RADIO & ELECTRONICS CONSTRUCTOR

Vol. 26 No. 7 FEBRUARY 1973 20p

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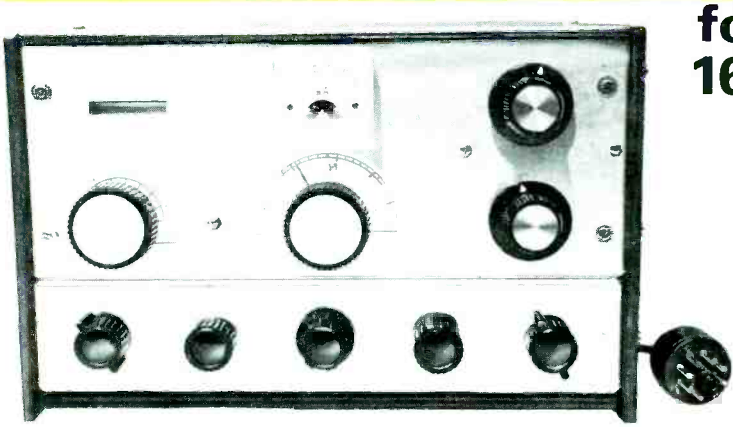

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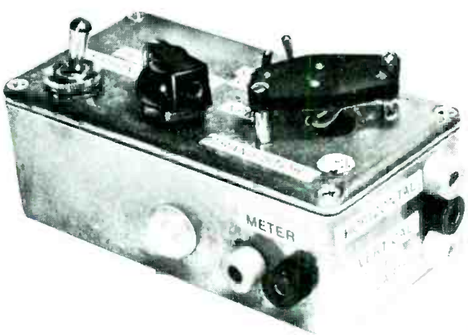

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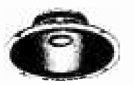

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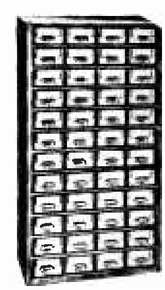

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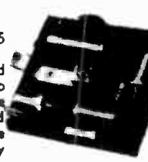

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TRIACS

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100	30	50	76
200	50	60	90
400	70	75	1-10

FULL RANGE OF ZENER DIODES VOLTAGE RANGE 2-33V. 400mW (DO-7 Case) 13p ea. 1½W (Top-Hat) 18p ea. 10W (SO-10 Stud) 25p ea. All fully tested 5% tol. and marked. State voltage required.

DIACS

FOR USE WITH TRIACS
BR100 (D32) 37p each

10 amp POTTED BRIDGE RECTIFIER on heat sink. 100 PIV. 90p each.

FREE

One 50p Pak of your own choice free with orders valued £4 or over.

NEW LINE

Plastic encapsulated 2 amp Bridge Rects.

50 v RMS 32p each
100 v RMS 37p each
400 v RMS 46p each

Size 15 mm x 6 mm

UNIJUNCTION
UT46. Eqvt. 2N2646, Eqvt. TI843. BEN3000 27p each. 25-99 25p 100 UP 20p.

BRAND NEW TEXAS GERM. TRANSISTORS
Coded and Guaranteed

Pak No.		EQVT
T1	8 2G3713	OC71
T2	8 D1374	OC75
T3	8 D1216	OC81D
T4	8 2G381T	OC81
T5	8 2G382T	OC82
T6	8 2G344B	OC44
T7	8 2G345B	OC45
T8	8 2G378	OC78
T9	8 2G399A	2N1302
T10	8 2G417	AF117

All 50p each pak

CADMIUM CELLS

ORP12 43p
ORP60, ORP61 40p each

2N2060 NPN SIL. DUAL TRANS. CODE D1699 TEXAS. Our price 25p each.

GENERAL PURPOSE NPN SILICON SWITCHING TRANS. TO-18 SIM. TO 2N706/8, BSY27/28/95A. All usable devices no open or short circuits. ALSO AVAILABLE in PNP Sim. to 2N2906, BCY70. When ordering please state preference NPN or PNP.

	£p		
20 For	0.50	100 For	1.75
50 For	1.00	500 For	7.50
		1000 For	18.00

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SIL. G.P. DIODES £p

300mW	30	0.50
40PIV(Min.)	100	1.50
Sub-Min.	500	5.00
Full Tested	1,000	9.00

Ideal for Organ Builders.

Sil. trans. suitable for P.E. Organ. Metal TO-18 Eqvt. ZTX300 5p each. Any Qty.

KING OF THE PAKS Unequalled Value and Quality

SUPER PAKS

NEW BI-PAK UNTESTED SEMICONDUCTORS

Satisfaction GUARANTEED in Every Pak, or money back.

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U4	40 Germanium Transistors like OC81, AC128	50p
U5	60 200mA Sub-Min. Silicon Diodes	50p
U6	30 Sil. Planar Trans. NPN like BSY95A, 2N706	50p
U7	16 Sil. Rectifiers Top-Hat 750mA Vltg. Range up to 1,000	50p
U8	50 Sil. Planar Diodes DO-7 Glass 250mA like OA200/202	50p
U9	20 Mixed Voltages, 1 Watt Zener Diodes	50p
U10	20 BAY50 charge storage Diodes DO-7 Glass	50p
U11	25 PNP Sil. Planar Trans. TO-5 like 2N1132, 2N2904	50p
U12	12 Silicon Rectifiers Epoxy 500 mA up to 800 PIV	50p
U13	30 PNP-NPN Sil. Transistors OC200 and 2S 104	50p
U14	150 Mixed Silicon and Germanium Diodes	50p
U15	25 NPN Sil. Planar Trans. TO-5 like BFY51, 2N697	50p
U16	10 3Amp Silicon Rectifiers Stud Type up to 1,000 PIV	50p
U17	30 Germanium PNP AF Transistors TO-5 like ACY 17-22	50p
U18	8 6Amp Silicon Rectifiers BYZ13 Type up to 600 PIV	50p
U19	25 Silicon NPN Transistors like BC108	50p
U20	12 1.5Amp Silicon Rectifiers Top-Hat up to 1,000 PIV	50p
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U23	30 MADT's like MHz Series PNP Transistors	50p
U24	20 Germanium 1 Amp Rectifiers GJM Series up to 300 PIV	50p
U25	25 300 MHz NPN Silicon Transistors 2N708, BSY27	50p
U26	30 Fast Switching Silicon Diodes like IN914 Micro-Min.	50p
U27	12 NPN Germanium AF Transistors TO-1 like AC127	50p
U29	10 1Amp SCR's TO-5 can, up to 600 PIV CRS1/25-600	£1.00
U30	15 Plastic Silicon Planar Trans. NPN 2N2926	50p
U31	20 Sil. Planar Plastic NPN Trans. Low Noise Amp 2N3707	50p
U32	25 Zener Diodes 400mW DO-7 case 3-18 volts mixed	50p
U33	15 Plastic Case 1 Amp Silicon Rectifiers IN4000 Series	50p
U34	30 Silicon PNP Alloy Trans. TO-5 BCY26 2S302/4	50p
U35	25 Silicon Planar Transistors PNP TO-18 2N2906	50p
U36	25 Silicon Planar NPN Transistors TO-5 BFY50/51/52	50p
U37	30 Silicon Alloy Transistors SO-2 PNP OC200, 2S322	50p
U38	20 Fast Switching Silicon Trans. NPN 400 MHs 2N3011	50p
U39	30 RF. Germ. PNP Transistors 2N1303/5 TO-5	50p
U40	10 Dual Transistors 6 lead TO-5 2N2060	50p
U41	25 RF Germanium Transistors TO-5, OC45, NKT72	50p
U42	10 VHF Germanium PNP Transistors TO-1 NKT667, AF117	50p
U43	25 Sil. Trans. Plastic TO-18 A.F. BC113/114	50p
U44	20 Sil. Trans. Plastic TO-5 BC115/NPN	50p
U45	7 3A SCR. TO66 up to 600 PIV	£1.00

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

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Qty.	1-24	25-99	100 up
Price each	45p	40p	35p

F.E.T.'S

2N3819	35p
2N3820	50p
2N3821	35p
2N3823	30p
2N5458	50p
2N5459	40p
BFW 10	40p
MPF105	40p

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TRANSISTOR EQUIVALENTS BOOK. A complete cross reference and equivalents book for European, American and Japanese Transistors. Exclusive to BI-PAK 90p each. Red cover edition.

A LARGE RANGE OF TECHNICAL AND DATA BOOKS ARE NOW AVAILABLE EX STOCK. SEND FOR FREE LIST.

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Pack	Description	Price £
Q1	20 Red spot transistors PNP	50p
Q2	16 White spot R.F. transistors PNP	50p
Q3	4 OC 77 type transistors	50p
Q4	6 Matched transistors OC44/45/81/81D	50p
Q5	4 OC 75 transistors	50p
Q6	5 OC 72 transistors	50p
Q7	4 AC 128 transistors PNP high grain.	50p
Q8	4 AC 126 transistors PNP	50p
Q9	7 OC 81 type transistors	50p
Q10	7 OC 71 type transistors	50p
Q11	2 AC 127/128 Comp. pairs PNP/NPN	50p
Q12	3 AF 116 type transistors	50p
Q13	3 AF 117 type transistors	50p
Q14	3 OC 171 H.F. type transistors	50p
Q15	7 2N2926 Sil. Epoxy trans. md colours	50p
Q16	2 GET880 low noise Germ. trans.	50p
Q17	5 NPN 2 x ST.141. and 3 x ST. 140	50p
Q18	4 MADT's 2 x MAT 100 & 2 x MAT 120	50p
Q19	3 MADT's 2 x MAT 101 & 1 x MAT 121	50p
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Q21	4 AC 127 NPN Germanium transistors	50p
Q22	20 NKT transistors A.F. R.F. coded	50p
Q23	10 OA 202 Silicon diodes sub-min.	50p
Q24	8 OA 81 diodes	50p
Q25	15 IN914 Silicon diodes 75PIV 75mA	50p
Q26	8 OA95 Germanium diodes sub-min IN69	50p
Q27	2 10A 600 PIV Sil. rectifiers IS425R	50p
Q28	2 Silicon power rectifiers BYZ 13	50p
Q29	4 Silicon trans. 2 x 2N696, 1 x 2N697, 1 x 2N698	50p
Q30	7 Sil. switch transistors 2N706 NPN	50p
Q31	6 Sil. switch transistors 2N708 NPN	50p
Q32	3 PNP Sil. trans. 2x2N1131, 1x2N1132	50p
Q33	3 Silicon NPN transistors 2N1711	50p
Q34	7 Sil. NPN trans. 2N2369, 500MHs (code P397)	50p
Q35	3 Sil. PNP TO-5, 2x2N2904 & 1x2N2905	50p
Q36	7 2N3646 TO-18 plastic 300 MHs NPN	50p
Q37	3 2N3053 NPN Silicon transistors	50p
Q38	7 PNP trans. 4 x 2N3703, 3 x 2N3702	50p
Q39	7 NPN trans. 4 x 2N3704, 3 x 2N3705	50p
Q40	7 NPN trans. 4x 2N3707, 3 x 2N3708	50p
Q41	3 Plastic NPN TO-18 2N3904	50p
Q42	6 NPN transistors 2N5172	50p
Q43	7 BC 107 NPN transistors	50p
Q44	7 NPN trans. 4 x BC 108, 3 x BC 109	50p
Q45	3 BC 113 NPN TO-18 transistors	50p
Q46	3 BC 115 NPN TO-5 transistors	50p
Q47	6 NPN high grain trans. 3 x BC167, 3 x BC168	50p
Q48	4 BCY 70 PNP transistors TO-18	50p
Q49	4 NPN trans. 2 x BFY51, 2 x BFY52	50p
Q50	7 BSY 28 NPN switch trans. TO-18	50p
Q51	7 BSY 95A NPN trans. 300MHz	50p
Q52	8 BY100 type silicon rectifiers	£1.00
Q53	25 Sil. & germ. trans. md all mkd new	£1.50

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The MK Slide Rule, designed to simplify electronic calculations features the following scales:— Conversion of Frequency and Wavelength. Calculation of L. C and fo of tuned circuits. Reactance and self inductance. Area of circles. Volume of cylinders. Resistance of conductors. Weight of conductors. Decibel calculations. Angle functions. Natural Logs. & 'e' functions. Multiplication & division. Squaring, cubing and square roots. Conversion of kW and Hp.
A must for every electronic engineer and enthusiast. Size 23cm x 4 cm. complete with case and instructions. PRICE EACH: £3.35

DTL & TTL INTEGRATED CIRCUITS

INTEGRATED CIRCUIT PAKS

Manufacturers "Fall Outs" which include Functional and part Functional Units. These are classed as "out-of-spec" from the maker's very rigid specifications, but are ideal for learning about I.C's and experimental work.

Pak No.	Contents	Price	Pak No.	Contents	Price	Pak No.	Contents	Price
UIC00	12 × 7400	50p	UIC46	5 × 7446	50p	UIC86	5 × 7486	50p
UIC01	12 × 7401	50p	UIC47	5 × 7447	50p	UIC90	5 × 7490	50p
UIC02	12 × 7402	50p	UIC48	5 × 7448	50p	UIC91	5 × 7491	50p
UIC03	12 × 7403	50p	UIC50	12 × 7450	50p	UIC92	5 × 7492	50p
UIC04	12 × 7404	50p	UIC51	12 × 7451	50p	UIC93	5 × 7493	50p
UIC05	12 × 7405	50p	UIC53	12 × 7453	50p	UIC94	5 × 7494	50p
UIC06	8 × 7406	50p	UIC54	12 × 7454	50p	UIC95	5 × 7495	50p
UIC07	8 × 7407	50p	UIC60	12 × 7460	50p	UIC96	5 × 7496	50p
UIC10	12 × 7410	50p	UIC70	8 × 7470	50p	UIC100	5 × 74100	50p
UIC13	8 × 7413	50p	UIC72	8 × 7472	60p	UIC121	5 × 74121	50p
UIC20	12 × 7420	50p	UIC73	8 × 7473	50p	UIC141	5 × 74141	50p
UIC30	12 × 7430	50p	UIC74	8 × 7474	50p	UIC151	5 × 74151	50p
UIC40	12 × 7440	50p	UIC75	8 × 7475	50p	UIC154	5 × 74154	50p
UIC41	5 × 7441	60p	UIC76	8 × 7476	50p	UIC193	5 × 74193	50p
UIC42	5 × 7442	50p	UIC80	5 × 7480	50p	UIC199	5 × 74199	50p
UIC43	5 × 7443	50p	UIC81	5 × 7481	50p	UIC X1	25 Asst. 74's	£1.50
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Packs cannot be split, but 25 assorted pieces (our mix) is available as PAK UIC X1.

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GENERAL PURPOSE GERM. PNP
Coded GP100. BRAND NEW TO-3 CASE. POSS. REPLACE.:—OC25-28-29-30-35-36. NKT 401-403-404-405-406-430-451-452-453. TI3027-3028, 2N250A, 2N456A-457A-458A, 2N511 A & B. 2G220-222, ETC. VCBO 80V VCEO 50V IC 10A PT. 30 WATTS Hfe 30-170.

PRICE	1-24	25-99	100 up
	43p each	40p each	38p each

SILICON High Voltage 250V NPN TO-3 case. G.P. Switching & Amplifier Applications. Brand new Coded R 2400 VCBO 250/VCEO 100/IC 6A/30 Watts. HFE type 20/fT 5MHZ.
OUR PRICE EACH:

1-24	25-99	100 up
50p	45p	40p

2N3055

115 WATT SIL. POWER NPN
50p EACH

AD161/AD162 *NPN*

M/P COMP
GERM TRANS.
OUR LOWEST PRICE
OF 55p *PER PAIR.*

SILICON 50 WATTS MATCHED NPN/PNP
BIP 19 NPN TO-3 Plastic.
BIP 20 PNP. Brand new.

VCBO 100/VCEO 50/IC 10A. HFE type 100/ft 3mHZ.
OUR PRICE PER PAIR:

1-24 prs.	25-99 prs.	100 prs.
60p	55p	50p

BI-PAKS NEW COMPONENT SHOP NOW OPEN WITH A WIDE RANGE OF ELECTRONIC COMPONENTS AND ACCESSORIES AT COMPETITIVE PRICES 18, BALDOCK STREET (A10), WARE, HERTS. TEL: 61593.
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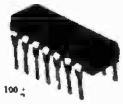

74 Series T.T.L. I.C'S

Bi-Pak Still Lowest in Price.
Full Specification Guaranteed.
All Famous Manufacturers.

	1	25	100+
SN7400	0.15	0.14	0.12
SN7401	0.15	0.14	0.12
SN7402	0.15	0.14	0.12
SN7403	0.15	0.14	0.12
SN7404	0.15	0.14	0.12
SN7405	0.15	0.14	0.12
SN7406	0.35	0.31	0.28
SN7407	0.35	0.31	0.28
SN7408	0.18	0.17	0.16
SN7409	0.18	0.17	0.16
SN7410	0.15	0.14	0.12
SN7411	0.25	0.24	0.23
SN7412	0.35	0.31	0.28
SN7413	0.29	0.26	0.24
SN7416	0.43	0.40	0.38
SN7417	0.43	0.40	0.38
SN7420	0.15	0.14	0.12
SN7422	0.50	0.48	0.45
SN7423	0.50	0.48	0.45
SN7425	0.50	0.48	0.45
SN7427	0.45	0.42	0.40
SN7428	0.70	0.65	0.60
SN7430	0.15	0.14	0.12
SN7432	0.45	0.42	0.40
SN7433	0.80	0.75	0.70
SN7437	0.64	0.62	0.60
SN7438	0.64	0.62	0.60
SN7440	0.15	0.14	0.12
SN7441	0.67	0.64	0.58
SN7442	0.67	0.64	0.58
SN7443	£1.30	£1.25	£1.20
SN7444	£1.30	£1.25	£1.20
SN7445	£1.80	£1.77	£1.75
SN7446	0.97	0.94	0.88
SN7447	£1.00	0.97	0.95
SN7448	£1.00	0.97	0.95
SN7450	0.15	0.14	0.12
SN7451	0.15	0.14	0.12
SN7453	0.15	0.14	0.12
SN7454	0.15	0.14	0.12
SN7460	0.15	0.14	0.12
SN7470	0.29	0.26	0.24
SN7472	0.29	0.26	0.24
SN7473	0.37	0.35	0.32
SN7474	0.37	0.35	0.32
SN7475	0.45	0.43	0.42
SN7476	0.40	0.38	0.36
SN7480	0.67	0.64	0.58
SN7481	£1.20	£1.15	£1.10
SN7482	0.87	0.86	0.85
SN7483	£1.10	£1.05	0.95
SN7484	£1.00	0.95	0.90
SN7485	£3.60	£3.50	£3.40
SN7486	0.32	0.31	0.30
SN7489	£5.50	£5.25	£5.00

	1	25	100+
SN7490	0.67	0.64	0.58
SN7491	£1.00	0.95	0.90
SN7492	0.67	0.64	0.58
SN7493	0.67	0.64	0.58
SN7494	0.77	0.74	0.68
SN7495	0.77	0.74	0.68
SN7496	0.87	0.84	0.78
SN74100	£1.65	£1.60	£1.55
SN74104	0.97	0.94	0.88
SN74105	0.97	0.94	0.88
SN74107	0.40	0.38	0.36
SN74110	0.55	0.53	0.50
SN74111	£1.25	£1.15	£1.10
SN74118	£1.00	0.95	0.90
SN74119	£1.35	£1.25	£1.10
SN74121	0.40	0.37	0.34
SN74122	£1.40	£1.30	£1.10
SN74123	£2.80	£2.70	£2.60
SN74141	0.67	0.64	0.58
SN74145	£1.50	£1.40	£1.30
SN74150	£3.00	£2.70	£2.50
SN74151	£1.00	0.95	0.90
SN74153	£1.20	£1.10	0.95
SN74154	£1.80	£1.70	£1.60
SN74155	£1.40	£1.30	£1.20
SN74156	£1.40	£1.30	£1.20
SN74157	£1.90	£1.80	£1.70
SN74160	£1.80	£1.70	£1.60
SN74161	£1.80	£1.70	£1.60
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SN74163	£4.00	£3.75	£3.50
SN74164	£2.20	£2.15	£2.10
SN74165	£2.25	£2.20	£2.15
SN74166	£3.50	£3.25	£3.00
SN74174	£2.30	£2.20	£2.10
SN74175	£1.50	£1.50	£1.40
SN74176	£2.50	£2.40	£2.30
SN74177	£2.50	£2.40	£2.30
SN74180	£2.00	£1.60	£1.40
SN74181	£5.50	£5.00	£4.75
SN74182	£2.00	£1.80	£1.60
SN74184	£3.50	£3.25	£3.00
SN74190	£1.95	£1.90	£1.85
SN74191	£1.90	£1.85	£1.80
SN74192	£1.95	£1.90	£1.85
SN74193	£2.00	£1.80	£1.75
SN74194	£2.70	£2.60	£2.50
SN74195	£2.00	£1.90	£1.80
SN74196	£1.80	£1.70	£1.60
SN74197	£1.80	£1.70	£1.60
SN74198	£5.50	£5.00	£4.50
SN74199	£5.50	£5.00	£4.50

LINEAR I.C's— FULL SPEC.

Type No.	Price 1-24	25-99	100 up
BP 201C—SL201C	63p	58p	45p
BP 701C—SL701C	63p	50p	45p
BP 702C—SL702C	63p	50p	45p
BP 702—72702	53p	45p	40p
BP 709—72709	36p	34p	30p
BP 709P—μA709C	36p	34p	30p
BP 710—72710	44p	42p	40p
BP 711—μA711	45p	43p	40p
BP 741—72741	75p	60p	50p
μA 703C—μA703C	28p	26p	24p
TA A263	70p	60p	55p
TA A293	90p	75p	70p
TA A350	170p	160p	150p

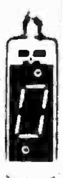
LOGIC DTL 930 SERIES I.C's

ROCK BOTTOM PRICES

Type No.	Price 1-24	25-99	100 up
BP930	15p	11p	10p
BP932	13p	12p	11p
BP933	13p	12p	11p
BP935	13p	12p	11p
BP936	13p	12p	11p
BP944	13p	12p	11p
BP945	26p	24p	22p
BP946	13p	11p	10p
BP948	26p	24p	22p
BP951	65p	60p	55p
BP962	13p	11p	10p
BP9093	40p	38p	35p
BP9094	40p	38p	35p
BP9097	40p	38p	35p
BP9099	40p	38p	35p

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

NUMERICAL INDICATOR TUBES



MODEL	CD66	GR 116	3015F
Anode voltage (Vdc)	170 min	175 min	5
Cathode cur'nt(mA)	2.3	14	
Numeral h'ght (mm)	16	13	9
Tube height (mm)	47	32	22
Tube diameter (mm)	19	13	12
I.C. driver rec.	BP41 or 141	BP41 or 141	BP47
PRICE EACH	£1.70	£1.56	£1.90

All indicators 0.9 + Decimal point: All side viewing: Full data for all types available on request.

RTL MICROLOGIC CIRCUITS

Epoxy TO-5 case	Price each 1-24	25-99	100 up
uL900 Buffer	35p	33p	27p
uL914 Dual 2I/p gate	35p	33p	27p
uL923 J-K flip-flop	50p	47p	45p

Date and Circuits Booklet for IC's Price 7p.

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14 & 16 Lead Sockets for use with DUAL-IN-LINE I.C.'s. TWO Ranges PROFESSIONAL and NEW LOW COST.

Prof. Type No.	1-24	25-99	100 up
TSO14 pin type	30p	27p	25p
TSO16 pin type	35p	32p	30p
Low Cost No.			
BPS 14	15p	13p	11p
BPS 16	16p	14p	12p

BI-PAK DO IT AGAIN!

50W pk 25w (RMS)

0.1% DISTORTION HI-FI AUDIO AMPLIFIER

THE AL50

★ Frequency response 15Hz to 100,000 - 1dB.

ONLY £3.25p each

★ Load - 3, 4, 8 or 16 ohms.

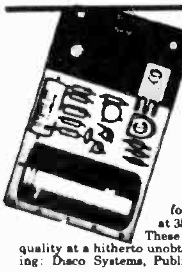
★ Distortion - better than .1% at 1KHz.

★ Supply voltage 10 - 35 Volts.

★ Signal to noise ratio 80dB.

★ Overall size 63mm x 105mm x 13mm.

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



STABILISED POWER MODULE SPM80

AP80 is especially designed to power 2 of the AL50 Amplifiers, up to 15 watt (rms) per channel, simultaneously. This module embodies the latest components and circuit techniques incorporating complete short circuit protection. With the addition of the Mains Transformer MT80, the unit will provide outputs of up to 1·5 amps at 35 volts. Size: 62mm x 106mm x 30mm.

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Built to a specification and NOT a price, and yet still the greatest value on the market, the PA100 stereo pre-amplifier has been conceived from the latest circuit techniques.

Designed for use with the AL50 power amplifier system, this quality made unit incorporates no less than eight silicon planar transistors, two of these are specially selected low noise NPN devices for use in the input stages.

Three switched stereo inputs, and rumble and scratch filters are features of the PA100, which also has a STEREO/MONO switch, volume, balance and continuously variable bass and treble controls.

SPECIFICATION

Frequency Response	20Hz — 20KHz ± 1dB
Harmonic Distortion	better than 0.1%
Inputs: 1. Tape Head	1.25 mV into 50KΩ
2. Radio, Tuner	35 mV into 50KΩ
3. Magnetic P.U.	1.5 mV into 50KΩ

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

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

Price £11.95

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4	3		
3	7		
2	5		
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EABC80	46p	PCC89	62p	UCL82	50p
EBF89	44p	PCF80	38p	UL84	50p
ECL82	44p	PCF82	50p	UY85	42p
ECL86	56p	PCL82	38p	UM84	32p
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50	50	
100	18	
125	10	
8	50	
12	20	
10	20	
8.2	20	
50	25	
2.5	64	
25	25	

MFD	Volt	
20	12	4p each
500	6	
100	25	
100	6	2p each
6	3	
8	6	
25	6.4	3p
250	18	7p
400	16	6p
400	40	10p
8	500	9p
100	200	10p

CONDENSERS

MFD	Volt	
0.005	500	2p each
0.001	1,250	
3.3PF	500	
500 PF	500	
2,200PF	500	
3,300PF	500	
0.1	350	
0.1	500	
0.25	150	
0.056	5% 350V	3p each
0.061		
0.066		
0.069		
0.075		
0.08		
0.1	1,500	4p each
0.25	350	
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0.22	250	5p
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H17	20	3 amp Silicon Stud rectifiers, mixed volts	50p
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Hex. Inverter	BMC935	12p	11p	10p
Hex. Inverter	BMC936	12p	11p	10p
Hex. Inverter	BMC937	12p	11p	10p
Hex. Inverter	BMC940	12p	11p	10p
Hex. Inverter	BMC941	12p	11p	10p
Type D Flip Flop	BMC942	20p	18p	16p
Ex. 2/4-input Power	BMC944	12p	11p	10p
Clocked Flip Flop	BMC945	20p	18p	16p
4/2 Input Nand Gate	BMC946	11p	10p	9p
Clocked Flip Flop	BMC948	20p	18p	16p
4/2 Input Nand Gate	BMC949	12p	11p	10p
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Monostable Multivib.	BMC951	25p	23p	21p
Dual J/K Flip Flop	BMC953	20p	18p	16p
Dual J/K Flip Flop	BMC955	20p	18p	16p
Dual J/K Flip Flop	BMC956	20p	18p	16p
Quad. 2-input Power	BMC958	12p	11p	10p
2/4-input Gate	BMC961	12p	11p	10p
3/3-input NAND Gate	BMC962	11p	10p	9p
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Audio Amp. 3-watts	SL403D	£1.50	£1.40	£1.36
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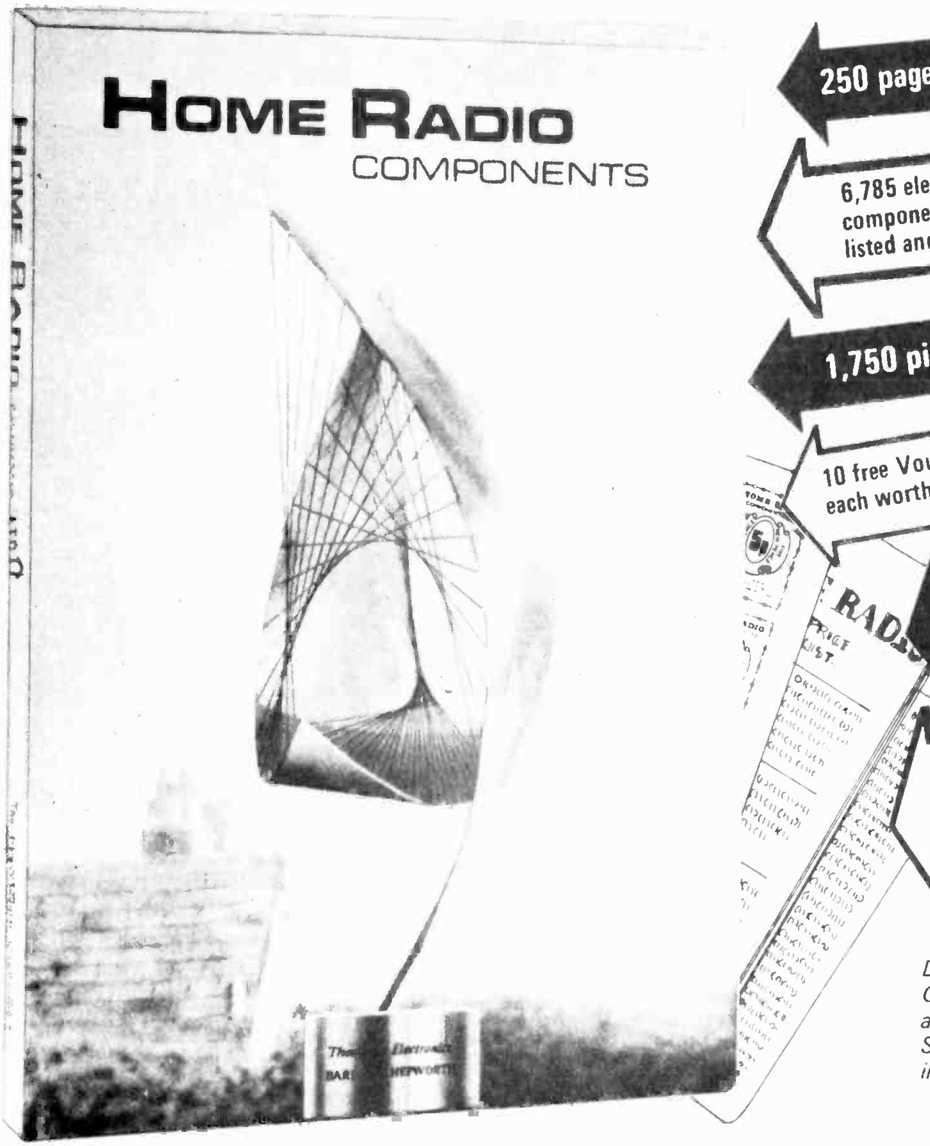

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Technical Queries. We regret that we are unable to answer queries other than those arising from articles appearing in this magazine nor can we advise on modifications to equipment described. We regret that such queries cannot be answered over the telephone; they must be submitted in writing and accompanied by a stamped addressed envelope for reply.

Correspondence should be addressed to the Editor, Advertising Manager, Subscription Manager or the Publishers as appropriate.

Opinions expressed by contributors are not necessarily those of the Editor or proprietors.

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BUILDING H.T.

by

F. G. Rayer, Assoc.I.E.R.E., G30GR

Some notes, with examples, on the design and construction of h.t. supplies. Particular emphasis is placed on supplies for transmitters.

SUPPLIES FOR EQUIPMENT SUCH AS AMPLIFIERS, TUNERS, harmonic markers, transmitters, transceivers and other equipment are often needed. The details given here should enable a supply to be constructed for any purpose, whether it be for a small item such as a tuner, or for small but more powerful equipment such as a Top Band or other transmitter, or for an s.s.b. transmitter.

HALF-WAVE RECTIFIER

The circuit in Fig. 1 is a good starting point, and is wholly adequate for small valve amplifiers, tuners, harmonic markers, and similar equipment.

T1 is the mains transformer, with a 220V 45mA h.t. winding, and a 6.3V 1.5A heater winding. The silicon or other type of rectifier, D1, provides half-wave rectification. C1 is the reservoir capacitor, L1 the smoothing choke, and C2 the smoothing capacitor. R1 is a bleeder resistor and it discharges the capacitors after switching off.

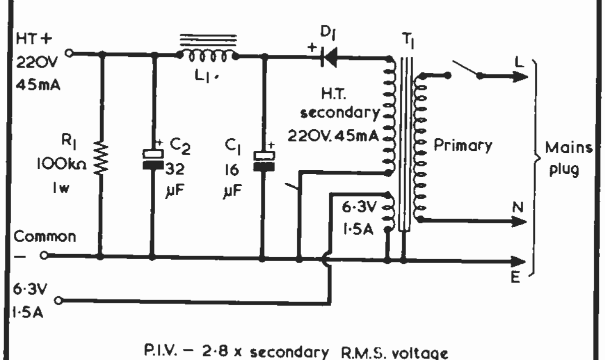


Fig. 1. A supply suitable for small equipment. This half-wave circuit is also employed to illustrate some of the basic concepts of h.t. supplies

Typically, D1 could be a 45mA 250V r.m.s. contact-cooled rectifier, L1 could be a 50mA 10 henry choke, C1 a 16µF 350 V.Wkg. capacitor, and C2 a 32µF 350 V.Wkg. capacitor. However, it is better to consider these items separately, because the points which dictate their minimum ratings will also apply to later circuits.

TRANSFORMER

A transformer with a half-wave secondary is employed only for small supplies. Other supplies have a full-wave secondary, such as in Figs. 2, 3 and 4. Such a secondary may be rated, as an example, at 250–0–250V 60mA. This means that 250V is available each side of the centre-tap, or 500V across the whole winding, and that the current drawn should not average more than 60mA. *Less* than the rated current can of course be taken.

The 250–0–250V is the r.m.s. (root mean square) voltage rating, and is that which would be shown if an ordinary testmeter were used to check the voltage. The actual h.t. voltage obtained will depend on factors which are mentioned later. A transformer is chosen which can provide the maximum voltage and current wanted for the equipment being supplied.

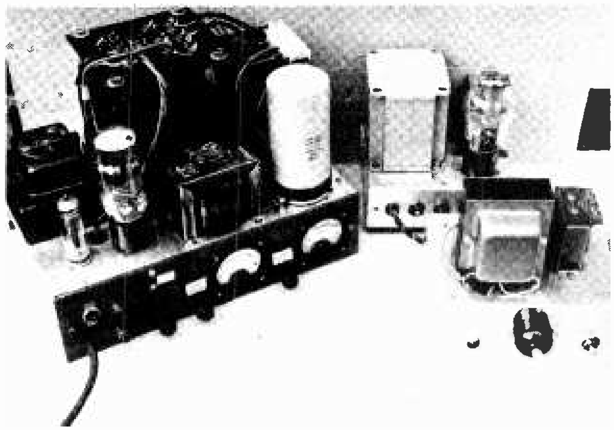
Transformers other than small types have a tapped primary, as in Fig. 2. This allows a primary tapping to be used to suit the local mains voltage.

Since, normally, the transformer will provide heater current as well, the heater current ratings of all the valves to be operated should be added together. The total should not exceed the heater winding rating. Larger transformers usually have two or more heater secondaries, as in Fig. 2. The heaters can then be separated into two circuits, each operated from its own winding, as illustrated. Where an h.t. output only is required, the heater windings are left unused.

RECTIFIERS

Rectifiers sometimes have an r.m.s. rating. A 250V r.m.s. rectifier can be used with any h.t. secondary of not over 250V.

SUPPLIES



Three typical power supplies. The supply at the left is for powering a transmitter, and it offers 500V at 250mA, 240V at 100mA, 25V negative bias and two outputs of 6.3V at 3A. The pack at back centre is a useful unit made from surplus receiver components and it provides 250V at 60mA and 6.3V at 2.5A. The right-hand unit gives 400V at 100mA, and its front runner carries a neon indicator, octal outlet socket and mains switch

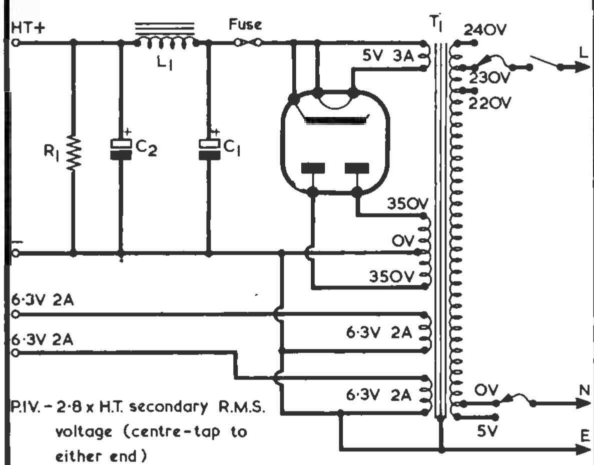


Fig. 2. Typical full-wave rectifier circuit, demonstrating also the use of mains transformer primary taps and the fitting of a fuse

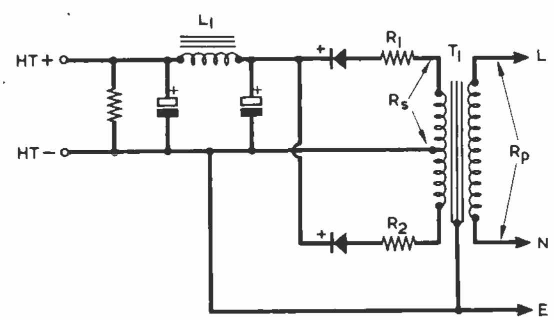


Fig. 3. A full-wave circuit with silicon rectifiers. R1 and R2 are included to increase the effective source resistance

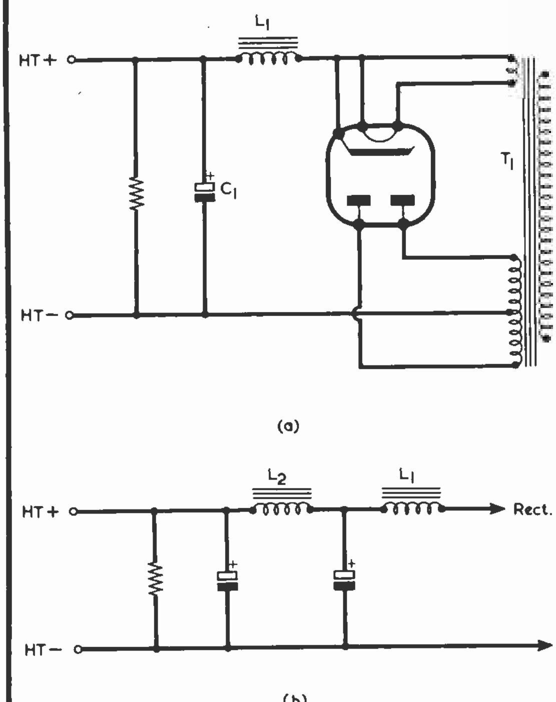


Fig. 4 (a). A choke input circuit with full-wave valve rectifier
(b). Adding a further stage of smoothing

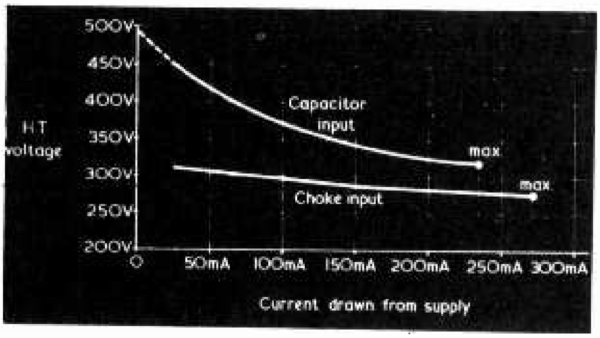


Fig. 5. As may be seen from these curves, which apply to a 5U4G rectifier fed by a 350–0–350V transformer secondary, the choke input circuit offers lower output voltage than the capacitor input circuit, but voltage regulation is better and a higher maximum current can be obtained

More frequently the p.i.v., or peak inverse voltage, rating is given. In Fig. 1, C1 may charge to about 1.4 times the r.m.s. rating of the h.t. secondary, while during negative half-cycles the secondary applies a similar peak voltage of opposite sign to it. The p.i.v. rating of the rectifier should thus be at least 2.8 times the secondary r.m.s. voltage. 800 p.i.v. rectifiers are convenient for 250V, and 1,000 p.i.v. rectifiers for 350V windings.

If silicon rectifiers are used in pairs in series in order to obtain a high overall p.i.v. rating, they should be of the same type and rating, and a resistor of about 470kΩ must be connected across each to equalise the reverse current and voltage.

The rectified current rating of the rectifier must at least equal the current wanted. Adequately rated silicon rectifiers are easily obtained. With valve rectifiers the valve data can be referred to, if necessary.

SMOOTHING CAPACITORS

With no load the voltage across the reservoir and smoothing capacitors may rise to about 1.4 times the secondary r.m.s. voltage. Because of this, the capacitors should be rated at 350V Wkg. at least for a 250V secondary, or 500V Wkg. for a 350V secondary. A bleeder resistor can reduce the maximum voltage given when load current is small or zero.

With high voltage supplies, it is often necessary to use capacitors in series, as shown in Fig. 6.

Smoothing is improved by using large value capacitors. However, a large value in the reservoir position increases rectifier peak current. A 16μF component is usually suitable here, whilst less than 8μF is unusual. C2 can be about 8μF to 100μF.

CHOKE

The current rating of the choke L1 should at least equal the current to be drawn.

Where the current is large or the h.t. voltage must be maintained stable, the choke needs a quite low resistance. Voltage drop, in volts, is equal to current in amps multiplied by resistance in ohms. Thus a 250Ω choke passing 100mA would drop 0.1 times 250, or 25V. Under the same circumstances a 100Ω choke would drop only 10V.

The choke inductance is commonly about 5 to 10 henrys. When using choke input with a valve rectifier (Fig. 4) the choke inductance should be at least the value specified for the rectifier.

BLEEDER

The bleeder resistor, R1 in Figs. 1 and 2, can be fitted for safety reasons or the safety factor can be combined with the provision of improved voltage regulation. For the safety application, the resistor can be roughly 500Ω per volt – say 100kΩ to 150kΩ for a 250V h.t. supply. A carbon resistor of adequate wattage should be employed. On this basis it can be 1 watt for 250V and 2 watts for 350V. The bleeder resistor discharges the reservoir and smoothing capacitors when the power supply is switched off.

If it is to improve voltage regulation, the bleeder resistor is of lower value and draws a larger current. Voltage regulation defines the extent to which the h.t. voltage varies with the current drawn from the supply, and regulation is stated to be good if the voltage change is small. The current drawn by the bleeder resistor is wasted, so this limits the choice of value. As an example, if the resistor draws 20mA and the mains transformer, rectifier and choke are intended to provide 100mA, only 80mA is available for the supplied equipment.

FULL-WAVE RECTIFICATION

Apart from small supplies, it is usual to employ full-wave rectification. A typical instance is given in Fig. 2. Here, the rectifier is indirectly heated, having its own heater winding.

Some indirectly heated valve rectifiers are designed to allow a high direct voltage to appear between the heater and cathode. This enables the heater to be connected to the same heater winding as the heaters in the supplied equipment, provided that the rectifier cathode-heater voltage rating is at least equal to or greater than the peak h.t. voltage. Directly heated rectifiers, in which the heater is also the cathode, must have their own heater winding.

H.T. FUSE

An h.t. fuse will protect the rectifier and transformer in the case of an h.t. short-circuit, and can be wired in as shown in Fig. 2. The fuse rating should be at

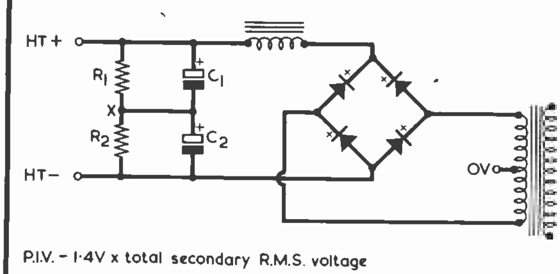


Fig. 6. A bridge rectifier circuit with choke input. The smoothing capacitance is given by two capacitors in series with equal-value resistors connected across them

least equal to the normal current which flows but the rating should not be so low that the fuse blows when switching on. Surge current depends on the value of the reservoir capacitor, the supply resistance offered by the mains transformer secondary, and the rectifier, and it will often be helpful to use an anti-surge type of fuse. A 60mA or 100mA fuse will be satisfactory for small supplies, and 150mA, 250mA or 500mA for large supplies. The fuse may alternatively be connected between the centre-tap of the mains transformer secondary and the negative line.

H.T. INDICATOR

A 'high tension on' neon indicator is useful as a reminder that voltage is present. It can be wired across the smoothing capacitor. The neon indicator should have an integral series resistor, as present in various lamp assemblies produced for this purpose, or the resistor must be added externally. It can be about 250kΩ for 250V, and 470kΩ for 350 to 500V.

An alternative is to fit a mains neon indicator across the primary of the transformer. Or, if a 6.3V winding and spare current are available, a 6.3V indicator lamp can be connected across one heater winding.

With experimental equipment, or a pack intended for some types of modulator or transmitting equipment, it is useful to have a current reading meter in the h.t. positive circuit. This can be a small panel instrument of 100mA, 250mA, or other suitable range, to suit the current drawn.

MAINS LEAD AND TAPS

In Fig. 2, connections are chosen to suit 220V, 230V or 240V mains. Tappings provided vary. Some larger transformers also have a 5V tapping, thus allowing for 225V, 235V and 245V as well.

Current for the equipment is drawn from a 3-pin plug, and 13A type plugs should be fitted with a 2A or 3A fuse. Use the yellow-green conductor of the cord for Earth, blue for Neutral, and brown for Live, connected as in Fig. 2. (In old cords, green is Earth, red is Live, and black is Neutral.)

SUPPLY RESISTANCE

If the transformer windings are of very low resistance, the peak rectifier current can be very large. So a minimum supply resistance or impedance is quoted for rectifiers. With circuits like Figs. 1 and 2, this is usually a few hundred ohms, and is provided by the resistance of the transformer windings.

With large, heavy-duty transformers, the windings may have insufficient d.c. resistance to limit peak rectifier current to a value which will not harm the rectifiers. This is particularly the case when using silicon rectifiers because of their low forward resistance. It is then necessary to make up sufficient series resistance by adding resistors R1 and R2, as in Fig. 3.

If the supply impedance needs to be found, measure the transformer primary resistance Rp with a meter, and also the secondary resistance Rs (from centre-tap

TABLE

Valve Rectifier Operating Conditions

Type	Input Capacitor	Input Choke	Secondary r.m.s. voltage (centre-tap to one end)	Minimum Supply resistance	Maximum current
5Z4G	16μF	—	250V	210Ω	130mA
5Z4G	16μF	—	350V	300Ω	125mA
5Z4G	16μF	—	500V	435Ω	80mA
5Z4G	—	2H	350V	—	150mA
5Z4G	—	5H	500V	—	125mA
5U4G	16μF	—	250V	35Ω	235mA
5U4G	16μF	—	350V	90Ω	230mA
5U4G	16μF	—	550V	200Ω	150mA
5U4G	—	1H	350V	—	270mA
5U4G	—	2H	550V	—	220mA
5R4GY	8μF	—	500V	350Ω	270mA
5R4GY	8μF	—	750V	505Ω	250mA
5R4GY	8μF	—	1kV	395Ω	120mA
5R4GY	—	1H	500V	—	300mA
5R4GY	—	5H	1kV	—	170mA

Silicon Rectifier Operating Conditions

Type	Peak Inverse Voltage	Maximum Current
BY100	800V	550mA
1N4007	1kV	1A

to one end with windings like Fig. 3). Determine the secondary to primary ratio from the voltage ratings. The supply resistance is equal to:

$$n^2Rp + Rs$$

where n is the full secondary to primary ratio in half-wave circuits or the half secondary (centre-tap to one end) to primary ratio in full-wave circuits. For example the ratio of a transformer with a 240V primary which gives 250 volts is near enough unity, or 1. If the primary resistance of such a transformer is 100Ω and the secondary resistance 250Ω, the supply resistance is equal to 350Ω approximately.

If the total is lower than quoted for the rectifier, add resistors R1 and R2, as in Fig. 3. Suppose in the example just given that the minimum supply resistance must be 450Ω, then R1 and R2 would each be 100Ω. The resistor wattage should be at least twice that found from I^2 times R. Thus, if I is 100mA and R is 100Ω, then 0.1 times 0.1 times 100 equals 1 watt, and 2 watt resistors should be fitted.

CHOKE INPUT

In Figs. 1, 2 and 3 a reservoir capacitor follows the rectifiers, and this type of circuit is termed 'capacitor input'. In Fig. 4(a) a choke follows the rectifier, and this is called 'choke input'. Choke input gives a lower h.t. voltage from a given h.t. winding, but can provide much better voltage regulation. It also limits peak rectifier current as compared with capacitor input.

The circuit of Fig. 4(a) has a single capacitor, and is much used for transmitting equipment. Fig. 4(b) employs a second choke and capacitor, for improved smoothing.

With choke input, the effective supply impedance can safely be zero ohms, so it is not necessary that some minimum series resistance be present as in the manner described for capacitor input circuits.

The choke L1 must have a certain minimum inductance value. If it is lower than this value the circuit will begin to operate as a capacitor input circuit at low currents. For maximum output, the windings of both T1 and L1 (and L2, if used) should have a low d.c. resistance.

RELATIVE REGULATION

Fig. 5 shows a typical comparison of results between capacitor input and choke input circuits. The curves are for a 5U4G rectifier and a 350–0–350V transformer.

With capacitor input, a maximum of 235mA may be drawn, the rectified voltage then being 320V. This rises to 375V at 100mA. At low currents, the voltage soars, reaching over 420V at 50mA and 450V at 25mA.

With choke input a maximum of 270mA may be drawn, the rectified voltage then being about 275V. With 100mA taken the voltage has only risen to 290V, while it is only a little over 300V at 50mA, and 310V at 25mA.

If a bleeder resistor drew 50mA, with capacitor input the rectified voltage would rise from 320V at maximum load current (now 185mA) to over 420V with no load. With choke input and the same bleeder current, the voltage rise is only from 280V on full load (now 220mA) to about 300V with no load.

Choke input is thus preferable for supplies where the current drawn will change considerably, as with a modulator or transmitter. It also enables the rectifier to provide more current. Against this, the transformer secondary requires to have a higher voltage rating than when capacitor input is used.

BRIDGE RECTIFICATION

Bridge rectification allows full-wave rectification with a half-wave type secondary, or gives twice the usual voltage with a centre-tapped secondary. See Fig. 6. A 300–0–300V secondary with choke input would provide about 240V h.t. in Fig. 4. In Fig. 6 an h.t. supply approaching 540V will be obtained.

For continuous working, the current rating of a centre-tapped secondary is halved. So if the transformer could provide 200mA in Fig. 4, the drain should not exceed 100mA in Fig. 6.

INTERMITTENT RATING

Transformers sold for use in amplifiers, radio receivers, etc., are rated for continuous operation. For amateur transmitting equipment where periods of duty are followed by periods of stand-by, rating can usually be increased by some 20% or so without danger. In c.w. and s.s.b. equipment peak current is intermittent, and no harm would normally be expected with a 25% increase.

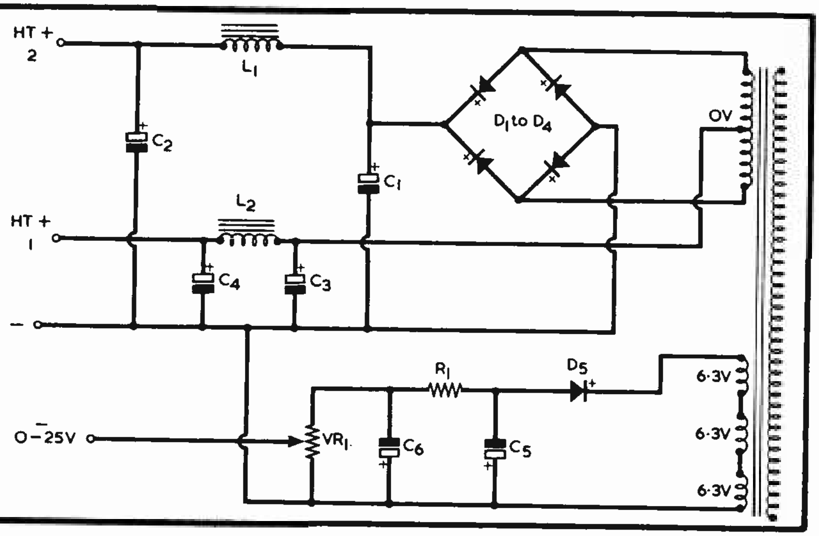


Fig. 7. A power supply circuit which offers two h.t. outputs and a variable negative bias output

H.T. ADJUSTMENT

Where the transformer provides h.t. only, as in Figs. 3 and 6, it is usually in order to bring about a variation in the h.t. voltage by changing the mains primary taps. As an example, with a 500V h.t. supply, changing the primary taps up or down 10V can modify the h.t. obtained from about 480V to 520V, and this can be very useful. An *increase* in h.t. voltage of more than about 10% by this means is not recommended, though this depends on the individual transformer. Nor should changes to the primary taps be made if the transformer supplies heaters.

SERIES CAPACITORS

Smoothing capacitors in series to cater for high voltage, as in Fig. 6 should be of equal value and rating, and each should have a resistor of equal value in parallel. As an example, with a 500V supply, two 450V 64µF capacitors in series will give the equivalent of 32µF, while each resistor could be 20kΩ 5W (or of lower value if current is available).

CONSTRUCTION

Any reasonable layout will be satisfactory. The smaller power supplies can usually be constructed with all h.t. positive and other live tags and connecting points under the chassis, and there is then no real need for a case or cover. If a chassis 2in., 3in. or 4in. deep is made from the readily available 'Universal Chassis' sides (Home Radio, Mitcham) flanges are available to enable a bottom plate to be screwed on for protection.

Provision to supply external equipment can be given by insulated terminals, separate insulated sockets, or a multi-way outlet into which matching plugs can be inserted.

Where the design of transformers, chokes, or other items means that bare tags will be on top, a cover or case should be provided for the power supply.

There must be adequate ventilation for items which grow hot, including in particular valve rectifiers and resistors. Ventilation is provided by holes or slots in the chassis and case or cover, or by apertures covered with expanded or perforated metal.

MULTIPLE SUPPLIES

For modulators or larger transmitters it is convenient to have a 250V or similar supply for early stages, and some 400V to 700V or as required for output stages. These supplies can be obtained from separate transformers, each with their own rectifiers and smoothing circuits, as in one of the packs illustrated in the photograph.

When a steady current is drawn it is practical to obtain lower voltages for early stages by means of voltage dropping resistors, but this process is wasteful of power for other than small currents. In a circuit such as Fig. 6, half the maximum voltage can be drawn at point X, but only at low current.

Fig. 7 shows a rectifier circuit which gives two outputs. That at H.T.+1 is approximately the same as is given by Fig. 3, while H.T.+2 gives about twice this voltage.

C1, C2 and L1 are rated for the high voltage supply, and C3, C4 and L2 for the lower voltage supply.

Three unused 6.3V windings in series, with D5, provide about 25V negative bias, at low current. The a.c. output of the windings is checked with a meter, and they are connected in the phase which gives a total voltage of 18.9V. C5 can be 25µF, and C6 100 to 250µF, 50V Wkg., R1 being 1kΩ and VR1 5kΩ.

The accompanying Table lists valve rectifier operating conditions, using a full-wave rectifier circuit as in Fig. 2 or Fig. 4(a). ■

Windows for viewing the universe

by J. B. Dance, M.Sc.

Some notes on present-day detection of space phenomena.

FOR MANY CENTURIES OUR ASTRONOMICAL IDEAS HAVE developed from information contained in the visible light reaching us from outside the earth's atmosphere. Rockets which can carry equipment above the atmosphere of the earth have enabled us to look at signals arriving from the sun and stars in the form of ultra-violet and X radiation.

PULSARS

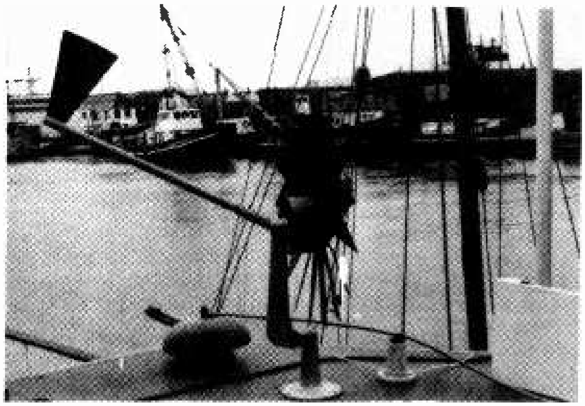
Radio-astronomy has provided us with another 'window', through which we can see a somewhat different view of the universe. It has, for example, led to the discovery of 'pulsars' which are believed to be neutron stars where gravitational forces are so great that electrons are forced into protons to form neutrons. The density of neutron stars is believed to be of the order of 10^{13} grams/cm^3 – similar to the density of a neutron or proton itself.

Other new windows for viewing the universe are becoming available. For example, various groups of workers have set up equipment to detect the neutrinos given out by reactions in the sun. These particles can travel through all matter almost unhindered and may enable us to view the inside of the sun.

It is almost certain that gravitational waves coming from the centre of our galaxy have been detected by Weber in the U.S.A. Like neutrinos, these waves can travel easily through the earth and are most difficult to detect, but it seems that the galactic centre is producing enormous amounts of energy in this form. The probable source of gravitational waves is collapsed neutron stars known as 'black holes' where matter has an infinite density and where the gravitational field is so great that no matter or light can escape. ■

NEWS . . . AND .

YACHTSMEN BEAT FLAT BATTERIES



The Aerocharge Wind Generator shown fitted to the cabin roof of a yacht with the wind vane in position.

A compact, portable wind generator, originally designed for charging boat batteries, has met with a large demand, not only from boat owners, but from users such as the Zambian Flying Doctor Service, the British Transport Docks Board and an oil Company operating inside the Arctic Circle.

The Aerocharge Wind Generator, developed by two Poole, Dorset, yachtsmen who are also professional engineers, is manufactured by Harber Ventus Limited, of Bridge Approach, Hamworthy, Poole. It comprises a 17 inch diameter impeller fan driven by the wind and a small built-in alternator which is free swivelling and kept into the wind by a small, detachable directional wind vane.

The electronic controls are mounted in a separate control box, which is fitted with an indicator light to show when the unit is charging.

Easily stored when not in use, it can, when required, be slipped on to a fixed mounting and the output leads connected to a battery circuit by simple plugs.

The unit gives an average charging rate of .25 amps at 12 volts with moderate wind conditions. A power input of 30 ampere hours is possible over five consecutive days.

The control unit is also so arranged that current from the battery cannot flow back to the generator and there is no risk, therefore, of the battery discharging when there is no wind.

The equipment ordered by the British Transport Docks Board is to test suitability for prolonging a state of charge in batteries located on an unmanned light vessel in the Humber estuary. The batteries being used to power radio-controlled fog alarms.

The wind generator is proving a boon to family yachtsmen, familiar with the predicament of returning to their boat after a week at the office only to find the battery flat.

The unit sells in the U.K. at £28.00p (Packing and Postage 50p).

COMMERCIAL LOCAL RADIO

At an Advertising Association dinner in Bournemouth, Sir John Eden, Minister of Posts and Telecommunications, explained why there must be a limitation on the number of local radio stations, a matter which is not always understood by the general public.

Sir John pointed out that we are part of a continent in which radio frequencies ". . . are exploited until they are almost bursting at the seams . . . . . a highly sophisticated garden in which there was room only for new plants of certain kinds and in certain quantities."

The Government's objective is that as many people as possible should be enabled to enjoy the new local radio service. In the circumstances it is anticipated that about 60 commercial local radio stations will be the maximum number which can operate without upsetting the proper ordering of frequencies, even so, they will add a new dimension to broadcasting in this country.

CORDLESS SOLDERING IRON

The world's first cordless soldering iron from the USA is available in this country from the exclusive distributors, Pact International Electronics Ltd., P.O. Box 19, Royston, Herts SG8 5HH.

The completely portable soldering iron needs no mains power source during operation. It uses a power source which is automatically recharged from the stand which itself is connected to the mains. A working light near the soldering tip makes it easy to use, even in dark corners. This precision instrument is used by professional electronic engineers for all types of soldering.

With a speeial push-button operation and pilot light there is little chance of accidental burning – a useful safety feature.

This soldering iron heats up in 3–5 seconds and has indestructible iron-plated tips. The iron costs £9.25 complete with recharging stand and fine-point soldering tip. A spare heavy-duty tip is also available.

. . . COMMENT

DIAMOND JUBILEE YEAR

We congratulate The Radio Society of Great Britain which this year celebrates the sixtieth anniversary of its foundation.

On the 5th January, Dr. J. A. Saxton, Ph.D. C.Eng., F.I.E.E., F.Inst.P., a former President of the Society, was installed as the thirty-ninth President, for this special Diamond Jubilee Year.

The Society is planning a number of special events in various parts of the country such as rallies, conventions, dinners, etc.

We wish the RSGB well in all the functions planned, and may it go from strength to strength in its sterling work for the radio amateur.

LONGEST STRAIGHT LINE

Dateline, London, one of the BBC's Topical Tape programmes, recently reported on the new giant radio telescope designed and built by the Mullard Radio Observatory in Cambridge. It is, in fact, made up of eight separate radio telescopes which move into position along the world's longest true straight line.

This line does not just follow the curvature of the earth like a canal. It is a true geometric straight line cut through the curvature of the earth, three miles long and accurate to one millimetre.

Topical Tapes produced by the BBC Overseas Regional Services and distributed by the BBC Transcription Service are regular weekly programmes in English especially designed for rebroadcasters throughout the world.

Each week, over 300 high quality radio tapes are sent by air from London direct to 70 subscribers radio organisations. They are regularly used either direct, or in further copies made locally, by more than 240 stations in some 60 countries.

IN BRIEF

● APT Electronics Ltd have delivered 600 specially-designed power supplies to GEC Telecommunications Ltd, for use in Lincompex equipment, since the late 1960s.

● Norwood Technical College, Knights Hill, London, SE27 0TX, commencing on Monday 12th February, are holding a short course of 7 lectures on Video Recording.

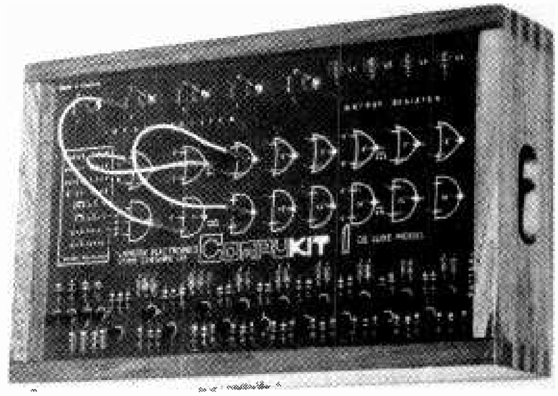
The course covers Monochrome and colour video recording and transmission systems, and tape, disc and electron beam techniques.

The fee is £3.00 and the lectures last from 6.30 to 8.30 p.m. Enquiries to Senior Administrative Officer.

● The MacRobert Award, often described as the Nobel Prize for engineering, for 1972 was awarded to Mr. Godfrey Hounsfield and EMI Ltd for the invention of a new X-Ray technique which forms the basis of a new computerised system for diagnosing brain disease.

HRH Prince Philip presented the £25,000 Award cheque to Mr. Hounsfield. The Gold Medal was presented to Sir Joseph Lockwood on behalf of EMI.

COMPUKIT 1 DELUXE MODEL



Limrose Electronics have announced improvements in the design of their very popular computer and logic teaching aid, Compukit 1 Deluxe Model, which is now also available in kit form.

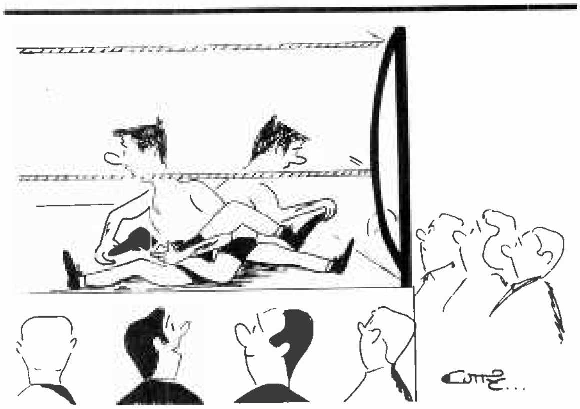
The assembled Compukit 1 Deluxe Model consists of sixteen NAND and NOR gates. Logic inputs are provided by five high quality switches.

The discrete components used in the design of the logic gates not only help students to understand the electronics involved, but also permit Wired-OR operations to be performed. This makes the unit particularly suitable for teaching the fundamentals of logic to students of electrical and mechanical engineering.

Full instructions for assembly are provided with the kit form of the Deluxe Model and the assembly can be completed in about two hours.

Both kit and assembled forms of Compukit 1 Deluxe Model are accompanied by a comprehensive instruction book entitled "Introduction to Logic and Digital Computers".

The cost of Compukit 1 Deluxe Model in kit form is £20 and that of the fully assembled and tested form is £24. Further information can be obtained from Limrose Electronics Limited, 8–10 Kingsway, Altrincham, Cheshire. WA14 1PJ.



That reminds me, I'm out of twisted pair cable

Cover Feature - 1

TRANSISTOR CURVE TRACER

by D. W. Nelson

A low-cost unit employing standard components which enables collector voltage-collector current curves to be directly displayed on an oscilloscope.

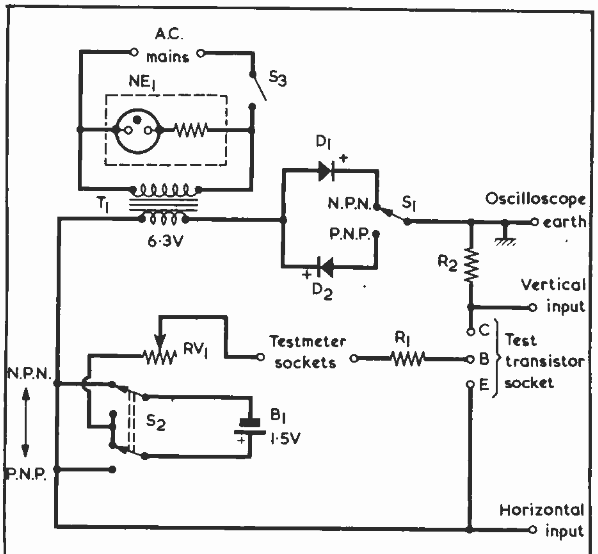
When obtaining the characteristic curves of individual transistors the normal procedure is to lay out the various components in a breadboard fashion with all the usual toggle switches, voltmeters, ammeters and variable voltage supplies taking up most of the available bench space. To obtain enough data for even one characteristic curve can be very time-consuming. For example, to obtain the characteristic curve of, say, collector current versus collector voltage it is necessary to increment one of the variables (e.g. collector voltage) whilst keeping the base current constant, and read off each new value of collector current. One such set of readings may take up to half an hour. By the time the results are plotted on suitable graph paper the experimenter usually feels he has done enough for one day. Imagine taking enough measurements to obtain a family of curves! To further investigate the effects of temperature on the transistor would require a prohibitive amount of time.

PATIENCE

The author, having now, he hopes, convinced the reader that he will need the patience of a saint to make a reasonable number of measurements, will next describe a technique which is simplicity itself and which not only permits various characteristic curves to be obtained in about two minutes but also allows a permanent photographic record to be made of a whole family of curves. The apparatus required is extremely simple (except for an oscilloscope) and will be found in virtually any experimenter's 'junk box'. In fact, with a little thoughtfulness and care a very comprehensive unit can be constructed which will prove invaluable in understanding characteristic curves.

CIRCUIT

The circuit of a device capable of producing transistor curves without wasting time is seen in the accompanying diagram. Base current for the transistor being checked is supplied by a small 1.5 volt cell, B1, and is adjusted by means of potentiometer RV1. The current is

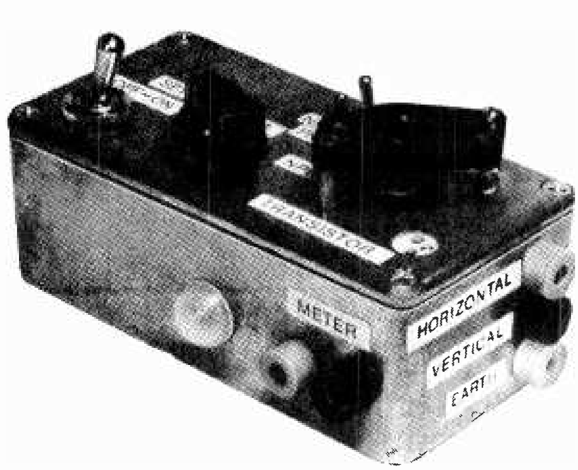


The circuit of the curve trace unit. This enables collector voltage-collector current curves to be displayed directly on an oscilloscope screen measured by an external testmeter, which is switched to a suitable range and coupled to two sockets on the unit. In order to accommodate both p.n.p. and n.p.n. transistors, switches S1 and S2 are incorporated. There is no need to provide an on-off switch for B1 because current is only drawn from it when a transistor is inserted in the test transistor socket.

To obtain a complete curve on the oscilloscope it is necessary to 'sweep' the transistor through its operating range. This is accomplished by applying a half-wave rectified voltage from the 6.3 volt winding of a small heater transformer to the transistor emitter and collector. The half-wave rectified voltage has a peak value in the order of 8 to 9 volts.

To provide a voltage sweep on the oscilloscope which is directly proportional to the applied collector-emitter voltage, the half-wave rectified voltage is coupled to its horizontal input. At the same time, by using a small series resistor (R2 in the diagram) in the collector circuit of the transistor being checked, another voltage becomes available which is directly proportional to the transistor collector current. This voltage is applied to the vertical input of the oscilloscope. Thus, the oscilloscope is now capable of tracing out a curve which has collector-emitter voltage as the horizontal axis and collector current as the vertical axis.

In some cases the oscilloscope traces obtained with the aid of the unit will not be the 'same way up' as are the characteristic curves normally seen in text-books, but of course the latter curves are 'rationalised' in terms of sign conversion and are all drawn in the same V-I quadrant. The simplicity of the present unit would be lost if an attempt were made to have it present all curves in the same manner as text-book curves and, in practice, the operator of the unit very soon becomes used to seeing curves which are oriented away from those normally encountered. The curves will usually be inverted either for p.n.p. transistors or for n.p.n. transistors. Measurements can, of course, be made just as easily with any curve orientation.



External view of the prototype unit. The three wander plug sockets for the oscilloscope may be seen on the right, whilst those for the external meter are on the front edge. Also on this edge is the neon lamp

COMPONENTS

Resistors
- R1 100Ω ¼ watt 10%
- R2 100Ω ½ watt 2%
- RV1 25kΩ potentiometer, linear

Transformer
- T1 6.3V heater transformer

Diodes
- D1 1N4002 or similar
- D2 1N4002 or similar

Switches
- S1 S.P.D.T. toggle
- S2 D.P.D.T. toggle
- S3 S.P.S.T. toggle

Neon
- NE1 240V neon lamp assembly with integral resistor

Battery
- B1 1.5V cell

Miscellaneous
- 5 wander plug socket
- Transistor sockets (as required)
- Knob
- Case

CONSTRUCTION

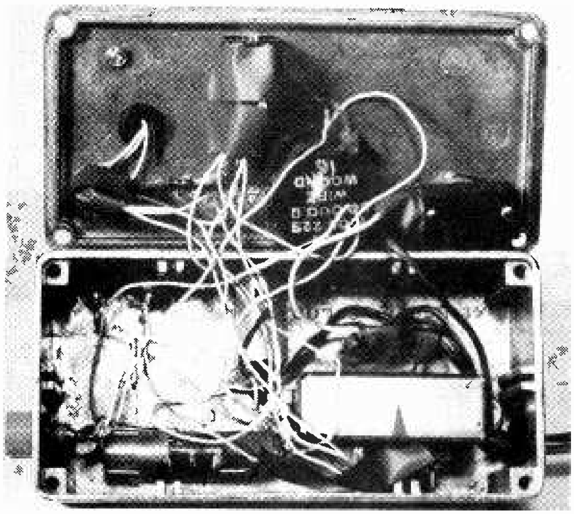
The layout of the unit is not at all critical and the dimensions of its housing depends on the size of the components employed. The writer constructed his unit in a small diecast box measuring 4¾ in. by 2⅜ in. by 1½ in. This employed a miniature mains transformer and miniature switches for S1 and S2. Readers employing standard size components will need to use a larger box. Care should be taken to ensure that there is no risk of circuit points at live mains potential touching the inside of the case. The mains lead should be securely anchored inside the box and should pass out through a rubber grommet.

The box has five wander plug sockets for external connections, three of these being for the oscilloscope and two for the external current reading meter. The question of sockets for the transistor being checked is left to the reader's discretion. The author's version has one small socket primarily intended for TO5 transistors and another socket capable of taking TO3 power transistors.

USING THE UNIT

The unit is coupled to the oscilloscope with which it is to be used and the external testmeter connected to the two appropriate wander plug sockets. S1 and S2 are set to 'n.p.n.' or 'p.n.p.', according to the type of transistor to be checked, the latter is connected to the unit and the mains supply is switched on by means of S3.

The desired base current, as indicated by the testmeter, is set up by means of RV1 and the gain and shift controls of the oscilloscope adjusted for an optimum image size. If no quantitive measurements on the



Inside the diecast box are mounted the miniature mains transformer and the 1.5 volt cell

transistor are required, then this characteristic curve may be demonstrated, say, to a class of students or used for discussion as a teaching aid. However, in most cases it will be necessary to take measurements of the characteristic curve and this will incur taking advantage of the voltage calibration of the oscilloscope. The collector-emitter voltage output from the unit is directly in volts. The collector current output has an amplitude of 0.1 volt per milliamp.

Having set up the oscilloscope gain controls for a desired presentation or calibration level these are left alone, and further curves corresponding to different base currents are then displayed.

To obtain a permanent record of the characteristic curve (or family of curves) being studied, one of several techniques may be used. The simplest method is, of course, to simply trace the curve. Alternatively, the single curve may be photographed.

It is possible to obtain a whole family of curves on a single photograph in the following manner. First, all calibration adjustments are carried out and the origin of the curve (i.e. the zero voltage zero current point) positioned conveniently. Then the first curve is 'put up' on the screen and photographed in the usual way. The transistor base current is then adjusted, causing a new curve to be given on the screen. Another exposure is then made on the same film, and the procedure is repeated until a whole family of curves is obtained. If the oscilloscope has a graticule it may be possible to illuminate this also and photograph it, whereupon it becomes superimposed on the curves.

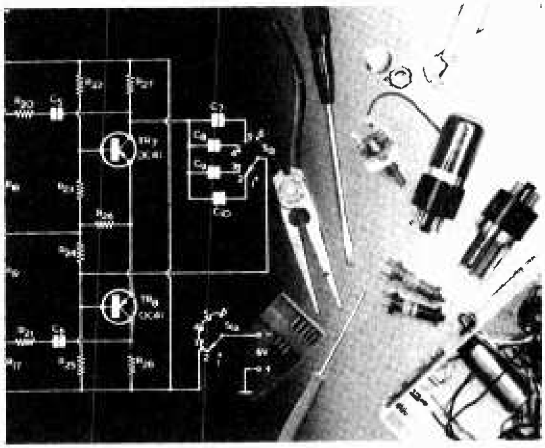
ALTERNATIVE APPROACHES

The approaches employed in the present design may be varied. For instance, a 12 volt mains transformer winding may be employed, thereby giving a higher emitter-collector voltage. Again, a Variac variable output transformer could be used, giving a continuously variable collector voltage. Obviously, the voltage applied to the transistor being checked should not exceed its maximum rating.

Other possibilities include the use of a resistor having a value lower than 100Ω in the R2 position. This will enable higher collector currents to be introduced. A 10Ω resistor will, for instance, produce a voltage of 10mV per milliamp.

The author's unit has been tried with several different oscilloscopes, and in particular with the Serviscope Type D31. An interesting experiment has been its use in the demonstration of the effect of temperature on transistor characteristics. The curve of a transistor is first displayed on the screen and a hot-air blower (hair dryer) is then directed onto the transistor. The results on the characteristic curve can be quite startling. ■

INTEGRATED CIRCUIT OHMMETER



by G. A. FRENCH

In the last two articles in the Suggested Circuit series the author described two items of test equipment incorporating the integrated circuit operational amplifier type ML741C. The first item (Suggested Circuit No. 265) was a voltmeter with a sensitivity of 200kΩ per volt, and the second (Suggested Circuit No. 266) was a microammeter having the ranges 0–5μA, 0–10μA and 0–20μA.

The 741 i.c. is an extremely useful device and it lends itself particularly well to the design of sensitive d.c. measuring instruments. Since the third d.c. quantity capable of measurement is resistance it was felt that an ohmmeter incorporating a 741 op-amp would complement the preceding two articles very well. Low-cost conventional ohmmeters are capable of measuring resistances above 1Ω or so with sufficient accuracy for most everyday work, and so it was decided to incorporate the 741 in an instrument which could measure much lower values of resistance. The ohmmeter to be described is capable of measuring resistance from less than 0.01Ω up to 10Ω. An unusual feature is that resistance is indicated on a linear scale, and not on a non-linear scale which is cramped at one end as occurs with conventional ohmmeters.

BASIC APPROACH

The basic approach to the ohmmeter design is illustrated in Fig. 1. In this diagram a known constant current is caused to pass through the 'test resistor', this being the resistor whose resistance it is desired to measure. A voltage which is proportional to its resistance appears across the test resistor, and this voltage is applied to the operational amplifier circuit. An amplified voltage appears at the output of the op-amp and is passed to a voltmeter. In consequence, the voltmeter gives a reading which is proportional to the resistance of the test resistor.

The output of the op-amp in Fig. 1 is coupled back to the inverting input via RY. If the test resistance is very much lower in value than RX, the voltage gain of the op-amp then becomes equal to RY divided by RX.

The full practical circuit of the ohmmeter is given in Fig. 2. Here, the constant current device is a transistor type BC214L, the base of which is held at a fixed potential by means of the four forward biased silicon diodes D2 to D5. The emitter current is selected by the range switch S2, the pre-set potentiometers R1, R2 and R3 being set up such that on Range 1 the BC214L passes a constant current of 0.5mA, on Range 2 a constant current of 5mA, and on Range 3 a constant current of 50mA. Power for the constant current circuit is provided by the 6 volt battery B3, and is present whenever push-button S4 is pressed.

On Range 1 the 0.5mA constant current causes a voltage of 5mV to appear across the test resistor when this has a value of 10Ω. Lower values of resistance will cause smaller voltages to appear. On Range 2, the constant

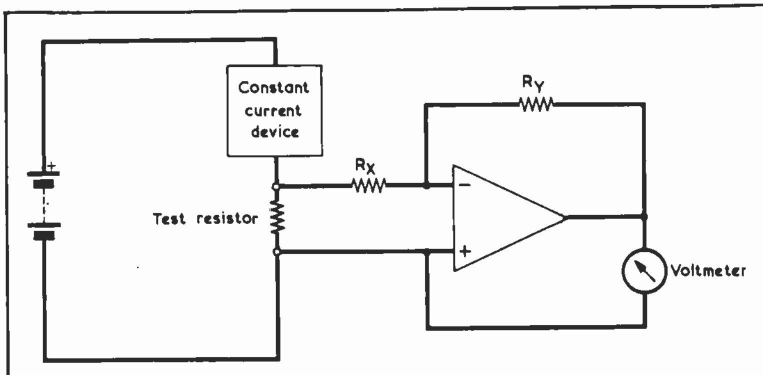


Fig 1. The basic method of operation of the ohmmeter. A known constant current is passed through the test resistor, the voltage across which is then amplified by the operational amplifier and passed to the voltmeter

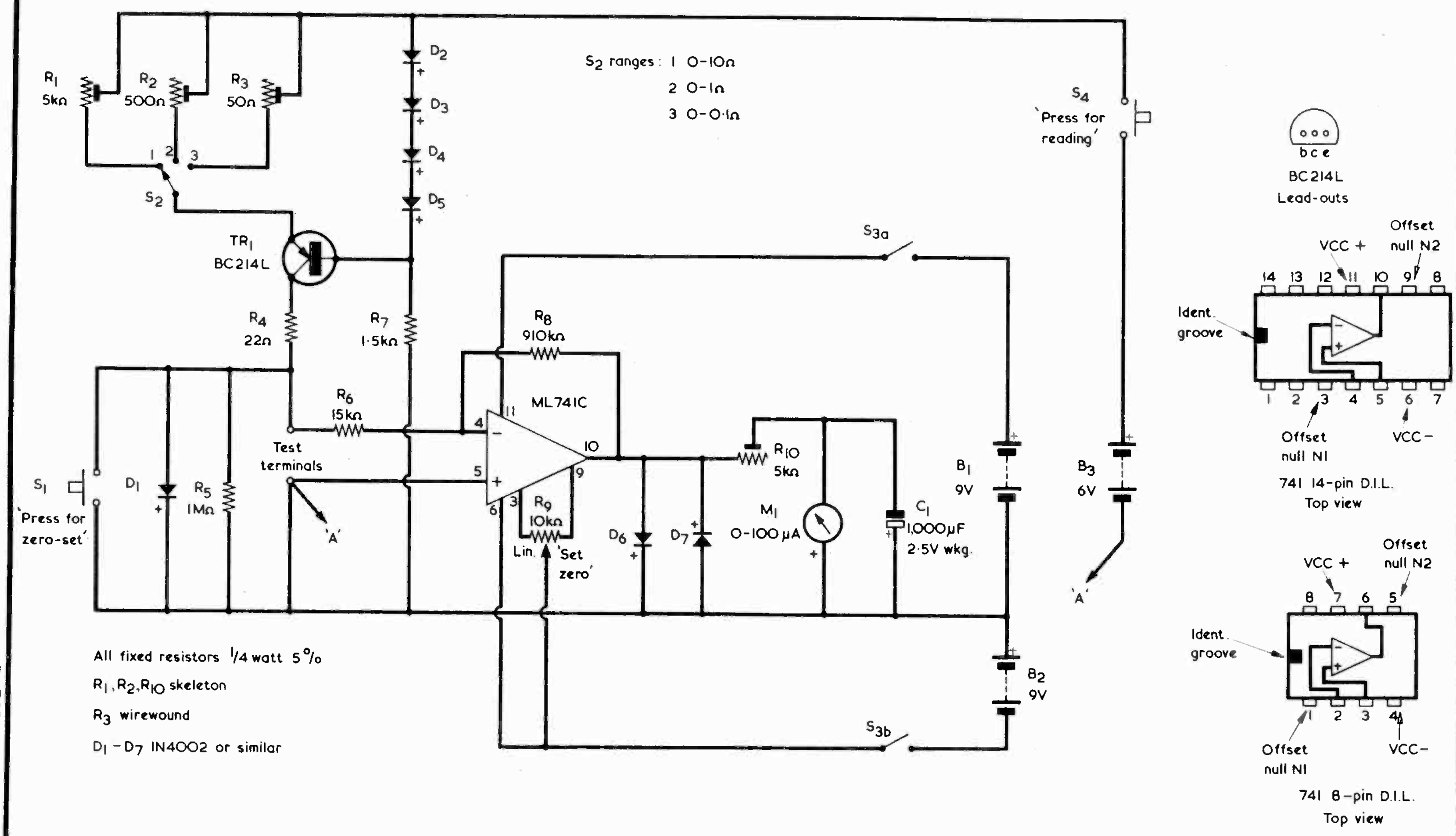


Fig. 2. Full circuit diagram for the ohmmeter. It is capable of measuring resistance down to less than 0.01Ω. The two circuit points marked 'A' are wired directly together

current of 5mA produces a voltage of 5mV if it flows through a test resistance of ·1Ω. A constant current of 50mA, given on Range 3, produces a voltage of 5mV when the test resistance is 0.1Ω. If the op-amp circuit can be made to cause the following voltmeter to give an f.s.d. reading for an input voltage of 5mV, then the arrangement becomes an ohmmeter having ranges of 0–10Ω, 0–1Ω and 0–0.1Ω.

The voltmeter following the op-amp is given by M1 and R10 in series. A convenient voltage at which f.s.d. can be indicated by M1 is 0.3 volt, since this allows the meter to be protected against overload by the two silicon diodes D6 and D7, which become fully conductive at around 0.6 volt. The amplification required to step up an input voltage of 5mV to an output voltage of 0.3 volt is 60 times, and this is provided (approximately) by making R8 (which appeared as RY in Fig. 1) some 60 times greater than R6 (which was RX in Fig. 1). There is no necessity for R8 and R6 to be close-tolerance components since, provided the amplification given by the op-amp is reasonably close to 60 times, any small deviation from this figure can be readily taken up in the adjustment of R10 during calibration. A voltage gain of 60 times is a convenient figure in practice, since it is not so high as to make zero-set adjustments critical.

TR1 achieves a constant current performance because it is effectively operated in the grounded base mode. Under these conditions collector current remains virtually unaltered for very large changes in collector voltage. It would be possible to obtain constant current operation with only two series silicon diodes to hold the base at a fixed potential, whereupon the pre-set potentiometers R1, R2 and R3 would require lower values. This could, however, result in inaccuracies in measurements because the lower values of emitter resistance could become comparable with contact resistance in switch S2. Having four diodes enables the emitter resistance inserted by R1, R2 and R3 to be considerably higher than any contact resistance likely to be inserted by a good quality switch in the S2 position.

Resistor R4 is a limiter resistor which reduces power dissipation in TR1, particularly on Range 3. Assuming a drop of 2.4 volts across D2 to D5, the power dissipation in TR1 on Range 3 without R4 would be of the order of 180mW, which is within the maximum rated power figure for the BC214L of 300mW. But there is little point in running a transistor at a higher power than is necessary, and R4 reduces the dissipation in TR1 to around 125mW.

Diode D1 across the test terminals limits the voltage across these to 0.6 volt if S4 should happen to be accidentally pressed when the test terminals are open-circuit. R5 is included merely to provide an earth return for the inverting input of the op-amp when the test terminals are open-circuit. Its high value has negligible effect upon the value of the resistance being measured. Since the inverting input is a virtual earth, R6 is also effectively in parallel with the resistance being measured. Its resistance is, nevertheless, much higher than the range of resistors it is intended that the ohmmeter should measure and it similarly has negligible effect on the test resistance.

It is essential that the current flowing in the test resistance be kept separate from the op-amp actuating currents as, otherwise, resistance in the wiring of the test instrument may give inaccurate results, particularly on Range 3. It is for this reason that the test resistance current is provided by a separate battery. The test resistance current should only encounter the op-amp circuit at the test terminals themselves, and the negative side of B3 connects into circuit at the lower test terminal itself, and at nowhere else in the circuit. Also, R4 connects directly to the upper test terminal and the operational amplifier inputs are taken direct from the test terminals as well.

As already stated, the gain of the operational amplifier is equal to R8 divided by R6, and is approximately 60 times. This gain is unaffected by the test resistance in series with R6, which is negligibly low in comparison. The output of the op-amp at f.s.d. is nominally 0.3 volt. In practice, the instrument is set up by connecting a close-tolerance 10Ω resistor across the test terminals and adjusting R10 for full-scale deflection in meter M1. Variances from a precise gain figure of 60 are thus taken up in the voltmeter section itself.

It is desirable to have a push-button in the test resistance current circuit since this helps to guard against the instance where test resistance current is accidentally applied when no resistor is connected across the test terminals. Under these circumstances a positive voltage of about 0.6 volt (limited by D1) is applied to the inverting input of the op-amp, the output of which swings negative until it is limited, also at approximately 0.6 volt, by D7. This output will also be given if the test resistance happens to be open-circuit or high value when S4 is pressed. The presence of D7 ensures that meter M1 cannot pass more than about twice its f.s.d. current. Capacitor C1 is included merely to damp the movement of the meter and it prevents the needle swinging hard against the end-stop under the circumstances just described. The capacitor causes a slight 'backlash' in meter reading: for an on-scale measurement the needle passes its final setting and then returns to it. This effect takes place quite quickly and does not detract from the usefulness of the instrument.

Zero setting is achieved with the aid

of R9, which couples into two transistor bases in the input differential amplifier inside the integrated circuit by way of pins 3 and 9. It is necessary for the test terminals to be short-circuited whilst adjusting R9 and this is achieved by pressing S1 during the operation.

Diode D6 limits the output voltage from the op-amp to 0.6 volt in the positive direction. An output voltage of this polarity will not occur during normal operation but could appear if R9 were set incorrectly. The op-amp does not need output current limiting because the output of the 741 i.c. is short-circuit proof.

COMPONENTS

The op-amp is the same type as was employed in the preceding two 'Suggested Circuit' articles and it is a type ML741C obtained from Henry's Radio, Ltd., who advertise it as a '741C(DIL)'. This is a 14 pin d.i.l. integrated circuit and the top view given inset in Fig. 2 shows the pin layout. Other i.c's of the 741 type should function equally well, although the writer should mention that he has only checked circuit operation with the device purchased from Henry's Radio. Integrated circuits type 741 can be obtained in 8 pin dual-in-line, and the pin layout for these is also given in Fig. 2. It should be noted that both the i.c. pin layouts are shown as top views, with the pins pointing *away* from the reader. The inset showing the BC214L lead-outs has the lead-outs pointing *towards* the reader. Some integrated circuits may have a paint spot at the pin 1 end instead of the identifying groove illustrated.

The circuit uses rather a large number of silicon diodes and these can all be any small type of silicon rectifier. The writer used rectifiers type 1N4002, which appear to be becoming a 'standard' for low voltage applications these days.

All the resistors are ¼ watt 5%. An improvement in long-term accuracy could result from the use of high-stability components for R6 and R8. The pre-set potentiometers are as specified in Fig. 2. R9 is a standard panel-mounting potentiometer. As already mentioned, a close tolerance 10Ω resistor is also required, this being used for calibration.

Switches S1 and S4 are standard push-buttons which close when pressed. S2 is a good quality rotary wafer switch. It would probably be best, here, to avoid using one of the popular low cost miniature rotary switches which are currently available, and to employ instead a switch having true Yaxley operation in which the moving contact passes between two contact leaves at each fixed contact position. Switch S3(a)(b) is a double-pole toggle switch. Slide or rotary switches should not be employed for S3(a)(b) as it is desirable to have both the 9 volt batteries switched on and off at the same instant.

Meter M1 can be any panel-mounting 0–100μA movement. The circuit should accommodate any internal meter resistance likely to be encountered.

Both the 9 volt batteries can be small types, as the current drawn from them is low. They should be fitted and discarded in pairs, since the unit should not be operated with one battery new and one battery partly exhausted. The current drawn from the 6 volt battery is the constant current selected by S2 plus several milliamps flowing in R7 and diodes D2 to D5. Since this current can be in excess of 50mA on Range 3, the 6 volt battery needs to be fairly large. Two 3 volt cycle lamp batteries (Ever Ready type 800) in series would represent a good choice. The constant current circuit incorporating TR1 ensures that test resistance current does not vary with changing battery voltage. Nevertheless, the 6 volt battery should be discarded when its voltage on load on Range 3 falls below some 4.5 volts. Incidentally, there is no need to provide B3 with an on-off switch since current is only drawn from it when S4 is pressed.

Finally the two test terminals should be large, heavy duty insulated types. It will be found that surprisingly large values of resistance can be introduced on Range 3 by quite thick conductors.

CONSTRUCTION AND SETTING UP

The ohmmeter can be housed in a plastic or wooden case with the meter, the four switches, R9 and the test terminals on the front panel. As already discussed, the negative terminal of the 6 volt battery must be wired directly to the lower test terminal, as also should the non-inverting input of the op-amp. R4 and R6 should be wired directly to the upper test terminal. The remainder of the wiring is not critical. It is preferable to use an integrated circuit holder for the i.c., the latter being fitted after the holder has been wired up.

Construction commences by wiring up R1 to R4, R7, S2, S4, D2 to D5, TR1, the test terminals and the 6 volt battery. The constant current potentiometers are then set up. Adjust R1, R2 and R3 to insert maximum resistance into circuit and connect a testmeter switched to read current to the test terminals with the positive lead to the upper terminal. It is essential at this stage that R1 to R3 insert *maximum* resistance. If any of these potentiometers offers a low resistance excess current can flow, with the risk of damage to TR1 and the testmeter. To guard against wiring errors, the testmeter should be initially switched to a high current range.

Set S2 to Range 1, press push-button S4 and gradually reduce the resistance inserted by R1 until the testmeter indicates 0.5mA. Next set S2 to Range 2 and similarly reduce the resistance in R2 until the testmeter reads 5mA. Repeat on Range 3, adjusting R3 for a current of 50mA. Constant current operation on any range can be confirmed by temporarily short-circuiting R4, whereupon there should be negligible change in the current indicated by the meter.

Potentiometers R1 to R3 are now set up and should not be touched again. The remainder of the circuit may next be wired up. If it is desired later to confirm the constant currents, this may be done by first disconnecting D1, coupling a testmeter to the test terminals and then proceeding as before. It is necessary to disconnect D1 because the universal shunt circuits in many testmeters cause a relatively high voltage to appear across them on the current ranges, and this voltage can approach that at which forward current flows in the diode. The diode is reconnected after the currents have been checked.

When construction has been completed, the unit has to be calibrated. Initially, R10 should be adjusted so as to insert maximum resistance into circuit. The instrument is then switched on by means of S3(a)(b), push-button S1 is closed and the meter zeroed by R9. S1 is released, S2 is set to Range 1 and a close tolerance 10Ω resistor is connected across the test terminals. Next, S4 is pressed and R10 adjusted for full-scale deflection in the meter. Since the voltmeter section is now more sensitive the sequence should be repeated, R9 being set again, if necessary, for zero reading and R10 readjusted for full-scale deflection. The ohmmeter is then set up for all three ranges.

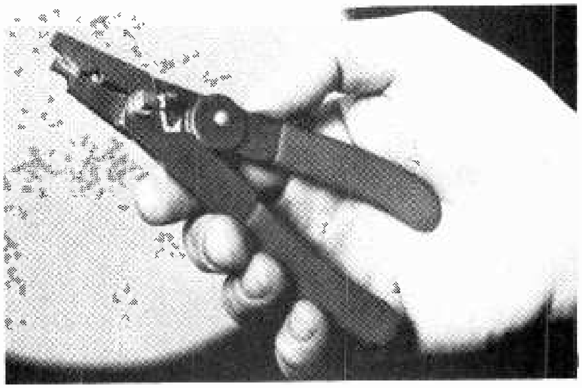
It should be noted that if the instrument is switched on with no test resistor connected, so that only R5 appears across the test terminals, the meter needle will drift from the zero position. This effect is unimportant.

In use, the ohmmeter is switched on by means of S3(a)(b) and S1 is pressed to check the zero setting, which is adjusted if necessary. The instrument is switched off again, the resistance to be measured connected across the test terminals, and S2 set to the requisite range. The instrument is switched on once more and S4 is then pressed to find the test resistance. It should be remembered that the resistance indications are linear. On Range 2, for instance, a reading of 100 in the meter corresponds to a resistance of 1Ω, a reading of 50 to a resistance of 0.5Ω, and so on.

The prototype circuit functioned reliably as described and there were no problems in setting up or handling. The current drawn from each 9 volt battery was 1.4mA only. The sensitivity on Range 3 was exceptionally high and it was both fascinating and instructive to measure the resistance offered by quite short lengths of standard connecting wire. ■

New Products

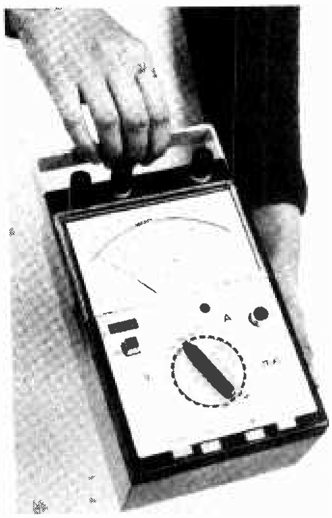
ELECTRICIAN'S MULTIPURPOSE TOOL



A new product from Spiralux is a specialists Electricians tool that would be useful around many homes. Basically, this ingenious gadget replaces three or four separate tools by combining their functions into one. It is a combination of wire stripper, wire looper and cutter together with a screwdriver. So in one handy tool, tradesman or handyman has the capacity to deal with most electrical jobs involving connections. The sturdy wire stripper is adjustable to various wire gauges. The Spiralux Wire Stripper is Tool No. 6075, is attractively carded and the recommended Retail Price is 40p.

For further information, please contact Hollands & Blair Ltd., Bensham Grove, Thornton Heath, Surrey.

NEW VENTURE MULTIMETER



The Multimeter 3 is a compact, easily carried, 52-range instrument cleanly designed around a single 24-position rotary switch. Sensitivity of the taut-ligament movement is 31.6 kohms/V for d.c. and 5 kohms/V for a.c., with accuracies of $\pm 1\%$ and $\pm 1.5\%$ respectively.

A single standard 1.5 V leak-resistant cell energises the movement on all five resistance ranges covering 0.2 ohms to 50 Mohm.

A.v. and d.c. 10/10-ranged scales are identical, and are selected by push-button, as is the ohms range. With ohms selected there is only one 'ohms adjust' control for all ranges. There is a welcome simplification provided on the resistance ranges for testing unidirectional components such as capacitors and diodes without the need to reverse leads or terminals: press-buttons select the polarity of test voltage, and simultaneously reverse the meter movement. The case of the instrument is of two-tone grey impact-resistant a.b.s. plastic, with a slide-away carrying handle.

The patented safety cut-out is of a type newly introduced. Its high-speed action is achieved by an electrical circuit which reacts to the *rise time* of the applied signal; it does not rely on the movement of the pointer, but actually breaks the circuit before the pointer reaches full scale. It is equally sensitive in the forward or reverse direction, and the circuit cannot be reconnected while the overload condition persists. Delay fuse, diodes and neons give further protection.

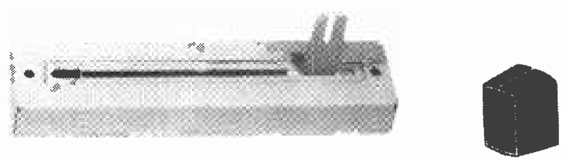
Price of the Multimeter 3 is £38.50; For further information please contact: British Central Electrical Co., Ltd., Banner Street, LONDON EC1Y 8QD.

RANGE OF SLIDER POTENTIOMETERS FOR CONSTRUCTORS

D. J. Electronics Ltd. announce the launching of their branded range of accessories.

They are primarily aimed at the home constructor and enthusiast. Leading this range are a series of Slider Potentiometers, complete with knob and fixing screws. These are available as single or double gang sliders in both logarithmic and linear configurations. A separate range of mounting plates, to accept the sliders are available, thus enabling the enthusiast to easily construct units with our sliders. These plates are offered in three types:- single way, double or triple.

The Retail prices are:- Single Gang Sliders 61p each, Double Gang Sliders 81p each.



Mounting plates will retail at 25p for the single way, 36p for the two way and 45p for the three way.

Further details from:- D.J. Electronics Ltd., 122 Balls Pond Road, London, N1 4AE.

R.F. Amplifier using Dual gate F.E.T.

by

N. FRIEL

An untuned aerial pre-amplifier which can boost the performance of low-cost communications receivers.

THE AUTHOR RECENTLY PURCHASED FOR HIS SON ONE of the cheaper communications receivers which are currently on the market, but its performance was found to be a little disappointing in terms of sensitivity due to the lack of an r.f. amplifier. Even when used with a 30 ft. wire aerial, the signal strength meter rarely moved above the S1 position.

SIGNAL AMPLIFIER

This failing has been completely overcome by the addition of a pre-mixer signal amplifier, based upon a dual gate MOSFET type 40602. Fig. 1 shows the circuit arrangement. The 40602 is available from Electrovalue Ltd., 28 St. Judes Road, Englefield Green, Egham, TW20 0HB.

The incoming signal is fed via the coupling capacitor C1 to gate 1, this input circuit being untuned. The drain of the f.e.t. is returned to V_{DD} positive (which is earthed) via the aerial input coil of the receiver, and so no additional tuned circuits are employed in the r.f. amplifier. The source bias is adjustable by means of RV1, which forms the r.f. gain control. Gate 2 is biased

COMPONENTS

Resistors
(All fixed values ¼ watt 10%)

R1 100kΩ
R2 150kΩ
R3 100kΩ
RV1 5kΩ potentiometer linear, with switch S1

Capacitors

C1 100pF silver mica or ceramic
C2 0.02μF ceramic or plastic foil
C3 0.02μF ceramic or plastic foil
C4 0.1μF plastic foil

Transistor

TR1 MOSFET type 40602

Switch

S1 s.p.s.t., part of RV1

Miscellaneous

9 volt battery
Knob
Veroboard, 0.15 in. matrix
Screened lead
Battery connectors

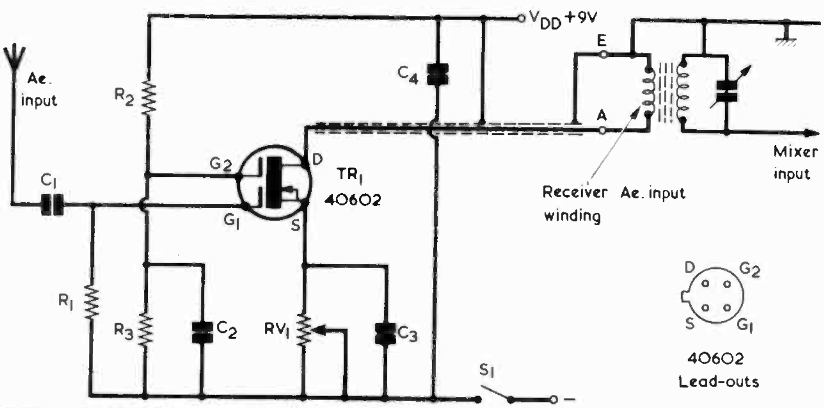


Fig. 1. The circuit of the dual gate f.e.t. amplifier

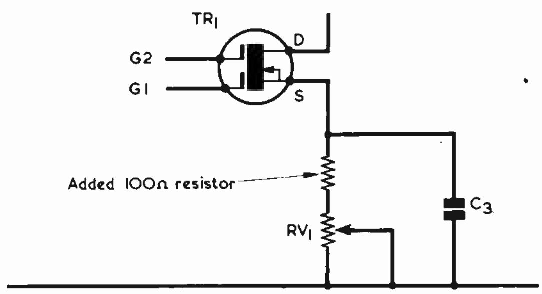


Fig. 2. If desired, current consumption at maximum gain may be reduced by inserting a 100Ω resistor in the source bias circuit

by means of the potential divider given by R2 and R3, these resistors having values which cause VG2 to be 0.4 times VDD. The capacitors C2 and C3 provide gate 2 and source decoupling and their values are in no way critical.

The current drawn from the 9 volt supply is 1.5mA when RV1 is set to insert maximum resistance and 18mA when RV1 inserts minimum resistance. If the maximum current figure is considered excessive it may be reduced by inserting a 100Ω resistor in series with RV1, as shown in Fig. 2.

ASSEMBLY

The original amplifier was constructed on a piece of 0.15 in. Veroboard as shown in Fig. 3. If this layout is followed and the output lead is screened no instability troubles should be encountered. Dual gate MOSFET's have very low feedback capacitance, a typical value being 0.02pF.

Special care should be exercised when handling MOSFET's and both gates should be kept short-circuited to the source until the device has been soldered into circuit. The reason for this is that sufficient static charges can easily build up on the gates to break down the thin insulating layer of silicon dioxide which separates them from the channel, whereupon the transistor would be rendered inoperative.

The method adopted by the author is to wrap thin fuse wire around the MOSFET lead-out wires to effectively short-circuit all the electrodes together. Only after the transistor has been soldered into circuit and the gate and source circuits are completed to the negative line via R1, R3 and RV1 is this short-circuit removed.

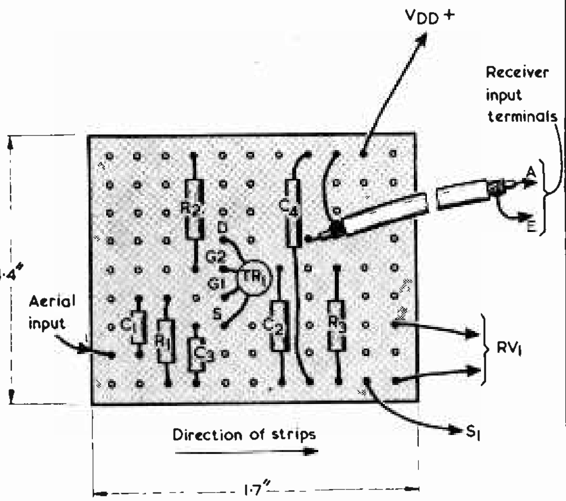


Fig. 3. Component side of the Veroboard assembly in the prototype amplifier. None of the copper strips are cut

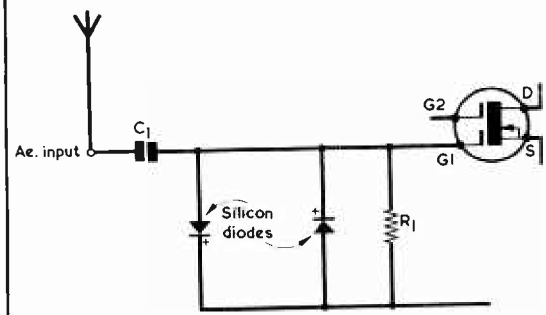


Fig. 4. Two silicon diodes may be added across R1 to protect the gate insulation

The prototype amplifier is housed in a small wooden box with its own PP6 battery. Unless the receiver has its positive rail earthed, it might prove difficult to power the r.f. amplifier from the receiver power supply, since the f.e.t. drain must be returned via the aerial input coil both to earth and to VDD positive. If there is a coupling capacitor in the receiver input circuit, this should be removed.

Should the amplifier be coupled to a large outdoor aerial there is a possibility that static 'spikes' could be passed to gate 1 during thundery weather and cause breakdown of the gate insulation. This risk may be overcome by connecting two silicon diodes across R1 in the manner shown in Fig. 4. These diodes become conductive at around 0.6 volt and would not therefore affect the much lower amplitude aerial input signals. The diodes were not considered necessary in the author's case, as the aerial normally employed is a relatively small indoor one. ■

Constant Current Lamp Circuit

by

L. Stephenson

The mysterious behaviour of three lamps connected in series.

HERE IS A SIMPLE AND INSTRUCTIVE LITTLE DEVICE which can mystify your electrically minded friends and acquaintances. It also demonstrates an important characteristic of the transistor.

SHORT-CIRCUITED LAMPS

The device can be presented in the form of a small box on which are mounted a switch and three m.e.s. torch bulbs rated at 2.5V 0.3A. These bulbs are fitted in Bakelite bulbholders having screw terminals of the type sold in Woolworths' stores, and they are obviously connected in series. The two end wires from the chain disappear into the inside of the box through two holes. Also provided are two test prods connected together by a short length of flexible wire. See Fig. 1.

When the switch on the box is operated the bulbs light up. The person to whom the device is being demonstrated is then invited to take up the test prods and short-circuit any one bulb, any two bulbs, or all three, by applying the prod ends to the bulbholder terminals. He will find, as is to be expected, that the short-circuited bulb or bulbs become extinguished. What is not so easy of explanation is that the remaining bulb or bulbs continue to glow at unaltered brilliance! Even when two bulbs are short-circuited, there is no change in the brightness of the third bulb which remains lit. If all three bulbs are short-circuited they all extinguish, but there are no sparks at the end terminal as would be evident if they were supplied by a battery in the normal way.

It is obvious that there is a mysterious element in the supply circuit which feeds the bulbs, and this is indeed the case. Fig. 2 shows the complete circuit, and it will be seen that the bulbs appear in the collector circuit of an AD162 transistor, this being connected so that it supplies a constant current. The additional components shown in Fig. 2 can be mounted inside the box on which the three bulbholders are fitted.

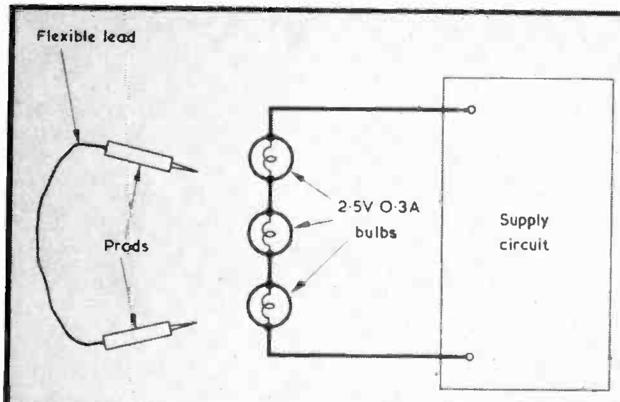


Fig. 1 If the test prods short-circuit any one or two of the bulbs shown here, the remaining bulbs or bulb continue to glow with unaltered brightness

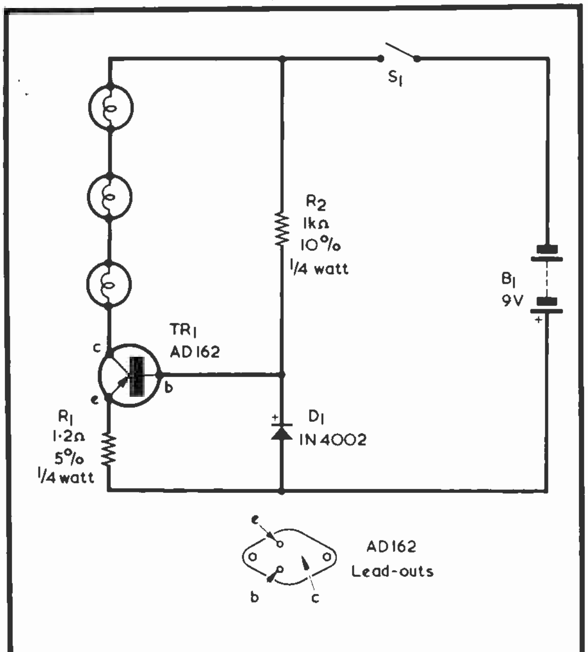


Fig. 2 The 'supply circuit' of Fig. 1. The transistor functions as a constant current generator

GROUNDED BASE

In Fig. 2, the AD162 is employed, effectively, in the grounded base mode. Transistors connected in the grounded base configuration exhibit the collector current-collector voltage characteristics illustrated in Fig. 3. The different lines shown here correspond to different values of emitter current. It will be seen that, at any given emitter current, as soon as collector voltage (with respect to base) passes the zero voltage point the collector current obtained remains virtually unaltered for all further increases in collector voltage.

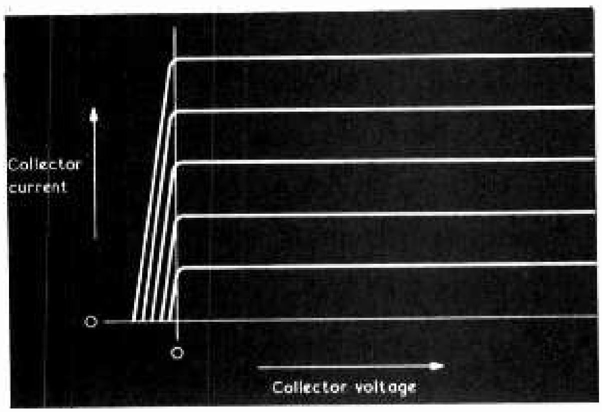


Fig. 3 Typical collector current-collector voltage characteristic curves for a grounded base transistor. The different curves correspond to different emitter currents

The collector voltage can be given any value (provided it isn't made so high as to cause the maximum ratings for the transistor to be exceeded) but there is no change in collector current.

In Fig. 2 the AD162 transistor is in the grounded base mode because its base is held at a constant potential with respect to the positive supply line due to the presence of silicon diode D1. This diode is made to pass forward current by R2 and, since it is a silicon component, a fixed voltage of about 0.55 volt appears across it. The transistor then has bias current applied to its emitter via R1. The AD162 is a germanium transistor, with the result that a voltage of approximately 0.2 volt appears across its base-emitter junction. In consequence, about 0.35 volt appears across R1, and from Ohm's Law $(I = \frac{E}{R})$ a current of very nearly 0.3A flows through it. The current gain for a transistor in the grounded base mode is always a little less than 1, so slightly less than 0.3A flows in the bulbs.

Since the collector current of the AD162 transistor is unaltered by the collector voltage all that happens, when short-circuiting any one or two of the bulbs, is that the collector voltage increases and that the same current continues to flow through the remaining bulb or bulbs. When all three bulbs are short-circuited the collector potential is equal to that on the negative terminal of the battery, but the same current still continues to flow. In this case it flows through the flexible wire joining the two test prods together (and, of course, in the remaining wires of the battery circuit).

The transistor configuration in Fig. 2 represents what is sometimes referred to as a 'constant current generator', and is frequently encountered in linear integrated circuits in which it acts as a common emitter supply element for two transistors in a differential amplifier. For the circuit to give as nearly unvarying a collector current as possible, the current flowing in D1 should be significantly larger than the collector current divided by the hFE of the transistor. The hFE of the AD162 transistor is quoted as 80-320, and if we choose the lower of these two figures (because it will give the highest current figure after division and thus correspond to the worst possible case) we find that the current in D1 should be greater than about 0.3A divided by 80, or about 3.75mA. The forward current in D1 provided by R2 (taking into account the 0.55 volt dropped across the diode) is approximately 8.4 volts divided by 1kΩ, which works out as 8.4mA. For present requirements, this current is adequately in excess of the 3.75mA which is required if an AD162 having the lowest gain figure for this type is used.

COMPONENTS

Some difficulty may be experienced in obtaining the 1.2Ω resistor R1. A 1.2Ω ½ watt resistor is, however, available from Home Radio under Cat. No. R5/8. A 1.2Ω resistor having a higher wattage rating than the ¼ watt figure shown in Fig. 2 can, of course, be used if available. Diode D1 can be any small silicon rectifier, instead of the 1N4002 indicated in Fig. 2. If the circuit is to be used for long periods, a good choice for B1 is given by three 3-volt cycle lamp batteries (Ever Ready No. 800) connected in series.

The AD162 transistor should be mounted on a metal heat sink measuring 1¾ by 2 in. This will provide more than adequate cooling. ■

TRANSMITTER — For 160 Metres

by F. G. Rayer

This article describes the circuit of a 160-metre transmitter-receiver and commences to give details of construction. These will be completed in the concluding article, to be published next month, which will also deal with the processes of setting up and operation.

ALTHOUGH THIS EQUIPMENT WAS BUILT TO GIVE A compact mobile station, it has proved highly satisfactory also at the author's permanent location. It covers 1.8 to 2.0MHz, with 10 watts input, adequately modulated, when transmitting. On reception the receiver section, which has a tuned r.f. stage, gives good sensitivity and freedom from second channel interference. An internal speaker is fitted. It is thus only necessary to provide a power supply, aerial and microphone to obtain a complete Top Band station.

SWITCHING

In equipment of this nature it is possible to have one or more circuits common to both receiving and transmitting sections. After experiments, however, common stages were not incorporated in the present design, the benefit being that each stage could then be designed for its own particular purpose only, whereupon there is a considerable simplification in switching. Other transceiver techniques, such as using the transmitter p.a. coil for aerial tuning on reception, were also tried but discarded. In this particular case, a separate aerial coil for reception gives a worth-while improvement in rejecting second channel signals.

Instead of switching a single meter to indicate p.a. input when transmitting and signal strength when receiving, a permanently connected meter is used in the transmitting circuits and an EM84 tuning indicator in the receiver section. A result of this circuitry is that the transmitter and receiver sections are virtually separate. This simplifies testing or possible modification later, and means that either the receiver or transmitter could in fact be built alone.

RECEIVER

The circuit of the receiver section is shown in Fig. 1. S1(a)(b) is a 2-pole 2-way Transmit-Receive switch. S1(a) couples the aerial to C1 on 'Receive', whilst S1(b), applies h.t. via R15. The full h.t. voltage of around 300 volts which is available is not required for the receiver, and it is reduced to about 220 volts by means of R15, R16 and the current drawn by the receiver valves.

L1 and L2 are the aerial and mixer signal frequency coils respectively, and L3 is the oscillator coil. Details of these, and the other coils in the equipment, are given in a Table which will appear in Part 2. Coverage is 1.8 to 2.0MHz with a little to spare, and this allows for easy tuning. VC2–VC3 is a 2-gang capacitor with ball tuning drive. VC1 is a panel aerial trimmer and is peaked for best reception to ensure that changes to the aerial do not cause loss of efficiency. VR1 is the r.f. gain control.

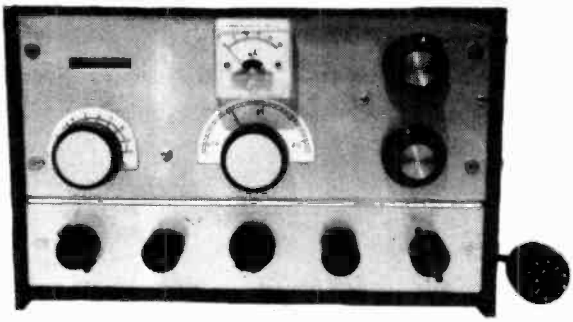
Diode D1 provides detection and a.g.c. bias, the latter being applied to V3 and the tuning indicator, V5. VR2 is the audio gain control, being followed by the double triode, V4, which functions as a 2-stage a.f. amplifier. The circuit has some simplifications, but it easily gives adequate speaker volume. H.T. drain is about 35mA.

S2(a) is part of a 2-pole 2-way switch. Its other section (shown in Fig. 2) applies h.t. to the transmitter v.f.o. and buffer amplifier when 'Net' is selected. When S2(a) is at 'Net' it inserts R7 in the cathode circuit of V3, thereby reducing the gain of this valve and ensuring that the output of the v.f.o. does not swamp the a.g.c. circuit. As a result, the tuning indicator, V5, may be used as an aid to tuning the receiver and transmitter to the same frequency, either to commence calling on a chosen frequency or to reply to a transmission whose frequency has been located by the receiver.

RECEIVER

***Cover Feature* - 2**

Part 1



Assoc.I.E.R.E., G30GR

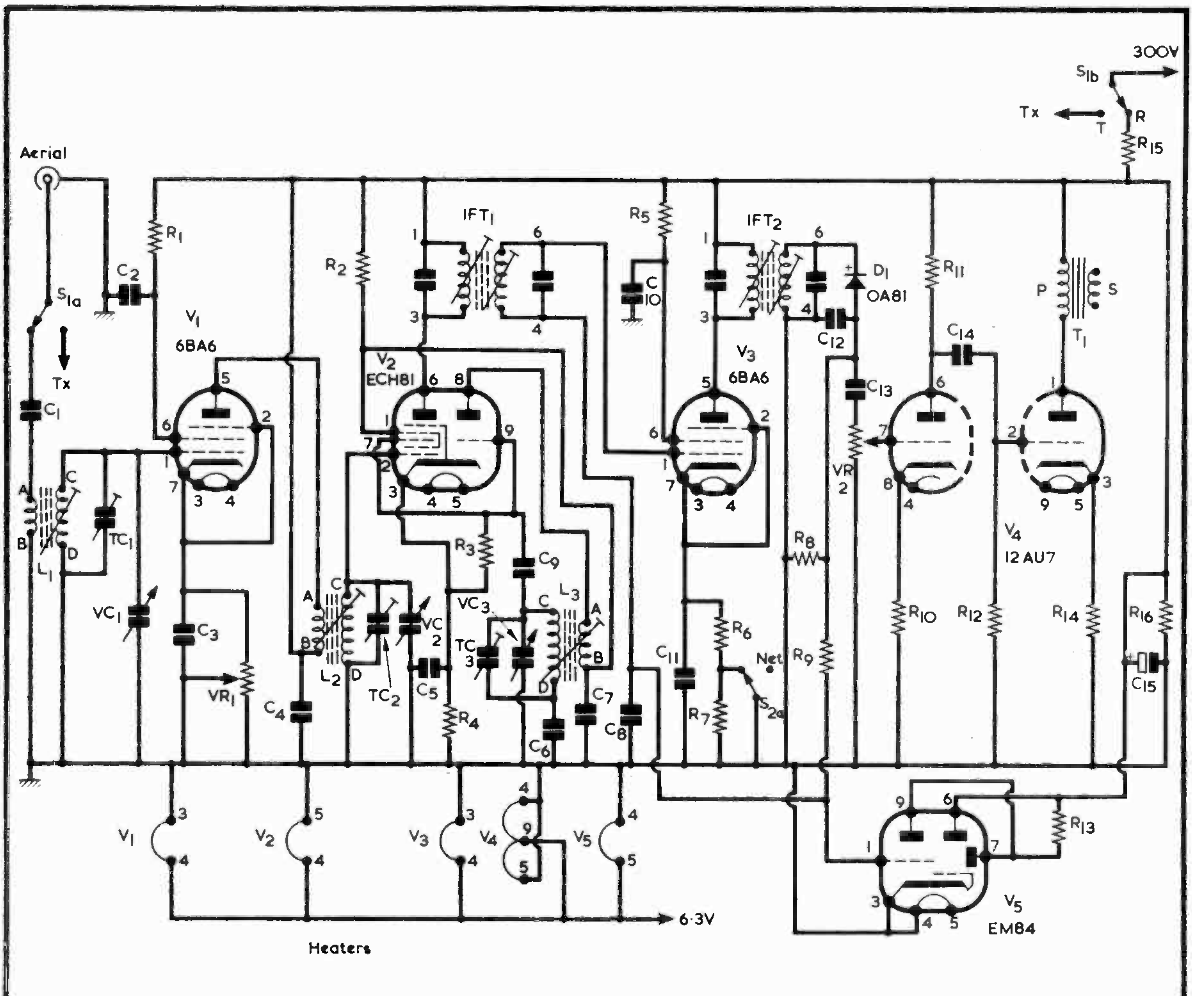


Fig. 1. The circuit of the receiver section of the transmitter-receiver

COMPONENTS *Receiver Section*

Resistors
(All fixed values 10%)

R1	47kΩ 1 watt
R2	22kΩ 1 watt
R3	47kΩ ½ watt
R4	220Ω ½ watt
R5	47kΩ 1 watt
R6	82Ω ½ watt
R7	220kΩ ½ watt
R8	270kΩ ½ watt
R9	2.2MΩ ½ watt
R10	2.2kΩ ½ watt
R11	220kΩ ½ watt
R12	470kΩ ½ watt
R13	470kΩ ½ watt
R14	1kΩ ½ watt
R15	5.6kΩ 5 watt
R16	22kΩ 3 watt
VR1	25kΩ 1 watt potentiometer, linear
VR2	500kΩ potentiometer, log.

Capacitors
(All fixed values 350 V.Wkg.)

C1	300pF silvered mica
C2	0.01μF plastic foil or ceramic
C3	0.01μF plastic foil or ceramic
C4	0.25μF plastic foil
C5	0.01μF plastic foil or ceramic
C6	400pF silvered mica
C7	0.02μF plastic foil
C8.	0.02μF plastic foil
C9	45pF silvered mica
C10	0.01μF plastic foil or ceramic
C11	0.1μF plastic foil
C12	300pF silvered mica or ceramic
C13	0.01μF plastic foil
C14	0.01μF plastic foil
C15	8μF electrolytic
VC1	50pF variable, type C804 (Jackson Bros.)
VC2-VC3	25+25pF, 2-gang type U101 (Jackson Bros.)
TC1	30pF or 60pF trimmer
TC2	30pF or 60pF trimmer
TC3	30pF or 60pF trimmer

Inductors

L1–L3	See Table (to appear in Part 2)
IFT1	i.f. transformer type IFT11/465 (Denco)
IFT2	i.f. transformer type IFT11/465 (Denco)
T1	Small valve output transformer, ratio around 40:1, Home Radio Cat. No. TO43 or similar

Valves

V1	6BA6	V4	12AU7
V2	ECH81	V5	EM84
V3	6BA6		

Diode

D1	OA81

Speaker 3Ω speaker, 3 or 3½ in.

Miscellaneous
2 epicyclic ball drives type 4511/F (Jackson Bros.)
2 B7G valveholders with skirts
3 B9A valveholders with skirts
1 spindle coupler
Speaker fabric

COMPONENTS *Transmitter Section*

Resistors
(All 10%)

R17	68kΩ ½ watt
R18	4.7kΩ 1 watt
R19	15kΩ 3 watt
R20	10kΩ 1 watt
R21	33kΩ 1 watt
R22	100kΩ ½ watt
R23	22kΩ 1 watt
R24	1kΩ ½ watt
R25	6.8kΩ 1 watt
R26	1MΩ ½ watt
R27	220kΩ ½ watt
R28	470kΩ ½ watt
R29	100kΩ 1 watt
R30	3.3kΩ ½ watt
R31	470kΩ ½ watt
R32	150Ω 1 watt

Capacitors
(All fixed values 350 V.Wkg unless otherwise stated)

C16	150pF silvered mica 1%
C17	680pF silvered mica 1%
C18	680pF silvered mica 1%
C19	2,000pF silvered mica
C20	100pF silvered mica
C21	0.01μF plastic foil or ceramic
C22	0.01μF plastic foil or ceramic
C23	100pF silvered mica
C24	2,000pF plastic foil 500 V.Wkg
C25	2,000pF plastic foil 600 V.Wkg
C26	2,000pF plastic foil 600 V.Wkg
C27	22pF silvered mica or ceramic
C28	2,000pF silvered mica or plastic foil
C29	0.01μF plastic foil
C30	25μF electrolytic, 25 V.Wkg
C31	0.01μF plastic foil, 600 V.Wkg
VC4	100pF variable, type U101 (Jackson Bros.)
VC5	500pF variable, type E1 (Jackson Bros.) or similar
VC6-VC7	500+500pF, 2-gang, type L2 (Jackson Bros.) or similar
TC4	30 or 60pF variable, ceramic or air-spaced

Inductors

L4-L7	See Table (to appear in Part 2)
RFC1	2.5mH r.f. choke, type CH1 (Repanco)
RFC2	2.6mH r.f. choke, type RFC5 (Denco)

Valves

V6	6C4
V7	6AM6
V8	5763
V9	12AX7
V10	EL84
V11	OB2

Meter

M1	0–100mA moving-coil meter. Henelec 38 series, or similar. (See text)

Miscellaneous
2 B7G valveholders with skirts and cans (for V6, V7)
1 B9A valveholder with skirt and can (for V9)
2 B9A valveholders
1 B7G valveholder

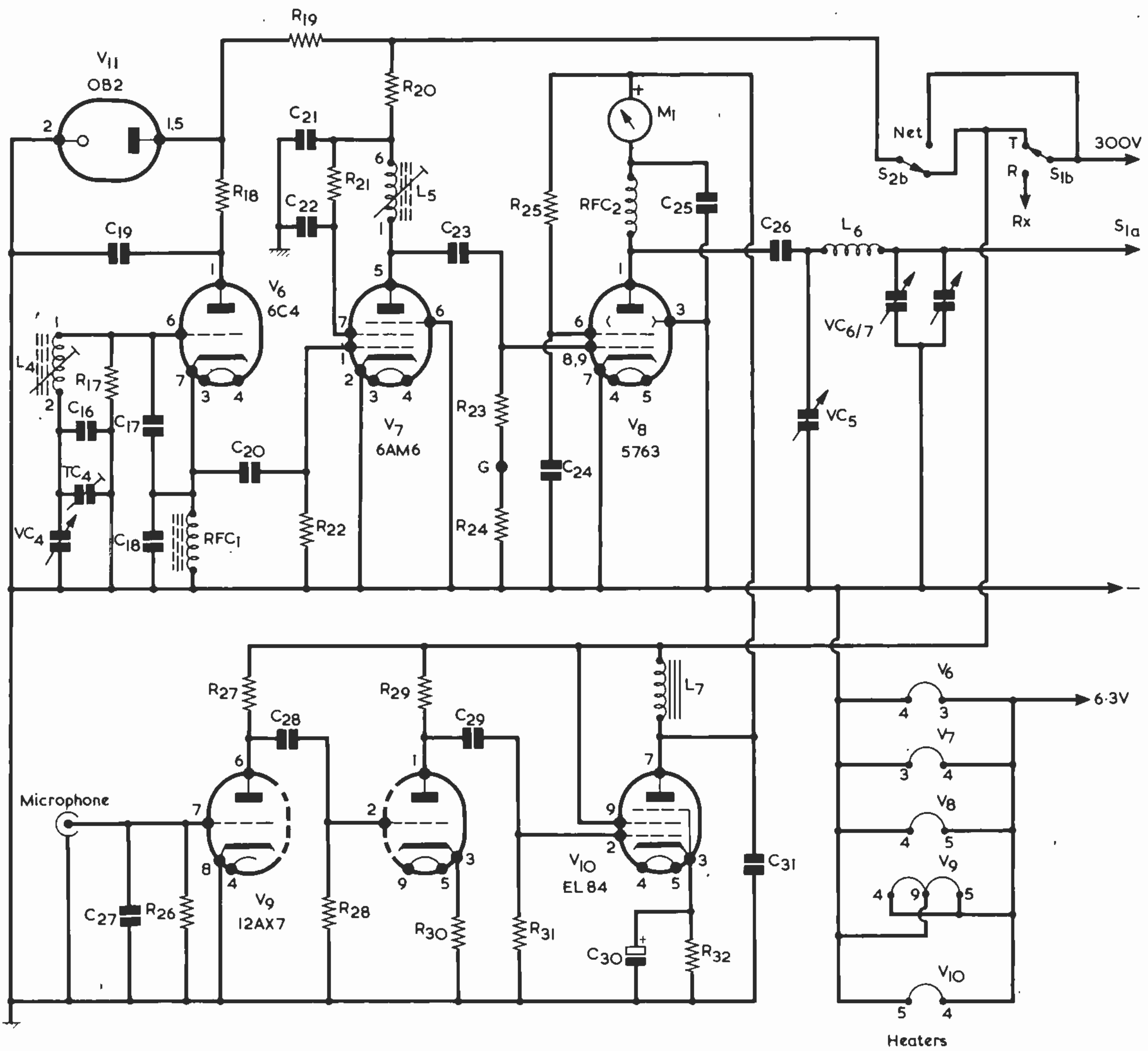


Fig. 2. The transmitter and modulator section

COMPONENTS

Common Items

Switches

S1(a)(b) 2-pole 2-way rotary
S2(a)(b) 2-pole 2-way rotary

Miscellaneous

2-off coaxial sockets
7-off ¾ to 1 in. knobs
2-off 1½ in. knobs
2-off 'Universal Chassis' flanged members 10 by 4 in. Cat. No. CU58A (Home Radio)
2-off flanged members, 10 × 2in., Cat. No. CU139 (Home Radio)
1-off flanged member, 9 × 2 in., Cat. No. CU138 (Home Radio)
1-off flat plate, 10 × 8 in., Cat. No. CU195 (Home Radio)
1-off flat plate, 2½ × 3½ in.
Case sides, top and bottom (see text)
Tagstrips, solder tags, etc.

TRANSMITTER

The transmitter circuit is shown in Fig. 2. Here, V6 is the v.f.o., and is tuned by VC4. Its h.t. supply is stabilised by V11. The band coverage is adjusted for 1.8 to 2.0MHz, with a little extra at the extreme positions of VC4, by adjusting TC4 and the core of L4.

The particular capacitor specified for VC4 may be difficult to obtain from retail sources. It can, if necessary be purchased direct from its manufacturers, Jackson Brothers (London) Limited, Kingsway, Waddon, Croydon, CR9 4DG.

V7 is a buffer amplifier, L5 being broadly resonant at about 1.9MHz. S2(b) allows h.t. to be applied to V6 and V7 alone when 'Net' is selected. When S1(b) is set to 'Transmit', h.t. is applied to all the transmitter stages.

The power amplifier, V8, is easily capable of offering the full 10 watts allowed on the band. A meter clipped between point 'G' and chassis allows V8 grid current to be checked when initially setting up the circuit. The pi tank network given by VC5, L6 and VC6–7 allows loading of the p.a. stage by the usual aerials, and meter

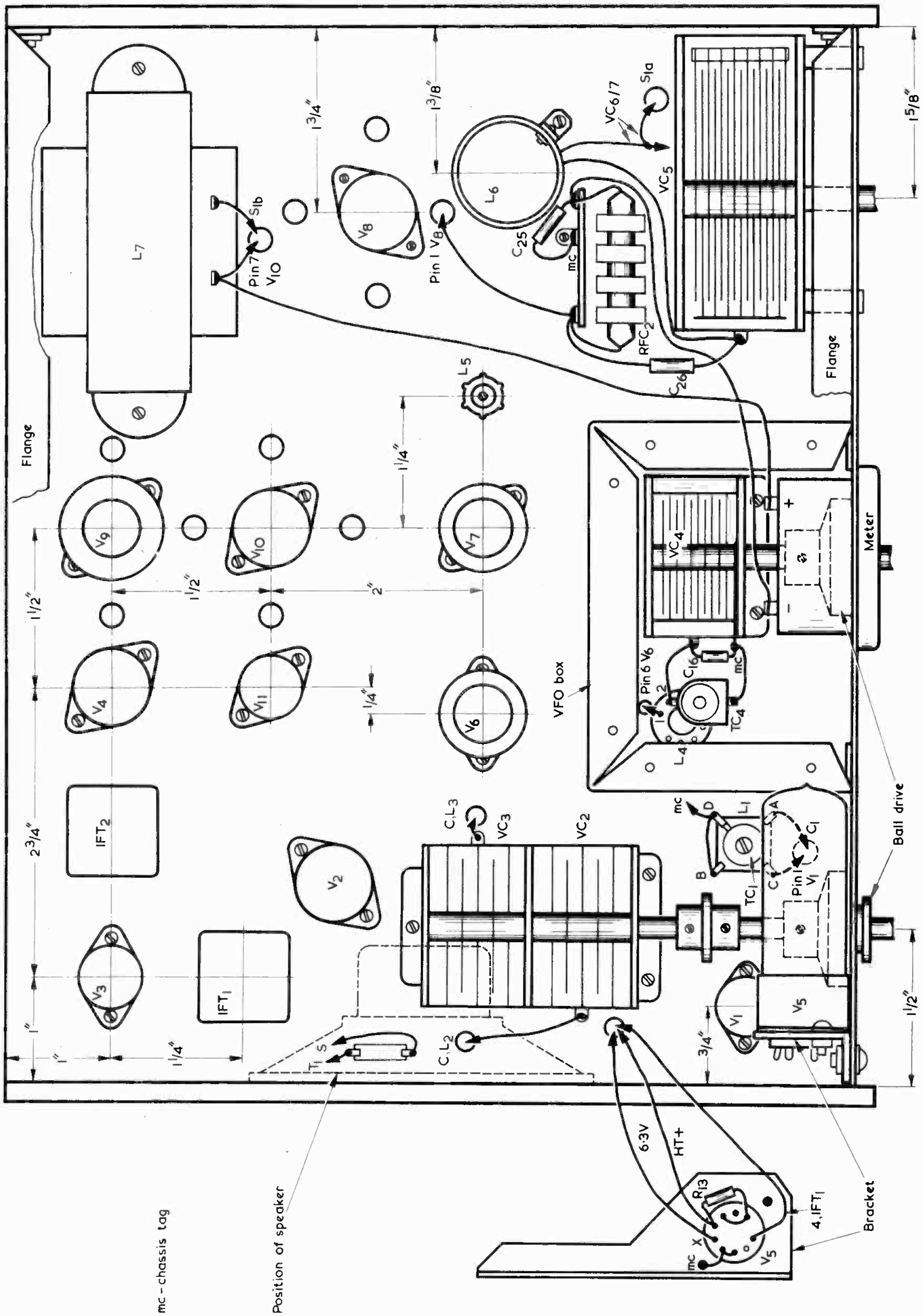


Fig. 3. Components and wiring above the chassis

M1 indicates the p.a. anode current.

V9 is a double-triode which provides two stages of a.f. amplification, and is followed by the choke modulator stage incorporating V10. The modulation amplifier given by V9 and V10 is intended for operation with a general purpose crystal microphone, with which it provides adequate gain. The gain can be increased a little by connecting a capacitor of around 50μF at 6 V.Wkg across R30, but this was not found necessary with the prototype.

No general h.t. bypass capacitor is included in the modulation amplifier circuit. This was found to work quite satisfactorily with leads to the power supply about 4 ft. long. If any trouble does arise due to the lack of a bypass capacitor (caused perhaps by a high output impedance in the supply) a 32μF 450 V.Wkg capacitor could be added between the amplifier h.t. positive line and chassis.

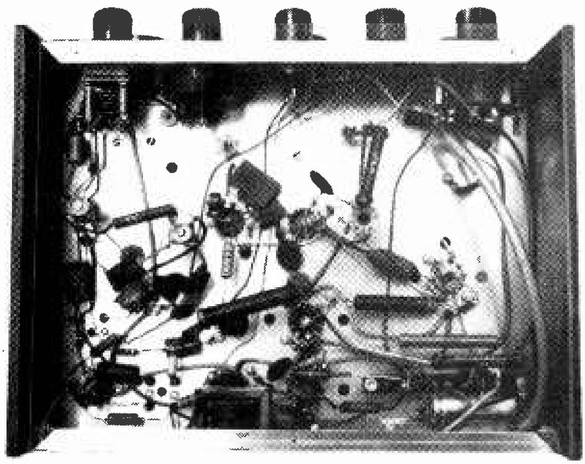
The power output of V10 is about 6 watts and, bearing in mind inevitable circuit losses and the fact that the screen-grid of V8 is modulated in addition to the anode, this output is quite adequate.

The meter employed in the prototype had an f.s.d. of 50mA and proved satisfactory in practice. However, it may be found a little more convenient to use a 0–100mA meter instead, and such a meter is specified in the Components List.

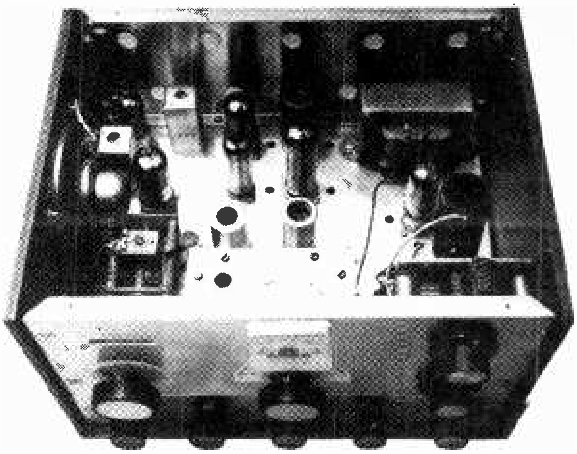
CASE

An inexpensive, strong and satisfactory case for the transmitter-receiver is made up largely from Home Radio 'Universal Chassis' parts. The front panel consists of a 10 by 4 in. flanged member with a 10 by 2 in. flanged member below it. Similar parts are employed for the rear of the case. The valveholders and other chassis components are mounted on a 10 by 8 in. flat plate. This is sandwiched between the adjacent flanges of the flanged members which make up the front panel and the case rear.

The sides of the case are 3-plywood, varnished in advance, and they measure 8¼ by 6¾ ins. These dimensions allow a projection of about ¼ in. at the front and top, and a projection of about ½ in. at the bottom which assists in providing ventilation. The front and rear panels are secured by bolts passing through the plywood



Wiring and components below the chassis



The components above the chassis.

and the end flanges of the flanged members. The flanged members are supplied with holes pierced for assembly, and those which appear at the front are filled with 6BA chrome bolts and washers. It should be remembered that a 3 in. diameter cut-out for the speaker is required in the left-hand plywood panel. Its position is best adjudged with the aid of the speaker itself, and it should enable the speaker to be clear of VC2–VC3 when this is mounted.

The two sides could alternatively be made of metal, if desired. The top of the author's transmitter-receiver is plywood to match the sides but, here again, metal could also be employed. The bottom is perforated metal measuring 10 by 8 in., and is fitted to the bottom flanges of the front panel and case rear. Alternatively, a 10 by 8 in. flat plate with ventilation holes could be used. Both the top and the bottom should be mounted so that they can be easily removed for checks and adjustments.

Five holes for controls are required along the centre of the lower flanged member of the front panel. Spacing is as shown in Fig. 4. Holes are required in the lower flanged member of the case rear for the coaxial aerial socket, the microphone input socket and the power lead. The microphone socket is a little to the left of the V9 valveholder, as shown in Fig. 4, and the aerial socket and power lead hole (not shown in the diagram) are to the left of the microphone socket.

The upper flanged member of the front panel requires holes for VC2–VC3, VC4, VC6–VC7 and VC5. Those for VC2–VC3 and VC4 should be 1 in. diameter to take the ball drives and their height is marked out from the capacitors themselves. The remaining two holes for the capacitors are ½ in. diameter. The hole for VC6–VC7 (mounted below VC5) may be marked out with the aid of the capacitor, and that for VC5 is directly above it. These last two capacitors, are mounted by bolts which pass through the front panel, and further details concerning their mounting are given later, when the top of the chassis assembly is discussed.

If it is desired to have the front panel holes for VC2–VC3, VC4 and VC6–VC7 on a horizontal line it may be necessary for the first two capacitors to be mounted on spacing pillars. This should not be done if it results in VC4 fouling the top of the v.f.o box, which is 2 ins. deep. Next to be cut out in the upper flanged member of the front panel are holes for the meter and a rectangular opening, 1⅜ by ¼ in., for the tuning indicator. These may be centred on a horizontal line with the spindle of VC5. Finally, two rows, each of five ½ in. diameter holes, are cut in the upper flanged member of the case

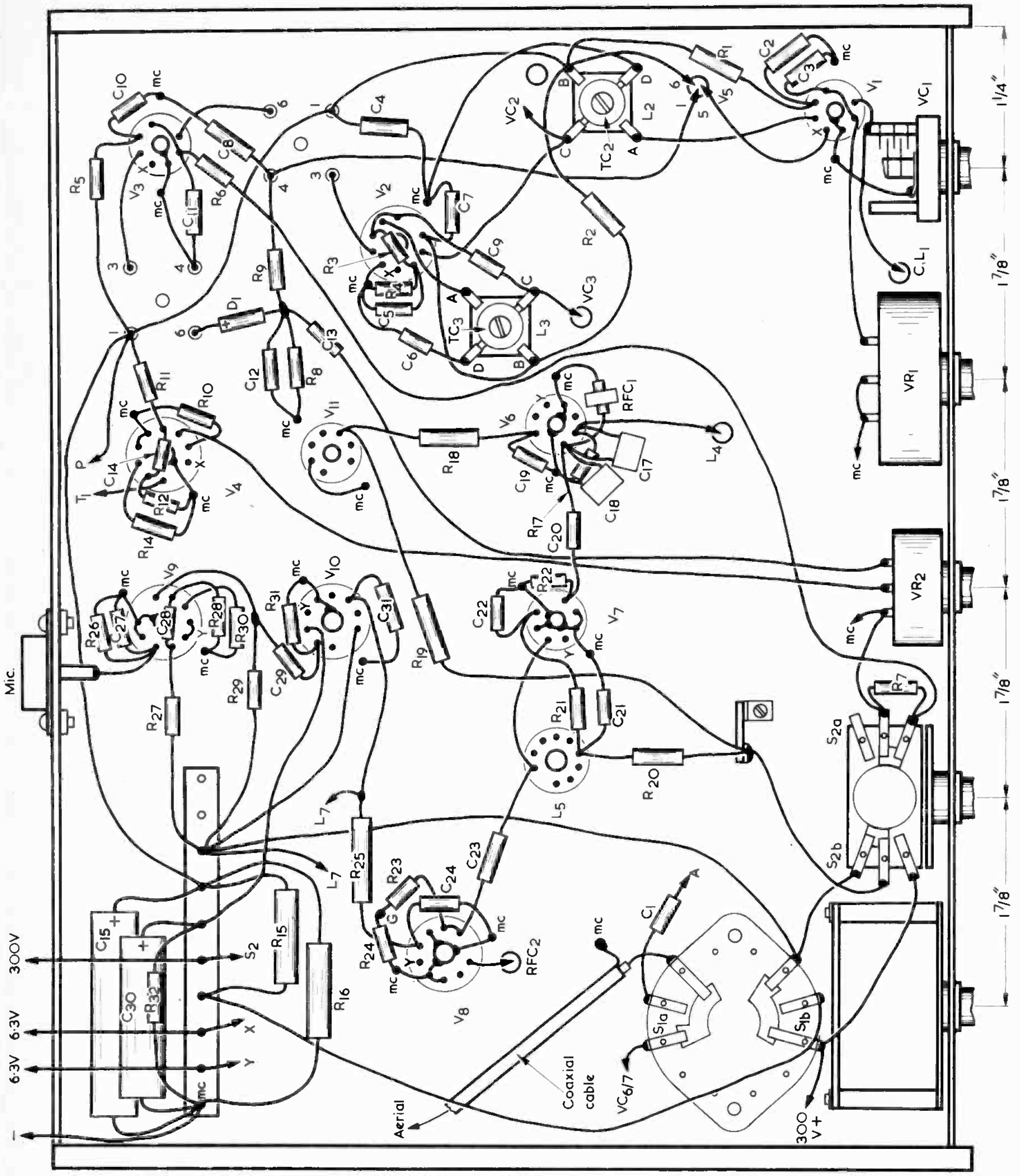


Fig. 4. Wiring and layout underneath the chassis

rear for ventilation.

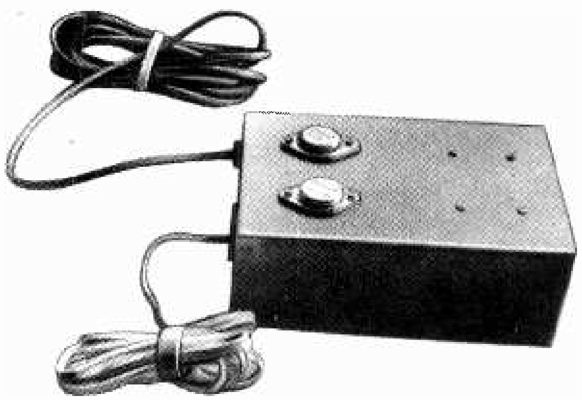
Valveholder holes are next cut in the 10 by 8 in. flat plate. Orient the valveholders to the positions shown in Fig. 4 and use them to mark out their mounting holes. Drill these for 6BA bolts. A few $\frac{1}{4}$ in. holes are drilled around the holders for V8 and V10 to provide ventilation. Note that some of the valves require skirted valveholders, these being noted in the Components List. V6, V7 and V9 are fitted, also, with screening cans. Drilling should, at this stage, be carried out for the i.f. transformers and other items, as indicated in Figs. 3 and 4. The holes for the i.f. transformer pins should be large enough to ensure adequate clearance. Insulated sleeving may be passed over these pins when the transformers are mounted, to ensure full insulation.

NEXT MONTH

Details of construction will be continued in the concluding article, which will appear in next month's issue. Some of the parts specified in the Components List will also be discussed further next month, these including, in particular, the coils.

(To be concluded)

KIT REVIEW . . .

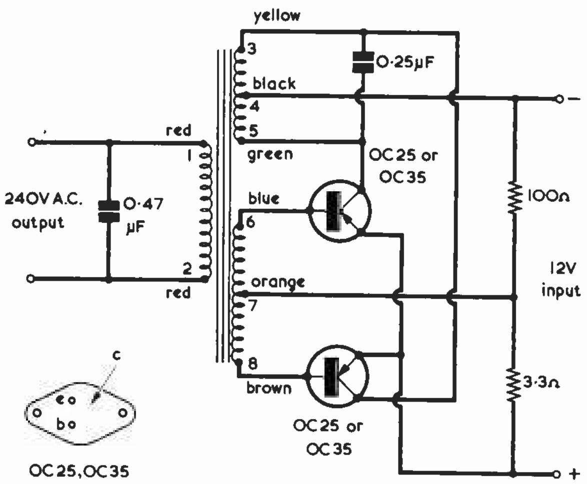


D.C. TO A.C. INVERTER KIT

Easily assembled kits which provide a 240 volt a.c. output from a 12 volt input

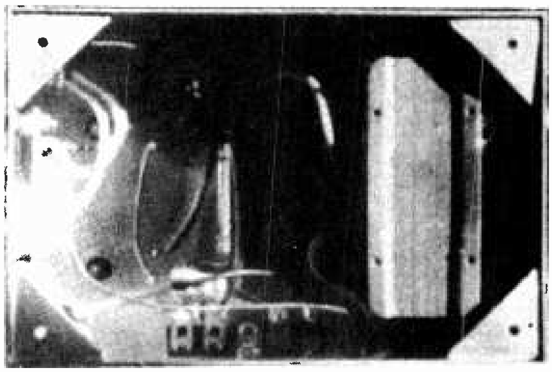
WITH THE CURRENT WIDESPREAD INTEREST IN caravanning, camping and boating, the ability to obtain a 240 volt a.c. supply from a 12 volt accumulator becomes very attractive. Simple transistor inverter kits are available from Henry's Radio Ltd., 303 Edgware Road, London, W.2 and these offer an output of 240 volts a.c. at a nominal frequency of 50Hz. Typical facilities offered by the inverters are the operation of electric razors and fluorescent lamps.

The kit shown in the accompanying photographs is the Type TT51A. This was recently assembled by the writer and provides an output of 15 watts. The kit comes complete with chassis, transformer and transistors, together with miscellaneous hardware and wire.



The circuit of the transistor d.c. to a.c. inverter type TT51A. The two transistors oscillate to produce the a.c. output. Input current at full load is 2 amps.

Construction can be completed within a couple of hours or so and presents few difficulties, even for the newcomer to do-it-yourself electronic construction. The photograph of the chassis interior illustrates how the various parts are accommodated, and gives an idea of the general layout of the components.

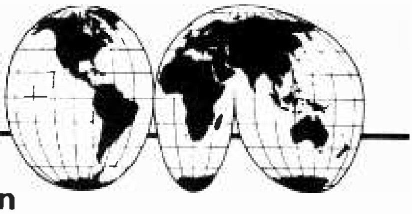


The internal components fit neatly inside the chassis

The chassis is supplied ready drilled to take the two transistors, which have to be insulated from it by means of mica washers and insulating bushes. The transistors are still in close thermal contact with the chassis, which acts as a heat sink. It is important to connect up the transformer correctly, and failure of the unit to function on completion will most probably be due to incorrect transformer connections.

The writer had little difficulty in assembling the unit, which worked perfectly as soon as construction was finished. ■

SHORT WAVE NEWS



FOR DX LISTENERS

By Frank A. Baldwin

Times=GMT *Frequencies*=kHz

Conditions on the short wave Broadcast Bands, up to the time of writing, have been rather poor to say the least. In fact, the writer cannot remember any other period in the past when worthwhile Dx signals were so hard to come by – and the memory goes back some forty years. Two well-known Dxers in recent conversations with the writer told how they even thought things were amiss with their respective receivers – no doubt others had the same thoughts! However, during the past few days breaks have appeared through the gloom and we have managed to log some interesting transmissions. Firstly, some news.

●BRAZIL
The Brasilia International Service now transmits as follows – in German from 1930 to 2030, French from 2030 to 2130, in Portuguese from 2130 to 2230, in English from 2230 to 2330 and in Spanish from 2330 to 0030 on **9665** (31.03 metres), **11720** (25.59m) and on **15447** (19.42m).

●GREECE
A new 100kW transmitter now radiates the Domestic Service (entirely in Greek) in various time-periods throughout the day from 0500 to 2250. That beamed to Europe is from 1900 to 1950 on **5960** (50.33m).

●TUNISIA
Radio Tunis, according to reports, is currently operating on **11925** (25.15m), **11970** (25.06m) and on **15266** (19.65m) from 0600 through to 1700.

●TURKEY
Radio Ankara now broadcasts to Europe in English from 2200 to 2230 on **11880** (25.25m).

●PAKISTAN
Radio Pakistan transmits to the U.K. in English from 2000 to 2130 on 7095 (42.28m), 7235 (41.46m) and on 9465 (31.69m).

●CONGO REPUBLIC
Brazzaville can be heard on **15190** (19.74m) carrying the local domestic service "The Voice of the Revolution" from 0600 to 1300 and from 1500 to 2130.

●FINLAND
Broadcasts in English to Europe from Helsinki may be heard on **15185** (19.75m) from 1400 to 1430, from 1800 to 1830 and from 2030 to 2100.

●KUWAIT
Radio Kuwait radiates in English from 1630 through to 1900 on **9750** (30.76m) and on **15415** (19.46m).

●CHINA
Radio Peking beams a programme in English to Europe from 2030 to 2130 on **6270** (47.84m), **6610** (45.38m) and on **7590** (39.52m).

CURRENT SCHEDULES

●CANADA
Radio Canada International radiates the following programmes in English to Europe – from 0700 to 0730 on **5975** (50.20m) and on **9625** (31.16m); from 1217 to 1313 on **15325** (19.57m) and **17820** (16.83m); from 1515 to 1522 (News) on **15325**, **17820** and on **21595** (13.89m) and from 2115 to 2152 on **6165** (48.66m), **9610** (31.21m) and **11850** (25.31m) all on a daily basis. On Saturdays and Sundays only the last transmission period is subject to the following time change – from 2100 to 2152.

●SWITZERLAND
SBC Berne has the following schedule in English for Europe – from 0700 to 0730 on **3985** (75.28m), **6165** (48.66m), **9535** (31.46m), **9590** (31.28m), **11775** (25.47m), **15305** (19.60m) and on **21520** (13.94m).

From 1100 to 1130 on **3985, 6165, 9535, 15430** (19.44m.), **17795** (16.85m), **21520** and on **21585** (13.89m).

From 1315 to 1345 on **3985, 6165, 9535, 11870** (25.27m), **15305, 17830** (16.82m), **21520.**

From 1530 to 1600 on **3985, 6165, 9535, 9590, 11870** and on **15305.**

From 2100 to 2130 on **3985, 6165, 9535, 9590, 11720, 11870** and on **15305.**

●CZECHOSLAVAKIA
Radio Prague has the following schedule in English directed to the U.K. From 1500 to 1530 on **6055** (49.46m) and on **9505** (31.56m). From 1630 to 1700 on **5930** (50.59m) and on **7345** (40.84m); from 1900 to 1930 on **5930** and on **7345** and from 2200 to 2230 on **6015** (49.87m).

The Radio Prague "Inter Programme" for Europe in English is as follows, all on **6055** and on **9505,** from 0745 to 0800, from 0845 to 0900, from 0945 to 1000, from 1045 to 1100 and from 1145 to 1200.

●NETHERLANDS
Radio Nederland has the following schedule in English for Europe (Mondays to Saturdays inclusive) from 0930 to 1050 on **6140** (48.85m) and **7275** (41.23m) from the Lopik (Netherlands) transmitter. From 1400 to 1520 on **6020** (49.83m) and **21480** (13.96m) from Lopik and on **11740** (25.55m), and **17810** (16.84m) from Madagascar. From 1830 to 1950 on **6020, 15350** (19.54m) and **17830** (16.82m) Lopik, also on 15375 (19.51m) from Bonaire (Netherlands Antilles).

●SWEDEN
Radio Sweden, in English for Europe, as follows – from 1100 to 1130 on **9630** (31.15m) and **21690** (13.83m); from 1230 to 1300 on **9630** and **9715** (30.88m); from 1600 to 1630 on **6065** (49.46m) and **11930** (25.14m) and from 2045 to 2115 on **6065** and **9715.**

●SOUTH AFRICA

Radio RSA "The Voice of South Africa", Johannesburg, radiates in English to Europe as follows – on weekdays from 1900 to 1950 on **7270** (41.26m), **11970** (25.06m) and on **15175** (19.76m); from 2215 to 2315 on **9525** (31.49m), **11900** (25.21m), **11970** and on **15220** (19.71m). On Sundays only from 1000 to 1150 on **21535** (13.93m).

A weekday omnidirectional transmission in the General Service is radiated in English from 0930 to 0946 on **17820** (16.83m), **21535** (13.93m) and on **25970** (11.55m).

●INDONESIA

"The Voice of Indonesia", Jakarta, has current programmes in English directed to Europe and the U.K. from 1900 to 2000 on **11715** (25.60m). Also in English as follows – from 0900 to 0930 on **6045** (49.62m) and **11715** to S.E. Asia and Pacific; from 1100 to 1200 on **9585** (31.29m) to Australia, N. Zealand and Pacific; from 1430 to 1530 on **9585** to S.E. Asia, India, Pakistan, Japan and N. America and from 2330 to 2400 on **7270** (41.26m) and **9585** to Malaysia, S.E. Asia and Pacific and to Singapore.

●NIGERIA

"The Voice of Nigeria", Lagos, broadcasts in English to Europe from 0545 to 0735 on **7255** (41.35m), **11900** (25.21m) and on **15185** (19.75m) and from 1800 to 1930 on **7275** (41.23m), **11770** (25.48m) and on **15185.**

Also in English to Africa and the Middle East from 1530 to 1700 on **7275, 15120** (19.84m) and on **15185;** from 1800 to 1930 on **7275, 11770** and on **15185.**

●HUNGARY

Radio Budapest transmits a programme for Dxers, in English to Europe, from 1615 to 1630 on **6025** (49.79m), **7220** (41.55m), **9833** (30.50m), **11910** (25.18m), **15160** (19.78m), **17890** (16.76m) and on **21505** (13.95m). Also from 2245 to 2300 on **6025, 7220, 9833, 11910, 15415** (19.46m), **17890** and on **21685** (13.83m).

●DX PROGRAMMES

Such programmes are radiated from many stations throughout the world on a regular basis. Listed here are those in English to Europe on Saturdays and Sundays.

Saturday

Berne, Switzerland, on 2nd and 4th Saturdays in month, at 0710 on **3985** (75.28m), **6165** (48.66m) and on **9535** (31.46m); also at 1110, 1325 and at 1540 on the same channels.

Radio Canada International, at 0715 on **5975** (50.20m) and on **9625** (31.16m); also at 2124 on **6165** (48.66m), **9610** (31.21m) and on **11850** (25.31m) and at 2316 on **5990** (50.08m), **9625** and on **11945** (25.11m).

Trans-World Radio, Monaco, at 0930 on **9640** (31.12m) and at 1745 on **7180** (41.78m) or **7245** (41.40m).

Sunday

Radio Australia at 0727 on **9570** (31.34m) and on **11765** (25.49m), and from 1300 on **9580** (31.31m) and on **11710** (25.61m) – this latter transmission to Eastern North America.

Radio Japan at 0810 on **17710** (16.93m) and on **17825** (16.83m); at 1010 on **5990** (50.08m), and on **9560** (31.38m), also at 1410 on the latter two channels and at 2040 on **7195** (41.69m) and on **9735** (30.81m) and from 2310 on **9735** (30.81m) and on **15105** (19.86m). On the 1st and 3rd Sundays, an additional transmission is made in Swedish at 0650 on **17710** and on **17825.**

Radio Norway at 1220 on **6130** (48.93m) also at 1820, both on 1st Sunday in month only.

BBC World Service, 0815 on World Service channels.

AROUND THE DIAL

●VATICAN

Vatican radio can be heard with a programme in English at 2045 on **6190** (48.46m), also heard in parallel on **9645** (31.10m).

●INDIA

All India Radio, Delhi, can be logged at 2100 on **9525** (31.49m) when a programme of Indian music with English announcements is usually featured. Delhi can also be logged on **4860** (61.72m), we heard them at 2220 in English with local music and identification and sign-off at 2230.

●MOZAMBIQUE

Radio Clube Mozambique can be logged on **4855** (61.79m) around 1930 onwards. We heard them at 1950 with announcements in French and light music.

●ALBANIA

Radio Tirana can be heard on 7065 (42.46m) at 2045 with a programme in English. May I call attention to the fact however that **7000** to **7100** is an Amateur allocation.

●GUINEA

The Republic of Guinea can be heard from 1830 (when we logged it) on **15310** (19.59m) with the news in French and Conakry identification at 1844.

●NETHERLANDS ANTILLES

Bonaire has found a very good channel in **11725** (25.58m) where we logged them at 2100 with the "Nightcall" programme, announced as being radiated every Friday and Saturday at the same time. Identification at 2127 "Trans-World Radio, Bonaire, Island of Flamingoes, famous for tea and sunshine".

●CHINA

Dxing some Chinese stations is quite a pastime in itself. The powerful Peking transmitters are easy to log but what of the local services stations? Try for the Peking Home Service 1 on **4800** (62.50m) around 2000, or the unlisted **6210** (48.30m) discovered by the writer and heard on several occasions, or the **6225** (48.19m) Home Service 1 or **6345** (47.28m) Home Service 2, all being heard between 2000 and 2330.

●COLOMBIA

HJCQ Radio Nacional, Bogotá, has been logged on the regular **9635** (31.13m) channel at 0058 with Latin America music and station identification in Spanish at 0100.

●LATIN AMERICA

Several Latin American stations, apart from that listed above, have been recently logged on the higher frequency bands, such as –

CE959 Santiago, Chile, on **9590** (31.28m) at 0057 with talk in Spanish;

ZYV40 Radio Cultura de Pocos, Brazil, on **9645** (31.10m) with identification at 2100.

ZYR227 Radio Gazeta, Brazil, on **9685** (30.97m) at 2055 with 'futebol' (what else!).

ZYB22 Radio Rio Mar, Brazil, at 2055 on **9695** (30.94m) also with 'futebol'.

COMPREHENSIVE TRANSISTOR ANALYSER

Part 2 by H. T. Kitchen

This concluding article describes the construction and setting-up of the wide-range test instrument whose circuit and functioning were discussed last month.

CONSTRUCTION

THE PROTOTYPE WAS BUILT INTO THE 12 BY 7 BY 7 IN. commercially available metal cabinet described in Part 1 (published last month). The front panel area of 12 by 7 in. proved just adequate for all the controls required, and these are positioned according to Fig. 4. The panel layout is the result of much thought and component juggling and is felt to be ergonomically correct. A major 'test component safety factor' is the very close proximity of the prototype indicating lamps to the test transistor sockets.

As far as the test transistor is concerned there are two ways of connecting it into the analyser circuit. One is by

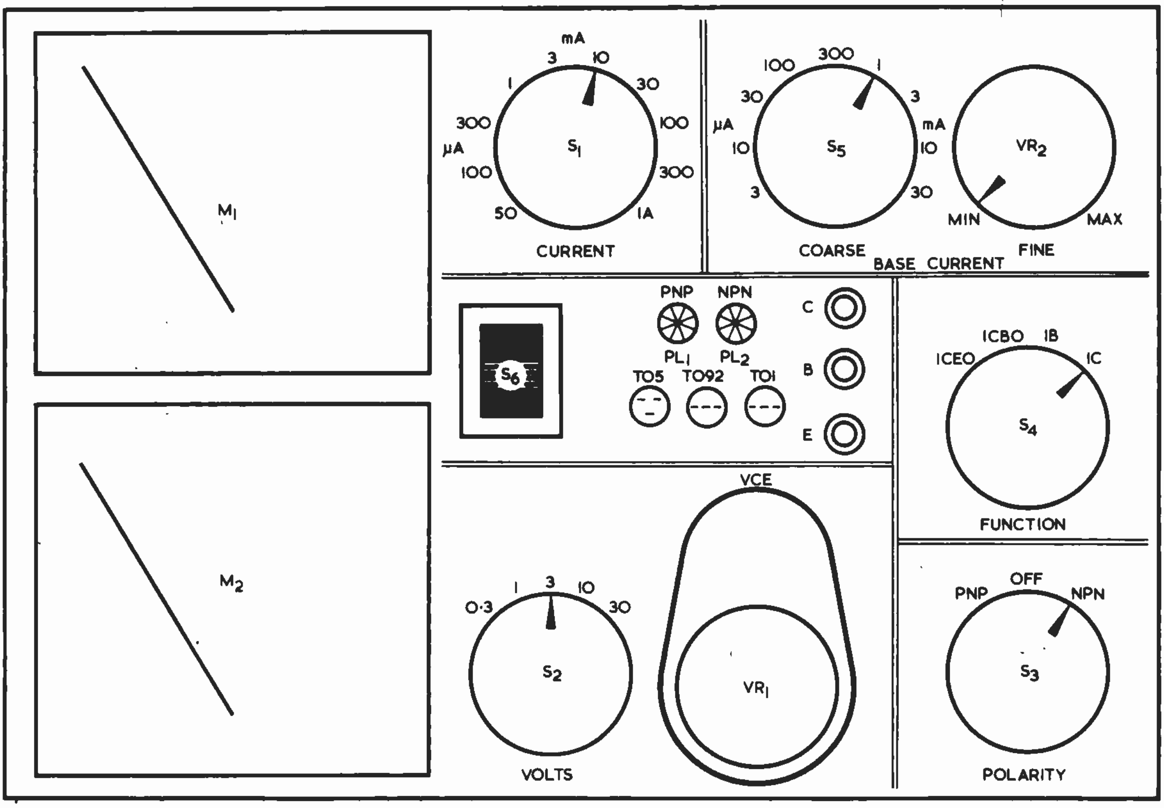
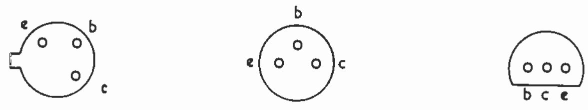


Fig. 4. The layout of the front panel of the prototype instrument

means of three separate 3 mm. sockets which enable 'outboard' testing to be accomplished by means of flying leads terminating in miniature crocodile clips. The other is by means of three panel mounted transistor sockets which enable 'inboard' testing to be accomplished. In order to accommodate the differences in lead configuration between TO5/TO18, TO1 and TO92 transistors, these sockets are wired to suit. Twisting and bending of transistor leads, with the resulting possibilities of inter-lead short-circuits, are thereby obviated. (The lead-outs of transistors in TO5/TO18, TO1 and TO92 are shown in Fig. 5.)



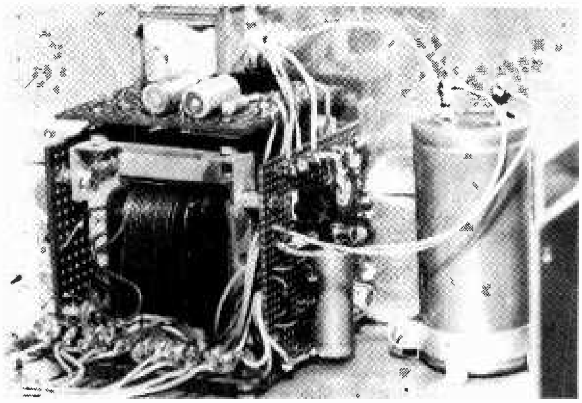
TO5/TO18 TO1 TO92

Fig. 5. The three transistor sockets are intended for TO5/TO18, TO1 and TO92 transistors. The lead-outs of these types are shown here

Finally, the two meters are mounted one above the other, so that both can be easily viewed without indulging in undue ocular contortions.

The back of panel wiring can be seen from the photographs. A detailed wiring diagram is not included, as components will vary from constructor to constructor, and such a diagram, it is felt, may cause errors in wiring up.

Three separate cableforms connect the front panel to the power supply contained within the cabinet. One cableform carries only mains voltage, to and from S6. The other two carry the main Vcc supply, the bias supply, the supplies for PL1 and PL2, and the connections for VR1 and VR2. The cableforms are secured under clips on the front panel, a rubber sleeve being interposed between the cableform and the panel to prevent chafing. P.V.C. covered 14/.0076 wire was used for these cableforms in varying colours. The use of properly laced cableforms is highly recommended, for not only do they result in a neat and durable assembly, but they also segregate the wires into groups, and so help in preventing wiring errors.



The three Veroboard panels in the power supply assembly are mounted on mains transformer T1. Capacitor C1 is mounted separately, as shown here

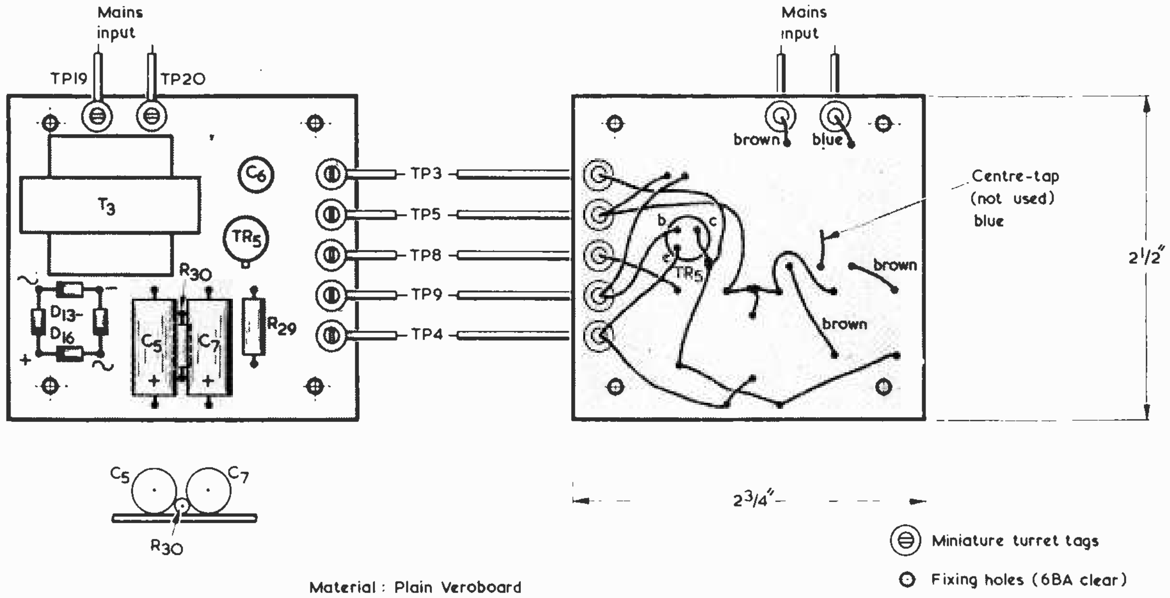


Fig. 6. Layout of the components on the bias voltage panel

VR1 should be wired up such that it inserts minimum resistance into circuit when it is fully anti-clockwise. VR2 is wired such that its slider is at the earthy end of its track (the end which connects to TP5) when it is fully anti-clockwise.

The power supply section comprises the three circuit panels of Figs. 6, 7 and 8. With the prototype it was possible to secure these to the universal mounting flange of the Belclere transformer used for T1. A similar method of assembly should be possible with the Douglas transformer suggested as an alternative, but the positions of the mounting holes in the Veroboard panels may be different. It may also be necessary to use Veroboard panels that are a little larger than those illustrated in Figs. 6, 7 and 8. TR4 is external to the transformer and Veroboard assembly, being mounted

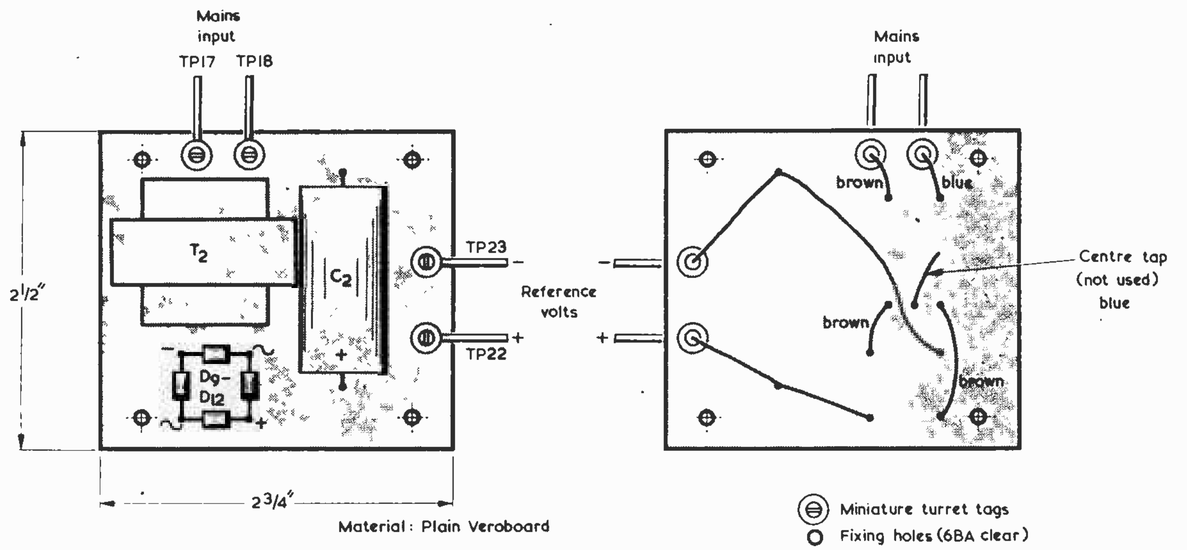


Fig. 7. Wiring and layout on the reference voltage panel

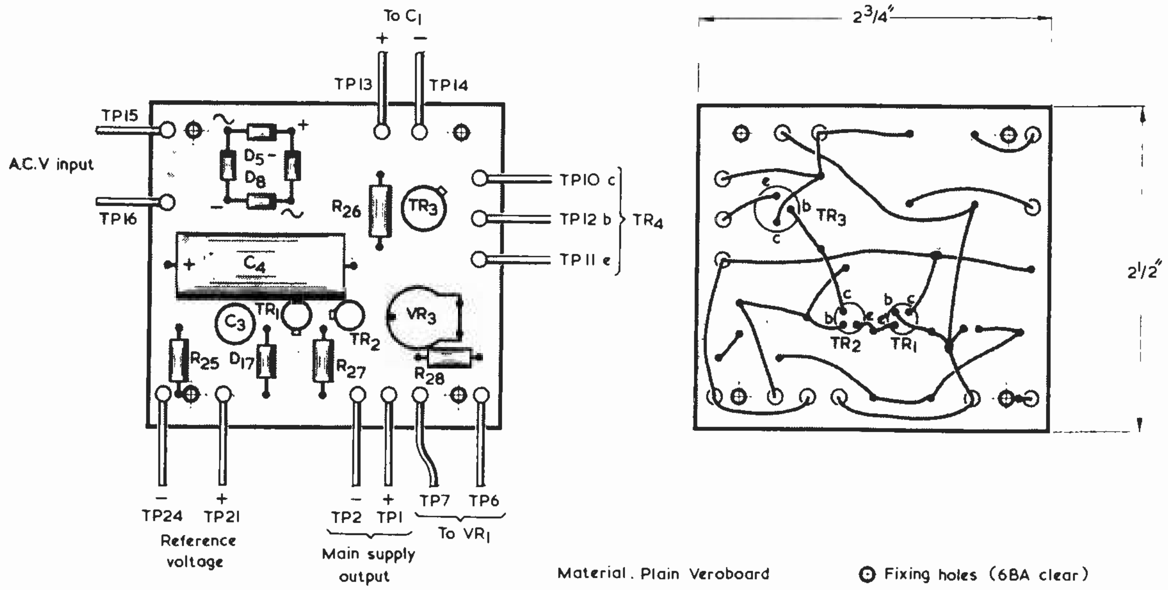


Fig. 8. The third Veroboard panel takes the main supply control components

on the rear wall of the cabinet. As previously mentioned, it is insulated from the cabinet wall by means of a mica washer and insulated mounting bushes. C1 is also external to the assembly, being fitted to the bottom of the case by means of its mounting clamp.

The three panels in the prototype comprise plain Veroboard cut into 2¾ by 2½ in. pieces, each being secured to the transformer frame by means of 6BA nuts and bolts, but spaced away from it by ⅜ in. Four holes, 6BA clearance, must be drilled in each corner of each board, these corresponding to the hole spacing in the frame of T1. Small slots are filed in two of the boards for the securing tabs of T2 and T3. All interconnections between boards or between boards and external circuits are to Veroboard pins or to miniature turret tags as shown in the diagrams. It may be necessary to enlarge the Veroboard holes to take the turret tags. If it is difficult to obtain suitable turret tags, Veroboard pins can be used throughout. As was mentioned in Part 1, TR3 and TR5 are fitted with heat sinks.

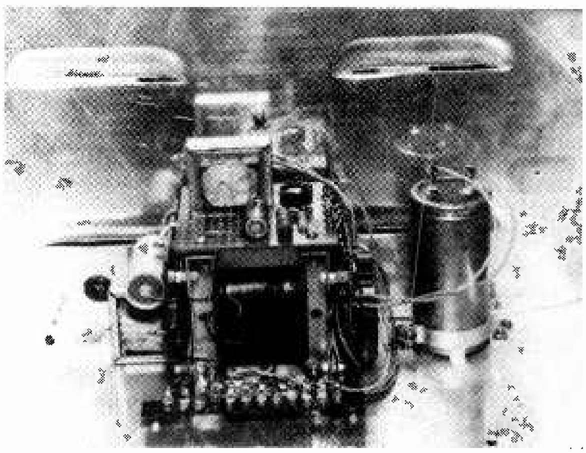
As far as wiring up is concerned, the principal causes of possible difficulty will most probably be given at S3 and S4. Here, it is suggested that the switches are wired up wafer by wafer, straight off the circuit diagram. If any switch has more 'ways' than are required, these should be blanked off. Wiper orientation must be checked and correctly synchronised. If the switch wafer is of the fully enclosed pattern a continuity check will be necessary, otherwise the possibility of having wipers 180° out of synchronisation may be realised.

An error in wiper synchronisation, or a wiring error involving S3 and S4, may prove extremely difficult to detect once wiring is completed. A systematic, logical approach must be adopted, with plenty of time for re-thinks. Whilst it will sound 'old hat' to the really experienced constructor, the old dodge of crossing a line through each wire or component as it is soldered in is a good one for the not so experienced to adopt.

S5 must have its wiper stop so adjusted that at no time can the wiper be connected directly to the emitter of TR5. Should this not prove possible, R15 must be mounted separately from the switch so that at all times it isolates the wiper of S5 from the emitter of TR5.

METER RESISTORS

Next to be dealt with are the meter range resistors R1 to R9 and R10 to R14. The simple calculations necessary were discussed in Part 1, and the values given in the Components List were arrived at by these means.



Another view of the power supply assembly

As was stated, these values apply to the particular R.S. Components meters referred to. Since the resistance of the coils in even these meters is subject to a tolerance of ±10%, some variation from these calculations may be necessary.

For R1 to R9 in the prototype, a suitable stock of 5% ½w high-stability resistors was assembled and, by comparison with a voltmeter and current meter known to be accurate, a number were selected for use. By these means, a nominal 2.4kΩ resistor was found that halved f.s.d. for the 100μA range (2,400Ω calculated), a 470Ω resistor was found for the 300μA range (480Ω calculated), two resistors of 270Ω each in parallel for 1mA, and so on. The 100mA shunt was made from 34 s.w.g. Eureka wire, and the 300mA and 1A shunts from 24 s.w.g. Eureka wire. The 34 s.w.g. Eureka wire has a resistance of 10Ω per yard approximately, and the 24 s.w.g. wire has a resistance of 1.7Ω per yard approximately.

The principle is very easy, and in conjunction with the shunts formula and wire having a known resistance per unit length, will enable any value of shunt to be constructed. Fig. 9 shows the essentials. A length of resistance wire is cut somewhat longer than the calculated value, and one end is carefully scraped clean and tinned with solder for ½ in. This end is connected to one side of a variable current source. The other end is also cleaned and tinned, but only for ¼ in. The second end is connected to a 'standard' current reading meter, its other terminal being returned to the current source so that all are in series. The current source is now adjusted to cause the requisite current to flow through the chain, as indicated by the 'standard' meter. One end of the meter to be used with the shunt is connected to the ½ in. tinned end of the resistance wire, and the other terminal is gradually 'tapped' along the shunt wire until the meter reads the same as the 'standard' meter. This point is carefully marked, and the wire is cut exactly ½ in. longer. This ½ in. of wire is also carefully scraped clean and tinned with solder. The complete length of wire is now wrapped round the body of a 1 watt resistor of high value, and the tinned ends are then wrapped round the resistor's own leads and carefully soldered to them. When cool, the shunt can be rechecked for accuracy. The same method is used for the other shunts. With care, very accurate shunts can be constructed in this manner. When complete, they should be coated with a moisture-repellant varnish.

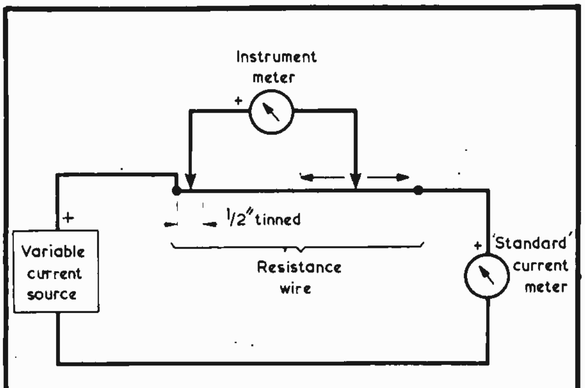


Fig 9. How to find the length of resistance wire required in the higher current shunts

It is of the utmost importance that the calibrating current is passed through the shunt as described, with the meter tapped across the shunt. Under these conditions, the meter cannot be harmed if contact with the shunt is momentarily lost. If the current were passed through the meter with the shunt being tapped across it, then any loss of contact would allow the full current to pass through the meter, and 1A through a 50μA movement is definitely not to the meter's advantage.

The voltage multiplier resistors R10 to R14 can similarly be found, again in comparison with a meter of known accuracy. Quite possibly, two resistors in series or parallel will be required for each multiplier. The starting point is a resistor which gives very nearly the required reading. If this reading is high, then an additional low value series resistor is required. Conversely, if the reading is low, then a high value parallel resistor is needed.

It must at all times be remembered that this is a measuring instrument, the future usefulness of which will depend upon care and skill exercised in constructing the series and shunt resistors in particular, and upon the quality of the components used and the workmanship in general.

SETTING-UP

The setting-up procedure is carried out after the current meter and voltmeter circuits have been accurately assembled, as just described. The two meters are used to check some of the steps in the setting-up procedure.

Initially, the controls should be set to the following positions: S1 at 1A, S2 at 30V, S3 at 'Off', S4 at Ic, S5 at 3μA and S6 at 'Off'. VR1 should be set fully anti-clockwise. VR2 should also be adjusted to the fully anti-clockwise position. VR3 should be set at mid position.

S6 should now be switched 'On'. M2 should indicate a low voltage, and both indicator lamps should be illuminated. There should be no reading in M1. If there is, switch off and recheck the wiring and components. S3 can now be switched to 'n.p.n.', when the green lamp should extinguish, leaving the red lamp illuminated. Switch to 'p.n.p.', and the red lamp should be extinguished whilst the green lamp should become illuminated.

R24 is selected to pass only some 30mA through a 24V 1 watt bulb, when only a single bulb is illuminated. This ensures adequate lamp brilliance without overrunning the filament; at the same time the load assists in keeping the voltage across C5 reasonably constant, and this in turn ensures a fairly consistent output from TR5.

VR3 can now be set for zero voltage output. S2 must be switched to a more sensitive range to enable this adjustment to be carried out more accurately. The zero voltage setting can be somewhat critical and, due to component tolerances, it may be necessary to settle for a minimum voltage output a few hundred millivolts above zero potential. S2 is restored to its 30V setting, and VR1 rotated clockwise, whereupon the output voltage should increase smoothly to a maximum of some 24V.

The bias voltage can next be checked by an independent meter connected across TP4 and TP5. A 330Ω resistor should also be connected across TP4 and TR5 to act as a temporary load. Rotating VR2 clockwise should cause the voltage to rise smoothly to a maximum of some 10V. If it is significantly different from 10V, then R29 can be altered in value to provide the required voltage. The meter and 330Ω resistor are now removed from TP4 and TP5.

The main supply voltage and the bias voltage polarities can now be checked across *all the output sockets*. S3 should be set to 'n.p.n.', when the voltages from collector to emitter and base to emitter should be positive. (S5 can be set at 30mA for this test). Switch S3 to 'p.n.p.', whereupon the collector to emitter and base to emitter voltages should reverse to negative. At the same time re-check that the appropriate lamp, red for 'n.p.n.', green for 'p.n.p.', is illuminated. With S3 at 'off' both lamps should be alight, and there should be no voltages present at the collector to emitter and base to emitter terminals.

If a current meter with a suitable f.s.d. is available, it can be connected between the base and emitter sockets. With S5 set at 30mA and VR2 fully clockwise, the meter should read approximately 30mA. The remaining base current ranges can be checked in a similar manner, whereupon current readings approximately equal to the setting indication of S5 should be given. The base current reading must not alter if S3 is switched from one polarity to the other, but it must, of course, drop to zero in the 'Off' position.

M1 can be checked by connecting a suitable resistance across the collector and emitter sockets. For instance, a 100Ω 10 watt resistor will cause 100mA to flow if V_{CE} is 10V, 200mA if V_{CE} is 20V, and so on. Obviously, if this test is to have any real significance, the load used must be of known accuracy.

The collector and emitter test sockets must *never* be directly short-circuited together. The internal resistance of the supply is very low, and under short-circuit conditions a current can flow of sufficient magnitude to cause damage to the meter, TR4, and the rectifier diodes. *During setting up, and during subsequent use, the greatest care must be exercised to prevent such a short-circuit from occurring.*

USING THE ANALYSER

The completed instrument, though designed to analyse a wide range of bipolar transistors can, if incorrectly used, be the means of damaging the transistor under test. Care is therefore necessary when using the instrument, and a logical and definite sequence of operations is most essential, and should always be adhered to.

The recommended sequence of operations is as follows, and it should be employed after having referred to the published data on the transistor under test.

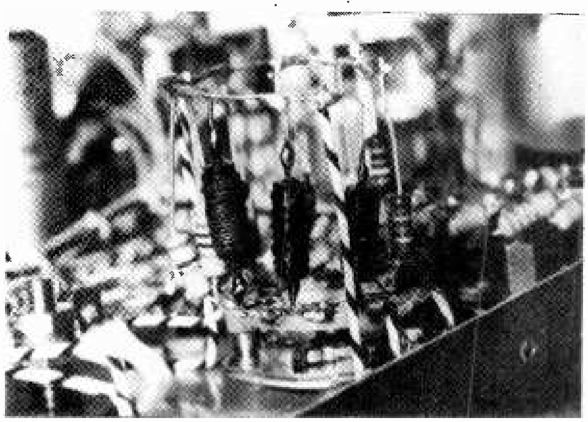
1. Set S1 to one range above required I_C.
2. Set S2 to the V_{CE} range required.
3. Set S3 to 'Off'.
4. Set S4 to I_C.
5. Set S5 to 3μA.
6. Set S6 to 'Off'.
7. Set VR1 to minimum and VR2 to minimum.
8. Switch S6 'On'.
9. Insert device into appropriate socket.
10. Switch S3 to required polarity.
11. Set VR1 for required V_{CE}.
12. Set S5 and VR2 for required I_C.
13. Switch S4 to I_B. Read I_B. Compute h_{FE} from $\frac{I_C}{I_B}$
14. Switch S4 to I_{CEO}. Read I_{CEO} by reducing S1 setting as required.
15. Switch S4 to I_{CBO}. Read I_{CBO} by setting S1 as required.
16. Recheck I_C and I_B.

After each check reduce all 'active' controls (i.e. S5, VR1 and VR2) to minimum, and all 'passive' controls (i.e. S1 and S2) to maximum. Set S3 to 'Off' and S4 to I_C. This is a 'fail-safe' routine and one that ensures that the next test can be safely commenced.

Though the tabulated check list may appear to be quite lengthy and formidable, this is a trait the analyser shares with many other instruments. After using the instrument for a short while, the modus operandi soon becomes second nature.

The transistor under test can be damaged by applying the incorrect polarity, or by its being inserted into the wrong socket. It can also be damaged by an *apparently correct test, due to incorrect interpretation of published data.*

An easy trap for the unwary or inexperienced to fall into concerns the two ratings BV_{CE} and BV_{CB}, or any similar symbols which indicate the absolute maximum ratings. Attempts to analyse a transistor with a V_{CE} equal to BV_{CE} or BV_{CB} can result in the rapid destruction of the transistor. V_{CE} should not be increased beyond 50% of these ratings.



The shunts for the meter M1 may be mounted directly to switch S1 in the manner shown here. The single wafer switch illustrated was later changed to a double wafer type, as described in the text

Another parameter which must be carefully watched is $P_{(TOT)}$, which is given by $I_C \times V_{CE}$. This is a 'fairy tale' parameter, which must be suitably derated after allowing for thermal resistances, so that the resultant 'safe' value of $P_{(TOT)}$ is perhaps only 20% or even less of the original value.

When a device is being analysed, a close watch must be kept on I_C, as it is quite possible to increase V_{CE} to the point where the transistor 'avalanches' even with the base current completely cut off. Under these conditions the very low internal resistance of the power supply will permit a destructive current to flow through the transistor.

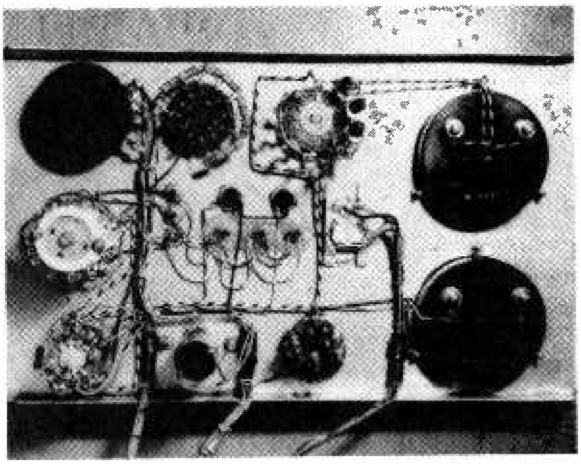
Should I_C start to increase rapidly, switch S3 to 'Off' and reduce V_{CE} and I_B. The analysis can then recommence with a reduced V_{CE}; this can slowly be increased and, by frequently checking I_C, I_{CEO} and I_{CBO}, a rapid and accurate analysis can be arrived at.

By means of the analyser, families of graphs can be drawn showing collector characteristics (variation of I_C with V_{CE}, I_B being fixed). Transfer characteristics can also be plotted, by means of which the relationship between h_{FE} and I_C can be seen.

Devices other than bipolar transistors can also be checked. Diodes can be checked for forward conduction and reverse leakage currents at the maximum voltage and current limits of 24V and 1A, using the collector and emitter sockets and the n.p.n.–p.n.p. positions of S3. This is why M2 has a 0.3V range.

Zener diodes can be checked for zener voltage and current, though here only a single polarity of voltage is required. The maximum power rating, given by $Z_I \times Z_V$, must not be exceeded, and due allowance must be made where applicable for thermal derating.

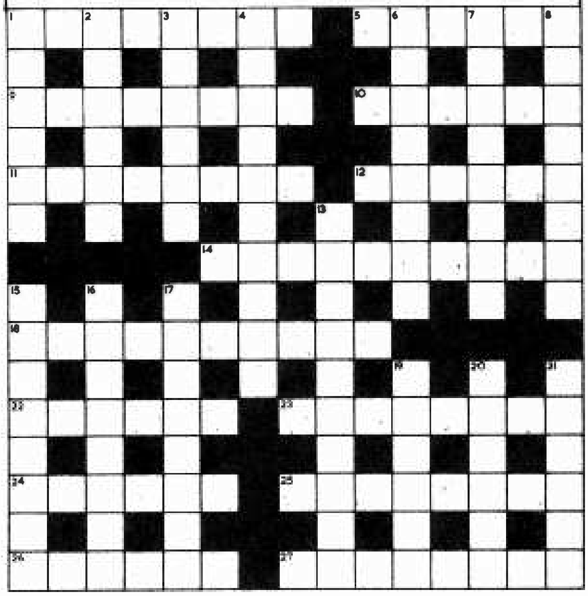
The last application of the analyser is that of a good quality stabilised power supply. For this purpose the collector and emitter sockets are used, whereupon the 0 to 24V and 0 to 1A capabilities of the supply can be utilised. The base and emitter terminals allow V_{BE} to be employed as a variable current source, variable from 0–30mA to 1–3–10 steps, or as a variable voltage source having a capability of 0–10V at 30mA.



Rear view of the front panel, showing the cableforms

As a final point, it is possible for a few transistors offering high gain at very high frequencies to give misleading results due to the onset of oscillation. This will be indicated by apparently random fluctuations in the meter readings as the controls are operated. After considerable experience with the analyser, the author has encountered the effect with only a few transistors. It may be cleared by slipping a ferrite bead over each of the transistor lead-outs before it is inserted in its test socket. ■

CROSSWORD



Clues Across

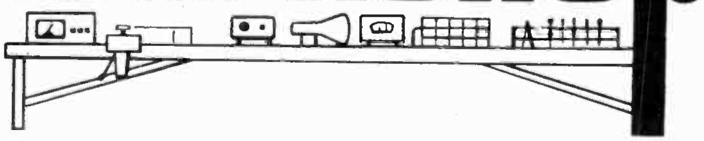
1. Muddled stories and R denote this. (8)
5. Potential effect of high voltage. (6)
9. Lay version of bootstrap? (4-4)
10. Useful paper for power curves. (3, 3)
11. Circle in a circle as in the dial drive. (8)
12. These are singularly equal to 'perfect' in circuit design. (6)
14. Flicker and shot contribute to this. (5, 5)
18. Ignominous position for the binary 100's. (2, 3, 5)
22. Mongrel unit uses valves and transistors. (6)
23. Anti-rocker, refined, deceased, to regulate. (8)
24. 0% distortion. (6)
25. Describes unwanted signals. (8)
26. Drive. (6)
27. Covers the case where induced currents oppose motion. (5, 3)

Clues Down

1. TV picture after close-down. (6)
2. Dim and thick. (6)
3. Synchro motor. (6)
4. Castrol oil furnishes this self-running device! (10)
6. Meter leads in shunning. (8)
7. Animated, as in frog's leg twitch. (8)
8. Data container. (8)
13. How to get that double peak. (10)
15. Piezoelectric seidlitz? (8)
16. Battery electrode controls the soda syphon acid. (8)
17. Challenger. (8)
19. Spoken breathalyser limits, frequency controller. (6)
20. Final winding. (1, 1, 4)
21. Playground phase-splitter. (6)

(Solution on page 464).

In your workshop



In this month's episode Smithy the Serviceman enlightens his assistant, Dick, on a number of aspects of the transistor multivibrator, dealing in particular with some of the misconceptions which exist in relation to this simple circuit. The pair conclude by constructing a novel 2-tone multivibrator oscillator.

"PRODUCE A MULTIVIBRATOR DEsign?" repeated Dick scornfully. "Blimey, that shouldn't be a particularly hard job for someone like you."

"I will agree," remarked Smithy mildly, "that the design of a conventional multivibrator is not excessively difficult. What I've been asked to do in the present instance is to make up a gadget which will produce an unusual warning note when a press-button is pushed. It's for one of our customers who has a small flat and who likes to be considered trendy and way-out. He wants a tone generator instead of a door-bell."

"Does he?" commented Dick. "Well, a tone generator would certainly make a welcome change from the usual ding-dong affair."

"I'm going," stated Smithy, "to use multivibrators in this tone generator. I've already worked out the circuit and what I want you to do today is to knock it up for me in practical form."

MULTIVIBRATOR OPERATION

"Fair enough," said Dick loftily. "It doesn't seem to me that it will be very complicated, though. Dash it all, a multivibrator circuit must be one of the simplest things going."

"Must it?" queried Smithy in an irritated tone. "Well, if you're so clever, just come over here and show me how a multivibrator functions."

"All right," replied Dick airily, as he took a ball-point pen from his overall pocket and walked towards Smithy's bench. "Let me have a bit of paper and I'll demonstrate exactly how a multivibrator works."

Smithy pulled his note-pad over. Dick concentrated, then drew out a circuit on the top sheet. (Fig. 1).

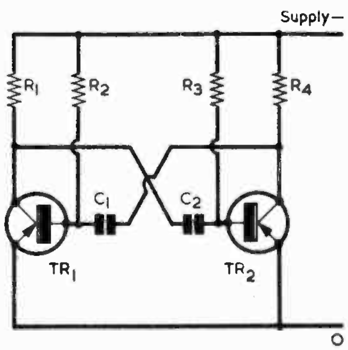


Fig. 1. A basic multivibrator. The transistors shown here are p.n.p.; if n.p.n. transistors are employed all polarities are reversed

"There you are," he pronounced triumphantly. "This is the circuit of a standard transistor multivibrator, and I've numbered the various components so as to make it easier to describe what they do. It so happens that I've used p.n.p. transistors here, but the circuit would work just as well with n.p.n. types if the supply polarity was changed over."

"Okey-doke," said Smithy, settling himself more comfortably on his stool. "Now explain its operation."

Dick marshalled his thoughts.

"When we apply the power to the multivibrator," he started, "both the capacitors are discharged. They then commence to charge. C1 commences to charge via R4 and the base-emitter junction of TR1, and C2 commences to charge via R1 and the base-emitter junction of TR2. This means that both the transistors start to pass collector current. Now, the rate of increase of collector current in one transistor is bound to be greater than that in the other because it would be impossible to have two devices that are exactly the same. Let's say that the transistor having the larger rate of increase in current is TR2."

"As you like," said Smithy obligingly. "What happens next?"

"The collector voltage of TR2," continued Dick, emboldened by his success so far, "drops more rapidly than that of TR1. Capacitor C1 is already partly charged, with its left-hand plate positive, whereupon the decrease in TR2 collector voltage causes the base of TR1 to go positive. TR1 passes less collector current than before, and its collector voltage increases. Since the collector of TR1 is coupled to the base of TR2 via C2, that base is pulled more negative. TR2 passes a greater collector current again and its collector goes even more positive. There is an overall regenerative effect and the final outcome is that TR2 becomes fully conductive and TR1 is fully cut off."

"Very good," commented Smithy approvingly. "Well, you've got the multivibrator started. How does it run?"

"We now," said Dick in reply, "have the situation where TR2 is turned on and TR1 is cut off. C2 now becomes charged up to nearly the full supply voltage via R1 and the base-emitter junction of TR2. C1 has a charge which causes its left-hand plate to be positive, but it now loses this charge because this left-hand plate couples to the negative supply rail by way of R2. After a period, the voltage on the left-hand plate of C1 becomes sufficiently negative to allow base current to flow in TR1. TR1 at once commences to draw collector current, whereupon its collector voltage goes positive. Since TR1 collector couples to TR2 base via C2, that base goes positive and TR2 draws less current. Its collector goes negative, causing increased base current in TR1. The overall regenerative action takes place all over again and it results in a changeover which ends with TR1 fully on and TR2 cut off."

"That sums up the situation so far," agreed Smithy. "The first half-cycle immediately after switching on isn't representative of normal running operation because the cross-coupling capacitor concerned hasn't achieved a proper charge and the half-cycle is shorter than the subsequent ones. In the case you described it was C1 which didn't have the full charge. After TR1 had cut off, however, C2 was able to charge up to nearly the full supply voltage, whereupon all the subsequent half-cycles occupied the correct length of time."

"That's right," broke in Dick. "The multivibrator now commences to run continually, with the two transistors being alternately turned on and cut off as the circuit changes state. The length of each half-cycle depends upon the values of the capacitors and of R2 and R3."

"You've got it," confirmed Smithy. "The length of time during which TR1 is cut off during the cycle is dependent upon the values of C1 and R2. And the length of time during which TR2 is cut off during the cycle is dependent upon the values of C2 and R3. The values of R1 and R4 don't, with conventional component values, affect the length of each period. The length of the off time for each transistor is, incidentally, approximately 0.7 times the time constant of the associated base capacitor and resistor."

"I got that description all right, didn't I?"

"You did," confirmed Smithy. "Now, what can you tell me about the values of the four resistors in the circuit?"

COMPONENT VALUES

"Oh," replied Dick nonchalently, "the resistors aren't all that critical. All you've got to do is to find the values required in the base resistors to give the desired off periods for each transistor. The collector resistors can be any old value."

"*Any* old value?"

'Pretty well," said Dick carelessly. "They mustn't, of course, be too low, or the transistor concerned may pass too much current and overheat."

"Well, *you* won't get very far in the multivibrator stakes," commented Smithy drily as he pulled his note-pad towards him. "I'll draw out one half of your multivibrator circuit just to show how important the values of the collector resistors really are."

Smithy quickly scribbled out the circuit. (Fig. 2).

"Here are the components around TR1," he announced. "During the regenerative changeover action which causes this transistor to come on, its base current is mainly given by charging current in C1. When, the changeover has taken place, though, C1 becomes fully charged up, after which the base bias current for TR1 is provided entirely by R2. R2 must pass sufficient current to maintain TR1 in a condition where its collector voltage is as low as possible."

"Well?"

"That collector voltage won't be sufficiently low," continued Smithy, "if the value of the collector resistor is too small. Let's say that R2 is 100kΩ, that R1 is 1kΩ and that the current gain of TR1 is 50 times. Also, to keep things nice and easy, let's say that the supply potential is 10 volts. 10 volts across 100kΩ gives a current of 0.1mA and this will, assuming zero voltage drop in the base-emitter junction of TR1, be the bias current which flows in TR1 base via R2. Now TR1 has a current gain of 50 times, and so its collector current will be 5mA. But 5mA in the 1kΩ resistor we've chosen for R1 will result in a voltage drop of 5 volts only. So, our choice of values for R2 and R1 will cause TR1 to give quite a peculiar performance. Immediately after the changeover period its collector voltage will be very low because of the charging current in C1. But as soon as C1 becomes charged the collector voltage of TR1 will rise to 5 volts! The multivibrator won't run very well under these conditions, if it runs at all."

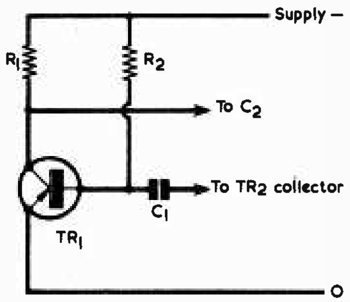


Fig. 2. Illustrating, as explained by Smithy, the importance of the relative values of the base and collector resistors for each transistor

"I can see what you mean, now," said Dick, crestfallen. "This makes things quite a lot more complicated than I'd realised."

"Don't be so glum about it," chuckled Smithy. "In practice the process of finding a suitable collector resistance is dead simple. The desired set of circumstances is given when the current in the base resistor causes very nearly the full supply voltage to appear across the collector resistor. Since both resistors will then have about the same voltage across them, the currents which flow in them are inversely proportional to their resistance values. The transistor will operate satisfactorily in the multivibrator if the value of the base resistor divided by the value of the collector resistor is equal to or lower than the current gain of the transistor. The two resistances in the example we considered just now were 100kΩ and 1kΩ, and the result of dividing the first by the second is 100. The gain of the transistor is only 50 and so this combination of resistance values couldn't provide correct operation. If we'd made the collector resistor 2kΩ, the result of the division exercise would be 50, and the values would just scrape by as being suitable for proper multivibrator operation with a transistor having a gain of 50 times. The 5mA collector current we talked about would this time cause a voltage drop of 10 volts in a 2kΩ collector resistor. In practice, it would be better to play safe and use a slightly higher collector resistor than that which just meets the transistor gain requirement. Suitable values in our example would be around 3 to 5kΩ."

"Why not," asked Dick, "make the collector resistor equal to the base resistor? The circuit would then work with any transistor provided it had a gain greater than 1!"

"Too high a collector resistor," stated Smithy, "raises another snag. Don't forget that the cross-coupling capacitor which couples to the collector in question has to charge up to nearly the full supply potential during the period when the transistor is cut off. If the collector resistor is too high in value the capacitor won't charge up to the desired potential. This may not stop the multivibrator from operating but the length of the period in which the remaining transistor is cut off won't be the figure calculated and it may vary a little from cycle to cycle. So you have to use a value of collector resistor which is high enough to meet the gain requirements of the transistor to which it connects, but which is not so high that the cross-coupling capacitor it feeds does not acquire a full charge."

COLLECTOR WAVEFORM

"Darn it," snorted Dick. "I used to think that a multivib could run with pretty well any resistor values you choose to give it. I now find that you've got to be quite careful about these resistor values."

"Things aren't as bad as all that," soothed Smithy. "With most multivibrator circuits, there's plenty of latitude in the values of collector resistor you can use. All you've got to do is to keep within the extreme lower and upper limits which are liable to upset circuit operation."

"Well," announced Dick decisively, "there's *one* thing I can talk about without mistakes so far as a multivibrator is concerned, and that is the collector voltage waveform for each transistor."

He pulled Smithy's note-pad back towards him and drew a series of multivibrator half-cycles. (Fig. 3).

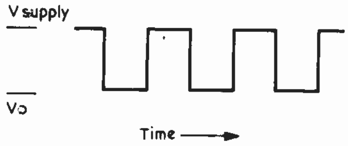


Fig. 3. It is commonly assumed that the collector voltage waveforms in a multivribrator have the form shown here

"Now this," he pronounced, "just can't be wrong. What I've drawn here is the collector voltage waveform for one of the transistors in a 50:50 multivibrator. That is to say, a multivibrator in which the values of both sets of base capacitor and resistor are equal, so that the off period in the cycle for each transistor is as long as its on period. The result is, of course, a square wave."

Smithy glanced briefly at Dick's waveform.

"It isn't, you know."

"It *must* be," retorted Dick heatedly. "Dash it all, the transistor goes on and off at a regular frequency and so the collector waveform must be a square wave."

"You're forgetting the cross-coupling capacitor which connects to the collector," said Smithy, sketching out a further circuit. "This one."

Smithy indicated the circuit to his assistant. (Fig. 4.)

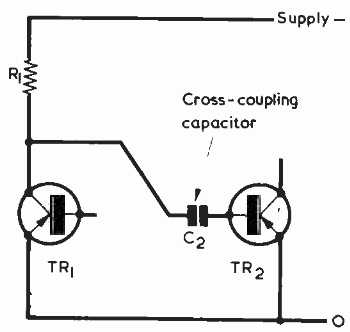


Fig. 4. When a transistor in the multivibrator turns off, the rise of its collector voltage is slightly delayed by the cross-coupling capacitor which couples to it. In this diagram the transistor and capacitor are TR1 and C2 of Fig. 1

"We've already seen," Smithy went on, "that the cross-coupling capacitor has to charge during the period when the transistor is off. The other end of the capacitor connects to the lower supply rail via the base-emitter junction of the opposite transistor, and that junction presents very little resistance. The consequence is that the collector to which the capacitor connects cannot rise *immediately* to the supply rail voltage when the transistor cuts off because it is held back by the charging capacitor, and the leading edge of this part of the waveform gets rounded off. Like this."

Smithy drew a further waveform, illustrating the rounding off effect. (Fig. 5).

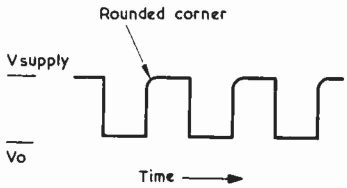


Fig. 5. The presence of the cross-coupling capacitor causes rounding off of the upward-going section of the collector waveform

"Lots of people," he continued, "seem to think that you can get a square wave from a multivibrator simply by connecting to one of the transistor collectors, but this just isn't so. Admittedly, the collector voltage goes down with a thump during the changeover which turns on the transistor concerned. But the rise in collector voltage after the changeover which turns the transistor *off* is by no means as abrupt, and it exhibits this rounded-off characteristic."

"Hell's teeth," groaned Dick. "That's another of my illusions shattered! Well, how *do* you get a square wave from a multivibrator?"

"There are quite a few methods," said Smithy. "One simple way of getting as true a square wave as possible consists of passing the multivibrator waveform through a clipper which removes the most rounded section of the upward-going waveform edge. Another method consists of adding a third transistor between the emitter of one of the multivibrator transistors and the lower supply rail. Here's the idea."

Smithy scribbled out a circuit which included the additional transistor. (Fig. 6).

"How does that work?"

"The base-emitter junction of the third transistor," explained Smithy, "carries both the base and collector currents of the multivibrator transistor to which it connects. So, when the latter comes on, the third transistor does, too. Similarly, when the latter turns off, so does the third transistor. Since the third transistor has no capacitor to hold down its collector voltage, this can then rise immediately, giving you a proper square wave. The added transistor is very useful, too, if you want the multivibrator to drive a low resistance or low impedance load, since it also amplifies the current in the multivibrator transistor."

"Hang on a jiff," said Dick thoughtfully. "I think I saw that third transistor idea in one of G. A. French's 'Suggested Circuits' recently."

"You did," confirmed Smithy. "He used it to allow a multivibrator to drive a speaker, and I think it appeared last November. As it happens I'm using the same idea in the tone generator you're going to make up."

For the moment, however, Dick's thoughts were removed from the subject of multivibrators.

"Old G. A. French," he mused. "He's been contributing to the 'Radio Constructor' for quite a few years now, hasn't he?"

" 'Radio and *Electronics* Constructor'," corrected Smithy, "*if* you don't mind."

"So far as I can recall," resumed Dick, "those 'Suggested Circuits' of his are running well past No. 260 by now. As there are 12 'Suggested Circuits' each year, he must have been turning them out for at least 21 years."

"An achievement," remarked Smithy, "which is not to be sniffed at."

"He must," went on Dick, proceed-

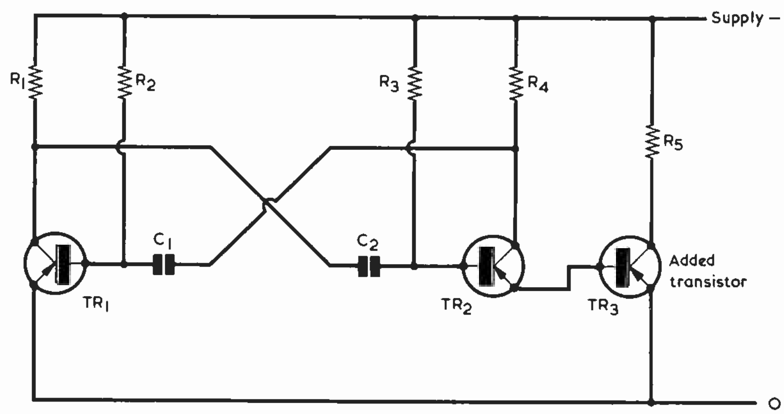


Fig. 6. A square wave is available at the collector of a third transistor, added to the multivibrator in the manner shown here. R5 represents the collector load of the third transistor

ing doggedly with his train of thought, "be really *ancient*, after all these years. Do you know, Smithy, I can visualise old G. A. French as an eccentric old geyser with a long white beard, shambling up Maida Vale every month to get his article in and tapping all the lamp posts as he passes by."

Smithy turned an irate glance on his assistant.

"It wouldn't half shake you," he said severely, "if a long bony finger came creeping over the edge of this page and dug you one in the lug-hole."

Dick looked hastily around him, then shivered violently.

"Don't talk like that, Smithy," he pleaded, "you'll scare the living daylights out of me."

"Fair enough, then," returned Smithy sternly. "But in future be careful what you say about your elders and betters."

REVERSE VOLTAGES

"All right, Smithy," said Dick, chastened. "Let's get back to those multivibrators. Are there any other points to look out for in multivibrator design?"

"There is a further important one," replied Smithy, "but before proceeding to this, I think I should mention that all the multivibrator circuits we are talking about today are those which have the conventional configuration where both emitters couple direct to the lower supply rail. There are other circuits which are less frequently encountered, these including the emitter-coupled multivibrator. Our comments today don't necessarily apply to these other types."

Smithy stopped for a moment to collect his ideas.

"Now," he went on, "the further important point in the conventional multivibrator concerns the reverse base-emitter voltage which is applied to each transistor when, during the cycle, it's turned off. At the instant before the transistor is turned off it is fully conducting and the capacitor which connects to its base is charged up to very nearly the full supply potential. The situation is then like this."

Smithy sketched out a circuit. (Fig. 7(a).)

"The changeover follows next," he carried on, "with the result that the first transistor comes on and the second transistor is turned off. Immediately after the changeover, the base of the transistor that's turned off is taken positive of the lower supply rail by the charged capacitor, the amount by which it is taken positive being very nearly equal to the supply voltage." (Fig. 7(b).)

"I see," commented Dick thoughtfully. "After that, the capacitor discharges and the reverse base-emitter voltage on the second transistor falls, doesn't it?"

"That's right."

"If the initial reverse base-emitter voltage is greater than the maximum base-emitter voltage rating for the transistor," queried Dick, "will the transistor become damaged?"

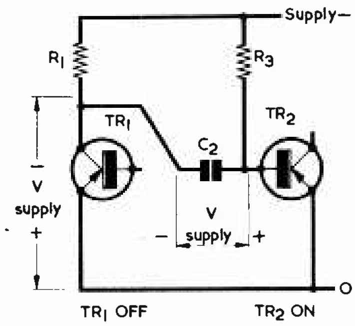
"Very probably not," said Smithy. "What will happen instead in most instances is that the base-emitter junction will function as a zener diode at its breakdown voltage. This will cause the capacitor connecting to the base to become partially discharged during the changeover process itself, and the subsequent off period for the transistor concerned would be shorter than the calculated period."

"Does that matter?"

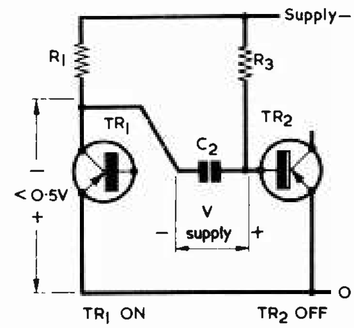
"Oh, definitely. For a start, the multivibrator circuit is not being used in the manner in which it is intended to operate. Also, there will be quite heavy discharge currents from the capacitor into the base-emitter junction which is acting as a zener diode and, whilst these currents may not be sufficiently high to cause eventual failure of the transistor, they obviously aren't going to do it any good. Another factor is that the manufacturer's reverse base-emitter voltage rating for a transistor represents a *minimum* figure only. The actual breakdown voltage for one transistor may be considerably higher than the minimum voltage rating, whilst that for another transistor of the same type number may be just above the rating figure. In consequence, in a multivibrator circuit where the reverse base-emitter voltage rating is exceeded, the first of these two transistors may not exhibit the zener diode effect at all and its off period will be equal to the calculated value. On the other hand the second of the two transistors, the one whose actual breakdown voltage is just a little higher than the rating, may exhibit the zener diode effect very noticeably and its off period will be shorter than the calculated value."

"That's awkward," commented Dick. "The circuit could give different off periods for two different transistors, even though they both had the same type number."

"Exactly," agreed Smithy. "Fortunately, there's a simple solution to this problem and it consists of selecting transistor types whose quoted reverse base-emitter voltage rating is greater than the multivibrator supply voltage. The zener diode effect cannot then take place at all with any transistors, and all transistors of the same type number will give an equivalent performance. Many of the popular low-cost silicon transistors which are available these days have quite low reverse base-emitter voltage ratings, these being of the order of 5 to 6 volts only. Germanium transistors, on the other hand, usually have much higher reverse base-emitter voltage ratings, and are frequently more useful than silicon types in multivibrators even though lots of people nowadays seem to think that germanium transistors are old-fashioned. The popular germanium transistors type ACY18 and ACY19 both have, for instance, a maximum reverse emitter-base voltage rating of 12 volts, which makes them suitable for use in any multivibrator having a power supply voltage that doesn't exceed this figure. And that brings me to my main topic."



(a)



(b)

Fig. 7(a). The situation just before the changeover which causes one transistor (TR2 here) to be turned off
(b). Immediately after the changeover nearly the full supply voltage is applied, as reverse bias, across the base-emitter junction of the cut off transistor. With n.p.n. transistors all the polarities would be reversed

TWO-TONE OSCILLATOR

Smithy opened a drawer in his bench and, with a flourish, produced a sheet of paper on which he had already drawn a circuit diagram. (Fig. 8.)

"What's that?" asked Dick.

"It's the circuit of the multivibrator gubbins which started this discussion off," stated Smithy. "It's the tone generator you'll be making for our customer's flat, and it uses four ACY18's and one ACY19."

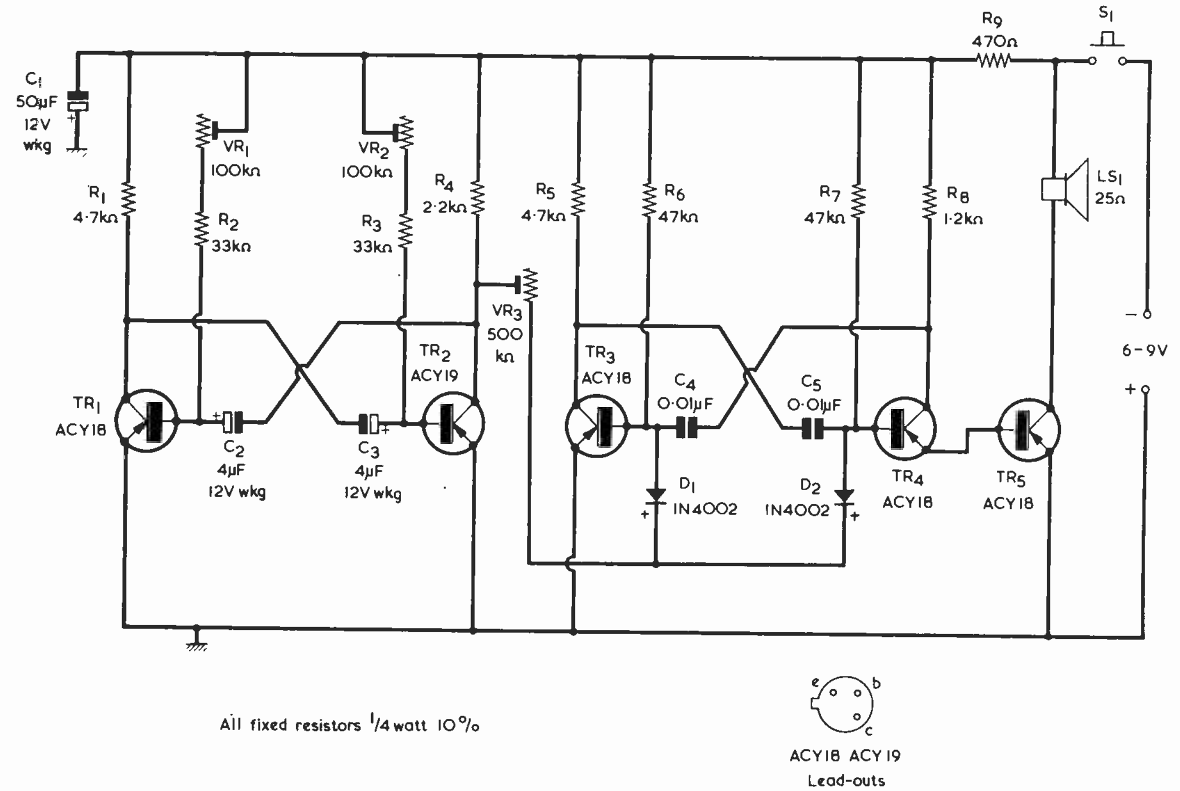


Fig. 8. A 2-tone generator incorporating two multivibrators. Push-button S1 may be a door bell-push coupled to the remainder of the circuit via twin wire

"That seems," remarked Dick suspiciously, "to be rather a lot of transistors."

"There are a few," admitted Smithy. "This is because there are two separate multivibrators in the circuit. One of these is given by TR3 and TR4. This multivibrator runs at an audible frequency and is coupled to the loudspeaker by TR5, which is inserted in the emitter circuit of TR4. This transistor enables the multivibrator to drive a low impedance load in the manner we discussed a short while ago. TR1 and TR2 form a second multivibrator and it runs at around 1 cycle per second."

"What does this second multivibrator do?"

"It varies the frequency of the multivibrator given by TR3 and TR4," explained Smithy. "The result is that you get a 'hee-haw' type of audio output which is reminiscent of that given by ambulances and fire-engines."

"Do you, indeed?" asked Dick, his interest rising. "That seems to be quite a knobby idea. I see that you've put pre-set pots in the base circuits of TR1 and TR2. Why is that?"

"The pre-set pots are to take up differences in actual capacitance in the cross-coupling capacitors C2 and C3," replied Smithy. "These capacitors need a value of around 4μF each and, if the circuit is to be economical, should be electrolytic types. Unfortunately, electrolytic capacitors have a very wide tolerance on nominal value, and the discrepancies in value are taken up by adjusting VR1 and VR2. Both VR1 and VR2 can be conventional skeleton types. So also, incidentally, can VR3."

"How is the frequency of the audio multivib changed?"

"By way of diodes D1 and D2," said Smithy. "If you ignore these two diodes for a moment, you'll see that the multivibrator around TR3 and TR4 is a standard circuit, the off period for each transistor being the time required for the appropriate 0.01μF cross-coupling capacitor to discharge via the 47kΩ resistor which couples it to the upper supply rail. If D1 and D2 are now taken into account, a second discharge path can be seen. When TR3 is off, its base is at a positive potential and diode D1 conducts. The second discharge path is then given via D1 and VR3. This same discharge path is similarly provided, but via D2, when TR4 is off. In consequence, each base circuit has the same second discharge path by way of the diode which connects to it, the diode which conducts being that which couples to the base which is most positive."

"Blimey," said Dick, impressed. "That's a crafty way of controlling multivib frequency."

"It is a useful circuit," agreed Smithy. "Now, the other end of VR3 is coupled to the collector of TR2. When TR2 is turned on, its collector is approximately at the same potential as the lower supply rail, and the discharge path via VR3 is to this relatively low potential. When, on the other hand, TR2 is off, the discharge path via VR3 is to the upper supply rail by way of R4, and the cross-coupling capacitor to which this discharge path is presented discharges much more rapidly. The result is that the audio multivibrator runs at a higher frequency when TR2 is off than when TR2 is on. VR3 is adjusted to give the final audio frequency variation required. In practice the frequency variation will increase as the resistance inserted by VR3 reduces, until a setting is reached where VR3 inserts too little resistance and upsets the functioning of the multivibrator. A further point is that I've included a decoupling circuit, which is provided by R9 and C1. TR5 draws quite a heavy current when it conducts and, if there was a fairly high internal resistance in the supply, this could upset the operation of TR1 and TR2 if the decoupling circuit were omitted. The average current drawn by the unit will be of the order of 100 to 150mA."

Smithy passed the circuit over to Dick.

"Shall I," asked that worthy, "knock it up now?"

"If you would, please," requested Smithy.

WORKING VERSION

Dick returned eagerly to his own bench, and Smithy proceeded to deal with some of his other work.

There was silence for nearly an hour, after which an excited call from Dick indicated that he had completed the assembly of the tone generator circuit. Smithy walked over and inspected his assistant's handiwork. Dick had wired up the components on a small neat chassis having two 2-way terminal blocks. One of these was intended for connection to the speaker and the other for connection to the supply via S1.

"Right," said Smithy. "Wire up a speaker now and fit two leads for connection to a 6 or 9 volt battery. We can couple direct to the battery for checking the generator out, and we won't need S1. Oh, and set VR3 to insert full resistance into circuit before you connect the battery."

Cheerfully, Dick carried out Smithy's instructions. As he connected the battery, a loud tone, a little higher than 1kHz, became audible from the speaker. This tone varied periodically in frequency by a small amount.

"Good," commented Smithy, rubbing his hands together. "Let's make a few adjustments now."

"Gosh," said Dick enthusiastically, as he listened to the sound from the speaker, "that sounds terrific."

"It's not too bad," confirmed Smithy, listening critically. "It's loud enough to replace a door bell in a small flat, although it wouldn't cope for a house."

"There seems," remarked Dick, "to be a slightly sharper transition from the high to the low frequency than in the other direction."

"That's true enough," agreed Smithy. "The difference between the two transitions is just about discernable. It's due, of course, to the rounding-off in the collector voltage waveform which I mentioned earlier. The collector voltage of TR2 drops abruptly when TR2 comes on, but it rises a little less abruptly when TR2 turns off. This doesn't detract from the overall effectiveness of the gadget."

"Could you," asked Dick, "use a mains power unit instead of a battery?"

"Definitely," stated Smithy. "One of those little bell transformers having secondary outputs of 3, 5 and 8 volts which they sell in Woolworth's would be just the job, and its 8 volt secondary could be coupled to a bridge rectifier and a 1,000μF reservoir capacitor. A power unit of this nature can be left permanently connected to the mains and it will draw negligible current. The d.c. output would be of the order of 8 volts when the push-button is pressed." (Fig. 9).

With a gesture of finality, Smithy disconnected the multivibrator circuit from its battery, and the piercing 2-tone output ceased.

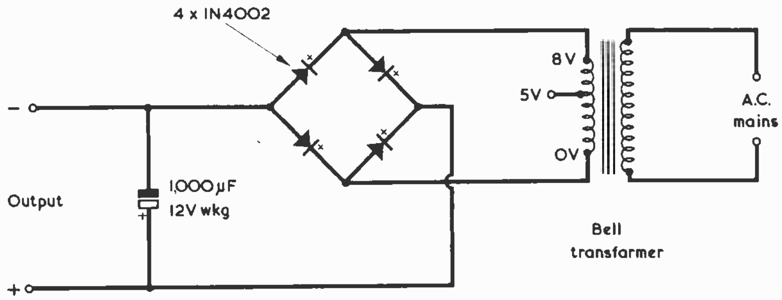


Fig. 9. The generator of Fig. 8 can be powered by a battery or by a small mains unit incorporating a bell transformer

He picked up a small screwdriver and slowly reduced the resistance inserted by VR3. The frequency changes became more and more pronounced as he adjusted the potentiometer, and he finally left it at a setting which he declared to be satisfactory. He next adjusted VR1 and VR2 until the two different frequency periods were equal and of a satisfactory length.

"Well," remarked Smithy philosophically, "that's another little job successfully completed. It's back to radio and TV servicing for you again now, my lad!"

And it wasn't long before Dick, the multivibrator unit already an item in the past, was completely immersed in the repair of a monochrome single-standard television receiver. ■

Radio Topics

By Recorder

BY THE TIME THESE NOTES APPEAR our presentation issue of last October, with which we gave away a free sample piece of Veroboard, will be past history. Nevertheless it is worth while referring to it because Veroboard represents a particularly unique approach towards the assembly of electronic circuits, and because it enables such neat results to be obtained. There is, further, a special sense of achievement in constructing small items on a Veroboard panel using the minumum number of copper strips and holes.

DESIGN APPROACH

Users of Veroboard tend to have their own pet techniques but my own experiences with this product may be of value, if only for newcomers. When a Veroboard unit is required in a hurry I find it slightly to advantage to cut the Veroboard so that the copper strips run across the width of a relatively narrow piece of board, in the same way that the lines of print run across the width of this column, rather than have the strips run the length of the board. This is purely for mental convenience since it enables each short strip to be assigned its own particular role, such as 'supply common', 'Vee positive', 'input', 'output', and so on, and few if any breaks in the strips are required. If one strip merely carries two connections there is still not, then, excessive wastage of the hole positions available. Similarly, if one strip does not have sufficient holes for all the connections that are to be made to it, there is no problem of connecting another strip to it by means of a jumper wire.

I find this approach is excellent for the case where I'm really rushed and I'm building up a circuit from scratch in as short a time as possible. And, of course, the result still looks good and neat.

If, on the other hand, I have more time to spare, I like to work out a layout design on paper first. Squared paper, such as is encountered in children's school exercise books, is excellent for this purpose. The intersections of the lines which form the squares represent the Veroboard holes. This method enables transistor lead-outs to fit into hole patterns, which correspond nicely with their lead-out layout, and also enables the larger capacitors to be installed between holes which just comfortably accommodate their length. If the circuit includes a transformer, a useful dodge consists of employing its two mounting lugs to jumper over one strip to another. The jumper connection is automatically carried over via the transformer frame itself. The transformer frame should normally be common with the earthy side of the supply, whereupon it can allow two separate strips to carry the earthy supply connection. Since the earthy side of the supply frequently takes more connections than any other conductor in a circuit, this idea can prove to be very convenient in practice.

Returning to the squared paper on which the initial design is worked out, I draw small circles in ink at the line intersections which correspond to the Veroboard holes, then sketch in the components, using circuit symbols, in pencil, 'Modifications' can then be carried out with an indiarubber. Also, the view is as seen from the component side of the board. With this method, incidentally, I find it better to have the copper strips run along the length of the Veroboard panel rather than across the width. as occurs with the quicker method of assembly. Naturally, there may be quite a few breaks in the strips.

I must stress that this pre-planning idea is simply one man's approach, and that many constructors will prefer to go straight to the Veroboard itself. Having assessed the size of board required for a particular project, they immediately start connecting up the components to it.

One final point about Veroboard which I like very much is its toughness. Ideally, once a component wire has been soldered at a Veroboard hole, it should be left alone. In practice, though, and provided reasonable care is used, it is surprising how many times, due to the trying out of different component values, connections can be soldered and unsoldered at a Veroboard hole before the copper foil and its adherence to the insulated board starts to suffer.

KNOB TROUBLE

We all do a bit of servicing every now and again. This isn't usually an unwelcome chore, and quite a lot of pleasure can be obtained from chasing down an obscure fault, repairing it and then seeing the equipment return to full working order.

Unfortunately, servicing has its minor vexations, these being caused not by the electronic team at the factory who designed the equipment to be repaired but by the presentation boys who set out to make it look attractive. I have no argument whatsoever over whether the finish of a set should be teak, veneer, plastic or anything else, but I would dearly love to have my own private aggro with those people, who dream up the nightmarish and impractical control knobs which appear on so many radio and TV receivers these days.

It is accepted practice for control knobs to be located on their spindles by means of springs, and this represents quite a happy state of affairs until the time comes to remove them. The knobs obviously have to be pulled off but the factory presentation team far too frequently design knobs which look highly decorative but offer no purchase whatsoever for their removal. One still occasionally also encounters knobs with long plastic extensions which pass right into the innards of the receiver before they encounter a spindle. It is only too easy to break the plastic whilst handling these knobs.

All these problems are infuriating enough, but I have now encountered what must be the ultimate in knob snags. It isn't even irritating – it's just ridiculous!

I recently had a fairly large transistor radio in for repair and, before taking the works out of its cabinet, I tried the effect of turning the wave-change switch from medium to long waves. The switch clicked over dutifully but the knob continued to turn. Somewhat mystified, I pulled the knob off the spindle, to find that I was holding its outer shell only. The plastic of the knob must have been badly cured during the moulding, and all its inside had simply *crumbled* away into a mass of floury powder!

STATIC

Nobody ever believes me when I say that I once got a sizeable belt, one hot Summer's day, on boarding a No. 16 bus at Marble Arch. I would hate to have to calculate how much static electricity a London Transport double-decker can pick up as it trundles along Oxford Street but on that occasion quite a quantity found a path to earth via me when I put my hand on its rail.

Static electricity was, of course, known about thousands of years before our present times, and the word 'electricity' actually derives from the Greek 'elektron', which mean 'amber'. In those days, our forebears couldn't pop out and buy a PP9 battery; they had to generate their electricity by rubbing pieces of amber.

The earlier aircraft used to suffer from the effects of static electricity and they could pick up quite an unpleasant charge after they had been airborne for a while. The solution in those days consisted of developing landing wheel tyres which had a small percentage of graphite in their composition. The charge then leaked away to earth by way of these tyres when the aircraft landed. Older readers may recall that, during the war, barrage balloons were launched, on wire hawsers, from rubber tyred trailers. The metalwork of these trailers had to be earthed. Barrage balloon crews can tell hair-raising stories about the amount of static electricity picked up by the hawser if the earth connection to the trailer happened to be broken.

Static electricity can be a source of considerable trouble in electronic work. M. G. Scroggie in the latest edition of 'Foundations of Wireless' (Iliffe Books) points out that sufficient static electricity to break down the gate insulation of a MOSFET can be produced in the body simply by taking a step or two across a dry floor in rubber soled shoes. Car radio aerials can also pick up static, and car radios frequently have aerial input circuits which guard against damage due to static electricity. For many years now, nurses in hospital operating theatres have been advised not to wear nylon underclothes. The atmosphere in an operating theatre can reach explosive levels and a static spark due to a charge generated in the nylon could have, to say the least, disastrous effects.

Talking of ladies' underwear, I see that the latest sales campaign in these garments is centred around a new grade of what is described as 'anti-static' nylon. Charnos, who claim to be 'first with the non-cling thing' now produce a range which is manufactured from Monsanto 'Ultron' anti-static nylon. This is guaranteed to be free from the clammy sticky feeling given by ordinary nylon. Quite a change from the old days of Shocking Pink! ■

CROSSWORD

(Solution to the puzzle on page 456).

Across. 1. Resistor; 5. Danger; 9. Shoe-lace; 10. Log. Log.; 11. Epicycle; 12. I deals; 14. Valve Noise; 18. On All Fours; 22. Hybrid; 23. Modulate; 24. Linear; 25. Spurious; 26. Excite; 27. Lenz's Law.

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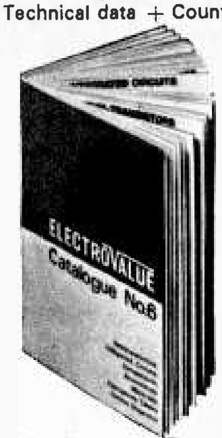

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SMALL ADVERTISEMENTS

(Continued from page 467)

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(Continued from page 469)

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	Dia. 1 in.				Dia. 1¼ in.			
Turns	l=¾ in.	l=1 in.	l=1¼ in.	l=1½ in.	l=¾ in.	l=1 in.	l=1¼ in.	l=1½ in.
4	0.33	0.27	0.24	0.21	0.48	0.40	0.34	0.30
6	0.75	0.62	0.53	0.46	1.1	0.90	0.78	0.61
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15	4.7	3.9	3.3	2.9	6.7	5.6	4.8	4.2
20	8.3	6.9	5.9	5.1	12.0	10.0	8.6	7.6
25	13.0	11.0	9.2	8.0	19.0	15.0	13.0	12.0
30	19.0	16.0	13.0	12.0	27.0	23.0	19.0	17.0
35	26.0	21.0	18.0	16.0	36.0	31.0	26.0	23.0
40	33.0	28.0	24.0	21.0	48.0	40.0	34.0	30.0
45	42.0	35.0	30.0	26.0	60.0	51.0	44.0	38.0
50	52.0	43.0	37.0	32.0	74.0	63.0	54.0	47.0
55	63.0	52.0	44.0	39.0	90.0	76.0	65.0	57.0
60	75.0	62.0	53.0	46.0	110.0	90.0	78.0	68.0