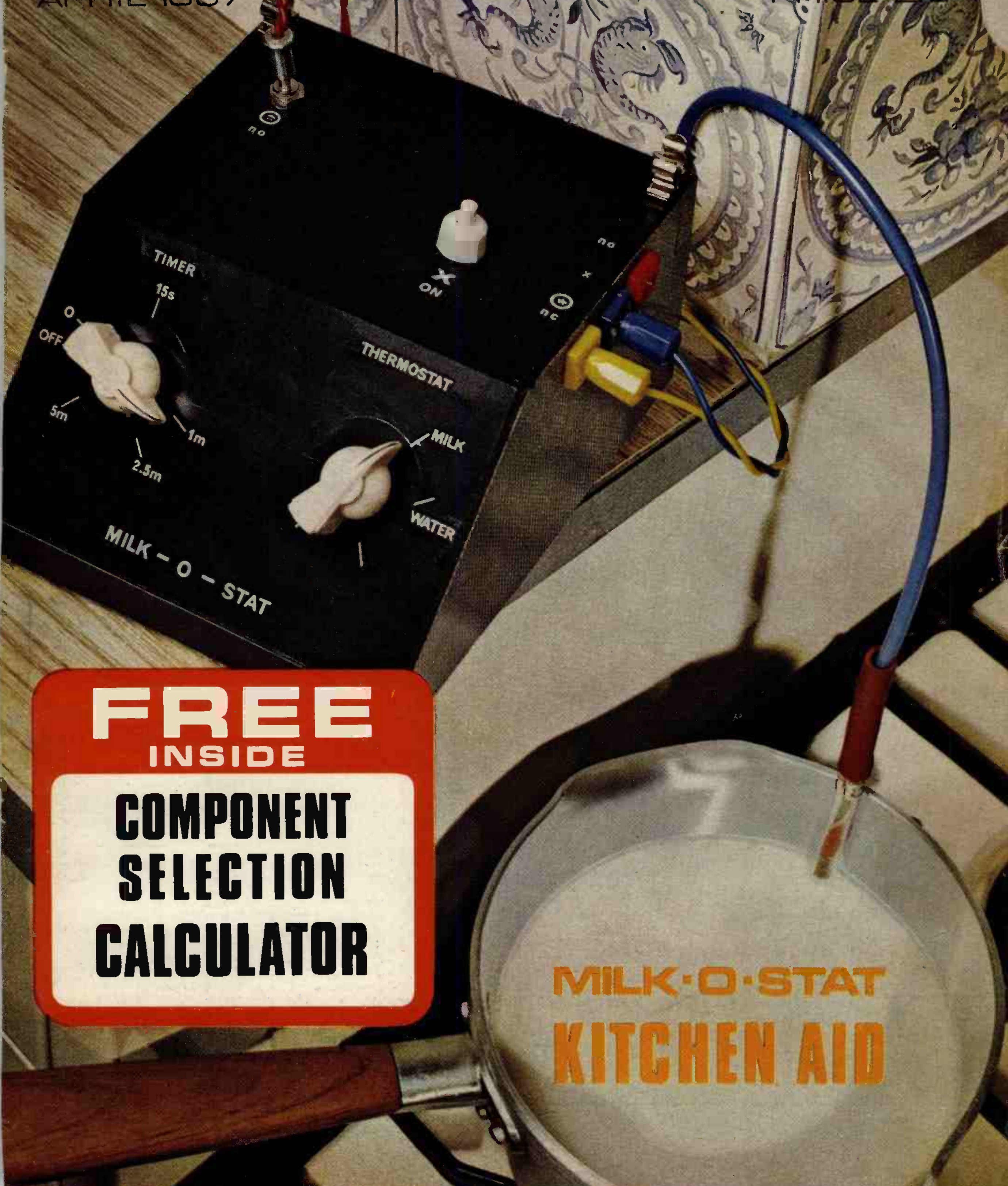
PRACTICAL ELECTRONICS

APRIL 1967

PRICE 2/6



FREE INSIDE

COMPONENT SELECTION CALCULATOR

MILK-O-STAT KITCHEN AID

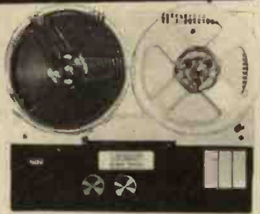
LASKY'S RADIO

For the Finest Value and Service to HOME CONSTRUCTORS & ELECTRONICS ENTHUSIASTS

We consider our construction parcels to be the finest value on the home constructor market. If on receipt you feel not competent to build the set, you may return it as received within 7 days, when the sum paid will be refunded less postage.

TAPE RECORDERS

MAGNAVOX 363 DECKS



The very latest 3 speed model—1⅞, 3¾, 7½ i.p.s. available with either ½ track or ¼ track head. Features include: pause control; digital counter; fast forward and rewind; new 4 pole fully screened induction motor; interlocking keys. Size of top plate: 13½ × 11 × 5¼in. deep below unit plate. For 200/250 v. A.C. mains, 50 c.p.s. operation. New unused and fully guaranteed.

LASKY'S PRICE ½ track model £10.10.0

LASKY'S PRICE ¼ track model £13.9.6

Carriage and Packing 7/6 extra.

SPECIAL FOR OVERSEAS CUSTOMERS — the new Magnavox-Collaro 363 Deck for 110/125 v. 50 or 60 c.p.s. mains now available, prices as above. Post to any part of the world 35/-.

MARTIN RECORD/REPLAY TAPE AMPS.

Latest models now available from stock—for use with the Magnavox 363 Tape Deck

½ track model .... LASKY'S PRICE £14.19.6

¼ track model .... LASKY'S PRICE £15.19.6

Carriage and Packing 4/6 extra

Optional extra: Control panel escutcheon to take deck and amplifier controls. LASKY'S PRICE 12/6. Post and Packing 2/6.

SPECIAL INTEREST ITEMS!

SPECIAL PURCHASE—UHF/VHF T.V. TUNERS

Well known British makers' surplus stocks. Now available for the first time to the Home Constructor. Add 2/6 Post and Packing on each.

VALVE UHF MODEL *(illustrated)*

In metal case size 4 × 6 × 1½in. Fully tunable—complete with PCC86 and PCC88 valves. LASKY'S PRICE 29/6. Without valves 12/6

TRANSISTORISED UHF MINIATURE MODEL 1

Shielded metal case only 3½ × 1½ × 3in. Fully tunable—complete with two AF 139 transistors. LASKY'S PRICE 39/6

TRANSISTORISED UHF MODEL 2

Metal case size 3½ (plus spindle) × 2½ × 1½in. Fully tunable with slow motion drive. Comp. with two AF186 transistors and leads. LASKY'S PRICE 25/6

TRANSISTORISED VHF TUNER

Sub-miniature turret type fitted with 12 sets of coils and 3 Mullard AF102 transistors In metal case size 3 × 1½ × 2½in. LASKY'S PRICE 37/6

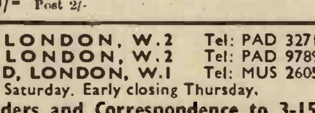
Add 2/6 Post and Packing on each.

MAKERS' SURPLUS TELEVISION IF AMPLIFIERS

38 Mc/s. Contains a large number of components, IF transformers, resistors, capacitors, etc., and the following valves: 2xPCF80, 1xEB91, EF80, EF183 and EF184. Overall size 11½" × 3½" × 4" deep. Ideal for servicemen and experimenters. This IF amp. when used with the Valve model UHF Tuner (above) provides a suitable conversion for B.B.C.2. Circuit supplied.

LASKY'S PRICE 29/6 Post 2/6

SPECIAL PACKAGE OFFER



Free standing table cabinet, size 17½ × 9 × 5½in., finished in medium Mahogany. Scale marked 21 to 68 (UHF band). Designed to accept the above IF Amplifier with space for a Valve UHF Tuner. Cabinet only 27/6 Post 3/6

Special Package Offer IF Amplifier, UHF Tuner with valves and Table Cabinet. PACKAGE PRICE 59/6 Post 6/-

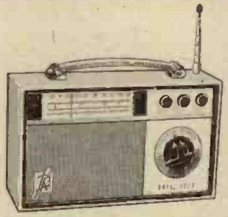
WATER TEMPERATURE THERMOSTATS

British made—orig. for use in high quality washing machine, range adjustable between 114°F and 230°F. Rating 200/250 V.A.C., 20 amps (also D.C. up to 125 V.A.). Size 2½×1½×1½ with 18in. capillary tube and 6in. bulb. Single hole fixing 3/16in spindle.

LASKY'S PRICE 15/- Post 2/-

CONSTRUCTORS BARGAINS

THE SKYROVER De Luxe

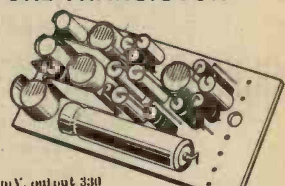


7 transistor plus 2 diode superhet, 6 waveband portable receiver covering the full Medium Waveband and Short Waveband 31-94M and also 4 separate switched bandspread ranges, 13M., 16M., 19M. and 25M., with Band Spread Tuning for accurate Station Selection. The coil pack and tuning heart is factory assembled, and tested. Uses 4 U2 batteries. 5 in. Ceramic Magnet P.M. Speaker. Telescopic and Ferrite Rod Aerial. Tone Circuit, wood cabinet, size 11½ × 6¾ × 3 in. covered with washable material, plastic trim and handle. Car aerial socket fitted.

Can be built for £8.19.6 Post 5/- H.P. Terms: 60/- deposit and 11 monthly payments of 12/9. Total H.P.P. £10.0.3. Data 2/6 extra; refunded if you purchase parcel. All parts avail. sep. Four U2 batt. 3/4 A simple additional circuit provides cover of the 1100/1950M Long Waveband. All components with construction data.

Only 10/- extra Post Free.

NEW—LASKY'S MINIATURE TRANSISTOR AMPLIFIER MODULES



Incorporating the very latest circuitry to provide high sensitivity and good quality in conjunction with extreme small size and compactness. High quality Newmarket transistors used throughout. All designed to operate on 9v. miniature battery. Add 1/- on each for post & packing

TYPE LRPC 1. 3 transistor. Input sens. 50 mV., output 150 mW, output imp. 40 Ω, size 2 × 1 × ¾in....... PRICE 27/6

TYPE LRPC 2. 5 transistor. Input sens. 1mV, output 330 mW, output imp. 15 Ω, size 2½ × 1½ × ¾in.... PRICE 22/6

TYPE LRPC 4. 5 transistor. Input sens. 150 mV, output 330 mV, output imp. 15 Ω, size 2½ × 1½ × ¾in. .... PRICE 22/6

TYPE LRPC 5. 6 transistor. Input sens. 8mV, output 3W, output imp. 3 Ω, size 5½ × 1¾ × 1in. .... PRICE 59/6

TYPE LRPC 6. Tape record/play back amp. (for use with self oscillating erase head). Output 750mW, output imp. 8 Ω. Size 4½ × 2 × 1in. .... LASKY'S PRICE 39/6

FULLY ENCAPSULATED MODULES

Special function modules — all one size 1½ × 1 × 1½in. Complete with detailed function and installation instructions. Send S.A.E. for data.

TYPE PA-1. Public address amp. for use with carbon, crystal or Dynamic microphones. 3 Ω output imp. .... PRICE 30/-

TYPE GR-1. Gramophone amplifier provides sufficient power to fill average room. 3 Ω output imp. .... PRICE 30/-

TYPE CO-1. Morse code practice oscillator for use with morse key and 3 Ω speaker. .... PRICE 20/-

TYPE MT-1. Metronome module provides audible and visual beat from 30 to 240 beats per minute (for use with 3 Ω speaker or ind. lamp)........ PRICE 22/6

SINCLAIR SUPER MINIATURE KITS

We stock the complete range. Write for details of package deals.

THE MICRO-6 miniature radio only 1¾ × 1 5/16 × 1½in.	£2 19 6
THE MICRO-FM. (tuner/receiver)	£5 19 6
THE X-20 20 watt P.W.M. amplifier Kit £7.19.6. Fully built	£9 19 6
STEREO 25 pre-amp control unit fully built	£9 19 6
THE Z-12 12 watt amplifier and pre-amplifier. Fully built and tested	£4 9 6
PZ-3 power pack for Z-12	£3 19 6

VEROBOARD — High grade laminated board with copper strips bonded to it and pierced with holes.

Boards			Accessories	
42/1503	2½ × 5 in.	3/11	Terminal pins — pkt. of 50	3/-
43/1504	2½ × 3¾ in.	3/3	Spot face cutter tool	7/3
45/1507	3¾ × 5 in.	5/6	Pin inserting tool	9/6
46/1508	3¾ × 3¾ in.	3/11	Post 6d. per item extra.	
44/1505	3¾ × 17 in.	15/6	Orders of 10/- and over post free.	

TRANSISTORS — ALL BRAND NEW AND GUARANTEED

GET 81, GET 85, GET 86 2/6; 873A, 874P 3/6; OC45, OC71, OC81D 4/6; OC 44, OC 70, OC 76, OC 81 5/6; pair (10/6); AF 117, OC 200 6/6; OC 42, OC 43, OC 73, OC 82D 7/6; OC 201, OC 204 15/-; OC 205, OC 206 19/6; OC28 24/6; OC 75 8/-.

TRANSFILTERS By BRUSH CRYSTAL CO. Available from stock.

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TO—02B 465 kc/s. ± 1 kc/s.
TO—02D 470 kc/s. ± 1 kc/s.
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33 TOTTENHAM CT. ROAD, LONDON, W.1 Tel: MUS 2605
The above branches open all day Saturday. Early closing Thursday.

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Both open all day Thursday. Early closing Saturday.

Please address all Mail Orders and Correspondence to 3-15 Cavell Street, Tower Hamlets, London, E.1. Tel.: STE 4821/2

LASKY'S FOR SPEEDY MAIL ORDER SERVICE

FULLY GUARANTEED INDIVIDUALLY PACKED VALVES

AC/HL	4/6	EBC41	8/6	EL37	16/-	MH4	5/-
ACP4	6/-	EBC80	5/-	EL38	17/6	ML6	6/-
AC6PEN	5/-	EBF80	6/6	EL41	8/-	N78	15/-
AL60	5/-	EBF83	7/6	EL42	8/-	NE17	7/-
AR8	5/-	EBF89	6/9	EL50	8/-	OA2	5/9
ARP3	3/-	EBL31	20/-	EL81	8/-	OB2	6/-
ARP12	2/6	EC52	4/-	EL83	6/3	OB3	7/-
ARP24	10/-	EC53	12/6	EL84	4/3	OC3	5/-
ATP4	2/3	EC70	4/-	EL85	7/6	OD3	5/-
ATP7	5/6	EC90	2/-	EL91	4/6	OZ4A	5/-
AU7	55/-	EC91	3/-	EL95	5/-	PC86	9/-
AZ31	9/-	ECC81	4/-	EM80	6/-	PC88	9/-
B6H	15/-	ECC82	5/-	EM81	7/-	PC97	7/6
BD78	40/-	ECC83	6/-	EM84	6/3	PC900	12/-
BL63	10/-	ECC84	5/6	EN31	10/-	PCC84	5/6
BS4	8/-	ECC85	6/6	ESU74	80/-	PCC89	10/-
BS5	20/-	ECC91	4/-	ESU208	6/-	PCF80	6/3
BS84	47/6	ECC189	9/6	EY51	5/6	PCF82	6/6
B2134	18/-	ECF80	7/-	EY86	6/6	PCF84	6/-
CC3L	2/-	ECF82	7/-	EY91	3/-	PCF86	8/-
CF23	10/6	ECH42	9/-	EZ40	6/6	PCF802	9/6
CL33	9/-	ECH81	5/-	EZ41	6/6	PCF805	11/-
CY31	6/6	ECH83	7/6	EZ80	5/6	PCL81	9/-
D1	1/6	ECL80	6/-	EZ81	4/6	PCL82	7/-
D41	3/3	ECL82	6/3	F/6057	5/-	PCL83	8/6
D61	6/-	ECL83	10/-	F/6061	5/-	PCL84	7/-
D77	3/3	ECL86	9/-	F/6063	4/-	PCL85	8/6
DA30	12/6	EF36	3/6	FW4/500	6/6	PCL86	8/-
DAF96	6/-	EF37A	7/-	FW4800	8/6	PEN25	4/6
DD41	4/-	EF40	8/-	G1/236G	29/-	PEN46	3/-
DF73	5/-	EF41	6/-	G50/2G	5/-	PFL200	17/6
DF91	3/-	EF50	2/6	GM4	45/-	PL36	9/-
DF92	3/-	EF52	6/-	GZ32	10/-	PL38	16/-
DF96	6/-	EF53	4/6	GZ34	10/-	PL81	7/-
DH63	5/-	EF55	8/-	HK54	22/6	PL82	6/6
DK96	5/6	EF71	7/6	HL2K	2/6	PL83	6/-
DL92	4/-	EF72	5/-	HL23	6/-	PL84	6/6
DL93	4/-	EF73	5/-	HL23DD	5/-	PL500	13/6
DL94	5/9	EF74	4/-	HL41	4/-	PM24A	5/-
DL96	7/-	EF80	5/-	HVR2	9/-	PT15	13/-
DL810	8/-	EF85	4/6	K3A	30/-	PT25H	7/6
DY86	7/6	EF86	6/6	KT32	8/-	PT25M	7/6
E80F	23/-	EF89	5/-	KT33C	6/-	PX4	14/-
E88CC	12/-	EF91	3/6	KT44	5/9	PX25	12/6
E90CC	10/-	EF92	2/-	KT63	4/-	PY33	8/6
EA50	1/-	EF95	5/-	KT66	16/-	PY80	5/6
EA73	7/-	EF95	5/-	KT67	25/-	PY81	5/6
EABC80	5/9	EF183	6/6	KT76	8/6	PY82	5/6
EAC91	3/6	EF184	6/6	KT88	22/-	PY83	6/-
EAF42	8/-	EH90	7/6	KTW61	4/6	PY800	7/-
EB34	1/6	EL32	3/9	KTW63	5/-	PZ1-35	9/-
EB91	3/-	EL34	10/-	KTZ41	6/-	PZ1-75	12/-
EBC33	6/-	EL35	5/-	KTZ63	5/-	QP21	6/-
						QP25	5/-
						QP230	5/-
						QS95/10	5/6
						QS1202	8/-
						QV04/7	8/-
						R8	8/-
						RK72	6/-

S11E12	10/-	UF89	6/-	1D8GT	6/-	3V4	5/9
SP2	8/6	UL41	7/6	1E7G	7/6	4C27	35/-
SP41	1/6	UL84	5/6	1F2	3/-	4D1	4/-
SP61	4/-	UU5	7/-	1G6GT	6/-	5A173G	5/-
SP210	3/6	UU9	8/6	1L4	2/6	5A174G	5/-
T41	12/6	UY21	7/6	1LA6	6/-	5B/251M	40/-
TP22	5/-	UY85	5/-	1LC6	7/-	5B/253M	15/-
TP25	15/-	VP23	3/-	1LH4	4/-	5B/254M	40/-
TT11	5/-	VP133	9/-	1N21B	5/-	5B/255M	35/-
TT15	35/-	VR99	5/-	1N43	4/-	5R4GY	9/-
TTR31	45/-	VR105/30	5/-	1N70	4/-	5TR	7/-
TZ20	16/-	VR150/30	5/-	1R4	5/-	5U4G	4/6
U81	8/-	VU33A	4/-	1R5	3/6	5V4G	8/-
U12/14	8/-	VU39	6/-	1S4	5/-		
U17	5/-	YX3208	5/-	1S5	4/6		
U18	6/-			1T4	3/-		
U25	13/-			2A3	5/-		

TRANSISTORS

OC16	20/-	OC81D	5/-	OC201	12/6	XC141	10/-
OC22	23/-	OC81M	5/-	OC202	15/-	XC142	15/-
OC25	9/6	OC82	10/-	OC203	12/6	XC155	20/-
OC35	12/6	OC82DM	5/-	OC204	17/6	XC156	22/6
OC44	6/-	OC83	5/-	OC206	22/6	2N247	9/6
OC45	5/-	OC83B	5/-	AAZ12	6/-	2N412	7/6
OC71	4/6	OC122	5/-	AC128	7/6	2N502	47/-
OC72	5/-	OC170	6/-	BCZ11	7/6	2N585	10/6
OC73	9/-	OC200	10/6	BY38	7/6	2N1090	20/6
OC81	5/-					2N1091	29/-

U26	13/-	W21	5/-	2B26	8/-	5X4G	8/6
U27	8/-	W118	8/-	2C26	7/-	5Y3GT	5/-
U52	4/6	W119	8/-	2C26A	3/-	5Y3WGTB	9/-
U191	11/6	X66	7/6	2C34	7/-	5Z4G	6/6
U801	17/-	X81M	18/-	2C45	22/6	6AB7	4/-
UABC80	6/-	X118	8/-	2C46	30/-	6AC7	3/-
UAF42	9/-	X145	8/-	2C51	12/-	6AG5	2/6
UBC41	6/-	YF	1/-	2D21	5/-	6AG7	6/-
UBF80	5/6	Y63	5/-	2X2	3/-	6AH6	10/-
UBF89	6/6	Y65	4/-	3A4	4/-	6AJ7	3/-
UBL21	10/-	Y66	8/-	3B7	5/-	6AK5	5/-
UCC85	6/6	Z800U	20/-	3B24	9/-	6AK6	6/-
UCH42	8/-	Z801U	10/-	3D6	4/-	6AK7	6/-
UCH81	6/-	1A3	3/-	3E29	50/-	6AK8	5/9
UCL82	8/-	1A5GT	5/-	3Q4	6/-	6AL5	3/-
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6AQ5W	9/-	6L7G	4/-	12AY7	10/-	57	6/-
6AS6	4/-	6L34	3/-	12BA6	5/-	58	6/-
6AS6W	9/-	6LD20	5/9	12BE6	7/-	59	6/-
6AS7G	15/-	6N7	6/-	12BH7	7/-	75	5/6
6AT6	4/-	6N7G	5/9	12C8	3/-	76	5/-
6AU6	6/-	6P25	12/-	12H6	2/-	77	6/6
6AX4	8/-	6Q7G	5/-	12J5GT	2/6	78	5/-
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6B7	6/-	6SA7	7/-	12K7GT	2/-	81	9/-
6B8G	2/6	6SA7GT	6/6	12K8M	10/-	82	8/-
6BA6	5/-	6SK7GT	4/-	12Q7GT	3/3	84	8/-
6BA7	5/-	6SC7	7/-	12SA7	4/6	85A2	8/-
6BE6	4/6	6SC7GT	5/-	12SC7	4/-	307A	5/6
6BJ6	7/6	6SF5GT	5/6	12SG7	3/-	313C	25/-
6BJ7	7/-	6SH7	3/6	12SH7	3/-	350B	8/-
6BR7	9/-	6SJ7	5/-	12SJ7	5/-	357A	70/-
6BW6	7/-	6SJ7GT	5/6	12SK7	5/-	368AS	30/-
6C4	2/-	6SJ7Y	6/6	12SN7GT	5/9	393A	27/6
6C5G	2/6	6SK7	5/6	12SR7	5/-	446A	8/-
6C5GT	6/-	6SL7GT	5/6	12Y4	2/-	6080	22/-
6C6	4/-	6SN7	3/6	14L7	7/-	6146	25/-
6C6G	3/-	6SQ7GT	6/-	14S7	18/-	703A	30/-
6C8G	3/-	6SS7	2/6	15D2	6/-	705A	10/-
6CH6	4/6	6U4GT	9/6	20P4	12/6	715B	60/-
6CL6	9/-	6V6G	5/-	21B6	7/-	717A	3/-
6CW4	12/-	6V6GT	7/6	25L6GT	5/6	724A	15/-
6D6	3/-	6V6M	8/-	25Y5	6/-	757	18/-
6E5	6/-	6X4	3/6	25Z4G	6/6	801	6/-
6F5G	5/3	6X5G	5/-	25Z5	7/6	803	22/6
6F5GT	5/9	6X5GT	5/3	25Z6GT	8/6	807	8/-
6F6G	4/-	6Y6G	6/-	28D7	6/-	808	8/-
6F7	6/-	6-30L2	8/6	30	5/-	813	75/-
6F17	5/-	6Z4	5/-	30C15	10/-	815	35/-
6F8G	6/6	7B7	7/6	30C18	11/-	829B	50/-
6F12	4/6	7C5	10/-	30F5	8/6	832	15/-
6F13	5/-	7C6	7/-	30FL1	10/6	832A	45/-
6F32	4/-	7C7	6/-	30FL12	19/-	866A	14/-
6F33	20/-	7H7	7/3	30FL13	6/-	884	10/-
6G6G	2/6	7Q7	7/-	30FL14	13/-	954	4/6
6H6M	1/6	7V7	5/-	30L15	15/-	955	2/6
6J4WA	10/-	7Y4	8/-	30P12	9/-	956	2/-
6J5	6/-	7Z4	4/6	30P19	13/-	957	5/-
6J5G	2/-	8D2	2/6	30PL1	15/-	958A	4/-
6J6	3/6	9D2	3/-	30PL13	15/-	C.R. Tubes	
6J6W	6/-	9D6	2/-	35L6GT	7/-	VCR97	40/-
6J7G	5/-	10F9	9/-	35T	17/6	VCR517	50/-
6J7M	8/-	12A6	2/6	35W4	5/-	VCR517B	55/-
6K6GT	5/6	12AH7	5/-	35Z3	10/-	VCR517C	60/-
6K7G	2/-	12AT6	5/-	35Z4GT	6/-	3FP7	45/-
6K7GT	4/9	12AT7	4/-	35Z5GT	6/-	5CP1	30/-
6K8G	3/-	12AT7WA	5/6	37	4/-	5FP7	12/6
6K8GT	8/3			38	4/-		

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Shepherds Bush 4946

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MANY OTHERS IN STOCK include Cathode Ray Tubes and Special Valves. U.K. Orders below £1 P. & P. 1/-; over £1, 2/-; over £3, P. & P. free. C.O.D. 2/6 extra. Overseas Postage extra at cost.

?

What is new from Richard Allan for the Audio Fair?

Well, for the moment we're keeping it dark, but we'll whet your appetite by telling you that it is a superb new Loudspeaker containing three units. This, however is where conventional similarity between it and other loudspeakers end, as it combines a refreshingly new approach to stereophonic reproduction with great flexibility and economy.

Designed and developed by the same team that produced the brilliant high fidelity module (which will also be making an appearance of course), you can be certain that something special will be heard in our demonstration room at the Audio Fair.

For further details please contact:
RICHARD ALLAN RADIO LIMITED
Bradford Rd., Gomersal, Nr. Leeds, Yorks.
Tel.: Cleckheaton 2442/3

Richard Allan

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AUTO TRANSFORMERS

For 110 v. equipment. Input 240 v., output 110 v., 3,000 watts. Completely enclosed in strong metal case. Terminal block output. £15, carr. 15/-.

2,000 watts. Enclosed in case fitted with two 2-pin American sockets or terminal blocks. Neon indicator. On/off switch and carrying handle. £10.19.6, carr. 10/-.

Also available. Completely shrouded, fitted with 2-pin American sockets, or terminal blocks. Please state which type required.

Wattage	Price	Carr.
1,500	£7.15.0	8/6
1,000	£4.19.6	7/6
500	£3.15.0	6/6
300	£2.9.6	5/6
150	£1.19.6	4/6
60	£1.12.6	4/-

CROUZET GEARED MOTORS

3 r.p.m., 24 v. A.C., 4 watts. Overall size 2½ × 2 in., length of spindle ¾ in. 25/-. P.P. 2/6.

SMITH'S GEAR MOTORS

1 rev. every 24 hours, 24 v. A.C., 50 cycles, 2 watts. Overall size 2 × 2 in., length of spindle ¾ in. 19/6, P.P. 2/-.

S.T.C. SELENIUM RECTIFIERS

Type B84-9-1 w. F.W. bridge. Max. A.C. input 162 v. D.C. output 140 v. 2½ amps., 57/6. P.P. 5/-. Type B67-9-1 w. 1½ amps. output, 37/6. P.P. 5/-. Type D84-4-3 w. Two required for F.W. Bridge. Max. A.C. input 72 v. D.C. output 60 v. 8 amps., 50/- per pair. P.P. 5/-.

RELAYS

Special Offer of Brand New 3000 Type Relays. All one price: 7/6 each. P.P. 1/6. 75Ω, 1CO, 3M, 1B. 150Ω, 2 Heavy Makes. 500Ω 6 CO. 2000Ω, 2 CO., 2 Heavy Makes.

Siemens Miniature Sealed Relays. Size 1½ × 1 × ¾ in. 700Ω, 4 CO. With Base. Brand New 8/6. P.P. 1/6.

MULTI-TAPPED TRANSFORMERS

MOST TYPES, FULLY SHROUDED AND TERMINAL BLOCK CONNECTIONS. ALL PRIMARIES 220-240 VOLTS

* Denotes Unshrouded Types

TYPE	SEC. TAPS	AMPS.	PRICE	CARR.
1A	25-33-40-50	15	£7 19 6	9/-
1B	25-33-40-50	10	£5 19 6	7/6
1C	25-33-40-50	6	£4 19 6	7/6
1D	25-33-40-50	3	£2 19 6	6/-
2A	4-16-24-32	12	£5 7 6	7/6
2B	4-16-24-32	8	£4 2 6	7/6
2C	4-16-24-32	4	£2 12 6	6/-
2D	4-16-24-32	2	£1 15 0	5/-
3A*	25-30-35	40	£12 15 0	15/-
3B*	25-30-35	20	£7 19 6	9/6
3C	25-30-35	10	£5 10 0	7/6
3D	25-30-35	5	£3 5 0	6/-
3E	25-30-35	2	£2 7 6	4/6
4A*	12-20-24	30	£9 15 0	10/-
4B	12-20-24	20	£5 19 6	8/6
4C	12-20-24	10	£3 19 6	7/6
4D	12-20-24	5	£2 15 0	6/-
5A	3-12-18	30	£7 5 0	7/6
5B	3-12-18	20	£5 9 6	7/6
5C	3-12-18	10	£3 5 0	6/-
5D	3-12-18	5	£2 5 0	5/-
6A	48-56-60	2	£2 17 6	4/6
6B	48-56-60	1	£1 19 6	4/6
7A*	6-12	50	£7 15 0	9/6
7B	6-12	20	£4 10 0	7/6
7C	6-12	10	£2 19 6	6/6
7D	6-12	5	£2 2 6	5/-
9A	15-30	1½	19 6	4/6
10A	1-15	2	19 6	4/6
11A	6-3	15	£1 17 6	5/6

Note: By using the Intermediate Taps many other voltages can be obtained. Example:

Range One 7-8-10-15-17-25-33-40-50 v.

Range Two 4-8-12-16-20-24-32 v.

Range Five 3-6-9-12-15-18 v.

SMITH'S 4 MINUTE TIMERS

Switch contacts 15 amp. 250 v. A.C., complete with chrome bezel and control knob. Min. operation time, 30 seconds, max. 4 minutes, brand new 17/6, p.p. 2/6.

NOW!

THE *World's smallest radio comes to you in the new "See for Yourself" sealed Kit pack*

SINCLAIR MICROMATIC

SIX STAGE TRANSISTOR RECEIVER

Now when you buy your Sinclair Micromatic kit, you see every component instantly in the new sealed polystyrene kit pack. Never before in the history of radio has any kit been so elegantly presented. Your Micromatic reaches you factory fresh and guaranteed. Check for yourself at once that every component is in place in the specially shaped and fitted case. The Micromatic does not cost you a penny more bought this way. Such is the appearance and performance of this brilliant new Sinclair design that you will want to build and use it immediately. There is no other set in the world as small, efficient and dependable as this. Reception both of home and overseas programmes often proves much easier than with larger conventional radios. In fact, your Micromatic will virtually play anywhere. ***It is also available ready built.***

- ★ MEASURES $1\frac{4}{5}'' \times 1\frac{3}{10}'' \times \frac{1}{2}''$
- ★ BEAUTIFULLY STYLED CASE
- ★ AMAZING POWER, RANGE AND SENSITIVITY
- ★ NEW CIRCUITRY
- ★ TUNES OVER M.W. BAND WITH BANDSPREAD AND A.G.C.
- ★ CALIBRATED TUNING DIAL
- ★ GUARANTEED 5 YEARS

TECHNICAL DESCRIPTION

The Sinclair Micromatic is housed in a neat plastic case with aluminium front panel and spun aluminium calibrated tuning dial.
Special Sinclair transistors are used in a six-stage circuit of exceptional power and sensitivity—two stages of powerful R.F. amplification; double diode detector; a high gain three stage audio amplifier. A.G.C. counteracts fading from distant stations. The set is powered by two Mallory ZM.312 Cells from radio shops, Boots Chemists, etc., for 1/7 each. Plugging in the earpiece included switches the set on, withdrawing switches off. Complete kit in pack with instructions and solder.

59/6

● READY BUILT

The Sinclair Micromatic is also available ready built, tested and guaranteed. Complete in presentation case with lightweight earpiece. **79/6**

FOR MORE BRILLIANT SINCLAIR DESIGNS SEE NEXT TWO PAGES

sinclair

SINCLAIR RADIONICS LTD., 22 NEWMARKET ROAD, CAMBRIDGE

Telephone 52996 (STD Code OCA3)

SINCLAIR STEREO 25

DE-LUXE PRE-AMP CONTROL UNIT

THE SINCLAIR STEREO 25 has been designed specially to ensure the highest possible standards of reproduction when used with two Z.12s or any other first class stereo power amplifier. Best possible components are used in the construction of this superb unit, whilst its appearance reflects the professional elegance characteristic of all Sinclair designs in hi-fi, radio and TV. The front panel of the Stereo 25 is in solid brushed and polished aluminium with beautifully styled solid aluminium control knobs. Mounting the unit is simple, and power is conveniently obtainable from the Sinclair PZ.3 which can also be used to supply two Z.12s to make a complete stereo assembly. Hi-fi enthusiasts seeking the ultimate in domestic listening will find all they want from this combination of Sinclair units. With a Micro FM for tuner, they will have an installation to compare favourably with anything costing from four to five times as much.

FOR USE WITH ANY GOOD STEREO SYSTEM

TECHNICAL SPECIFICATIONS

Performance figures obtained using Stereo 25, two Z.12s and a PZ.3.

- **SENSITIVITY** for 10 watts into 1.5 ohms load per channel. Mic.—2 mV into 50K ohms. Pick-up—3 mV into 50K ohms. Radio—20 mV into 4.7K ohms.
- **FREQUENCY RESPONSE** (Mic. and Radio)—25 c/s to 30 kc/s ± 1dB extending to 100 kc/s ± 3dB.
- **EQUALISATION** — Correct to within ± 1dB on RIAA curve from 50 c/s to 20 kc/s.
- **TONE CONTROLS** Treble +12dB to —10dB at 10 kc/s. Bass +15dB to —12dB at 100 c/s.
- **SIZE**—6¾in.x2¾in.x2½in. overall, plus knobs.
- **FINISH** — Front panel sectioned in brushed and polished solid aluminium with solid aluminium knobs. Black figuring on front panel.

BUILT, TESTED AND GUARANTEED **£9.19.6**

"Although a complete novice to radio I was able to assemble it (Micro-FM) without undue difficulty thanks to your clear and lucid instructions. I receive all B.B.C. programmes and local......very strongly."
H.T., Warrington, Lancs.

"The quality of reception (with Micro-FM) is 100%. I shall now purchase your Z.12 amplifier to go with it."
N.T.S., Luton, Beds

"I consider your after sales service is excellent. I wish very much that other suppliers treated their customers in the way you do. I have tried out the Micro-FM with the Z.12 and my Quad speaker and am very pleased with the results."
H.A., London, N.6

SINCLAIR MICRO-FM

COMBINED FM TUNER AND POCKET FM RECEIVER

ANYONE CAN BUILD IT

7 TRANSISTORS
●
NO ALIGNING
●
PULSE COUNTING DISCRIMINATOR
●
A.F.C.
●
TUNES 88-108 Mc/s
●
SIZE—less than 3″×1¾″×¾″

This unique, superbly engineered FM superhet is the only set in the world which can be used both as an FM tuner and an independent FM pocket receiver just whenever you wish. Problems of alignment have been completely eliminated making the Micro-FM ready for use the moment you have built it. The pulse counting discriminator ensures best possible audio quality; sensitivity is such that the telescopic aerial included with the kit assures good reception in all but the very poorest reception areas. The Sinclair Micro-FM will give you all you want in FM reception and the satisfaction of building a unique design that will save you pounds.

FM superhet using 7 transistors and 2 diodes. The R.F. amplifier is followed by a self-oscillating mixer and three stages of I.F. amplification which dispense with I.F. transformers and all problems of alignment. The final I.F. amplifier produces a square wave which is converted to produce the original modulation exactly. A pulse-counting discriminator ensures better audio quality. One output is for feeding to amplifier or recorder and the other enables the Micro-FM to be used as an independent self-contained pocket portable. A.F.C. "locks" the programme tuned in.

Complete kit, including transistors, case, aerial, earpiece, etc.

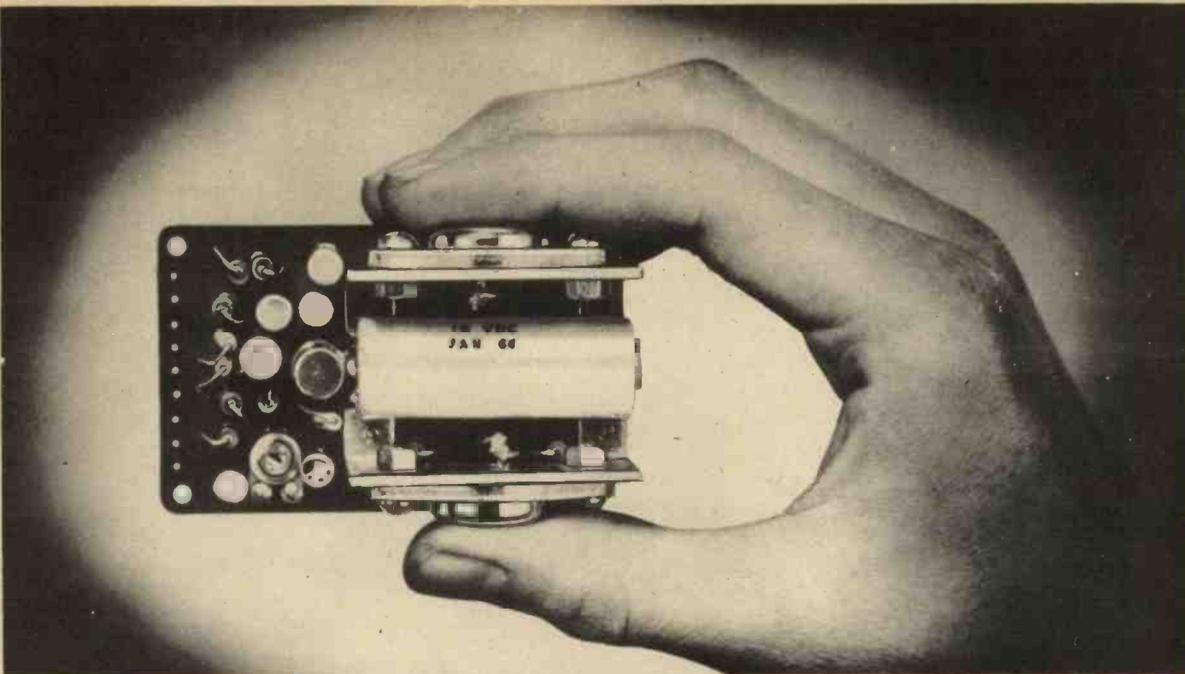
£5.19.6

FULL SERVICE FACILITIES AVAILABLE TO ALL SINCLAIR CUSTOMERS

sinclair

SINCLAIR RADIONICS LTD., 22 Newmarket Rd., CAMBRIDGE

Telephone 52996 (STD Code OCA3)



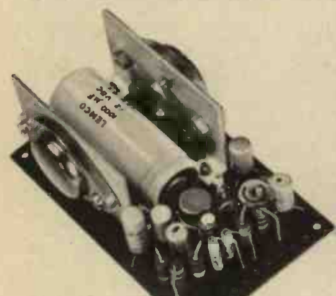
SINCLAIR Z.12

COMBINED 12 WATT HIGH-FIDELITY AMPLIFIER AND PRE-AMP

12 WATTS R.M.S. OUTPUT
CONTINUOUS SINE WAVE (24W. PEAK)

8 TRANSISTOR CIRCUIT WITH CLASS B ULTRALINEAR OUTPUT

IDEAL FOR HI-FI (STEREO OR MONO) CAR RADIO, ELECTRIC GUITAR, P.A., INTERCOM, ETC.



The amazing adaptability and rugged construction of this very powerful and exceptionally compact amplifier make it possible to use just one type of unit with outstanding success in an unusually wide variety of applications. Eight special H.F. transistors are used in a highly original circuit to achieve the characteristics demanded of any quality amplifier irrespective of price, yet this Sinclair unit costs well under £5, including its own integrated pre-amplifier. The Z.12 accepts radio, microphone and pick-up inputs. Detailed instructions for connecting these in mono and stereo are given in the manual supplied with every unit. A number of different control networks are also shown. The Z.12 will operate efficiently from any supply between 6 and 20 V. d.c, making it very convenient to run the amplifier from a car battery. Where it is required to run the Z.12 from mains supply, the PZ.3 is recommended. Those wishing to have a ready made pre-amp control unit can feed inputs via the Stereo 25, which, with two Z.12s will provide the finest stereophonic hi-fi possible—and the saving in cost is fantastic.

TECHNICAL SPECIFICATIONS

- Size 3 in. × 1¾ in. × 1¼ in.
- Class "B" ultralinear output
- **RESPONSE** 15-50,000 c/s ± 1 dB.
- Suitable for 3, 7·5 or 15Ω speakers. Two 3Ω speakers may be used in parallel
- **INPUT**—2mV into 2kΩ
- **OUTPUT**—12 watts R.M.S. continuous sine wave (24 w. peak); 15 watts music power (30 w. peak)
- Signal to noise ratio better than 60dB.
- Quiescent current consumption—15mA.

Built, tested and guaranteed. Ready for immediate use. With Z.12 manual.

89/6

YOUR SINCLAIR GUARANTEE
If you are not completely satisfied when you receive your purchase from us, your money will be refunded at once in full and without question.

If you prefer not to cut this page, please mention PE.467 when writing your order

PZ.3 MAINS POWER SUPPLY UNIT

This special power supply unit uses advanced transistorised circuitry to achieve exceptionally good smoothing. Ripple is a barely measurable 0.05 v. The PZ.3 will power two Z.12s and a Stereo 25 with ease.

79/6

To: SINCLAIR RADIONICS LTD., 22 NEWMARKET ROAD, CAMBRIDGE

Please send items detailed below: ....

NAME................................

ADDRESS................................

For which I enclose cash/cheque/money order PE.467

A new Sinclair Set—see page 243

sinclair

SINCLAIR RADIONICS LTD.
22 Newmarket Road, Cambridge 52996

COMPARE THESE PRICES

ELECTROLYTIC CONDENSERS

64uf.	..2·5V.	5uf.	.. 6V.	30uf.	..10V.	750uf.	..18V.
125uf.	..2·5V.	20uf.	.. 6V.	3uf.	..12V.	2·5uf.	..25V.
640uf.	..2·5V.	25uf.	.. 6V.	4uf.	..12V.	3uf.	..25V.
0·25uf.	.. 3V.	30uf.	.. 6V.	25uf.	..12V.	4uf.	..25V.
2uf.	.. 3V.	50uf.	.. 6V.	200uf.	..12V.	10uf.	..25V.
40uf.	.. 3V.	100uf.	.. 6V.	2·5uf.	..16V.	25uf.	..25V.
4uf.	.. 4V.	3·2uf.	..6·4V.	64uf.	..16V.	12·5uf	..40V.
500uf.	.. 4V.	40uf.	..6·4V.	200uf.	..16V.	3·2uf.	. 64V.

All at 1/- each, 9/- per dozen or mixed packet (our selection) 20 for 10/-.
150uf., 25V.: 400uf., 25V., 2/6 each. 5,000uf., 12V., 4/- each.
200/100, 275V.; 200/200, 275V.: 125/300/50, 275V.; 5/- each, 3 for 10/-.

PAPER CONDENSERS. SPECIAL CLEARANCE!
0·35uf., 150V.; 0·02uf., 350V.; A.C. 0·25uf., 350V.; 0·5uf., 350V.; 0·5uf., 500 V.; ALL at 15/- per 100.

Mixed packet containing 0·0001uf., 200V. to 0·5uf., 500V.
Very useful for service work! 50 condensers for 10/-.

RESISTORS

¼ watt, well assorted values, 10/- per 100, 55/- per 1,000.
½ watt to 3 watt, well assorted values, 10/- per 100, 55/- per 1,000.
TO CLEAR: 10 Meg. 1/6th watt resistors—to clear £1 per 1,000.

TRANSISTORS

Untested mixed, 50 for 10/-.
NPN Switching transistors; Min. 200 m/cs. 6 for 10/-.
PNP Switching transistors; Min. 200 m/cs. 6 for 10/-.

DIODES

Suitable for keying electronic organs, 20 for 10/-.
BY100 type rectifiers, 30/- per dozen.
ORP12 light cells, 9/- each.
TRANSISTOR BATTERY ELIMINATOR—same size as PP9, 30/-, PP6, £1.
BATTERY CHARGERS with meter, 4 amp, 6 or 12 V, 55/-.
LAPEL MICROPHONES, crystal or magnetic, 10/- each.
MINIATURE EARPIECES, complete with plug and lead, 5/- each.
SIGNAL INJECTOR, parts and circuit to make, 10/- each.
SIGNAL TRACER, parts and circuit to make, 10/- each.
MOTOR CAR REV. COUNTER, parts and circuit to make, 10/- each.
PORTABLE RADIOS, complete with leather case, earpiece, etc., fully guaranteed, 79/6 complete.
ACOS PICK-UP HEADS, Mono, 10/-, Stereo, 12/6, Diamond, 17/6.
SAPPHIRE STYLI, TC8LP; GC2LP; GC8LP; BF40LP; GP67LP; TC8 Stereo LP; Studio OLP; GP37; GP59; ALL AT 3/6 each.
POTENTIOMETERS—PRE-SET. 100 ohm to 680 K. ohm, 12 for 10/- (mixed)
MAGNETIC RECORDING TAPE, BRITISH MADE, FULLY GUARANTEED

STANDARD PLAY
3in., 150 ft., 3/6; 5in., 600 ft., 10/6; 5¾in., 900 ft., 13/6; 7in., 1,200 ft., 16/3.

LONG PLAY
3in., 225 ft., 4/-; 5in., 900 ft., 12/9; 5¾in., 1,200 ft., 15/9; 7in., 1,800 ft., 21/6.

DOUBLE PLAY
3in., 400 ft., 6/6; 5in., 1,200 ft., 20/-; 5¾in., 1,800 ft., 28/-; 7in., 2,400 ft. 34/-. 2½in. 300 ft., 6/9.

TRIPLE PLAY, POLYESTER
3in., 600 ft., 12/6; 4in., 900 ft., 16/6.
WELLER INSTANT HEAT SOLDERING KIT. 72/6 complete.
WELLER DUAL-HEAT SOLDERING GUN, only 57/6 complete.
PISTOL GRIP SOLDERING IRON ONLY, 10/-.
PHILIPS/STELLA/COSSOR remote control unit, value 3 gns., our price, 10/-.
RUMBLE AND SCRATCH FILTER, parts and circuit to make, 30/-.
TRANSISTORS, COMPONENTS AND CIRCUIT to convert 1ma. meter to 0 to 10 Meg. ohmmeter, 10/-.

G. F. MILWARD

17 PEEL CLOSE, DRAYTON BASSETT, NR. TAMWORTH, STAFFS.
TAMWORTH 2321 **POST ONLY**

Due to recent heavy increase in parcel rates, please include part postage cost.

the Wyndsor Vanguard . . . the most versatile recorder at its price* offering so many outstanding features . . .

- 4 track-3 speeds —7 in. spools
- Separate Record and replay amplifiers
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- Detachable lid fitted 8" speaker
- Tape Monitoring facility

- Push button controls
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- Straight through amplifier facility
- Bass, treble, volume and record gain controls
- Many other features

Before you buy an ordinary tape recorder write for full details of the Vanguard and other models.

* **All British and full value for money at only 59 gns. inc.1800 ft. LP tape and Tape manual. (less mike).**

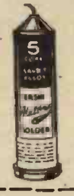
WYNDSOR RECORDING CO. LTD. (Dept. PE3)
Wyndsor Works, Bellevue Road, Friern Barnet, London, N.11. ENT. 2226

For quick, easy faultless soldering

ERSIN Multicore 5 CORE SOLDER

THE QUEEN'S AWARD TO INDUSTRY 1966

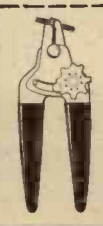
Easy to use and economical. Containing 5 cores of non-corrosive flux, instantly cleaning heavily oxidised surfaces. No extra flux required. Ersin Multicore Savbit Alloy reduces wear of copper soldering iron bits.



SIZE 5 HANDY SOLDER DISPENSER
Contains 12 ft. of coil 18 s.w.g. Ersin Multicore Savbit Alloy. Quick and easy to use.
2/6 each

NEW SIZE 15
21 ft coil of 60/40 Alloy. 22 s.w.g. in a dispenser. Ideal for small components, transistors, diodes, etc.
3/- each

SIZE 12
Ideal for home constructors. Contains 102 ft. of 18 s.w.g. Ersin Multicore Savbit Alloy on a plastic reel. 15/- each (Also available in other sizes)



BIB MODEL 8 WIRE STRIPPER AND CUTTER
Strips insulation without nicking the wire, cuts wire and splits plastic twin flex. Plastic cushioned handles. 8/6 each

From Electrical or Hardware shops. If unobtainable write to:
MULTICORE SOLDERS LTD., Hemel Hempstead, Herts. M29 B

See the **HEATHKIT EXHIBITION** (Concurrent with the Audio Fair)
at the GRAND HOTEL, SOUTHAMPTON ROW, LONDON. *Admission Free*
March 30th—April 2nd. 11 a.m.-9 p.m. (Sunday 8 p.m.). *The latest models will be on view*

Treat yourself to superb LW, MW entertainment with the High-Performance Car Radio Kit, CR-1

Complete your motoring pleasure with this small, compact, high-performance car radio. It can be fitted to any make of car having 12 volt positive or negative earth system. Tastefully styled in neutral grey with matching black knobs and chrome trim to harmonise with any car colour scheme.
Features include: Six-transistor, 2-diode circuit. Completely pre-assembled and aligned tuning unit. High sensitivity, combined with wide range automatic gain control (AGC), minimises fading under weak reception conditions. Easy-tune dial. Push button Long, Medium and Tone selection.

The car radio is available for your convenience, in two separate units; RF Amplifier Kit CR-1T £1 . 13 . 6 incl. P.T., IF/AF Amplifier Kit CR-1A £11 . 3 . 6.

TOTAL PRICE KIT (excluding Loudspeaker) £12 . 17 . 0 incl. P.T.
8"×5" Loudspeaker Pt. No. 401-505 £1 . 16 . 1 incl. P.T.

The Transistor Amplifier you have been looking for!

Low-cost Stereo Amplifier Kit, TS-23
Breaks the price barrier in quality Transistor Amplifier cost

Incorporates all the essential features for good quality reproduction from gramophone records, radio and other sources.
Its many features include: 3 watts rms (15Ω) each channel. Good frequency response for outstanding fidelity. Compact slim-line styling. Ganged BASS, TREBLE and VOL. controls, 6-position SELECTOR switch for programme sources. Attractive perspex two-tone front panel. 16 transistor, 4 diode circuit. Handsome fully-finished walnut veneered cabinet. Outputs for 8 or 15 ohm loudspeakers. Printed circuit boards. For free-standing or cabinet mounting. Size 3⅞"×13"×8" deep.

PRICES: Amplifier Kit £17 . 15 . 0
Amplifier Kit and Cabinet £18 . 19 . 0
Walnut Veneered Cabinet separate £2 . 0 . 0

Hi-Fi performance from a "Mini" Speaker Kit with the "AVON" BOOKSHELF SPEAKER SYSTEM

The challenge to our acoustic engineers was to design a speaker occupying the minimum space consistent with first class reproduction. The results of our efforts was this "AVON" compact unit of exceptional quality.
Features: Two special speakers 6½" BASS, 3⅜" HF unit and crossover network. Good frequency response. Beautiful fully-finished walnut veneered cabinet, size only 7¾"×13¼"×8⅜" deep.
Supplied in two units. Can be built for a total price.

Kit £13 . 16 . 0 incl. P.T.

A 3" Service Oscilloscope Kit with outstanding features. Model OS-2

The attractively styled OS-2 is a compact, lightweight, portable oscilloscope that fulfills many of the general requirements in Laboratories, Service Departments and Educational Training. It is ideal for use in production line testing where otherwise expensive equipment would be tied up on ordinary routine tests. The bandwidth of the OS-2 is from 2 c/s-3 Mc/s ±3dB, this 'scope can therefore be used in applications ranging through audio, ultrasonic and radio frequencies. The time base operates from 20 c/s to 200 kc/s in four ranges. Size 5"×7¾"×12" deep. Weight 9¾ lb.

Kit £23 . 18 . 0. Assembled £31 . 18 . 0
Optional extra L/Cap Probe Kit, PK-1 Kit £3 . 12 . 6

Many other models in wide range.
Prices quoted are Mail Order, Retail Prices in general 5% extra.
Full specification sheets of any model available upon request.

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for which I enclose £ s. d. post paid

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ADDRESS ....
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P.E.4

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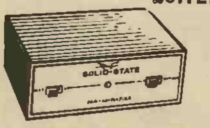
ALL ITEMS SENT POST FREE

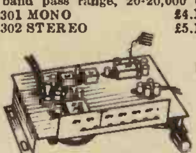
CP.110 11-PIECE CHASSIS PUNCH SET

Top grade machined steel. Contains ⅜", ½", ¾", 1" and 1¼" punches, complete with gripper and accessories in carrying case. **£3.12.6**



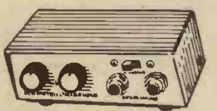
ALL TRANSISTOR MONO & STEREO PRE AMPLIFIERS

Provide extra stage of amplification for use with magnetic cartridges, tape and microphone inputs. Both models feature wide band pass range, 20-20,000 cps.
PRE 301 MONO £4.12.6
PRE 302 STEREO £5.15.0



EAGLE FMT41. FM TUNER

Sub-miniature 6 transistor 3 diode F.M. Tuner. Covers 88-108 Mc. Operates from 9-volt battery, micro miniature circuit giving brilliant FM reception. Ready to use, simply connect to your Hi-Fi amplifier. Instructions supplied. **£8.10.0**



REMOTE CONTROL STEREO HEADPHONE STATION LS.2

A junction box for connecting stereo headphones to a stereo or monaural system. Separate controls for each channel. On/off switch. Stereo sockets allow two sets of headphones to be used. With instructions and 20 ft. of 5 conductor cable. **£3.5.0**

EEK28. 28 PROJECT CONSTRUCTIONAL KIT

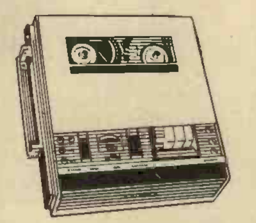
This advanced educational kit is excellent for beginners as well as the more advanced experimenter. Not even a soldering iron is needed. Complete with 60-page booklet giving full details of suggested circuits. **£6.10.0**

LA9P. AC ELIMINATOR

with a double wound step down transformer to operate 9v Radios, etc., from AC Mains. **£1.8.6**

SPECIAL OFFER! GOOSENECK PENCIL TYPE DYNAMIC MICROPHONE

Imp.: 50K ohm. Output —52db. Response 40—13,500 c.p.s. With base with on/off switch, stand adaptor and cable.
USUAL PRICE 4 GNS.
SPECIL OFFER PRICE 59/6.



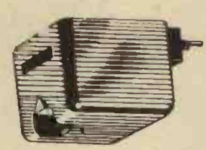
AIWA. TP. 712 2-SPEED 5' REEL MAINS AND BATTERY TAPE RECORDER

Loaded with features hitherto only found in more expensive tape recorders: AVC system adjusts recording volume level. TWO-WAY OPERATION: AC mains or batteries. TWO HOURS OF RECORDING TIME: using 1.5 mil 600 ft0. REMOTE CONTROL: TONE CONTROL: LEVEL METER: indicates recording and battery levels. Other features include 1⅞ and 3¾ ips speeds, smooth operating push-button keyboard, input for radio, record player, TV, etc., socket for an external speaker. Complete with Dynamic microphone, earphone, 5" 600' tape, 5" empty reel, batteries and AC lead.
Size: 12½" × 10¾" × 3½". **26½ gns.**

EAGLE PRODUCTS. MAGNETIC STEREO CARTRIDGES

As reviewed in Hi-Fi News, Sept. 1965.

M1007G. GOLD	M1007F. SILVER
Response: 20-20,000cps	Response: 20-18,000cps
Output: 5MV at 1Kc/5 cm/Sec.	Output: 10MV at 1Kc/5cm/Sec.
Stylus: 0.5 Mildiamond	Stylus: 0.7 Mildiamond
Tracking Pressure 1–2.5 grams.	Tracking Pressure 2–4 grams.
£6.12.6	**£5.14.6**



Both feature singularly smooth reproduction and incisive separation of stereo channels

EAGLE SA100. 10W INTEGRATED STEREO AMPLIFIER

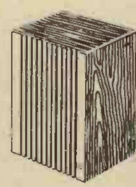
A compact, versatile integrated unit for monaural or stereophonic reproduction from record player, tape recorder and tuner. Power output 3 watts per channel. Frequency response 40-20,000 c.p.s. **£18.0.0**

EAGLE AFM100. AM-FM TUNER

Combines a host of advanced features that easily make it the finest AM-FM tuner in its class. A tuned RF stage on FM, AFC circuit and a heavy flywheel giving smooth but effortless tuning, built in AM Ferrite aerial. FM.88-108Mc. AM 535-1605 K/s. **£29.0.0**

MS80. 20W ROSEWOOD SPEAKER SYSTEM

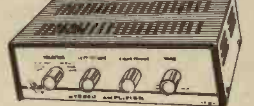
The perfect answer for the music lover who wants full range fidelity in a compact system. Features an 8in. full range high compliance speaker with an output capacity of 20 watts RMS. Frequency response: 30-20,000 c.p.s. Resonant frequency: 30-40 c.p.s. Sensitivity: 97 db/w. Flux density: Over 12,000. Impedance: 16 ohm. Size 14¼in. high × 10 5/16 in. wide × 8in. deep. **£14.14.0**

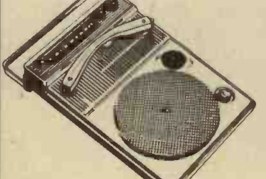


As well as this beautifully designed speaker there are two other models MS65. 10 watts RMS at £12.12.0 and MS40 5 watts RMS £8.10.0.
All three speakers are finished in magnificent rosewood and the entire cabinet filled with acoustic damping material.

SA. 80N. 8-WATT INTEGRATED STEREO AMPLIFIER

Recognised as the leading low price stereo amplifier. 4 watts per channel. Inputs for Pick-up (100mV) and Tuner (100mV). Frequency response 50-15,000 cps 200/250v. AC. Styled in Grey and Silver with metal knobs. **£12.0.0**





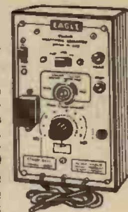
AIWA. P.172 3-SPEED 3-BAND MAINS AND BATTERY RADIO-RECORD PLAYER

Plays all records, 33⅓, 45 and 78 r.p.m., plus built-in LW/MW/FM radio. All in, a smartly designed portable, offering the best of both worlds: battery or AC mains operation. Large oval speaker gives exciting reproduction of your records and favourite radio stations anywhere and everywhere you go. 13-transistor circuit produces big power output. Complete with earphone, batteries, AC lead, carrying handle and 33⅓ rpm test record. Size: 10½" × 15¾" × 4". **29½ gns.**

FOR FULL DETAILS OF THESE AND MANY OTHER ITEMS SEND FOR FREE COMPREHENSIVE CATALOGUE, EAGLE NEWS AND ORDER FORM. ALL ITEMS AVAILABLE POST FREE AND COVERED BY 12 MONTHS' GUARANTEE.

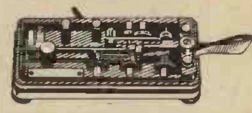
CALLERS WELCOME AT OUR HI-FI SHOWROOM

TT.144. Dynamic Transistor Tester



Tests in-circuit or out of circuit. Identifies PNP and NPN types. Indicates electrode open circuits, short circuits and current drain. Complete with instructions. £4.10.0

TT.145. De luxe Transistor Diode Tester. £9.7.6

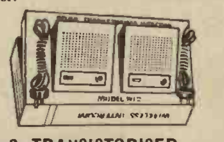


KY.102 SEMI-AUTOMATIC BUG KEY

7 adjustments for speed and comfort. Key adjustment for tension, swing, speed, etc. Precision, tooled anti rust, nickel-plated, brass and stainless steel operating parts. Variable speed capable of 5 to approx. 60 wpm. Complete with cord and transparent dust cover **£5.12.6**

RF.40 RF FIELD INDICATOR

Broad tuning covers 1-250 Mc/s in five calibrated bands. Can also be used as frequency checker. Detects undesired radiation or spurious frequencies. RF is measured on an accurate 200 μA panel meter. **£4.10.0**

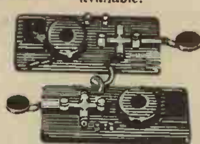


WI-2. TRANSISTORISED WIRELESS INTERCOM

No wires, no installation needed, simply plug them into AC power point and talk. Units have press-to-talk lock switch and on-off volume control. Ideal Intercom or Baby Alarm for home, office, factory. **£14.12.0** Complete.

DP303. DOOR PHONE INTERCOM

Ultra sensitive transistorized intercom designed so that you may answer the door from within for greater convenience and safety.
£4.12.6 Other intercoms available.



MCK.2. MORSE CODE KIT

Two station morse code kit supplied with instructions, 50ft. of connection wire and morse code charts. **£2.2.0**

WIRELESS MICROPHONES

WM909 (as illustrated) Pocket FM Wireless transmitter complete with tie-pin microphone. Transmits clearly up to 100 yds. and is fully tunable over the entire FM band. Simply used with an FM radio or tuner. **£14.0.0**

Also available WM808 Professional stick type FM Wireless Microphone. **£21.0.0**

These cannot be operated in U.K.

RELDA RADIO LTD. (Dept. P.E.16), 87 Tottenham Court Road, London, W.1

THE AMPLIFIER FOR CERAMIC PICKUPS

222 STEREO AMPLIFIER

There are a number of ceramic pickups capable of giving excellent results with a good amplifier.

Our 222 was expressly designed for these pickups. It has all the facilities you look for in a high fidelity amplifier and a choice of matching FM and AM-FM tuners.

For those who wish to use a magnetic pickup there is the 221 amplifier, which has other additional facilities.

221 STEREO AMPLIFIER	£35 10 0
222 STEREO AMPLIFIER	£28 15 0
223 AM-FM TUNER	£31 9 0
224 FM TUNER	£25 2 3
OPTIONAL CASE, teak and vinyl hide as illustrated. All models	£3 10 0
M5 STEREO RADIO DECODER	£14 10 0

For full details and technical specifications of all models, plus list of stockists, post coupon or write mentioning 4PE67.

ARMSTRONG AUDIO LIMITED
WARLTERS ROAD, LONDON, N.7
Telephone: NORTH 3213

Armstrong

AUDIO FAIR. BOOTH 45 — ENQUIRY ROOM 539, DEMONSTRATION ROOM 538

name ....

address ....

4PE67 ....

RADIOGRAM CABINETS 19 Gns.

An elegant Stereogram Cabinet in modern Veneered Mahogany and Cloth covered Front Panel
BLACK LEATHERETTE SIDE PANELS
Dimensions : 52 × 17½ × 12
Speaker positions for Twin 10" × 5" Speakers
OTHER MODELS—SEND FOR LIST

TWO-YEAR GUARANTEE EX-RENTAL TELEVISIONS

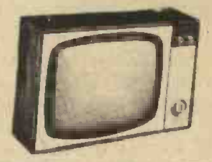
17 in. £11.10.0
3 star Guarantee

★ Tube
★ Valves
★ Components

Channels for all areas
Insured Carriage 30/-

FREE ILLUSTRATED LIST

Slim line models
17" — 19" — 21" — 23"
A wide range of sizes, models and prices.
Demonstrations daily



TRANSISTOR CASES 7/6. 9½" × 6½" × 4½" P. & P. 3/6.

TRANSISTOR CASES 19/6. Cloth covered, many colours. Size 9½" × 6½" × 3½" P. & P. 3/6. Similar cases in plastic 7/6.

RECORD PLAYER CABINETS 49/6. Latest designed covered cabinets. Takes any modern Autochanger. P. & P. 7/6.

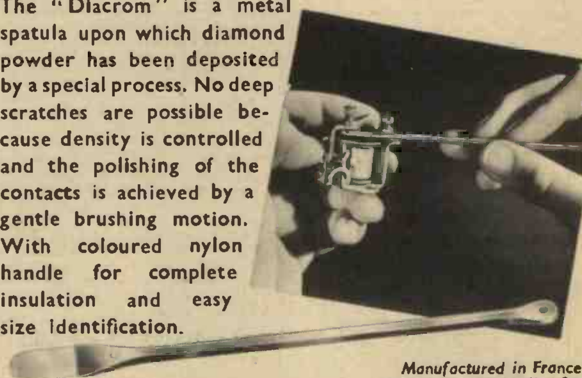
SINGLE PLAYER CABINETS 19/6. P. & P. 7/6.

T.V. TURRET TUNERS 2/6.
New Less Valves. Slim Models 5/-. Press Button Models 19/6. P. & P. 2/6.

DUKE & CO. (LONDON) LTD.
621/3 Romford Road, Manor Park, E.12
Phone: ILFord 600-1-2-3. Stamp for Free List.

Keep those Contacts CLEAN by using a
DIACROM SPATULA

The "Diacrom" is a metal spatula upon which diamond powder has been deposited by a special process. No deep scratches are possible because density is controlled and the polishing of the contacts is achieved by a gentle brushing motion. With coloured nylon handle for complete insulation and easy size identification.



Manufactured in France
British Patents applied for

- Grain size 200, thickness 55/100 mm., both faces diamonded. For quick cleaning of industrial relays and switching equipment, etc.
- Grain size 300, thickness 55/100 mm., both faces diamonded. For smaller equipments, like telephone relays, computer relays, etc.
- Grain size 400, thickness 25/100 mm., one face diamonded. For sensitive relays and tiny contacts. Two close contacts facing each other can be individually cleaned, because only one face of the spatula is abrasive.

Sole Distributors for the United Kingdom

SPECIAL PRODUCTS (DISTRIBUTORS) LTD.
81 Piccadilly, London, W.1. Phone: (01) 629 9556

As supplied to the War Office, U.K.A.E.A., Electricity Generating Boards, British Railways and other public authorities; also to leading electronic and industrial users throughout the United Kingdom.

NEW BARGAINS

Moving coil meter. 2½in. flush mounting 5-0-5 MA centre zero. 25/- each.
Moving coil meter. 2½in. flush mounting 250-0-250 micro amps centre zero. 29/6 each.
50 ohm 50 watt wire wound pot-meter 8/6 each.
20 K wire wound pot-meter. 20 watt type made by Colvern complete with control knob 10/- each.
1 meg. miniature pot-meter Morganite standard ¼in. spindle 1/- each. 9/- per dozen.
1 meg. miniature pot-meter Morganite pre-set screwdriver control. 9d. each. 8/- per dozen.
Pre-set 100 K by Welwyn with intrical bakelite knob. 1/- each. 9/- per dozen.
100 K pot-meter miniature type with double pole switch and standard ¼in. spindle, by Morganite 2/- each. 18/- per dozen.
25 K pot-meter standard size with double pole switch by Egan with full length ¼in. spindle 3/- each. 36/- per dozen.
Blanketstat glass enclosed, normally closed circuit, will open should blanket overheat. 4/6 each.
Thermal Relay. Can be used to delay the supply of HT while heaters warm up, or will enable 15 amp. loads to be controlled by miniature switches or relays. Regular list price over £2, price 7/6 each.
Siemens high speed relay. Twin 1000 ohm coils. Platinum points changeover contacts. Ex equipment 8/6 each.
Electrolytic condenser. 500 MF 50v. working. 5/- each. 48/- per dozen.
Waterproof heating element. 26 yards length, 70 watt. Self regulating temperature control. 10/- post free.
Footswitch. Two snap-action switches in metal box with flex lead. Ideal to control tape-recorder, dark room lamp, etc. 18/6 plus 2/9 postage and insurance.
Toggle Switch Bargain. 10 amp. 250 volt normal one hole fitting. 2/9 each or 30/- per dozen.
Electric Lock. 24 volt coil, but rewindable to other voltages. 4/6 each.
Compression Trimmers. Twin 100PF. 1/- each. 9/- per dozen.
Miniature Relay. American make. 630 ohm coil 20/30 volt operation. 2 pole changeover. 3/- each. 30/- per dozen.
Precision Wheatstone Bridge. Opportunity to build cheaply. 100K wire wound pot. 15 watt rating only 5/-.
Sheet Paxolin. Ideal for transistor projects. 12 panels each 5 × 8in. 5/-.
3in. PM Loudspeakers. 3 ohm 12/6. 80 ohm 13/6.
Transistor Ferrite Slab Aerial with medium and long wave coils 7/6 each.
Slide Switch. Sub miniature double pole changeover 2/- each. 18/- per dozen.
Magslips (Selsyns) American made transmitter and receiver 27/6 each. Post 4/6 for any one or the pair.

SEMI-CONDUCTOR BARGAINS

Type No.	*Price*	*Type No.*	*Price*	*Type No.*	*Price*
2N1727	15/-	MAT101	8/6	OC71	3/6
2N1728	10/-	MAT120	7/9	OC72	5/-
2N1742	25/-	MAT121	8/6	OC75	6/-
2N1747	25/-	OA5	5/-	OC76	5/-
2N1748	10/-	OA10	6/-	OC77	7/-
AC107	9/-	OA47	3/-	OC78	5/-
AC127	9/-	OA70	2/-	OC78D	5/-
ACY17	8/6	OA79	2/6	OC81	5/-
ACY18	5/6	OA81	2/6	OC81D	5/-
ACY19	6/6	OA85	2/6	OC82	5/-
ACY20	5/6	OA90	2/6	OC83	5/-
ACY21	6/-	OA91	2/6	OC84	6/-
ACY22	4/6	OA200	3/3	OC139	8/6
AF114	7/-	OA202	4/3	OC140	12/6
AF115	6/6	OC22	10/-	OC170	5/-
AF116	7/-	OC23	17/6	OC171	6/-
AF117	5/-	OC24	15/-	OC200	9/-
AF118	10/-	OC26	7/6	OC201	12/6
AF139	12/6	OC28	15/-	OC202	13/6
AF186	17/6	OC29	17/6	OC203	12/6
AFZ12	15/-	OC35	12/6	OCP71	15/-
ASZ21	15/-	OC36	15/-	ORP12	8/6
BC107	14/6	OC42	6/6	ORP60	5/-
BY100	4/6	OC44	4/-	SB078	6/6
BYZ13	7/6	OC45	3/6	SB305	8/6
MAT100	7/9	OC70	4/-	SB251	10/-

S.C.Rs (THYRISTORS)
100 v. 1 amp. 6/6, 3 amp. 7/6, 12 amp. 15/-, 400 v. 1 amp. 15/-, 3 amp. 17/6, 5 amp. 22/6, 25 amp. £3, 50 v. 1 amp. 6/6, 3 amp. 7/6, 10 amp. 10/-, 25 amp. 30/-.

SILICON PLANAR TRANSISTORS

2N2926 — general purpose type. Suitable for A.F. or R.F. up to 200 mc/s, 3/- each or 4 for 10/-.

SILICON RECTIFIERS
Tested and guaranteed

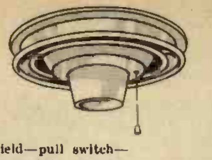
750mA 100v. 1/3 — 200v. 1/6 — 400v. 3/6
1 Amp 100v. 3/- — 200v. 4/6 — 400v. 6/-
3A 100v. 3/6 — 200v. 5/- — 400v. 7/6 — 600v. 9/6
10 Amp 100v. 9/6 — 200v. 12/6 — 400v. 14/6

Sub miniature glass encased—only approx. ⅛in. long wire ended.
750mA 50v. 1/6 100v. 2/6 200v. 4/6 400v. 6/6

FLUORESCENT LIGHT KITS

Comprising choke, lampholders, starter and two chrome tube clips. 20 watt 19/6. 40 watt 11/6. Super Silent 40 watt 17/6. 80 watt 17/6. 65 watt 19/6. All 4/6 P. & P.

HEAT AND LIGHT UNIT

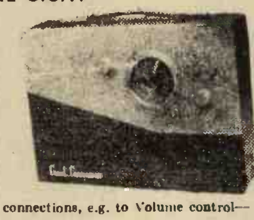


Bring luxury to your bathroom—have comforting heat where you now only have light—all the parts to build a full size (16in. diameter) model are now available—you will build it in an hour—12in 750 watt circular silica glass encased element—opal bowl for up to 100 watt lamp—non-rust spun reflector—white enamelled base heat shield—pull switch—magnificent unit as sold normally at £4.5.0 only 49/6 plus 7/6 carr. and insurance.

NIM COMPUTER

This computer will play games and do simple tricks and will provide endless amusement as well as education into computerisation. Kit comprises all the components, the printed front panel and full instructions. The box is not included but this can be made very simply from plywood. Price £4.17.6 plus 3/6 post and insurance.

SUPERTONE G.C.V.



Saves you work—
It's partly built
Like its predecessors this latest Companion has full fi performance—such as only a good wooden cabinet and biflux speaker can give, and due to its being partly built you will have it going in an evening. Note these features:

- All Mullard Transistors including 3 × AF117.
- Two-tone Cabinet. size 11 × 8 × 3in.
- All circuit requirements—Push-pull output—A.V.C. and feed back, etc.
- Printed circuit board all wired only connections, e.g. to Volume control—W C. Switch and Tuning Condenser.
- Pre-aligned IF stages complete with full instructions. Price only £3.19.6 plus 6/6 post and insurance.

THIS MONTH'S SNIP

THE VECTRONOME CAPSTAN DRIVEN TAPE RECORDER

This is a truly portable self-contained instrument with built-in microphone and loudspeaker using a 7 transistor amplifier with P.P. output and suitable for operation from mains or by chargeable batteries. Tape capacity is 25 minutes on easily change spools. A tape position indicator gives quick reference to any part of dictation. Recording level is automatically preset during dictation and can be adjusted to suit operator. Interlock prevents unintentional erasures. Tape speed controlled by fly wheel driven capstan. Very portable in neat case with carrying handle, overall size of which is approximately 6¼ × 7½ × 2in. Price with tape and mains unit but less batteries. £5.19.6 (rather less than 1/3 original price). Postage and insurance 7/6. Unused and in perfect working order.

F.M. TUNER

of exceptional quality, giving really fantastic results with virtually no noise. Suitable for mains or battery operation. 6 transistors—three IF stages—double tuned discriminator. Complete, new, and built up all ready to work on chassis. Size 6in × 4in. × 2in. with tuning scale and slow motion drive. A £12.12.0 tuner for only £8.10.0.

FINE RECORD PLAYERS ARE GARRARDS

and because they have been making record players for so long, GARRARD are your best choice—big range always in stock.
7/6 for post and ins.

2000	£6 9 6
3000	£7 19 6
AT60	£11 11 0
SP25	£10 9 0
LAB80	£25 0 0
SRP12	£3 9 0

Complete with service sheet and template.

HALF PRICE PROPRIETARY TAPES

brand new, unused and guaranteed perfect and not second in any way—a connoisseur's tape on normal spools and in normal boxes.

Standard Play	5in.	600ft 9/-		Long play	5in.	900ft 11/6
	5¾in.	900ft. 11/6			5¾in.	1,200ft. 16/-
	7in.	1,200ft. 16/-			7in.	1,800ft. 23/-

£3 post free otherwise add 2/- post and ins.

MINIATURE WAFER SWITCHES

Number of Positions

	2	3	4	6	12
1 pole	3/6	3/6	3/6	3/6	3/6
2 pole	3/6	3/6	3/6	3/6	
3 pole	3/6	3/6	3/6		
4 pole	3/6	3/6			

Any 12 switches ordered together 40/-.

MAINS TRANSISTOR POWER PACK

Designed to operate transistor sets and amplifiers. Adjustable output 6v. 9v. 12 volts for up to 500 mA (class B working). Takes the place of any of the following batteries: PP1, PP3, PP4, PP6, PP7, PP9, and others. Kit comprises: mains transformer-rectifier, smoothing and load resistor, 5,000 and 500 mfd. condensers, Zener diode and instructions. Real snip at only 14/6, plus 3/6 postage.

HI-FI SPEAKER BARGAIN

12in. High fidelity loudspeaker. High flux permanent magnet type with either 3 or 15 ohm speech coils. Will handle up to 10 watts. Brand new by famous maker. Price 29/6 with built-in tweeter 35/- plus 3/6 post and insurance.

TUBULAR HEATERS

New and unused made by G.E.C. rated at 60 watts per ft.—these are ideal in airing cupboards, bedrooms, offices, stores, greenhouses, etc., curtains or papers can touch them without fear of scorching or fire. Supplied complete with fixing brackets and available in the following sizes. Prices which are about ⅓ of list price includes carriage by B.R.S. 8ft. 30/-; 10ft. 36/-; 12ft. 42/-. Also in twin assemblies (one pipe above the other) 4ft. 40/-; 5ft. 46/-; 6ft. 52/-.

750mW TRANSISTOR AMPLIFIER

4 transistors including two in push - pull input for crystal or magnetic microphone or pick-up—feed back loops—sensitivity 5 m/v.

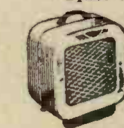
Price 19/6

Post and insurance 2/6. Speakers 3in. 12/6; 5in. 13/6; 6 × 4in. 14/6.

PHOTO ELECTRIC KIT

All parts to make light operated switch/burglar alarm/counter, etc. Kit comprises printed circuit, Laminated Boards and chemicals. Latching relay. Infra-red sensitive Photocell and Hood. 2 Transistors, cond., Terminal block. Plastic case. Essential data, circuits and P.C. chassis plans of 10 photo electric devices including auto. car parking light, modulated light alarm. Simple invisible ray switch—counter—stray light alarm—warbling tone electronic alarm—projector lamp stabiliser, etc., etc. Only 39/6 plus 2/- post and insurance.

2½kW FAN HEATER

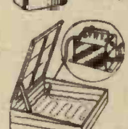


3 heat positions to suit changes in weather: 1kW. 1½kW and 2½kW: also blows cold for summer. has thermostatic safety cut out "Proper" price £5.17.6. Yours for only £3.15.0. Plus 7/6 post and insurance.

MOVING COIL METER BARGAIN

Panel meters are always being needed and they are jolly costly when you have to buy them in a hurry—so you should take advantage of this offer: 2in. moving coil flush mounting meters only 5/6. These are actually R.F. meters and cost about £3 each but if you don't want them for R.F. then all you have to do is to remove the thermocouple and you will have a 2-3 mA. meter which you can make into almost anything by adding shunts or series resistor. These are ex-government, of course

PP3 Eliminator—play your pocket radio from the mains! Save £'s. Complete component kit comprises 4 rectifiers—mains dropper resistances, smoothing condenser and instructions. Only 6/6 + 1/- post.



Be first this year
SEED AND PLANT RAISING
Soil heating wire and transformer. Suitable for standard size garden frame. **19/6** plus 3/6 post and ins.

NEON MAINS TESTER

Good length leads 2/6.

Where postage is not definitely stated as an extra then orders over £3 are post free. Below £3 add 2/9.

ELECTRONICS (CROYDON) LIMITED

(Dept. PE), 102/3 TAMWORTH RD., CROYDON, SURREY *(Opp. W. Croydon Stn.)*
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VOL. 3 No. 4
APRIL 1967

PRACTICAL ELECTRONICS

FALSE ECONOMY

WHICH consideration is uppermost in most amateurs' minds when the building of a piece of equipment is contemplated—is it technical performance, or is it cost?

Just as when purchasing a piece of commercially made equipment, "you get what you pay for" broadly speaking. But in this case you are paying for materials alone. (Other considerations apart, there is always a built-in economy in any self-made equipment since the labour is free; indeed, this provides an additional bonus in the form of the pleasure and satisfaction arising from a job well done.)

The amateur is thus left to decide whether the material cost is of prime importance, or whether the aim first and foremost is to achieve a performance and reliability of a high standard of excellence.

Certainly the materials involved and hence the cost of the project cannot be lightly regarded in any case, particularly if one is without an accumulated stock of components upon which to draw. The amateur will naturally enough look for a design which is not unnecessarily extravagant in components, but which will provide the desired performance.

This is where a pitfall looms for the unwary. . . . Superficial examination of a particular circuit diagram may provoke the thought that this could be reduced to a simpler form and considerable economy thus effected in component costs.

Often it is very tempting to see if the desired function can be obtained with a more rudimentary form of circuit. A component or two may appear superfluous in the published design and indeed the device may operate (apparently quite efficiently) without their aid. Alas, the initial good fortune of the innovator may well prove to be but an illusion and sudden failure or deterioration in performance, or the emergence of other defects, may cause unwarranted incriminations to be levelled at the original designer!

We would be the last to discourage individual enterprise. Published designs are frequently amenable to modification—sometimes for the better. But we do suggest that the would-be innovator makes certain he is well acquainted with the philosophy underlying the circuit design and that the intention of the original designer is understood before seeking to effect improvements.

This caution applies equally well whether the motivation to introduce changes arises from economic or from technical considerations.

THIS MONTH

CONSTRUCTIONAL PROJECTS

SPECIAL SERIES

GENERAL FEATURES

NEWS AND COMMENT

Our May issue will be published on Friday, April 14

All correspondence intended for the Editor should be addressed to: The Editor, PRACTICAL ELECTRONICS, George Newnes Ltd., Tower House, Southampton Street, London, W.C.2. Editorial and Advertisement Offices: PRACTICAL ELECTRONICS, George Newnes Ltd., Tower House, Southampton Street, London, W.C.2. Phone: Temple Bar 4363. Telegrams: Newnes Rand London. Subscription Rates including postage for one year, to any part of the world, 36s.

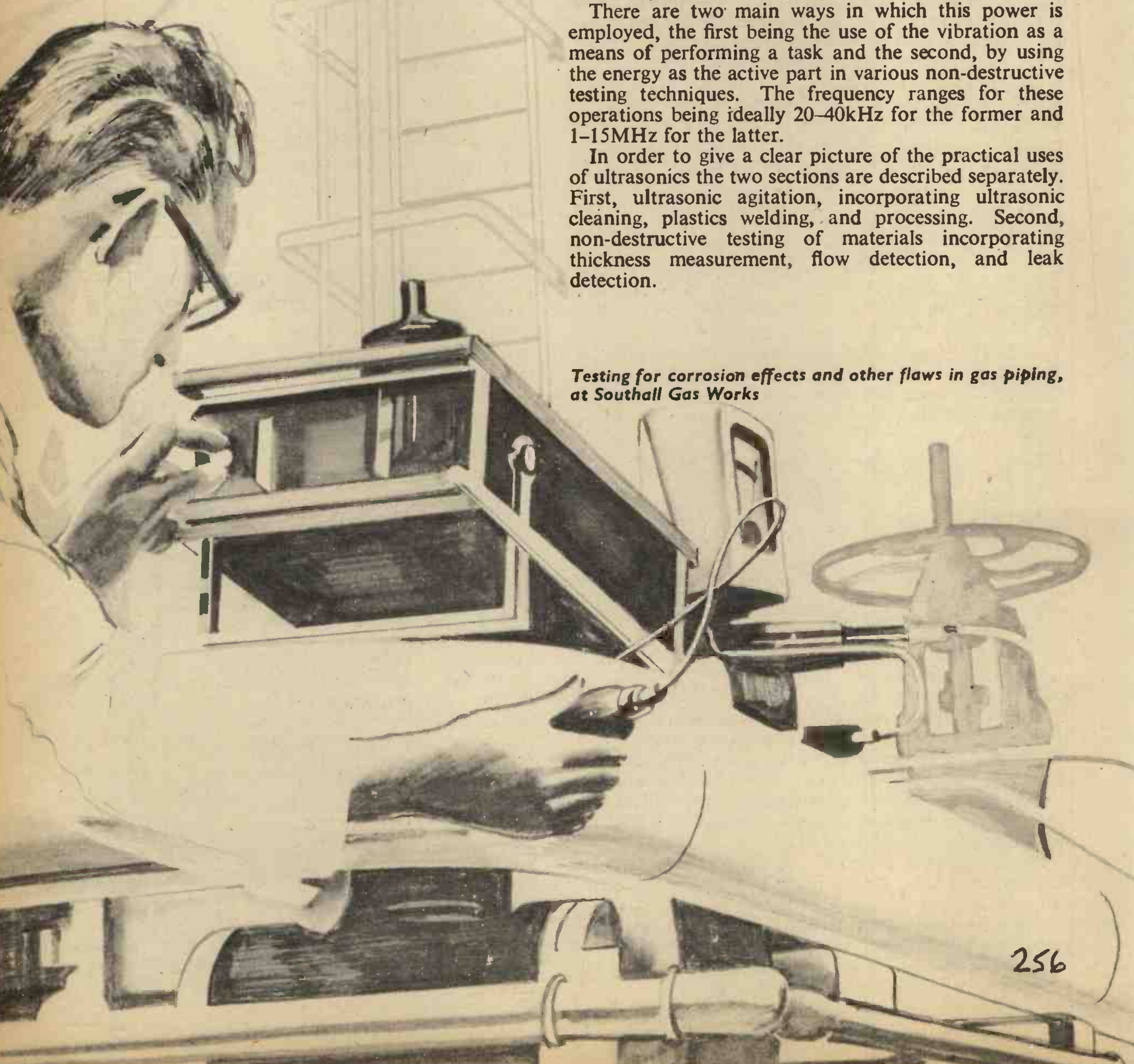
ULTRASONICS

By C. P. Wright
Dawe Instruments Limited

ULTRASONICS—acoustic energy above the hearing range of the normal human ear—has been in use for several years, although the discovery of new applications is still a common occurrence. The actual working power of ultrasonics is obtained when the ultrasonic sound energy is converted, by a transducer, into mechanical energy at the same frequency, i.e. above 20,000Hz.

There are two main ways in which this power is employed, the first being the use of the vibration as a means of performing a task and the second, by using the energy as the active part in various non-destructive testing techniques. The frequency ranges for these operations being ideally 20–40kHz for the former and 1–15MHz for the latter.

In order to give a clear picture of the practical uses of ultrasonics the two sections are described separately. First, ultrasonic agitation, incorporating ultrasonic cleaning, plastics welding, and processing. Second, non-destructive testing of materials incorporating thickness measurement, flow detection, and leak detection.



Testing for corrosion effects and other flaws in gas piping, at Southall Gas Works

AT WORK

ULTRASONIC CLEANING

Ultrasonics provides an unrivalled method of cleaning small and delicate parts, large complex castings and even complete assemblies both quickly and thoroughly without risk of damage.

Three basic components are required, an ultrasonic generator or power supply, a transducer and a cleaning tank. A high voltage at a frequency of, say, 25kHz from the generator is applied to the transducer, where it is converted into mechanical vibrations of the same frequency.

The active part of the transducer is a piezo-electric, ceramic, or magneto-strictive element having a very high transfer efficiency (electrical energy to mechanical energy) which will physically vibrate when the output from the generator is applied to it. Multiples of these transducers are attached to the underside of the radiating surface of either a stainless steel cleaning tank or a waterproof immersible container.

The ultrasonic energy from the transducer is transmitted into the cleaning fluid where, at a sufficient power level, the liquid will be caused to cavitate. The cavitation of the liquid produces a scrubbing action on the surface of the part to be cleaned and removes extremely tenacious soil.

There are many occasions where the part to be cleaned has some almost inaccessible surfaces, e.g. complete electrical assemblies or blind holes in complex castings. The ultrasonic vibrations will penetrate even the smallest crevice.

A recent development uses automatic generators which are self-tuning to give high cleaning efficiency regardless of changes in the operating conditions of the cleaning tank, i.e. load, liquid level, temperature. This type of generator is suitable for production line cleaning. In some instances, the application demands special treatment which is not suited to a standard generator and cleaning tank combination. In such cases special ultrasonic cleaning units, incorporating several generators, tanks, filters and ancillary equipment are usually designed by the manufacturer.

To take an example, a unit has recently been installed to clean stainless steel hypodermic needles. The point of the needle is formed by a grinding process during which time each needle, held on a piece of sticky tape, picks up swarf or grinding wheel abrasive which is removed by ultrasonic cleaning. The taped needles are rolled and placed vertically into a tray which is immersed into each tank in turn.

The first tank contains an alkaline solution. The second tank rinses this solution off the needle by using hot water. The third tank contains a heated acid solution and is agitated by ultrasonic transducers. The tank is fitted with two immersible transducers, which are driven by a manually tuned ultrasonic generator, having an average power output of 300 watts, housed at the end of the console.

The fourth tank contains a hot water rinse and the needles are finally rinsed in de-ionised water in the fifth tank.

The solutions in the first, third and fourth tanks are continually filtered, the filter for the third tank being designed to remove all particles larger than 5 microns (approximately 0·0002in).

PLASTICS WELDING

Similarly it is possible to weld together rigid thermoplastic parts without the use of solvents, adhesives or heat. The ultrasonic energy is transformed into mechanical vibrations by the vertically mounted transducer. The ultrasonic vibrations, emitted from the horn, are coupled into the plastics by touching the tip against either of the two parts being joined. The vibrating plastics remains perfectly cool, except at the periphery, where there is a rapid dissipation of energy and an instantaneous weld occurs around the periphery of the object.

This process was introduced to this country fairly recently for the manufacture and assembly of two-tone plastics bowls. Each bowl consisted of an injection moulded inner and outer skin, joined together at the rim by ultrasonic welding. No finishing operation is necessary after welding.

Further developments are currently being carried out on this technique and it has already been found possible to weld metal inserts into plastics by ultrasonics.

ULTRASONIC PROCESSING

The use of ultrasonic power for processing biological cells, performing or accelerating chemical activity in liquids or for other similar operations is performed by a similar system to that used for ultrasonic cleaning.

A generator converts the electrical input to ultrasonic power at about 20kHz and this is fed to a vertically mounted sonic converter, the active element of which is a piezo-electric ceramic, lead zirconate titanate, which transforms the ultrasonic power to mechanical vibrations. Energy from the transducer is concentrated and intensified by a "step-horn" and focused in the tip. The resulting energy radiates from the tip into the material being treated.

Using this equipment, with adjustment to output level and period of application, it is possible to perform the following processes: the disruption of individual cells; the homogenisation of cell components; the fragmentation of tissue into its component cells; the acceleration of enzymatic and chemical activity; the stimulation or inhibition of bacterial activity; the homogenisation and emulsification of immiscible liquids; the dispersion of solids in liquids and the de-gassing and deaerating of liquids.

Vertical sonic-converter, fitted with a "step-horn" to intensify the energy

NON-DESTRUCTIVE TESTING

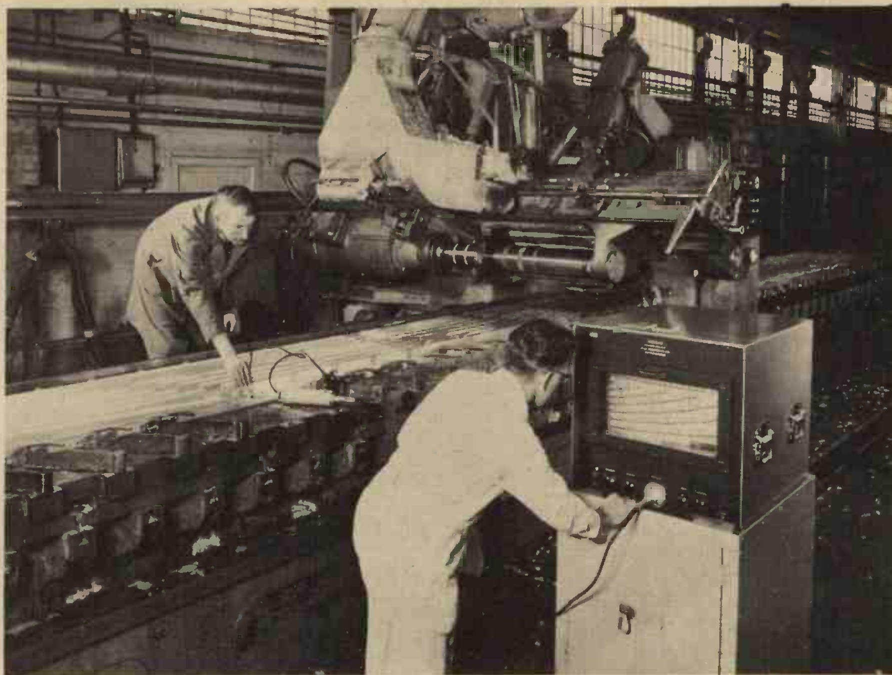
Over the past decade, ultrasonics has become an established science for testing, gauging, quality control and maintenance in many forms of industry. The basic theory behind its use is in the interpretation of the behaviour of vibrational waves in materials.

From this information it is possible to measure the thickness of the material, successfully detect and locate flaws and discontinuities, obtain knowledge of the material's own properties and determine its hardness. Recent developments have enabled accurate location of leaks from pressurised vessels to be made.

THICKNESS GAUGING AND FLAW DETECTION

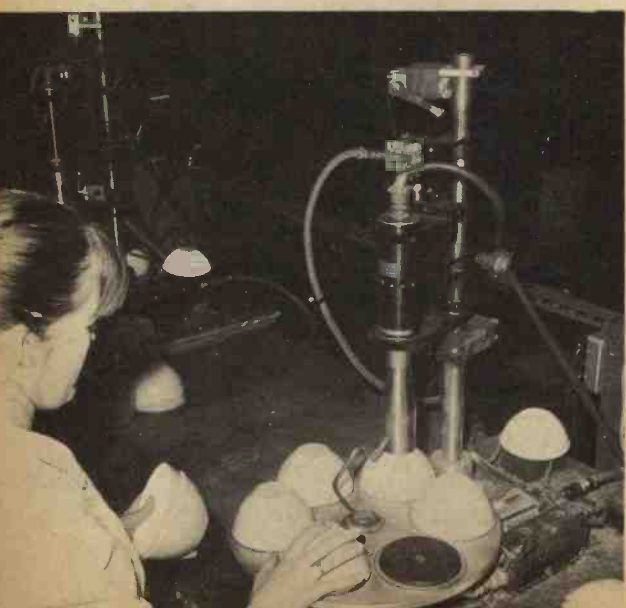
There are two basic methods of testing by ultrasonics which are classified as pulse-echo and resonance techniques.

The operating principle of the pulse-echo technique is similar to that used for measuring the depth of the sea. An electrical pulse is generated in the instrument and transmitted, via a cable to the transducer. There it is converted to mechanical energy and transmitted through a "coupling", normally oil, water or glycerine, into the material to be tested, as a pulse of high frequency sound.



Thickness gauge employed in production line testing of aircraft wing components

Ultrasonic plastics welding equipment being used for joining two colour skins of plastics bowls



The ultrasonic pulse continues through the material until it strikes a reflecting boundary. This could be the far side of the material or a flaw which obstructs the course of the beam. It is then reflected back to the transducer where the sound energy is converted back into electrical energy and returned to the measuring unit.

Signals from the test piece are amplified and displayed on a cathode ray tube as vertical deflections of the timebase. The position of a flaw signal, in relation to the initial pulse, is proportional to the depth of the flaw in the part. The magnitude of the flaw signal indicates the relative size of the flaw.

This type of instrument is used for flaw detection and thickness gauging up to 450 inches in, for example, large complex machinery or castings.

RESONANCE TECHNIQUE

The resonance method of thickness gauging is ideal for very thin materials and is carried out by an instrument consisting of a sweep oscillator which generates a signal which is converted into ultrasonic power to drive a transducer coupled to the material as before. However, with this method the energy is transmitted as part of a continuous wave train.

Each material of a given thickness has its own natural resonant frequency. At this frequency (or multiples of it), when the transmitted and reflected waves are in phase, there will be a relatively large increase in the amplitude of the waves in the material. When the material is under resonant conditions, occurring at the fundamental frequency applied, the thickness is determined by its inverse relationship to this frequency, which is also directly proportional to the velocity of sound in the material.

The material is also resonant to a lesser degree at harmonics (multiples of the fundamental frequency). Since the velocity of sound in a given material is a known constant, the fundamental frequency required to produce resonance is an accurate and reliable measure of an unknown thickness.

As the oscillator sweeps through the resonant frequency of the material, or any harmonics of this frequency, a vertical resonance indication appears on a cathode ray tube display. Accuracies can be very high with this technique, in many cases it is possible to measure to within 0·001in.

MATERIALS TESTING

The ultrasonic testing of heterogeneous materials, such as concrete, timber, rock, and graphite, is performed by using a comparatively low ultrasonic frequency and transmission technique.

Vibrational waves in the frequency range 60kHz to 150kHz are injected into the material and the velocity of their propogation measured. The transmitting and receiving transducers are held in contact with opposite faces of the material, which may be up to 10ft thick. The time taken by the vibrations to traverse the material is measured by the associated equipment to an accuracy of $\pm 0 \cdot 1$ microseconds.

As the leads from the transducers to the main instrument may be up to 100ft long there is no difficulty in using this method to evaluate very large structures, such as the walls of a concrete building.

HARDNESS TESTING

A far more recent development than those described so far is the ultrasonic method of determining the surface compliance or hardness of material, particularly metal.

A diamond tipped magnetostrictive rod is resonated at its natural frequency of about 18 to 20kHz, depending on the dimensions of the rod. When the diamond tip is brought into contact with a workpiece, using a predetermined engagement pressure, the diamond slightly penetrates the surface of the testpiece.

This penetration shortens the effective length of the rod, thereby causing the resonant frequency of the rod to shift to a higher value. Since, under constant pressure conditions, the penetration of the diamond tip is proportional to the hardness of the material, the amount of the frequency shift indicates this degree of hardness.

This method leaves a surface indentation of less than 0·005in and therefore, since it is so minute, it is well within the bounds of the term "non-destructive" and very much smaller than with conventional methods. Unlike mechanical testers this type of equipment does not require optics, high pressure, or an impact force for measurement.

LEAK DETECTION

Ultrasonic energy is generated by gas or steam as it leaks from any pressurised container. The frequency of this energy depends on the velocity of the escaping gas, which in turn is dependent on the pressure and the dimensions of the orifice. In all cases, however, there is a broad frequency spectrum in the 40kHz region and this fact may be utilised even though there may be considerable audible sound in the same area.

The detector consists of a highly directional ceramic microphone type transducer which is coupled to a tuned 40kHz transistor amplifier. Visual and audible output is indicated on a meter and headphones when the instrument is directed towards a leak. The accurate location of the leak is then determined by following through in the direction of the source of ultrasonic energy. By using this technique it is possible to locate accurately a leak from an orifice as small as 0·01in diameter at a pressure of less than 10lb/in² at a distance of 45ft. ★

The location of a leak is now nearing completion with the Ultrasonic Leak Detector

MILK-O-STAT

By Peter B. Walker

ARE YOUR "SOFT" EGGS ALWAYS HARD?

DOES OVERFLOWING BOILING MILK ON THE COOKER ALWAYS ANNOY YOU?

DO YOU DISLIKE OVERCOOKED FOOD?

LET THE MILK-O-STAT TAKE THE WORRY OUT OF IT ALL!

THE Milk-o-Stat can be very loosely termed an electronic thermostat. It incorporates a unijunction transistor timer and a heat sensitive bridge amplifier to control a thyristor operated alarm.

When in operation, the Milk-o-Stat is designed to emit an audible warning in the following cases:

(a) Whenever the liquid being boiled reaches a certain predetermined temperature, e.g. when the milk is about to boil over;
(b) whenever a certain prearranged time has lapsed;
(c) After a combination of cases (a) and (b).

As well as giving an audible alarm the Milk-o-Stat automatically switches itself off. This minimises human error and power consumption. The saving in battery life is thus considerable. Under normal conditions of use the battery should last well over a year.

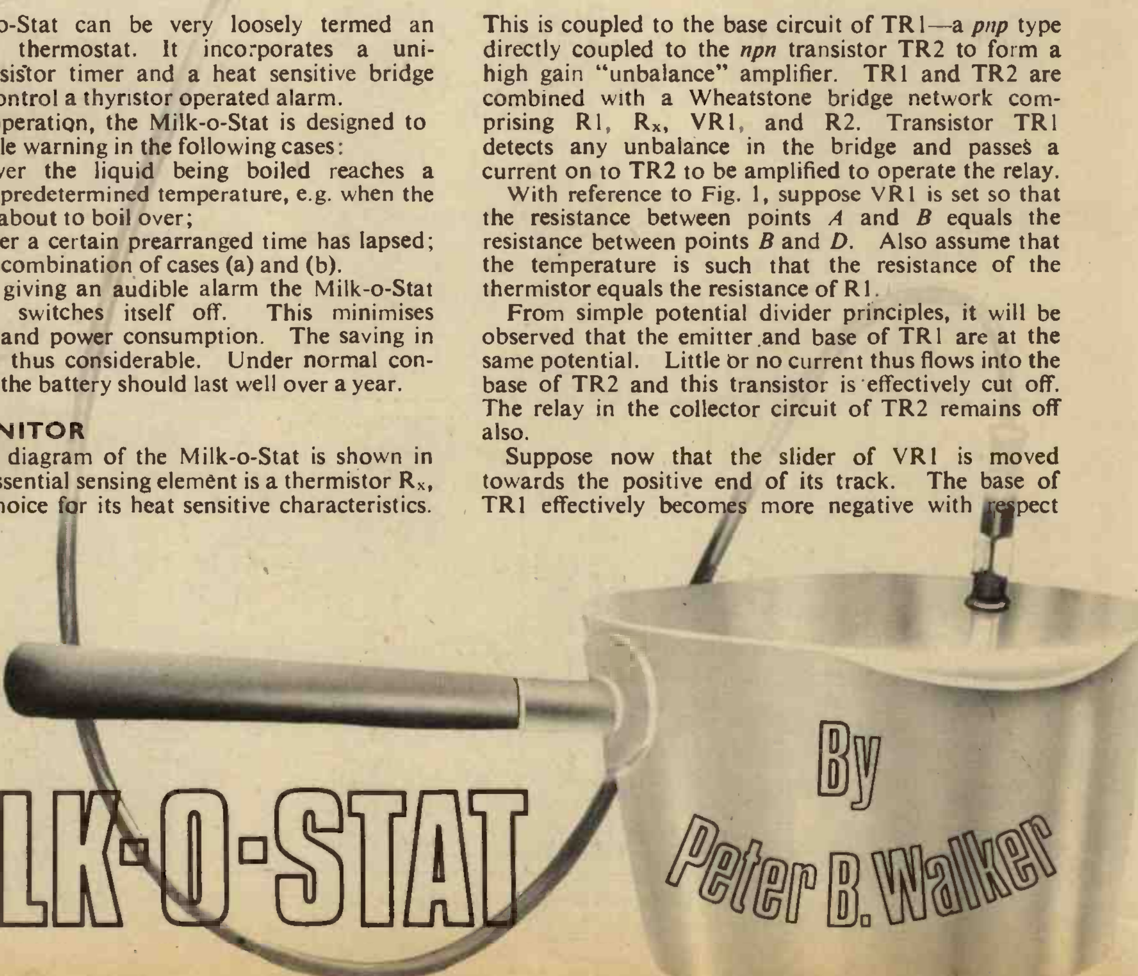
HEAT MONITOR

The circuit diagram of the Milk-o-Stat is shown in Fig. 1. The essential sensing element is a thermistor R_x, an obvious choice for its heat sensitive characteristics. This is coupled to the base circuit of TR1—a *pnp* type directly coupled to the *npn* transistor TR2 to form a high gain "unbalance" amplifier. TR1 and TR2 are combined with a Wheatstone bridge network comprising R1, R_x, VR1, and R2. Transistor TR1 detects any unbalance in the bridge and passes a current on to TR2 to be amplified to operate the relay.

With reference to Fig. 1, suppose VR1 is set so that the resistance between points *A* and *B* equals the resistance between points *B* and *D*. Also assume that the temperature is such that the resistance of the thermistor equals the resistance of R1.

From simple potential divider principles, it will be observed that the emitter and base of TR1 are at the same potential. Little or no current thus flows into the base of TR2 and this transistor is effectively cut off. The relay in the collector circuit of TR2 remains off also.

Suppose now that the slider of VR1 is moved towards the positive end of its track. The base of TR1 effectively becomes more negative with respect



COMPONENTS . . .

Resistors
R1 6·8kΩ 5% ½W high stability
R2 560Ω
R3 47Ω
R4 33Ω
R5 220Ω
All 10% ½W except R1

Potentiometers
VR1 5kΩ linear wirewound
VR2 100kΩ log. carbon with d.p.s.t. switch S2

Capacitor
C1 1,000μF elect. 15V

Thermistor
R_x VA1010 (Mullard) *or* TH6 (Radiospares)
9·6kΩ cold, 240Ω at 100mA hot

Thyristor
SCR1 50V 1A (e.g. type SCR01 International Rectifier)

Transistors
TR1 OC44
TR2 OC139 or 2N1302
TR3 OC71
TR4 2N492 or 2N2160

Diode
D1 OA81

Relay
RLA 185Ω 6V with 2 pole changeover contacts (Keyswitch Relays Ltd.)

Switches
S1 Single pole on/off push button
S2 Double pole on/off ganged to VR2

Battery
BY1 9V type PP9

Plugs and Sockets
PL1, PL2, PL3 Wander plugs (3 off)
SK1, SK2, SK3 Sockets for wander plugs (3 off)

Miscellaneous
Veroboard 0·15 in matrix 2½in × 3¾in
Plywood for case (see text)
Laminated plastics sheet (see text)
Miniature Terry clips (2 off)
Glass tube—0·25in bore
Pointer knobs
Battery connectors

to the emitter. TR1 is now forward biased. The base of TR2 will become progressively more positive and TR2 also will become forward biased. Increased current will flow in TR1 collector and when a sufficient value of current has been reached, say 8mA, the relay will switch on.

The circuit is now primed ready for operation. The thermistor, mounted in a suitable waterproof tube is immersed in the liquid to be boiled. As the temperature of the liquid rises, the resistance of the thermistor will drop. When the liquid reaches boiling point, and assuming VR1 has been set correctly, TR1 will cut off again, followed by TR2. The relay will release, turning off the Milk-o-Stat via RLA1. At this point it is arranged that an audible warning signal is brought into operation via RLA2 contacts, a warning which summons the housewife to tell her the milk is ready.

PRESET TIMER

With S2a and S2b closed, the time circuit is switched on. By varying the value of VR2 any time delay from a few seconds up to five minutes can be obtained.

An important feature of the unijunction transistor TR4 is the high impedance across the base 1-emitter

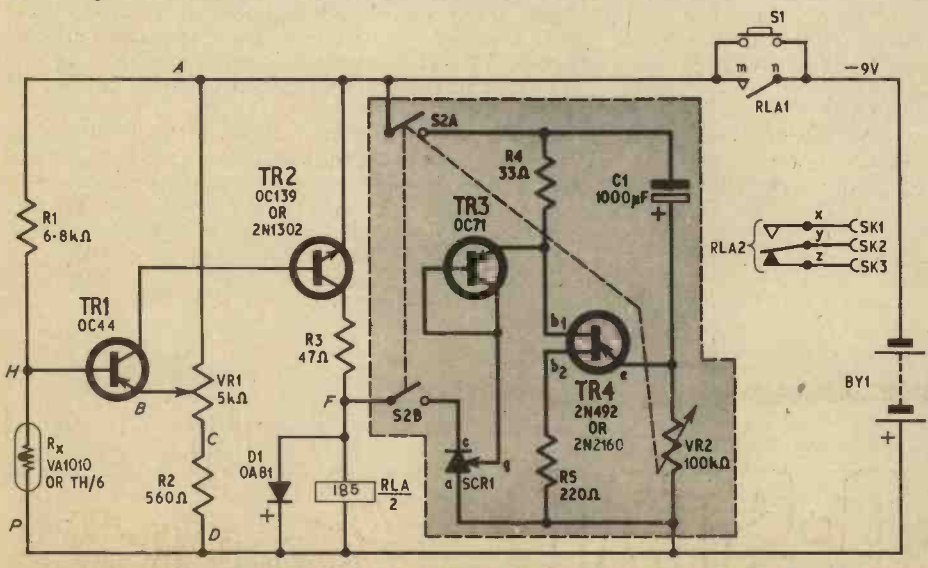
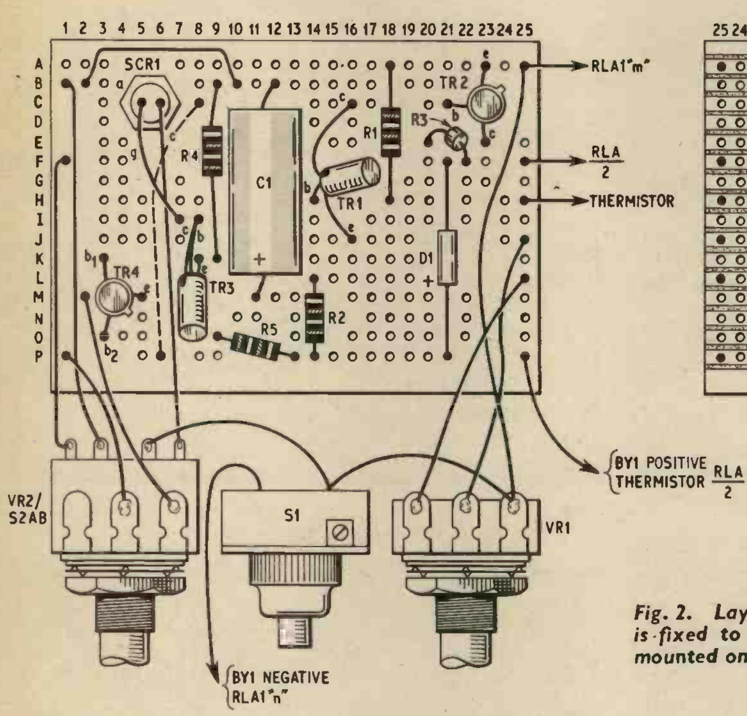


Fig. 1. Complete circuit diagram of the Milk-o-Stat. The shaded area is the timer section of the circuit which may be excluded if not required



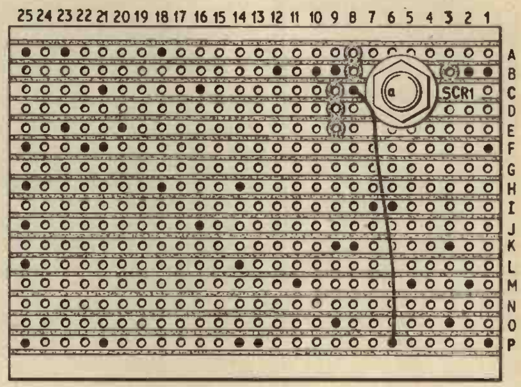


Fig. 2. Layout of the components on the board. The relay is fixed to the case; the controls VR1, VR2, and S1 are mounted on the sloping front panel

junction. However, as C1 charges up through VR2, the potential of the eb_1 junction will rise progressively. When the emitter reaches a certain potential, say 6 volts positive with respect to b_1, the resistance of the junction will suddenly drop to a very low value, and C1 will discharge through this junction and R4. The resultant sharp-edged positive going pulse is applied to the gate of the thyristor SCR1 via TR3, and triggers the thyristor into the on state. Thus, after the specified time delay, SCR1 fires, shorting out the relay and turning it off.

The relay "hold" contacts are simultaneously broken, and the Milk-o-Stat thus turns itself off. R3 acts as a current limiting resistor to ensure that TR2 is not overloaded when SCR1 fires. TR3 is an OC71 wired up with its base and collector strapped together. Wired in this mode, TR3 acts as a diode with a very low forward resistance, typically 10 ohms. This ensures that the SCR1 gate receives adequate trigger current of the correct polarity.

AUDIBLE WARNING

For optimum simplicity, reliability, and minimum cost, an existing battery transistor portable radio would be a good choice for the audible alarm. Even a small transistor radio tuned to a suitable station could make enough noise to be heard by the housewife.

A simple way of adapting your radio to operate in conjunction with the Milk-o-Stat is to connect points x and y (SK1 and SK2) or y and z (SK2 and SK3) of RLA2 contacts in series with the radio battery. An electric bicycle horn or electric bell will function just as well if a radio set is not available. The important point is that audible warning must be given immediately the relay operates, therefore valve radio sets are unsuitable.

AUTO-HOLD

Auto-hold is achieved by S1 in parallel with RLA1 contacts. By pressing S1, the momentary contact switch, the Milk-o-Stat relay is activated, and RLA1 closes holding the circuit on. When RLA is released the auto-hold circuit is opened and the Milk-o-Stat turns itself off automatically.

ASSEMBLING THE COMPONENTS

The circuit was built up on a piece of Veroboard 3·75in × 2·5in (Fig. 2). The positions of the components are not critical and the actual wiring up of the circuit presents no particular problems.

The thermistor used is fairly sensitive to changes in temperature and can be obtained quite cheaply.

It is housed in a piece of glass tubing which is sealed at one end (See Fig. 3). The glass tubing is about 5in long with an inner diameter of 0·25in, sufficient to accept the thermistor and a thin wire side by side. The tube is carefully sealed by heating the glass at one end until it melts

After sealing the tube and allowing it to cool, test to see if it is watertight by holding the sealed end under running water, and check for any water droplets in the inside of the tubing. If any water droplets are found, heat the end of the tubing again and repeat the test procedure until the seal is watertight. It is essential for the reliable operation of the Milk-o-Stat, that no water comes into contact with the sensitive thermistor.

The case for the Milk-o-Stat is made from stout plywood with the following dimensions:

(a) Baseboard 6in × 4in × $\frac{1}{2}$in thick;
(b) Side panels 6in × 3in × $\frac{1}{4}$in thick;
(c) Back panel 5in × 3in × $\frac{1}{4}$in thick.

The top, sloping front, and trim front pieces are laminated decorative plastics sheet such as Formica or Warerite (see heading picture). These pieces are cut to fit after the wooden panels are glued and pinned together.

Before finally fitting the plastics panels, drill appropriate holes to accept the controls VR1 and VR2 ($\frac{3}{8}$in diameter), the push button switch S1 (to suit component size), and 6 B.A. clearance holes (No. 32 drill) for Terry clips to hold the probe sensor. The exact positions of these is not important. Wander plug sockets are mounted on the side of the box to provide connection between RLA contacts and the external audible warning device.

CALIBRATION AND SETTING-UP PROCEDURE

1. Check that the timer is switched off.
2. Insert an ammeter (0–20mA) between relay RLA and the positive pole of the battery.
3. Connect up battery.
4. Set VR1 to about the mid-position of the track.
5. Press S1 to switch the unit on.

Put the sensor in cold milk and gradually bring to the boil. The current should gradually drop from 15mA to 5mA as the temperature of the milk increases.

Ideally the Milk-o-Stat should turn itself off when the milk is about to boil. However, if the alarm sounds too early, i.e. before boiling point is reached, turn VR1 slider a little more to the positive end (clockwise). If the alarm sounds after the milk is boiling, turn VR1 slider counter-clockwise.

When the slider has been correctly positioned, calibrate VR1, marking the point found as "MILK". Similarly calibrate for water or any other requirement.

For various positions of VR2 note the time delay accurately, using a watch with a seconds hand, and mark the time delays so found on VR2 dial.

It is advisable to keep the glass probe scrupulously clean. This can be done by rinsing in *warm* water then inserting into Milton. Never insert the tube into boiling water rapidly.

Do not let any part other than the glass tube come into contact with food or water for the sake of hygiene.

BOILED!

There should be no more mess now! Switch on the Milk-o-Stat, tune in to your favourite radio programme, put the milk pan on the cooker—and walk away. Use the Milk-o-Stat as an egg timer: a 3 minute egg will be soft, a 5 minute egg should be hard. You can tell when the water for boiling the egg boils—an electronic "whistling" kettle! All you need to do is to repeat the calibration procedure, but using water.

As a short period timer the Milk-o-Stat should also come in very handy in the amateur photographer's dark room.

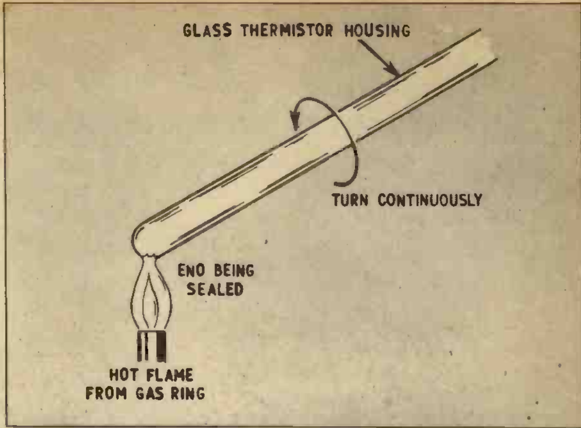


Fig. 3. The glass tube is heated by a bunsen burner or gas ring to seal the end

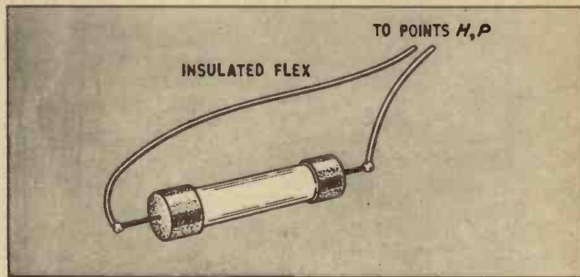


Fig. 4. The thermistor has flexible wires connected to it before insertion in the glass tube

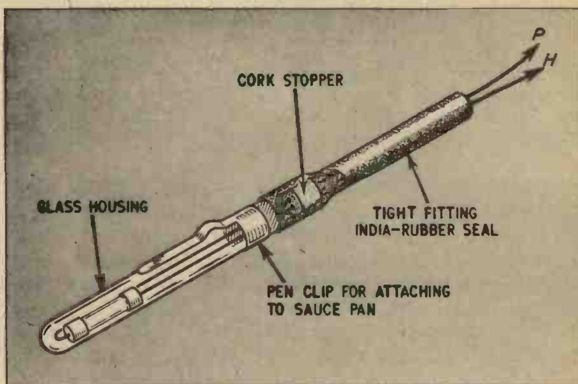
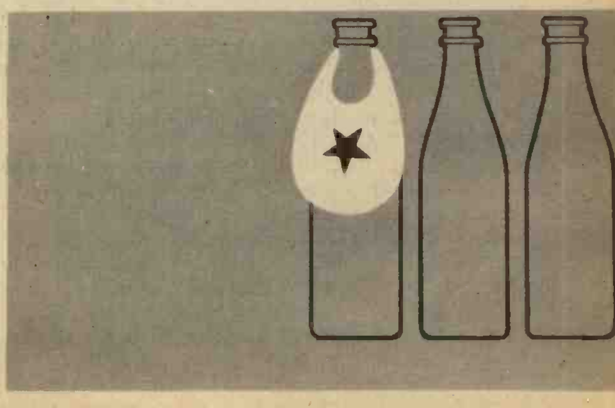


Fig. 5. The finished probe with pen clip for attaching to the pan and rubber seal to exclude moisture from the thermistor



UNLIMITED!

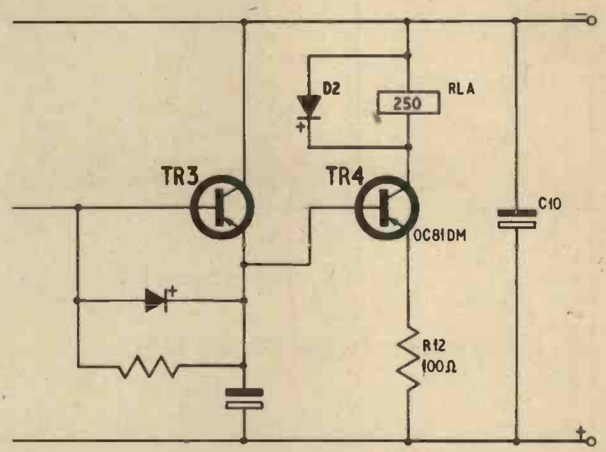
IN THIS feature we hope, from time to time, to be able to publish suggestions submitted by some of our readers on the possible improvement of projects previously described in PRACTICAL ELECTRONICS; short contributions on other subjects may be included. The aim is not to find fault or undermine the abilities or knowledge of our contributors. It may well be that the original article is *par exellence* but it could be improved or adapted to suit individual requirements. The views expressed by readers are not necessarily those of the Editor.

RELIABLE SYNCHRONISER

I THOUGHT you might be interested in a modification that I have made to the *Slide Synchroniser* project that you published in September 1965. I made this synchroniser about a year ago, but was unable to obtain the small 150 ohm relay mentioned. The nearest I could get was a somewhat cumbersome 150 ohm Post Office type. Whereas this was operated satisfactorily by the pulse direct, it was a chancy business when the recorded pulse was in operation.

I added a further stage of amplification but felt that this might tend to overload the OC81 a little, besides being somewhat extravagant from a financial point of view. Eventually I added an OC81DM in a switching capacity to provide the relay with practically full battery potential, whatever the strength of d.c. pulse emanating from TR3. The modified device has provided me with hours of reliable service so far.

J. Davies,
East Grinstead,
Sussex.



COMBINED AIDS FOR THE MOTORIST

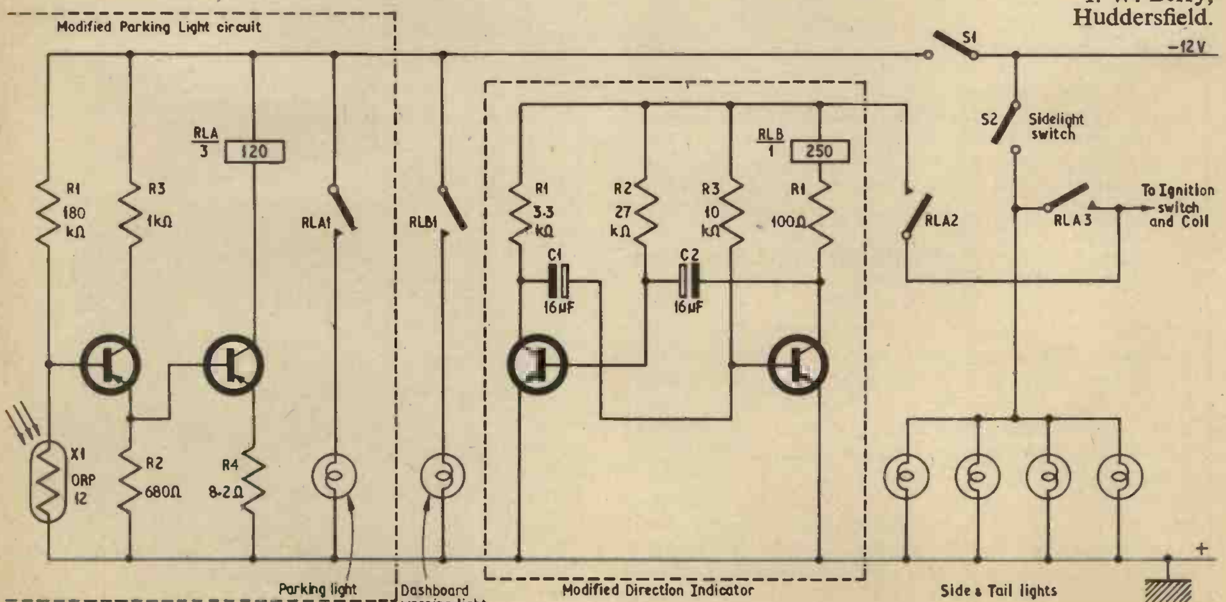
THE other day I overheard someone complaining about having to pay a fine for driving through the town centre after dark without lights, having forgotten to switch them on.

I took two circuits from the May 1966 issue of PRACTICAL ELECTRONICS, modified them, and combined them to switch on the side lights and give a flashing warning when darkness falls.

The lights are switched on by the same relay that switches on the parking light, but does not become operative until the ignition is switched on. As this circuit becomes operative the small dash light keyed by the multivibrator begins to flash.

It will continue to flash until switch S1 is returned to the off position. The l.d.r. parking light also is switched off by S1.

I. W. Berry,
Huddersfield.



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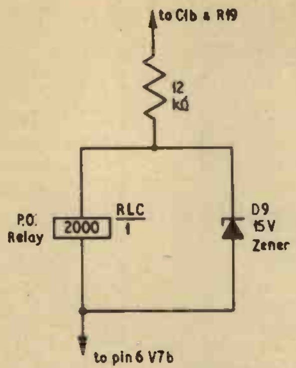
LUMOSTAT HINTS

I WOULD like to express my appreciation for the articles on the *Lumostat*. I have made this, and it promises to be an indispensible aid in the darkroom.

May I offer the following advice to anyone constructing this equipment. In the "auto" function, particularly during long exposures, the circuit insulation is critical. The auto/time switch, S8 in particular may be found to be at fault. Various toggle switches tried were found to have leakage resistance of about 300 megohms which is too small to be tolerated in this circuit. A satisfactory substitute was found to be a rotary ceramic type, with leakage resistance greater than 10,000 megohms.

With this substitution, it was found that certain capacitors associated with S9 had to be altered to give the correct logarithmic time intervals. Correct values were found to be: C28 0·017μF; C29 0·027μF; C30 0·033μF and C31 0·05μF. The values given in the article are obviously not in keeping with the rest of the capacitors, probably as a result of leakage at switch S8.



Some saving in cost is possible by using P.O. relays. Almost any 24V type may be used for relay B. Relay C is more difficult, but a satisfactory substitution, using a 2,000 ohm P.O. relay, operating at 6mA is shown in the circuit diagram. A slip of paper between core and armature suppresses any tendency to bounce. The saving on the Zener diode is also appreciable.

Finally, a word of warning! The photocell 90AV is not sensitive to normal darkroom illumination, but it is sensitive to light from an electric fire. Switch this off during calibration of the unit.

S. C. Hooson,
Liverpool, 16.

HOW TO USE THE

COMPONENT SELECTION CALCULATOR

GIVEN FREE WITH THIS ISSUE OF PRACTICAL ELECTRONICS

Component Tolerance Calculator

IT FREQUENTLY occurs that the constructor requires to select a certain value of component from several (e.g. resistor, capacitor, etc.) with a close nominal value, i.e. the value given on the component.

If, for example, 80 kilohms is required the tolerance calculator can find what nominal values can be used to select, by measurement, the required value. Set the centre line of each grey panel on the slide in turn against the required exact value in this case against 80 on the lower scale. It will be seen that near preferred values for selection could be: 82kΩ at 5, 10, or 20 per cent; 75kΩ at 10 or 20 per cent; 68kΩ at 20 per cent; 91kΩ at 20 per cent. Now you have a wide range of components from which 80kΩ may be found by more accurate measurement.

Conversely, if you have a component of a given nominal value (e.g. 100kΩ ±20 per cent) the range of values within this tolerance can be found by setting the centre line of the appropriate grey panel against the nominal value and reading off the adjacent scale. In this example, for 100Ω ±20 per cent, the actual component value may be between 80kΩ and 120kΩ.

It is important that the decimal multiplier, although not given on this calculator, is easily taken care of by memory. This will be obvious from the examples given. The upper scale is continued on the lower scale with some overlap—40 to 50. This makes calculation easier within this range so that either scale is selected for convenience.

From 8 to 20 the upper scale is marked in halves, but if intermediate values are required you can transfer to the lower scale and use 80 to 200. Again allow for the decimal multiple.

This procedure is the same for any component.

Time Constant Calculator

THE calculation of time constants (T = CR) usually involves awkward multiple and submultiple values of capacitance and resistance and this Time Constant calculator was designed to offset these difficulties.

The range of time constants available on the calculator is from 0·01 to 10^9 microseconds enabling rapid evaluation to be made of the choice of timing components that are so commonly encountered in pulse circuits, RC oscillators, waveform shapers and tone control filters, to mention but a few.

(a) Set lower limit of chosen kilohm scale, i.e. A, B, C or D against chosen capacitor value (p or μ scale).
(b) Read off the number that coincides with the multiplying resistance on the p or μ scale.
(c) The multiple of this number of microseconds is found directly above or below it by the lines referenced by the scales involved, for example, Ap, Bμ, etc., and so provides the time constant.

It will be appreciated that the formula can be manipulated. For example, the components for a particular time constant would be realised by using the converse of the operations as set out before.

As an example, find the time constant of a 4μF capacitor and a 50 kilohm resistor.

50 kilohms appears on the slide scale B, so the *lower* limit 10 on this scale is aligned with the 4μF mark on the μ scale. The figure that concurs with 50 kilohms on the μ scale is the number of the time constant, i.e. 2. To interpret this value in microseconds, refer to the scale Bμ which provides directly the limits of reference in microseconds for the number read off, namely 10^5 and 10^6, therefore the time constant is 2×10^5 microseconds.

FIELD STRENGTH METER for 27 MHz MODEL CONTROL BAND

By P. W. HAND

THIS field strength meter will be a useful addition to any radio control enthusiast's equipment. The main function of this instrument is to enable the transmitter or transmitter aerial to be checked. It may also be used for modulation checks and also to ascertain whether another transmitter is operating on one's own frequency or an adjacent frequency.

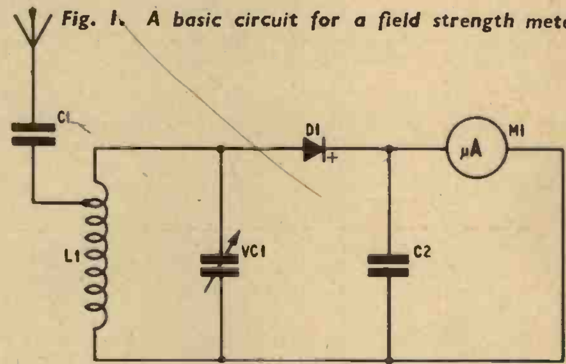
The basic circuit arrangement for a field strength meter is shown in Fig. 1. It consists of a tuned circuit VC1, L1, a diode detector D1, and a microammeter M1 to measure the diode current. Calibration of the meter is of no great consequence, and may be in milliamps, volts, or decibels; the instrument is used for comparative measurements only. This elementary circuit suffers from the disadvantage that a sudden increase in signal strength may readily damage the meter movement.

In the design to be described in this article, a transistor amplifier has been incorporated; this increases the sensitivity of the instrument, and also provides a degree of protection for the meter movement.

THE FINAL CIRCUIT

Referring to the circuit diagram Fig. 2, upon receipt of a signal the diode D1 conducts, and causes a positive voltage to be applied to the base of transistor TR1 so reducing the collector current. The meter M1 is in the collector circuit, and so registers a fall in current with an incoming signal.

Fig. 1. A basic circuit for a field strength meter



The diode D1 is connected to a tapping one turn from the bottom, or "earthy" end, of the coil L1 to prevent damping the coil unduly. This tapping may be moved to the second or third turn for an increase in sensitivity, with only a slight increase in damping on the coil.

The coil L1 consists of 11 turns of 18 s.w.g. enamelled copper wire, wound on a 1in former and the winding is spaced to occupy 1in. This coil is tuned to 27MHz by a 65pF air spaced variable capacitor VC1 in series with a 30pF Phillips concentric trimmer TC1. The trimmer is adjusted to bring the operating frequency to the centre of the dial.

A phone jack JK1 is included for audio monitoring of the signal when making modulation checks.

CONSTRUCTION

As the illustrations show, the prototype was built in a metal case with a sloping front panel. This style of case enhances the general appearance as well as facilitating reading the meter. This is not an essential feature of course, and any metal box or case of approximately the same dimensions will be quite satisfactory.

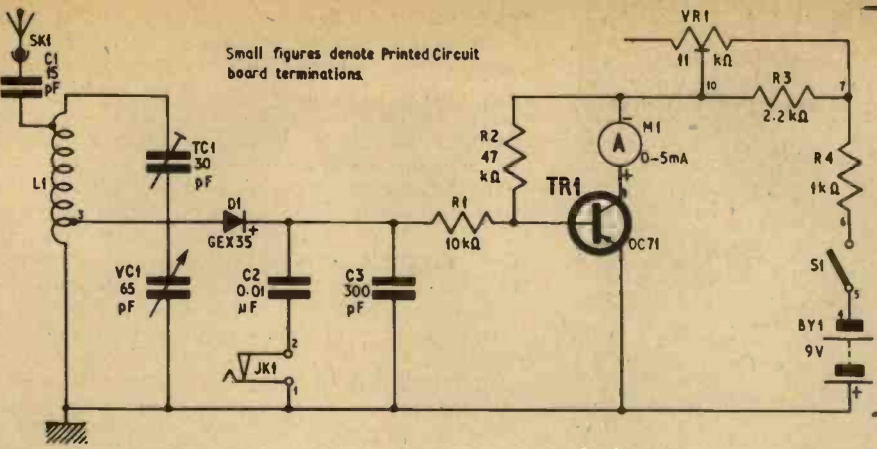
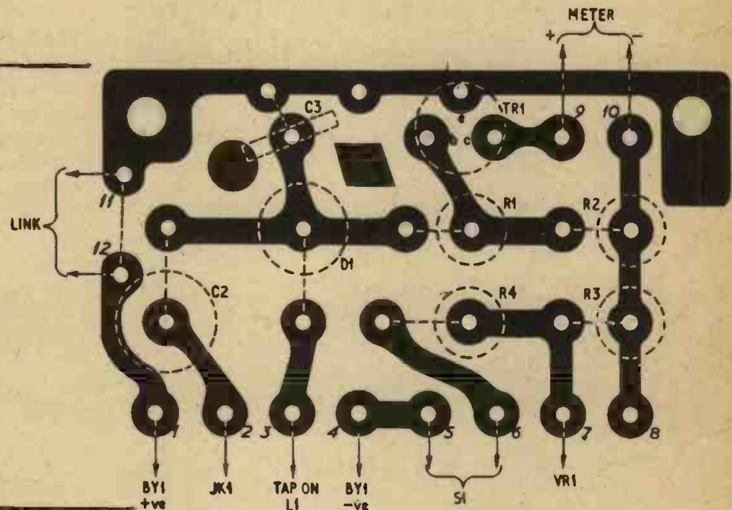


Fig. 2. Circuit of the finalised design

Fig. 3. Underside view of the printed circuit board



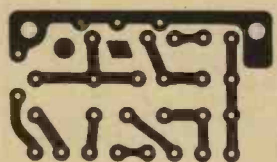


Fig. 4. The printed circuit board reproduced actual size

The arrangement of the components can be seen in the photograph, and the wiring is given in Fig. 6.

PRINTED CIRCUIT BOARD

All the smaller components are mounted on a printed circuit board. Since this method of construction may be unfamiliar to some readers, the technique involved in the preparation of this printed circuit board will be described in some detail.

Initially all component sizes and their lead spacing were noted. Then several small sketches were made until a satisfactory layout was obtained. (It should be mentioned here that the writer was endeavouring to make the printed circuit as small as possible.) The printed circuit was then drawn to an enlarged scale in indian ink. This drawing was photographed on to Kodak Lith film with the aid of an ordinary photographic enlarger. Next a negative was made of the correct size to contact print direct onto the copper laminate which had previously been coated with Kodak Printed Circuit Resist. The printed board is shown actual size in Fig. 4. For component layout see Fig. 5.

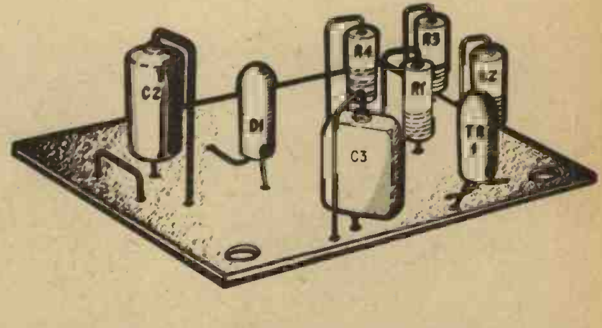


Fig. 5. Top view of the printed circuit board with the components in position

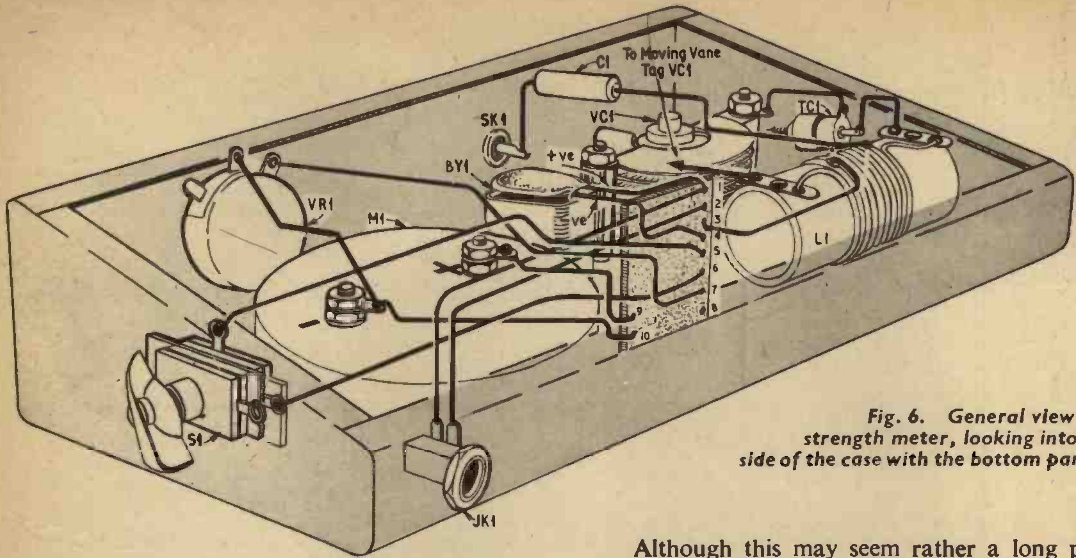


Fig. 6. General view of the field strength meter, looking into the underside of the case with the bottom panel removed

Although this may seem rather a long process for such a small circuit or simple project such as this field strength meter, it does provide an excellent way of gaining experience before tackling more elaborate circuits.

COMPONENTS . . .

Resistors

R1	10kΩ	R3	2·2kΩ
R2	47kΩ	R4	1kΩ

All ±10%, ½W carbon

Potentiometer

VR1 11kΩ preset

Capacitors

- C1 15pF mica or ceramic
- C2 0·01μF paper
- C3 300pF mica
- VC1 65pF air spaced tuning capacitor
- TC1 30pF concentric trimmer (Phillips type)

Miscellaneous

- D1 Germanium diode, GEX35 or equivalent
- TR1 Transistor, OC71
- M1 Moving coil meter, 5mA f.s.d.
- JK1 Open circuit jack socket
- SK1 Aerial socket
- S1 Single pole on/off switch
- BY1 9V battery, PP3

Material for case. Copper clad board for printed circuit and escutcheon. Two knobs.

TUNING ESCUTCHEON

The escutcheon for the tuning control was made of copper laminate in the same manner as the circuit board, except that a positive was used here. Thus the letters and the dial engraving were etched away, leaving the majority of the copper surface intact.

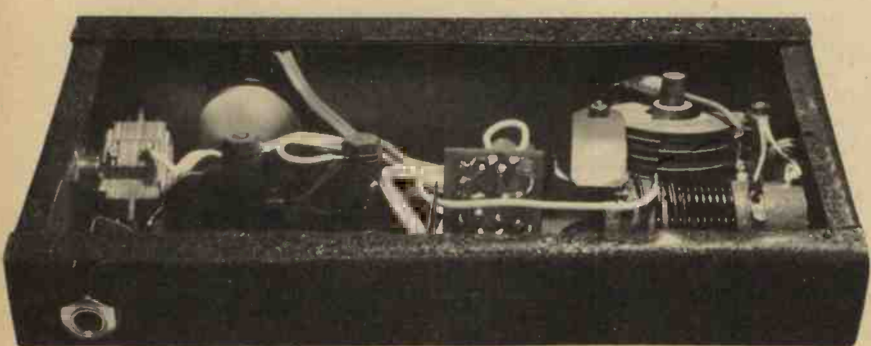
OPERATION

A length of 16 s.w.g. copper wire should be attached to the aerial socket SK1 at the rear of the case. If the same length of pick-up wire is always used, fairly accurate comparative results can be obtained by always positioning the meter the same distance from the transmitter aerial. The distance will depend on the sensitivity of the meter, and the aerials used. It may be five yards, or so, and farther away for more powerful transmitters.

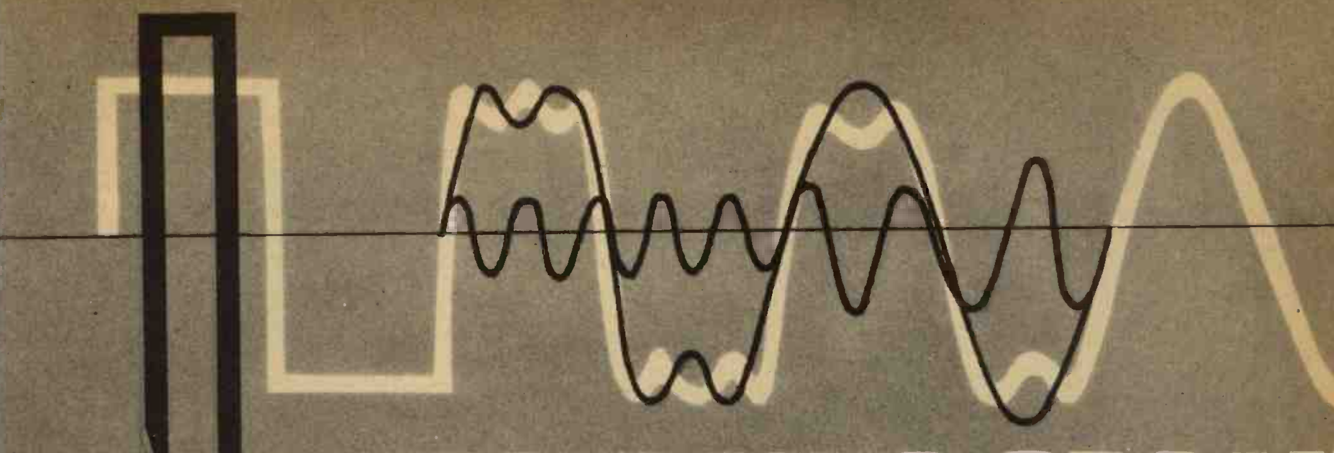
First it is necessary to adjust VR1 for full scale deflection of the meter pointer with *no signal input applied*. The instrument is now ready for normal use.

Tuning is performed by adjusting VC1 for *minimum* reading on the meter. Adjustments to the aerial, or the transmitter, are directed towards *reducing* the meter reading; this indicates an *increase* in signal strength.

If the reading is reduced to zero, then the field strength meter should be moved farther away from the transmitter, when some deflection will be obtained. This reading should then be reduced again if possible by careful retuning of the instrument.



Audio monitoring can be performed by inserting a pair of headphones into JK1. In this way the modulation of the transmitter may be checked. It is also possible to check whether any interference is likely from other transmissions on the same or adjacent frequency. ★



THE ELECTRONIC ORGAN

PART FIVE

By ALAN DOUGLAS, Sen. Mem. I.E.E.

TONE FORMING FILTER CIRCUITS

We all know that the appeal of an organ does not rest with any one particular sound, but rather on a number of harmonious blends of the different voices built into the instrument. Of course, there are sounds found *only* in the organ—the diapason, tibia, the ponderous basses which exist nowhere else. But we must not fly too high, for whilst one could truthfully say that there is no limit to the voicings possible from organ pipes, there is a definite limit to the tonal differences possible from electronic circuits.

If we have a common waveform, that is, one waveform only (of whatever kind) to cover a range of 61 notes or a frequency ratio of approximately 32:1, it is quite evident that with any one passive filter network we are going to find some parts of the compass where it does not work at all, and at best the action of any tone circuits must be very severe to greatly modify the tone.

BASIC FILTER CIRCUITS

The single tone network is the most commonly encountered, some of its deficiencies being mitigated by the fact that extremes of the compass are not much used; and that by combining stops, the resultant juggling with harmonics tends to obscure weaknesses in other stops. On the other hand, certain circuits with certain waveforms work very well.

The basic or elementary forms of the common filters have been so often described that it is hardly necessary to go over all this again; but briefly, low pass cascaded sections will attenuate high notes, though with considerable loss of signal strength, Fig. 5.1a. The inversion of this circuit, the high pass filter, will remove low frequencies, Fig. 5.1b. And the resonant, band pass or band stop filter accentuates some frequencies at the expense of others, Figs. 5.1c and d.

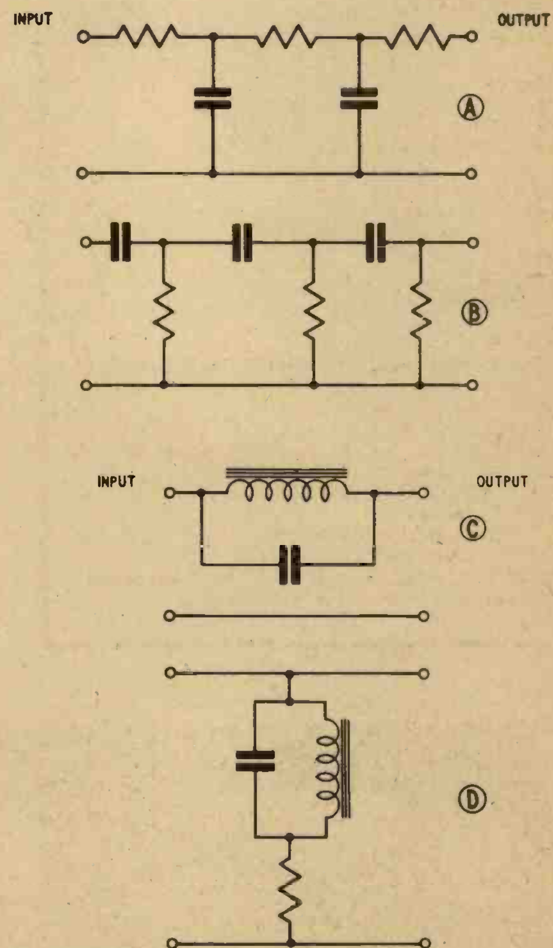


Fig. 5.1. Basic filter circuits. (a) low-pass cascoded sections, attenuates high frequencies; (b) high-pass cascoded sections, attenuates low frequencies; (c) resonant band-stop filter; (d) resonant band-pass filter

All of these circuits can be extended or combined, and all can have more than one waveform injected. Such tone circuits are called subtractive, because we are removing unwanted frequencies from a complex waveform.

One of the basic organ tones is the flute; if made considerably louder, we could call it a tibia—the foundation stop of the theatre organ. Organ flutes have quite a number of harmonics, in general quite small in amplitude. Fig. 5.2a shows the harmonic content of a soft flute note, and Fig. 5.2b that of the same note twice as loud. It will be seen that some harmonics barely alter, but the second and fourth become very powerful. If we subdue these we still have a good flute, but if we take away the 4th, 6th and 8th we find only a very dull sound remaining. Later on we will see examples of tone circuits to simulate this condition, but in the organ to be described later we actually generate the required waveform directly (Fig. 5.2c) and the small adjustments to be carried out (which are greatly dependent on the loudspeakers and the room in which they are used) can be made *note by note* if required, which would be quite impossible with a frequency divider system. Nonetheless we do use flutes from our dividers and these are formed as shown in Fig. 5.3a.

The constants for the four-section filters are of course related to the pitch range involved, but even with a sawtooth wave there are inclined to be too many upper harmonics and these are equalised as far as possible by attenuators between the adjacent octaves of the busbars, Fig. 5.3b.

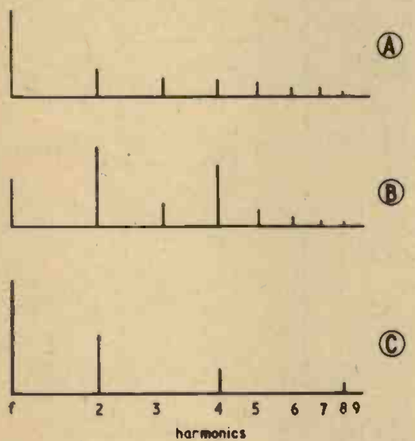


Fig. 5.2. Harmonic content for organ flute. (a) soft flute tone; (b) same note twice as loud; (c) required content

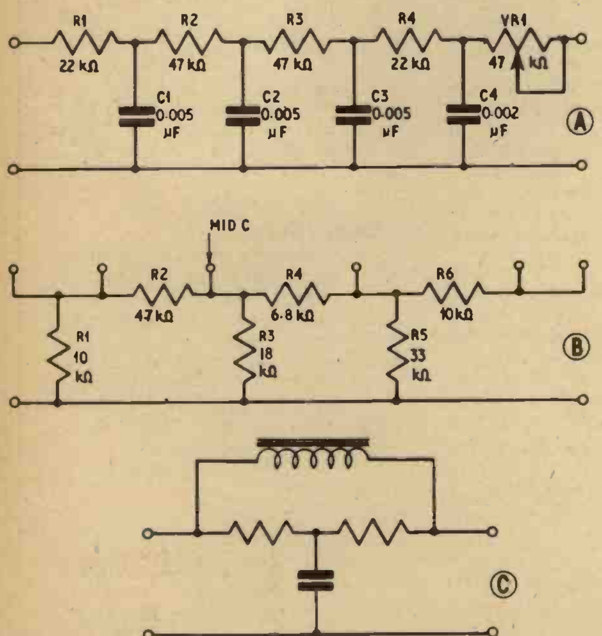


Fig. 5.3. Passive equalising circuits. (a) flute forming circuit; (b) attenuator for upper harmonics; (c) circuit for progressive attenuation of upper harmonics

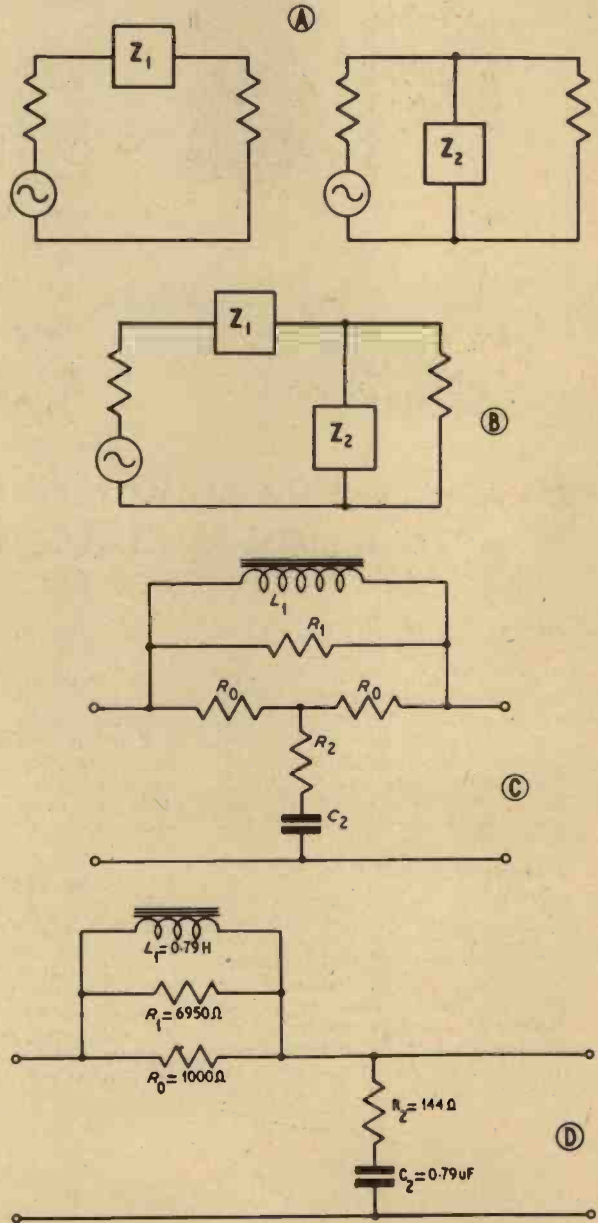


Fig. 5.4. Reactive filters. (a) general principles, series and shunt reactances; (b) combined series and shunt reactances; (c) bridged-T filter; (d) complete equaliser

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A rather better way to reduce the harmonics is by an equalising circuit as in Fig. 5.3c. Here we progressively cut down higher harmonics until they assume roughly the same values as the lowest frequency required, as follows. But first note that the equalisation is far from perfect because we cannot terminate the circuit with exactly correct impedances.

REACTIVE COMPONENTS

The simple low pass filter produces a loss which increases without limit as the frequency rises, and the inverse applies to the simple high pass circuit. But if we introduce reactive components, such as inductances, we can regulate the frequencies between which the filter is effective.

Taking the simple case of Fig. 5.4a, we find a generator, source impedance, load impedance and a series impedance Z_1 or a shunt impedance Z_2, more commonly combined as a complete section Fig. 5.4b. In this, if Z_1 is a series capacitor, it will reduce the level of low frequencies; equally, an inductance Z_2 acts as a variable shunt, allowing high frequencies to pass whilst reducing low frequencies. Thus the whole of the circuit attenuates low frequencies. The converse is true, if Z_1 is an inductance low frequency signals can pass to the load whilst a capacitor Z_2 in shunt reduces the high frequency response.

Again, if Z_1 is a series resonant circuit and Z_2 an anti-resonant circuit at the same frequency, then at resonance, Z_1 is a short circuit to this frequency which passes unaltered to the load. At all other frequencies the impedance of Z_1 is greater than zero, so signals arriving at the load are reduced in amplitude. Z_2 is an open circuit at resonance but at other frequencies is less than infinite, so it acts as a shunt across the load, thus, the output falls off away from resonance. It is clear that by choosing the Q of these circuits, or shunting them with resistors, many alternative frequency bands may be accentuated or diminished.

Later on we will see working examples of this kind of circuit, which is essential for the simulation of reeds. All such physical tone producers consist of a vibrating system coupled to a resonating tube, and this coupled system induces certain bands of frequencies which are common to many fundamental notes and are called formants. It is by simulating formants or exciting them and their harmonics that we are able to imitate the sounds of reed pipes, because the range and level of all the formants have been known and measured for many organ pipes and orchestral instruments.

BRIDGED-T EQUALISER

We mentioned that it might be desirable to limit the attenuation of a low pass filter so that, after a certain frequency is reached, the loss does not increase. This can be achieved with a circuit like that of Fig. 5.4c which is a bridged-T equaliser.

In this, Z_1 is a parallel combination of resistance and inductance and Z_2 is a series arrangement of capacitance and resistance. If we take Z_1 alone; at very low frequencies the reactance of L_1 is quite small, and effectively short circuits R_1, so there is little loss. As the frequency rises, so does the reactance of L_1, increasing the loss. Should the frequency continue to rise, the reactance of L_1 eventually reaches a value at which it is 10 times greater than R_1. At this frequency, by the rule of parallel circuits, Z_1 is approximately equal to R_1; further increases in frequency have no effect.

Now looking at Z_2, at very low frequencies the reactance of C_2 is almost an open circuit so Z_2 introduces little loss. As the frequency increases, the loss rises and eventually the reactance drops to a value $\frac{1}{10}$th that of R_2, so that Z_2 is approximately equal to R_2. Thus, looking at the whole circuit, the effect of X_{L1} is nil because it is too large and X_{C2} is negligible because it is too small.

What is left is a bridged-T pad providing a constant loss at all frequencies above that at which $X_{L1} = 10R_1$ and $X_{C2} = R_2/10$. The resulting pad loss, as it is called, is found from $D = 20 \log_{10} N$ decibels from which can be found by transposing:

$$N = \log^{-1}\frac{D}{20}$$

where

$$N = \frac{V_{out}}{V_{in}}$$

We find then that with a circuit of this kind we have both a low and a high frequency stop band, with a slope between formed by the constants R_1, R_2, L_1 and C_2 and to some extent by the source and load impedances; for such equalisers work tolerably well between very different impedances. So without wearying the reader with the complete calculations, we could suppose that for a pedal 8ft flute stop we have a waveform which is (or can be made so by the circuit constants) flat up to 100Hz and then increases by 18dB at 2kHz, where again it is held by the equaliser constants. Then, to flatten this curve so that the response from 100Hz to 2kHz is practically uniform, the constants given in Fig. 5.4d will produce the result required, assuming a source impedance of 1,000 ohms, which is not unrealistic for transistor preamplifiers.

TRIAL AND ERROR

Resonant and antiresonant circuits can be assembled in the same way, and in fact many examples of these are to be found in commercial organs; but clearly the slope or linearity of the applied basic waveform has a profound effect on the success of these circuits and this is the reason why a linear sawtooth is so much preferable to a square wave when real fidelity is required.

On the other hand, such voices as the clarinet, bassoon, lieblich gedackt, etc. must have a square wave since they contain no even harmonics. Moreover, it may be desirable to inject more than one waveform into a complex tone circuit or, having modified the pass band by a filter or equaliser, it might be desirable to *rectify* the wave and then subject it to further treatment. So it is evident that the successful employment of tone filters is largely a matter for trial and error. This also follows from the fact that one maker's concept of (say) an organ trumpet is not the same as another maker's. Nowhere is this more noticeable than in the pipe organ world.

The natural outcome of many years' experience yields a certain number of circuits which are really effective if supplied with the correct initial waveform, whilst dozens of theoretically good networks do not produce anything of value. We therefore conclude this section by illustrating two groups of tone networks, one of which requires a sawtooth input and the other, a square wave. In any event, if all the tone networks are to be terminated in a busbar feeding a common amplifier, then of course there must be appreciable series resistance left in each filter to prevent short circuits.

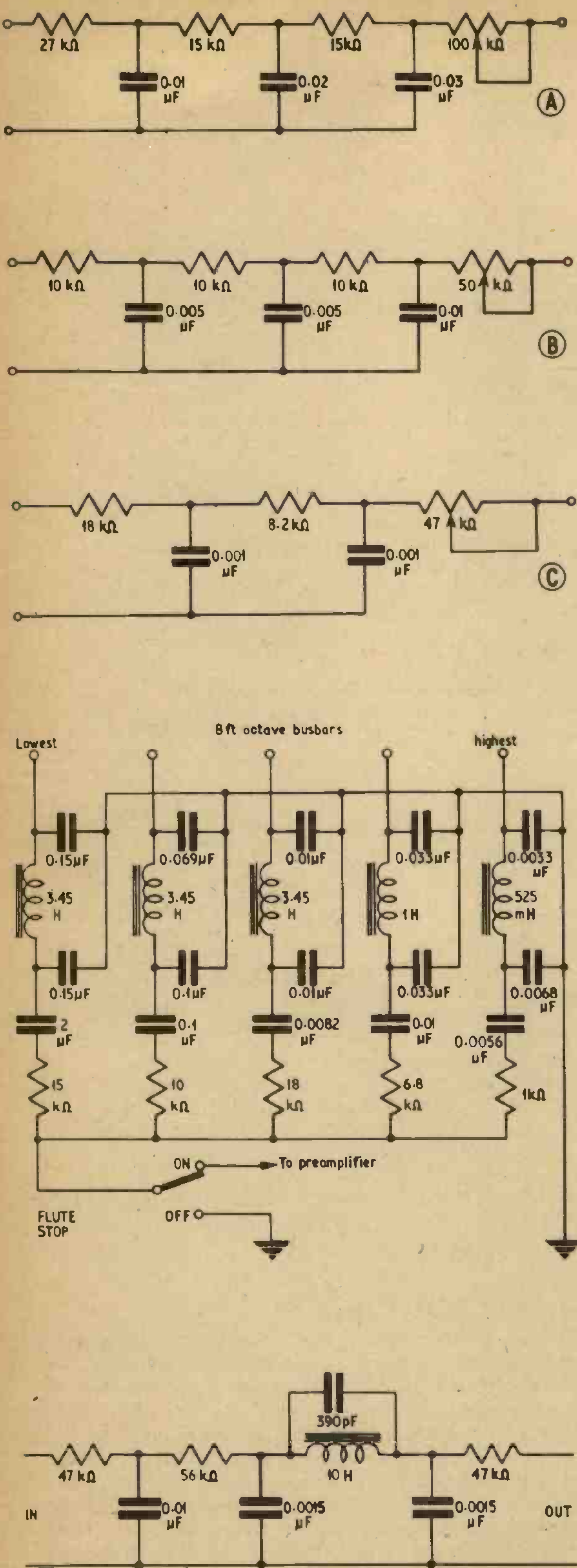


Fig. 5.5. Commercial flute networks. (a) 16ft Bourdon; (b) 8ft flute; (c) 4ft flute; (d) highly corrected flute; (e) 16ft contra tibia

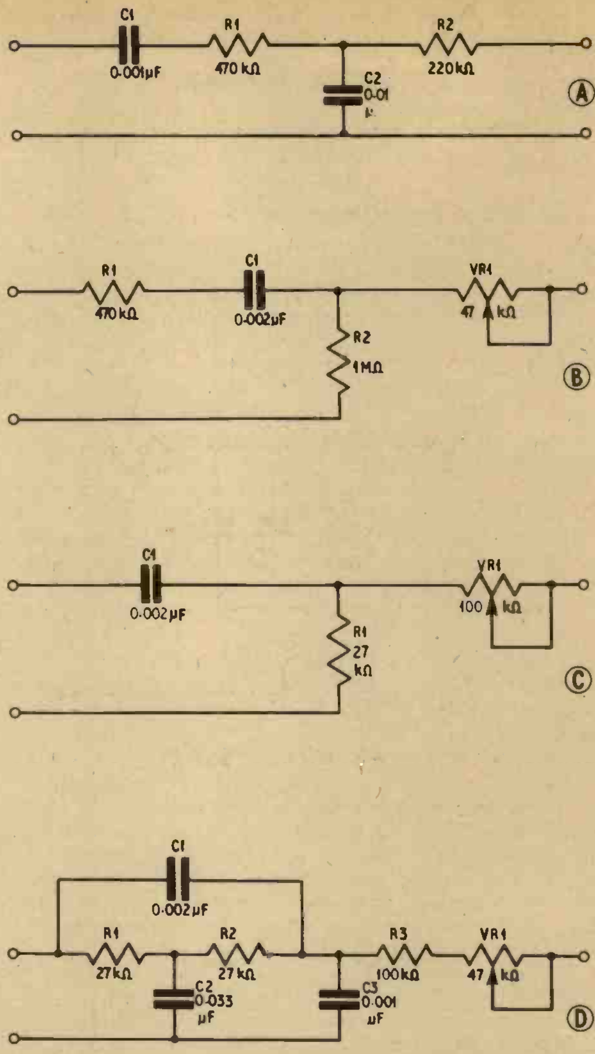


Fig. 5.6. String tone filters. (a) 16ft violes; (b) 8ft violes; (c) 4ft violes; (d) 8ft violes

The alternative is to feed each tone circuit into its own amplifier which is much more costly but sometimes desirable.

SAWTOOTH INPUT

Taking the flute-like tones first, in Fig. 5.5 we see a 16ft Bourdon at a, an 8ft flute at b and a 4ft flute at c. All require a sawtooth input. At d we find an 8ft flute extracted from a square wave, and this is also required for the 16ft contra tibia of Fig. 5.5e. Note the input circuits for the 8ft flute above, derived octave by octave rather in the manner of the equaliser just described.

String tone pipes always present a problem in stability, but we have an advantage here in that any sufficiently strong cluster of high harmonics will resemble a string organ pipe quite reasonably well.

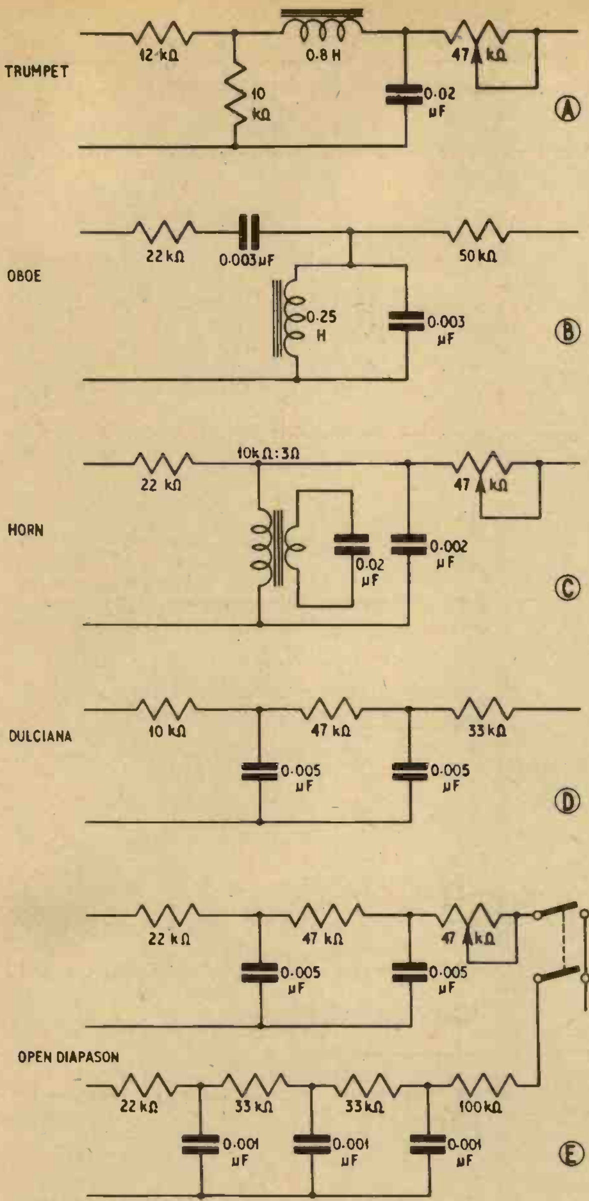


Fig. 5.7. Circuits for deriving conventional organ voices from sawtooth inputs

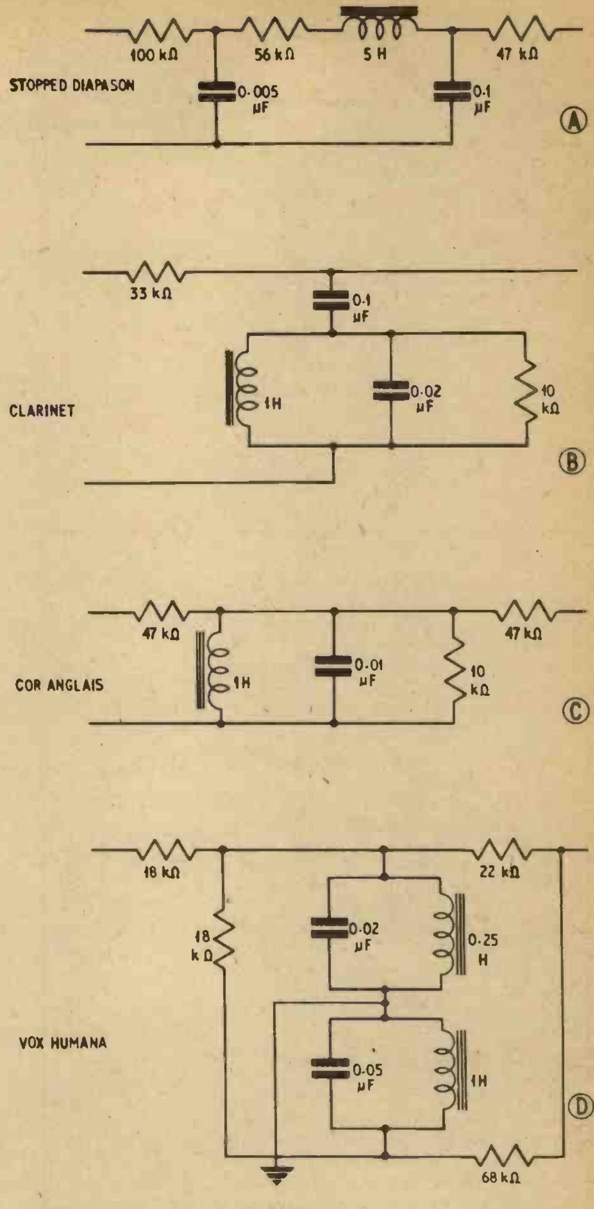


Fig. 5.8. Circuits for organ voices, derived from square wave inputs

Accordingly we show, in Figs. 5.6a, b, c, both 16, 8 and 4ft violes for a sawtooth input, also an 8ft viole for a square wave input (Fig. 5.6d).

In the matter of more conventional organ voices, assuming a sawtooth input, we can show circuits in Fig. 5.7 for 8ft trumpet, oboe, horn, dulciana, and open diapason. Note that this latter voice requires injection from a 4ft sawtooth as well as the 8ft basic pitch.

Finally, some interesting effects can be obtained from overlapping resonant circuits joined in series across a sawtooth line. This process has, in particular, been carried much further in the Bode Melochord, where contacts on each key continually retune resonant circuits so that the inevitable change in tone quality at the extremes of the compass is overcome.

SQUARE WAVE INPUT

Those organ sounds dependent on a square wave comprise the stopped diapason, clarinet, and cor anglais. There are, of course, many others, but we would not find them of much value in practice. Tone shapers for these voices are illustrated in Figs. 5.8a, b, c. An interesting circuit for an 8ft vox humana is given in Fig. 5.8d and requires a square wave.

In applying any or all of the foregoing, we must not forget that the loudness at which each voice is set greatly influences both its fidelity and its mixing properties. And all of these effects can be enhanced or reduced by the application of vibrato in various forms, and by the loudspeaker system and its placement in the room. We will examine these matters next month.

MARKET PLACE

TRANSISTORS

With so much happening in the world of electronics it is practically impossible to keep step with the lightning pace of the large organisations. But some of the "giants" of industry realise that the amateur market is no small market and make most of their components available to good recommended retailers.

Mullard is a typical example and they have just announced the addition of seven new *pnp* types to their range of silicon planar transistors. Five have power rating of 600mW and two power ratings of 350mW. Because of their linear gain/current characteristics all the new types are suitable for both switching and linear applications. Their *pnp* characteristic permits complementary operation in conjunction with established Mullard *npn* types.

The two 350mW devices are numbered BCY70 and BCY72. The former has a high V_{ceo} of 40V and a low saturation voltage. It is primarily intended for medium speed switching applications. The general purpose transistor type BCY72 is suitable for use in switching and amplifying applications requiring less stringent operational requirements.

A low leakage current, low saturation voltage and a high cut-off frequency, generally in excess of 200MHz, are features of the new 600mW transistor types 2N2904, 2N2904A, 2N1131, 2N1132 and 2N3133.

Applications for the 600mW group of devices are similar to those recommended for the lower rated devices although the high power rating also makes them suitable for use in driver and output stages.

The silicon diffused junction rectifier BY105 is a newcomer to the **Brimar** range. Rated at 800V, and using metal "top hat" encapsulation, the BY105 can operate at 1·1A. This gives it a substantial advantage over the earlier BY100 (even though this has now been uprated to 750mA), since both types are offered at the same price.

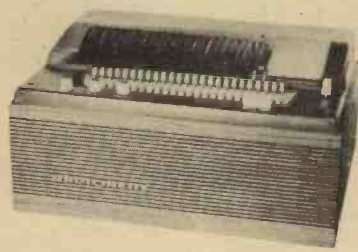
Whilst still on the subject of rectifiers a new addition to the existing range of Sanken silicon rectifiers is the type HF SA-3A from **Photain Controls Ltd.**, Randalls Road, Leatherhead, Surrey.

The peak reverse voltage is 600V with a r.m.s. input voltage of 420V and d.c. output current of 1·5A. Reverse current is 1μA at peak reverse voltage, forward voltage drop is 0·93V and recovery time is 1μs. Junction temperature is 150 degrees centigrade and surge current is 100A for 10ms.

International Rectifier Co. Ltd., have introduced a new selection of Zener diodes. Called the Zecon range they are available in 1 watt ratings up to 35 degrees centigrade and voltage values range from 3·9 to 30 volts in standard +10 per cent tolerance gradings.

BCY70 transistor from Mullard

Sinclair "Micromatic" Receiver



Radionette Multiplayer 50

"Commodore" portable receiver by KB

HOME LISTENING

Claimed to be the smallest receiver in the world the **Sinclair Micromatic** is housed in an elegant black plastics case with a polished aluminium front panel. Measuring only $1\frac{5}{8}$in × $1\frac{3}{16}$in × $\frac{1}{2}$in it contains a six-stage transistor circuit, ferrite rod aerial and two Mallory Mercury cells type ZM312 or RM312, which give up to 70 hours playing time.

The new circuit uses three special Sinclair transistors to assure good selectivity and reception from a wide range of stations over the medium waveband. The set is switched on by inserting a lightweight earpiece, withdrawing it automatically switches the set off.

Available in kit form for 59s 6d complete with earpiece and instructions, or ready built for 79s 6d, the Micromatic is covered by a five year guarantee.

The **Radionette** Multiplayer 50 is a compact transistorised multiple record player in a teak cabinet with Perspex cover, now being imported from Norway by Denham & Morley Ltd., 173–5, Cleveland Street, London, W.1.

This automatic "juke box" is capable of playing 25 discs or 50 sides in any pre-arranged order. Operated by push-button controls you can start, stop or replay any record or have six hours continuous music. Incorporating a 15watt amplifier with separate bass and treble controls, it plays at two speeds, 33 and 45 r.p.m., selected by a simple changeover switch. The frequency range is 47 to 17,000Hz ± 3dB at 1W output.

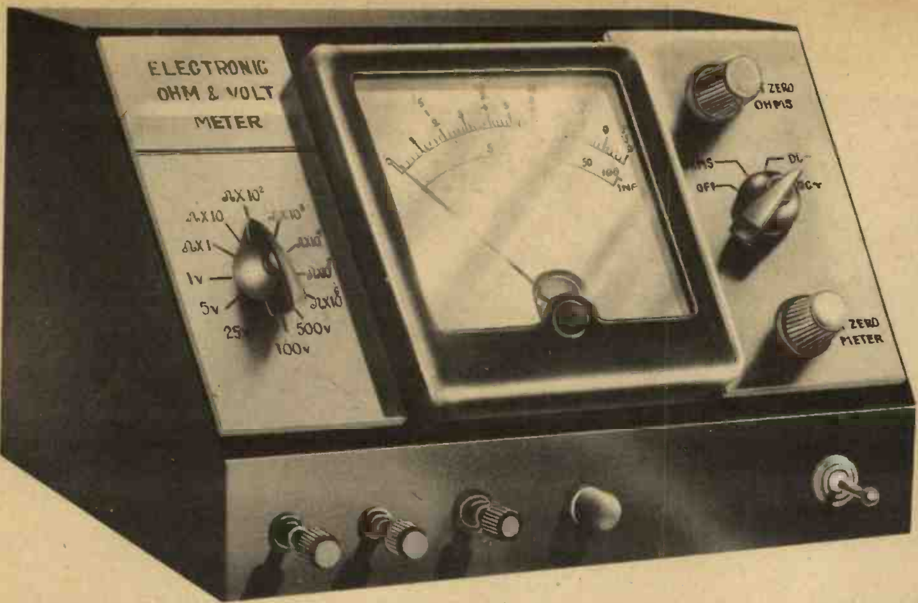
We recently had the opportunity of trying out a new KB portable radio, *Commodore* (model KR022). This set doubles as self-contained portable and car radio. For the latter function, the directional properties of the internal rod aerial are nullified by plugging the car aerial into the socket provided.

Lively performance was obtained in various locations. A sensible feature is the bandspreading of medium waves. Two wave bands (555-275m and 280-185m) simplify accurate tuning of the multitude of stations. The third band covers long waves.

Vital statistics: Seven transistors plus diode; earpiece socket; tape recording socket; car aerial socket; 7 in × $12\frac{5}{8}$ in × $2\frac{3}{4}$ in.; 4 lb $8\frac{1}{2}$ oz. 18 gns plus 5s 3d tax surcharge.

One black mark: back panel slightly bowed; suggest this would be prevented if *two* securing screws were provided at ends rather than the single screw at top centre of the panel.

Finally, look for the new modular techniques in hi fi at the Audio Festival and Fair (Hotel Russell, London, W.C.1. March 30 to April 2).



By H. T. KITCHEN

VALVE VOLTMETER & OHMMETER

SPECIFICATION

HIGH RESISTANCE VOLTMETER

Five d.c. ranges up to:
1V, 5V, 25V, 100V, 500V f.s.d.
Input resistance 10MΩ
Accuracy better than ±5% at f.s.d.
Linearity better than ±5% at f.s.d.

MULTI-RANGE OHMMETER

Seven ranges based on left-hand zero, 10 ohms calibration at centre of scale, and 100 ohms near to right-hand end: Scale X1; X10; X100; X1,000; X100,000; X1,000,000
Reference voltage 1·5 volts from dry cell
Accuracy better than ±5% at f.s.d.

SINCE good test equipment is essential to the serious hobbyist, one item, the valve voltmeter (v.v.m.), is one of the most useful units to grace the workbench. This article presents the design of a good and reliable, yet simple and inexpensive v.v.m. together with an exposition of why it is necessary and how it works.

In order to explain why a v.v.m. is necessary it is essential to have at least an elementary knowledge of an ordinary voltmeter. All voltmeters extract power, however minute, from the circuits to which they are connected so that the less power they extract the more accurate the final result—provided the initial meter calibration is correct.

This is particularly applicable to high impedance circuits which, as a rule, have very small currents flowing through them. A typical example is a voltage amplifying valve stage with a very high value of anode load resistor.

The effect of connecting voltmeters of differing sensitivities into such a circuit is shown in Fig. 1. In Fig. 1a, R_L = 100 kilohms, the h.t. supply is 300 volts, and the anode current is 1mA. Now by Ohm's law, 1mA through 100 kilohms will cause a voltage drop of 100V across R_L leaving 200V on the anode which is the true anode d.c. voltage.

If a voltmeter with a sensitivity of 1,000 ohms per volt, is connected as shown in Fig. 1b, the current drawn by the meter will be 1mA for full scale deflection. Since the valve requires 1mA and the meter also requires 1mA the total current flowing through R_L will be 2mA, which by Ohm's law will cause 200V to be dropped across R_L leaving 100V on the anode—and this is the voltage the meter will indicate, an error of no less than 50 per cent. The unwary could go chasing non-existant faults unnecessarily.

Now consider a 20,000 ohms per volt meter with a full scale deflection of 50μA (Fig. 1c). This would show a truer picture since it only requires one twentieth of the current used by the first meter. The total current passing through R_L is now 1·05mA, causing a voltage drop of 210V, and leaving 190V on the anode, which would be indicated by the meter. Although not absolutely correct, this is a more reliable reading than the first example.

VALVE VOLTMETER

A valve voltmeter with a very high input resistance, typically 10MΩ, would be better still since it would cause only an additional 20μA to flow through R_L, increasing the voltage drop to 102V and leaving 198V on the anode.

A valve voltmeter uses a kind of impedance converter which allows a milliammeter or microammeter with an inherently low impedance to be connected into a high impedance circuit without adversely affecting the true value being measured.

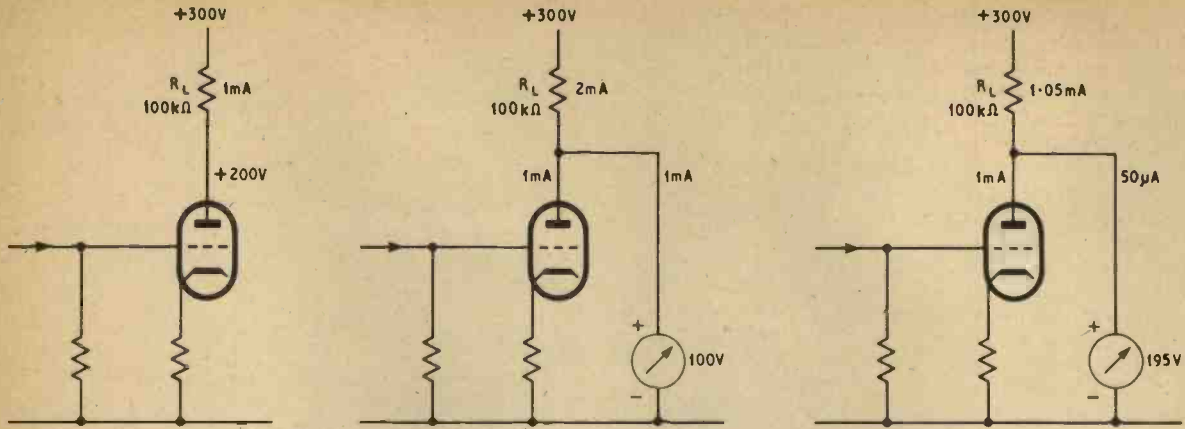


Fig. 1. Illustrating the effect of circuit loading on anode voltage when using meters of differing sensitivity

The ideal v.v.m. would be one having infinite input impedance and zero output impedance which are in practice unattainable, although a number of proven circuits do go a long way towards the ideal. They are necessarily comparatively complex and correspondingly expensive. However, it is possible for most amateur needs to be fulfilled by simpler and cheaper circuits.

Impedance conversion is not the only function of a v.v.m. for it has also to provide a degree of current amplification. On the 1 volt range for instance the current extracted from the circuit under test is 0·1µA. This gives an f.s.d. reading on the meter of 50µA necessitating an amplification of 500 times or 54 decibels.

The valve operates as a push-pull cathode follower, the two halves of the double triode V1a and V1b being balanced for current equality by means of the potentiometer VR1, when of course the meter will not register (see Fig. 2). The circuit is in effect a balanced bridge which is unbalanced when a voltage is applied upon either grid, the unbalance being shown by a deflection on the meter. This unbalance will depend on the polarity of this voltage, so that a centre-zero meter would register either way.

In practice it is preferable, and usual, to use an ordinary meter and use a polarity reversal switch which adds a slight complication but effectively doubles the scale length of the meter. The grid of V1a is connected to the potential dividing resistors R1 to R5 via R13 which reduces the ratio of maximum to minimum grid resistance as S1 is rotated. Without R13 the maximum resistance in circuit is 10MΩ on the 1V range and 20kΩ on the 500V range—a ratio of 500: 1.

With R13 in circuit the maximum grid resistance is about 13MΩ and the minimum about 3MΩ, a ratio of 4·3:1. This reduces the variations in zero setting due to grid current which would be caused by the extreme variation in grid resistance without R13. This variation is also reduced still further by running the valve with a very low anode potential.

The potentiometer VR1 enables the electrical zero to be set to coincide with the mechanical zero. It also enables the pointer to be positioned anywhere on the scale, which is a most useful facility since it enables the v.v.m. to be used as a centre-zero meter for f.m. receiver alignment.

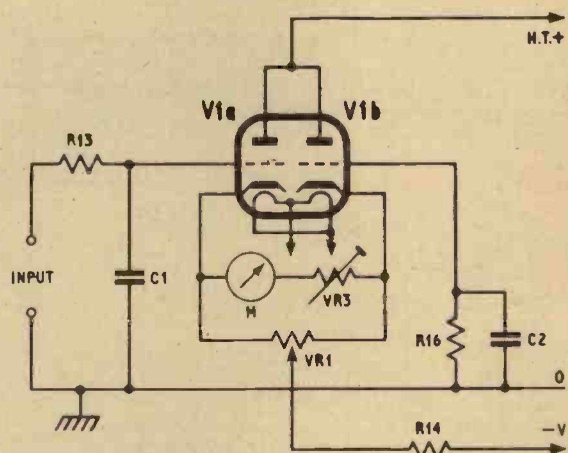


Fig. 2. Circuit diagram of a basic bridge valve voltmeter

VR2 and VR3 are selected as required by S2 and fulfil the following functions. VR3 allows the meter to be calibrated for a given input and is not used after initial calibration is complete, it is made a preset control. VR2 allows the meter to be set to full scale deflection for resistance measurement. Since it will require periodical adjustment, it is brought out as a front panel control.

S2 also reverses the meter polarity so that either a positive or a negative potential (with respect to chassis) can be measured, when VR3 will be in circuit. On the "ohms" range VR2 is brought into use. In the "off" condition the meter is disconnected from circuit and a short circuit placed across it, which effectively damps the movement, protecting the needle from excessive swinging during transit. When not in use the unit must also be disconnected from the power supply by S3.

OHMMETER

The ohmmeter is part of the v.v.m. circuit and allows a very wide range of resistance to be measured, which in the prototype was made from 1Ω to 100MΩ.

The top range could be increased to 1,000MΩ if a standard 100MΩ resistor is obtainable. The circuit operates by measuring the voltage present at the junction of the standard resistor R5 and the unknown resistor Rx both of which are connected in series across the reference voltage (see Fig. 3).

In the complete circuit the standard resistor is replaced by resistors R6 to R12 and the reference voltage is provided by a 1·5V pen torch cell; full-scale deflection is set by VR2.

In this context it must be explained that the electronic ohmmeter works in reverse to the normal type in which f.s.d. corresponds to zero resistance. If the unknown resistor Rx is now connected in circuit the meter will indicate the reading which is proportional to the ratio of Rx to Ry. When Rx = Ry the meter will read mid-scale.

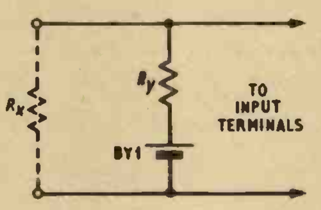


Fig. 3. Ohmmeter grid divider circuit showing how input voltage varies with terminal resistance

POWER SUPPLY

The power supply requirements are very modest so that a comparatively simple circuit is quite adequate. The h.t. required is −65V, +65V at 3·5mA, the negative supply being used for grid biasing. Smoothing is provided by C3, C4 and R19, the negative voltage being developed across R18.

COMPONENTS

Fig. 4 shows the complete circuit with the voltage dividing network R1–R5 for selecting the appropriate voltage range. The standard resistors for the ohms ranges are selected by S1b.

Stability of indication is as important as initial calibration accuracy, for it is pointless calibrating a meter to a fine accuracy if it is going to be wildly inaccurate on a subsequent occasion.

Variations due to fluctuating h.t. and heater supplies are largely cancelled out due to the push-pull operation, so one has to look further afield for possible sources of trouble.

The potential divider resistors R1–R5 must be of the highest quality possible, preferably 1 per cent high stability types, though 5 per cent hi-stabs could be used if one is prepared to accept a reduction in overall accuracy. Resistors R6 to R12 should also be 1 per cent hi-stabs. Two other resistors should be hi-stab types, these being R13 and R16 although here accuracy can be relaxed to 5 per cent or even 10 per cent.

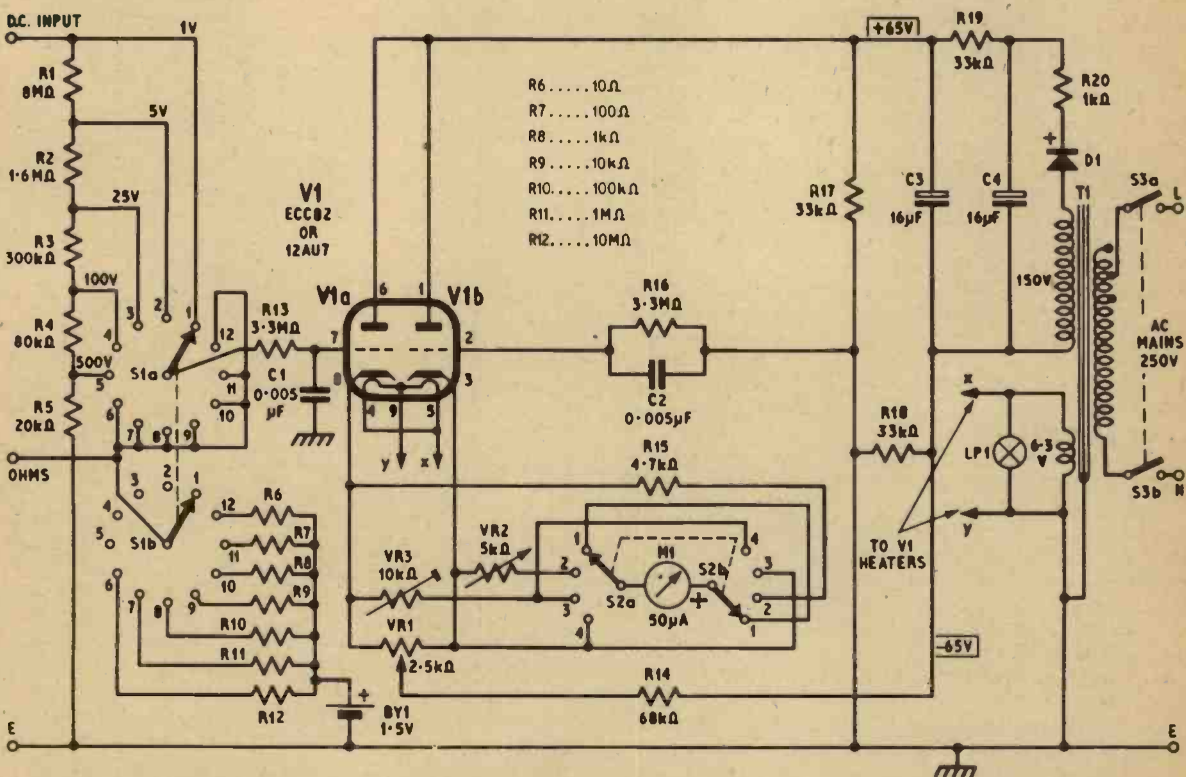


Fig. 4. Circuit diagram of the valve voltmeter and ohmmeter. The following are the function ranges for S1 and S2

D.C. Volts (S1)	Ohms (S1)		S2 Ranges
Position 1 ...... 1V	Position 6 ... ΩX10⁶	Position 10... ΩX10²	Position 1.........Meter Off
Position 2 ...... 5V	Position 7 ... ΩX10⁵	Position 11... ΩX10	Position 2.........Ohms
Position 3 ...... 25V	Position 8 ... ΩX10⁴		Position 3.........D.C. Negative Volts
Position 4 ...... 100V	Position 9 ... ΩX10³	Position 12... ΩX1	Position 4.........D.C. Positive Volts
Position 5 ...... 500V			

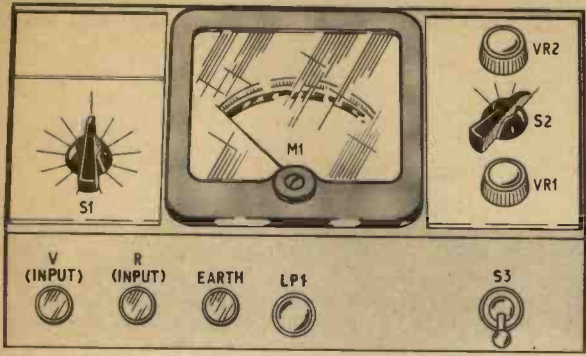


Fig. 5. Front panel layout

The only capacitors deserving special mention are C1 and C2, which decouple both grids against any a.c. signals which may reach them. Although the actual value is unimportant their insulation properties must be absolutely first class. Since they are both connected across very high resistances, any leakage will adversely affect the v.v.m. Any value from 0·001μF to 0·01μF should prove suitable particularly if they are polystyrene or silver mica types.

The range switch S1 must be of good quality. Although the author was fortunate enough to possess an instrument quality stud switch, it is possible that most constructors will not have one to spare—and they are expensive items to buy new. The wafer switch specified should however prove quite satisfactory. S2 can also be a wafer switch with only 4 of the 6 ways used.

The meter will almost certainly be the most expensive single item. The larger the meter the more accurately and easily can readings be made. It must be borne in mind that some meters are accurate only if used vertically or horizontally.

The valve can be any medium impedance double triode such as the one specified. The valve holder should preferably have either ceramic or p.t.f.e. insulation to minimise capacitance leakage between adjacent pin connectors.

CONSTRUCTION

The cabinet was constructed from ½in softwood for the sides and hardboard for the front, rear, and bottom. Many of the dimensions given in Fig. 6 are the inside ones and are given for guidance only. It is possible that the positions of some holes may require altering to suit different components.

The final angle or slant on the cabinet was chosen because it permits easy meter viewing whether one is standing or sitting, a great convenience although it

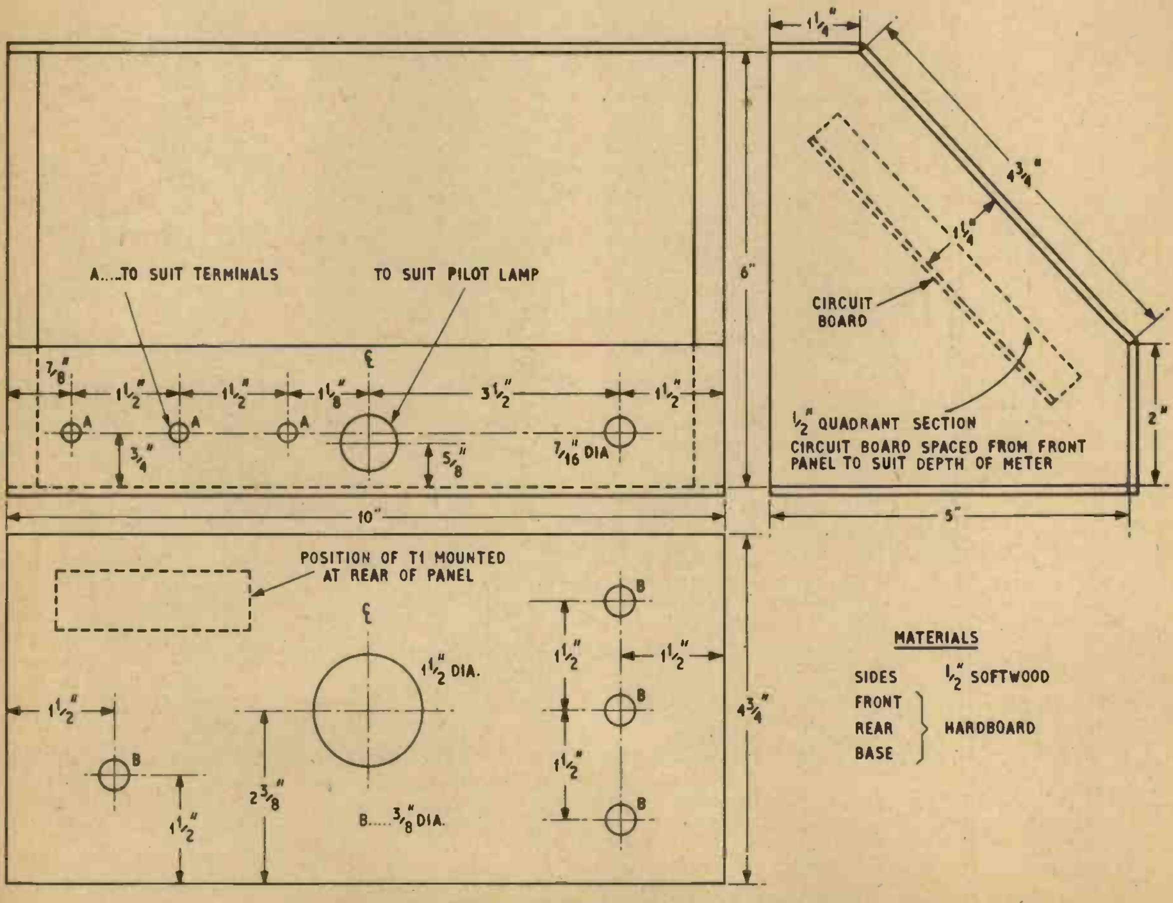


Fig. 6. Constructional and drilling details of panel assembly

COMPONENTS . . .

Resistors

R1 8MΩ (4·7MΩ + 3·3MΩ in series)
R2 1·6MΩ (3·3MΩ + 3·3MΩ in parallel)
R3 300kΩ (150kΩ + 150kΩ in series)
R4 80kΩ (47kΩ + 33kΩ in series)
R5 20kΩ (10kΩ + 10kΩ in series)
R6 10Ω 1%, $\frac{1}{4}$W (metal film) (Waycom)
R7 100Ω
R8 1kΩ
R9 10kΩ
R10 100kΩ
R11 1MΩ
R12 10MΩ
R13 3·3MΩ 5%, $\frac{1}{4}$W
R14 68kΩ 10%, $\frac{1}{4}$W
R15 4·7kΩ 10%, $\frac{1}{4}$W
R16 3·3MΩ 5%, $\frac{1}{4}$W
R17 33kΩ 10%, 1W
R18 33kΩ 10%, 1W
R19 33kΩ 10%, 1W
R20 1kΩ 10%, 1W

All 1% high stability, $\frac{1}{2}$W except where otherwise stated. Alternative resistor combinations shown in brackets should also be 1%

Potentiometers

VR1 2·5kΩ linear carbon
VR2 5kΩ linear carbon
VR3 10kΩ linear carbon preset

Capacitors

C1 0·005μF mica 350V
C2 0·005μF mica 350V
C3, 4 16+16μF elect. 350V

Transformer

T1 Mains Transformer:
Pri. 200–250V mains;
Sec. 1. 150V 5mA; Sec. 2. 6·3V 0·4A

Valve

V1 ECC82 or 12AU7

Rectifier

D1 250V 50mA contact cooled, half wave

Meter

M1 50μA f.s.d. 1,100Ω int. resistance (type Sifam M202) or MR3P (Henry's Radio)

Switches

S1 2 pole 12 ways (2 bank wafer switch)
S2 2 pole 6 ways (2 ways not used)
S3 Double pole on/off toggle switch (see text for notes on S1 and S2)

Miscellaneous

BY1 1·5V pen torch cell
LP1 Lamp 6V m.e.s. with holder
Valveholder B9A ceramic or p.t.f.e.
Insulated screw terminals (3 off)
Turret tags and soldering eyelet tags
Four knobs

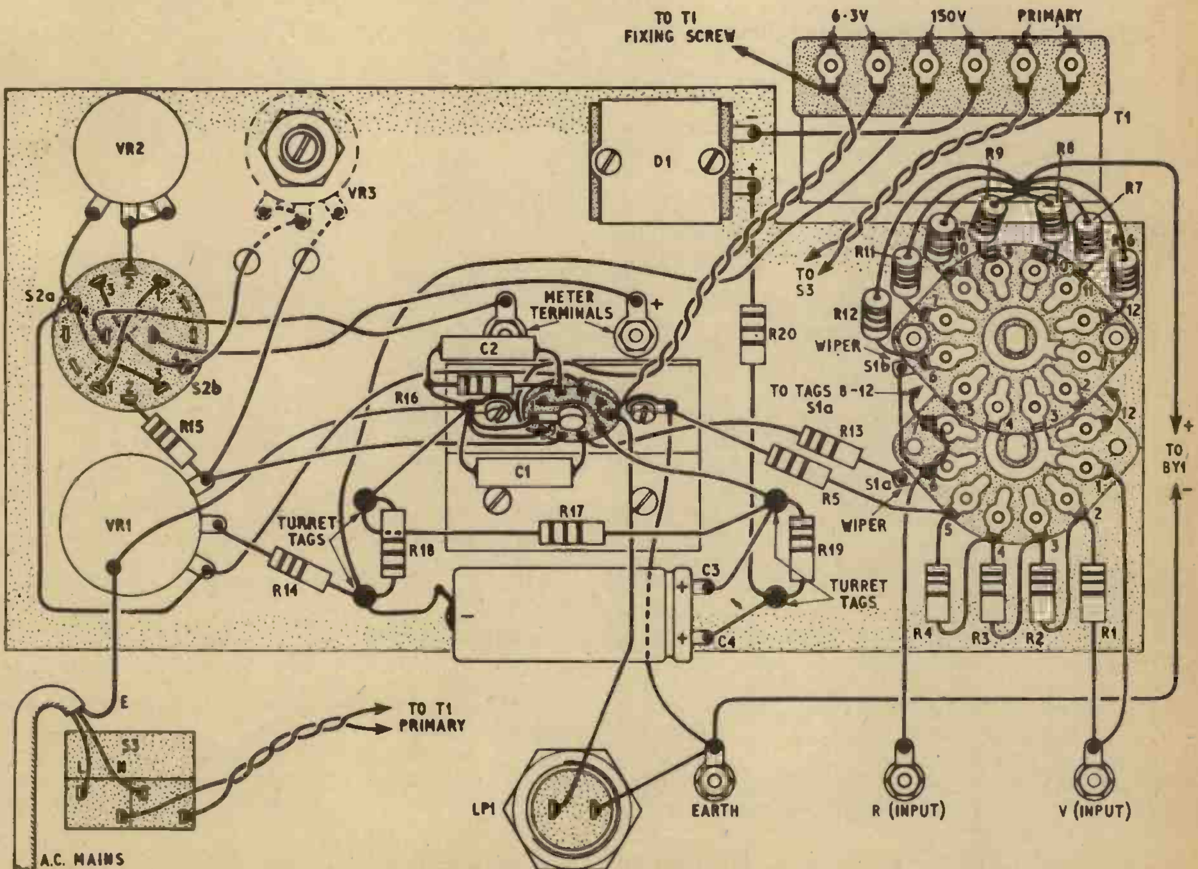


Fig. 7. Component assembly and wiring details

must be stressed that most accurate readings are made by viewing straight in line with the meter needle. Use of a mirror which is sometimes fitted behind the needle of a high quality meter, is recommended for accurate interpretation of the meter reading. Ventilation holes are drilled along the top and bottom edges of the cabinet to allow the heat from the valve to escape.

Almost the entire circuit is assembled on a sheet of s.r.b.p. measuring 9in ×4½in (Fig. 7). This is fixed to the cabinet by ½in quadrant section supports glued to the cabinet sides. The distance of these pieces from the front panel will depend upon the depth of the meter casing within the cabinet, since the connecting terminals of the meter also serve to hold it in place (see Fig. 8). If the meter holds the board quite firmly, these quadrant pieces may not be necessary.

The potentiometers and switches that have their spindles protruding through the front panel should be

TESTING

The v.v.m. is now ready for testing but before the mains are connected the controls should be set as follows: S1 to 5 volts range; S2 to d.c. positive; VR1 to approximately mid-position; VR2 and VR3 with maximum resistance in circuit. The mains supply can then be connected and switched on.

As the valve warms up the meter needle will swing from side to side and then take up a definite position at or near the zero position. If not VR1 must be adjusted to bring the needle to zero. If zero can only be obtained with VR1 at one end of its track the valve is unbalanced and another specimen should be tried. If zero is obtained with VR1 at its mid-position, the two triodes are passing near equal cathode currents and all is well. The zero setting should not alter as S1 is run though all ranges, or if S2 is switched to d.c. negative or ohms.

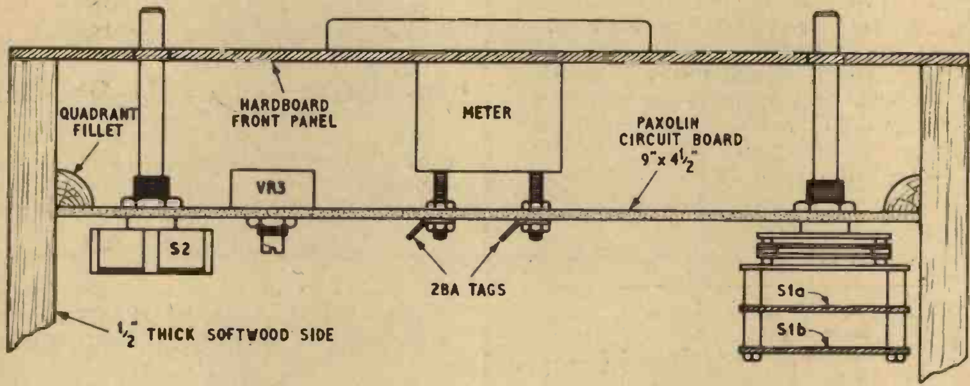


Fig. 8. Component board disposition relative to front panel. Note that fillet fixing distance will depend on the meter depth

fixed in position on the panel and corresponding holes drilled through the box. The s.r.b.p. panel is offered up to the front panel of the box from behind and the positions of the holes scribed on to the rear of the box front panel. Remove the s.r.b.p. panel then drill out the holes in the box.

A piece will have to be cut out of the s.r.b.p. to clear the mains transformer which is bolted to the front panel by 4 B.A. nuts and bolts. Four turret tags or 4 B.A. soldering tags are inserted into the s.r.b.p. in the positions shown to support R18, C3, C4, and R19.

The 1·5V pen cell is fixed to the side of the box, first removing the cardboard cover so that connection is made between the zinc case and the metal clip. A soldering tag is held under the clip fixing screw. This tag is then connected to the common earth terminal. A short piece of insulated wire is soldered to the battery positive terminal, the other end going to the junction of the resistance standards—a common tag situated as convenient for resistors R6 to R12.

Although wiring should be straight forward it is advisable to treat the high stability resistors with some care. The use of a heat shunt is advisable while soldering, for even the best hi-stabs will fail if roughly treated to an overdose of heat from the soldering iron. To avoid any risk of damage to the meter it should not be fixed in position until wiring is complete. It is advisable to reset the wiring and to remove any stray pieces of solder or wire that can have such disastrous results if overlooked.

CALIBRATION

Calibration can be carried out after allowing ample time to settle down (about 10 minutes) using the circuit of Fig. 9. The 10kΩ linear potentiometer is adjusted until the standard meter reads precisely 5V when VR3 can be adjusted to allow the v.v.m. to read correspondingly. The zero setting should be checked and if necessary readjusted and then the full-scale reading rechecked. The two are slightly interconnected and several adjustments may have to be made. The battery and v.v.m. polarities should be reversed and the full-scale reading checked for a negative input. This reading should be identical whether one measures positive or negative voltages both, of course, with respect to earth.

The linearity of the v.v.m. scale can be checked by reducing VR1 slowly, comparing the standard and v.v.m. readings every 0·5V. The deviation should not exceed 5 per cent.

The calibration of the ohms ranges is somewhat more complicated, requiring the use of a resistance substitution box or a collection of 1 per cent standards. Five or 10 per cent standards could no doubt be used but, taking into account human, electrical and mechanical errors, the net result would not be of much use apart from rough resistance checks. Ideally also, each resistance range should be individually calibrated, a quite formidable task requiring a wide selection of standards.

It may be possible to calibrate one range (e.g. 10kΩ) to a reasonable accuracy and assume the others to be calibrated automatically. Checks above and below with the occasional 1 per cent hi-stab resistors showed very little error, so that it is not unreasonable to suppose that overall accuracy is sufficient for most servicing needs.

NON-STANDARD RESISTOR VALUES

Some constructors may find it difficult to obtain the exact resistance values suggested for R1 to R5 as most of them are non-standard. These were chosen to allow a voltage step of 5 : 1 from range to range as this permits rather more overlaps at the bottom end of each range resulting in improved accuracy. Alternative combinations are given in the components list. Where 10 to 1 steps aren't objected to or where the specific values for R1 to R5 cannot be obtained, a change can be made in resistance values and R1 to R5 changed to 10MΩ, 1MΩ, 100kΩ, and 10kΩ allowing voltages of 1V, 10V, 100V, and 1,000V respectively to be measured. R5 can be deleted.

It is most inadvisable to replace this with a 1kΩ resistor and to try for a 10kV range as the insulating properties of the input terminal and S1a will almost certainly be inadequate. The quoted values for R1–R5 can be made up using two or more resistors in series or parallel in each case.

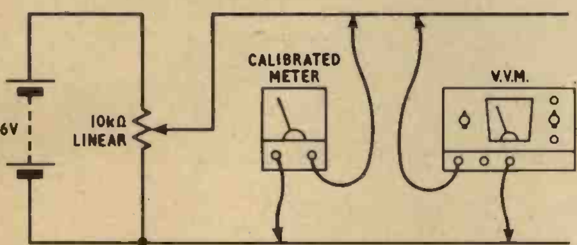


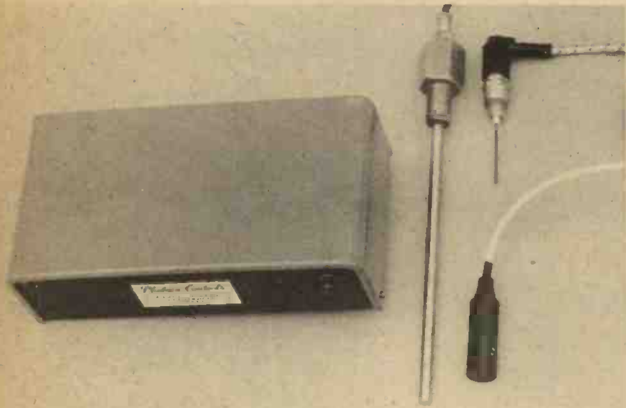
Fig. 9. Test set-up for calibration of the valve voltmeter

Some 12-way wafer switches are actually 11-way types; the twelfth position being used to switch off when the wafer is left on its input wiper position. In this case the seven resistance ranges can be retained and the voltage range converted to the 1V, 10V, 100V and 1,000V sequence, resulting in a total of 11 ranges. The switch must never be left "off" when the v.v.m. is switched on as the grid will be "floating" with consequently possible damage to the valve.

It is desirable to mark the scales on the meter dial. Particular care is necessary when removing the meter movement from its case. Before doing so turn S2 off to damp the movement. Be careful not to touch the needle otherwise it may be easily damaged or bent. A fine mapping pen is suitable for marking the dial. Switch S1 and S2 to the appropriate positions for calibration. On completion of calibration switch S2 to off and carefully replace the movement in the case.

In conclusion, a word of warning. Always bear in mind that one meter lead is earthed so that any attempt to measure directly across a floating voltage may have dire consequences. A floating voltage is one that has a certain potential difference across, for example, a resistor, both ends being above chassis potential. ★

ELECTRONORAMA



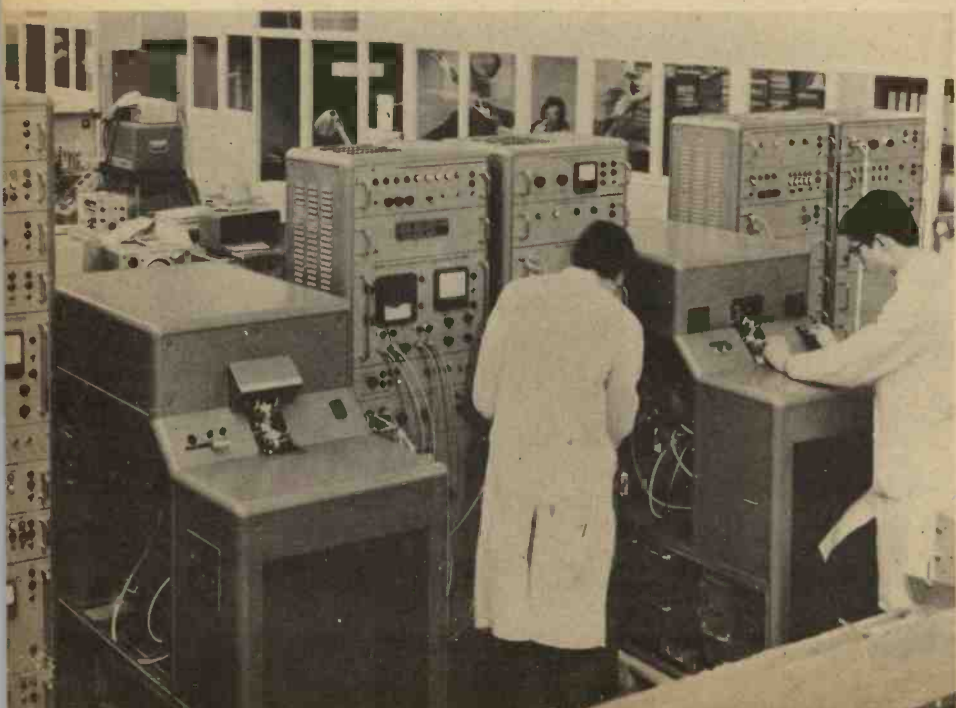
Capacitance Probe Proximity Detectors

CAPACITANCE type proximity detectors often depend upon a change of capacitance relative to earth to alter the balance in a bridge network. These systems are not always suitable for all applications because the area of capacitance between probe and "earth" becomes a factor which limits the use of such probes near pipes and girders.

Photain Controls of Leatherhead have a Patent Application on a system, which overcomes this difficulty, using a high frequency oscillator. Two equally balanced coils form a balanced bridge with no reference to earth other than by fixed capacitors. The probe area can be to any required dimension and the capacitance detection area is fully directional. Our photograph above shows the control unit with three probes for different applications such as counting, limit switching, conveyor process control, or liquid level control.

Micro-integrated Computer

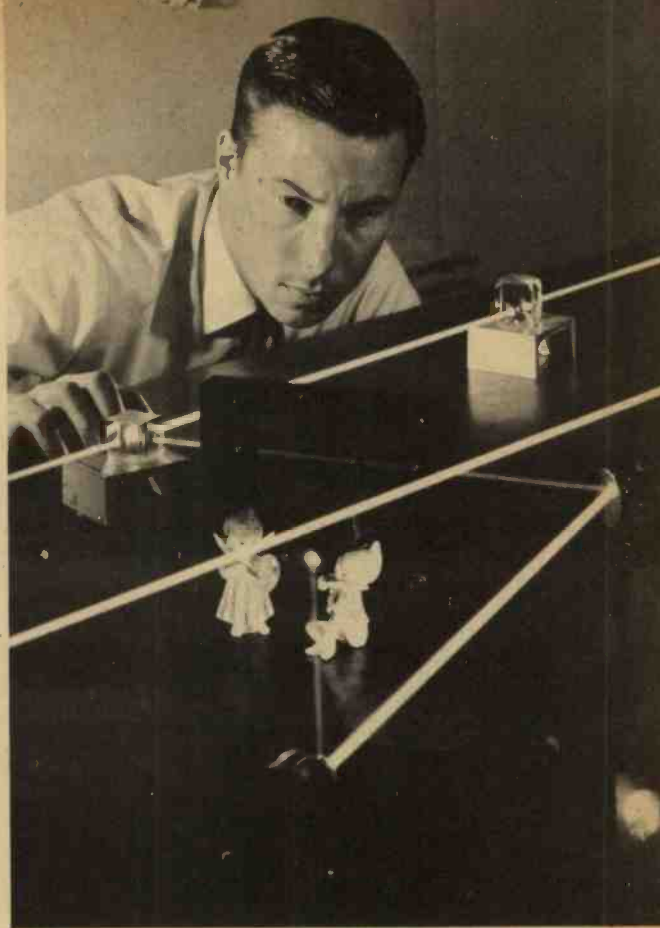
AN English Electric Leo Marconi computer production centre, now under construction at Winsford, Cheshire, will produce the new System 4 computers under the managership of Mr I. H. Owen, who is seen top right with System 4 magnetic tape units at Kidsgrove. These computers are said to be Britain's most advanced third generation machines and use micro-integrated circuits.



Automatic Sorters for Capacitors

THESE clean-line consoles (left) are German Klemt automatic capacitor sorters being tested by engineers of the U.K. agents Livingstone Electronics.

An operator places components to be tested in the sixty sets of jaws on a large rotating wheel. Pre-programmed tests are carried out as the wheel rotates, then components are sorted into grade or reject bins. The programmed test equipment is housed in the adjacent racks.



Laser Photography

HOLOGRAPHY, a technique of lensless photography, is one of the latest uses of the laser's "light fantastic". Dr Ronald Lundgren of Hughes Aircraft Company's research laboratories in California is shown (right) recording a "hologram", a true three-dimensional image, without the use of a lens. In the holographic reconstruction of the image, by playing the laser light back through the plate, one can see the pixie-like figurines in foreground in true three-dimensional form from any angle, as if looking through a window. Scientists believe that holographic techniques may someday be used for target recognition from air to ground, and that we may eventually have holographic movies and television.

A Mere Bagatelle!

THIS machine may look a bit like a pin-table indicator board but, in fact, is a highly sophisticated transistor tester, the Teradyne T207. This is an automatic, high-speed, go/no-go instrument for production line testing. Standard industrial d.c. tests are performed in 35 milliseconds per semiconductor.

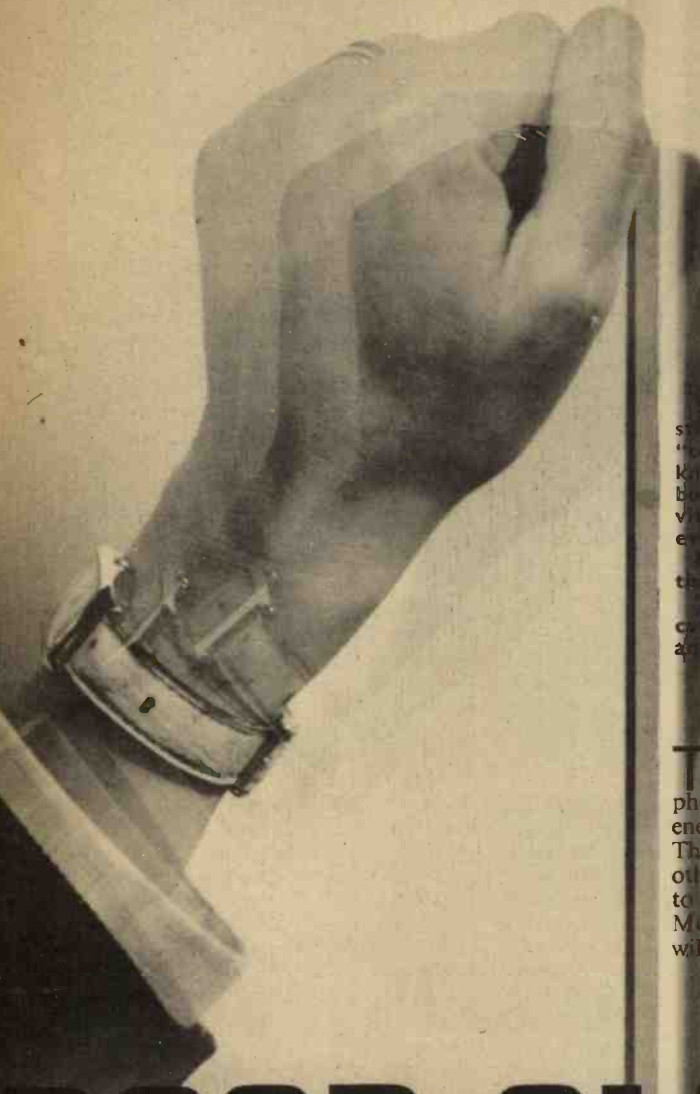
On automatic handling over 4,000 transistors are tested per hour.

Programming all conditions for each test is easily performed at a single position on the front panel. Programming switches are so arranged and test circuits are so designed that it is not possible to damage inadvertently the device under test, the test instrument, or even the operator.

For highly complex classification and for data logging requirements, the T207 is readily modified for control by a digital computer.

Modular construction with digital readout is under a 10 year guarantee. The price?—around £7,000. A Rolls Royce or a mere bagatelle?

S.T. ANDREWS
AUTHOR



Some time ago the writer developed a form of constitutional laziness, this being an objection to shouting "come in!" over the noise of an office, whenever anyone knocked on the door. It was therefore decided to build some simple electronic gadget which would give a visible signal, for example the lighting of a lamp, whenever there was a sharp tap on the door.

Such a device was built, tested, and is the subject of this article.

There are almost unlimited variations on the application of the circuit described, both in its basic use, and in the method of display of the results.

THE Door Slave is, essentially, a sound-sensitive switch: whenever a sound is picked up by a microphone a relay closes for a few seconds, then it is de-energised and the circuit returned to the resting state. The relay is made to operate a lamp or do whatever other function may be required. The circuits required to do this are simple and form the basic unit. Modifications and extensions can be added later and will be discussed at the end of this article.

DOOR SLAVE

THE BASIC UNIT

The block diagram of the basic unit is given in Fig. 1 and the circuit diagram in Fig. 2.

TR1 and TR2 form a conventional two-stage voltage amplifier with a voltage gain of about 200 times, consequently an input of a few millivolts will give up to one volt output across resistor R9. The actual gain is dependent on the sensitivity control, VR1, and the method of setting this will be described later. TR1 and TR2 are decoupled from the rest of the circuit by R10 and C8. As it stands the circuit is best fed from a crystal microphone; this can be a cheap type since the fidelity is obviously not important, but anything giving an output of a few millivolts will do.

INTEGRATOR

The output from TR2 is taken to a very simple form of integrating circuit, D1, R11, R12 and Cx. The function of this circuit is to take the a.c. signal output of the amplifier and convert it into a short d.c. pulse which is then amplified by TR3. The value of Cx in this circuit is very variable; it may need to be several μFs in order to get a good output pulse but, conversely, as in the writer's prototype, it may work best with Cx missing entirely. TR3 is merely a d.c. amplifier and in the resting stage it is biased to cut-off. A sudden signal applied to the amplifier will be converted, by the integrator, to a negative-going pulse tending to cause TR3 to conduct and producing a positive-going pulse across R14.

TR4 and TR5 together form a monostable switch, or flip-flop. In the resting state TR4 is conducting and the voltage developed across the collector load is passed to TR5 via R17 keeping TR5 cut off and its collector negative. When a positive-going pulse is applied to TR4 base this transistor is temporarily cut off and TR5 conducts instead. This condition lasts, however, only for a short time, until C7 has charged enough to allow TR4 to begin conducting again; an avalanche action then occurs and the circuit flops back to its initial state with TR5 cut off. The triggering voltage pulse appearing across R14 is coupled to the flip-flop by C6 and R15.

The flip-flop cannot, as it stands, drive a relay directly and so a current amplifier is needed. This is the function of TR6 which is coupled to TR4 via R21 and has the relay RLA as its collector load. As long as TR4 is conducting and its collector is at nearly the zero line voltage, this transistor will be held cut off. When the flip-flop is triggered and TR4 ceases to conduct temporarily, then the base of TR6 rises to near the -9 volt line, the transistor conducts and the relay operates.

The circuit action can be summarised as follows: When a sound of sufficient amplitude is picked up by the microphone it is amplified, converted to a d.c. voltage pulse, and used to trigger a flip-flop. As long as this remains in the triggered state the relay will be closed and the appropriate action will occur. After a short time the flip-flop will revert spontaneously to the stable state and the relay will be de-energised.

REMOTE CONTROL UNIT

So far only the most basic circuit has been described and to make the device into a practical unit, some form of control unit is very desirable. This is simply to enable the Door Slave to be controlled from where the operator normally sits.

The recommended system of wiring between the control unit, the main unit, and the lamp unit is given in Fig. 3. It will be seen that a 9-way cable connects the control unit to the main unit, and a 4-way cable links the latter with the lamp unit.

Controls mounted on the control unit are: S1, overall on/off; S4, the lamp selector, i.e. "come in", "engaged",

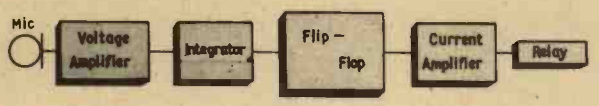


Fig. 1. Block diagram of the basic unit

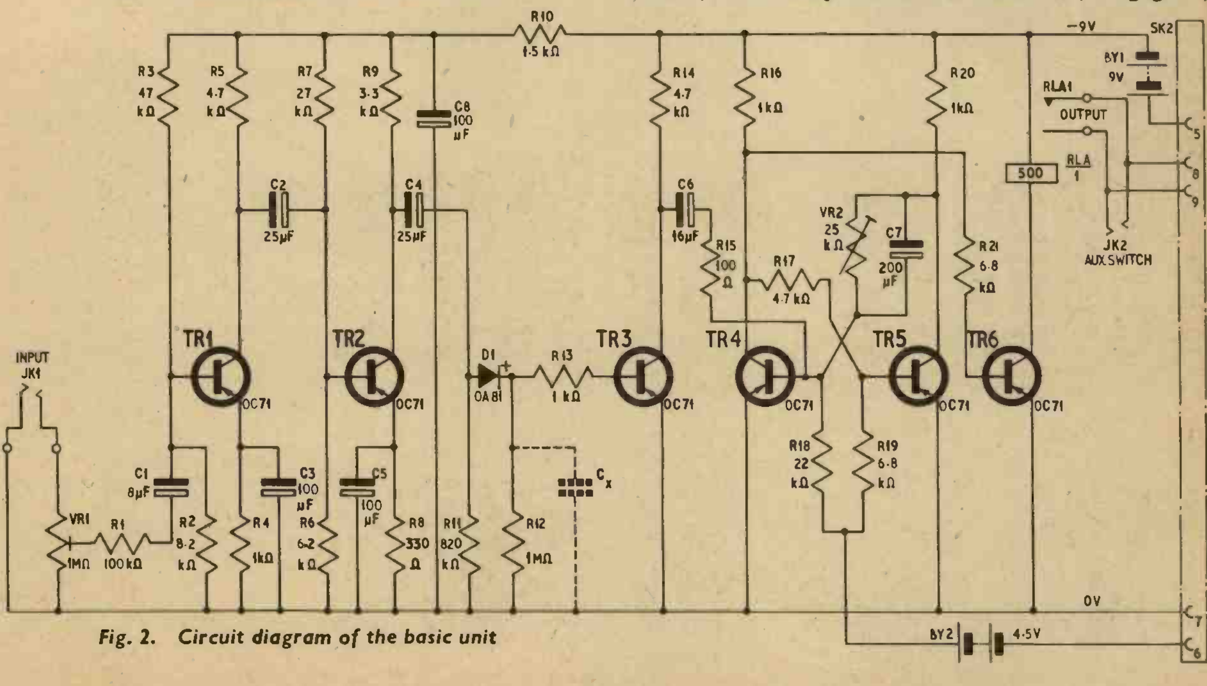
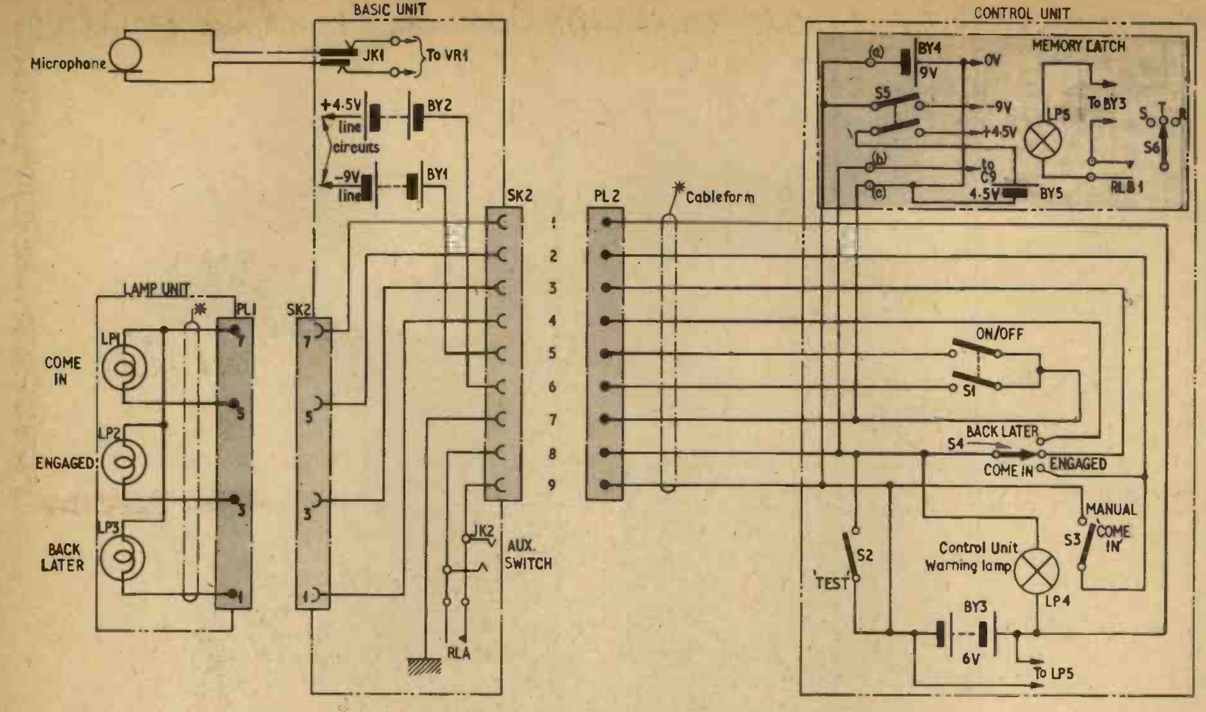


Fig. 2. Circuit diagram of the basic unit



COMPONENTS . . .

Resistors

R1	100kΩ	R8	330Ω	R15	100Ω
R2	8·2kΩ	R9	3·3kΩ	R16	1kΩ
R3	47kΩ	R10	1·5kΩ	R17	4·7kΩ
R4	1kΩ	R11	820kΩ	R18	22kΩ
R5	4·7kΩ	R12	1MΩ	R19	6·8kΩ
R6	6·2kΩ	R13	1kΩ	R20	1kΩ
R7	27kΩ	R14	4·7kΩ	R21	6·8kΩ

All ±10%, ¼W carbon

Potentiometers

VR1 1MΩ Preset
VR2 25kΩ Preset

Capacitors

C1	8μF	12V	C5	100μF	6V
C2	25μF	12V	C6	16μF	12V
C3	100μF	6V	C7	200μF	15V
C4	25μF	12V	C8	100μF	12V

All miniature electrolytic.

Transistors

TR1–6 OC71 (6 off)

Diode

D1 OA81

Relay

RLA 500Ω coil. One make-break contact.

Switches

S1 Double pole on/off
S2 Single pole on/off
S3 Single pole on/off
S4 Single pole 3-way
(may be separate component or ex G.P.O. telephone switchboard—see text)

Plugs and Sockets

SK1, 2 B9A valveholder (2 off)
PL1, 2 B9A plug (2 off)
JK1, 2 Open circuit jack socket 2 (off)

Batteries

BY1 9V
BY2 4·5V
BY3 6V

Lamps

LP1 (etc.) 6V 0·3A (quantity as required)

Miscellaneous

BASIC UNIT: Wooden baseboard 6in × 7in; metal or wooden case 6in × 7in × 4in.
Two 20-way group boards, or tag strips
Crystal microphone and jack plug

CONTROL UNIT: *Metal panel 12in × 4in
Baseboard 12in × 9in. Metal or wooden case 12in × 4in × 9in

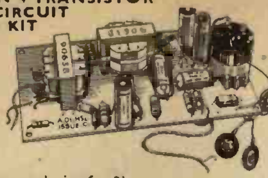
(*not required if ex G.P.O. telephone switchboard is used)

LAMP UNIT: Plywood for case. Three M.E.S. batten type lamp holders. Connector block.
Perspex sheet 3in × 1½in × 8in
Wire for inter-unit connections

MEMORY UNIT

Components for the Memory Unit will be given next month

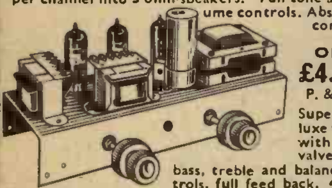
HIGH GAIN 4 TRANSISTOR PRINTED CIRCUIT AMPLIFIER KIT Type TAI



● Peak output in excess of 1¼ watts. ● All standard British components. ● Built on printed circuit panel, size 6 x 3in. ● Generous size Driver and Output Transformers. ● Output transformer tapped for 3 ohm and 15 ohm speakers. ● Transistors (GET 114' or 81 Mullard OC81D and matched pair of OC81 o/p). ● 9 volt operation. ● Everything supplied, wire, battery clips, solder, etc. ● Comprehensive easy to follow instructions and circuit diagram 1/6 (Free with Kit). All parts sold separately. **SPECIAL PRICE 45/-** P. & P. 3/-. Also ready built and tested, 52/6. P. & P. 3/-. A pair of TAIs are ideal for stereo.

STEREO AMPLIFIER

Incorporating 2 ECL86s and 1 EZ80, heavy duty double wound mains transformer. Output 4 watts per channel into 3 ohm speakers. Full tone and volume controls. Absolutely complete.



ONLY £4.19.6 P. & P. 8/-

Super De luxe version with ECL86 valves, sep. bass, treble and balance controls, full feed back. 4 watts per channel into 3 ohm speakers. 8 gns. P. & P. 8/-.

WELL-KNOWN MAKERS' SURPLUS! ONE TRANSISTOR PRE-AMP.

Suitable for use with Medium or High Impedance mikes, guitars, gram pickups, tape decks, etc. For operation from 200/300 volt H.T. rail or 9 volt battery. Gain approx. 14:1. Fully isolated input by Mu-Metal screened transformer. Size 4½" × 1" × 1". Ready built complete with full circuit diagram and instructions. ONLY 15/-. Post free.

SPECIAL PURCHASE! TURRET TUNERS

By famous maker. Brand new and unused. Complete with PCC84 and PCF80 valves 34-38 Mc/s IF. Biscuits for Channel 1 to 5 and 8 and 9. Circuit diagram supplied. ONLY 25/- each. P. & P. 3/9.

GÖRLER F.M. TUNER HEAD

88-100 Mc/s 10.7 Mc/s. I.F., 15/-, plus 2/- P. & P. (ECC85 valve, 8/6 extra).

TAPE DECKS

B.S.R. MONARDECK (Single speed) 3¾in. per sec., simple control, uses 5¾in. spools, £6/15/-.

LATEST COLLARO MAGNAVOX 363 TAPE DECK DE LUXE. Three speeds, 2 track, takes up to 7 in. spools. 10 gns. Plus 7/6 carr. and ins. on each. (Tapes extra on both.)

QUALITY PORTABLE TAPE RECORDER CASE. Brand new. Beautifully made. Few only at 49/6. P. & P. 8/6.

ACOS CRYSTAL MIKES. High imp. For desk or hand use. High sensitivity, 18/6. P. & P. 1/6.

TSL CRYSTAL STICK MIKE. Listed at 45/-. Our price, 18/6. P. & P. 1/6.

TWIN TELESCOPIC AERIAL. Two 3-section heavily chromed rods. Closed 12-in. each extending to 32 in. Completely adjustable. Universal mounting bracket, coax lead and plug. Ideal for F.M. or T.V. 12/6. P. & P. 2/6.

QUALITY RECORD PLAYER AMPLIFIER Mk II

A top-quality record player amplifier employing heavy duty double wound mains transformer, ECC83, EL84, EZ80 valves. Separate Bass, Treble and Volume controls. Complete with output transformer matched for 3 ohm speaker. Size 7in. w. x 3in. d. x 6in. h. Ready built and tested. **PRICE 69/6.** P. & P. 6/-.

ALSO AVAILABLE mounted on board with output transformer and speaker ready to fit into cabinet below. **PRICE 89/6.** P. & P. 7/6.

DE LUXE QUALITY PORTABLE R/P CABINET

Uncut motor board size 14½in. x 12in. clearance 2in. below, 5½in. above. Will take above amplifier and any B.S.R. or GARRARD Autochanger or Single Player Unit (except AT60 and SP25). Size 18in. x 15in. x 8in. **PRICE £3/9/6.** P. & P. 9/6.

4-SPEED PLAYER UNIT BARGAINS

All brand new in maker's original packing.

SINGLE PLAYERS

B.S.R. TU/12 .... £3/9/6. Carr. 5/6.
GARRARD SP25 De Luxe... £10/10/0. Carr. 5/6.
B.S.R. GU7 with unit mounted pickup arm. £4/18/8. Carr. 5/6.

AUTO. CHANGERS

Latest B.S.R. UA25 Super slim	£6	2	6
GARRARD 1000 with special Hi-Fi cart.	£6	19	6
GARRARD 2000	£7	10	0
GARRARD 3000	£8	15	0

GARRARD AT60 £9.19.6. Carr. 6/6 on each.

All the above units are complete with t/o mono head and sapphire styli or can be supplied with compatible stereo head for 12/6 extra.

BRAND NEW CARTRIDGE BARGAIN!

ACOS GP67-1. Mono complete. List price 21/-. Our price 13/6. P. & P. 1/-.

BRAND NEW. 12" 15w. H/D Speakers, 3 or 15 ohm. Current production by well-known British maker. Offered below list price at 89/6. P. & P. 5/-. Guitar models: 25w. £5.5.0; 35w. £8.8.0.

BRAND NEW 3 OHM LOUDSPEAKERS

5 in., 12/6; 6½ in., 15/-; 8 in., 21/-; 10 in., 25/-; 7 in. x 4 in., 15/-; 10 in. x 6 in., 26/-.
E.M.I. 8 in. x 5 in. with high flux magnet 21/-.
E.M.I. 13½ x 8 in. with high flux ceramic magnet, 42/-. (15 ohm, 45/-). P. & P. 4" & 5" 2/-, 6½" & 8" 2/6, 10" & 12" 3/6 per speaker.

E.M.I. PLASTIC CONED TWEETER. 2½". 3 ohm. Limited number: 12/6 each, P. & P. 1/6.

SPECIAL OFFER! Limited number of 12 in. 10 watt "R.A." Speakers: 3 ohm 25/-; 15 ohm, 27/6. P. & P. 3/6.

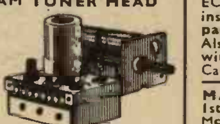
VYNAIR AND REXINE SPEAKER AND CABINET FABRICS app. 54 in. wide. Usually 35/- yd., our price 13/6 per yd. length (min. 1yd.) P. & P. 2/6. S.A.E. for samples.

7-10 watt OUTPUT TRANSFORMERS to match pair of ECL 86's in push-pull to 3 ohm output. ONLY 11/-. P. & P. 2/6.

MAINS TRANSFORMER for transistor power supplies. Tapped pri 200-250v. Sec. 40-0-40 at 1 amp (with electrostatic screen) and 6·3v. at ·5 amp for dial lamps etc. Drop thro mounting. Stack size 1¾" x 3¾" x 3¼" 27/6. P. & P. 4/6.

MATCHED PAIR OF 2½ WATT TRANSISTOR DRIVER AND OUTPUT TRANSFORMERS. Stack size 1¾ x 1¼ x ⅞ in. Output trans. tapped for 3 ohm and 15 ohm output. 10/- pair plus 2/- P. & P.

SPECIAL OFFER! FM/AM TUNER HEAD



Beautifully designed and precision engineered by Dormer and Wadsworth Ltd. Supplied ready fitted with twin ·0005 tuning condenser for AM connection. Prealigned FM section covers 86 — 102 Mc/s. I.F. output 10.7 Mc/s. Complete with ECC85 (6L12) valve and full circuit diagram of tuner head. Another special bulk purchase enables us to offer these at 27/6 each. P. & P. 3/-. Order quickly! Limited number also available with precision geared 3:1 reduction drive. 30/-. P. & P. 3/-.

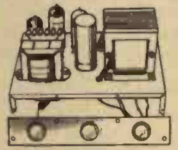
3-VALVE AUDIO AMPLIFIER MODEL HA34

Designed for Hi-Fi reproduction of records. A.C. Mains operation. Ready built on plated heavy gauge metal chassis, size 7½in. w. x 4in. d. x 4½in. h. Incorporates ECC83, EL84, EZ80 valves. Heavy duty, double wound mains transformer and output transformer matched for 3 ohm speaker, separate Bass, Treble and volume controls. Negative feedback line. Output 4½ watts. Front panel can be detached and leads extended for remote mounting of controls.

The HA34 has been specially designed for us and our quantity order enables us to offer them complete with knobs, valves, etc., wired and tested for only **£4.5.0** P. & P. 6/-.

HSL 'FOUR' AMPLIFIER KIT

A.C. Mains 200/250v., 4 watt, using ECC83, EL84, EZ80 valves



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This kit although similar in appearance to HA34 employs entirely different and advanced circuitry.

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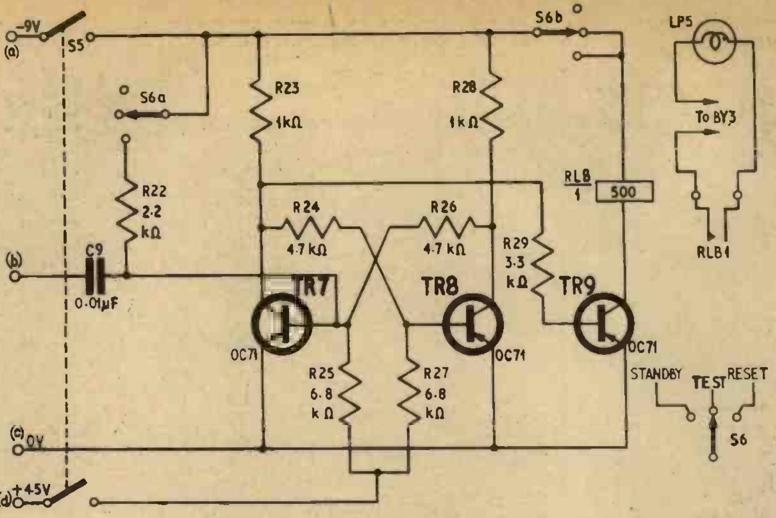


Fig. 4. Circuit diagram of the memory latch

"back later"; S3, a separate switch to illuminate the "come in" lamp; S2, a "test" switch which is wired across the relay contacts and can be used to illuminate any of the lamps for testing. Two extra switches will also be required if the memory latch—to be described later—is included in the system.

MEMORY LATCH

A very useful feature which can be added at very little extra cost is a memory latch. This is a circuit which remembers if there are any callers when the device is left unattended.

The circuit is given in Fig. 4 and is seen to consist of two parts, a bistable switch and a current amplifier similar to the one used in the basic unit. S5 is the on/off switch and supplies power to the bistable only. S6 has three positions: "Standby", "Test", and "Reset". It is normally left in the "Standby" position.

To use the memory unit it is turned on by S5 and S6 is depressed to the "Reset" position and then returned to "Standby". S6b at this point shorts TR1 base to the −9 volt line via R7 thus ensuring that the bistable has TR1 conducting and TR2 cut off. If left undisturbed, i.e. if no-one comes, then the circuit will remain in this state permanently. However, if someone knocks on the door, the relay closes and re-opens (lighting, presumably, the "back later" lamp) and the voltage pulse across the relay contacts is applied to TR1 via C1, causing it to cut off and permitting TR2 to conduct instead. The circuit will remain thus set indefinitely, and further triggering pulses will not affect it.

When the owner returns and moves S6 to the "Test" position TR3 will conduct heavily if TR1 is cut off, this causes the relay to operate and the lamp to light, indicating that someone had called during the owner's absence. If no-one had been then TR1 would still be conducting, its collector would be at about 0 volt and TR3 would remain cut off when S6 was moved to "Test".

Constructional details will be given next month.

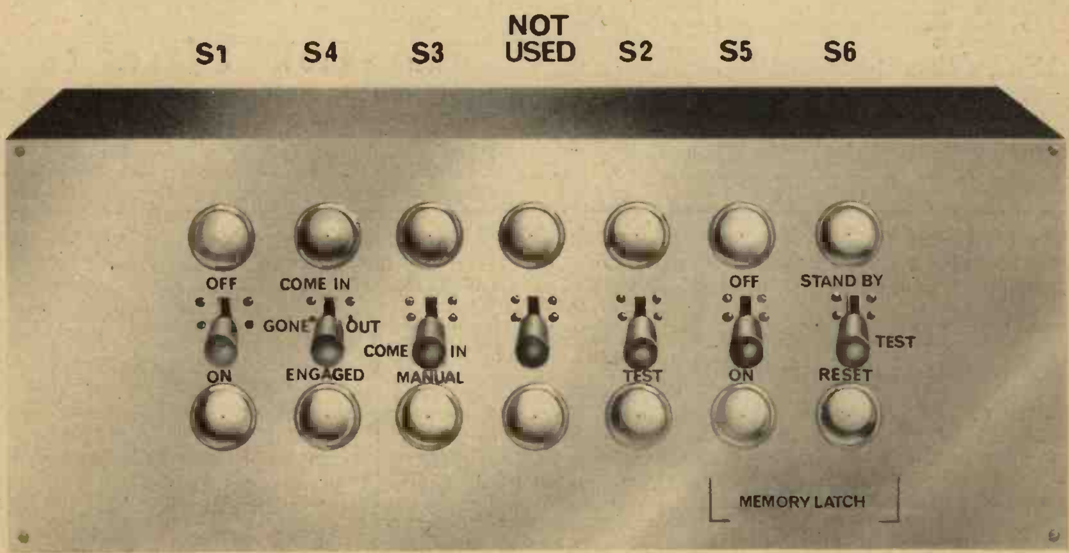


Fig. 5. The control unit

The Oscilloscope

PART TWO

and its applications

By P. Cairns

The two commercial instruments shown illustrate extremes in oscilloscope design. The *Tektronix 547*, with automatic display switching, is used in specialised laboratory applications; plug-in units adapt the instrument to a wide range of measurement capability. The *Advance OS12* oscilloscope, with its simple control panel, is intended as an educational aid or systems monitor in colleges and industry.

THE oscilloscope, when used in conjunction with a signal generator can prove very useful in radio and television servicing. With a suitably modulated signal injected into the receiver input, the function of each stage can be examined in detail. If a wobbulator or frequency modulated ganging oscillator is available the response curve of each i.f. stage in the receiver can be displayed or an overall response curve shown.

SERVICING AID

The wobbulator signal is injected into the grid of the frequency changer, care being taken not to overload the receiver. If an overall response curve is required it is injected into the aerial. The frequency of the injected signal is that of the i.f. of the receiver under test.

The circuit may be set up as in Fig. 8, the output developed across the second detector being applied to the c.r.o. Y input. The wobbulator sweep is often obtained by applying the sawtooth waveform from the c.r.t. X deflection plate to the wobbulator sweep input socket; this also gives automatic sync. During these tests ensure that the receiver a.v.c. is shorted out and the local oscillator short circuited.

The i.f. transformers are then trimmed in turn, beginning with the last one, i.e. the i.f. transformer nearest the second detector. The trace on the screen will depend upon the degree of error in the i.f. alignment, the trace to be aimed for having steep sides with a reasonably flat top. Typical traces are shown in Figs. 9a to e.

If the receiver is badly out of alignment it may be found necessary to increase the input signal to begin with so as to obtain a reasonable deflection, the signal being gradually reduced as the i.f. circuits are tuned to resonance. This method of aligning receivers is extremely accurate, particularly where staggered tuning is necessary. Only the general outline of these tests can be given as the procedure and set up may vary between different types of wobbulators and receivers.

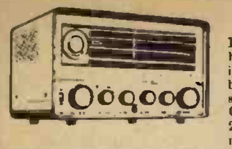
Similar tests can be carried out when aligning f.m. and television receivers, though the procedure is rather more involved and beyond the scope of this article due to space limitations.

The oscilloscope is particularly useful when tracing hum troubles. The ripple on the h.t. line should be only a very small percentage of the h.t. d.c. level. This ripple can be measured by connecting the Y amplifier input across the smoothing filter output, the trace appearing as in Fig. 10a. With a faulty smoothing circuit the ripple will appear as in Fig. 10b and have a much greater amplitude.

A.C. coupling to the Y amplifier is necessary, the input capacitor blocking the large d.c. component of voltage and allowing the small ripple value to be displayed. A relatively high sensitivity setting on the Y amplifier is necessary.

In the case of television receivers the waveforms are often much more complex, and while the linearity of the line and frame time base circuits can be checked on most oscilloscopes, an instrument having a Y amplifier with a good frequency response is necessary for viewing the composite video signal at the video output stage. Special triggering facilities are also sometimes required, many modern oscilloscopes providing both internal frame and line synchronising.

An important point to be remembered when testing television receivers and many radio receivers is that they employ the a.c./d.c. type of power supply. The chassis may thus be at mains potential. As the common input point on the oscilloscope is normally earthed, connecting this point to the chassis of a receiver *could be extremely*



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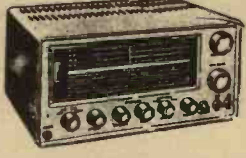

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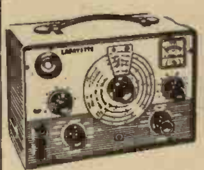

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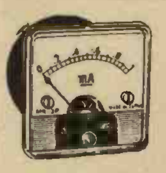

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10mA	22/6	5A D.C.	22/6	50V A.C.	22/6
20mA	22/6	3V D.C.	22/6	150V A.C.	22/6
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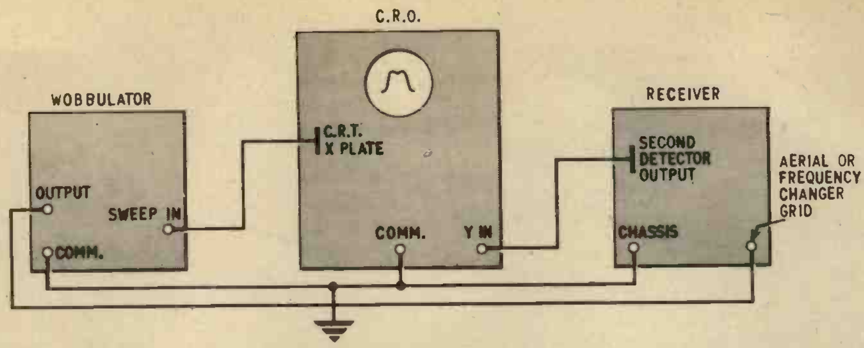


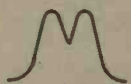
Fig. 8. Test set-up for checking or aligning the i.f. stages of a receiver

(a) c.r.o. time base sweep speed too slow. Increase sweep speed until trace is linear

(b) overloading of i.f. stage. Reduce input drive

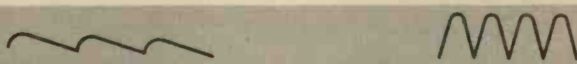
(c) good broad response curve. Overall effect of staggered tuning as required by some receivers

(d) linear trace with correct sweep speed. Good overall response curve



(e) effect of off-tuning

Fig. 9. Typical traces obtained using the set-up as in Fig. 8



(a) slight h.t. hum ripple

(b) aggravated ripple due to faulty smoothing circuit

Fig. 10. Comparative examples of ripple voltage

dangerous. Some oscilloscopes overcome this to a certain extent by means of an internal link which can be removed so as to isolate the common input line from chassis and earth. Another and simpler method is to connect a 1 : 1 ratio isolating transformer of suitable VA between the receiver under test and the mains.

LISSAJOUS FIGURES

One very important application of the oscilloscope is in frequency measurement and comparison. This can be carried out by means of either Lissajous figures or spot wheel patterns. In both of these applications the time base is dispensed with.

In the case of Lissajous figures, one frequency is applied to the Y input and the other to the X input, the appropriate gains being adjusted to give a similar deflection in each plane. The resultant pattern obtained will depend upon the frequency difference between the signals. Normally one signal is of a fixed known frequency, say 50Hz, and the other unknown and variable. When the unknown signal frequency is adjusted to give a circle on the screen, both signals are of the same frequency.

As the variable frequency is increased various patterns are obtained, the frequency ratio between the two signals being found by counting the number of "crowns" in the pattern. In practice this method is generally only usable for a frequency difference of about six or eight to one as the number of "crowns" becomes difficult to count due to the pattern tending to revolve as one or both of the oscillators drift slightly. This method is extremely accurate however as errors as low as a few cycles per minute can be observed, the oscillators being exactly in step only when the pattern remains completely stationary.

This system can be conveniently used when calibrating an unknown variable frequency source against a known fixed or variable source. Some typical Lissajous figures are shown in Figs. 11a to f with the frequency ratios they represent. The pattern for a particular figure may appear to change, the appearance of the pattern depending upon the point at which it is "locked" on the screen.

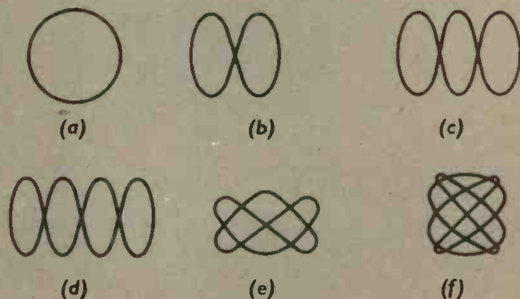


Fig. 11. Typical Lissajous figures showing relative frequency ratios (a) 1 : 1; (b) 2 : 1; (c) 3 : 1; (d) 4 : 1; (e) 3 : 2; (f) 3 : 4

SPOT WHEEL PATTERNS

The spot wheel method can be used over a much larger frequency ratio and is simpler to compute. The spot wheel pattern is obtained by means of an external phase shift circuit and intensity modulation of the c.r.t. First the known frequency signal source is fed into the phase shift unit, again the 50Hz mains is a good basic reference. The phase shift unit should have, or be adjusted to, a 90 degree shift. The two output signals with this 90 degree phase difference are then fed into the X and Y input terminals on the c.r.o. If both gain controls are adjusted to give the same sensitivity, a circular trace results.

The unknown frequency is then fed into the intensity modulation terminal on the c.r.o. or if one is not available it can be fed via a 0·1μF capacitor to either the grid or cathode of the c.r.t. The capacitor should be of suitable voltage working as the tube electrodes may be at a high potential with respect to earth. When the amplitude of this signal is increased a number of blank spaces will appear symmetrically in the circular trace, the number of spaces (or sections of trace remaining) represents the ratio between the known and unknown frequencies.

The action of this circuit is quite straightforward. When the unknown frequency is applied to the grid of the c.r.t., every negative half cycle blanks the trace out as the tube will be driven past cut-off during this period. Similarly, with the signal applied to the cathode each positive half cycle cuts the tube off. Thus, each complete cycle is represented by one space and one section of trace. This method can be used quite successfully with frequency ratios up to 30 : 1 or even higher. A stationary trace represents an exact ratio; with a slight frequency difference the trace appears to be slowly revolving. A typical test circuit is shown in Fig. 12, while some resultant patterns appear in Fig. 13.

Z MODULATION

A simple modification to the oscilloscope designed by the present writer and published in this periodical[1] is shown in Fig. 14. This allows an intensity modulation input point to be added for the addition of only three components. This circuit may also be used on many other oscilloscopes which do not include an intensity modulation point.

The purpose of R1 is to give some isolation between the input signal to the grid and the e.h.t. d.c. supply. The clipping diode D1 prevents the grid being driven positive on positive half cycles. This should be connected in all such circuits as the tube could be damaged if the grid were repeatedly driven positive over long periods. C1 gives the necessary d.c. isolation between the input point and the tube electrode circuit. When viewing spot wheel patterns the brilliance should be turned as low as possible. A signal of at least 10 volts r.m.s. and preferably larger is necessary to modulate the circuit described. Some commercial oscilloscopes include an internal intensity modulation amplifier to allow much smaller values of modulation signal to be applied.

1. An Inexpensive Oscilloscope (March, April and May 1965).

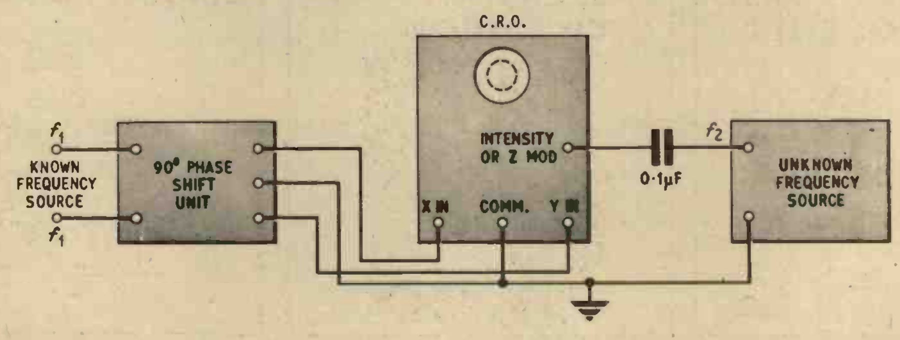


Fig. 12. Test set-up for producing spot wheel patterns

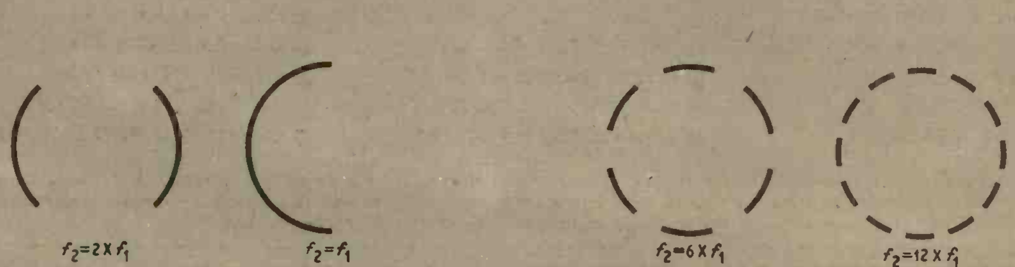


Fig. 13. Some typical spot wheel patterns using the set-up as in Fig. 12

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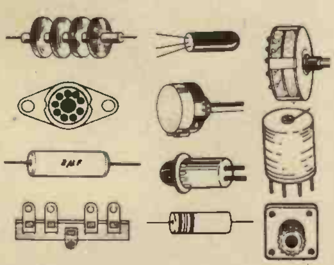

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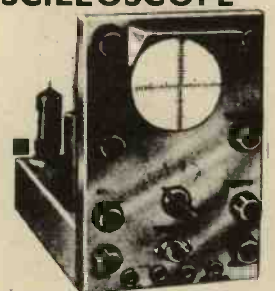

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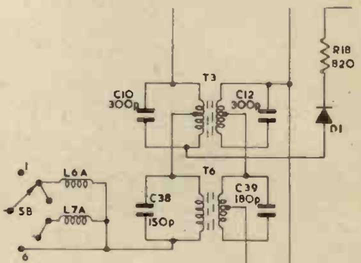

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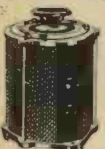

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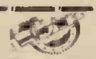

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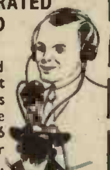

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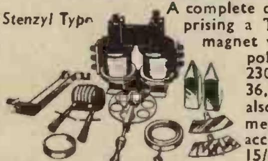

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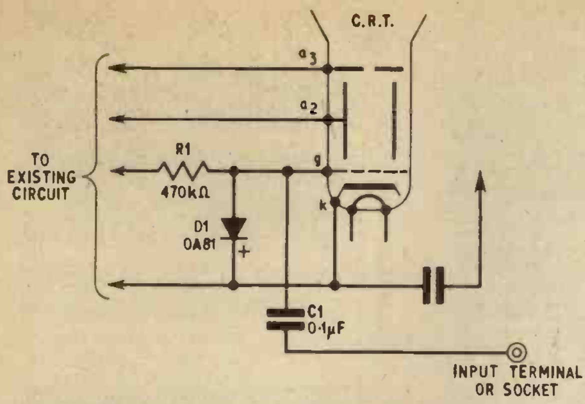


Fig. 14. Modifications to oscilloscope for the addition of an intensity modulation input

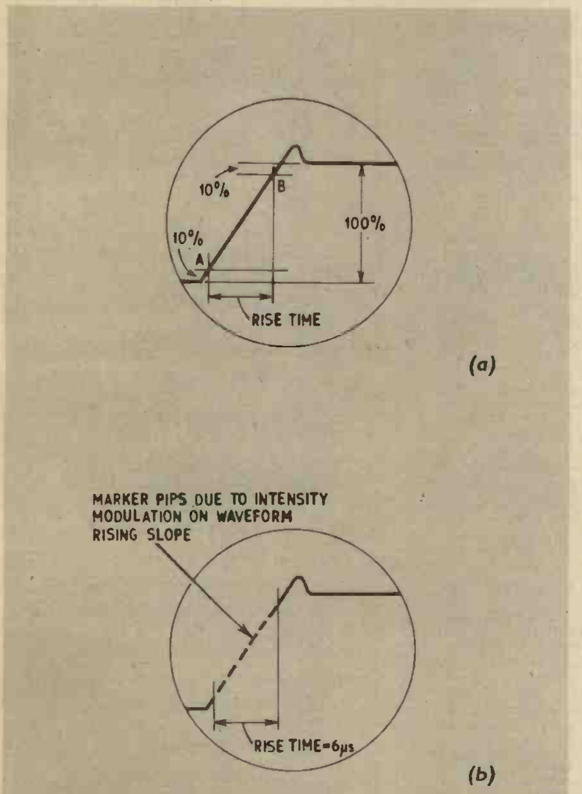


Fig. 15. Measurement of stepped function rise times

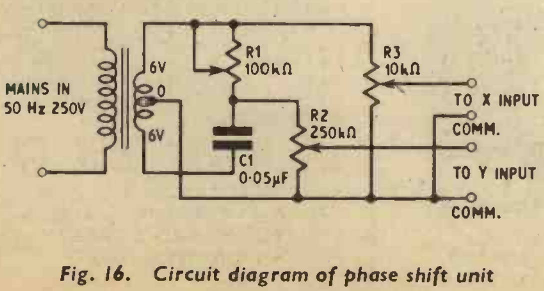


Fig. 16. Circuit diagram of phase shift unit

Intensity modulation can also be used for the accurate measurement of stepped function rise times, particularly where the time base sweep speed is not fast enough to expand the step into a measurable slope in the horizontal direction. With the c.r.o. working in the conventional manner and a stepped waveform or square wave displayed on the screen, the time base and Y amplifier gain controls are adjusted to give a picture similar to that in Fig. 15a. To measure the rise time a signal of appropriate frequency and of sufficient amplitude to intensity modulate the c.r.t. is applied via the intensity or Z modulation terminal. If the rise time is in the μs region a 1MHz signal would be suitable, 1 cycle being equal to 1μs. A series of gaps at 1μs intervals would thus appear on the slope of the waveform as in Fig. 15b. The number of gaps (or sections) are then counted, this being the rise time of the slope in μs. Normally the rise time is taken as that part of the slope lying between −10 per cent and +10 per cent of the maximum and minimum peak values, this is shown in Fig. 15a.

To measure such a rise time by dropping two lines from these points (A and B) to the time base scale and trying to measure this on the time calibration is not only difficult but tends to be rather inaccurate, whereas the method described is as accurate as the frequency of the intensity modulation signal. For faster rise times this signal can be increased as high as 10MHz (0·1μs), for slower rise times a 100kHz or 500kHz. I.e. (10μs or 2μs) signal may be used.

Some oscilloscopes, particularly those designed for pulse applications, have one or more intensity modulation oscillators built into the c.r.o., these being switched in as required. This makes rise and duration times in pulse measurements much simpler and obviates the use of an external signal source.

PHASE SHIFT NETWORK

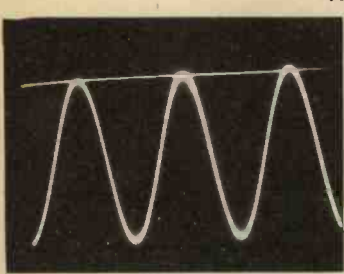
The writer has at various times in this article advocated the use of a phase shift network, such a unit being very useful in oscilloscope work. A suitable circuit which can be made into a very compact unit will therefore be described. The circuit is adjustable in phase between 0 degrees and approximately 110 degrees, both outputs also being adjustable in amplitude being sufficient to drive both X and Y amplifiers of the majority of oscilloscopes.

The circuit is driven from the 50Hz mains supply, this being the reference frequency. The circuit could however be driven from a variable frequency source of sufficient output though the capacitor would have to be decreased in value as the frequency was increased. The complete circuit with component values is shown in Fig. 16.

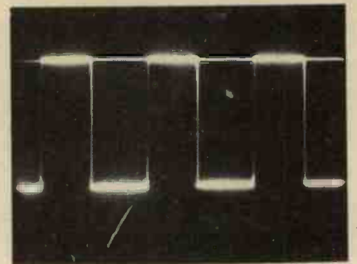
The action of the circuit is quite easy to follow, the phase shift in the voltage across the C1–R1 divider occurring due to the presence of the capacitive reactance in the resistive circuit. A phase shift of exactly 90 degrees will occur when the reactance of the capacitor at 50Hz) C1 is equal to the value of the resistor R1.

The phase angle is reduced as R1 is decreased in value, the reactance of C1 then being greater than the value of R1. The circuit and vector diagram in Fig. 19 shows the function of the circuit quite clearly. Referring to this diagram shows that the output voltage V is of constant amplitude but lags the supply voltage E by an angle θ which depends upon the value of R. It can be seen from the figure that in the relation between R and θ is by no means linear and that the extreme case θ approaches 180 degrees, requiring R to approach

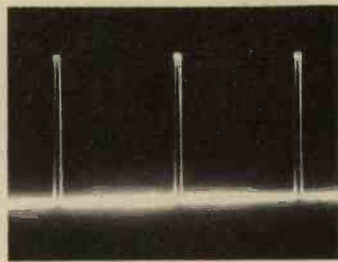
Fig. 20. OSCILLOGRAMS



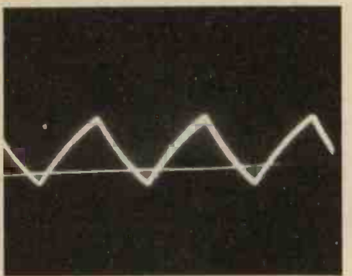
(a) Sine wave input



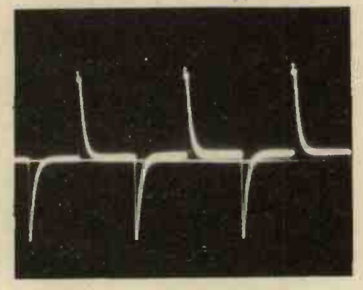
(b) Square wave input



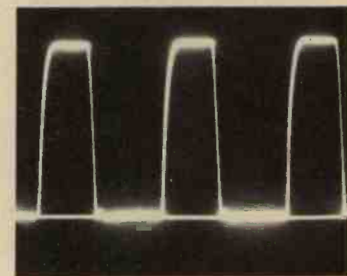
(c) 20ms marker pulses (1ms wide) derived from square wave



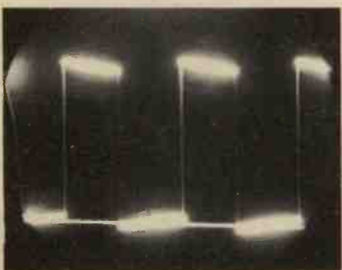
(d) Integrated square wave



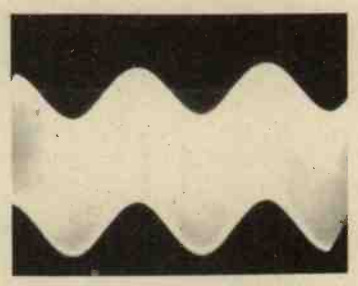
(e) Differentiated square wave



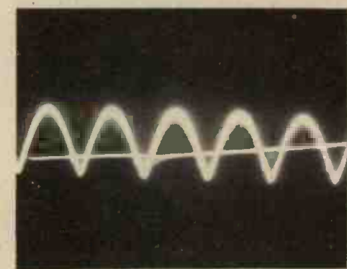
(f) Slight h.f. reduction with parasitic ringing



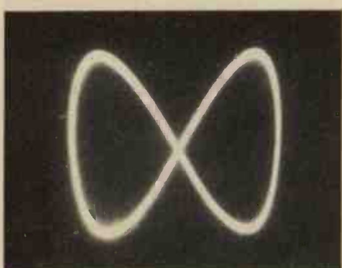
(g) Slight l.f. reduction due to a.c. coupling



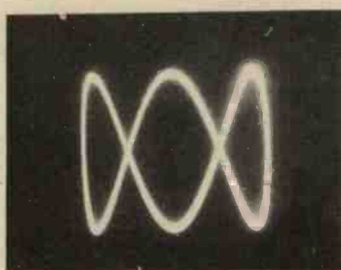
(h) 50Hz hum on h.f. carrier



(i) 100Hz ripple on h.t. line

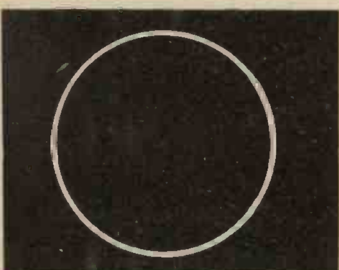


(j) Lissajous pattern showing 2 : 1 frequency ratio

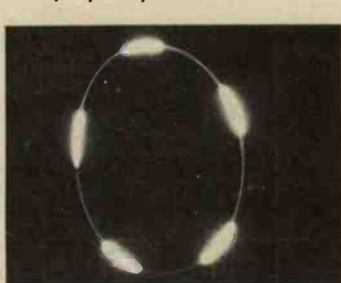


(k) Lissajous pattern showing 3 : 1 frequency ratio

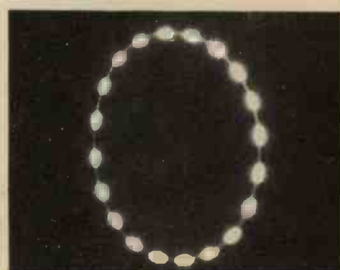
(l) Small angle phase shift due to reactive circuit



(m) 90 degree phase shift of X and Y input



(n) Spot wheel pattern where $f_2 = 5 \times f_1$ *(see text)*



(o) Spot wheel pattern where $f_2 = 20 \times f_1$ *(see text)*

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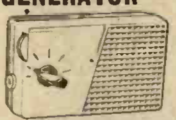

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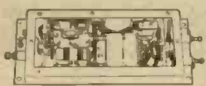

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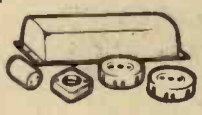

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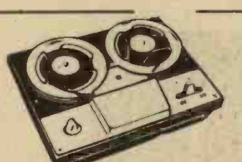

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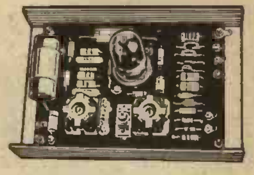

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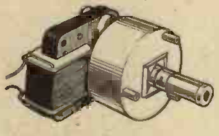

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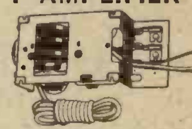

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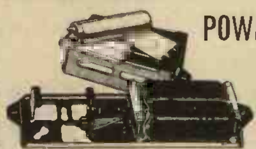

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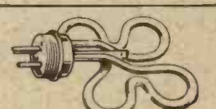

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infinity, which is not possible. The simple circuit thus has certain imperfections (a non-linear scale) but it has beeen described because it illustrates the principle of deriving the phase shift of a voltage of constant amplitude by exploiting the semicircular locus which is a common feature of many electrical circuit responses.

The value of R1 was chosen so that at maximum value it was greater than the reactance of C1, thus allowing phase shifts of greater than 90 degrees to be obtained. The amplitude of the output voltages to the c.r.o. are individually adjustable by means of R2 and R3. With these voltages set to give equal deflection in both vertical and horizontal planes on the c.r.t. screen, and the phase shift control set to exactly 90 degrees, a circular trace will be obtained. If the phase shift control is varied above and below this point an ellipse having various magnitudes of minor axis will be observed. The phase shift control can be calibrated by means of one or both of the methods described at the beginning of this article, see Figs. 2d and e.

While the transformer used is shown as a 12 volt heater transformer with a centre tapped winding, a transformer having two 6·3 volt windings could be used, the windings being connected in series and the centre tap taken from the junction. If such a transformer is used the finish of the first winding must be taken to the start of the second winding. If they were connected in reverse order, no output would result due to the windings being in opposition. This unit, when completed and calibrated, is not only very useful for general oscilloscope work but may also be used for demonstration purposes.

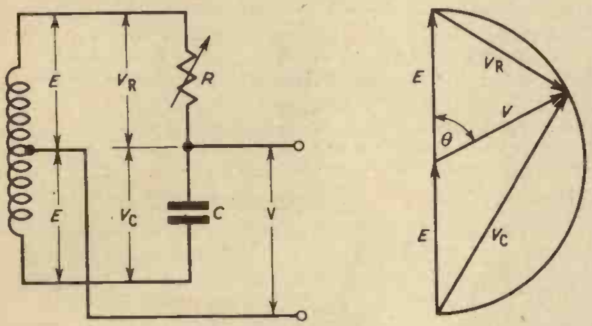


Fig. 19. Illustrating the function of the phase shift unit

OSCILLOGRAMS

Finally a number of oscillograms are shown in Figs. 20a to o, these being photographic records of actual oscilloscope traces. These oscillograms illustrate very clearly some of the points and oscilloscope techniques discussed in this article. These records were taken at various times, no special apparatus being used other than the test circuits described in this article.

It is hoped that this rather brief summary of the oscilloscope and some of its more everyday applications show that it is not simply a device for "viewing waveforms" but an extremely versatile and reliable instrument capable of a relatively high degree of accuracy. It can be used to carry out tests and achieve results which would be possible on no other instrument, its limitations often being simply the limitations of the user. ★

NEWS BRIEFS

Radar and Electronics Association

CONGRATULATIONS to the Radar and Electronics Association on "becoming of age".

Twenty-one years ago the Radar Association was founded at R.A.F. 60 Group Headquarters, Leighton Buzzard. From then the Association has steadily progressed, and with the change of name some years ago, is now a fully recognised body of ex-Service personnel and technicians. Among the members are some of the world's greatest scientists, as well as students from all parts of the world and a large number of ex-members of the forces.

Membership is open to those who have worked on radar or other branches of electronics for 3 years or more, in industry or the armed forces.

Particulars can be obtained from The Secretary, 43 Grove Park Road, Chiswick, London, W.4.

Audio Festival and Fair

THE Audio Festival and Fair will be held at the Hotel Russell, Russell Square, London, W.C.1 from March 30 to April 2. Tickets may be obtained free of charge through the usual retail shops.

Russian Premier sees British Electronics

IN response to his request to be shown the most advanced automation equipment in Britain, the Russian Prime Minister, Mr Alexei Kosygin was invited to tour the Borehamwood factory of Elliott-Automation where exhibits of particular interest to Russia were assembled including microelectronics, space research and laser applications.

Highlights of the exhibition were the microminiature 920M computer and part of the blind landing system for the Anglo-French Concorde supersonic airliner. Mr Kosygin was accompanied on his tour by the Minister of Technology, the Rt. Hon. Anthony Wedgwood Benn, M.P., and Sir Leon Bagrit, Chairman of Elliott Automation. The visit was part of a very full programme of engagements on February 8.

Larger R.S.G.B. Show

THE R.S.G.B. International Radio Engineering and Communications Exhibition is to be enlarged and held this year at the Royal Horticultural New Hall, London, S.W.1.

The new venue will provide twice the space of previous exhibitions and Government services are expected to give support.

The dates to note (earlier than usual) are Wednesday, September 27 to Saturday, September 30 inclusive.

BBC Handbook 1967

THIS compilation of facts and figures provides an informative guide to the structure of the BBC and its programme services and engineering. This latter section describes briefly the transmitters used on the broadcast bands and includes comprehensive lists of the frequencies and channels used, with practical tips on achieving optimum reception. Coloured maps provide the locations and service areas of BBC-1 and BBC-2 television channels and v.h.f. regional sound radio stations.

Containing 264 pages of information with a considerable number of photographs, this handbook is available from the BBC Publications Dept., 35 Marylebone High Street, London, W.1. — price 7s 6d.

detached particles

JOHN VALENCE

COMMUNICATIONS THE KEY

Are our political leaders over-selling technology as the key factor in our future prosperity? There are certainly plenty of critics who listen disbelievingly to pleadings that we must strive and make even greater efforts in this field.

If such unbelievers fail to be swayed by the urgent voices crying out in their own country, maybe they will heed the words of an outsider. Here I am referring to Mr R. W. Sarnoff, President of the Radio Corporation of America. In a recent address to a group of British business men, Mr Sarnoff stated that Britain stands on the threshold of its greatest era of prosperity since the Victorian age—*provided it makes full use of new communications and information technology.*

Let me remind the faint hearts and doubters amongst us that we have not done so badly in the field of communications in the past. It was due to the encouragement and financial backing from the British Post Office that young Marconi was able to develop his early experimental work into the resounding practical achievement of long distance communication without wires. That was in 1896.

Today the Post Office (despite much belabouring from less informed members of the public) is still very much on its toes and ready to seize opportunities for sponsoring and exploiting new techniques.

Currently the P.O. is pioneering in the field of pulse code modulation. Its new EMPress exchange, due to be operational at the end of this year, will be the world's first pulse code modulation tandem exchange.

Another knock at our doubting Thomas's: Pulse code modulation was the brain child of an Englishman, Mr A. H. Reeves. It would be fair to add that this invention of the 1930's was not capable of practical implementation until the transistor was born, and we must acknowledge the American parentage of this particular electronic marvel.

A final thought on communications brings me back to politicians again. Surely it was an inspired gesture for our Prime Minister to present Mr Kosygin with a Pye Pocketfone system during the Soviet P.M.'s visit to Britain. A symbol of some significance, let us hope.

MARRIAGE COUNSEL

Since electronic computers are now entering the field as matchmakers, it behoves electronics technology to do all in its power to ensure the permanency of the marriages it may have instigated.

I don't know how many cases in the divorce courts stem from one of the partners' habit of snoring. If of sufficient repetition rate and peak audio power, this kind of interference could I suppose be considered to constitute a form of cruelty and lead to the dissolution of the marriage.

However, should you be an inveterate snorer, do not despair that your marriage will end on the rocks . . . there is hope in the form of an electronic device now being tested on patients in a Sussex hospital.

A throat microphone picks up the snores and this signal triggers off a tiny pulse generator strapped to the patient's arm, and an electric impulse is received. It is claimed that the "shocks" are not strong enough to wake the person, but they do set up a mental block against snoring. Eventually the apparatus can be dispensed with but the effect continues, so they say.

Just another of electronics' gifts to humanity.

"Personally, I prefer live music."

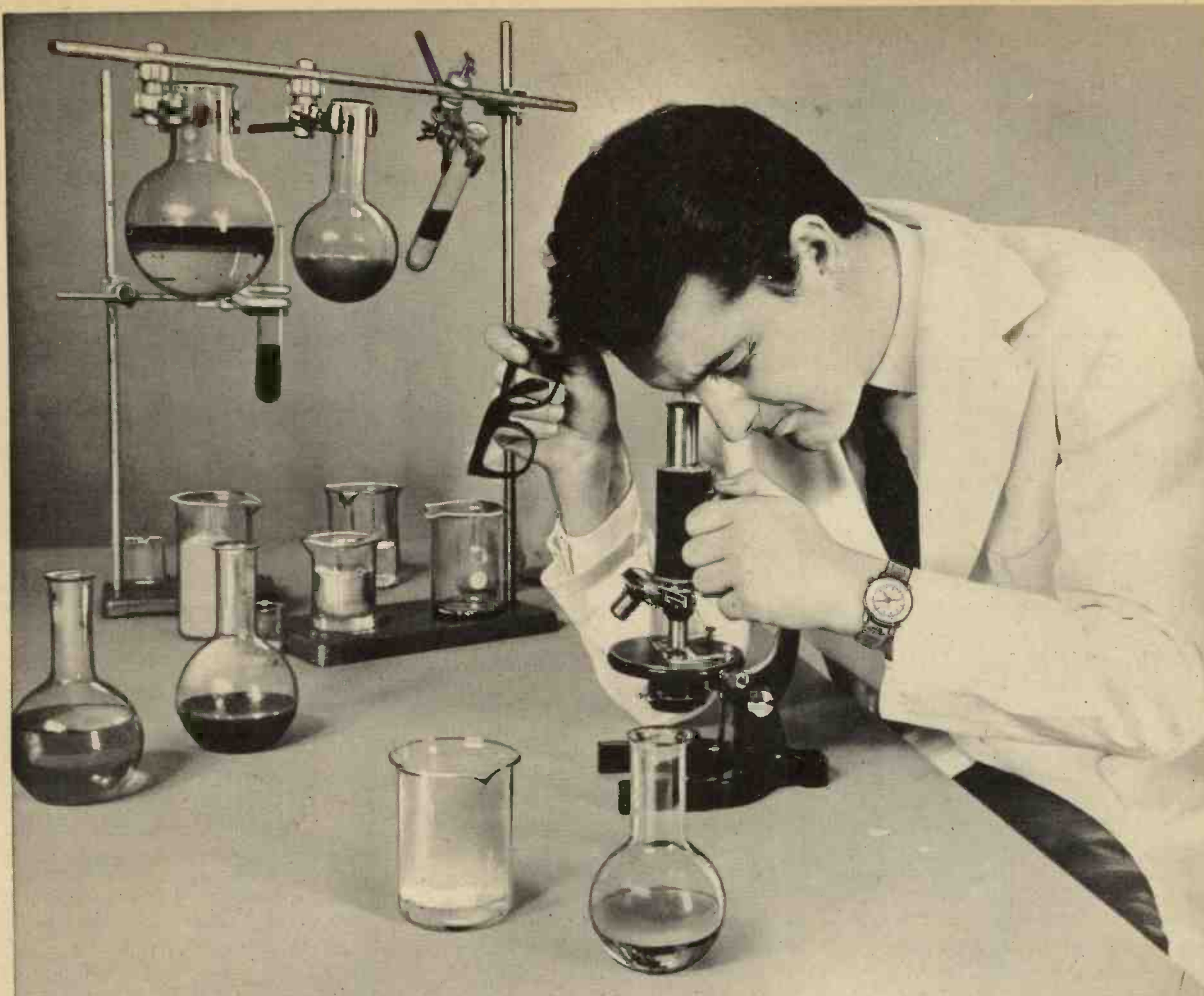
TAKE-OFF TRANQUILISER

The well meaning attempt by British Rail to entertain their passengers in main line termini has been badly received, as I mentioned last month. But the British traveller is not always so adamant in his objection to background music. Apparently his views change remarkably when he takes to the air.

In response to popular demand (!) British European Airways will as from this April play recorded music to their passengers both before and after take-off. Trident and Comet aircraft have been equipped to provide this new service. Light music of the "My Fair Lady" type (pops are definitely *out*) will be reproduced from cassette type tape recorders operated by the cabin staff.

I was at first a little mystified by the official statement that ". . . light music is to be played before and after take-off. BEA cabin staff will ensure that the music IS turned off when the aircraft is airborne." Then it dawned on me. Just a short spell of sweet, soothing soporific music to carry us over those anxious moments as our aircraft shrieks down the runway. (Even seasoned air travellers will admit to a certain apprehension during these few moments).

. . . From Ringway, back to Piccadilly, Manchester: perhaps British Rail can take heart from the fact that *their* passengers do not (it seems) require any such sweet sounds to cajole them to board the London bound express. Something here, methinks, for the BR publicity people to turn to good account. A chance for some real oneupmanship, if they are *really* clever.



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Readout—

A SELECTION FROM OUR POSTBAG

Battle cry

Sir—May I join the valve versus transistor battle? I have been unable to find any decent transistor designs. To give one example, look at Mr. R. Hirst's stereo amplifier (December 1966), and compare it with the Mullard 5–20 circuit of 1955 vintage. On paper, my stereo version of this costs the same as Mr. Hirst's to build, and the amplifier occupies approximately the same space; (it uses a separate power supply box, which may be hidden) but here the similarity ends.

The basic valve amplifier has a better signal to hum and noise ratio (90dB below 20W r.m.s. as opposed to 90dB below 10W) at approximately the same sensitivity (250mV into 1MΩ); a vastly superior frequency response (30Hz–20kHz ±0·5dB at 27W r.m.s.); excellent rise time (5μs); very low overall phase-shift (20 degrees at 20kHz); and a remarkable damping factor of 50 (into 15Ω) and hence excellent stability, compared with the transistor amplifier.

Although some people will say that a maximum output power in excess of 100W (music power) is too much, just think how well it will perform at lower outputs, remembering that it costs the same as an inferior transistor amplifier.. The 5–20 will give 20W r.m.s. at 0·05% distortion, rising to only 0·1% at 27W. Inter-modulation and beat-note distortion products total 0·7% of carrier amplitude at 27W r.m.s. There is, of course, no crossover distortion with valves. Using d.c. heating, a hum and noise figure as good as, if not better than, the transistor pre-amp may be achieved with EF86 (−70dB). All this, coupled with the fact that no 'scope is required for setting up, and that earth return impedances are not critical, you have to admit that the valve amplifier using the ubiquitous EL34, easy to obtain, hard to destroy, not requiring matched valves (where on earth does one get matched NKT403 from, and for how much?), is far better value for money than the semiconductor one.

For those with very small rooms, the famous 5–10 amplifier has identical performance to Mr. Hirst's but costs a very great deal less to build, and need not occupy very much more space. Printed circuit panels for valve amplifiers are very easy to design (i.e. both 5–20 and 5–10) and etch since there is only a quarter of the components involved. This could lead to greater reliability in those of us whose soldering is not quite what it should be, since there will only be a quarter of the joints involved as well.

Please could someone explain the purpose of the f.e.t. input of this transistor amplifier. The best ceramics give 100mV into 250pF, and all the speakers (both ESL & EMLs) that I have ever heard of cut off below 30Hz, so presumably there will be insufficient signal to drive the amplifier, and to drown the l.f. oscillations (rumble) that many enclosures seem to give without high-pass filters (the 5–20 amplifies down to 15Hz easily, but Mullard recommends that signals below 30Hz be attenuated, presumably for this reason.) What sort of phono (ugh!) gives 250mV and needs 50MΩ anyway?

* These figures were obtained from a Mullard publication, "Mullard Book of Audio Amplifiers".

F. Middleton,
London, S.W.2.

It would appear from your recent letter that you find very little use for any unit that may be transistorised and this seems to be based on quite a quota of incorrect assumptions which I have listed below.

To contain a stereo version of the Mullard 20 Watt amplifier with it's associated pre-amplifiers, a cabinet area of approximately 3000 cubic inches is required and yet for my 10 Watt transistorised design which incidentally will deliver 17 Watts per channel, an area of approximately 700 cubic inches is required.

The delight of listening to an amplifier capable of giving an output with a distortion content of less than 0·05% must be immense. I have yet to meet any listening expert capable of determining better than 0·2% under normal listening conditions.

Output valves are notorious for becoming defficient in emission in a relatively short period of time whereas transistors could have a useful life of 25 years or more, depending upon the treatment.

Nothing is simple in the design of a high fidelity system, even the printed circuit board, and it is entirely incorrect to assume that earth return paths are of no consequence in a valve system.

Economically the entire transistorised version may be purchased for less than it would cost to buy the transformers and valves for a valved version.

The signal to noise ratio for the Mullard Unit is not 90dB as you assume but 53dB, not quite up to the 90dB of the transistor version (Ref.: page 79 "Mullard circuits for Audio Amplifiers").

You also may notice that reference is made to the inadequacy of the 100kΩ input impedance (page 79) and notice the 35dB of compensation required to restore the bass response to something of it's original value. With a standard transducer having a capacitive output in the order of 1000pF then it would be necessary to ensure that the input impedance of the amplifier is in excess of 5 megohms to have a relatively flat output at 70Hz.

The explanation that you require is contained in the following equation showing that the output from a capacitive source will be 3dB down when,
X_C = the input impedance of the amplifier.

Later works by P. Tharma of Mullard Ltd. described in detail transistor power amplifiers, obviously for some good reason.
—R.H.

Wanted!

Sir—Young radio enthusiasts willing to form a club in South London for young people (up to about 20 years). Meetings will be made as interesting and varied as possible with outings, competitions, etc., and always at least one "ham" station on the air.

If the turnout is reasonable, the Sir Philip Game Boy's Club (near East Croydon station) will let us use part of their premises.

Will anyone interested please contact me at the address below. All letters will be answered giving details of meetings when known.

A. D. A. Hansen, G3VLJ
(aged 16),
99, Stretton Road,
East Croydon, Surrey.

Readout—

A SELECTION FROM OUR POSTBAG

continued

Cold comfort

Sir—In the *Detached Particles* page in the January issue, under the above heading, it is suggested that the Electricity Council's "peep into the future" failed to take account of the impact of the younger branches of technology such as transistors and cold cathode fluorescent lamps which, on your reckoning, will lead to reduced heat gains.

The fact is that fluorescent lighting, despite its relatively high efficiency, is today the major source of heat from light. Incidentally, cold cathode fluorescent lamps produce, paradoxically enough, more heat for the same light output than the hot cathode lamps which are mostly used today, while electroluminescent panels produce far more heat than either!

If we were prepared to accept green light we could get nearer to the cold light ideal, failing which we have to accept a definite limitation, imposed by our visual mechanism, on the efficiency of production of white light.

The best present day light sources are closer to this optimum efficiency than is often realised and, with artificial lighting levels still only a fraction of natural lighting levels, we must expect heat from light to become even more important in the future.

As to transistors, they may produce less heat than thermionic valves but this factor is infinitesimal compared with the inevitable increase in the energy controlled by them.

Finally, may I correct the impression given in your comment that the all-electric new town represents a "peep into the future". It can be built *now*, it makes sense *now*, and it might well be the only sort of new town which will still make sense when it is finished.

R. H. Phillips,
The Electricity Council,
EDA Division,
London, S.W.1.

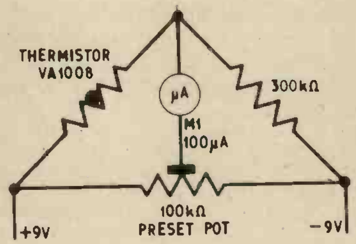
Temperature loss

Sir—I am writing in connection about the article *Remote Temperature Measurement* which appeared in the January issue.

I have constructed the circuit and have found it to be unsatisfactory for these reasons:

1. costly to build
2. tends to be large in size
3. not very sensitive

To combat these problems I have reconstructed the circuit entirely and based it on a simple d.c. resistance network (see diagram).



The circuit has worked very well indeed and using a Radiospares MR26 meter I have obtained a f.s.d. of 100 degrees centigrade and a zero for 0 degrees centigrade. The negative temperature coefficient resistor used was sealed in a glass tube using Araldite.

L. G. Jones,
Worksop,
Notts.

The reply to Mr Jones' three main objections to my article are as follows:

1. *Costly to build.*
   No, the electronic circuitry is in effect used as a d.c. amplifier and uses cheap transistors. The total cost of the parts mounted on the Veroboard could be as little as 15s 0d, this virtually offsets the addition of a 100μA as against a 1mA meter. Whatever system is used, a meter, thermistors and potentiometer are required.
2. *Tends to be large in size.*
   No, the size is controlled by the meter and switching arrangement, the Veroboard and components take up a small volume compared with these.
3. *Not very sensitive.*
   No, this system was used to greatly improve sensitivity and enables various temperature ranges to be accommodated.

Mr. Jones' design requires a setting up potentiometer for each temperature measurement, as does the published design. The meter reading is dependent on battery voltage to a large degree. The thermistor will suffer from self heating effects due to the current flowing through it. The 100μA meter is more expensive than a 1mA meter which can be used in the published design. The MR26 meter costs £6 retail. 1mA meters are obtainable for 10s 0d. This was the main reason for using the pulse amplifier method.

Switching for more than one range will be more complicated due to having to switch two of the potentiometer connections and one of the thermistor. There is no padding of the thermistor which adjusts for the variation in the thermistor law. Other types of thermistors may be used in the published circuit, as long as they are between 100kΩ and 300kΩ at 20 degrees centigrade; the A25 may be obtained at much reduced cost from L.S.T. Components, 23 New Road, Brentwood, Essex.

The VA 1008 is cheaper but has too wide a tolerance for multi-range use.

I think Mr Jones has made the mistake which quite a lot of people do when first looking at a diagram; it is often easy to visualise something far more rudimentary which will seemingly perform the desired function but it is only when such devices are put to the test that the need for a more refined circuit becomes apparent.—A.T.

Idle pinch

Sir—Having just read the article *Tape Recorder Auto-Switch* by Mr P. Rush in your January issue, I feel that it should be pointed out to your readers that damage may be caused to their tape recorders if it is used.

With the device described the tape recorder will have to be left with its function switch to the "record" position for a period of time during which the motors are not running, and this will cause damage to both the pinch wheel and idler, which in turn will result in a permanent increase in the "flutter" level.

T. J. Ledger, B.Tech.
Longlands,
Middlesbrough.

We admit that this device has certain limitations and that this was not made clear in the article itself. Apart from this, however, the auto-switch as described is an ideal device for use with inexpensive recorders. The author tells us he has not been able to detect any trace of wow or flutter as a result of its use. No doubt, if an expensive recorder was involved, such deficiencies would certainly come to light but, on the other hand, one assumes that owners of more sophisticated equipment would in fact invest in a more advanced switching system. In fact, the higher quality tape recorders do often incorporate electro-magnetic devices for enabling remote control of the pinch wheel.

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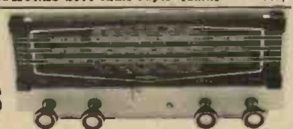

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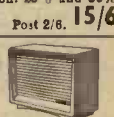

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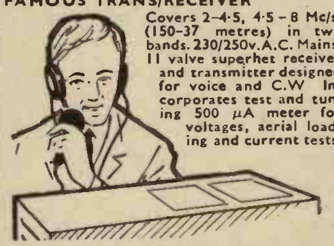

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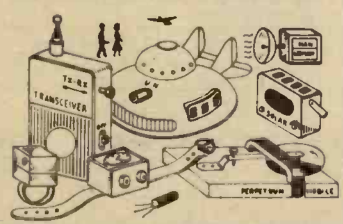

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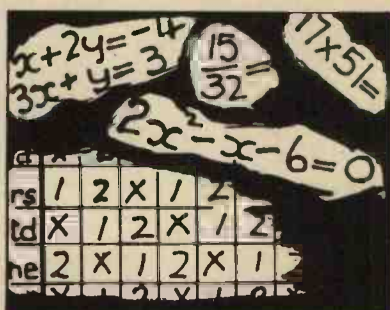

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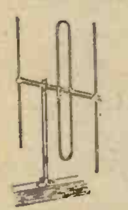

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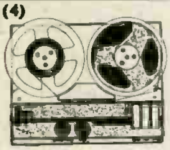

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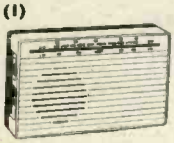

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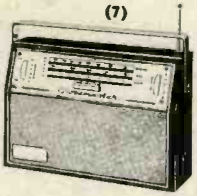

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