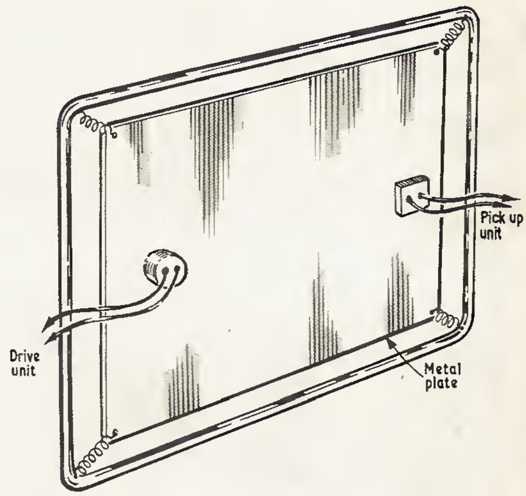


Fig. 2. Basic idea of the metal plate reverberator

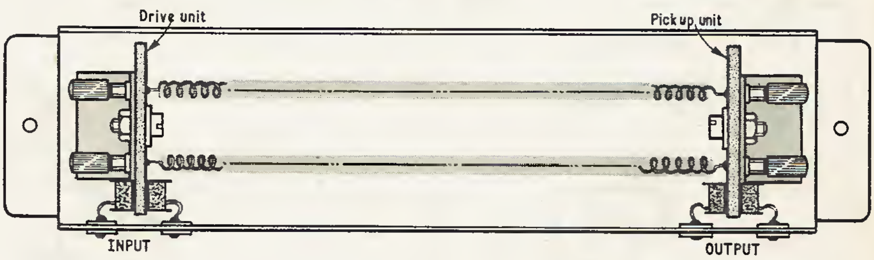


Fig. 3. Basic spring line reverberation system

SPECIFICATION . . .

Frequency range	20 to 20,000kHz
Frequency response	−3dB at 20Hz, −2dB at 20kHz (ref. level at 1kHz)
Distortion (without reverb.)	Less than 0·5 per cent
Reverb. frequency range	Approx. 100 to 4,000Hz
Signal to noise ratio	Better than 50dB
Minimum input required with VR1 or VR2 set to full gain	100 to 150mV
Maximum signal output	1 volt
Input impedance (either channel)	10 kilohms
Output load impedance	Not less than 1,000 ohms or 600Ω at reduced output signal level)

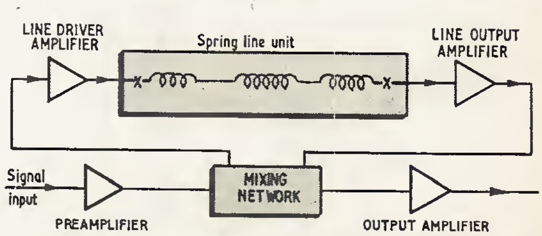


Fig. 4. Block diagram of the complete spring line reverberation system described in this article

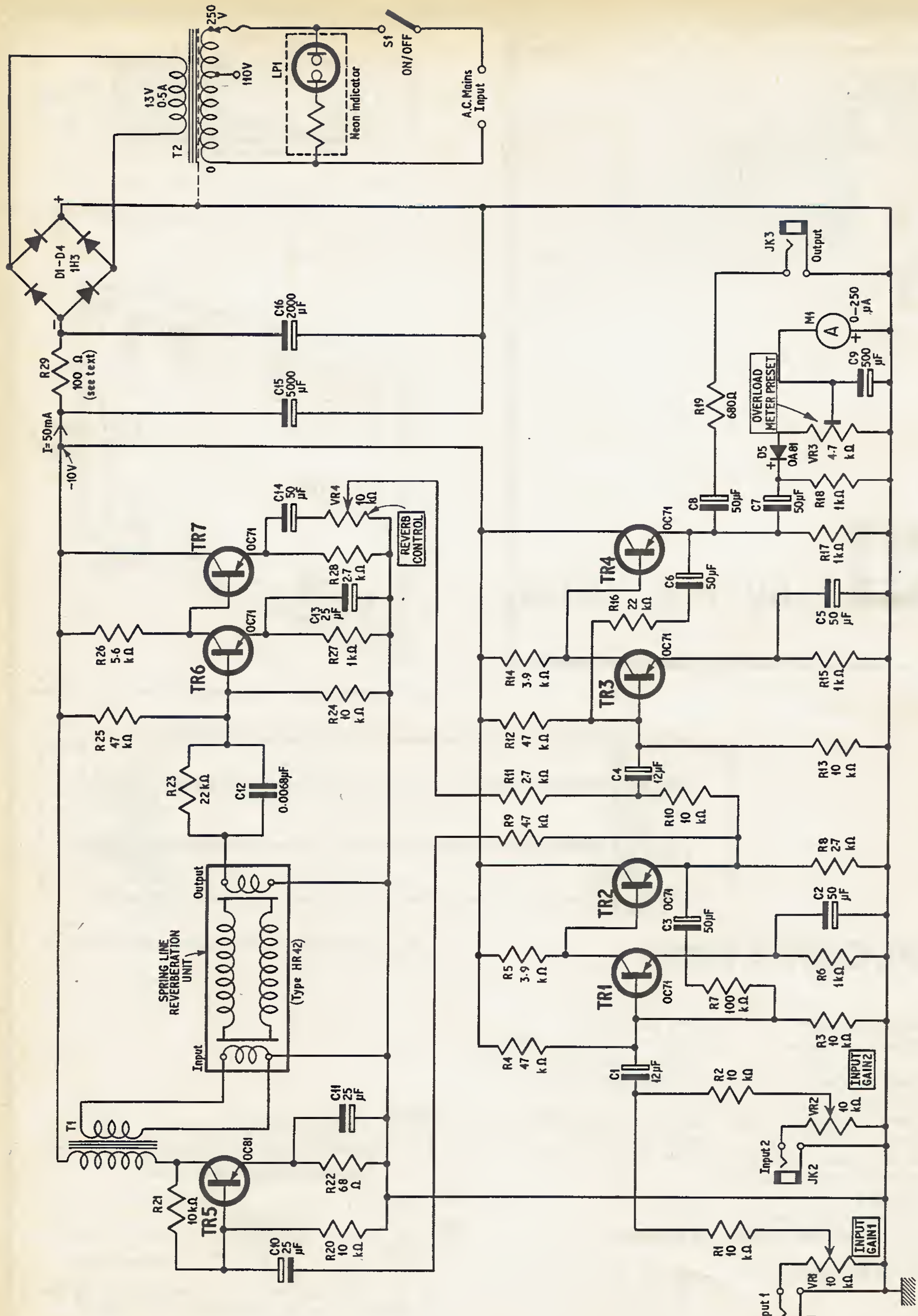


Fig. 5. Circuit diagram of the complete spring line reverberation unit

COMPONENTS . . .

Resistors

R1	10kΩ	R11	2·7kΩ	R21	10kΩ
R2	10kΩ	R12	47kΩ	R22	68Ω
R3	10kΩ	R13	10kΩ	R23	22kΩ
R4	47kΩ	R14	3·9kΩ	R24	10kΩ
R5	3·9kΩ	R15	1kΩ	R25	47kΩ
R6	1kΩ	R16	22kΩ	R26	5·6kΩ
R7	100kΩ	R17	1kΩ	R27	1kΩ
R8	2·7kΩ	R18	1kΩ	R28	2·7kΩ
R9	4·7kΩ	R19	680Ω	R29	100Ω
R10	10kΩ	R20	10kΩ		(see text)

Potentiometers

VR1 10kΩ log.
VR2 10kΩ log.
VR3 4·7kΩ or 5kΩ log. preset
VR4 10kΩ log.

Capacitors

C1	12μF elect. 25V	C9	500μF elect. 25V
C2	50μF elect. 12V	C10	25μF elect. 15V
C3	50μF elect. 12V	C11	25μF elect. 15V
C4	12μF elect. 25V	C12	0·0068μF paper 200V
C5	50μF elect. 12V	C13	25μF elect. 15V
C6	50μF elect. 12V	C14	50μF elect. 12V
C7	50μF elect. 12V	C15	5,000μF elect. 15V
C8	50μF elect. 12V	C16	2,000μF elect. 25V

Transformers

T1 3·75 : 1 2 watt car radio output transformer; secondary 3 to 5 ohms (Repanco type TT12)
T2 Primary 0–110, 250V mains; sec. 13V 0·5A with electrostatic screen. Type PS12/5

Spring Reverberation Unit

Model HR42 (full details in Henry's Radio catalogue)

Transistors

TR1, 2, 3, 4, 6, 7 OC71 (6 off)
TR5 OC81

Diodes

D1 to 4 30V 400mA Contact cooled bridge rectifier type 1H3 (one unit)
D5 OA81

Meter

M1 250μA 280 ohms level meter type V250

Lamp

LP1 Neon mains indicator with ballast resistor

Switch

S1 Single-pole, on/off, toggle

Jacks and plugs

JK1, JK2, JK3 Tip and sleeve standard jacks with screened plugs

Miscellaneous

Perforated s.r.b.p. 0·15in pitch without copper strips 5in × 3in (2 off)
Angle aluminium strip ⅜in to support perforated boards
Aluminium case 11¼in × 6⅛in × 3¼in (Electroniques type 2222)
Control knobs with numbered skirts

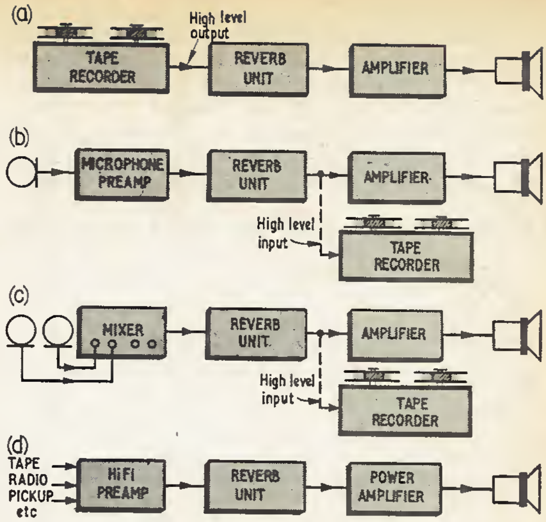


Fig. 6. Various ways in which the unit can be used: (a) adding reverb to a pre-recorded tape; (b) recording from a microphone; (c) mixing two microphone signals for recording; (d) adding reverberation effects to any sound source

mixing amplifier. An overload meter has therefore been provided which can be adjusted by the preset control VR3 to indicate the onset of overload when the pointer reaches approximately 0·75 of full scale reading.

The meter should have a 250μA movement; the one chosen for the prototype reverb unit has a horizontal scale type used for recording level indication on tape recorders. It is coloured red above about 0·75 of full scale. An ordinary round scale meter could of course be used.

PERFORMANCE

As the current consumption of the unit is a little on the high side (50mA) for economical battery operation, a mains power supply consisting of T2, the bridge rectifier D1 to D4, and the smoothing components C15, C16 and R29 have been included.

The ample smoothing ensures negligible ripple on the supply, in fact the total hum and noise level of the unit is around 50dB below an output signal level of 1 volt. Note that the value of R29 may have to be adjusted slightly to obtain the correct line voltage if the supply transformer is other than that used for the prototype (see components list).

The frequency range of the unit extends from 15Hz to well over 20,000Hz, the response being −3dB at 20Hz and −2dB at 20,000Hz (reference 1,000Hz). Note that the response of the spring line amplifier section has been adjusted to suit the characteristics of the HR42 unit. The performance of the unit is given in the specification.

The circuit provides for fairly flexible use; for instance, it can be fed from signal sources with impedances ranging from about 600 ohms up to one megohm or so, and it can be coupled to a following amplifier or tape recorder with input impedances ranging from about 1,000 ohms to a megohm or more.

The prototype has been tested with microphone mixers, tape recorders and amplifiers of different types and can be used in various ways as shown by the block diagrams in Fig. 6. The unit has insufficient sensitivity for the direct connection of microphones or pick-up cartridges; a pre-amp will be necessary to achieve the required signal level in this case.

CONSTRUCTION

The entire circuitry was built in an Electroniques aluminium case type 2222, as shown in the photographs. Details of the panel layout and the distribution of the amplifier boards and power supply components within the case are given in Fig. 7. The two amplifier sections are assembled on perforated s.r.b.p. boards cut to size and fitted with a mounting bracket as shown in Fig. 7.

The layouts of the components on the two amplifier boards shown in Figs. 8 and 9 are as used in the prototype. Note that the components for the overload meter (C7, C9, R18, the meter rectifier D5 and pre-set control VR3) are located on board B. The OC81 transistor (line driver) on this board must be provided with a wrap round type heat sink.

It is most important that the spring line unit is mounted with the output end furthest from the mains transformer T2, otherwise there is a risk of hum being induced in the spring line pick-up coil.

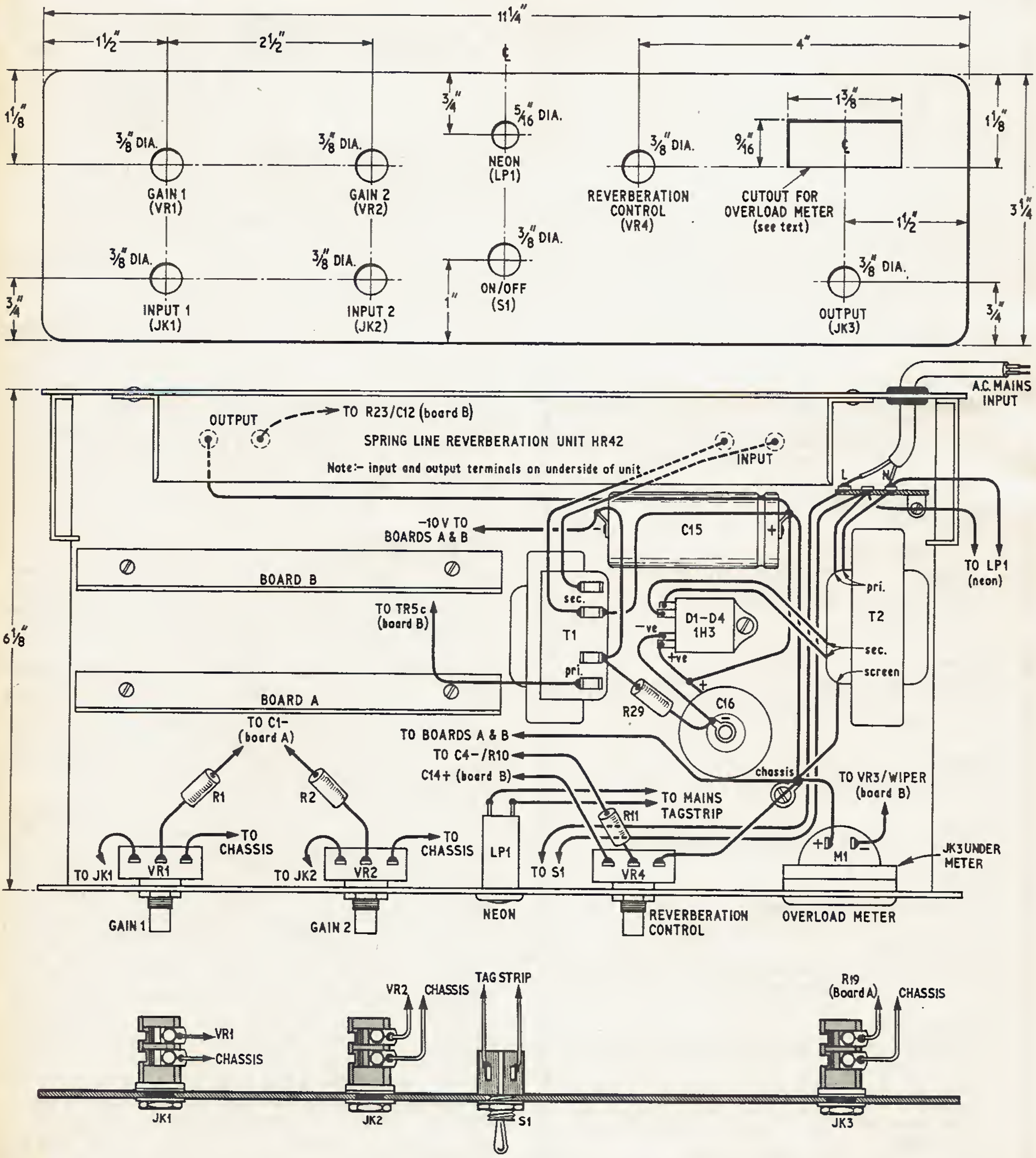


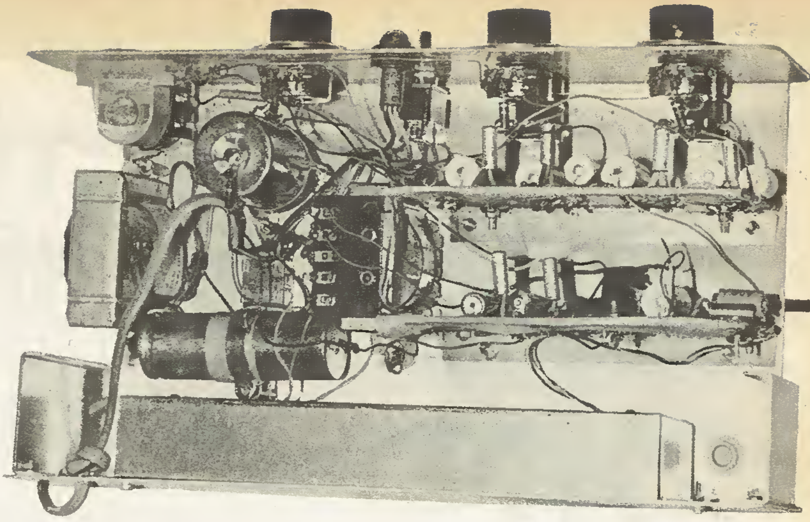
Fig. 7. Drilling details for front panel and layout of boards and components in the case

TESTING THE UNIT

A satisfactory performance will be obtained if the unit can be tested with an audio signal generator and high impedance transistor or valve voltmeter. First test the unit with the reverb control off.

With an input signal of 100 to 150mV r.m.s. (either input) the output should be approximately 1 volt r.m.s. The input gain control in use should be at maximum for this.

Now reduce the input signal until the output level is approximately 300mV. The preset control VR3 is now adjusted until the overload meter reads approximately half scale. The onset of overload will be indicated (with or without the reverberation on) when the meter reads approximately 0·75 full scale or at the beginning of the red section if the meter is as indicated in the components list.



The interior showing the position of the circuit boards, the spring line unit and the layout of the power supply components, etc.

The frequency response curves given in Fig. 10 may be useful for checking each of the amplifier sections. The overall response is of course that between input and output with the reverb. control turned off.

The response of the spring line driver amplifier only (TR5) can be checked between C10 and the secondary of T1, and should approximate to that shown in Fig. 10.

The response of the spring line output amplifier TR6/TR7 can be checked between the input to C12/R23 (with the spring line disconnected) and the output at the junction of VR3 and C14. The response should approximate to that in Fig. 10 and has been adjusted to suit the characteristics of the spring line unit.

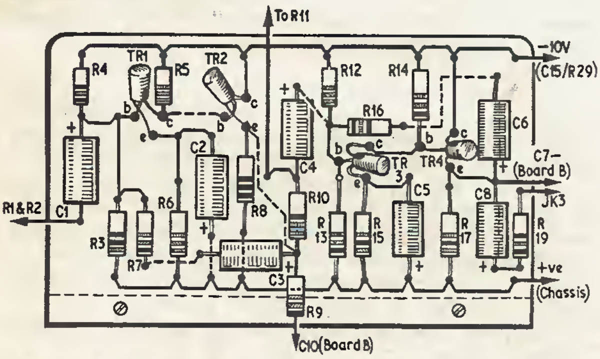


Fig. 9. Assembly board "A". Layout of components for the input and output amplifiers

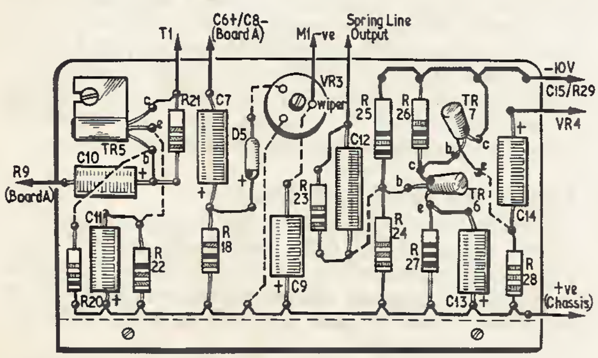


Fig. 8. Assembly board "B" layout of components. This contains the spring line driver amplifier, its output amplifier and the components for the overload meter

REVERB UNIT IN USE

A unit of this nature is intended for the simulation of reverberation in varying degrees ranging from that of a small empty room to the longer and slightly more hollow sounding reverberation of a large hall.

If used excessively, especially on music, the effect can be unpleasant or at least unnatural. The real object of this form of reverberation is to introduce an effect, i.e. to simulate changes in acoustic environment, in plays for instance, where the speaker moves from the open air to an interior.

It can also be used by vocalists to create the "singing-in-a-cathedral" sound which is perhaps more pleasant than the tape-head type of echo for this particular application.

One final point concerns the placement of the unit when in use. Spring lines are very sensitive to mechanical vibration and can give an effect like valve microphony. Do not place the unit too close to a loudspeaker that carries reverberated signals. Avoid knocking the unit whilst it is in use; it may be worthwhile standing the unit on a rubber cushion.

Finally, a note on components: all components are readily available. Deviation from the recommended types in the components list could result in inadequate performance compared with the given specification. ★

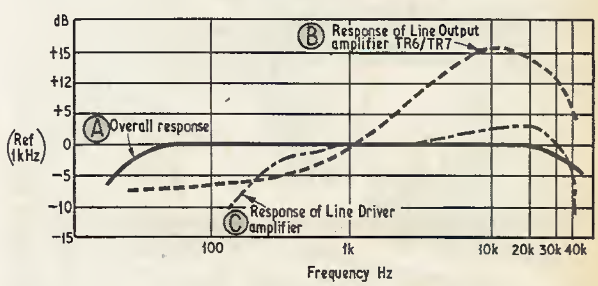


Fig. 10. Frequency responses: (a) overall response of the spring line reverberation unit; (b) line output amplifier and (c) line driver amplifier

ELECTRONICS for the BOAT OWNER

By M. Kenward

MANY thousands of small craft are driven, blown, rowed and even pedalled off shore, up-river or around lakes every weekend and, as with almost every other sport, electronics is there if required to aid every captain and helmsman.

Many of the smaller craft that are used for racing and cruising from the host of clubs both on inland waterways and around the coast find little call for electronics aboard. Often these craft are protected by various electronic aids supplied by their clubs and by such people as the coast guards, the R.N.L.I., the R.N. and the R.A.F.

Owners of larger craft do however find a greater need for electronic aids of one kind or another.

The Decca 101 marine radar installed in a yacht. The display unit can be seen through the cabin window

AVAILABLE RANGE OF EQUIPMENT

Over the last ten years the introduction of electronic navigational and emergency warning devices to craft of all sizes has become more widespread. Specialist electronic firms have done much for the development of suitable equipment in this field and now produce high quality units that have been carefully designed, manufactured and tested with the smaller boat owner in mind.

The evolution of the highly scientific racing yacht has also brought about electronic racing aids. The use of electronics in racing yachts is restricted in the various classes but nowadays most of the cruising classes and the boats in the junior offshore group are well equipped with various instruments as are the larger offshore power boats.

Instruments showing relative wind direction to boat heading and boat speed are now available for the smaller craft and are beginning to be introduced in racing dinghys, although their use has recently been restricted.

The first and main interest of the larger yacht owner is one of navigation and positional "fixes" especially during bad weather. The range of electronic equipment now available for this purpose is vast and covers a field from electronic gyroscopic compasses and marine radar as used in large vessels, down to direction finding (d.f.) accessories that can be used with transistorised radios.

Nowadays marine radar is fairly standard on the larger motor yachts (for those who can afford such luxuries) and one system that appears repeatedly is the Decca 101. The photograph shows a typical installation with the aerial and transceiver unit mounted on the cabin roof and the display and power supply units inside the cabin. The major advantages of this system is the absence of wave-guide and the associated installation problems that can often be very costly.

AIDS FOR SMALLER CRAFT

Coming down in boat size to the now very popular 15 to 30ft range. Many firms manufacture small "aids" to the yachtsman which are mainly operated from their own internal batteries. These instruments are designed to be water resistant and can thus be mounted in the cockpit if so desired.

Most firms list instruments covering the range, boat speed and distance travelled through the water (not allowing for currents), depth of water, apparent wind direction (in two scales—one for sailing "on the wind"), and windspeed indicators.

Recently introduced equipment by Brookes and Gatehouse is the "Hadrian" automatic dead reckoning computer and the "Helios" radio compass.

The d.r. computer is an innovation in the range of electronic gear for small craft and has been designed for use with the Harrier log and Hestia electronic compass from the same firm. This computer has an accuracy, depending on the calibration of Harrier and Hestia, of 180ft per mile sailed maximum (neglecting errors in tidal and leeway allowances).

Repeater meters are available for most of the instruments and some firms market special housings for mounting repeaters. The bottom photograph shows a typical layout of instruments in a modern racing yacht. The cost of such an installation would be in the region of £400 to £1,000.

As any readers who are also concerned with such racing craft will know, these instruments are now considered necessary by owners and the cost is just another addition to their already expensive sport.

Many readers may have previously considered the possibility of constructing their own instruments and some suggestions will be made later in this article. A great saving in cost can be achieved by constructing some of the various aids.

For the dinghy sailor and runabout owner, the range of electronic instruments is limited and many people argue that these instruments detract from the enjoyment of small boat sailing. However, instruments such as boat speed and revolution counters for power craft and apparent wind direction indicators for sailing dinghys are available although, unless these devices are home constructed, the price may be prohibitive.

Commercial equipment can cost as much as a small boat—about £60 for a wind indicator. Such instruments are normally only used by the "experts". Once again, boat owners must check if such instruments are allowed by class rules if they are to be used when racing.

RADIO EQUIPMENT

Radio equipment for small craft can mean anything from a small emergency distress signaller—not necessarily a communication link—to a telephone transmitter-receiver. There are many firms marketing equipment in this range and the price of distress beacons is no longer prohibitive when one considers their life saving ability.

The photographs in this article show examples of distress and radio equipment used by small craft. Most small receivers are available with d.f. equipment and some have this facility built in.

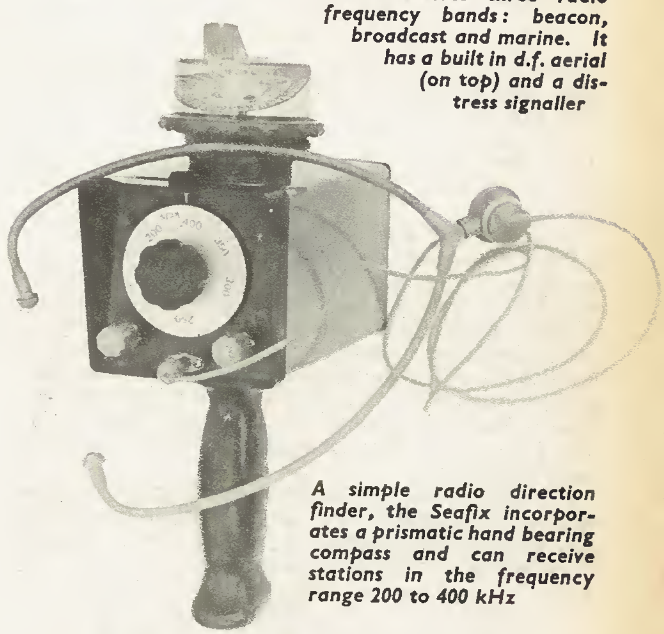
Generally radio direction finding equipment relies on the operator getting a null indication, either on a meter or earphones, of the signals transmitted by the various navigational beacons around the coast and, in the case of aircraft beacons, inland. This process has the disadvantage that the result is ambiguous and the operator has a choice of two directly opposite readings; however, results can be verified by taking a second reading on another beacon.

It should be pointed out that such instruments cannot give an exact positional "fix"; they are intended as an aid to navigation and are in this respect excellent instruments.

DESIGN POINTS FOR THE CONSTRUCTOR

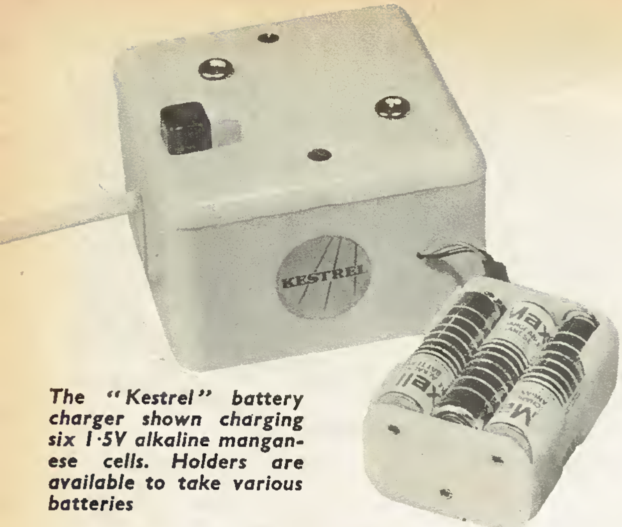
The amateur constructor in this field must restrict himself to the more simple equipment and, unless

The Nova Pal portable radio direction finder. This instrument receives three radio frequency bands: beacon, broadcast and marine. It has a built in d.f. aerial (on top) and a distress signaller



A simple radio direction finder, the Seafix incorporates a prismatic hand bearing compass and can receive stations in the frequency range 200 to 400 kHz

A complete installation of Brookes and Gatehouse instruments showing repeaters mounted in a special console where they are easily seen by the helmsman. The navigator is shown taking a radio fix on a beacon



The "Kestrel" battery charger shown charging six 1·5V alkaline manganese cells. Holders are available to take various batteries

calibration facilities are available to him, equipment upon which his safety does not depend! Although this rules out such instruments as direction finders and possibly depth sounders, because of the circuit complexity and the need for accurate readings, the constructor still has a large range of possibilities open to him.

There are, of course, certain special considerations to be made when designing and building equipment to be used afloat. The major factors to be taken into account are those concerned with protecting equipment from the elements, stock and misuse.

When installed in small craft the instruments are very likely to get sprayed or even covered in salt water and protection must be afforded them for this reason. Careful choice of material for cases and meters is a must and all materials should be protected by a marine paint of some kind.

The shock factor may at first seem slightly odd but after sailing in a small boat, punching into a heavy sea, this suggestion will appear more reasonable. Shock also comes under the term misuse.

Many sailors have no knowledge of electronics and if a reading is disbelieved the unknowing person will flick switches and try to "persuade" the instrument to correct itself with a friendly "pat on the back".

Not all boats use the same supply voltage; on most small craft this can be 12, 24 or 36 volts. This voltage must be checked before the circuit is designed and fitted if it is to be supplied from the boat's internal power.

Many proprietary devices are equipped with internal batteries (but this can prove expensive) and a battery voltage checking facility should be provided. There are some small battery chargers now available for recharging alkaline manganese cells and these can result in a saving of battery costs—one unit for this purpose is the "Kestrel" battery charger available from DCB Instruments and Lighting as shown left.

A few items that the home constructor, having some knowledge of electronics, should be able to construct and install are given below with suggested operational methods and the various difficulties that may arise. (This magazine hopes to be able to publish some constructional articles of the following nature in the future—Ed.)

It is suggested that all the electronic parts of the various aids are enclosed in die-cast metal cases of the type often used for "normal" electronic work. These cases should be carefully painted both inside and out and as few holes as possible made in the outer surface; lids should be sealed by thin strips of rubber.

Protection to the circuit board itself can be carried out in many ways but generally this prevents components being changed and should not be necessary if the case is carefully sealed.

WIND SPEED INDICATOR

The main design problem connected with the wind speed indicator is the type of "transducer" to be used. One of the easiest ways of measuring wind speed is to convert the revolutions of a normal anemometer speed indicator into electrical pulses and measure the frequency of the resultant output.

The conversion of rotation to an electrical signal must be done with little or no friction being applied to the rotor. Two possible methods of arranging this conversion are:

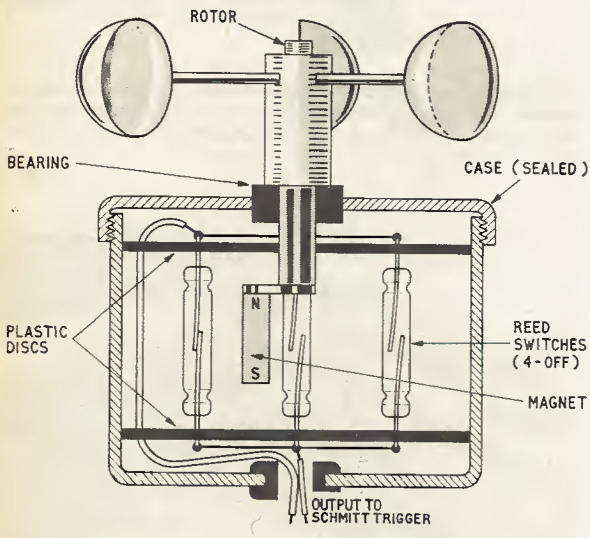


***Fig. 1.** Mechanical construction of wind speed indicator using reed switches*

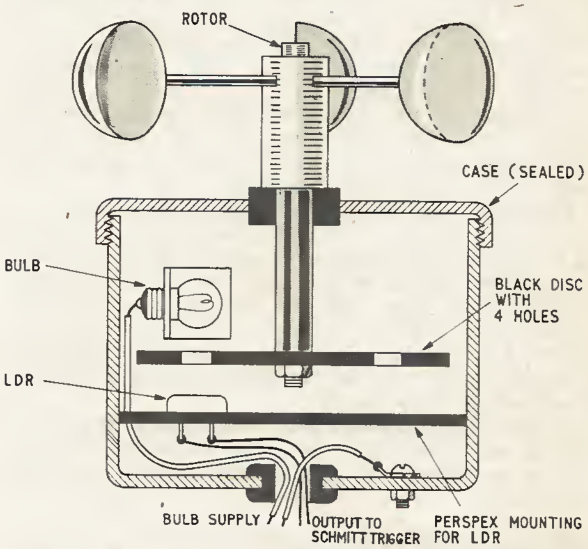
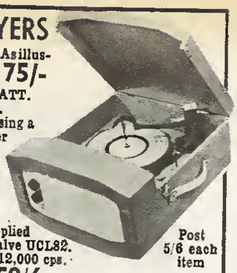


***Fig. 2.** Mechanical construction of wind speed indicator using an l.d.r.*

DE LUXE PLAYERS



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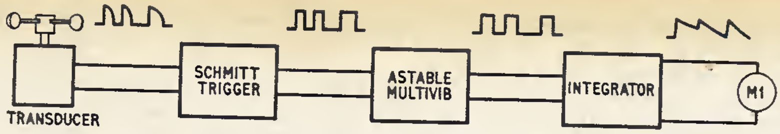


Fig. 3. Block diagram of basic circuit for the wind speed indicator

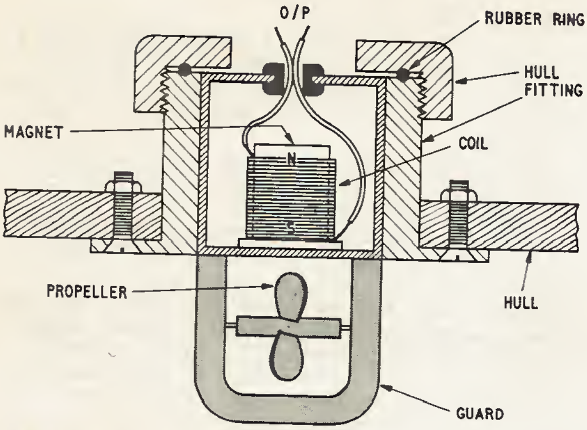


Fig. 4. Mechanical construction of boat speed indicator showing the hull fitting

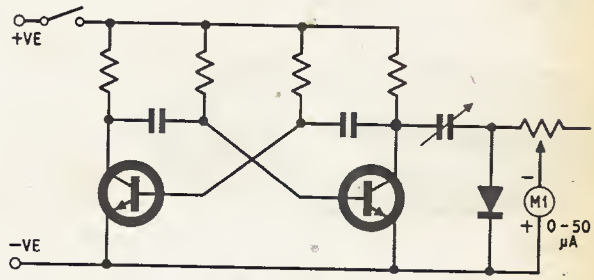


Fig. 5. Basic circuit for the apparent wind direction indicator. Circuit values depend on supply voltage and the value of the variable capacitor used

(1) By firing reed switches with a magnet attached to the rotor (see Fig. 1).

(2) By arranging a rotating mask with holes in to block the light from a bulb falling on a light dependent resistor. Thus the resistance of the l.d.r. will change each time the holes in the mask allow light to fall on its sensitive surface (see Fig. 2).

Method (1) is fairly simple to make and set up but, to give a steady meter reading at low wind speeds, three or four reed switches should be used to step up the frequency.

Method (2) has the obvious disadvantage that a supply to feed the bulb must be provided. However, if the case around the l.d.r. is made light-proof apart from one hole, the ambient light can be used during daylight hours to operate the l.d.r. It is possible that the mast-head light on larger sailing craft could be used for firing the circuit at night but this calls for careful arrangement of the anemometer which may not always be possible or practical.

WIND SPEED CIRCUITRY

The circuitry used for both measuring methods would be essentially the same and should consist of a Schmitt trigger to shape the pulses coming from the transducer and provide a square wave output. This square wave is then used to trigger an astable multivibrator circuit which will provide a train of equal duration pulses, the frequency of which will vary in sympathy with the speed of rotation of the "transducer".

The pulse length must be carefully chosen to accommodate the maximum possible frequency or the frequency corresponding to the highest wind speed to be measured.

These pulses are then fed to an integrator circuit which will provide an output, the amplitude of which will vary with the frequency of the input. Thus a meter reading can be obtained that varies linearly with wind speed. Fig. 3 shows a block diagram of the electronics involved in the windspeed indicator.

BOAT SPEED INDICATOR

Once again the design and manufacture of a transducer presents a greater problem than the electronics. The most suitable method is to use a small propeller, that is driven around by the water moving past the boat, to induce a frequency into a coil by placing the propeller in a magnetic field. The induced signal can then be amplified by a single transistor stage and the frequency measured—possibly by the same method as given above—to produce a voltage output and thus a meter reading of boat speed.

There are various pitfalls in this method, the major one being that slip of the propeller is not taken into account and an accurate calibration method must be found. The accuracy of the instrument can be altered quite drastically depending on its underwater position.

A suggested transducer arrangement is shown in Fig. 4. If possible the transducer should be made removable in order to free it of any weed or other debris that may foul it.

It is normal practice to link the speed indicator to an electronic log that indicates distance travelled through the water, but this can be difficult for the amateur and if attempted the final unit must be accurate if it is to be of any use. Again this type of instrument would be difficult to calibrate accurately.

WIND DIRECTION INDICATOR

This is probably one of the easiest instruments that the boat owner can construct and also one of the most useful, especially when sailing on the wind or when sailing at night. The transducer is simply a variable capacitor of about 100pF. To this capacitor is attached the wind vane. The bearings should be made free running by degreasing them before installation, and the capacitor must be of the continuously rotating type; able to be varied from 1–2pF to its maximum value.

The variable capacitor is placed in circuit as shown in Fig. 5 and the potentiometer set to give an f.s.d. reading on the meter with maximum capacitance in circuit. The meter is then calibrated 90–0–90 degrees corresponding to the increase of the capacitance from minimum to maximum (see Fig. 6). It may be necessary to supress the meter zero point slightly by using the manual "set zero" control.

With the vane set on the capacitor as shown in Fig. 7 the meter will read from 0 degrees to 90 degrees as the apparent wind direction to the boat varies from head-on to abeam, and then return from 90 degrees to 0 degrees as the wind direction moves from abeam to dead astern. Thus, by this method wind position all around the boat can be shown although some ambiguity may arise when the apparent wind is at 90 degrees to the boat's heading.

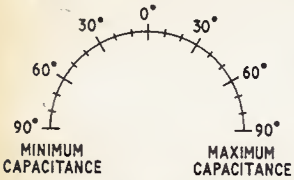


Fig. 6. Meter calibration for the apparent wind direction indicator

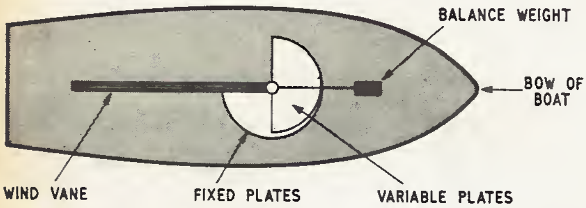
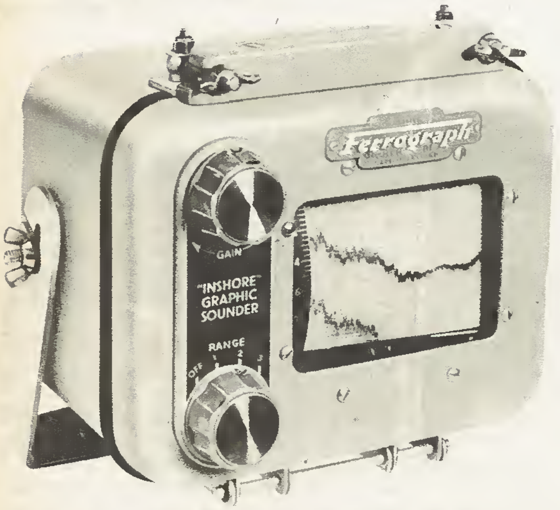


Fig. 7. Showing arrangement of the wind vane and capacitor plates with respect to the boat



The Ferrograph graphic echo sounder that gives a continuous permanent record of depth

A marine radiotelephone giving 25 watts of transmitted power and covering the frequency ranges 1·6 to 3·8MHz (transmitter) and 160kHz to 4,100kHz (receiver). Manufactured by Ajax Electronics Ltd

WATER LEVEL ALARM

It is very easy to forget to pump the bilge during a prolonged passage and, whilst this is hardly ever dangerous, water in storage lockers and all over the floor and engine can be very annoying and possibly expensive.

Again an electronic gadget of simple design and construction can be used to give advanced warning of the depth of bilge water.

Water level is sensed by two wire probes across the base emitter junction of a *pnp* transistor. When the probes are not under water the resistance across them is almost infinite and the transistor is turned off. As soon as water covers both probes a current path is formed between them thus turning on the transistor.

By the use of one or two stages and a suitable power transistor or relay, the circuit can be made to turn on a warning device of some description.

OTHER ELECTRONIC AIDS

Various other simple gadgets are also useful aboard small boats, many of which are described in these pages from time to time. A few examples are as follows.

Light operated switch. This device can be very useful when moored in an area where riding lights are necessary. The switch can be wired up to turn on the light in the evening and off again at dawn. This can result in power saving and the worry of remembering to switch on and off.

D.C.–A.C. converter. This equipment can be useful in many ways and is fairly simple to construct although the power output is limited. Such things as fluorescent lights, electric shavers and other low power a.c. equipment can be operated from the boat's d.c. supply.

Burglar alarm. Many boats are left moored in rivers, often amongst hundreds of others, and are vulnerable to theft. Although a burglar alarm may not necessarily prevent this, it is a great deterrent to the would-be thief.

All that is necessary is a number of microswitches on the hatches, wired in parallel to a latching relay circuit that feeds on alarm. The relay should be connected to a simple time switch to turn it off after two or three minutes, and reset for subsequent readiness.

By this method the alarm will be sounded as soon as a hatch is opened and will continue to sound, even if the hatch is then closed, until the timing circuit resets it.

Although not electronic, radar deflectors, generators and rotary converters are also very useful items to have aboard.

There are many other uses for electronics in sailing and not only for use aboard small craft, e.g. power amplifiers for use by clubs to give directions to members and for starting signals.

There are also many devices such as detectors for gas and petrol fumes and distress signallers that have not been discussed because of design considerations and calibration problems. However, perhaps the more inventive readers of this magazine may be able to overcome some of the inherent problems. ★

SPACEWATCH

By Frank W. Hyde

OTHER MOONS

It has been suggested by J. Bagby of the Hughes Aircraft Company that Earth has at least ten natural satellites. This claim is based on recent telescopic and photographic observations. The data gathered together by Bagby on suspected observations, when added to the indirect evidence available, indicated that several moonlets existed. From this evidence orbits were calculated.

A thorough search carried out last year with a camera having a very large field of view revealed two satellites in the orbits that had been predicted. The size of these moonlets is of the order of 100 feet in diameter.

The indirect evidence for the existence of such bodies comes from the perturbations of the orbits of artificial satellites. In particular *Explorer 26* showed a marked jump in its orbit inclination, and also in its apogee and perigee distance in December 1965. This was caused, it is said, by moonlet IIIc, and it is a fact that natural satellites could cause the anomalies that have been noted in more that 150 cases.

On theoretical grounds it is quite possible for Earth to capture small bodies but it has not been generally accepted that it has done so. The important thing about this present claim is that if the orbits are projected backwards in time it suggests that there was a large natural satellite circling the Earth until December 1955, at which time it broke up leaving the debris in orbit.

STARS WITH PLANETS

Some of the results of a lifetime study of nearby stars has been released by Peter van de Kamp. According to his special observations of sixty of the near stars, no less than seven have planetary companions. They are dark and unseen so a special technique is required to establish their existence.

Briefly the technique is to watch the star over long periods of years by regular photographic exposures. The photographs are compared in a special viewing unit which shows up any variations or wobble against the background stars.

Van de Kamp has photographs which cover the last thirty years of observations and the wobble he has detected indicates the effects of gravity caused by the unseen companion.

One star, 61 Cygni, is some eleven light years away and has a planet that revolves round its parent in approximately five years. Its mass is about one hundredth that of the Sun. Another star known as Barnard's star has a very rapid motion across the sky and in this case it is easy to detect small changes in its motion. It is probable that it has two planets.

Of the seven stars with planets, Van de Kamp has calculated the masses of five of the planets that accompany them. These masses are not greater than the masses of Saturn or Jupiter and it is not thought that they could support life as we know it.

For example, Barnard's star, as a sun to its possible two planets, is too cold to have conditions like Earth. However, should some of the other stars such as 61 Cygni have intelligent life it will be eleven years before they learn of earthmen journeying to the moon.

MORE MASCONS ON THE MOON

The number of known "mascons" (mass concentrations) is now increased to twelve according to a report from the Jet Propulsion Laboratory of California Institute of Technology. Radio tracking of the lunar orbiter spacecraft has revealed six more areas which show the characteristic change in gravity.

Four of the new mascons are under typical ringed plains and these are well delineated and are named Mare Crientale, Grimaldi, Mare Humboldtianum and Mare Smythii. Although the other two have the appearance of partially obliterated mare areas, they have not been considered significant enough to be given names, and are therefore known by their latitude and longitude co-ordinates.

There is still an open mind on these oddities and what they are; two current suggestions are that at one time there was considerable water on the moon and the other a simple suggestion that in fact the maria are at a much higher level than was originally thought. Here is one project at least for the lunar explorer of the future.

JETS MAY CHASE LUNAR SHADOW

On the 7 March 1970, there will be a total eclipse of the Sun and it is hoped that it may be possible to chase the shadow with a jet aircraft for about ninety minutes, thus keeping in view the chromosphere and corona.

So much has to be done in the short period of totality (about 3·5 minutes) that any extension of the period must be of great value to observers. The U.S. Air Force reconnaissance aircraft *SR-71A* could follow the track of the shadow at a supersonic speed of 1,400 knots or so.

In 1970 the path of totality runs from south west of Mexico north eastward over the Gulf of Mexico and Florida and thence over Newfoundland. If the aircraft flew between 65,000 and 75,000ft unique observations could be made, as the eclipse would be seen against a dark cloudless sky with only about a thirtieth of the atmosphere above the plane and clear of all water vapour.

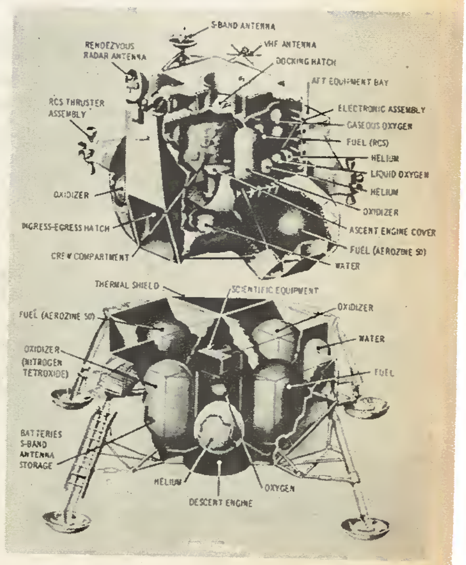
This would enable so many important observations to be made at the same time that the million dollars required for the conversion would be well worth while, particularly as the same plane could be used for subsequent eclipses, of which there are six in the next ten years.

SIZE OF ICARUS

Caltech's Jet Propulsion Laboratory have determined that the asteroid Icarus, which comes very close to Earth on occasions, is about 900 metres in diameter. It has a rotation period of between 1·5 and 3·3 hours.

The measurements were made over a three day period at the Goldstone tracking station where one of the 26 metre aerials was fitted with a 450kW transmitter operating at 2,388MHz. The receiving aerial was at Goldstone's 64 metre aerial located 23 miles from the transmitter.

The distance of Icarus at that time was 6×10^6km from Earth so that the round trip of the radar pulses was about 43 seconds. The echoes were faint but readable and while the composition of the minor planet cannot be determined from such measurements the indications are that it is jagged, and in the words of Dr R. M. Golstein "somewhat oval and rough like a peach stone".



The Apollo II Lunar Module in which astronauts Armstrong and Aldrin will descend to the surface of the moon

QUANTITATIVE measurements at very high radio frequencies usually involve expensive test gear or, alternatively, somewhat devious methods of obtaining the desired result. This is particularly so when relatively low voltages and currents are to be measured.

This r.f. wattmeter is a simple instrument, devised to give accurate readings of power over an extremely wide frequency range, extending to the v.h.f. band.

One well tried method of establishing the magnitude of an r.f. current is to use it to heat a short, straight length of resistance wire, then to assess the amount of heat developed. The virtues of this system are that the current path is short, the wire has a very small self-capacitance, and a minimum of self-inductance, thus making calibration virtually independent of frequency.

Starting at 60mW, the scale proceeds by divisions of 3mW up to the maximum reading of 120mW, corresponding to the full scale deflection of the meter. By the use of shunts, described later, a much wider range can be covered.

No on-off switch is necessary in the instrument, as the dark current of the ORP60 is a minute fraction of a microamp. The probe leads should, however, always be disconnected whenever the bulb is removed from its tube, as ambient light could overload the meter.

SIMPLE ASSEMBLY

The prototype was built in a small box, measuring 4in square by 2½in deep (Fig. 3). This can be made from plastics materials, wood, or hardboard. A large hole

R.F. WATTMETER

By D. BOLLEN

Thermocouple ammeters and hot-wire ammeters work in this way but have the disadvantages of being somewhat insensitive and very prone to burn out when overloaded. Another even simpler method is the familiar flash-lamp bulb and loop, used to give rough indications of power maxima when coupled to small transmitters.

A refinement of this is the photometric method of comparing the brilliance of the bulb when illuminated by an r.f. current with its brilliance when fed from a known d.c. source.

With a suitable bulb, outputs of less than 100 milliwatts can be accurately measured, and if the bulb blows it can be replaced without difficulty and at low cost.

Normally, photometric methods of measurement are somewhat cumbersome but if a light meter is used, directly calibrated in terms of electrical power, the device becomes very simple. Taking this as a starting point, the following circuit was evolved.

LIGHT PROOF CYLINDER

The bulb is contained in a small light-proof cylinder together with a light dependent resistor (l.d.r.). As the bulb glows, the resistance of the l.d.r. drops and this change is measured by the simple ohmmeter circuit of Fig. 1. With suitable adjustment of VR1, a linear reading can be obtained over a major portion of the meter scale, allowing direct calibration.

The graph in Fig. 2 shows that there is a serious departure from linearity below the 100μA division on the meter, but this is, if anything, an advantage as the result is a usefully expanded scale with a suppressed zero.

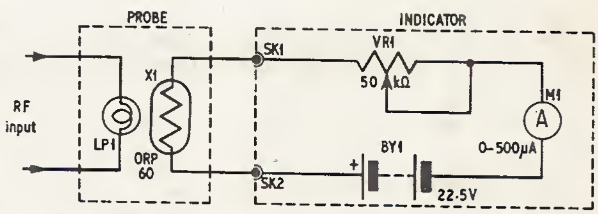


Fig. 1. Complete circuit of the r.f. wattmeter

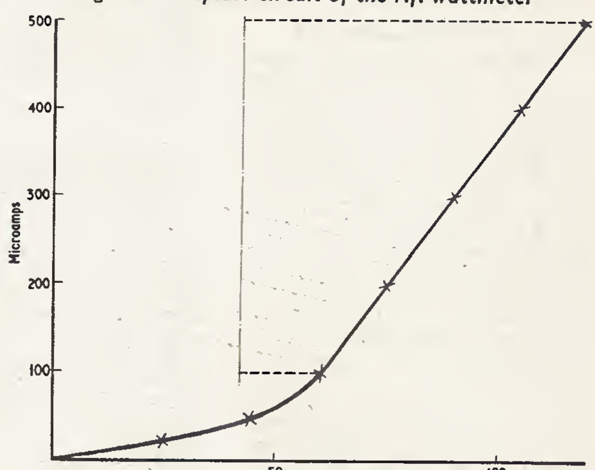


Fig. 2. Graph showing the relationship between the 500μA meter scale and the power measurement calibration required

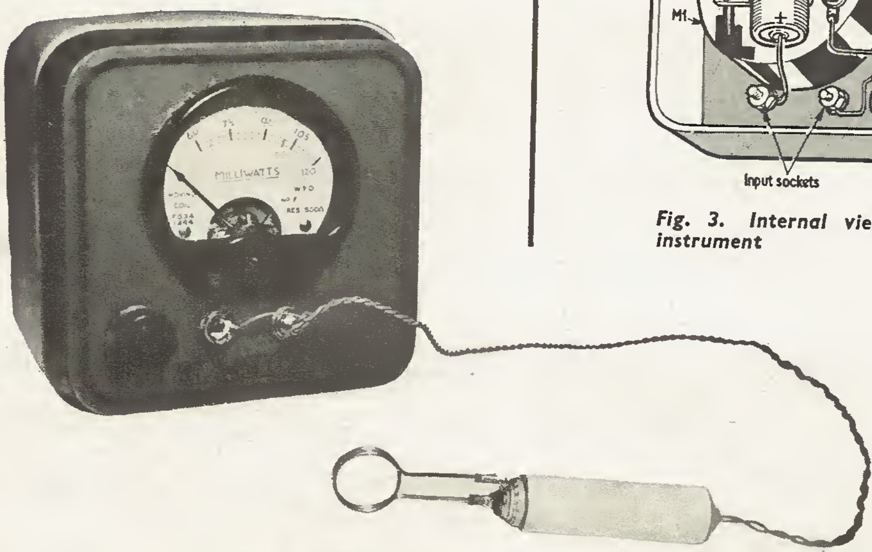
is cut into the lid to take the meter movement. Sufficient space must be allowed when positioning so that the potentiometer (VR1) and the terminals can also be fitted to the lid. These terminals can be of the press stud variety, taken from transistor radio batteries, or screw terminals could be employed if first-class contact is to be assured.

The 22½ volt hearing-aid battery specified is small enough to be clamped to the back of the meter and with normal use should last almost as long as its shelf life.

PROBE ASSEMBLY

The probe can be made from a cylinder of several layers of gummed paper wound on a ½in former, afterwards being painted or covered with self-adhesive plastic. When thin leads have been soldered to the l.d.r., taking care not to bend the wires too close to the encapsulation, a suitable rubber grommet is pushed into the tube so that the l.d.r. is firmly held in place (Fig. 4). The leads can then be threaded through a small cap which fits the end of the tube.

Thin strips of gummed paper are wound round the threads of the bulb, to allow a good sliding fit in the cylinder so that the bulb position can be easily adjusted during setting up. To the bulb are soldered two sockets taken from a B7G valve holder. These can be carefully pressed out of the moulding if all surplus solder is first removed from the tags.



METER SCALE

The meter scale can be modified quite easily without unscrewing the scale. After removing the meter cover, erase the existing numerals with a typewriter rubber and also the divisions. Inscribe the new numerals with a sharp soft pencil (as in Fig. 5), taking care not to damage the exposed pointer and movement.

Any mistakes can be removed with the rubber. If the meter is not calibrated 0–500 or if it is not wished to modify the meter, a suitable conversion chart can be pasted to the front face of the wattmeter.

The range of the instrument can be multiplied in exactly the same way as an ammeter, although it is not

COMPONENTS . . .

VR1 50kΩ preset miniature potentiometer
XI ORP60 light dependent resistor
M1 500µA meter
BY1 22½ volts, hearing aid battery
LP1 Lamp 6V 0·06mA m.e.s.
SK1 & SK2 Wander plug sockets (2 off)
Materials for case and tube (see text)

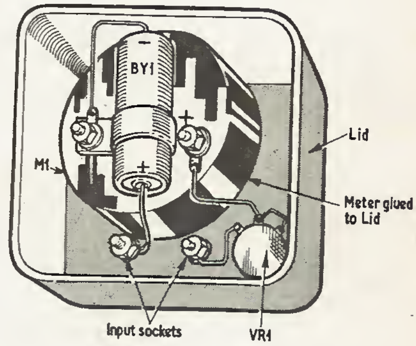


Fig. 3. Internal view of the instrument

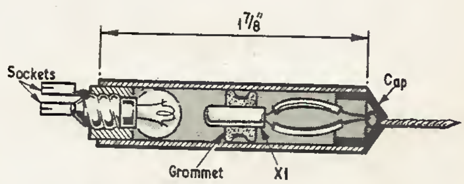


Fig. 4. Sectional view of the interior of the probe tube with lamp and l.d.r.

Fig. 5. New meter scale calibrated in milliwatts

Continued on page 593

components

P.E. LOOKS AT CURRENT TRENDS AT THE INTERNATIONAL LONDON ELECTRONIC COMPONENTS SHOW

MUCH HAS been talked about the financial costs of providing a colour television service in this country in recent months. It can only be expected that sales of colour receivers would be slow due to present-day credit restrictions and high capital costs. But in spite of this, the manufacturing industry is forging ahead developing new components specifically for this luxury commodity in preparation for an assumed mass audience of tri-channel coverage.

This development in particular is, to say the least, speculative and, in the interests of the health of the domestic electronics industry, one hopes it proves worthwhile and profitable.

In another field of technical endeavour, the public at large finds much to criticise in the expenditure of vast sums on exploration of outer space, without really realising that the by-products of such efforts are widely applied to industrial developments using electronic equipment in other fields. *Concorde* has also become victim of some unjust criticism.

The biennial Electronic Components Show, this year turned international for the first time and held at Olympia from May 20 to 23, was a real eye-opener to those who tend to take domestic luxuries and necessities for granted. Although a few of these developments are mentioned in this review, it must not be forgotten that, were it not for such stimulating projects as previously mentioned, the strength of the British electronics industry in the overseas market would not be as prominent as it certainly is. The amateur market also derives considerable benefit from these beginnings in the use of improved techniques.

The average British man (and woman) can tend to be a little insular when watching *Apollo* on television and before criticising would do well to spare a thought for the expertise gained in all channels of communication for the general betterment of his mode of life.

SEMICONDUCTORS

Semiconductor devices often imply transistors, which in turn (to the mass population) spell pocket radios. Lest we forget, the term semiconductors also includes diodes, thyristors, special purpose transducers, integrated circuits and so on. In fact the whole electronics industry is virtually revolutionised around the use in some form or other of silicon slices.

Mullard, for example, devoted half their massive stand to semiconductor devices applicable to television circuitry. We should be seeing some of their new integrated circuits incorporated in colour receivers which must bring the size, complexity and price of colour television down to manageable domestic proportions; reliablity should also be improved.

A new transistor designed for television line output stages, the BU 105, claims a high V_{CB} rating of 1,500V and current rating of 2·5A. Two of these in series will provide adequate line output voltage for colour.

Thyristors are called for to stabilise the line deflection supplies and are superior to using transistor circuitry here due to simplicity and higher reliability.

VARIABLE CAPACITANCE DIODES

It looks as if the days of the troublesome turret tuner are definitely numbered, and service engineers and viewers will look forward to seeing the "Varicap" tuner. No mechanical linkage between tuner and control is required in the form of rotary selectors. The new tuner will use push buttons to apply d.c. potentials to variable capacitance diodes in the r.f. and local oscillator stages. Consequently tuning drift is eliminated because the switches do not have to carry vulnerable high frequencies.

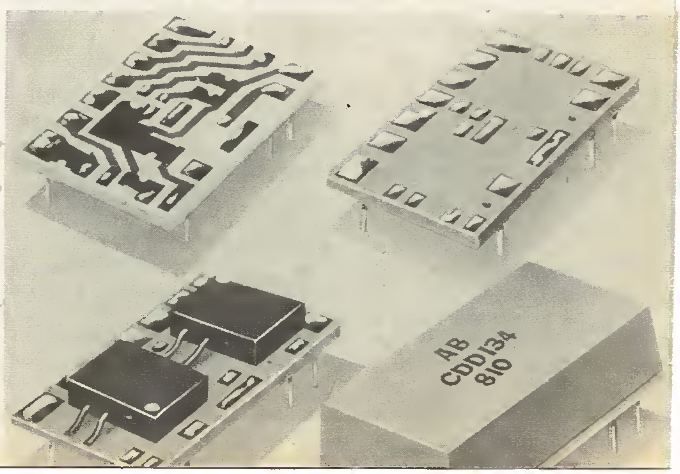
Also of interest on the Mullard stand was a new 30W power amplifier using pulse width modulation digital techniques. Typical harmonic distortion is given as 0·25 per cent with 30dB of feedback. But here is the rub! The pop singer or guitarist will be able to carry it in his pocket (being no bigger than a cigarette packet) thanks to integrated circuits.

INTEGRATED CIRCUITS

Several smaller or otherwise engaged firms have developed their own integrated circuit plant for prototype and small batch production. It is particularly encouraging to see them making maximum use of their resources for outside contract work.

Technograph International Developments offer a "customer service" using ceramic based circuits with copper, nickel and gold conductors, specially aimed at high frequency applications.

Dual-in-line active hybrid modules on thick film are now being supplied to customers' requirements by A.B. Electronic Components (see photograph below).



Granulated glass and sintered preforms made from Pilkington glass by Mansol (Great Britain) Ltd.

A new range of monolithic wideband amplifiers, suitable for audio hi fi, video, instrumentation, and high speed analogue computers, is under development by SGS (United Kingdom) Ltd. A 4kHz bandwidth telephone amplifier for electronic exchanges has been produced in integrated circuit form; its gain is in excess of 16dB for an output power of 40mW into 600 ohms.

SMALLER CHIPS

A significant advance in silicon growth and epitaxial layer deposition has enabled S.G.S. to carry out deposition at a lower temperature, so avoiding impurity diffusion out of the substrate slice. The benefits expected are in increased yield through smaller chip size and increased performance through greater design freedom.

A good example of space saving was illustrated by the new Plessey MOS circuits. A complete eight-channel balanced multiplexer has been designed for aircraft data handling, feeding information from strategically positioned transducers in the aircraft to the flight recorder (black box). The multiplexer is built on a silicon chip.

PASSIVE COMPONENTS

The fundamental discrete electronic components—resistors and capacitors—are still sold in increasing quantities despite the advances being made in the integrated circuit field. The trend in discrete components is towards smaller physical size combined with improved performance and reliability. Many components are becoming more specialised in application and new materials are continually being developed to meet users' demands.

Glass plays a very large part in the manufacture of electronic components and it is appropriate that the large Pilkington group should co-operate with the electronics industry in development work. Their latest is a solid state ultrasonic delay line glass for colour television, being supplied to the British STC Components group within the I.T.T., now being recognised with the new name ITT Components.

CAPACITORS

The available range of capacitors is ever increasing and this is one field where new materials play an important role in development of improved smaller types. Tantalum capacitors are one instance of a new material making available the type of components required by industry for microelectronic work, and a vast future for these and the new polypropylene types is forseeable. In particular polypropylene has been dubbed the "material of the 70's"; the use of this material will decrease the size and increase the working temperatures of electrolytics of the future.

Many types of capacitors were on display at the exhibition and Mullard displayed their new range of polycarbonate film a.c. capacitors. These types are available covering the capacitance range 1·5 to 10μF with tolerances of $\pm$10 per cent.

Chip capacitors for integrated circuits were shown on the Plessey stand. A special feature of these small size capacitors is the use of palladium for the electrodes; palladium has less tendency to dissolve in solder than silver.

Demonstrating the advances being made in capacitors the new ITT range of solid tantalum types covers capacitance values from 1·2 to 680μF at working voltages up to 35V d.c.

RESISTORS

As with capacitors the demand for resistors increases as their size decreases; for applications where discrete components are used with integrated circuits, size and accuracy are of paramount importance. New materials are assisting in improving quality and in the production of special types, although it is generally the case that new materials are being used with old manufacturing methods. This is the case with the precision wirewound resistors displayed by Muirhead Ltd.

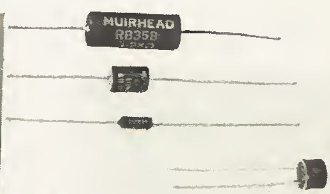
Claimed to be the smallest wirewound resistor available, the RBO3 is made of a new type of wire which ensures greatly increased stability. Also marketed by Muirhead is the RBO6 which is mounted in a TO5 "transistor type can" having standard lead spacing (three leads, one resistor?). It is claimed that using this type of case the assembly of instruments can be streamlined.

Many firms displayed metal film and metal oxide resistors and Electrosil showed their glass-tin oxide range of resistors. These are manufactured in all sizes from $\frac{1}{16}$W up to 6,000W.

POTENTIOMETERS

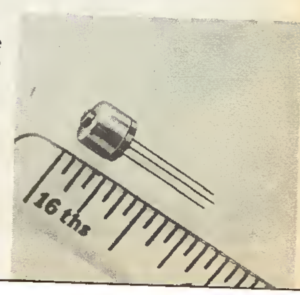
Perhaps one of the most diverse fields of components is the potentiometer types. Various versions of everything from a small preset or trimmer to large high resolution vernier types were displayed on many stands around the show.

Size reduction is a good selling point for presets but many "front panel" types are the same size as in previous years since there is no point in making them any smaller. Among the smallest of all the potentiometers on display was the $\frac{1}{4}$in cermet type from Painton. This component is



Muirhead precision wirewound resistors (left)

Chance-Pilkington delay line glass for colour television (left)



Painton sub-miniature cermet potentiometer (right) a single turn type in a cylindrical case measuring only $\frac{1}{4}$in long, it is available in resistance values ranging from 100 ohms to 100 kilohms and can handle a maximum input voltage of 300V d.c. at a power rating of 0·5W.

Ferranti announced a new range of conductive plastic potentiometers that have been developed over the last few years to provide a range of environmentally proven components of high stability and very high resolution. The new potentiometers are continuously rotatable and have a claimed life expectancy of better than ten million sweeps.

An interesting development in potentiometers is a new type from Computer Controls which incorporates solid state circuitry to provide low output impedance and high input impedance.

RELAYS

Although relays cannot truly be considered electronic they are still a necessity for many applications of electronics. Over the last few years the design of relays has improved vastly and with new manufacturing techniques and materials they are no longer the bulky mechanical nightmare of days gone by.

Most firms were showing small encapsulated reed relays generally with printed circuit pins. The photograph shows the type R12 manufactured by B. and R. Relays. This design is typical of the latest types and incorporates two normally open reed switches mounted on either side of the operating coil. Positioning the switches in this way ensures the effects of thermal e.m.f., due to the operating temperature of the coil, are kept to a minimum.

The previously more common solenoid type have also been improved in many ways other than size. Most firms now produce their relays in some form of plastics cover and one firm, Oliver Pell Control Ltd., are marketing what they claim to be the only direct mounting printed circuit board relay available in this country.

INDUCTIVE COMPONENTS

Miniaturisation and improved performances are to the fore in transformer and inductor manufacture and these requirements are being fulfilled mainly by improved design. Ferrite pot cores appeared on numerous stands and many were designed for printed circuit applications. Of particular interest in this field is the new square module pot cores from ITT. These cores, shown in the photograph, are designed to plug straight into printed circuit boards and their shape is such that an increased packing density is achieved.

Other firms displayed numerous types of mains, audio and auto-transformers as well as a large variety of inductive components. Gardners Transformers showed a new range of invertor transformers and modules and were giving away a newly published manual describing their complete range. Inductive components for computer applications were to be found on a few stands and the advent and development of such devices will no doubt aid the design of the more commonplace mains and audio transformers.

Relay type R12 by B & R Relays designed for printed circuit boards

PANEL METERS

Once again the range of meters available is extensive and the general trend is to larger and more clearly defined scales. The latest designs use virtually the whole meter face area for the scale and are thus conservative of space whilst still being easily read. Displayed by Taylor Electrical Instruments were their latest wide angle miniature moving coil panel meter. This instrument has a scale length of 4$\frac{5}{8}$in and a panel width of only just over 2$\frac{1}{2}$in.

General trend in this field is for wider angle scales and plain faces. Most instruments now have back-of-panel fixing; this also helps to provide an uncluttered face and more room for scale markings.

SOLDER AND SOLDERING TECHNIQUES

At first there does not seem to be any great changes in this field but, when a closer scrutiny is made, a number of improvements come to light. One of the main advances has been the higher purity attained in solders during manufacture.

Multicore Solders introduced "Extrusol" solder which is primarily designed for solder machines. This solder is available in bars, solid wire and pellets, is claimed to have less dross on initial melting, improved "wetting" of components and circuit boards, and fewer reject joints. Various melting temperature grades of solder are now available. Both Multicore Solders and Enthoven Solders are producing preforms for assembly line techniques with temperature melting points to specification. Superspeed preforms in the production of television receivers was demonstrated on the Enthoven stand.

Weller Electric demonstrated the versatility of their established temperature controlled irons for soldering and desoldering. For the latter, they demonstrated how 16 and 14 lead integrated circuit packs could be desoldered using their SK137 and SK126 tips. They also showed their simple suction desoldering tool in operation.

PRINTED CIRCUITS AND WIRING BOARDS

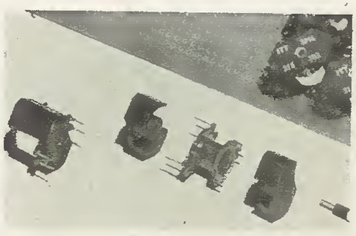
This area was widely represented and is probably the most interesting, although confined largely to machine and chemical manufacturing techniques.

The main improvement seems to be the use of glass fibre to give greater resistance to leakage between copper strips. Glass fibre board is also able to withstand varying temperature changes and robust handling.

On the G. T. Schjeldahl stand their Mini-etcher was shown producing flexible printed circuits. The flexible printed circuits can be produced to fit directly to the rigid type of printed board.

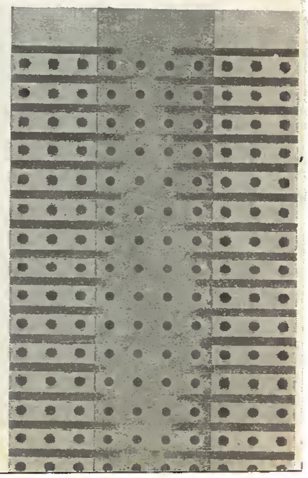
Formica displayed several grades of laminates suitable both for flexible and rigid printed circuit boards. One of Electrosil Advanced Products Division exhibits was the Augat 8136 Series of high density boards, with solder tab or wire-wrap facility. These boards are specially designed for i.c.'s and can be rack mounted in cases.

A printed circuit development pack was one of many items on show from Guest Electronics. This pack costs approximately £15 and contains 50 perforated boards;



Square module pot cores by ITT (above)

New style Veroboard component group board (right)



300ft self-adhesive copper tape 0·062in wide and 100ft 0·125in wide; 6 pieces self-adhesive copper sheets; reel of transparent insulating tape; tube of soldering pins with insertion tool; surgical knife; pair of tweezers and a bottle of lacquer and lacquer brush.

To make up any prototype printed circuit or one-off unit the copper is cut to size, the backing paper removed and the copper pressed firmly into position on a perforated board. Once the adhesive has been allowed to dry for four hours, solder connections can be made direct to the copper, or in the case of integrated circuit modules the push-fit pins can be used as termination points. The lacquer is included to protect the copper against oxidisation, and includes a fluxing agent so that any subsequent soldering can be carried out through the protective coating.

A new type of component group panel was one of the new products of interest to the experimenter on Vero Electronics stand. These boards are like strips of standard Veroboard; a wide centre channel with no copper strips saves material for component grouping. The strips are easily cut to the required number of component groups.

Another wiring board very similar to Veroboard was shown by Radiatron. Here the board composition is of fibre glass, giving greater electrical insulation; the copper strips and hole matrix has a reference grid printed on the underside. This, we feel, is an excellent improvement and we hope to see it on the retail market in the near future.

SWITCHES

The range of switches currently available is not surprisingly large and the one noticeable advance apart from miniaturisation is the use of coloured mouldings to provide for colour coding of controls.

Many heavy-duty and miniature rotary switches were prominent at most stands. A new general purpose rotary switch from A.B. Electronic Components was announced. This switch, type Nu-M, is available as 1-pole 12-way to 4-pole 3-way with make-before-break or break-before-make contacts. The switch is also available with printed circuit mounting contacts.

A miniature rotary thumbwheel switch, called the Miniswitch 500, was one of the many varied switches exhibited by Painton. Another type of thumbwheel switch, claimed to be the smallest produced, was announced by Kynmore Engineering. Designated Mini-Stac, the switch is available in binary coded decimal or straight decimal 10-positions.

Microswitches were displayed in abundance and the various types of operating techniques was very interesting. Cozet England Ltd., had microswitches with various methods of lever, sprung and press-button operating dollies suitable for alarms, timers, automobiles, and so on. One of the Plessey exhibits was the recently introduced Licon microswitch rated 10A at 250 volts a.c.

A 25- to 50-way reed switch from FR Electronics was one of their more interesting products. Once this switch is assembled the number of contacts can easily be increased or decreased as desired.

A dry reed relay uniselector with a memory circuit was displayed for the first time on the B & R Relays stand. The relays are mounted on plug-in printed circuit cards. The drive circuit incorporates a pulse generator relay which stores the input pulse and passes it on to the selected circuit when the pulse ceases. The pulse generator relay can be delayed for a given time to offset any effects of contact bounce.

Numerous lever switches, push-button and toggle switches were shown; representive of these was the 250V 2A a.c. lever switch from N.S.F. Bulgin have improved versions of their large range of toggle switches and both Bulgin and Arrow Electric Switches had illuminated push-button switches to offer.

CONNECTORS

Connectors play an important part in the electronics field and were well represented at the show. Belling-Lee, probably the largest supplier, had connectors for coaxial leads to ribbon cable forms on show. The use of stand-off insulators, solder pins and lead through connectors were shown by Henry & Thomas.

CASES

The range of equipment cases seems to be on the increase each year. This year plastics and metal cases were in abundance and were all designed with both aesthetic and practical considerations in mind.

The West Hyde Developments Contil cases, Vero circuit board cabinets, Imhof cases and racking equipment, Lektrokit systems from A.P.T. Electronics Industries, and Datum cases by Bedco were all well represented. Some very colourful finishes were conspicuous on some stands, although we understand that these are usually specials and cost a little more than the standard battleship grey kind of finish.

BATTERIES

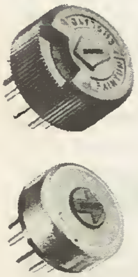
Better performance and reliability was the claim at the battery manufacturers' stands. Nickel cadmium, alkaline, and mercury cells were the main topics at Deac (Great Britain), Mallory Batteries, Ever Ready, Cadmium Nickel Batteries and many other exhibitors' stands.

The present aim seems to be towards the more popular use of rechargeable types, although the prices will have to fall slightly if they are to achieve massive sales.

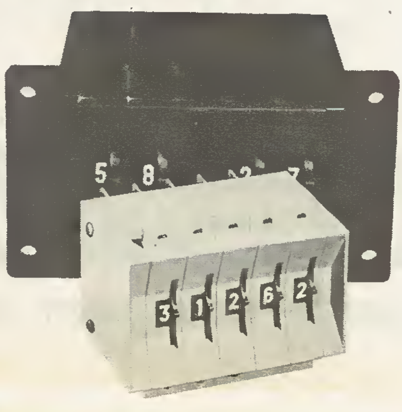
EQUIPMENTS

A new mast-head amplifier for colour and monochrome television reception was announced by Wolsey Electronics. The amplifier can also be mounted on the rear of a television and is ideal for fringe areas.

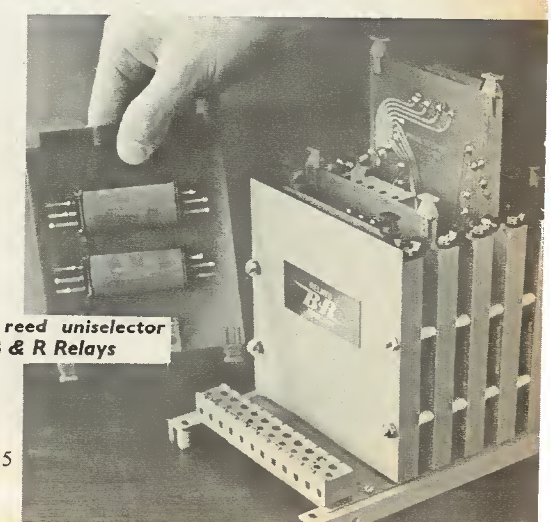
Daystrom displayed their usual range of Heathkit audio equipment, although there were many more test and laboratory equipments. We were told that in the next few months we should see many more pieces of test apparatus appearing on the market as they intend to make a concerted effort in this lucrative field.



Painton "Miniswitch 500"



"Mini-Stac" thumbwheel switch by Kynmore Engineering



Dry reed uniselector by B & R Relays

RESINS AND LUBRICANTS

The increasing use of silicones, resins and lubricants was shown by Midland Silicones, CIBA (A.R.L.), and Electrolube. CIBA had various items that had been impregnated with Araldite resins.

A wire with a p.v.c. covering that does not shrink back when in contact with a hot iron was exhibited on the ITT Components Group stand.

The increasing use of dry transfer circuit symbols for aiding the electronics draughtsman were the main products shown by Circuitape. These transfers are self-adhesive backed and can be used on prototype printed circuit layouts for preparing for silk-screen printing, litho printing and for photographic enlarging.

STANDARDS

British Standards are fast becoming international standards through the International Electro-technical Commission, at any rate as far as other European countries are involved. The important every day role to be played by adopting the metric system of measurements will undoubtedly be seen by many as the key to simplified units and multiples. The Ministry of Technology's B.S.I. representation, related to the electrical industry, discussed the metric system to visitors and introduced the BS 9000 scheme.

The BS 9000 is a new comprehensive system of specifications for electronic components, backed by several years of research and discussion with leading professional bodies in the electronics industry. The publication of generic specifications and a qualified parts list (GPL) will help purchasers and designers to specify their requirements under a common language. ★

POINTS ARISING

POCKET RADIATION MONITOR (*April 1969*)

We have been informed by Fortiphone Ltd., that they no longer manufacture miniature transformers, and that the transformer side of their business has been taken over by Messrs Parmeko Ltd., who supply ex-Fortiphone type transformers.

PHOTOGRAPHIC TIMER (*March 1969*)

Plessey "Double High Cap" capacitor 68μF 75V is available from Southwell Radio and T.V. Electric Engineering, 5, Southall, Hornsey, Yorkshire.

Southwell are not an official Plessey supplier but have been kind enough to distribute these capacitors to readers, price £1 11s 11d including postage and packing.

OSCILLOSCOPE PRE-AMPLIFIER

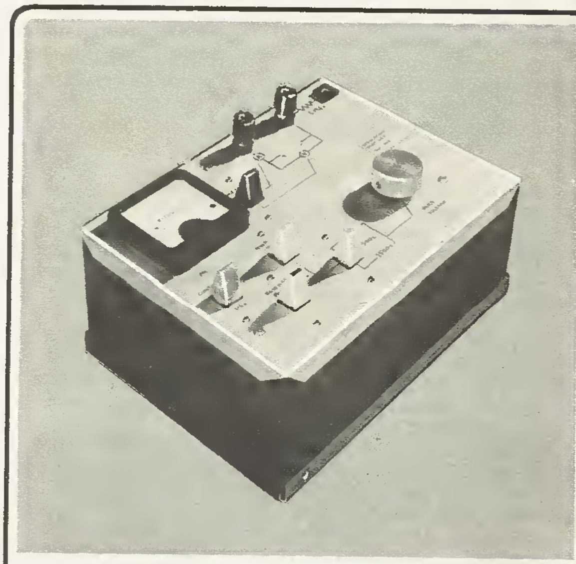
(*Ingenuity Unlimited July 1969*)

It should be noted that TR2 collector should be connected to R3, R5 and SK2 output socket.

COLD CATHODE TUBES—PART 4

We regret that, due to shortage of space this month, Part 4 of Cold Cathode Tubes has been held over. It will appear in the September issue.

TWO IMPORTANT FEATURES IN THE SEPTEMBER ISSUE



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PRACTICAL ELECTRONICS

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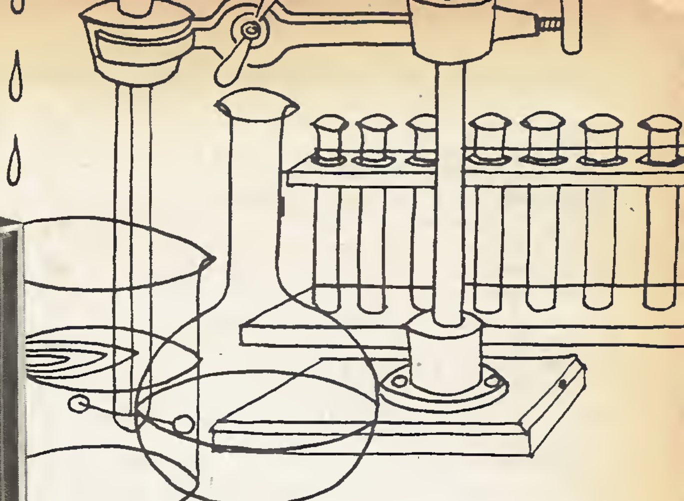
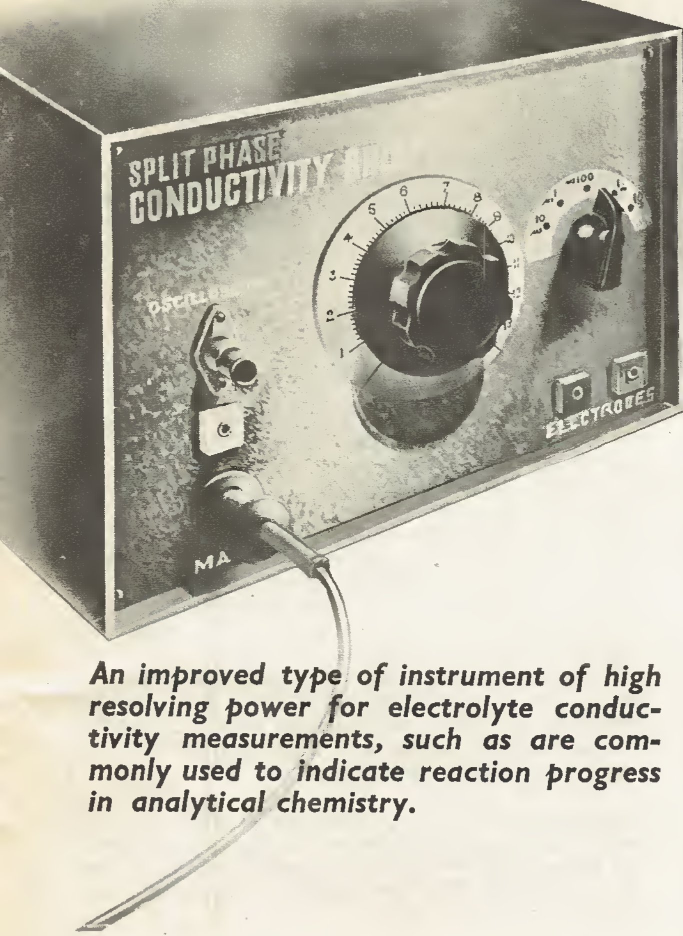
By M.L.MICHAELIS M.A.





Split Phase conductivity bridge

An improved type of instrument of high resolving power for electrolyte conductivity measurements, such as are commonly used to indicate reaction progress in analytical chemistry.

ALL chemical reactions give rise to characteristic electrical effects, which can be detected and measured with suitably designed electronic equipment of adequate sensitivity. This is true in particular for electrolytes and electrolyte reactions.

One of the simplest classes of electrical measurements which can be performed on electrolyte solutions is the determination of electrical conductivity. Many of the standard, less expensive instruments designed for this purpose do however suffer certain limitations.

Conventional derivatives of the Wheatstone bridge using a small transformer or induction coil, a slidewire, headphones and a resistance box, generally suffer from poor balance-point sharpness because they attempt to measure the out-of-balance voltage of the bridge to determine when this voltage reaches zero at balance. In fact it never reaches zero, because stray capacitances and electrode capacitances produce phase-shifts and spurious bypass currents.

Very many conductivity bridge circuits found in school textbooks of chemical analysis have not progressed beyond this primitive stage, whose attendant inaccuracy and, above all, very poor differential resolution has prevented appreciation of the true power of the conductometric method.

SPLIT PHASE BRIDGE

A much better approach is to sense the peak voltage in each bridge arm, in a manner irrespective of the relative phase angle between the voltage waveform peaks, and then to detect when these peak voltages are equal. This can be done by rectifying each waveform separately with a peak rectifier, then applying the two rectified voltages to a null detector. This merely involves the insertion of a rectifier and reservoir capacitor on each side of the balance meter in a conventional bridge circuit, but it completely fails to remove the second cause of poor balance readings which lies in the absence of a nominal balance marker.

This can be provided by feeding the voltage waveforms from the two bridge arms alternately via an electronic switch to an oscilloscope or magic eye indicator, using a fast timebase in the former case. This gives a double raster on the oscilloscope screen, or a double sector on the magic eye. At balance the double raster coincides to a single raster or the magic eye sectors coincide to a single sharp-edged sector.

EXTREMELY SHARP BALANCE

This type of balance indication is *extremely sharp*, and not disturbed even to the slightest extent by very large capacitive shunts and phase-shifts. It may be thought that this arrangement can be realised only at the price of undue circuit complexity, but a glance at Fig. 1 and Fig. 2 shows that the additional outlay with respect to a conventional bridge circuit is negligible. The trick is to operate the two bridge arms in antiphase from a centre-tapped transformer as shown in Fig. 1b. The same centre-tapped winding drives two switch transistors in phase cross-over to function as an electronic switch. The entire electronic switch thus uses nothing more than two transistors, two diodes and six resistors.

Especially when used in conjunction with a fairly large-screen conventional oscilloscope, this circuit principle leads to such high differential resolution that a number of titrations with large non-participating ionic background become readily possible.

Furthermore, on account of its complete tolerance of even very large capacitive phase shifts, the split phase bridge can work with the 50Hz mains frequency even when highly conducting solutions are used. This obviates the audio oscillator providing the necessary higher supply frequency under such conditions in conventional bridges. Since the electronic switch used in the present design is very much simpler than an audio oscillator and associated switching, the split phase bridge is altogether simpler, apart from its superior performance.

READOUT DEVICES

The oscilloscope is not an essential necessity for the read-out section; an ordinary magic eye circuit as used in conventional bridges is also usable at somewhat reduced differential resolution.

(A later article will provide full constructional details for a simple magic eye balance indicator as a separate unit which may be used by those readers who do not have an oscilloscope available and do not wish to go to the expense of procuring one. There is of course no objection to integrating the split phase bridge and the magic eye indicator into a single cabinet. Details can safely be left to the individual constructor, because there are no special problems involved in such an integration.)

REQUIRED RANGE

We find that actual resistances of the electrolyte between the electrodes with solutions of any strength likely to be encountered in ordinary routine analyses, are normally greater than 10 ohms but less than 1 megohm. This total range must be expressed in reciprocal units, since we are interested in determining the conductance values.

The reciprocal ohm is still known conventionally as the mho, but the author finds this nomenclature clumsy. In several continental countries the siemens, abbreviated S, is being applied as the new name for the reciprocal ohm as conductance unit. Thus 1 siemens (1S) and 1 mho are identical. We shall use the siemens for the remainder of this article. The required resistance range from 10 ohms to 1 megohm corresponds to a conductance range from 1 microsiemens (μS) to 100 millisiemens (mS).

PRACTICAL BRIDGE CIRCUIT

The full circuit of the practical split phase conductivity bridge is shown in Fig. 2. The bridge arm containing the electrolyte cell consists of SK1, SK2 and the resistor selected by the range switch S1B. The other bridge arm consists of R3 (shunted by R4, R5 in the highest range) and the bridge potentiometer VR1 in series with its range limiting resistor R6. These two bridge arms are fed in antiphase from T1.

To ensure that the antiphase voltages are truly of equal magnitude, T1 secondary should be wound bifilar and the nominal current rating must be about ten times the maximum actual current. This calls for a transformer rating of at least 1 amp, although normally only 100 to 150mA maximum current is drawn by the bridge. If it is not possible to have a transformer wound to suit these requirements, then the standard component given in the components list will generally prove quite adequate in many cases.

The same antiphase voltages, in cross-over connection, drive the bases of two switch transistors TR1 and TR2, respectively, connected to the centre points of the bridge arms. Each drive connection is via a diode (D1 and D3). The arrangement is such that each

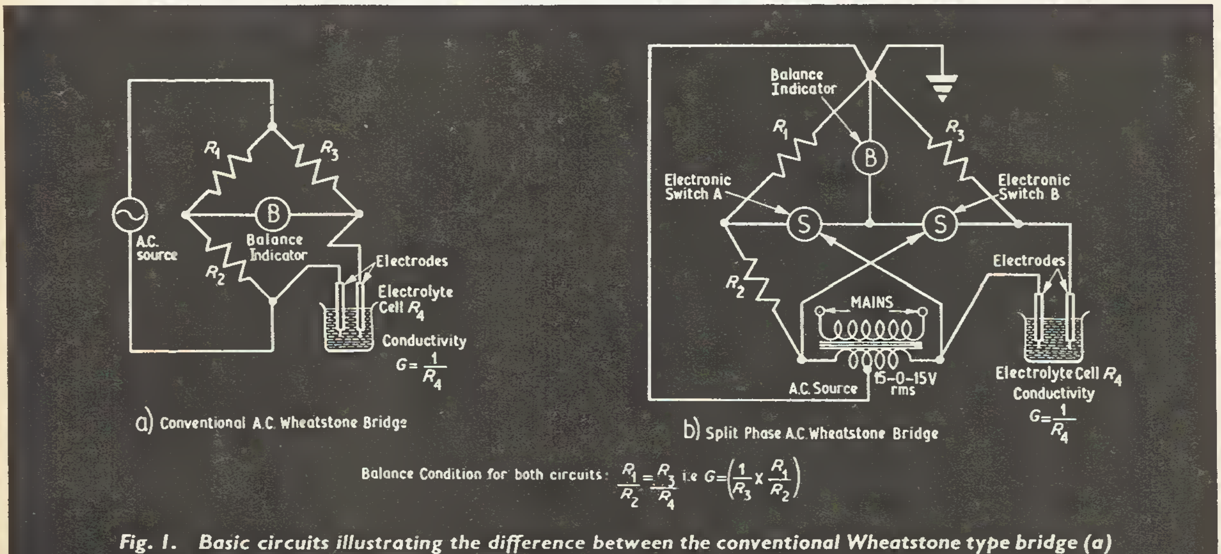


Fig. 1. Basic circuits illustrating the difference between the conventional Wheatstone type bridge (a) and the split phase arrangement as used in this design (b)

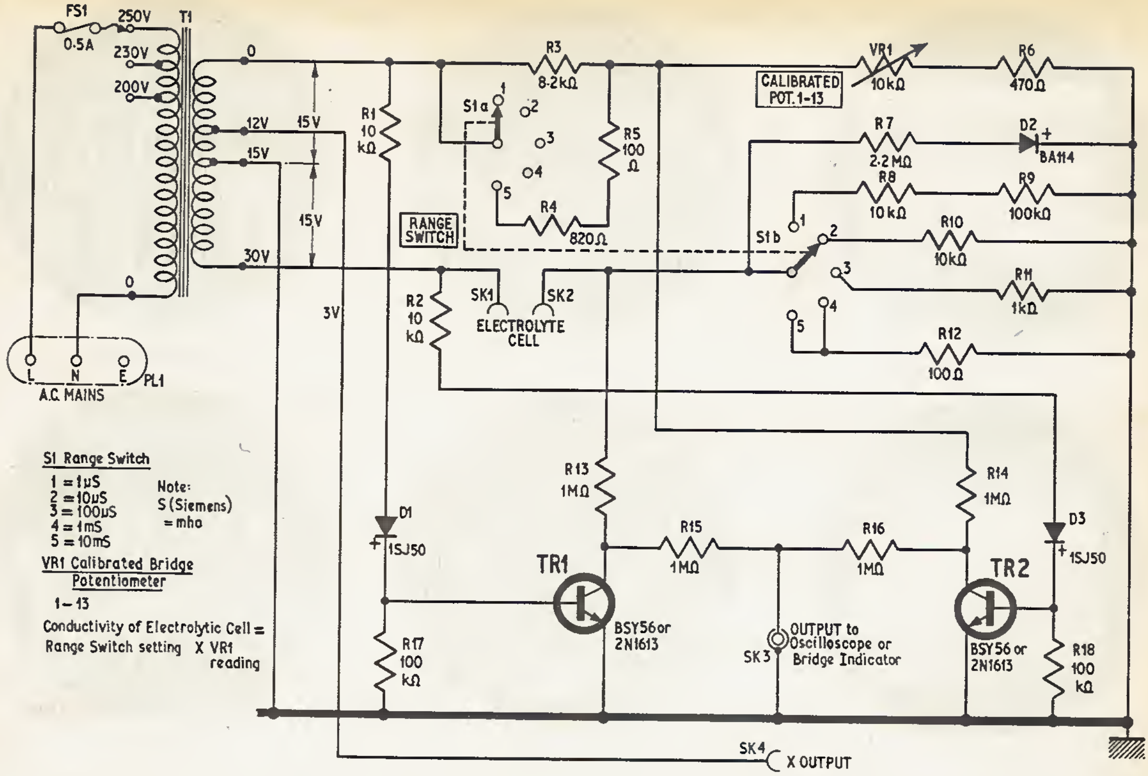


Fig. 2. Circuit diagram of the split phase conductivity bridge

transistor short-circuits the negative half-cycles of the bridge waveform it is sensing, as seen at the bottom end of R13 or R14. These two resistors are inserted to avoid short-circuiting of the bridge itself on negative half-cycles. However, the net impedance seen by the electrolyte cell bridge arm would be slightly lower on negative half-cycles, because R13 then shunts the resistors on S1B directly via TR1, but only indirectly via the remainder of the switching resistor network R15, R16 and TR2 on the positive half-cycles when TR1 is cut off. This amounts to slight partial rectification in this bridge arm and R7 and D2 just cancel this by imposing the right amount of additional loading on the positive half-cycles too.

COMPENSATION PROBLEMS

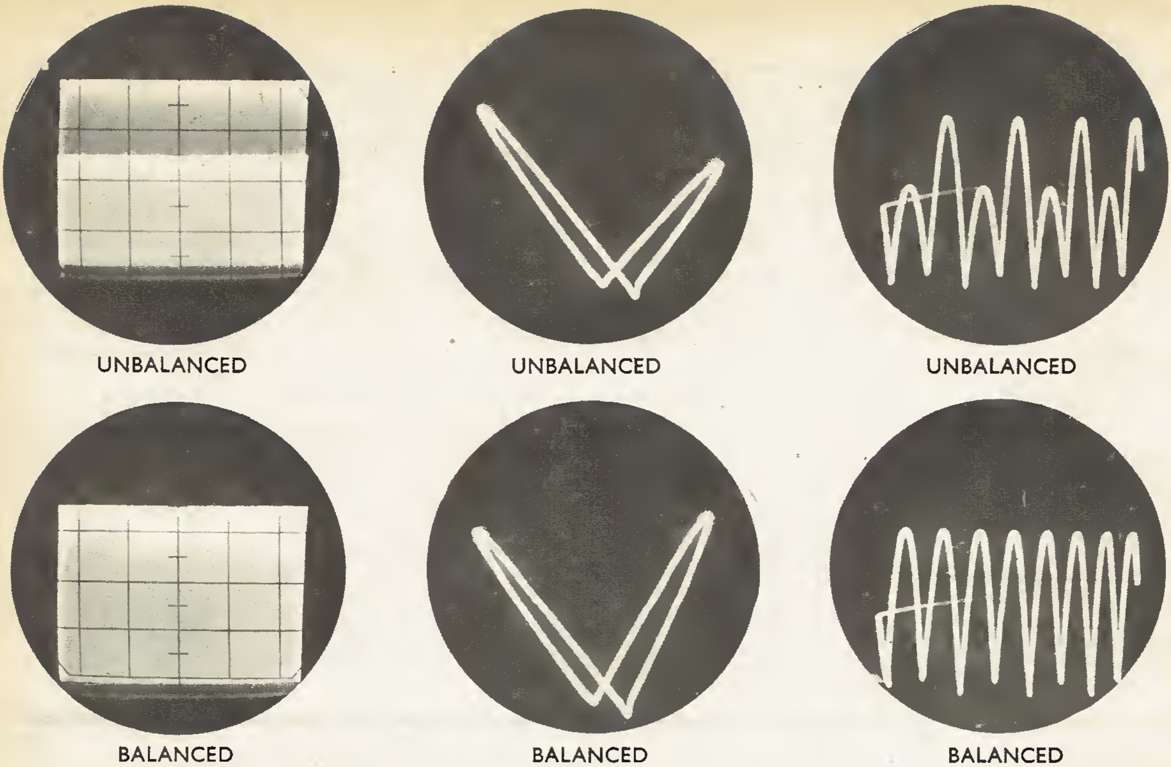
This form of compensation is satisfactory only if the highest bridge arm impedance (highest value of resistor selected by S1B in the lowest conductivity range) is at most 10 per cent of the electronic switch impedance. The latter is nominally a megohm to match standard oscilloscopes and magic eye indicators, so that we are limited to a maximum bridge resistor value of 100 kilohms (which has to be corrected to 110 kilohms with R8 to allow for the switch shunting effect).

We require a total range from 1 microsiemens to 100 millisiemens, i.e. five decades. Thus if we switch the bridge resistor down in five decades starting at 100 kilohm, we would arrive at 10 ohm in the highest range. This is not permissible, since 100 ohm is the smallest usable bridge resistor without exceeding the polarisation range. Thus we have had to retain the 100 ohm bridge resistor R12 of range 4 for range 5 too, instead reducing the impedance of the corresponding branch in the opposite bridge arm by a factor of ten, by shunting R3 with R4, R5 when switching from range 4 to range 5. This slightly sacrifices differential resolution at the extreme top end of the highest range.

ELECTRONIC SWITCH OPERATION

The electronic switch operates entirely with a.c. voltages, requiring no separate rectified collector supply. Considering either transistor alone, when the bridge arm feeding its collector is describing a positive half-cycle, the transistor collector is receiving normal polarity, but the base is cut off because zero voltage is applied to it. The diode in series with the base drive holds off the actual negative voltage applied from the other bridge arm, which is just describing its negative half-cycle. Without the diode, reverse breakdown would occur between base and emitter of the transistor.

Now consider the negative half-cycle in the bridge arm feeding the collector. This inverts the transistor, i.e. interchanges the roles of collector and emitter, a condition leading to particularly small residual switch voltages. At the same time the other bridge arm is now describing its positive half-cycle, so that the base diode conducts and turns the transistor hard on. The transistor thus behaves as a very efficient short-circuit to chassis, especially as it is running inverted in this phase period. Only the signal from the *other* bridge arm, which is describing the positive half-cycle, can get through to the output terminal SK3. Thus the composite signal at SK3 is a train of positive sinewave half-cycles, with alternate ones belonging to the respective bridge arms.



Types of split phase bridge displays on an oscilloscope (left) double bright-edge raster; (centre) phase pointers; (right) direct display of switch output waveform

MAGIC EYE INDICATOR

If this signal is applied to an amplifier feeding a magic eye, we obtain two luminous sectors of differing apex angles as long as the bridge is out of balance and thus alternate half-cycles at SK3 are of unequal amplitude. When the bridge is balanced, all half-cycles at SK3 become of equal amplitude and the two luminous sectors of the magic eye indicator coincide exactly to constitute a single sector. The actual width of this sector is unimportant and can be set to any convenient size by adjusting the amplifier gain control. Note the very clean action of the electronic switch as demonstrated by the oscillograms.

USE OF OSCILLOSCOPE

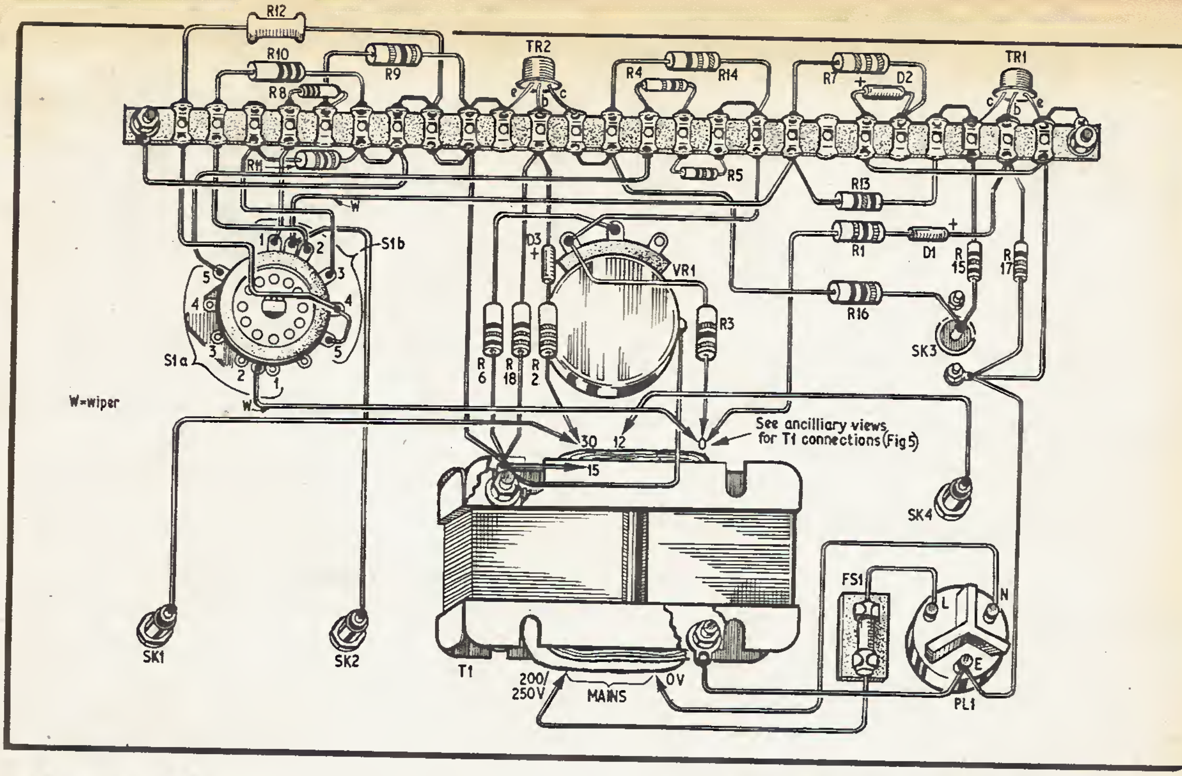
If the signal from SK3 is applied to an oscilloscope, three forms of display may be used, of which the double bright-edge raster type is the best for general work. Here the signal from SK3 is fed to the Y-amplifier input and the internal timebase is set unsynchronised to the highest available repetition frequency, at least 20kHz and preferably 100kHz. Numerous timebase strokes will thus be traced during each mains-frequency half-cycle, so that we obtain a raster in a manner similar to a television raster. However, since the sinewave spends much more time near its peak value, many more timebase traces will fall there, giving the raster a sharp bright upper edge.

When the bridge is still unbalanced, each half-cycle amplitude will produce its own bright-edge raster. The two bright edges coincide to a single bright edge at balance. This balance criterion is *extremely sharp,* irrespective of polarisation, giving an outstandingly good differential resolution. The slightest off-balance is evident at once as a split-up of the single bright edge into two sharp bright edges. Differential resolutions of much better than 0·1 per cent are easily obtainable with a 3in oscilloscope.

The magic eye type of indicator does not produce bright edges, but only sharp edges of the sectors, because a given voltage produces a full sector and not merely the sector limit lines. Thus light integration is always towards the centre of the sector when applying a varying voltage to a magic eye. This makes the double sector display on a magic eye inherently poorer than the double bright-edge raster on an oscilloscope, especially if the gain control is set too high, giving a large sector. Always set the gain control to give a sector as small as possible whilst allowing clear balance observation.

The second type of oscilloscope display is the phase pointer diagram. This is obtained by feeding the signal from SK3 as before to the Y-amplifier input, but now switching to external X-input and feeding a sample of the drive voltage of one bridge arm from SK4 to the X-input of the oscilloscope. This produces two pointers on the screen, like the hands of a clock. The bridge is balanced when both pointers rest at the same height. Provided the working conditions do not involve too large polarisation, this type of display is visually very good for demonstrations given to complete classes.

Alternatively, as the third type of display, the waveform from SK3 may be 'scoped directly in the normal manner to show the train of successive half cycles. The bridge is balanced when all half-cycles are of the same peak amplitude. Only the double bright-edge raster display can be accurately balanced, and only it is quite free from disturbance through polarisation phase shifts. Thus this display alone is recommended for routine work.



COMPONENTS . . .

Resistors

R1	10kΩ ±10% 1W	R10	10kΩ ±1% 1W
R2	10kΩ ±10% 1W	R11	1kΩ ±1% 1W
R3	8·2kΩ ±5% 1W	R12	100Ω ±1% 5W ww
R4	820Ω ±5% 1W	*R13	1MΩ ±5% 1W
R5	100Ω ±5% 1W	*R14	1MΩ ±5% 1W
R6	470Ω ±5% 1W	*R15	1MΩ ±5% 1W
R7	2·2MΩ ±10% ½W	*R16	1MΩ ±5% 1W
R8	10kΩ ±5% ½W	R17	100kΩ ±10% 1W
R9	100k ±1% 1W	R18	100kΩ ±10% 1W

All carbon except R12
* Mutually matched to ±1%, if possible

Potentiometer

VR1 10kΩ carbon track potentiometer, linear. Standard large volume control type

Semiconductors

D1, D3 Silicon rectifier 1SJ50 (Radiospares) (2 off)
D2 Silicon diode BA114 (Mullard)
TR1, 2 Silicon transistor, BSY56 *or* 2N1613 (2 off)

Miscellaneous

S1 2-pole 5-way wafer switch (Radiospares Makaswitch)
T1 Mains transformer. Secondary tapped at 12, 15, 20, 24, 30V 2A. Douglas MT3AT
or Rewind secondary of 6·3V 5A heater transformer to provide bifilar double 15V winding—see text
FS1 Fuse cartridge and holder, 0·5A
PL1 Mains panel connector 3pin, 5A and cable socket (Bulgin SA1861)
SK1, 2, 4 Insulated wanderplug sockets; yellow, black and red (3 off)
SK3 Coaxial socket
Case 12¼in × 7½in × 5½in (Olson 27A—Home Radio)
One small pointer knob. One large instrument type skirted knob (with pointer). Tag strip, 25 way

Electrodes

Materials as specified in Fig. 6b

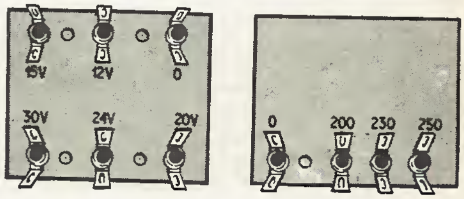


Fig. 3. Rear view of front panel. This shows all components and wiring. Details of the mains transformer connections are given in the inset diagram

CONSTRUCTIONAL DETAILS

The entire circuitry for the split phase bridge is assembled on the front panel of a standard instrument case, measuring 12·25in by 7·5in by 5·5in deep. The 16 s.w.g. steel front panel is sufficiently rigid to carry the mains transformer.

Fig. 3 and Fig. 4 show full constructional details. Layout is uncritical and there are no special problems involved.

Observe the component tolerance limits specified in the components list. The resistors on S1b should be mutually matched in decimal steps, so that continuity of differential linearity is preserved if it is necessary to switch over to a different range in the course of a titration.

In general, try to avoid range switching during a titration. If, for example, conductivity falls in the course of the titration, arrange to start with a reading close to the upper limit of a range. If the reading falls below 50 per cent of the optimum range, switch down to the next lower range and add more water until the reading comes in at the top of the new range. Conversely, for cases where conductivity rises in the course of the titration.

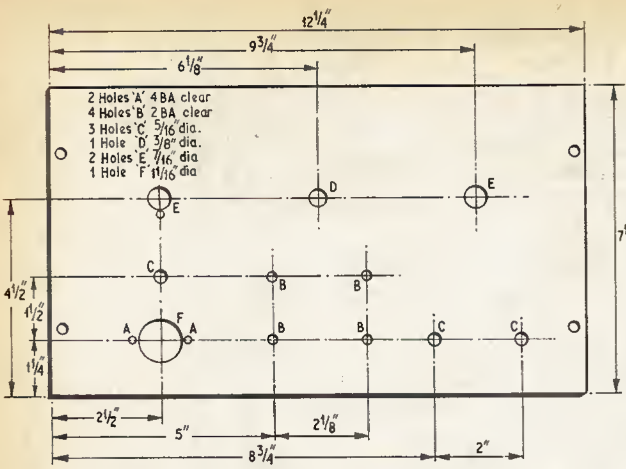


Fig. 4. Drilling details for the front panel

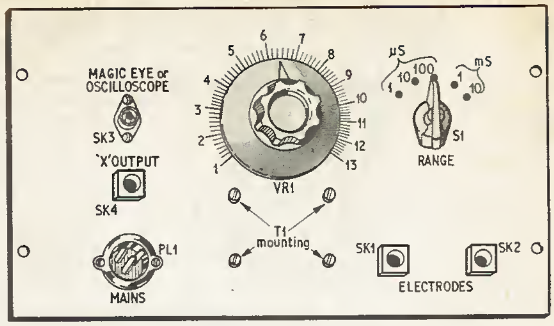


Fig. 5. General view of front panel with all components in position

CALIBRATION

Provided that resistors conforming to the tolerance limits specified have been used, it is merely necessary to provide VR1 with a scale calibrated from 1 to 13 such that the numerical reading multiplied by the unit conductance value selected with S1 gives the absolute conductance seen between SK1 and SK2. It is best to use graded standard resistors connected to these sockets, e.g. a resistance substitution box.

Calibrate in range 3 to strike the best compromise between low impedance and low current. The calibration should hold on all ranges if the resistors on S1B have been properly matched. Pad the resistors of the other ranges if necessary. Finally, check that differential continuity is preserved when switching from range 4 to range 5, correcting any discrepancies by padding R4, R5 accordingly.

ELECTRODE CONSTRUCTION

Fig. 6 shows some common electrode constructions for conductometry.

Type (a) is strongly recommended, but usually has to be purchased commercially and is not cheap (prices range to 5 guineas and more). Note the lateral horizontal ball-ended electrode pins. Any heating at the electrodes here sets up immediate convection, so that fresh liquid at the mean temperature of the bulk is continuously presented to the electrode pins. Furthermore, if the polarisation does exceed the electrolysis threshold during brief phase angles in each cycle, the gas bubbles can escape upwards without building pockets between the electrode pins, so that balance fluctuations and errors are minimised even under these extreme conditions.

The type of electrode shown in Fig. 6a is thus least subject to giving trouble under arduous conditions. It

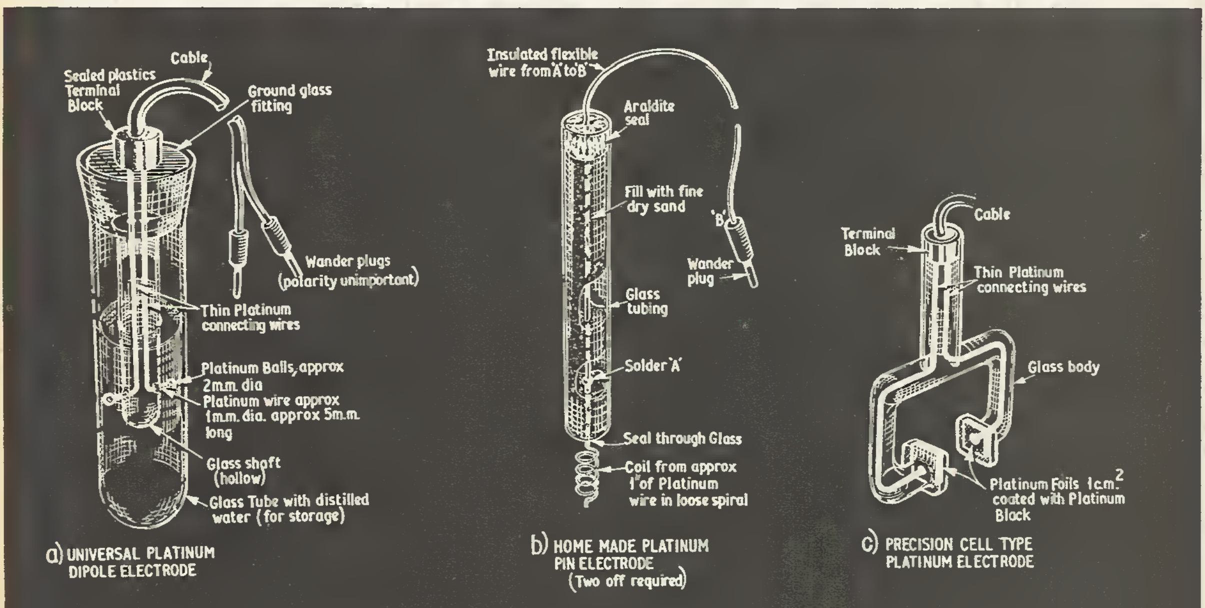


Fig. 6. Platinum electrodes for conductivity measurements

often works well even in the absence of stirring, and should be used if at all possible when no magnetic stirrer is available and intermittent manual stirring with a glass rod is resorted to.

Electrodes constructed according to Fig. 6b are easily home-made and give very good performance in conjunction with efficient stirring. The length and diameter of the platinum wire, or the dimensions of the spiral, are in no way critical, but do not use excessive length or too thin a wire gauge. The spiral form promotes convection. The required amount of platinum wire costs only a few shillings from chemical apparatus dealers, the remaining items costing only a few pence.

The electrode type shown in Fig. 6c is normally used when the intention is to make absolute measurements, as distinct from the mere differential methods involved in conductometric titrations. This type of electrode gives more definite geometric conditions which can be related to specific conductivity for unit cube of the electrolyte. It is expensive and not to be recommended for the work envisaged by this article.

All electrodes used for conductometry should be coated with platinum black, an amorphous form of platinum which vastly increases the effective surface area and thus boosts the polarisation capacitance value, and so the maximum alternating current which can be accommodated within the polarisation range for a given frequency.

COATING THE ELECTRODES

Platinum electrodes of types shown in Fig. 6a or b are coated with platinum black according to the procedure now described.

Take the bright platinum electrode(s) and support them in concentrated nitric acid diluted with two parts of distilled water. Switch the split phase bridge to the highest conductivity range (switch setting 10mS) and connect up to the mains and to the electrodes. Brisk electrolysis with gas evolution will be observed, because the polarisation capacitance of the blank electrodes is too small to accommodate the 150mA current.

After 5 minutes, the gas evolution will have slowed down markedly, and after some 10 to 15 minutes it should have ceased altogether. The electrode pins are now covered with a silky black layer. The actual active agent in this process is the trace of hydrochloric acid present in almost all specimens of nitric acid. If the sample of acid is too pure, marked by persistent electrolysis, add a few drops of concentrated hydrochloric acid.

When electrolysis has ceased completely, carefully wash the electrodes several times with distilled water, and store in distilled water in a jacket tube as shown in Fig. 6a.

The deposit of platinum black formed in this simple manner is very delicate and easily rubbed off. However, it is not disturbed by agitated solutions during normal titrations, even if suspended precipitates are formed in the course of reactions. If allowed to go dry, the platinum black deposit falls off of its own accord. Thus wash the electrode carefully with distilled water and return to the storage tube after use.

If damaged mechanically or by going dry, rub off the entire deposit, clean the electrode with fine emery paper and then repeat the coating process. This is also advisable if the deposit has become poisoned by certain substances and balance readings consequently fluctuate erratically. ★

R.F. WATTMETER

Continued from page 581

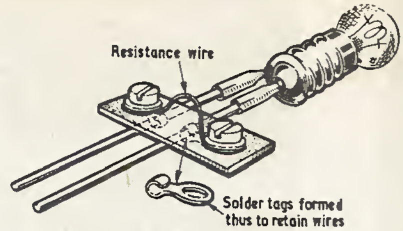


Fig. 6. Construction of the r.f. shunt strip and probe wire on the bulb

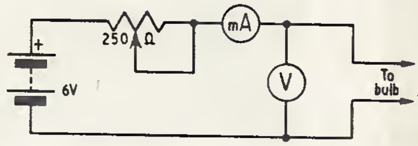


Fig. 7. Calibration circuit for the ammeter

desirable of course, to introduce switching to cover the ranges at radio frequencies.

An r.f. shunt is shown in Fig. 6. A strip of s.r.b.p. on which two solder tags are screwed, can be soldered to the parallel input wires as illustrated. The resistance wire, taken from suitable wirewound resistors, is clamped between washers under the heads of the screws and adjusted in length until the correct value is found.

The resistance wire should not be coiled as this will introduce appreciable self-inductance. It is better to find the right gauge of wire of roughly the length to match the distance between the screws.

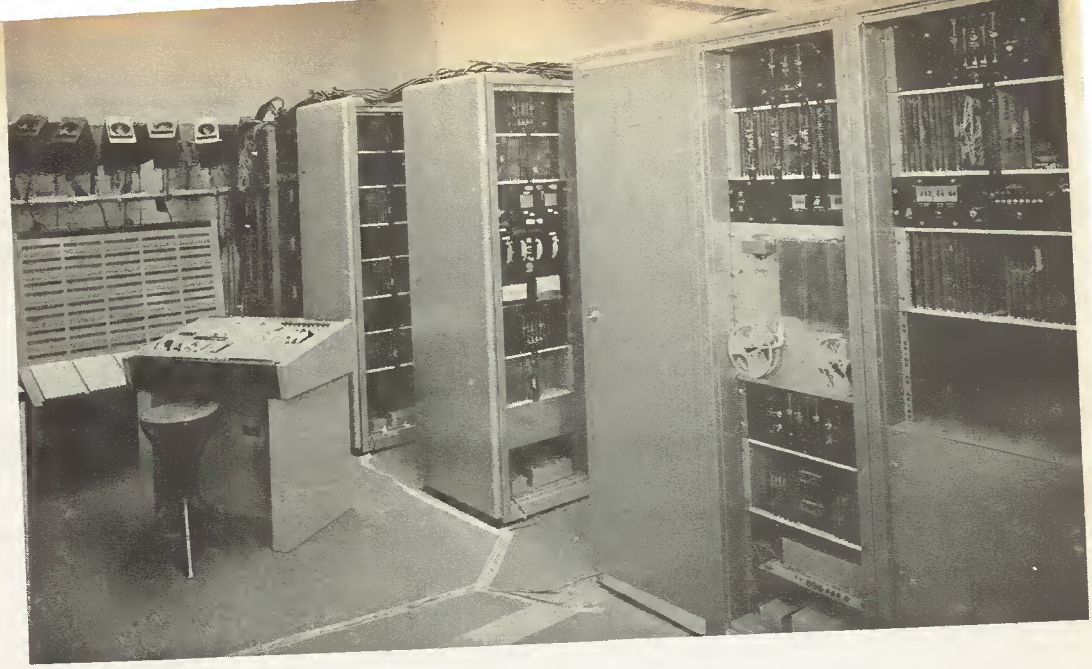
If the wire is too thin it will run at white heat, thus quickly leading to its deterioration in free air and a large change in its resistance at high temperatures. Both of these effects will destroy calibration accuracy.

As a guide, if the scale is to be multiplied by ten to read 1,200 milliwatts full scale the shunt resistance should be 8·3 ohm, and wire taken from a 500 ohm 10 watt resistor was found to be suitable.

Obviously the whole range of possible shunts cannot be described here. For audio applications, however, ordinary carbon resistors of the correct rating can be employed. Non-inductive resistors will also serve as shunts for the lower radio frequencies.

CALIBRATION

To calibrate the wattmeter on its basic range, a 50mA meter and a 5V meter are arranged as in Fig. 7. Adjust the bulb consumption until it is exactly 60mW, then slide the bulb in or out of the probe tube until the wattmeter pointer is on the 100μA division. Set the bulb consumption to 120mW and adjust VR1 until the wattmeter reads full scale. Repeat the procedure again until no further adjustment is required, then lightly glue the bulb to the tube. It should be found that the intermediate divisions on the wattmeter scale correspond to the product of volts × milliamps shown by the calibration rig. To calibrate any shunts, replace the 50mA meter with one giving a multiple of 100mW. ★



LIGHTING CONTROL

THE opening on May 31 in Ottawa of Canada's National Centre for Performing Arts attracted attention to two of the world's most advanced stage lighting control systems that have been installed in the main hall and theatre of the Centre.

The lighting control systems, which have been made in Britain and exported to Canada by the Strand Electric Company, depend for their memory on Sperry memory systems which incorporate magnetic storage drums.

The main hall lighting system controls 250 lighting circuits and 300 combinations of these circuits together with their light intensities are recorded on the magnetic storage drum making it possible to reproduce, night after night, the exact lighting sequences chosen by the lighting director during rehearsal.

The theatre lighting system is similar to that of the main hall except that it controls 200 combinations of 180 channels.

The lighting systems are extremely flexible in operation and it is possible to modify the lighting during a performance without affecting the light settings already recorded. There is also provision for permanently recording a complete lighting script on punched paper tape for future use. To repeat a performance, the paper tape is fed back into the system and the lighting sequences are automatically reset.

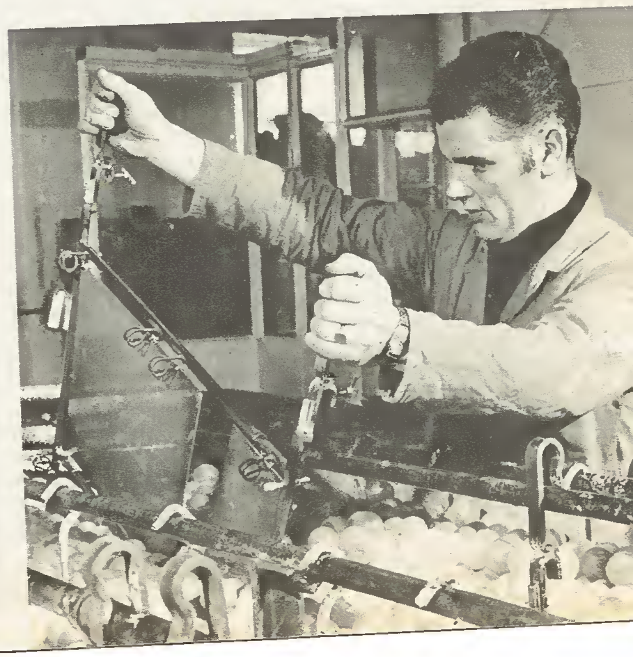
Type-out facilities are also provided to enable lamp settings to be recorded in an easily-read manner.

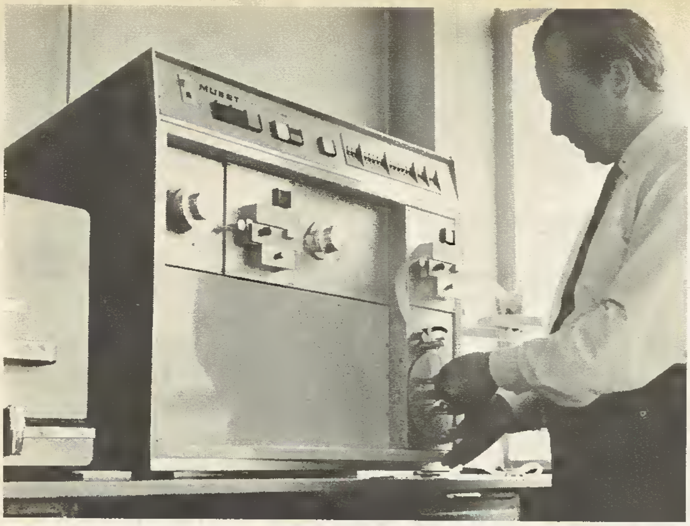
The photograph shows the memory system for the larger lighting system undergoing tests at Sperry's Research and Development Centre.

PRINTED CIRCUIT MANUFACTURE

THE latest technique developed at Palmer's Camberley factory is the production of multi-layer circuits which, they say, will soon allow them to produce up to 16 layers at a time. Among other new methods of manufacture is a plated-through process by which boards can be produced as easily as a conventional etched double-sided panel.

Prior to "printing" an operative at Palmer Aero Products' printed circuit factory, removes boards from the copper pyrophosphate tank during the production of plated-through circuits. The ping-pong balls on top of the tank help to keep the solution's heat constant by preventing the escape of steam.

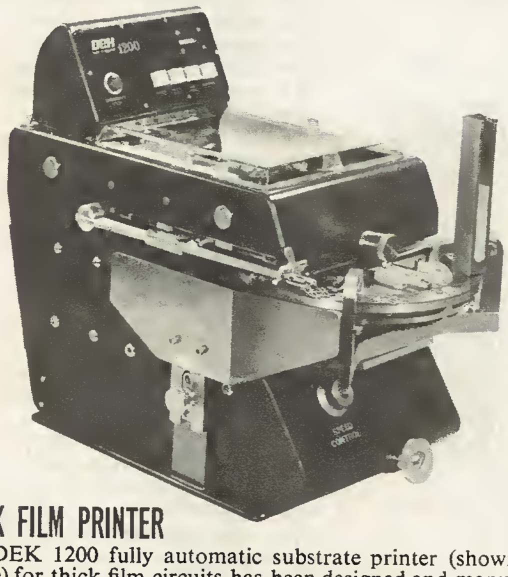




AUTOMATIC TYPE COMPOSING

BRITAIN's latest automatic type composing equipment, which is equally suitable for large and small printers, was exhibited for the first time anywhere in the world, at the International Exhibition of Modern Printing Machinery—Inpolygraphmash 69—in Moscow from July 9 to 23.

Muset K-380-B, shown above, which is claimed to be the simplest and lowest-priced computer capable of 100 per cent correct word hyphenation, has been developed and manufactured by Muirhead Limited. Muset uses the latest solid state microcircuits, does not require air-conditioning or temperature control, consumes only 360 watts and occupies only four and a half square feet of tabletop space.



THICK FILM PRINTER

The DEK 1200 fully automatic substrate printer (shown above) for thick film circuits has been designed and manufactured in Britain by DEK Printing Machines Ltd. It embodies all the features required for repetitive work.

Controlled setting of squeegee pressure, length of print stroke, distribution of medium on return stroke and gap between substrate and underside of screen. Print stroke speed is smooth and adjustable by calibrated setting, up to 1500 impressions per hour; substrates can be fed by magazine or vibratory bowl.

When displayed at the Paris Components Show considerable interest was shown by representatives of various companies from five countries outside Britain, including Russia.

ANOTHER MEMORY

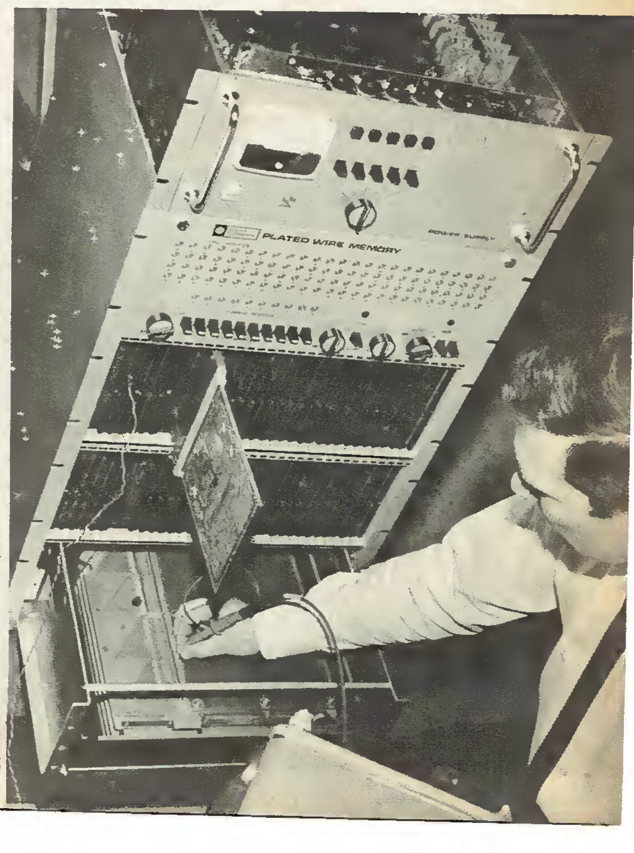
EUROPE's fastest commercially viable computer memory, the Plessey Mark 1 S250, has been delivered to the Ministry of Technology by the Automation Divisions of Plessey Electronics Group. It is shown, below, being commissioned.

This memory system has a 290 nanosecond cycle time and offers substantial improvements in performance margins and simplicity with immediate cost advantages over ferrite core and film techniques at 300 nanoseconds cycle time and less.

The system operates in the destructive read-out mode using plated wire storage elements: the elements are formed at the crosspoints of beryllium copper wires which are continuously plated with nickel iron and the word strip lines which are printed on to flexible sheets. Thus the stack design uses normal production techniques and avoids the high labour content associated with core memories.

The system electronics is based on high speed TTL integrated circuits. Full self test facilities were designed into the system so that comprehensive performance monitoring can be carried out independently from the main processor.

The Mark 1 S250 has a capacity of 100,000 bits and represents an important breakthrough for the British electronics industry.



PE ORGAN PART 4

LAST month we ended with the pedal cables attached at one end to the upper manual printed circuit board. Now we must terminate these free ends.

PEDAL RESISTOR BOARDS

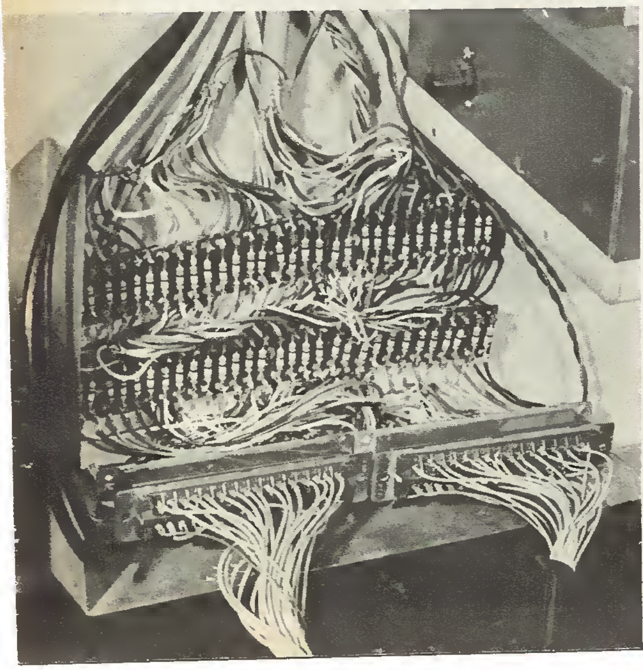
Just as we have anti-robbing resistors in the manual contact assemblies so we require them in the tone outlets, to the pedals. As there are 30 16ft pitch wires and 30 8ft pitch wires emanating from the upper manual, two 30 way miniature tag boards are required for mounting the pedal resistors.

These are made up from four, 18-way tag boards each being screwed to the back of the kneeboard using backing bakelite plates as insulators (see photograph). Reference to the console rear view photograph in Part Two will clarify their positioning.

Across each pair of turret lugs connect a 100 kilohm ½ watt 10 per cent resistor. When the pedal cable wiring is completed these resistors will be in series with the tone outlets and in due course with the pedal contacts—when we get onto that part of the organ.

First connect the 30 16ft pitch wires to two of the boards. Fig. 4.1 shows the order of these connections in terms of the wiring colour code adopted for the 16ft pitch wires only. The black wire, 32·7Hz, is soldered on at turret tag marked X, then the brown wire to the tag adjacent until all 30 wires are used up. The wiring of the 30 8ft pitch wires to their two boards is identical in its sequence but now the black wire, 65·4Hz, goes to the tag marked X and wiring continues till all 30 wires are exhausted.

Pedal resistor boards in position on console kneeboard. Here the pedal plugs are shown mated to the sockets



PLUGS AND SOCKETS

To mate the pedals to the console, a floating plug arrangement was decided on as this makes it much easier for the constructor to set and adjust the contacts on the pedals, away from the organ.

Two pairs of 32-way plugs and sockets are required, although only the sockets are used at this stage; the plugs will be attached later to the pedal board.

In Fig. 4.1 is shown the top side of the 16ft pitch socket. To make the connections from this to the

COMPONENTS . . .

PEDAL RESISTOR BOARDS

R1–60 100kΩ ½ watt 10% resistors (60 off)

PL1, 2 32-way plugs (2 off)
SK1, 2 32-way sockets (2 off)
(Electroniques, Edinburgh Way, Harlow, Essex.)

Miniature 18 way tag boards (4 off)
Bakelite backing plates (4 off)

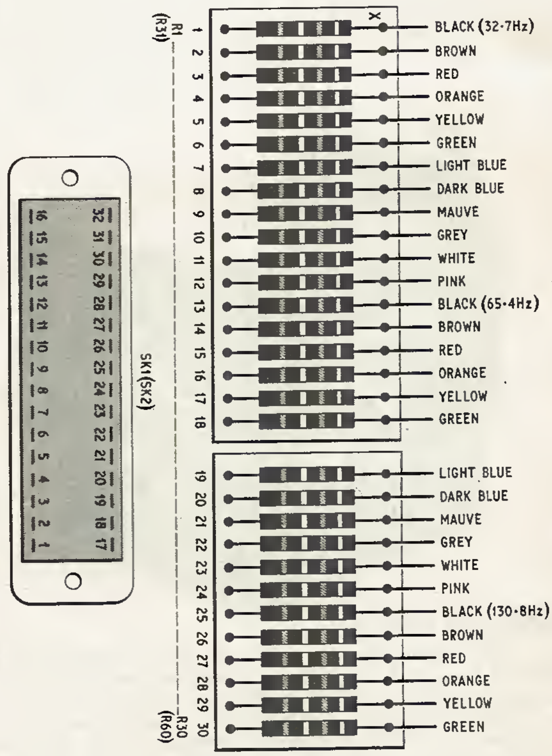


Fig. 4.1. Upper manual wiring to 16ft pitch pedal resistor boards and socket SK1. For the 8ft pitch boards a black lead (65.4Hz) is connected to tag X and subsequent note wires attached until all 30 tags are terminated. Pins 31 and 32 on the sockets will eventually be terminated with the 16ft and 8ft busbar return wires from the pedals

MAIN AMPLIFIERS & POWER UNITS

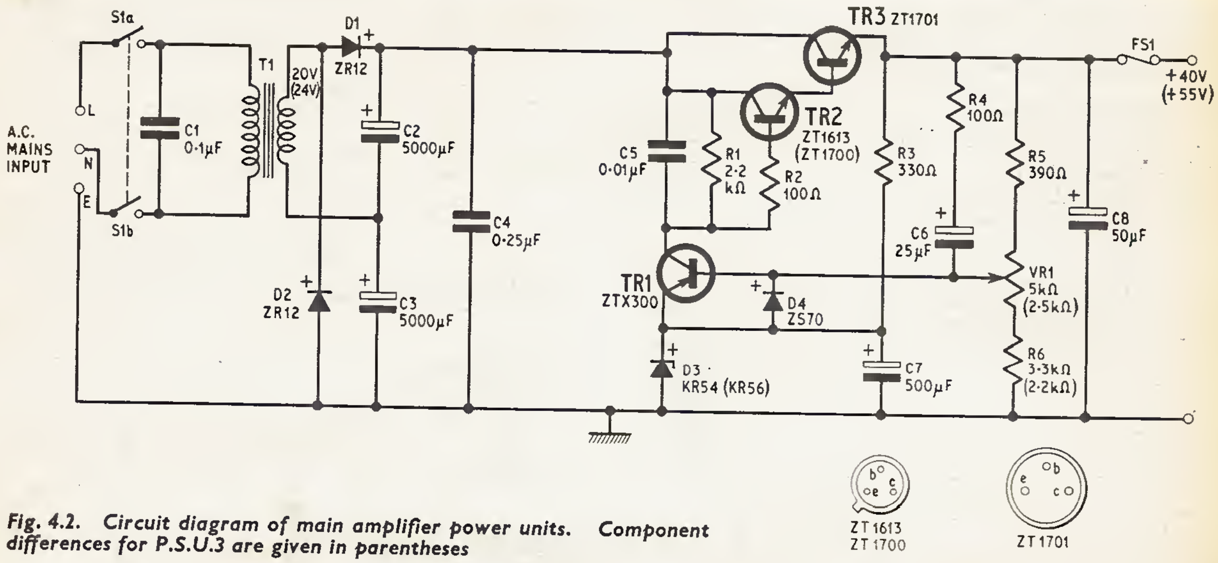


Fig. 4.2. Circuit diagram of main amplifier power units. Component differences for P.S.U.3 are given in parentheses

resistors on the 16ft pitch tag boards merely means joining with short insulated wire lengths between the commonly numbered tags, that is, one to one, two to two, etc.

For the 8ft pitch boards the other socket is used, the numbering and wiring being the same. The sockets should now be carefully fixed to the kneeboard using 6B.A. countersunk screws and ¾in spacers.

AMPLIFIERS AND POWER SUPPLIES

Since we decided on silicon planar transistors for the tone generating system, the choice of this advantageous semiconductor is a natural one for the amplifiers and power supplies.

For the pedals a 7 watt amplifier is used, and a 15 watt unit for the two manuals. Both employ transformerless Class B circuits capable of delivering the full specified power into their respective 15 ohm loudspeaker loads in the frequency range 20Hz to 20kHz with a total harmonic distortion of less than 0·25 per cent.

With the large current taken by Class B output stages the power supply units need to be stabilised. This feature results in the associated power amplifier having a much greater low frequency stability.

The following details of the amplifiers and power supplies are reproduced with acknowledgement to Ferranti Ltd.

P.S.U.2 AND P.S.U.3

Reference to Fig. 1.1, the block diagram of the organ, shows that the power supplies P.S.U.2 and P.S.U.3 feed the pedal amplifier P.A.1, and the manual amplifier P.A.2, respectively.

The circuit diagram for both power units is given in Fig. 4.2. As can be seen the basic configuration applies for the two units, the only difference being in the components required. Changes for P.S.U.3 are shown in parenthesis.

CIRCUIT DETAILS

The stabiliser circuit is fed from a voltage doubler comprising of D1, D2, C2 and C3. The reference voltage is developed across the Zener diode D3 which is compared with a proportion of the output voltage by TR1. This transistor is directly coupled to TR2 and TR3 and controls the voltage dropped across them.

If the output voltage should rise the base potential of TR1 rises; the current in TR1 increases resulting in a larger voltage drop across R1. This is transferred to the output via TR2 and TR3 as a voltage drop. The capacitor C8 ensures a low output impedance at high frequencies. A good feature of this circuit is the delayed switching effected by the capacitor C5, which obviates unpleasant transients in the output.

CONSTRUCTION

Since there are only slight component value differences in the power units, the chassis wiring layout of Fig. 4.3 can be applied to both.

A 3in miniature tag board is used for small component mounting, this being mounted on two ¾in spacers and fixed by 1in 6B.A. nuts and bolts.

For those who prefer a printed circuit board alternative, an etched wiring and component layout is given in Fig. 4.4 and Fig. 4.5.

Diode D3 should be bolted to the power supply chassis which serves as a heat sink. Transistors TR2 and TR3 are mounted on a common heat sink of 4in × 4in × $\frac{1}{16}$in aluminium which is insulated from the chassis by three nylon feed-through bushes.

Both the transistors heat sink and diode mounting to chassis can be seen in the photograph.

COMPONENTS . . .

P.S.U.2 AND P.S.U.3

Component differences for P.S.U.3 are given in parentheses

Resistors

R1	2·2kΩ	R4	100Ω
R2	100Ω	R5	390Ω
R3	330Ω	R6	3·3kΩ (2·2kΩ)

All 10%, ½ watt carbon

Potentiometers

VR1 5kΩ lin. (2·5kΩ lin)

Capacitors

C1 0·1μF
C2 5,000μF elect. 50V
C3 5,000μF elect. 50V
C4 0·25μF
C5 0·01μF
C6 25μF elect. 25V
C7 500μF elect. 60V
C8 50μF elect. 100V

Transistors

TR1 ZTX300 (Ferranti)
TR2 ZT1613 (ZT1700) (Ferranti)
TR3 ZT1701 (Ferranti)

Diodes

D1 ZR12 (Ferranti)
D2 ZR12 (Ferranti)
D3 KR54 33V Zener (KR56 47V Zener) (Ferranti)
D4 Z570 (Ferranti)

Transformers

T1 Douglas MT3AT. Prim. 230V Sec. 20V 2A. (Prim. 230V Sec. 24V 2A) (Home Radio)

Switches

S1 Mains double pole on/off

Fuses

FS1 1 amp

Miscellaneous

Fuse holder, Chassis 8in × 6in × 2½in 18 s.w.g. Heat sink 4in × 4in × 1/16in. Miniature 12-way tag board 2¾in long. Two-way terminal block.

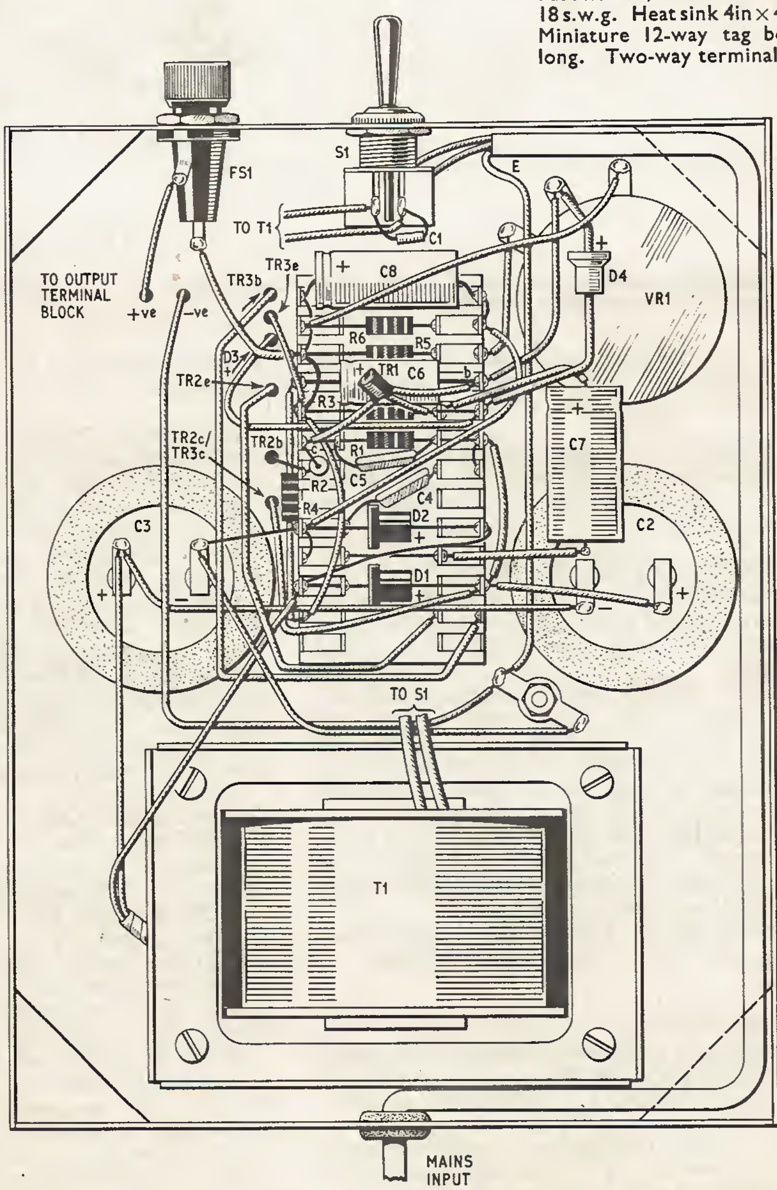
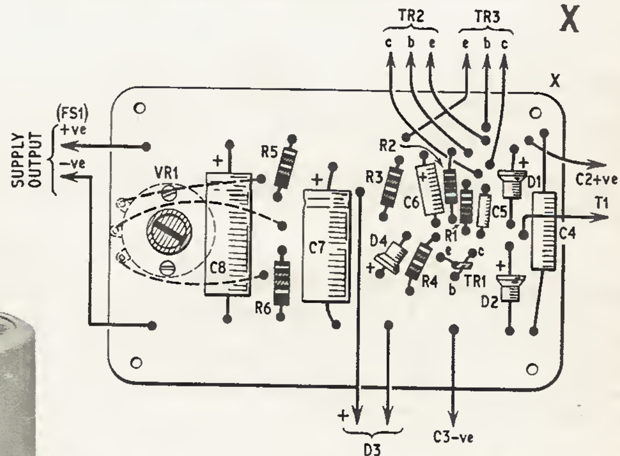


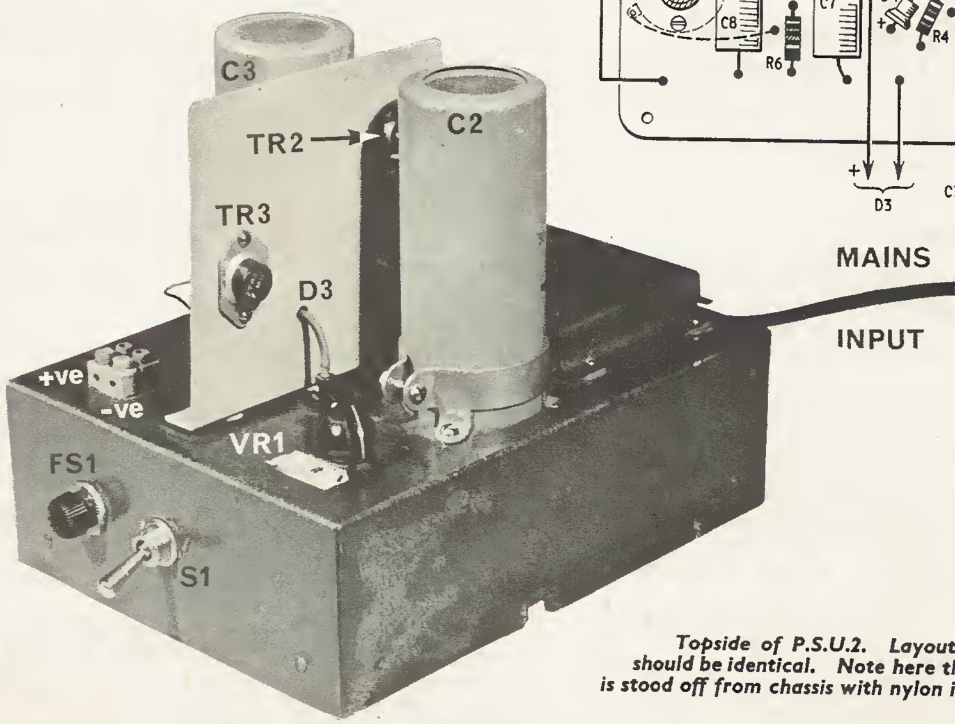
Fig. 4.3. Wiring layout which can be applied for both P.S.U.2 and P.S.U.3. The d.c. output wires go to the terminal block shown in the chassis top-side layout in the photograph opposite

PRINTED CIRCUIT VERSION WIRING

Fig. 4.4 (above). Printed circuit board alternative for power supplies, full size

Fig. 4.5 (right). Component layout and wiring for the printed circuit version





Topside of P.S.U.2. Layout for P.S.U.3 should be identical. Note here that heat sink is stood off from chassis with nylon insulators

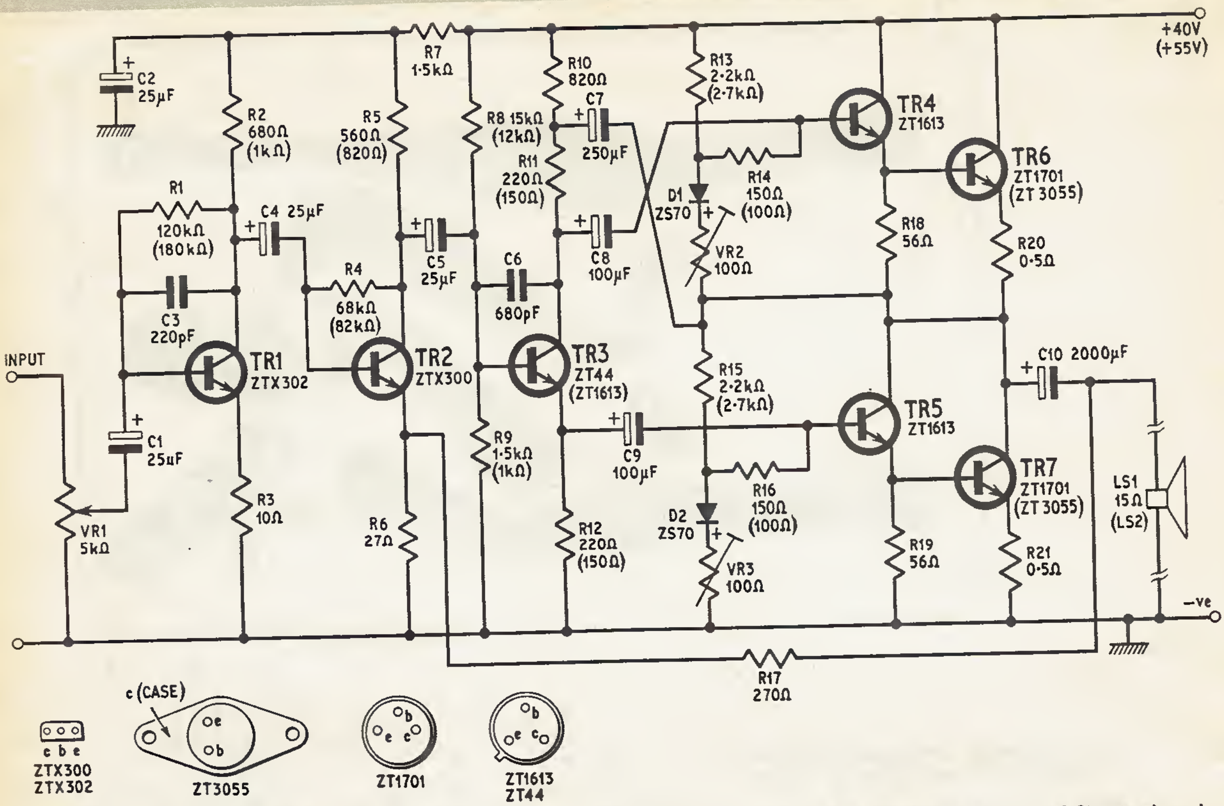


Fig. 4.6. Circuit diagram for pedal (P.A.1) and manual (P.A.2) amplifier. Component differences for P.A.2 are given in parentheses

PEDAL AND MANUAL AMPLIFIERS

The audio amplifier circuit to be described serves to supply 7 watts for the pedal output (P.A.1) and 15 watts for the manuals (P.A.2). The circuit given in Fig. 4.6 is fundamental to both, component differences for P.A.2 being shown in parenthesis.

CIRCUIT DESCRIPTION

The input is fed via the volume control potentiometer VR1 and amplified through the two a.c. coupled, common emitter stages, TR1 and TR2. These have local feedback from collector to base, while overall feedback from the output is taken to the emitter of TR2 by way of R17.

TR3 is a split load phase inverter which provides the necessary assymetrical drive to the two halves of the driver stages TR4 and TR5. Diodes D1 and D2 serve to provide a stable bias for the drivers, which being directly coupled to the output stage, produce a standing current in the output transistors which eliminates crossover distortion. Positive bootstrap feedback, developed across R10 via C7, is used to equalise the power gain of the two halves.

The output stage is basically symmetrical with TR6 connected as an emitter follower and TR7 in the common emitter mode. The low source impedance presented by the emitter follower drivers to this stage does much to enhance the high frequency response and minimise harmonic distortion.

SPECIFICATION . . .

Nominal input impedance	approximately 1 kilohm
Nominal output impedance	less than 1 ohm
Sensitivity	20mV for rated output
Nominal power output (P.A.1)	7 watts
Nominal power output (P.A.2)	15 watts
Total harmonic distortion	less than 0·25 per cent
Frequency response	Within 1dB over range 20Hz to 20kHz
Total current for full power output at 1kHz	
P.A.1	300mA
P.A.2	500mA

CONSTRUCTION

The design is intended for construction on a printed circuit board but as lead lengths are of no great consequence other methods can be employed; but it is essential that a low impedance earth path is provided when laying out to prevent instability arising.

In the prototype organ both tag board and printed board assemblies were used in the construction of the amplifiers and power units to prove that variations in layout would not affect performance.

Whilst latitude is permissible in component layout, it is important that no attempt should be made to integrate an amplifier and power unit on a single chassis. Separate unit construction minimises the adverse effect of ripple current flow.

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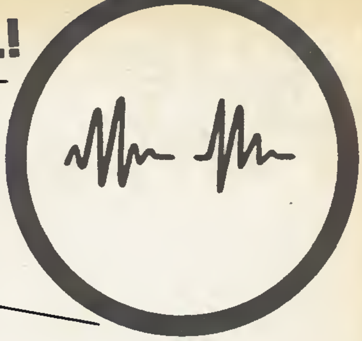

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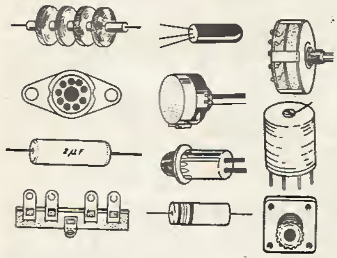

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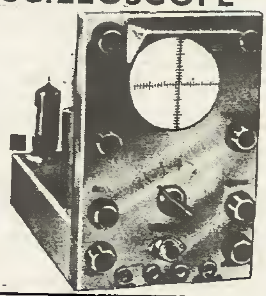

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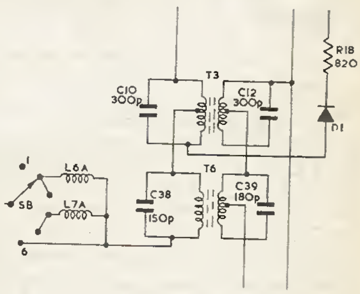

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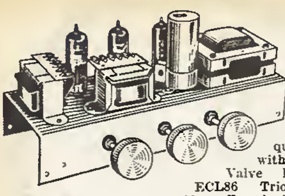

A.c. mains 200–240 volts. Using heavy duty fully isolated mains transformer with full wave rectification giving adequate smoothing with negligible hum. Valve line up:—2× ECL86 Triode Pentodes. 1×EZ80 as full wave rectifier. Two dual potentiometers are provided for bass and treble control, giving bass and treble boost and cut. A dual volume control is used. Balance of the left and right hand channels can be adjusted by means of a separate "balance" control fitted at the rear of the chassis. Input sensitivity is approximately 300m/v for full peak output of 4 watts per channel (8 watts mono), into 3 ohm speakers. Full negative feedback in a carefully calculated circuit, allows high volume levels to be used with negligible distortion. Supplied complete with knobs, chassis size 11in. w × 4in. x. Overall height including valves 5in. Ready built and tested to a high standard. **Price 8 gns.** P. & P. 8/-.

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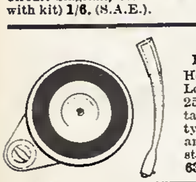
Circuit diagram, construction details and parts list (free with kit) **1/6.** (S.A.E.).



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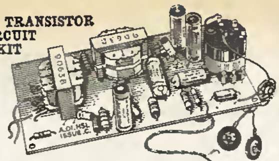

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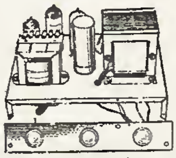

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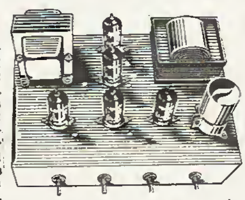

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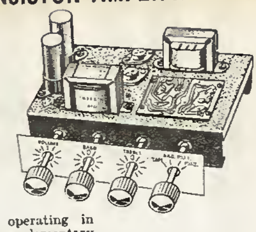

A really high fidelity monaural amplifier with performance characteristics to suit the most discriminating listener. 6 transistor circuit with integrated preamplifier assembled on special printed sub panel. AD161-AD162 operating in symmetrical complementary pair. Output transformer coupled to 3 ohm and 15 ohm speaker sockets. Standard phono input sockets. Full wave bridge rectifier power supply for a.c. mains 200–240v. Controls: bass, treble, volume/on/off. Function selector for PU1, PU2, tape, radio. The HSL.700 is strongly constructed on rigid steel chassis bronze hammer enamel finish, size 9¼ × 5 × 4½in. high.

Performance figures:

Sensitivity—PU1—50m/v, 56K input impedance.
PU2—110m/v, 1 meg input impedance.
Tape—110m/v, 1 meg input impedance.
Radio—110m/v, 1 meg input impedance.

Output power measured at 1Kc—6·2 watts RMS into 3 ohms, 5·8 watts RMS into 15 ohm. Overall frequency response 30c/s–18Kc/s: Continuously variable tone controls: Bass, +8db to −12db at 100c/s. Treble, +10db to −10db at 10Kc/s.

The HSL.700 has been designed for true high fidelity reproduction from radio tuner, gramophone deck and tape recorder pre amp but is also capable of being used in conjunction with a guitar by connecting to PU1 socket and the peak output power will then be in the region of 15 watts.

Supplied ready built and tested, complete with knobs, attractive anodised aluminium front escutcheon panel, long spindles (can be cut to suit your housing requirements) full circuit diagram and operating instructions.

OUR SPECIAL PRICE £7.19.6. P. & P. 7/6.

COLLARO MAGNAVOX 363 STEREO TAPE DECK. 3-speeds, 4 track, up to 7in. spools. **£16.10.0.** Carr. 10/-.

HIGH IMPEDANCE CRYSTAL STICK MIKES. OUR PRICE **21/-.** P. & P. 1/6.

CARBON MIKE INSERTS. Brand New. 2½in. dia. **5/-.** P. & P. 1/6.

QUALITY RECORD PLAYER AMPLIFIER MK II

A top-quality record player amplifier employing heavy duty double wound mains transformer, ECC83, EL84, EZ80 valves. Separate Bass, Treble and Volume controls. Complete with output transformer matched for 3 ohm speaker. Size 7in. w. × 3 d. × 6 h. Ready built and tested. PRICE **75/-.** P. & P. 6/-. ALSO AVAILABLE mounted on board with output transformer and speaker ready to fit into cabinet below. PRICE **97/6.** P. & P. 7/6.

DE LUXE QUALITY PORTABLE R/P CABINET MK II Uncut motor board size 14½ × 12in., clearance 2in. below, 5½in. above. Will take above amplifier and any B.S.R. or GARRARD changer or Single Player (except AT60 and SP25). Size 18 × 15 × 8in. PRICE **79/6.** P. & P. 9/6.

MAINS TRANSFORMER. Primary 200-240V two separate ½ wave secondaries giving approx. 16V at 1 amp and 20V at 1·2 amp; secs. can be connected in series for 36V at 1·5 amp. Ideal for transistor power supplies. Drop through mounting. Stack size 2¾ × 3½ × ⅞in. **15/-.** P. & P. 6/-.

MAINS TRANSFORMER. For transistor power supplies. Pri. 200/240V. Sec. 9–0–9 at 500mA. **11/-.** P. & P. 2/6. Pri. 200/240V. Sec. 12–0–12 at 1 amp. **14/6.** P. & P. 2/6. Pri. 200/240V. Sec. 10–0–10 at 2 amp. **27/6.** P. & P. 3/6.

MATCHED PAIR OF 2½ WATT TRANSISTOR DRIVER AND OUTPUT TRANSFORMERS. Stack size 1¼ × 1⅛ × ⅞in. Output trans. tapped for 3 ohm and 15 ohm output. **10/-** pair plus 2/- P. & P.

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104 SALISBURY ROAD
HIGH BARNET
01-449 3087

SPECIAL NO. 1		SPECIAL NO. 2		SPECIAL NO. 3			
AC127	4/-	BC108	3/3	BY127	4/-	OC35	7/6
NKT123	4/11	OA200	2/-	2N706A	3/3	2N3704	5/6
NKT124	8/9	OA81	1/6	2N2219	8/9	ACY20	4/9
NKT125	5/9	OA95	1/6	2N2368	4/6	ACY21	5/-
NKT126	6/3	OC44	2/6	2N2369	5/-	ACY22	3/3
NKT135	5/3	OC45	1/8	2N2369A	5/6	ACY32	5/3
NKT137	7/6	OC70	4/6	2N2926	3/9	ACY40	3/6
NKT214	3/9	OC71	2/3	2N3391	6/-	AC126	4/-
NKT275	4/-	OC72	2/6	2N3391A	6/9	AC127	5/-
NKT277	5/-	OC74	3/9	2N3392	4/9	AF114	4/3
NKT453	8/-	OC75	3/9	2N3393	3/9	AF115	3/9
NKT603F	6/-	OC78	5/-	2N3394	3/9	AF116	2/9
NKT613F	7/-	OC81	2/2	2N3402	6/9	AF117	2/9
NKT674F	5/6	OC81D	2/3	2N3403	7/6	BC107	4/-
NKT713	5/3	OC170	2/3	2N3404	7/6	BC109	4/-
NKT734	5/4	OC171	3/3	2N3405	9/-		
NKT736	6/6	OC172	3/6	2N3414	4/6		
NKT773	4/9	RESISTORS ¼W 3d.		Cash with order		P. & P. 1/-	

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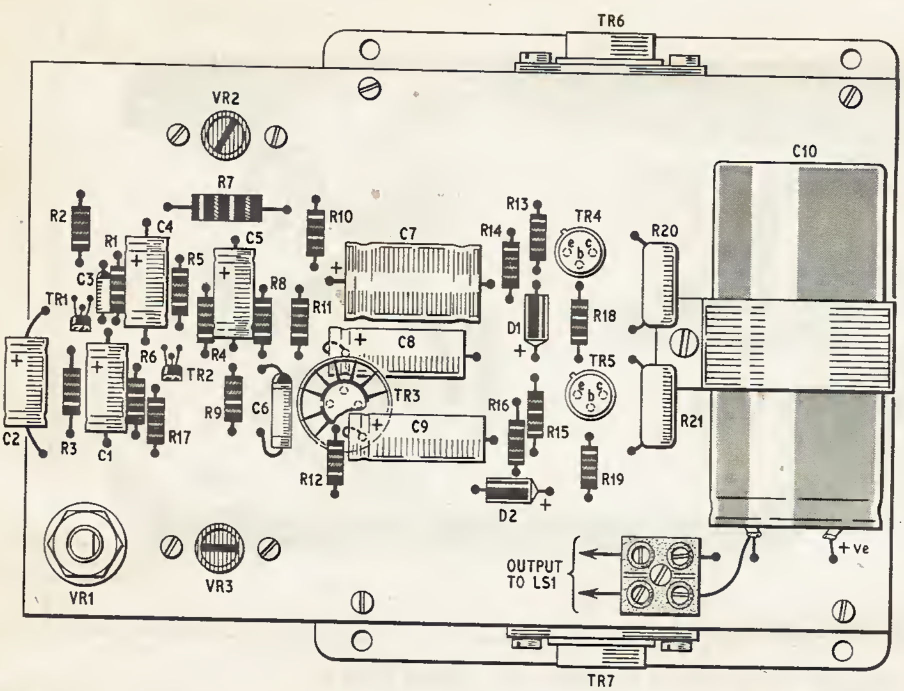


Fig. 4.7. Component layout on topside of printed circuit board for P.A.1 and P.A.2. For details of heat sink see Fig. 4.10. Note the radial cooler for TR3

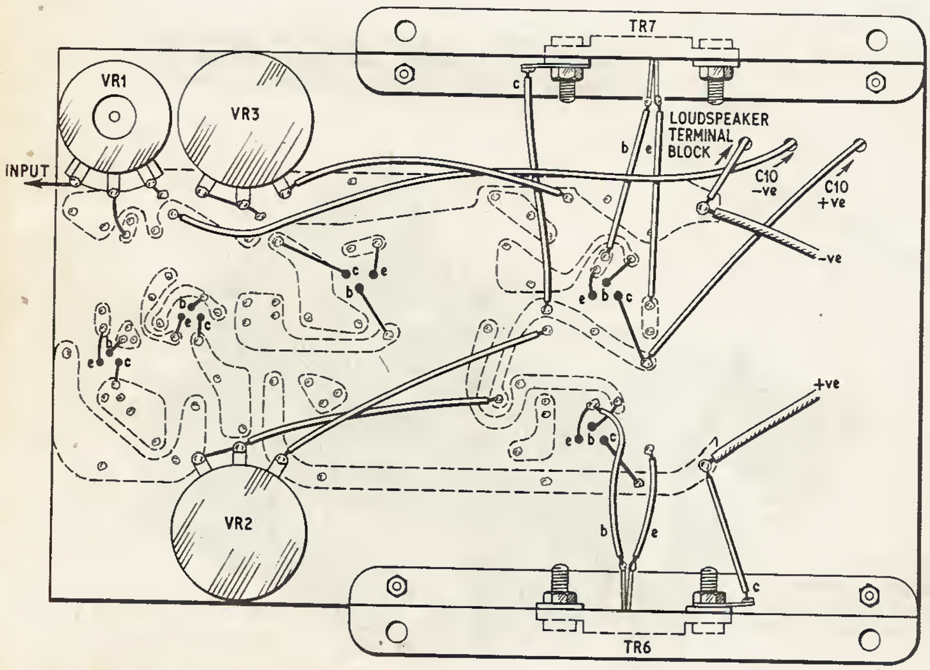


Fig. 4.8. Wiring of potentiometer and transistors to underside of amplifier printed circuit boards

COMPONENTS . . .

P.A.1 AND P.A.2
Component differences for P.A.2 are given in parentheses

Resistors

R1	120kΩ (180kΩ)
R2	680Ω (1kΩ)
R3	10Ω
R4	68kΩ (82kΩ)
R5	560Ω (820Ω)
R6	27Ω
R7	1·5kΩ 1W
R8	15kΩ (12kΩ)
R9	1·5kΩ (1kΩ)
R10	820Ω
R11	220Ω (150Ω)
R12	220Ω (150Ω)
R13	2·2kΩ (2·7kΩ)
R14	150Ω (100Ω)
R15	2·2kΩ (2·7kΩ)
R16	150Ω (100Ω)
R17	270Ω
R18	56Ω
R19	56Ω
R20	0·5Ω 2W
R21	0·5Ω 2W

All 10%, ½ watt carbon unless otherwise stated

Capacitors

C1	25μF elect. 12V
C2	25μF elect. 25V
C3	220pF
C4	25μF elect. 12V
C5	25μF elect. 12V
C6	680pF
C7	250μF elect. 12V
C8	100μF elect. 12V
C9	100μF elect. 12V
C10	2,000μF elect. 50V

Potentiometers

VR1	5kΩ lin.
VR2	100Ω preset
VR3	100Ω preset

Transistors

TR1	ZTX302
TR2	ZTX300
TR3	ZT44 (ZT1613)
TR4, 5	ZT1613
TR6	ZT1701 (ZT3055)

All Ferranti types

Diodes

D1, 2 ZS70 (Ferranti)

Loudspeakers

LS1	WB. HF1016
LS2	WB. HF1214

Miscellaneous

Printed circuit boards. Aluminium heat sinks (minimum area 4 sq. in) Radial cooler for TR3 Components and printed circuit boards for the amplifiers and power supplies can be obtained from: Welbrook Engineering and Electronics Ltd., Brooks Street, Stockport, Cheshire

Fig. 4.9. Printed circuit board for P.A.I and P.A.2, full size

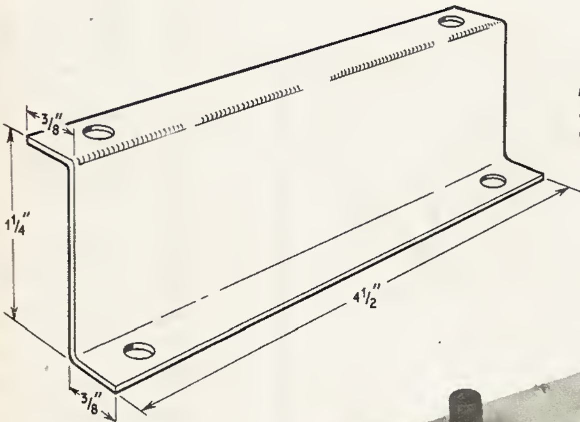
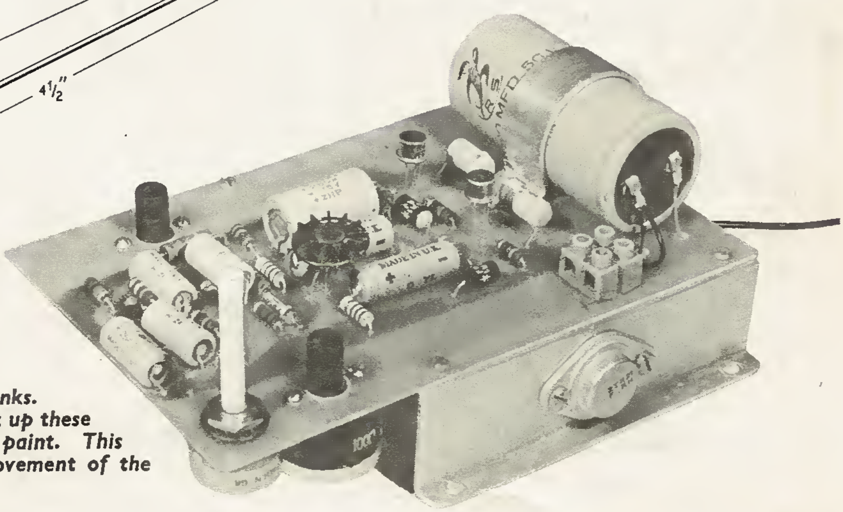


Fig. 4.10 (left). Heat sink details for amplifiers. Lead holes for output transistors should be drilled to conform with their relevant geometries



View of P.A.2 standing on heat sinks. When the preset resistors are set up these snould be marked with a spot of paint. This will indicate any accidental movement of the wiper when installing

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HI-TONE RECORDING TAPE

BRITISH MADE TOP QUALITY

J1001	3"	Long Play PVC	225ft	**5/6**	P. & P. 1/2
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J1003	5"	Long Play PVC	900ft	**10/-**	P. & P. 1/8
J1004	5"	Double Play Poly	1200ft	**15/-**	P. & P. 1/8
J1005	5¾"	Long Play PVC	1200ft	**12/6**	P. & P. 2/-
J1006	5¾"	Double Play Poly	1800ft	**22/6**	P. & P. 2/-
J1007	7"	Standard Play PVC	1200ft	**12/6**	P. & P. 2/6
J1008	7"	Long Play PVC	1800ft	**17/6**	P. & P. 2/6
J1009	7"	Double Play Poly	2400ft	**25/-**	P. & P. 2/6
J1010	7"	Triple Play Poly	3600ft	**50/-**	P. & P. 2/6

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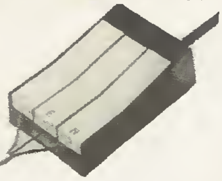
MAINS KEYNECTOR
SAVES TIME—SAFELY!



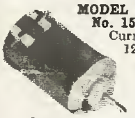
One mains "Keynector" instantly and safely connects electrical appliances to mains supply without the use of a plug. A number of appliances may be used simultaneously up to the full 13 amp rating of this device. A red light glows when "live". The "Keynector" is fused and has its own robust switch which is interlocked to prevent connections when "live".
Invaluable to handymen, servicemen, demonstrators, etc.

39/6 P. & P. 3/-.

VHF AIRCRAFT BAND CONVERTOR.

When placed within 1in. of a MW band radio full coverage of VHF Aircraft Band 108-135Mc/s. can be obtained. All transistor, 9V battery operation. Fully tunable 18½in. × 7 section telescopic aerial. Size 4 × 2¾ × 1½in. **79/6.** P. & P. 3/6.

MODEL MAKER'S MOTOR No. 15RN.

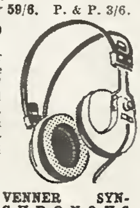


Voltage 11·5V. Current 400mA. Torque 12g.cm. Body size 1⅜" × long × ⅞" dia. Shaft 7/16" long × ⅛" dia. Ideal for small models and toys. **5/6** each. P. & P. 1/3. 3 for **15/-**. P. & P. 2/6.

DE-LUXE STEREO HEADPHONES

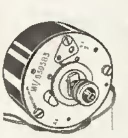
With soft rubber earpieces. Impedance 8-16 ohms. Frequency response 23-13,000cps. With lead and stereo plug.
Only **59/6.** P. & P. 3/6.

NEW STEREO/MONO HEADPHONES.



SDH-7. Soft rubber earpieces with slide switch for mono/stereo listening and ind. vol. controls. Impedance 8-16 ohm Freq. response 25-15,000cps. With lead and stereo plug.
£6.6.0. P. & P. 3/6.

VENNER SYNCHRONOUS MOTOR UNIT



Brand New. Mains voltage (200/250V), 1 rev. per hour. Precision movement (enclosed in case), self starting, silent running. Shaft complete with knurled clamping nut. Overall dimensions: 2⅞in diam., 2 11/16in deep (including shaft). Shaft diam. 3/32in. **27/6.** P. & P. 3/6.

TRANSFORMERS

AUTO WOUND TRANSFORMERS

All winding voltage ratings and tappings 0-115-200-220-240V, except MT113 0-115-210-240V

		Size	Weight	Price	
MT113	20W	2⅞ × 1 11/16 × 1⅞in	11oz	**12/6**	(P. & P. 2/6)
MT64	75W	2⅞ × 2½ × 2⅝in	1lb 14oz	**21/9**	(P. & P. 4/6)
MT4	150W	3½ × 2⅞ × 3in	3lb	**33/-**	(P. & P. 6/-)
MT65	200W	3½ × 4½ × 4in	4lb	**39/6**	(P. & P. 6/-)
MT66	300W	4 × 4 × 3⅞in	6lb 7oz	**59/4**	(P. & P. 9/-)
MT110	400W	4⅞ × 4½ × 4in	11lb	**85/-**	(P. & P. 10/-)
MT67	500W	5½ × 4 × 4½in	12lb 8oz	**89/-**	(P. & P. 10/6)
MT83	750W	4½ × 5½ × 5¼in	13lb 4oz	**95/7**	(P. & P. 10/6)
MT84	1000W	4½ × 5½ × 5¼in	16lb	**142/2**	(Carr. extra)
MT93	1500W	5 3/16 × 5⅞ × 6½in	28lb 9oz	**170/6**	(Carr. extra)
MT94	1750W	5 3/16 × 6⅜ × 6½in	31lb	**195/-**	(Carr. extra)
MT95	2000W	7 × 6½ × 8½in	40lb	**211/2**	(Carr. extra)
MT73	3000W	6⅞ × 7½ × 8⅞in	45lb 8oz	**300/-**	(Carr. extra)

LOW VOLTAGE 12V RANGE

Primary 200-250V; secondary 12V

MT111	0·5A	3 × 2½ × 1⅞in	12oz	**15/3**	(P. & P. 2/6)
MT71	2A	2⅞ × 2½ × 2¼in	1lb	**19/-**	(P. & P. 3/9)
MT69	4A	3½ × 2⅞ × 2⅞in	2lb 4oz	**28/-**	(P. & P. 6/-)
MT70	6A	4 × 3 × 3⅜in	3lb 12oz	**39/-**	(P. & P. 6/-)
MT72	10A	3½ × 4½ × 4in	6lb 3oz	**51/-**	(P. & P. 9/-)
MT115	20A	4⅞ × 4½ × 4in	11lb 13oz	**95/-**	(P. & P. 9/-)
MT187	30A	5½ × 4⅞ × 4⅞in	16lb 12oz	**180/-**	(P. & P. 13/6)

LOW VOLTAGE 24V RANGE

Primary 200/250V; secondary 24V

MT58	1A	2⅞ × 2⅜ × 2½	1lb 7oz	**23/9**	(P. & P. 4/6)
MT114	3A	2½ × 3 × 3in	3lb 6oz	**38/-**	(P. & P. 6/-)
MT72	5A	4 × 3⅞ × 3⅜in	5lb 12oz	**53/10**	(P. & P. 6/-)
MT17	8A	4⅞ × 3⅞ × 4in	7lb 8oz	**72/7**	(P. & P. 9/-)
MT115	10A	4⅞ × 4½ × 4in	11lb 13oz	**95/-**	(P. & P. 11/-)

LOW VOLTAGE 30V RANGE

Primary 200/250V; secondary tapped 12-15-20-24-30V

MT112	0·5A	3½ × 2 7/16 × 1 5/16in	1lb 4oz	**17/4**	(P. & P. 3/9)
MT79	1A	2⅞ × 2½ × 2⅜in	2lb	**23/-**	(P. & P. 6/-)
MT20	3A	4 × 3½ × 3⅜in	4lb 6oz	**46/2**	(P. & P. 6/-)
MT51	5A	4⅞ × 3½ × 4in	6lb 8oz	**60/9**	(P. & P. 9/-)
MT88	8A	5½ × 3⅞ × 4½in	9lb 6oz	**92/4**	(P. & P. 11/-)
MT89	10A	5½ × 4 × 4½in	12lb 2oz	**103/6**	(P. & P. 11/-)

LOW VOLTAGE 50V RANGE

Primary 200-250V; secondary tapped 19-25-33-40-50V

MT102	0·5A	2⅞ × 2⅞ × 2½in	1lb 11oz	**21/3**	(P. & P. 6/-)
MT104	2A	4 × 3½ × 3⅜in	5lb	**45/8**	(P. & P. 6/-)
MT106	4A	4⅞ × 4½ × 4	9lb 4oz	**77/-**	(P. & P. 9/-)
MT118	8A	5½ × 5½ × 4⅞in	18lb 9oz	**132/-**	(P. & P. 13/6)
MT119	10A	6½ × 4½ × 6⅞in	19lb 12oz	**165/-**	(P. & P. 15/6)

LOW VOLTAGE 60V RANGE

Primary 200/250V; secondary tapped 24-30-40-48-60V

MT124	0·5A	3½ × 2⅞ × 2⅝in	2lb 4oz	**24/-**	(P. & P. 6/-)
MT127	2A	4 × 3½ × 3⅜in	5lb 6oz	**52/10**	(P. & P. 6/-)
MT123	4A	4½ × 3⅞ × 4½in	10lb 6oz	**99/-**	(P. & P. 11/-)
MT122	10A	6½ × 5 × 6⅞in	23lb 2oz	**152/-**	(Carr. extra)

MAINS H.T. RANGE

				Size	Price	P&P
MT1AT	250-0-250V	80MA	6·3V 3·5A 5/6·3V 1A	3½ × 3 × 3in	**33/-**	6/-
MT6AT	250-0-250V	100MA	6·3V 3·5A 5/6·3V 1A	4 × 3½ × 3½in	**38/3**	6/-
MT110	250-0-250V	120MA	6·3V 3·5A 5/6·3V 1A	4 × 4 × 3½in	**44/9**	6/-
MT11AT	300-0-300V	100MA	6·3V 3·5A 5/6·3V 1A	4 × 3½ × 3⅜in	**37/9**	6/-
MT12AT	300-0-300V	120MA	6·3V 4A 5/6·3V 1A	4 × 3⅞ × 3⅜in	**46/2**	9/-
MT33AT	300-0-300V	150	6·3V 4A 5/6·3V 1A	4 × 4 × 3½in	**59/4**	9/-
MT2AT	350-0-350V	80	6·3V 3·5A 5/6V 1A	4 × 3½ × 3⅜in	**38/6**	6/-
MT7	350-0-350V	100	6·3V 3·5A 5/6·3V 1A	4 × 3½ × 3⅜in	**42/4**	6/-
MT8	350-0-350V	120	6·3V 3·5A 5/6·3V 1A	4 × 3⅞ × 3⅜in	**50/-**	6/-

BATTERY CHARGER TYPES

Primary voltage 200-250V; secondary 6-12V

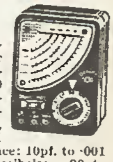
MT77	1A	2⅞ × 2⅛ × 2⅜in	1lb 6oz	**15/-**	(P. & P. 4/6)
MT45	1·5A	2⅞ × 2⅜ × 2⅜in	1lb 9oz	**21/9**	(P. & P. 4/6)
MT46	2A	3½ × 2⅝ × 2⅜in	2lb 4oz	**25/4**	(P. & P. 6/-)
MT47	3A	4 × 3 × 3⅜in	3lb 8oz	**28/4**	(P. & P. 6/-)
MT5	4A	4 × 2⅞ × 3½in	3lb 11oz	**33/-**	(P. & P. 6/-)
MT78	5A	4 × 3½ × 3⅜in	5lb 4oz	**42/-**	(P. & P. 6/-)
MT86	6A	4 × 3½ × 3⅞in	5lb 12oz	**48/-**	(P. & P. 6/-)
MT48	7A	4 × 4 × 3⅜in	6lb	**56/7**	(P. & P. 9/-)
MT146	8A	3½ × 4 × 4in	6lb 4oz	**75/-**	(P. & P. 9/-)
MT49	9A	4⅞ × 3⅞ × 4in	7lb 8oz	**99/-**	(P. & P. 9/-)
MT147	10A	4⅞ × 3½ × 4in	9lb 3oz	**105/-**	(P. & P. 9/-)
MT50	12·5A	5½ × 4½ × 4⅞in	11lb 14oz	**125/-**	(P. & P. 11/-)

Amperages are d.c. with nominal selenium bridge rectifiers
MAINS ISOLATING RANGE also available

TTC.C1001 MULTITESTER in leather case.

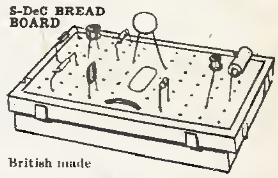
20,000 opv. AC volts 10, 50, 250, 1,000V. DC. volts 5-25, 125, 500, 2,500V. D.C. Current 0-50μA, 0-250mA Resistance 0-60K, 0-6 Megohm. Decibels −20 to +22dB. Size of meter 4½ × 3⅞ × 1in. **85/-.** P. & P. 3/6.

SHIRA 62D MULTI-TESTER 20,000 o.p.v.



DC voltage: 5-25-50-250-500-2·5K (20,000 ohms per volt). AC Voltage: 10-50-100-500 1000 volts (10,000 ohms per volt). DC Current: 0-50μA, 0-2·5mA, 0-250mA. Resistance: 0-6K, 0-6Mg (300 ohm and 30K at centre scale). Capacitance: 10pf. to ·001 mfd, ·001μf to ·1μF. Decibels: −20 to +22dB. Size 4½ × 3½ × 1in. Complete with case **77/-.** P. & P. 3/6.

S-DeC BREAD BOARD



British made

Solderless breadboard panels, for fast reliable component connections.
Single DeCs. One S-DeC with Control Panel, Jig and Accessories for solderless connections to controls, etc., with booklet "Projects on S-DeC" giving construction details for a variety of circuits. **29/6.** P. & P. 2/6.
4-DeC KIT. Four S-DeCs wth two Control Panels, Jigs and Accessories and, the booklet "Projects on S-DeC" all contained in a strong attractive plastic case. Ideal for the professional user. **£5.17.6.** P. & P. 3/6.

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SRP22 less cartridge	**£5. 9.6**
1025 Stereo/Mono with cart.	**£6.19.6**
2025 Stereo/Mono with cart.	**£7.19.6**
3000S Stereo/Mono with cart. ..	**£9.19.6**
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In addition, the earth line connection between amplifier and attendant power unit must be made to the earth line at the output end of the amplifier, not to the end where the potentiometer VR1 is connected to the earth line.

The amplifier component layout and wiring is given in Fig. 4.7 and Fig 4.8, the etched printed circuit pattern is depicted full size in Fig. 4.9.

The output transistors TR6 and TR7 are each mounted on an aluminium heat sink. Since these transistors have case collectors they must be insulated from the aluminium with suitable mica washers. Details of one of the heat sinks is given in Fig. 4.10. Reference to the photograph of a completed amplifier (P.A.2) shows how the sinks afford a mounting base for the printed circuit board.

To complete the amplifiers the wiring of the potentiometers and transistors to the underside of the printed board is given in Fig. 4.8

SETTING UP

The preset resistors VR2 and VR3 shown in Fig. 4.8 provide a means of setting the standing current of the output transistors for elimination of crossover distortion and ensuring maximum voltage swing across the loudspeaker load.

To adjust these in each of the amplifiers a milliameter is inserted in the positive supply line from the serving power supply unit. A d.c. voltmeter is then connected from TR7 collector to the earth line. With the relevant power unit switched on, each of the 100 ohm preset resistors is adjusted from minimum resistance until the current in the milliameter increases by approximately 15 milliamps. At the same time it is necessary to ensure that the d.c. collector voltage at TR7 is approximately half the value of the supply voltage.

Both in the setting up and with any dynamic checks that might be made on the amplifiers the loudspeaker loads should be included.

With the completion of the setting up of the amplifiers these should be temporarily placed to one side.

END CHEEKS FOR S.K.A. KEYBOARDS

In Part One of this series we gave as an alternative to

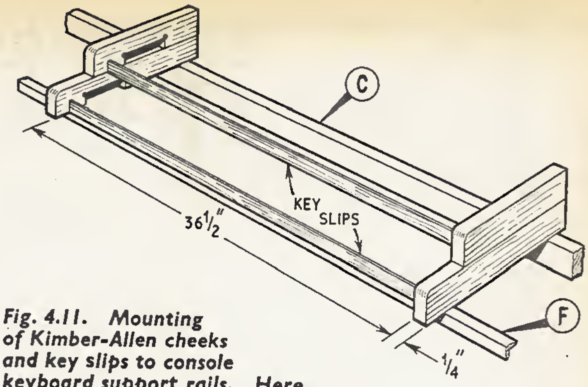

Fig. 4.11. Mounting of Kimber-Allen cheeks and key slips to console keyboard support rails. Here cheek recesses can be clearly seen

the Goddard keyboards those manufactured by Kimber-Allen Ltd. Unfortunately, the geometry of the latter keyframes precludes fitting in the cheek assembly given in Fig. 1.9. Since then Kimber-Allen Ltd. have produced special hardwood end cheeks which are slotted in such a way to enable the 61 note S.K.A. keyboards to be pushed in, then screw-attached.

It follows, of course, that complete accuracy of fitting is ensured with these manufactured cheeks since both keyboards are finally held in their proper relative positions. For purchasers of the keyboards and end cheeks, fully dimensional drawings are shown in Fig. 4.11 and Fig. 4.12 to enable the fixing of these to the keyboard supports C and F as shown in Fig. 1.4.

The Harmonics contact assemblies will fit quite easily under the Kimber-Allen plastic keys; should the holes for the actuators come in the wrong place by any mischance, the keys are easily taken off while new holes are drilled. It should be noted that the plastic actuators fitted to the Kimber-Allen keys are not now required and simply pull out, leaving the dollies of the Harmonics contact assemblies to contact the underside of the keys directly.

Next month we will introduce the tone forming circuits.

To be continued

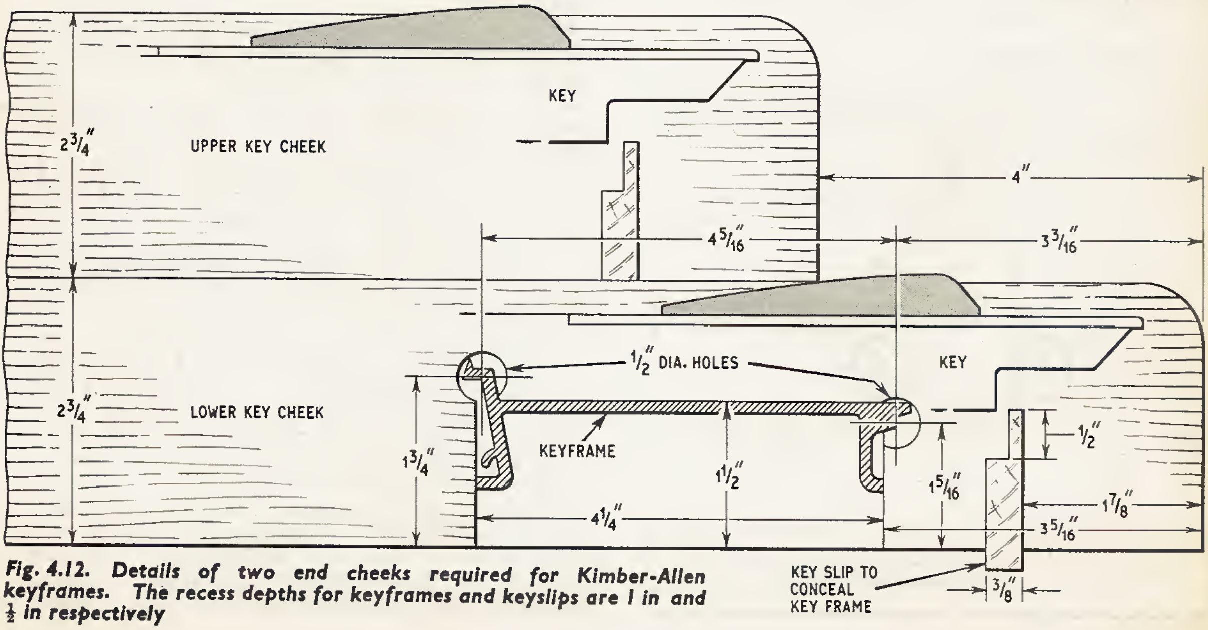

Fig. 4.12. Details of two end cheeks required for Kimber-Allen keyframes. The recess depths for keyframes and keyslips are 1 in and ½ in respectively

EXPERIMENTS WITH THE OPERATIONAL AMPLIFIER

By G. K. FAIRFIELD

Part 3 Design criteria

This concluding article will consider the design of some typical operational amplifiers which can be used in any of the applications described in the two previous articles.

As explained earlier, the greater the open-loop gain of the amplifier, then the less important will be the deterioration of its active elements (valves or transistors) and the voltage stability of its power supplies. A high gain also allows its gain with feedback components added to be determined only by the value of these components. Finally a high gain permits a high input impedance to be obtained, which facilitates certain applications such as the meter described last month.

Operational amplifiers used in highly accurate analogue computers have open loop gains of the order 10^6 to 10^8. Such large stable d.c. gains can only be obtained by elaborate chopper stabilised amplifier designs and, as such, are expensive to purchase and quite difficult to design. However, if the required gain can be reduced to about 10^4 then considerable simplification is possible in a practical design.

Such a gain is quite adequate for the amplifiers used in the applications quoted previously, as the requirements are by no means as stringent as is the case with an analogue computer. Two transistorised examples of such an amplifier are described below.

AMPLIFIER DESIGN

The most important feature of a high gain d.c. amplifier is its performance with regard to change of temperature at its output terminal when the amplifier input is short-circuited.

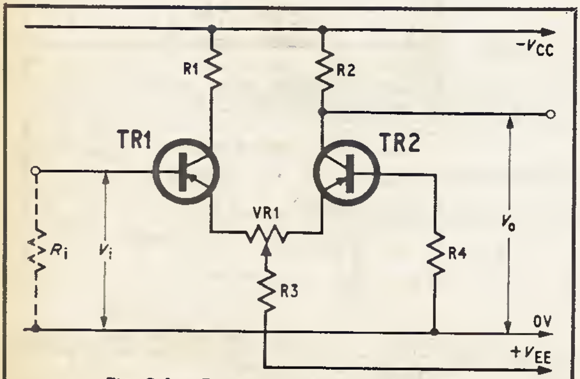

Fig. 3.1. Basic emitter coupled stage

This is known as the d.c. drift of the amplifier and is usually stated as so many microamps per degree C, and refers to the equivalent drift of its output current, assuming all of this occurs at the input terminals. Thus the drift of the output current due to temperature change is the number of microamps per degree C multiplied by the overall amplifier gain.

There are very many ways of compensating for the inevitable drift that occurs in a practical amplifier. A well-known method is to use a temperature sensitive resistor at some point in the circuit, whose purpose is to introduce an equal and opposite current change to cancel out that due to change in transistor characteristics. This requires fairly careful design however and the compensation technique is never completely successful.

An alternative method which, although using more amplifier components, is easier to apply and is known as the emitter coupled transistor amplifier. The fundamental principle is to assume that a pair of transistors will drift a similar amount and to arrange the circuit so that these drifts will cancel out and not be added to the d.c. level of the signal being amplified.

EMITTER-COUPLED TRANSISTOR AMPLIFIER

The basic emitter coupled stage is shown in Fig. 3.1. The two transistors should have similar characteristics and ideally be mounted in the same can. The static collector currents must be identical and a potentiometer VR1 is included to permit adjustment of these currents to equality.

The circuit operation is as follows. Provided that R3 is large, the signal voltage is divided equally between R_i, the base-emitter diode of TR2 and R4 in the ratio of their resistance values. Assuming that the transistors are identical then the voltage across the base-emitter diodes are the same, causing equal and opposite inputs to the two transistors.

Where R4 is zero a voltage $V_i/2$ appears at the mid-point of VR1. However, more usually R_i is fairly large and R4 must be made equal to it. For this reason an appreciable part of the input voltage V_i appears across R4 and as a result the gain of the stage is reduced.

The large value of R3 causes the sum of the two emitter currents, and hence the collector currents to be stabilised as $-V_{EE}/R_3$. Hence the in-phase changes of current through the two transistors are almost completely prevented, and current changes due to identical variation of the temperature-dependent transistor parameters are considerably reduced. In a similar

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AC128	2/6	OC201	7/–
AC176	5/–	2G301	2/6
ACY17	3/–	2G303	2/6
AF114	4/–	2N711	10/–
AF115	3/6	2N1302-3	4/–
AF116	3/6	2N1304-5	5/–
AF117	3/6	2N1306-7	6/–
AF239	12/6	2N1308-9	8/–
AF186	10/–	2N3844A	5/–
AF139	10/–	**Power**	
BFY50	4/–	**Transistors**	
BSY25	7/6	OC20	10/–
BSY26	3/–	OC23	10/–
BSY27	3/–	OC25	8/–
BSY28	3/–	OC26	5/–
BSY29	3/–	OC28	7/6
BSY95A	3/–	OC35	5/–
OC41	2/6	OC36	7/6
OC44	2/6	AD149	10/–
OC45	2/6	AUY10	30/–
OC71	2/6	2N3055	15/–
OC72	2/6	**Diodes**	
OC73	3/6	AAY42	2/–
OC81	2/6	OA95	2/–
OC81D	2/6	OA70	1/9
OC83	4/–	OA79	1/9
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OC140	3/6	IN914	1/6

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way the output is reasonably independent of supply voltage variations.

In order to achieve a high value for R3 this resistor is often replaced by a transistor having a common-base configuration so that three transistors are required for one emitter-coupled stage.

PRACTICAL CIRCUIT

An operational amplifier using several d.c. emitter-coupled stages is shown in Fig. 3.2. The input is applied to the base of TR1 (single-ended input) or where a push-pull balanced signal is available to the bases of both TR1 and TR2, through input resistors R_{i_1} and R_{i_2}. If no signal is applied via R_{i_1}, then its free end is connected to ground.

This first pair of transistors TR1 and TR2 makes use of a transistor (TR7) connected to give a very high impedance in the common emitter supply lead. Potentiometer VR1 is adjusted to give a total current through R1 of about 0·5mA, and the balance potentiometer VR2 is adjusted to give equality of collector currents for TR1 and TR2. A simple way to check this is to connect a high resistance millivoltmeter between the collectors and adjust for a null reading.

The second emitter coupled pair TR3 and TR4 is directly coupled to TR1 and TR2 and no adjustment should be necessary to the junction point of R7 and R8. If these transistors are slightly out of balance then a compensating adjustment to VR2 can be made.

The final stage draws rather more current through its common emitter lead in order that the output impedance may be reasonably low in comparison with the value of the feedback resistors R_{fb_1} and R_{fb_2}. An adjustment is made to the common emitter current by means of VR3. The purpose of this is to enable the output terminal at the collectors of TR5 and TR6 to be adjusted to zero potential in the absence of an input signal to TR1 and TR2.

The input and feedback impedances are shown connected by dotted lines in the diagram. The gain with feedback is R_{fb_1}/R_{i_1} or R_{fb_2}/R_{i_2}; although R_{fb_2} can be omitted when R_{i_2} is connected to ground (single ended input) it is advisable to keep the circuit completely symmetrical by making $R_{fb_1} = R_{fb_2}$ and $R_{i_1} = R_{i_2}$ if only one input and one output is to be used. This is to avoid any possibility of instability when a large loop gain is used.

The amplifier design has a gain of 10,000 at frequencies up to 100kHz; phase compensating capacitors C1 and C2 enable a level frequency response up to this frequency to be obtained.

With several of the applications mentioned earlier, it may not be possible to duplicate the input and feedback impedances in the way described above. In such cases R_{i_2} is grounded and R_{fb_2} is omitted so that the circuit becomes a single-ended amplifier. The gain is a little reduced and more care must be taken with the initial balancing to avoid instability, otherwise the connection is quite straightfoward.

The complete amplifier can be constructed by soldering the components directly on to a printed wiring board.

Setting-up of the amplifier is quite simple. VR1 is first adjusted to give a current of about 0·5mA through R1. The output current of 3mA is then adjusted by VR3 with the current meter placed in series with VR3.

Finally with a high resistance, low current meter connected between the collectors of TR5 and TR6, VR2 is adjusted to give a null reading on the meter. It may then be necessary to readjust VR3 to obtain the required current of 3mA.

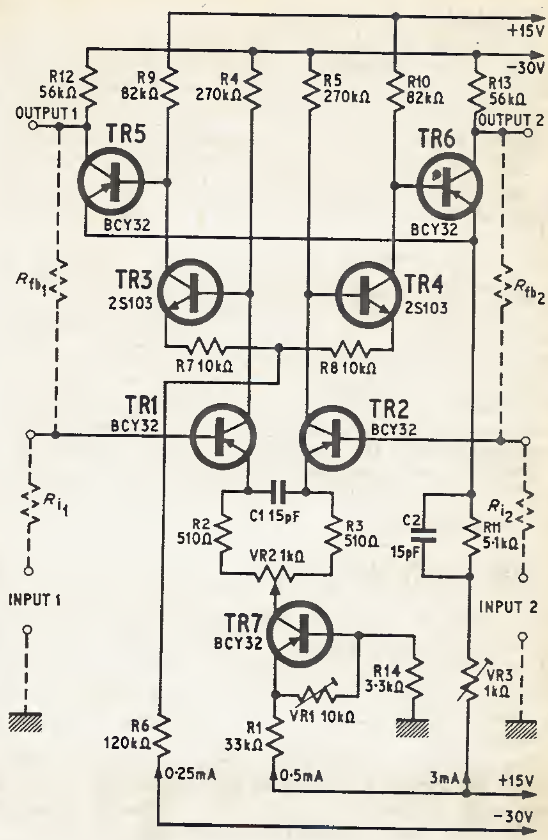

Fig. 3.2. Practical operational amplifier design with a gain of 10,000

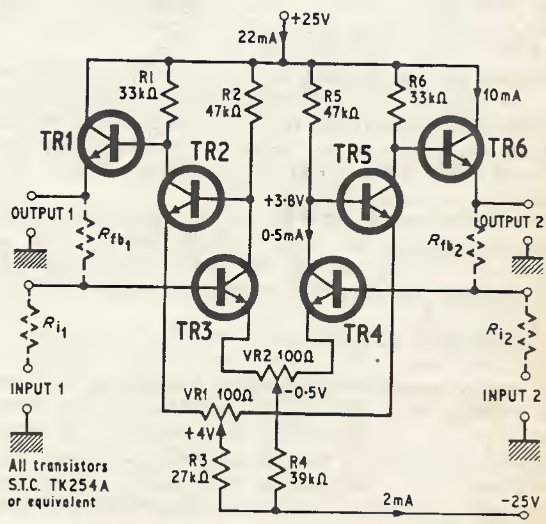

Fig. 3.3 Simple balanced pair design with a gain of 8,000

All of these adjustments should be carried out with the input terminals grounded.

ALTERNATIVE DESIGN

One of the difficulties in providing a good match for the pairs of transistors used in the emitter-coupled amplifier is due to the fact that the transistors were often manufactured separately and will not necessarily have identical characteristics. Fortunately manufacturers are becoming aware of the need for matched pairs and are able to supply transistors made from the same "chip" of semiconductor material and mounted in the same can.

A design based on transistor pairs of this type is shown in Fig. 3.3. This uses the S.T.C. dual transistors TK254A or equivalent. The design is a little simpler than the one given in Fig. 3.2 and only two potentiometers are necessary for balance adjustment.

The drift characteristics of this amplifier are very good, due to the similar characteristics of the transistor pairs, and is about 10μA/degrees centigrade, which compares favourably with some computer amplifiers.

The open loop gain will depend upon the spread in gain for the transistors, but a gain of at least 8,000 should be realised.

INTEGRATED CIRCUITS

This series of articles on the operational amplifier would not be complete without a mention of the integrated circuit amplifier. The question the reader will probably pose in this connection is whether he should take advantage of the recent developments in integrated circuits and purchase, instead of construct, the amplifier.

The cost of an integrated circuit amplifier having a similar performance to the designs described above is now quite comparable to the cost of the components required for a unit constructed of discrete elements.

Operational amplifiers are now produced by several manufacturers, fabricated on a single chip of silicon, including all the interconnecting resistors, and mounted in a single transistor can. The complexity of the sort of design realised in this way can be judged from the schematic diagram of the integrated circuit amplifier, type 702A, shown in Fig. 3.4a. The eight leads to the amplifier are brought out of the can and are shown in the connection diagram Fig. 3.4b.

A loop gain of 10,000 is available which is adequate for the applications described previously. If the high frequency response of the amplifier is important, which may be the case where it is used as, say, an oscilloscope pre-amplifier, then a small capacitor should be connected across terminals 5 and 6.

The actual value depends on the closed loop gain required and can be found by experiment. For a typical closed loop gain of 100 then a value of 500pF will permit a level frequency response of up to 30MHz to be obtained.

A monolithic construction is used for the integrated circuit amplifier. This means that all the transistors and resistors are fabricated under identical conditions and situated very close to one another on the same silicon chip. Consequently the matching between critical components is very good and under operating conditions the temperature differential from one component to another is quite small causing minimum d.c. drift.

The integrated circuit is produced by diffusing layers of *n*- and *p*-type material into the silicon chip in order to fabricate the circuit by purely chemical means. A cross-section of a part of a Texas Instruments operational amplifier (type SN523a) is shown in Fig. 3.5 to give an idea of this form of construction.

ADVANCED OPERATIONAL AMPLIFIER APPLICATION

To complete this series of articles the use of an operational amplifier to produce a simple frequency filter will be described.

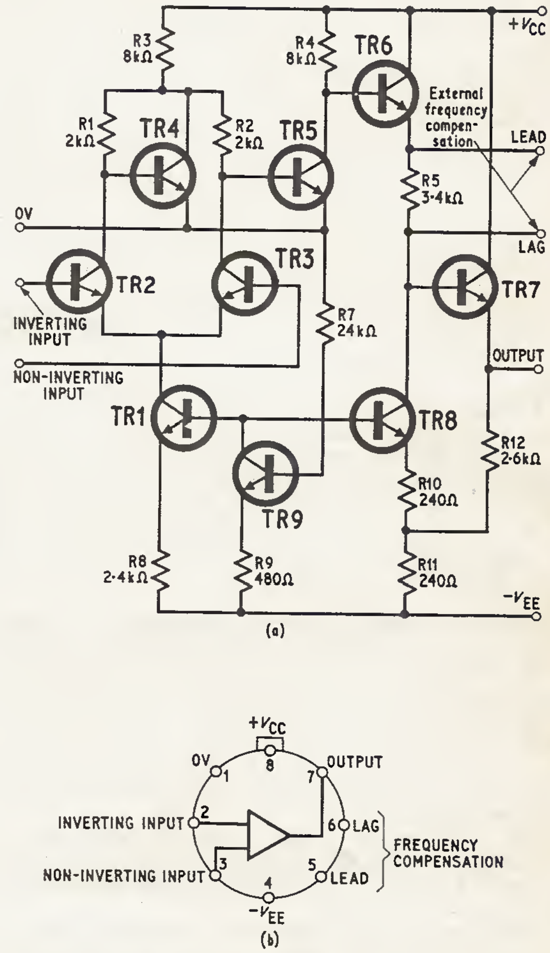

Fig. 3.4. A 702A integrated circuit operational amplifier; (a) the theoretical circuit, (b) the i.c. lead-out connections

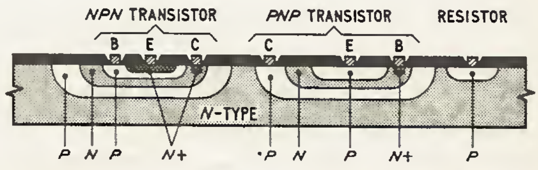

Fig. 3.5. Quadruple diffused planar operational amplifier in the Texas Series 52

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0·1 ..	10d	7/1	15/6	51/–
0·2 ..	1/2	10/–	20/10	68/6
0·5 ..	2/–	17/6	37/6	125/–

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470, 560, 680, 820, 1,000, 1,500 ..	6d	4/–	8/8	26/8
2,200, 3,300, 4,700, 5,600 ..	7d	5/–	10/10	33/4
6,800, 8,200, 10,000, 15,000 ..	8d	6/–	13/–	40/–
22,000 ..	9d	6/9	18/–	45/4

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220, 270, 330, 390, 470, 560, 680, 820 ..	1/3	10/8	23/1	71/–
1,000, 1,200, 1,500, 2,200, 2,700 ..	1/6	13/10	29/11	92/–
3,300, 3,900, 4,700, 5,600 ..	1/9	14/1	31/–	96/–
6,800, 8,200, 10,000, 12,000 ..	1/9	15/2	32/10	101/–
15,000, 18,000 ..	2/–	15/11	34/9	107/4
22,000, 27,000 ..	2/3	17/3	37/10	115/–
33,000, 39,000 ..	2/6	20/1	43/6	133/9
47,000, 56,000 ..	2/9	22/1	47/10	147/4
68,000 ..	3/–	24/9	53/8	165/4
82,000 ..	3/3	26/1	56/6	173/9
0·1μF ..	3/6	27/5	59/4	182/8
0·12μF ..	3/9	30/3	65/10	202/–
0·15μF ..	4/3	34/2	73/7	228/–
0·18μF ..	5/–	37/10	81/11	252/3
0·22μF ..	6/–	47/–	101/10	313/4
0·27μF ..	6/9	53/9	116/8	358/4
0·33μF ..	7/3	58/10	126/11	390/–
0·39μF ..	7/9	65/–	140/10	433/4
0·47μF, 0·5μF ..	9/9	75/2	137/7	500/–

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Subminiature: 0·1W at 70°C. ±20% below 2·5M, ±30% above.
Prices—per ohmic value

	each	10 off	25 off	100 off
Miniature (0·3W) ..	1/–	8/9	18/9	66/8
Subminiature (0·1W) ..	10d	7/1	14/7	46/8

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P2.	2/6	23/4	54/2	200/–
P3.	6/6	60/–	137/6	500/–
P4.	6/2	56/6	127/6	455/–
P5.	2/2	19/2	43/9	158/4
P6.	1/8	15/–	33/4	116/8

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25V	1·6	6·4	12·5	25	50	80
40V	1	4	8	16	32	50
64V	0·64	2·5	5	10	20	32
Price	1/4	1/3	1/2	1/–	1/1	1/2

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25V	160	250	400	640
40V	100	160	250	400
64V	64	100	160	250
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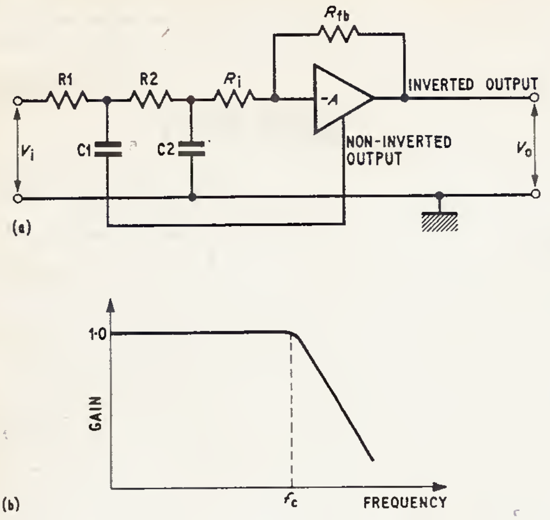

Fig. 3.6. Low pass filter circuit (a) and the typical frequency response (b)

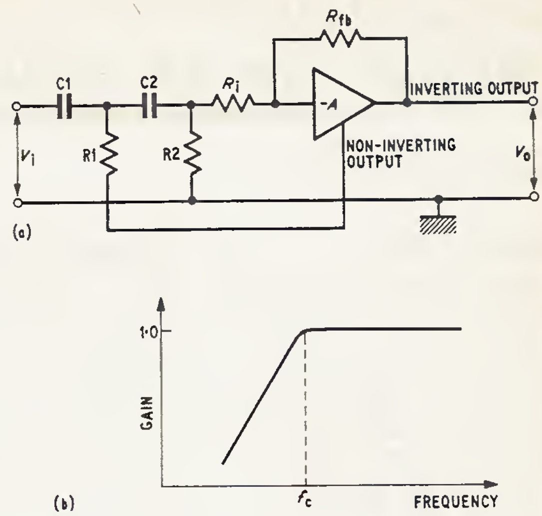

Fig. 3.7. High pass filter circuit (a) and the typical frequency response (b)

For this application an operational amplifier is required that does not invert the signal applied to its input. This is easily obtained with emitter-coupled amplifiers shown in Figs. 3.2 and 3.3. Since outputs can be obtained from either collector output terminal, one will be inverted and used for stabilising feedback and the other is required for filter feedback purposes.

The circuit for a low-pass filter is shown in Fig. 3.6a. This circuit will pass signals of a frequency lower than the turn-over frequency f_c without any attenuation. At frequencies higher than this the signals are considerably reduced. This is shown in Fig. 3.6b which gives the filter gain performance.

With $R_i = R_{fb} = 100\text{k}\Omega$ and $R1 = 100\text{k}\Omega$ and $R2 = 600\text{k}\Omega$ then the cut-off frequency of the filter depends on the values chosen for C1 and C2. The relationship is:

$$C1 = \frac{2{\cdot}1}{f_c}\ \mu\text{F}$$

and

$$C2 = \frac{0{\cdot}35}{f_c}\ \mu\text{F}$$

where f_c is the turn-over frequency in hertz.

Thus if we required a filter to cut all frequencies higher than 9kHz, then with the resistance values given above,

$$C1 = \frac{2{\cdot}1 \times 10^6}{9{,}000} = 233\text{pF}$$

and

$$C2 = \frac{0{\cdot}35 \times 10^6}{9{,}000} = 40\text{pF}$$

The counterpart of this filter is the high-pass filter which attenuates all signals below the turn-over frequency, f_c. The circuit is given in Fig. 7a.

Here $R_i = R_{fb} = 100\text{k}\Omega$ as before, and with $R1 = 250\text{k}\Omega$ and $R2 = 1\text{M}\Omega$ the capacitors are given as;

$$C1 = C2 = \frac{0{\cdot}5}{f_c}\mu\text{F}$$

again with f_c given in hertz.

This filter might be used to cut out turntable rumble in a record reproducing system. For example, if we let $f_c = 60\text{Hz}$ then with the resistance values given above,

$$C1 = C2 = \frac{0{\cdot}5}{60} = 0{\cdot}083\mu\text{F}$$

The component values need to be accurate to ± 10 per cent if the correct cut-off frequency is to be obtained.

It is possible by using two operational amplifiers to assemble a bandpass filter quickly from a combination of a low-pass filter in series with a high-pass filter. This may be useful where a particular frequency or band of frequencies are to be excluded from a signal extending over a range of frequencies.

It is hoped that these three articles have illustrated the wide versatility of the operational amplifier. Many other applications are possible than those given and will suggest themselves to the user as familiarity is gained in the use of the amplifier. Indeed the experimenter may well find the operational amplifier becoming an indispensible part of his workshop tool kit for solving almost any electronic problem!

★

Readout—
A SELECTION FROM OUR POSTBAG

correspondents wishing a reply must enclose a stamped addressed envelope

Tongue Tied

Sir—The article *An International Technical Language* by R. Spathaky in June P.E. made me wonder if fellow readers are aware that a working international language already exists? Esperanto, spoken by several million people throughout our world, meets all the requirements for a simple technical language.

Technical books in Esperanto are all available through the "Brita Esperantista Asocio", Holland Park Avenue, London, W.1.

The International Electrotechnical Commission, which your article mentions in its opening paragraph, include Esperanto in their multi-language dictionary of technical terms.

I enclose a copy of a translation of the first two paragraphs of your article about voltage indicators.

Tensiaj Indikiloj

Miniaturaj neonaj diodoj kiuj enhavas malgrandajn elektrodojn ofte troviĝas en hejma aparataro. La speco de cirkvito kiun oni povas uzi montriĝas per figuro 2.1. La diodoj posedas du identajn elektrodojn por ke la kurento tra ili povas flui ambaŭdirekten sen troa damaĝo; la diodoj kiuj montriĝas en la cirkvito estas tial reprezentataj per simetria simbolo, ĉiu elektrodo kombinas la simbolojn de la anodo kaj malvarma katodo.

Kiam la ŝaltilo fermiĝas, la neona diodo arkas tuj kiam la momenta tensio de la alterniga linia enfluo atingas la arkan tension de la diodo uzata. La tubo estingiĝos kiam la linia tensio falas sub la subtenanta tensio ĉe la fino de ĉiu duonckilo sed ekbrilos denove dum la sekvanta duonciklo. Tial la tubo eligas 100 ekbrilojn po sekunde sed la okulo vidas plene konstantan lumadon.

A. McConachie,
Great Malvern.

Computer Collaboration

Sir—I should like to get in touch with any of your readers who have built and are now using the PRACTICAL ELECTRONICS analogue computer PEAC, with a view to discussing further modifications and applications of this apparatus.

J. G. Boylan,
Langley Park School for Boys, Kent.

Alarm circuitry

Sir—I was interested to read Mr Bollen's excellent article on his modulated light burglar alarm but I was surprised to see his complicated solution to the problem of an a.c. latching relay. Might I propose a simpler circuit which would not require delicate setting up adjustments? See Fig. 1 below.

Though I have not had an opportunity of verifying this, I feel sure that the output of Mr Bollen's amplifier would operate a suitable low impedance relay or reed relay without biasing.

I also have another suggestion which I discovered in another connection; a greater modulated light output may be obtained from a low voltage filament bulb by operating it on unfiltered half-wave rectified a.c. rather than plain a.c. (see Fig. 2 below).

It is safe to increase the supply voltage slightly.

J. Wrigley,
Cambridge.

Although the relay system chosen for the I.R. Alarm might appear to be complicated and difficult to set up, a closer examination will show that it offers several advantages when compared with more familiar systems.

Firstly, a magnetically biased reed relay will operate at inputs of typically less than 8mW, an unbiased reed relay at 30mW, and a similar priced conventional armature relay at more than 200mW. Also, bearing in mind that a changeover reed switch costs four times as much as a "make and break" reed switch, the price of a biased reed relay, including magnet, works out at about two thirds that of a reed or armature latching relay. It follows from the above that the magnetically biased reed switch was chosen for the I.R. Alarm because it offered the best sensitivity for the lowest cost, and is, in fact, not at all difficult to adjust and set up.

Mr Wrigley's second point concerning the use of unfiltered half-wave rectified a.c. to supply the bulb is quite valid, and should increase the maximum beam path of the I.R. Alarm by giving a greater depth of modulation of the light.

D. Bollen

Strobe Effect

Sir—I feel I must write to you with a serious warning about the use of stroboscopes at low frequencies.

It is well known in neurological circles that a light flashing at a rate of 10 to 15Hz can induce an epileptic fit into some members of our species —especially if the eyes are closed or if the ambient light level is low. For this reason if a stroboscope is used at these frequencies it must be in conditions of high ambient lighting and for short periods only. Also for this reason it is advisable to have some form of push button switch on the light unit itself so that should epilepsy set in the light will cease to operate.

One word of consolation—although the experience is very unpleasant it should leave no after effects and the condition ceases as soon as stimulation is removed.

Anyone interested in this phenomena would do well to read Dr Gray-Walter's book the *Living Brain* which not only deals with this subject but also has quite a lot of space devoted to two "animals" *Machina speculatrix* and *Machina doeilis*.

C. J. Manwell,
University of Wales Institute of Science & Technology,
Penylan, Cardiff.

Mobile Rally

Sir—I would be very grateful if you could find space in your next issue to publish details of our first mobile rally.

Called the "White Rose Mobile Rally", it will be held on the July 27 at Allerton Girls' High School, Leeds, Yorkshire. There is ample car parking facilities and talk-in is on 160 and 2 metres.

There will be a demonstration station, refreshments, and something for XYLs and children.

R. Short, G3YEE,
Pudsey and District Radio Club,
Bramley Liberal Club,
Bramley, Leeds.

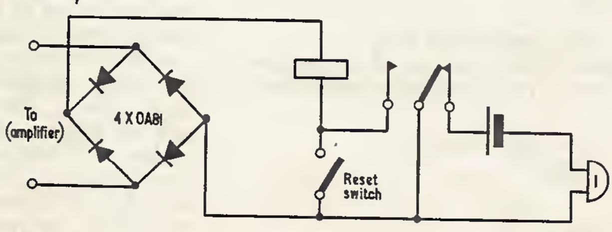

Fig. 1. Simple a.c. latching relay circuit

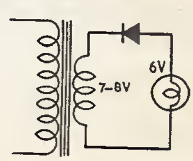

Fig. 2.

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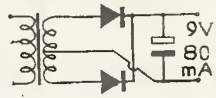

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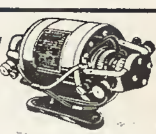

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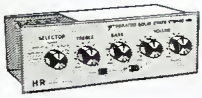

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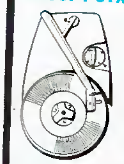

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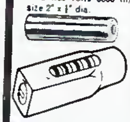

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