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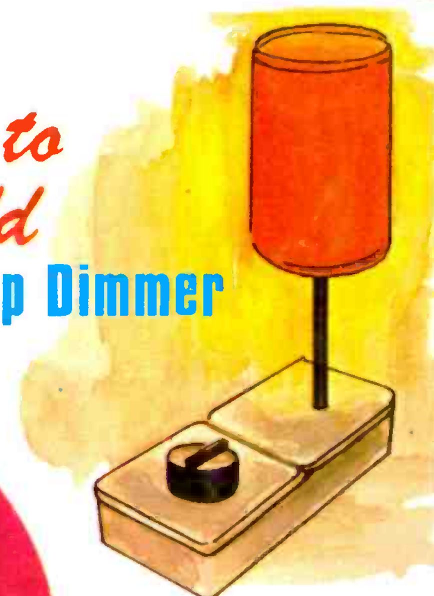

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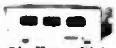

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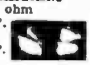

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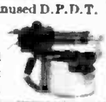

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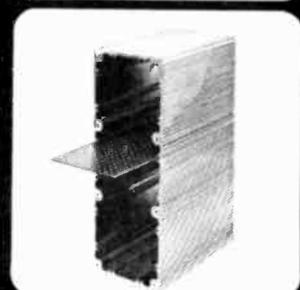

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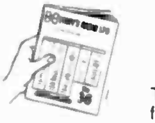

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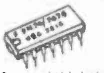

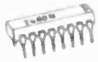

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SN7403AN	0·38	0·38	0·33
SN7404N	0·24	0·21	0·18
SN7405N	0·20	0·18	0·16
SN7405AN	0·44	0·44	0·38
SN7406N	0·40	0·38	0·35
SN7407N	0·40	0·38	0·35
SN7408N	0·25	0·22	0·19
SN7409N	0·33	0·33	0·28
SN7409AN	0·44	0·44	0·38
SN7410N	0·20	0·18	0·16
SN7411N	0·25	0·23	0·21
SN7412N	0·28	0·28	0·25
SN7412AN	0·38	0·38	0·33
SN7413N	0·30	0·27	0·25
SN7414N	0·72	0·72	0·63
SN7416N	0·30	0·27	0·25
SN7417N	0·30	0·27	0·25
SN7420N	0·20	0·18	0·16
SN7422N	0·28	0·28	0·25
SN7422AN	0·38	0·38	0·33
SN7423N	0·37	0·34	0·32
SN7425N	0·37	0·37	0·32
SN7427N	0·37	0·37	0·32
SN7428N	0·43	0·43	0·37
SN7430N	0·20	0·18	0·16
SN7432N	0·37	0·37	0·32
SN7433N	0·43	0·43	0·38
SN7433AN	0·57	0·57	0·50
SN7437N	0·43	0·43	0·37
SN7438N	0·43	0·43	0·37
SN7438AN	0·57	0·57	0·50
SN7440N	0·20	0·18	0·16
SN7441AN	0·85	0·79	0·73
SN7442N	0·85	0·79	0·73
SN7443N	1·50	1·27	1·13
SN7444N	1·50	1·27	1·13
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SN7448N	1·50	1·27	1·13
SN7450N	0·20	0·18	0·16
SN7451N	0·20	0·18	0·16
SN7453N	0·20	0·18	0·16
SN7454N	0·20	0·18	0·16
SN7460N	0·20	0·18	0·16
SN7470N	0·33	0·30	0·27
SN7472N	0·38	0·38	0·34
SN7473N	0·44	0·41	0·37
SN7474N	0·48	0·48	0·42
SN7475N	0·59	0·55	0·51
SN7476N	0·45	0·36	0·32
SN7480N	0·80	0·70	0·50
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SN7482N	0·87	0·80	0·72
SN7483N	1·20	1·10	1·00
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SN7492N	0·75	0·70	0·63
SN7493N	0·75	0·70	0·63
SN7494N	0·85	0·80	0·75
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SN74105N	0·60	0·53	0·45
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SN74110N	0·57	0·57	0·50
SN74111N	0·86	0·86	0·75
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SN74120N	1·05	1·05	0·92
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SN74122N	0·80	0·80	0·70
SN74123N	1·44	1·44	1·26
SN74125N	0·69	0·69	0·60
SN74126N	0·69	0·69	0·60
SN74132N	0·72	0·72	0·63
SN74136N	0·63	0·63	0·55
SN74141N	1·00	0·90	0·80
[illegible]	[illegible]	[illegible]	2·52
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SN74147N	2·30	2·30	1·83
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SN74161N	1·58	1·58	1·38
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SN74164N	2·01	2·01	1·76
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SN74176N	1·44	1·44	1·26
SN74177N	1·44	1·44	1·26
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SN74181N	5·18	5·18	4·53
SN74182N	1·44	1·44	1·26
SN74184N	2·16	2·16	1·89
SN74185AN	2·16	2·16	1·89
SN74188N	6·48	6·48	5·67
SN74190N	2·30	2·30	2·01
SN74191N	2·30	2·30	2·01
SN74192N	2·30	2·30	2·01
SN74193N	2·30	2·30	2·01
SN74194N	1·72	1·72	1·51
SN74195N	1·44	1·44	1·26
SN74196N	1·58	1·58	1·38
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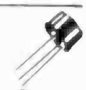

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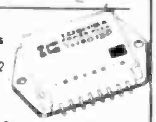

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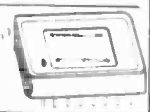

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400 m/w BZY88/BZX83. From 3·3 volt – 33 volts **10p** each

1·3 watts 5% Miniature Tubulars IN4700 series. From 3·3 volt – 33 volt **18p** each.

10 watts. Stnd Mounting. ZS series 6·8 volts – 100 volts 5% **40p** each.

LINEAR I.C.

702C (T05)	75p
709C (T05)	39p
709C (D.I.L.)	39p
723C (T099)	90p
723C (D.I.L.)	90p
728C (D.I.L.)	45p
728C (T099)	45p
741C (T05)	50p
741C (D.I.L.)	50p
747C (T099)	£1·0p
748C (D.I.L.)	61p

SILICON RECTIFIERS
1 amp series IN4001 to IN4007 From **6p** ea
1·5 amp PL4001 to PL4007 From **8p** ea
3 amp PL7001/IN5400 From **14p** ea
Send for full list 36

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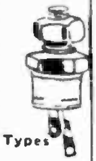
TRIACS – Stnd. mounting with accessories

Type	P.I.V.	1–11 Price ea.
3 AMP RANGE		
SC35A	100v	80p
SC35B	200v	85p
SC35D	400v	90p
SC35E	500v	£1·20
6 AMP RANGE		
SC40A	100v	90p
SC40B	200v	95p
SC40D	400v	£1·20
SC40E	500v	£1·50
10 AMP RANGE		
SC45A	100v	£1·05
SC45B	200v	£1·15
SC45D	400v	£1·45
SC45E	500v	£1·85
15 AMP RANGE		
SC50A	100v	£1·45
SC50B	200v	£1·65
SC50D	400v	£1·95
SC50E	500v	£2·25

3 Amp
T048



TRIACS – Additional Types
40430 TRIAC (T066) 85p
40669 TRIAC (Plastic) 90p
40486 TRIAC (T05) 75p

NEW RANGES
BRIDGE RECTIFIERS
FEATURES SMALL SIZE AND LOW COST Sizes are approx.

250M/A QUARTER AMP
B025/05 50 PIV 16p
B025/10 100 PIV 18p
¼ x ¼ x ¼" dia.

½ AMP 1-11 Pricing

Type	P.I.V.	Price ea.
B05/05	50v	20p
B05/10	100v	22p
B05/20	200v	23p
B05/40	400v	25p
B05/60	600v	27p

½H x ½L x $\frac{3}{16}$" dia.

1 AMP P.I.V.

	P.I.V.	
B1/05	50v	25p
B1/10	100v	25p
B1/20	200v	28p
B1/60	600v	30p

½H x ½L x $\frac{3}{16}$" dia.

1 AMP P.I.V.

	P.I.V.	
W005	50v	29p
W01	100v	30p
W02	200v	32p
W06	600v	35p

⅜ x ⅜" Tubular

2 AMPS P.I.V.

	P.I.V.	
B2/05	50v	35p
B2/10	100v	40p
B2/20	200v	45p
B2/60	600v	50p
B2/100	1000v	55p

½H x ½L x $\frac{3}{16}$" dia.

4 AMPS P.I.V.

	P.I.V.	
B4/100	100v	55p
B4/200	200v	59p
B4/400	400v	65p
B4/600	600v	75p
B4/800	800v	£1·00

½H x ½L x $\frac{3}{16}$" dia.

6 AMPS P.I.V.

Type	P.I.V.	Price
B6/05	50v	65p
B6/10	100v	70p
B6/20	200v	80p
B6/40	400v	90p
B6/6x0	600v	£1·00

½H x ½L x $\frac{3}{16}$" dia.

SILICON CONTROLLED RECTIFIERS

Type	P.I.V	1–11
ONE AMP (T05)		
CRS 1/05AF	50v	30p
CRS 1/10AF	100v	30p
CRS 1/20AF	200v	35p
CRS 1/40AF	400v	45p
CRS 1/60AF	600v	55p
THREE AMP (T048)		
CRS 3/05AF	50v	40p
CRS 3/10AF	100v	40p
CRS 3/20AF	200v	45p
CRS 3/40AF	400v	55p
CRS 3/60AF	600v	65p
FIVE AMP		
CRS 5/400	400v	60p
SEVEN AMP (T048)		
CRS 7/100	100v	60p
CRS 7/200	200v	67p
CRS 7/400	400v	85p
CRS 7/600	600v	95p

All types offered subject to availabilty. Prices correct at time of press E. & O. E. 10% VAT to be added to all orders. UK post, etc, 15p. per order.

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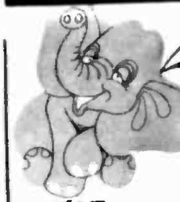

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TE40	AC Millivoltmeter 1·2mHz	18·75 carr. 35p
TE65	28 Range valve voltmeter	19·25 carr. 40p
TE20D	120kHz–500mHz RF Generator	16·95 carr. 40p
TE22D	20Hz–200kHz Audio Generator	18·75 carr. 40p
SE350A	Deluxe Signal Tracer	9·95 carr. 20p
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A SELECTION OF INTERESTING ITEMS

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D1203	Teleamp. with PU coil	3·60 p & p 20p
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Car Tachometer Electronic		7·50 p & p 15p
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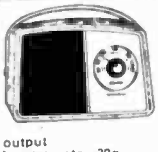
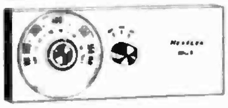
B2004 2 ch. Stereo mixer		4·75 p & p 15p

BUILD THIS RADIO



Portable MW / LW radio kit using Mullard RF/IF module. Features MW — bandspread for extra selectivity. Slow motion tuning. Fibre glass PVC cabinet. 600MW output All parts £7·98 (battery 22p). carr. etc 32p



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MW/LW Radio Turner to use with any amplifier. Features Mullard RF/IF module Ferrite aerial, built in battery. Excellent results. Size 7" x 2¾" x 3⅛". All parts £4·85, carr. 15p.

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65	Simple transistor tester	1·18
115	8 watt Amplifier	2·87
120	12 watt amplifier	3·88
125	Stereo control unit	4·20
130	Mono control unit	3·52
605	Power supply for 115	3·88
610	Power supply for 120	4·08
615	Power supply for 2 x 120	4·85
230	AM/FM aerial amplifier	2·70
240	Auto packing light	5·18
275	Mic. preamplifier	5·83
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575	Sq. wave generator 20Hz–20Khz	12·87
590	SWR meter	10·24
620	NI-CAD Charger 1·2–12v	7·47
630	STAB Power supply 6-12v 0·25-0·1A	7·65
690	DC motor speed Gov.	2·63
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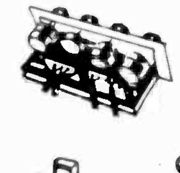
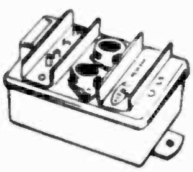
465	Quartz XTAL checker	7·89

ALL KITS OFFERED SUBJECT TO STOCK AVAILABILITY





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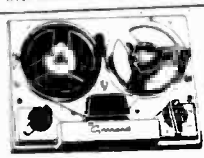
(carr./packing 40p)

All transistor circuits with hand books

All types offered subject to availability. Prices correct at time of press E & OE. 10% VAT TO BE ADDED TO ALL ORDERS. UK post etc. 15p per order.



GARRARD BATTERY TAPE DECK

GARRARD 2 speed 9 volt tape decks. Fitted record/play and oscillator/Erase heads. Wind and rewind controls. Takes up to 4" spools. Brand new complete with head circuits.
£9·50 carr. 30p

TOP QUALITY SLIDER CONTROLS

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Singles Log and Lin 5K, 10K, 22K, 50K, 100K, 250K, 500K, 1 Meg. 45p each.

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555, 3 watt 12 volt	2·85
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608, 10 watt 24 volt	4·10
410, 10 watt 28 volt	4·95
Z30, 15 watt 30 volt	3·57
E1206, 30 watt 45 volt	9·75
Z50, 30 watt 50 volt	4·37
E1210, 2½ + 2½ watts 12 volt	5·25
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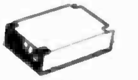

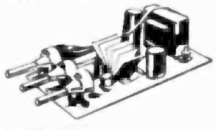

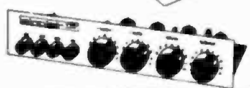

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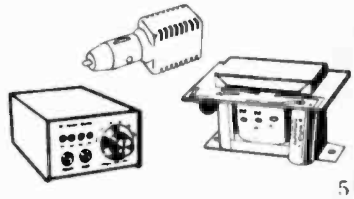

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Q32	8·70		
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Philips	RF839	55·95
Philips	GF829	39·95
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PYE	9115	27·75
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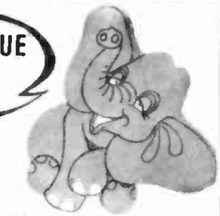

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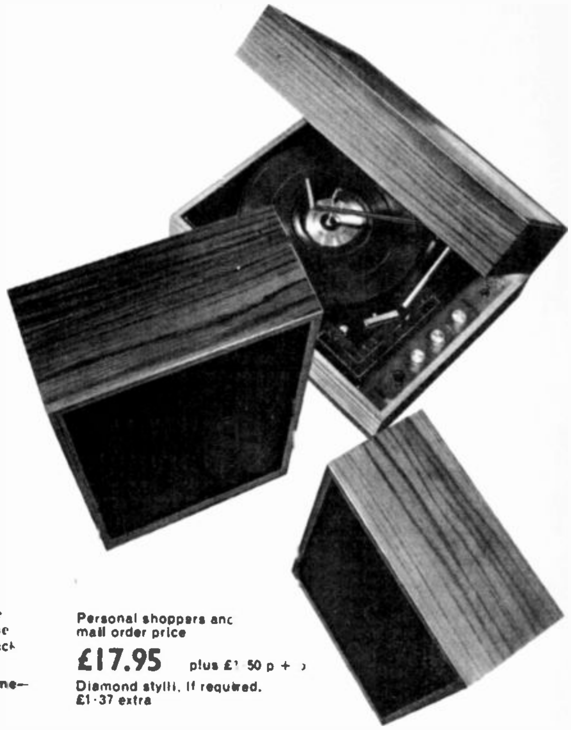

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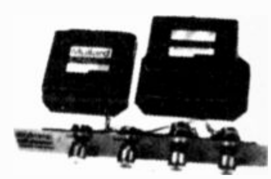

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Features of the Sinclair Cambridge

* Uniquely handy package. $4\frac{1}{2}$" x 2" x $\frac{11}{16}$", weight $3\frac{1}{2}$ oz.
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* Algebraic logic.
* Four operators (+, −, x, ÷), with constant on all four.
* Constant acts as last entry in a calculation.
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5. Case mouldings, with buttons, window and light-up display in position.
6. Printed circuit board.
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9. Battery clips and on/off switch.
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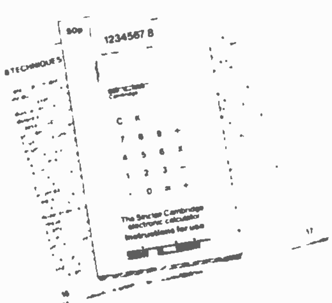

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everyday electronics

PROJECTS...
THEORY......

JOIN THE CLUB!

Welcome to the Club! Several ardent hobbyists have already suggested that "being a reader of EVERYDAY ELECTRONICS is just like belonging to a special kind of club."

We are flattered and highly delighted to hear such a view expressed. Also, we are mindful of our responsibilities, and will certainly do all in our power to preserve, and extend whenever possible, this spirit of *camaraderie* which undoubtedly exists between fellow electronic enthusiasts—be they readers or contributors, or members of the editorial team.

Well, a club must have a Constitution, so here goes.

1. The aims of the Everyday Electronics Club are:
   (a) To encourage the use of electronic techniques by the ordinary person in order to solve everyday needs, through relatively simple and inexpensive designs.
   (b) To take any stuffiness out of electronics, to dispel its mystique and to present this subject, in theory and practice, in the clearest and most objective fashion.
2. Membership shall be open to any individual who has a curiosity about electronics and wishes to participate in an interesting creative hobby.
3. No formal education or training in electronics is necessary since the Club undertakes to provide, at regular intervals, adequate instruction for beginners, in both theoretical and practical matters.

How about that, then?

A NEW SEASON STARTS

In the formal sense our "Club" may indeed be a mere figment of the imagination. But the above "constitution" is actually a restatement of this magazine's well established policy. And it is worth spelling it out again at this particular time, because we are now on the eve of another busy season for constructors.

Apart from many old stalwarts returning to their favourite hobby after an "ease up" during the summer, we anticipate a large influx of newcomers to electronics around this time.

To each and everyone of these beginners, a very special welcome. You couldn't have chosen a better month to "discover" electronics. The *Teach-In '74* series (commencing in this issue) has been prepared just for you. We hope you like the series. Follow each article carefully and carry out the simple experiments described. It's our guess that very soon you will become an enthusiastic "member of the Club", like many thousand others. Good Luck with your new-found hobby!

Fred Bennett.

Our November issue will be published on Friday, October 19

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VOL. 2 NO. 10 OCTOBER 1973

CONSTRUCTIONAL PROJECTS

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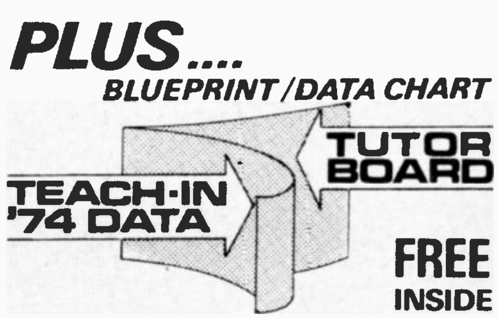
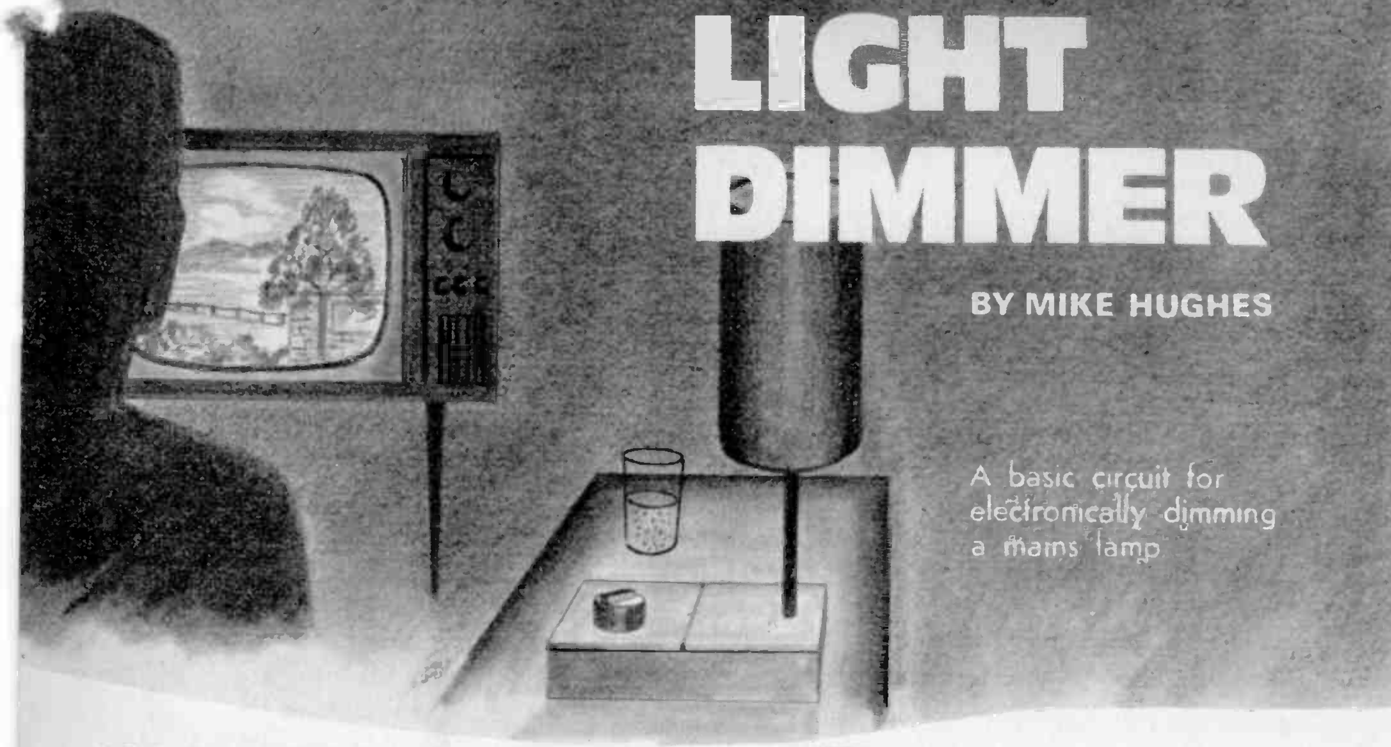




LIGHT DIMMER

BY MIKE HUGHES

A basic circuit for electronically dimming a mains lamp

THE few components and novel construction of this Light Dimmer enable it to be made by virtually anyone and the result is a really smart contemporary style tablelamp that will grace any decor. Basically the unit is a dimmer circuit built into the base of a simple lamp stand; there is no reason why the dimmer circuit should not be used in isolation or in conjunction with other lighting circuits provided the maximum current drawn does not exceed 1 amp (i.e. the bulb should not require more than 250 watts when run off 250V mains).

The dimmer is only suitable for controlling non-inductive loads—tungsten filament bulbs—it should **not** be used in conjunction with fluorescent tubes.

Approximate cost of components including V.A.T.
£3·50 all parts listed

DIAC AND TRIAC

The circuit is shown in Fig. 1 and as can be seen is in series with the main light circuit. This means that it can be simply wired into the lighting system in place of, or as well as, the existing switch. The important components are D1 which is called a **diac** (sometimes a **trigger diode**) and CSR1 which is a **triac**.

The diac will not normally pass current in either direction unless the voltage across it exceeds a certain value (the trigger voltage). When this happens the device conducts completely and—like a thyristor—will continue to pass current until the current falls below a certain level. A diac will operate with either polarity and

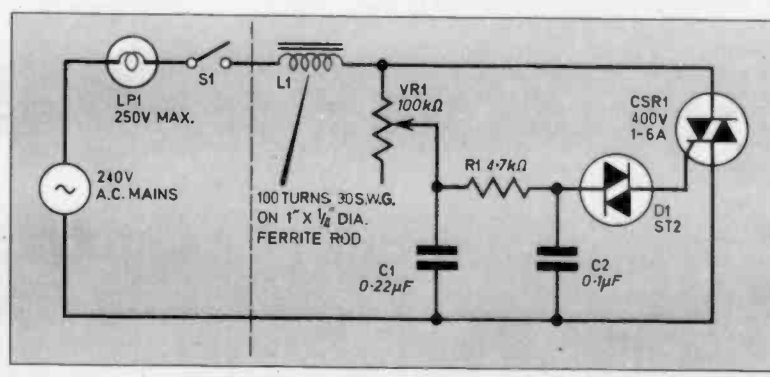


Fig. 1. The complete circuit diagram of the Light Dimmer. Only the circuitry to the right of the dotted line is assembled on the tag board.

therefore it does not matter which way round it is connected in the circuit.

The triac works rather like a thyristor except that it can also operate with either polarity across it. Normally it does not conduct but if the gate is made positive or negative with respect to MT1 (main terminal one) and gate current of about 30mA is allowed to flow the device goes into conduction and stays in conduction until the current flowing through it falls below the holding current level. When operating from a.c. mains this occurs every half cycle.

CIRCUIT OPERATION

Dimming is effected by triggering the gate of the triac at different points on the mains half cycle waveforms (Fig. 2). If triggered early in the half cycle almost full power is obtained and this can be reduced to almost zero power as the triggering point is progressively moved later within the cycle. We use the combination of VR1, C1, R1 and C2 to delay the voltage rise across the diac—relative to the timing of the mains waveform.

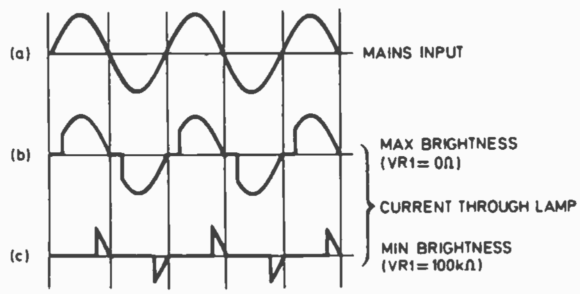


Fig. 2. Waveforms of current through the lamp for triggering (b) early in the half circle (c) late in the half circle.

In this circuit the delay can be from virtually zero to 10 milliseconds, which corresponds to the time for a half cycle of 50Hz mains. Thus we can say we obtain a phase shift of nearly 180 degrees.

The diac needs about 20V across it for it to trigger—and hence pass current into the gate of the triac. If VR1 is set to a low value the potential across C1 builds up rapidly and in almost exact step with the mains; likewise across C2 although there will be a slight fixed delay caused by R1. As soon as the mains rises to plus or minus 20V the diac will trigger and the triac conducts. The voltage between the top end of VR1 and the bottom end of C1 will fall to almost zero and both C1 and C2 discharge into the gate of the triac.

By increasing the value of VR1 to 100 kilohm C2 will not reach 20V until much later in the cycle. The former setting gives near maximum light output while the latter gives minimum. As stated previously it does not matter whether the mains is on a positive or negative half cycle, the triac will still function in this way.

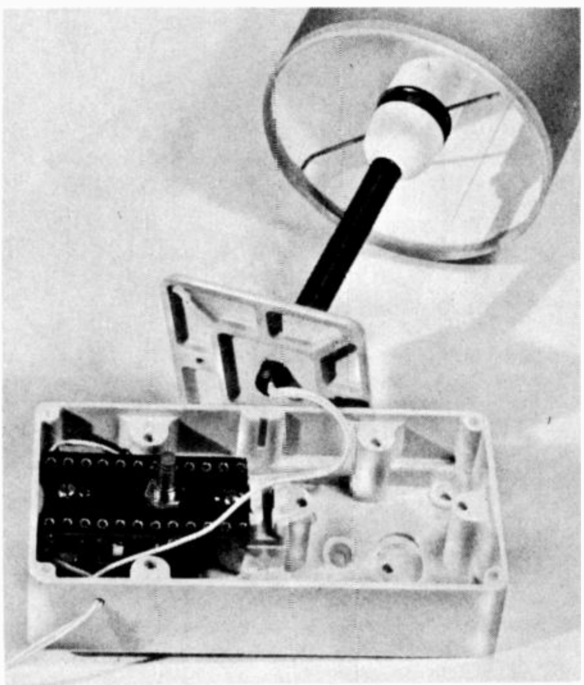
COMPONENTS

The values of VR1, C1, R1 and C2 are fairly important to maintain the correct range of control. For example C1 is specified as 0·22μF; if you make this 0·33μF the circuit will still work but minimum light intensity will be obtained well before you have turned VR1 to maximum resistance—this means the control movement of the knob becomes cramped.

It is suggested that VR1 is a wirewound potentiometer—not so much because of power dissipation but because of better reliability. The capacitors should be of 250V working and the Mullard C240 range of polyester devices are ideal. You might have a bit of trouble locating diacs and triacs—particularly when it comes to their specifications. Most of them are sold "unbranded" which means that you must state the voltage and currents you require when ordering.

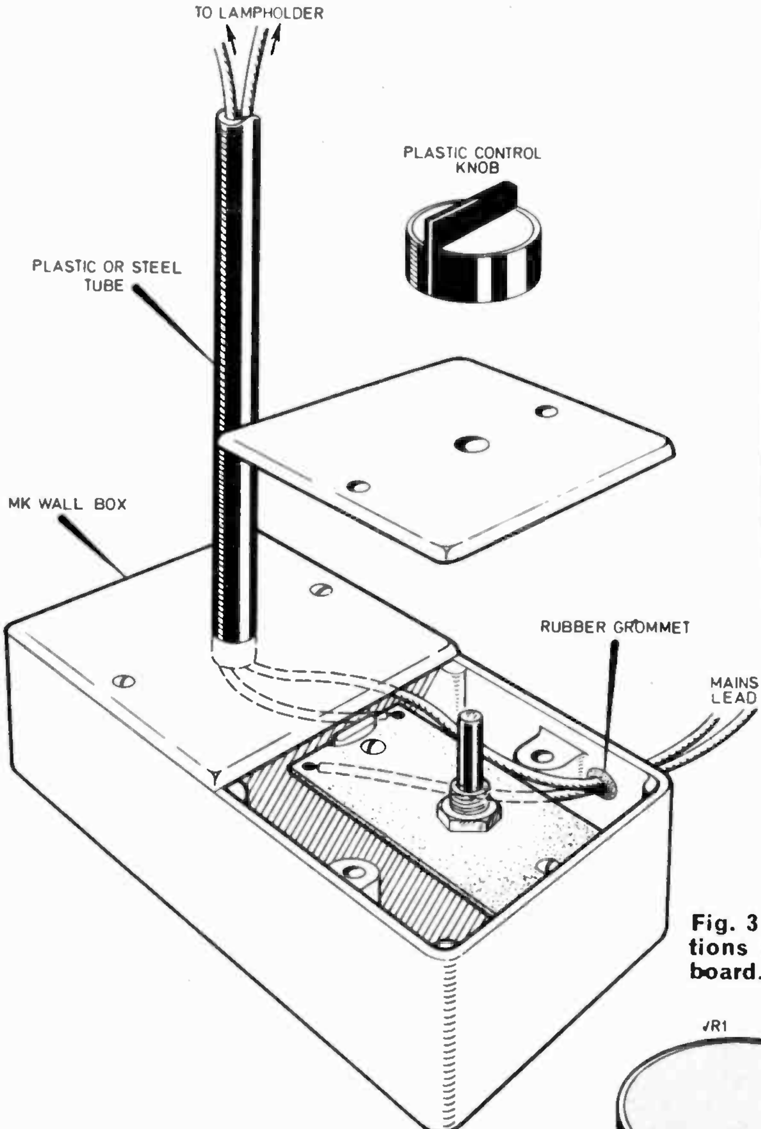
In this circuit almost any diac will do but you must make sure the triac is at least a 400V device with a current rating of at least 1 amp. A triac in a TO-5 transistor encapsulation will do but these are not as readily available as the "stud" mounting variety. We have therefore designed the mechanical construction around the latter.

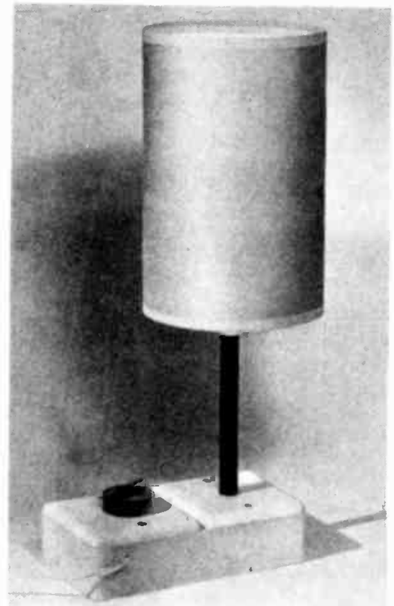
The inductor L1 is there purely to act as an interference suppressor and is a "home wound" job. About 100 turns (a few more will not hurt, but don't cut down on the 100) of 30 s.w.g. enamelled copper wire are wound on a 25mm (one inch) length of ¼ inch diameter ferrite aerial rod and Araldited into position.



Photograph of the Lamp Dimmer in final stages of assembly.

LIGHT DIMMER





Photograph of completed unit.

Fig. 3 (below). The component positions and wiring details on the tag board.

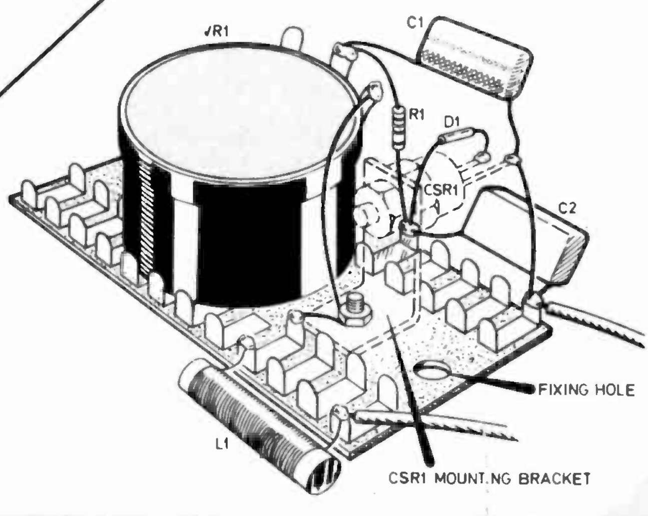


Fig. 4 (above). Fixing the component board in its case. Also shown is stem for holding lamp holder and shade.

Components....

Resistors
- R1 4·7kΩ ¼W ±10% carbon
- VR1 100kΩ wirewound potentiometer

Capacitors
- C1 0·22μF 250V polyester
- C2 0·1μF 250V polyester

SEE SHOP TALK

Semiconductors
- D1 ST2 or similar diac
- CSR1 400V 1 to 6 amp triac

Miscellaneous
- L1 Interference suppressor—see text
- LP1 240V lamp (up to 250W)
- S1 On/off switch incorporated in lamp-holder

Piece of 12-way twin tagboard 76mm long, MK double plastic wall box, 2MK plastic cover plates, 130mm length of ½ inch diameter gas pipe, insulated knob, bayonet lamp holder (incorporating S1), lamp shade (Woolworths), aluminium for CSR1 mounting, length of twin mains flex.

CONSTRUCTION

All the electronic components are mounted on a piece of tag board as shown in Fig. 3 which is then fixed within one half of a double MK wall box (the white plastic type). A hole is drilled in a blank white cover plate to allow the spindle of the potentiometer to pass through and this will ultimately be positioned over the circuit half of the box (Fig. 4).

The lamp holder is made from a 130mm length of ½ inch diameter steel gas pipe—screwed or stuck into a second blank cover plate with a switched bayonet lamp holder fixed, likewise, to the top end. The mains input wires are brought into the side of the box; one lead goes straight to the lamp holder, the other is broken and goes via the circuitry. To finish the unit off give the steel pipe a touch of paint and select a **fully insulated** knob to match the general appearance of the unit.

The advantage of using a plastic case is that you do not have to worry too much about insulation problems. If you use a metal case such as a standard "sunk" metal wall box ensure that none of the circuitry touches the metalwork. If in doubt you can cover the inside of the box with two layers of good quality insulating tape. ▣

...Counter Intelligence

BY PAUL YOUNG

A retailer discusses component supply matters.

Component consumers are our "bread and butter." As an electronic component retailer I say this advisedly, because you constructors are indeed just this.

Specialisation

Now the variations in electronic circuit components are proliferating so fast that the first thing you are going to have to face up to, is that you are highly unlikely to get *all* your requirements from one source. I know a large component firm in South East London who do not stock any "radio-frequency" goods at all. This may sound as though it's against your interests, but is it? It means in practice they can carry a bigger range and bigger stocks of "audio frequency" components.

I think this trend may go on for quite a while, and each dealer will have to specialise in a smaller section of the field. The disadvantage is that it will make it essential for you to deal with several firms, an obvious complication. On the credit side: if each dealer is doing his job well, he should be able to offer you a large range, (within his limits) and be able to buy bigger stocks, which will help to keep down prices.

To anyone embarking on this hobby I therefore suggest that their first purchase should be *catalogues*. Buy several of the electronic magazines and read all the advertisements. In this way you will come to know supplier's strengths and weaknesses.

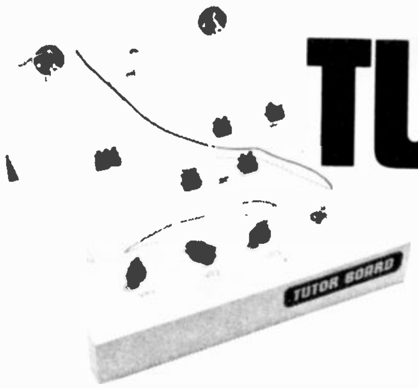
Mail Order

Now since all these suppliers will be spread out over a fair size area, most of your orders will have to be through the mail. A few points relating to ordering by mail order are in order. Use the firm's own order form (if they have one). Write your name and address clearly (preferably print in BLOCK CAPITALS) and clearly state your wants. If you are using a firm's catalogue, I would emphasise particularly, do not put down something they do not list, because if you do, your order will have to be specially dealt with, and my guess is that it will be the very last to be tackled. Above all don't write queries on your order form.

Queries

It might be an appropriate moment to consider exactly what kind of queries you can expect your supplier to deal with. Every supplier will of course have his own ideas on this subject. However, I would suggest that they must be confined to information about that particular dealer's own stock; and even then, if they concern data that is not readily available, I would not condemn a supplier if he limited his help to giving you the name and address of the manufacturer concerned.

It is not in the province of the dealer to answer technical queries about articles appearing in the electronics magazines. In any case it is always far more satisfactory to contact the magazine concerned. As my partner so rightly remarked, "Extra good service for the one, means poorer service for the many." Translated into practical terms, it means that while we are struggling with your one query, twenty other customers' orders are held up!



TUTOR BOARD

How to Construct

By PHIL ALLCOCK*

Designed specifically for use in the Teach-In '74 series for beginners.

THE Tutor Board to be described here and on the blueprint presented free with this issue of EVERYDAY ELECTRONICS, is an essential piece of apparatus for use in the *Teach-In '74* series for beginners in electronics.

The Tutor Board will be used extensively throughout the series its primary function being to carry out experiments to illustrate the theory.

It is not essential to adhere exactly to the given dimensions for the Tutor Board and some readers may wish to modify the construction to suit materials at hand. If major changes are contemplated it is necessary first to ensure that adequate space and clearances are available, especially for the potentiometers, meter and batteries.

BUILDING

Cut the plywood base and rear panel (pieces A and B) to the dimensions shown on the blueprint and drill all the holes with reference to the heading DRILLING.

The large hole for the meter can be cut out by a fret saw, an expandable wood bit or by drilling a series of closely spaced holes round the inside of a marked circle In the latter case the centre disc of wood can be removed by cutting along the holes with a sharp knife on both sides of the plywood Finally the hole edge must be smoothed with sandpaper.

Next cut the front and rear supports (pieces C) to the sizes indicated and then fix, with glue and panel pins, to the baseboard as shown.

Now cut to size the battery support, piece D, and glue and pin to the back panel as indicated on the blueprint. When the glue has completely set, the base and rear panel can be sanded down before finishing with two coats of emulsion paint.

The rear panel is held to the base by three screws so that the Tutor Board can be taken apart if necessary for storage, in say a shallow drawer, or repainting.

As the Tutor Board will be used throughout the series it is worth making as good a job of this as possible. A high standard should always be the aim and this applies especially to electronics because most problems arise from poor workmanship or untidy work. Good workmanship from the start will repay itself as the series develops and will give more pleasure and satisfaction in the long run.

TERMINAL BLOCKS

While the paintwork is drying the electrical components can be studied. The Data Chart illustrates the various components, to aid identification, and it is worth spending a little time examining the chart and the actual components until they can all be readily identified.

An important part of the Tutor Board system is the terminal blocks. These are supplied in strips of twelve connectors and must be cut with a sharp knife to give smaller blocks. Using the first strip carefully cut along the grooves to give two blocks each having three connectors, two blocks each having two connectors and two blocks each having one connector. The remaining two strips of twelve should be cut to give twelve blocks, each having two connectors.

The two three-connector blocks are for the BC107 transistors (see Fig. 1a), which have three leads each, but as these are not required straight away they can be stored with the other components until needed.

The two-connector blocks will have a single fixing hole, Fig. 1b, and at this stage it is advisable to check that the wire nails are a good fit when pushed into the fixing hole so that the barbs on the nail enter the plastic block. If all is well the nails can be cut to length to suit the thickness of the plywood used for the baseboard. In the prototype, which uses 4mm plywood, a cut nail length of 10mm was found ideal see Fig. 1c. The cut ends should be rounded slightly with a file to remove any sharp edges or burrs. A total of about 15 or 20 cut nails will ensure some spares to replace any that are lost during the series.

Two of the pointed nail off-cuts are required to make up a pair of test prods and after filing away any burrs these can be clamped firmly in each of the two single-connector blocks using one of the screws; this is shown in Fig. 1d. The unused screw in each single connector is for the connection of a flexible lead later on.

It is worth noting at this stage that the test prod point can be used to push out the fixing nails of the other terminal blocks when they have to be removed or repositioned on the baseboard.

CONNECTING LEADS

The next requirement is preparation of the connecting leads. Five different colours are used and leads of different lengths will be required, see Table 1.

Table 1: Coloured Wire Lengths

Colour	Length (mm)	Quantity	Use
Red	45	1	positive test prod
	40	2	positive battery connectors
	30	2	general
Black	45	1	negative test prod
	40	2	negative battery connectors
	30	2	general
Blue	10	6	general
	30	4	general
Green	10	6	general
	30	4	general
Yellow	15	4	general
	20	6	general

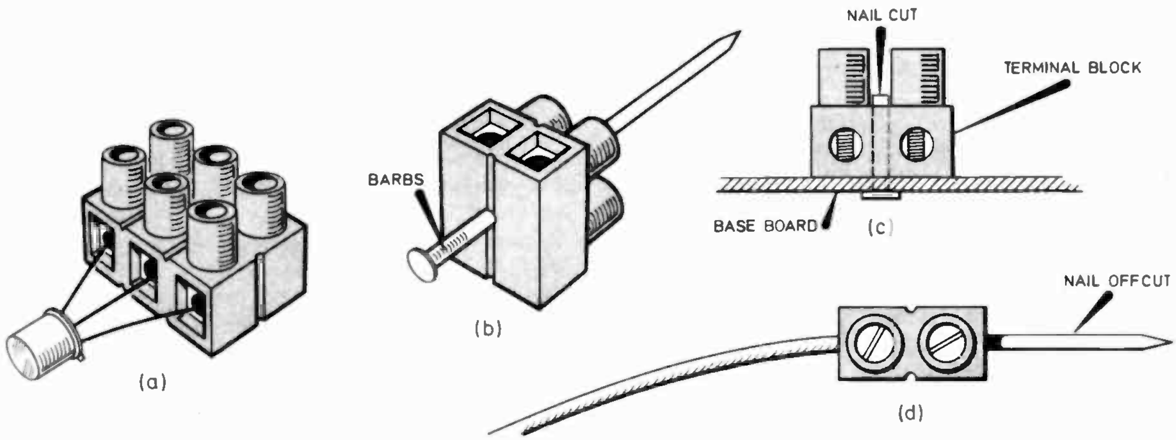


Fig. 1 (a). Shows the three-connector block for mounting transistors (b) checking that the nail fits snugly in the terminal block (c) method of fixing the terminal blocks to the Tudor Board baseboard (d) a made up test prod.

Components....

SEE SHOP TALK

Resistors

100Ω	1W ± 5% carbon	(1 off)
1kΩ	½W ± 5% carbon	(2 off)
4·7kΩ	½W ± 5% carbon	(2 off)
10kΩ	½W ± 5% carbon	(2 off)
47kΩ	½W ± 5% carbon	(2 off)
100kΩ	½W ± 5% carbon	(2 off)
100kΩ	½W ± 2% thick film	(1 off)

Potentiometers

100Ω 1W wirewound semi-precision
5kΩ 1W wirewound semi-precision
100kΩ carbon linear

Capacitors

1000μF elect. 9 to 25V (1 off)
250μF elect. 9 to 25V (2 off)

Semiconductors

BC107 silicon *npn* (2 off)
IN4001 silicon diode (1 off)
BZY88 4·7V 400mW Zener diode (1 off)

Miscellaneous

Meter 0-100μA d.c. moving coil—SEW MR45P or similar; 12-way 2A terminal blocks (3 off); M.E.S. batten mounting lampholders (2 off); M.E.S. 6V 60mA bulbs (2 off); S.P.D.T. toggle switch; pointer knobs (3 off); miniature crocodile clips (24 off); coloured 7/0·2mm wire—one of each colour Red, Black, Blue, Green, Yellow—each 2 metres long.

The components listed above are those required for the first six months of *Teach-In '74*, see page 535. Approximate cost including V.A.T. £7-00.

Hardware

4mm Plywood 300 x 300mm
6mm Plywood 150 x 300mm
Deal or similar soft wood 48 x 22 x 300mm (2 off)
Deal or similar soft wood 18 x 22 x 300mm
Wood glue; half inch panel pins; No. 10 round headed screws (3 off); screw hooks (4 off); screws for lampholders (4 off); stout rubber bands (2 off). **Drill bits:** 10mm dia.; 13mm dia.; 4mm dia.; No. 42.

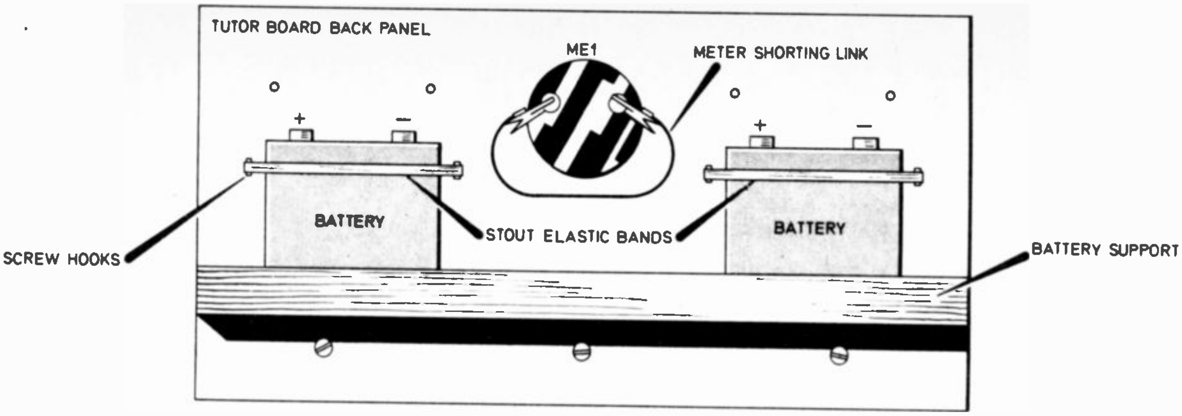


Fig. 2. Details of the battery mountings and meter short-circuit lead.

Using your wire strippers, carefully set so as not to cut or nick the wire strands, about 10mm of the outer plastic insulation should be removed from each end of all the above wires. This process may take a little practice and for short wire lengths it is sometimes convenient to grip the wire with pliers near the end to be stripped whilst levering the strippers outwards, away from the pliers.

With the strippers set at the correct gap excessive force is not necessary—too small a gap causes damage to the strands of wire. After stripping, the bare wire strands should be twisted tightly together.

CROCODILE CLIPS

Half of the 20, 30 and 40mm leads of each colour can now be fitted with a miniatiure crocodile clip at *one* end only, as shown on the Data Chart. Other leads can be similarly prepared if needed. The tubular end of the clip should be gently squeezed until it grips the plastic lead firmly as this provides added strength and the leads will be more durable.

One of the 10mm leads should be fitted with clips at both ends and reserved for use as a short circuit link across the meter terminals when this is not in use. The thin wire across the terminals of the meter serves the same function during transit and the need for this will be covered later. At this stage it is sufficient to say that a shorting lead helps to protect the delicate moving coil and needle from damage during handling. When the meter is used in an experiment the lead is always removed.

When the paint on the Tutor Board is completely dry, the final stages of fitting out can be performed. The meter should be fixed in the rear panel cut out—do not overtighten the fixing nuts as this may cause the plastic case to crack.

When this stage is complete the thin wire across the meter terminals may be removed and replaced by the 10mm lead with crocodile clips at each end, Fig. 2. Attach one clip to the tag on each meter terminal.

Next the batteries should be attached using four small screw hooks and rubber bands as shown, see Fig. 2. The two batten lamp holders for the 6V bulbs should be screwed into position, and the toggle switch mounted in position, see blueprint and Fig. 3.

The rotary carbon and wire wound potentiometers should now be fitted as detailed on the blueprint and in Fig. 3. The carbon potentiometer has a spindle which must be shortened to the same length as the other potentiometers. The free end of the spindle should be held firmly in a vice and then cut through with a hacksaw—at no time must any stress be applied to the body of the component as this could cause damage. Any burrs on the cut end should be removed with a file. The Tutor Board is now complete and ready for use. ▣

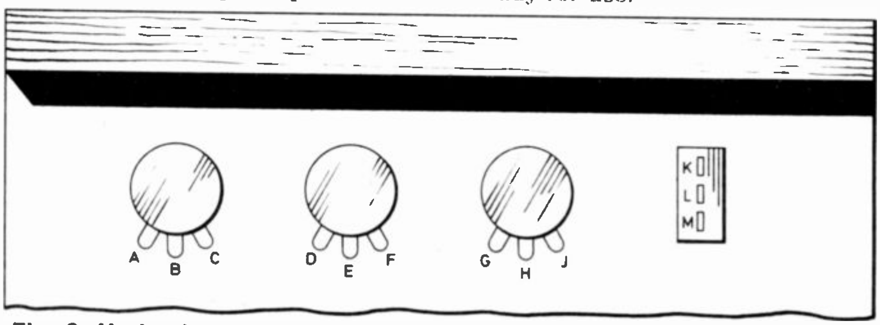


Fig. 3. Underside view of the Tutor Board showing potentiometer and switch labels to be referred to in the Teach-In '74 series.

TEACH-IN '74

FOR BEGINNERS IN ELECTRONICS... THEORY AND EXPERIMENTS

TUTOR: PHIL ALLCOCK*

LESSON 1 Current Flow and Resistance

THIS completely new series has been designed to run for approximately twelve months and provides an introduction to the basic practical and theoretical aspects of electronics. No previous knowledge or skill is required and the series is in fact ideally suited to anyone who is interested in learning the basics of electronics. Basic experiments will be described for each part and these can be performed without the need for soldering.

TUTOR BOARD

The series has been devised around a low-cost Tutor Board designed to obviate soldering. As a consequence the initial expenditure is kept to a minimum and the risk of damage to any of the components, by excess heat, is avoided. The construction of the Tutor Board is very simple and the Blueprint, enclosed with this issue of E.E. gives the constructional details for the board, this, together with the article on page 532 provides full construction information.

All the electrical components specified are readily available from advertisers in this issue and can be purchased through some of our advertisers in the form of a kit, providing all the components for approximately the first six parts. To assist those who wish to purchase all the electrical components for the first half of the series a components list is included in the Tutor Board article.

The Blueprint/Data Chart enclosed in this issue also contains basic information for use with this series and electronics in general.

TOOLS

As with most constructional hobbies a few tools are necessary from the outset and the basic requirements are: a small screwdriver, wire strippers and wire cutters (side cutters). A pair of long nosed pliers might also prove useful for wire bending. Note that the screwdriver should have a narrow blade and must be small enough to fit the screws in the terminal blocks. (A kit containing all these tools except the wire strippers will be available next month).

Good quality tools are an investment in the long run as they are more durable and often easier to handle. It is assumed that the few tools required to cut and assemble the wooden parts of the Tutor Board are already to hand.

Before any experiments can be undertaken it is necessary to look at some basic ideas regarding electricity and to introduce the ideas of a circuit, current flow, resistance and voltage.

ELECTRICAL CIRCUITS

Perhaps much of the apparent mystique surrounding electronics stems from the fact that electricity itself cannot be seen. In some ways this may seem a real stumbling block but need not be so because the presence of electricity can easily be demonstrated. The "switching-on" of a room light or a torch is a simple example in which electricity makes its presence known by the light (and heat) that it produces when the switch is operated.

All materials are made of atoms in each of which there is a central core or nucleus and outside this one or more electrons. For our purposes the electron can be considered to be a minute package of electricity (or more correctly electrical charge). In some materials, like glass, these electrons are prevented from moving away from their parent atom by strong forces of attraction. As a result electrons cannot flow in these materials and they are called insulators.

Materials like copper and aluminium on the other hand do not possess these same restrictions and many of the electrons are free to move within the material. It is this movement which gives us the idea of electrical current or flow of electrons and we can in fact think of current flow in metal wires in the same way that we think of water flow in pipes of a central heating system. Metals are good conductors of electricity.

* North Staffordshire Polytechnic *(Any communications arising from the Teach-In '74 series must be addressed to Everyday Electronics, Fleetway House, Farringdon Street, London E.C.4)*

In a heating system the flow of water may be due to the pressure produced by a small pump where in an electrical circuit the pressure may arise from chemical effects inside a battery. The water is guided by ensuring that it always flows in a system of pipes or closed vessels and in the electrical circuit the current is made to flow where we want it to by using insulation round the wires and other components.

A common insulation is the plastic covering on the wires used for the Tutor Board. Fortunately air, when dry, is also a good insulator which is just as well as otherwise electricity might never have been found.

RESISTANCE

The amount of current that can flow in a circuit for a given pressure or battery depends on the ease with which the electrons can pass along the various parts of the circuit. The amount of opposition to current flow is determined by what is known as the electrical resistance of the material.

The resistance of a wire, say, depends on the material from which the wire is made, the length of the wire and wire diameter. Increasing the wire length increases the resistance whilst increasing the diameter reduces the resistance.

The connecting wires used with the Tutor Board are stranded and consist of seven wires side by side. Because the material is copper, a very good electrical conductor, the resistance of the wire is very low and when we require appreciable resistance we must add it to our circuit by connecting a resistor into the system.

The resistor is simply a component that has been manufactured to have a certain amount of resistance and this is often marked on the body of the component by a special colour code which is covered in more detail later on.

OHM'S LAW

So far we have introduced three terms which are very important, namely current flow, resistance and pressure. Each of the quantities can be measured and for this we must specify the units used. Pressure is measured by referring to the electromotive force (e.m.f.) of the battery and the unit used is the volt.

Current flow round the circuit is measured in amperes, often abbreviated simply to amps, whilst resistance is measured in terms of a unit called the ohm. The Data Chart gives the symbols that are normally used for these and several other quantities that will be introduced later.

These three quantities are related to each other by a well known law called Ohm's law. This simply states that current is proportional to the voltage and consequently inversely proportional to the resistance. As an equation this can be written as:

$$\text{current in amps} = \frac{\text{e.m.f. in volts}}{\text{resistance in ohms}}$$

CURRENT MEASUREMENT

Strictly speaking the ampere is a measure of the number of electrons that flow past a given point in one second. Each electron carries the same fixed amount of electrical charge (measured in coulombs) and a current of one ampere represents the movement of approximately six million million million electrons per second! Do not let this large number worry you—it is impossible for most people to visualise such a large number anyway.

On the Tutor Board current flow can be measured by using the moving coil meter. The current is allowed to flow through a coil of very fine wire which has the pointer attached to it. The current reacts with a magnet system placed near the coil and the coil rotates on its pivot. The deflection of the pointer across a calibrated scale is used to measure the amount of current.

The meter specified for this series is very sensitive and could easily be damaged by misuse. A full scale deflection, shown as 100 on the scale, occurs for a current of only 100 millionths of an ampere. Just as we can divide the inch unit into thousandths of an inch or the metre into centimetres so we can divide our electrical units. As shown on the Data Chart our new current unit can be written as

1 millionth of an ampere = 1 microamp = 1 μA

VOLTAGE MEASUREMENT

Thus the meter requires 100 microamps for full deflection. The meter can be transformed into a device for measuring e.m.f. or voltage by adding a resistance in series with the meter. The combination is then known as a moving coil voltmeter. To determine the resistance required we must use Ohm's law.

Let us change the full scale current of 100 microamps into say a reading of 10 volts i.e.: 100 on the scale will represent a voltage of 10 volts applied to the meter and resistor taken together. Thus:

$$\text{resistance required} = \frac{10\ \text{(volts)}}{0{\cdot}0001\ \text{(amps)}} = 100{,}000\Omega$$

From the Data Chart we see that this value can be written as 100kΩ (100 kilohms). To make the total resistance of the voltmeter equal to 100 kilohms we must allow for the resistance of the coil of wire in the meter. For the meter chosen this is about 800 ohms which is much smaller than the total resistance required and can be ignored, so we can make our voltmeter simply by adding a 100 kilohm resistor in series with the meter. The arrangement can be illustrated by what is known as a schematic circuit in which the various components are represented by the circuit symbols shown on the Data Chart. Our voltmeter representation is therefore as shown in Fig. 1.1.

The small circles in the schematic representation are included to indicate connector points

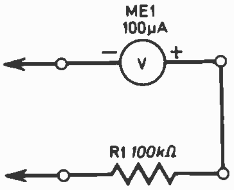


Fig. 1.1. Schematic circuit of the voltmeter.

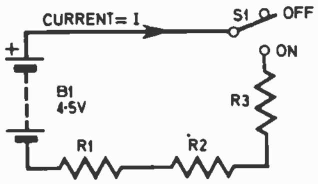


Fig. 1.2. A switch and three resistors in series with the battery.

but would not normally be shown in such a diagram. Wire connections are simply shown as solid lines joining the components (represented by their particular symbols) together.

RESISTORS IN SERIES

To illustrate this principle further, consider Fig. 1.2. This schematic diagram shows a series arrangement of a switch S1., three resistors (R1, R2, R3) and a 4·5 volt battery B1. The circuit is said to be a series arrangement because the current flow (when S1 is closed) is through all the components, one after another. In other words the same current flows in all components. This is not always the case and it is possible to have components in parallel so that they all experience the same voltage. This will be covered in more detail later.

As already mentioned the resistance value of each resistor is indicated by a series of coloured bands on the body of the component. Using the information given on the Data Chart study this method of colour coding and hence locate the 100 kilohm ±2 per cent resistor. The shopping list shows three 100 kilohm resistors but the ±2 per cent tolerance component should be specially reserved for making up the 0 to 10V voltmeter by the method already outlined, whenever it is needed.

This close tolerance resistor can be permanently mounted on one of the two-connector blocks as shown in Fig. 1.3. It is inadvisable to bend the resistor wires too close to the case, it is better to leave the wires long to avoid any stress in the component. Flexible leads can be connected to the other ends of each metallic connector as required.

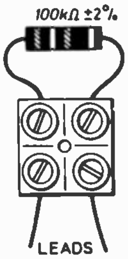


Fig. 1.3. The method of mounting a resistor in one of the connecting blocks. The resistor should be identified with reference to the Data Chart.

If we return for a moment to Fig. 1.2 and consider the effect of the current flow when switch S1 closes, we can see that the total circuit resistance (i.e. opposition to current flow) is due to the combined effect of R1, R2 and R3 taken together. If we call the total resistance R_T ohms then $R_T = (R1+R2+R3)$, the sum of all the individual resistance values. This is a necessary consequence of the series circuit connection and the fact that the current is common to all components. The circuit current, I, can be found by applying Ohm's law:—

$$\text{I = current in amps (switch closed)} = \frac{\text{battery e.m.f. in volts}}{\text{total circuit resistance in ohms.}}$$

$$\text{Hence } I = \frac{4\cdot5}{R_T} \text{ amps.}$$

KIRCHOFF'S VOLTAGE LAW

The current, in flowing through each resistor gives rise to a voltage difference (sometimes called a potential difference or p.d.) across each component's terminals. These voltage differences can also be found by using Ohm's law and if we work out the values for each resistor we get:

$$\text{Voltage difference across R1} = I \times R1 = \frac{4\cdot5}{R_T} \times R1$$

$$\text{,, ,, ,, } R2 = I \times R2 = \frac{4\cdot5}{R_T} \times R2$$

$$\text{,, ,, ,, } R3 = I \times R3 = \frac{4\cdot5}{R_T} \times R3$$

If we add these voltage differences together to determine the total voltage difference for the three resistors we find, since $\frac{4\cdot5}{R_T}$ is common to all terms, that:—

$$\text{Total voltage difference} = \frac{4\cdot5}{R_T} \times (R1 + R2 + R3) = 4\cdot5$$

volts since $R_T = (R1 + R2 + R3)$.

This might well have been expected and simply shows that the total voltage drop across all components in a series circuit is the same as the battery e.m.f. (This is known as Kirchoff's voltage law.)

Well, that is enough basic theory for the time being. Study the circuit and ideas carefully before proceeding to the experimental section of this part. The experimental work will give greater benefit if the basic theory is clearly understood beforehand.

TESTS

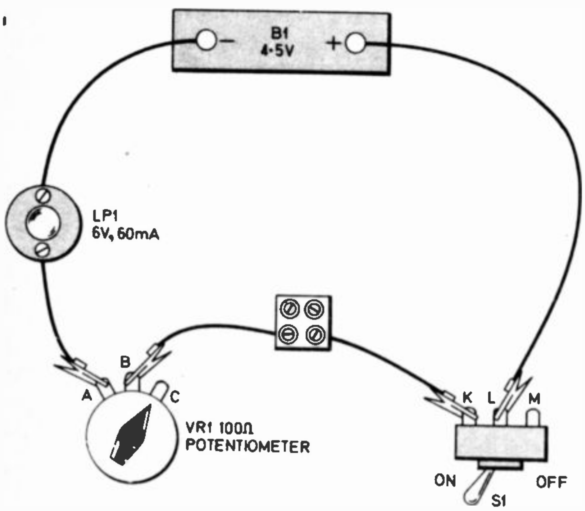
The tests should be done in the order indicated. Do not miss out any test as this may give difficulty in later tests.

The tests for this month start on the next page and should only be attempted when the theory has been fully studied. A number of tests will be given each month and will be based on the Tutor Board.

Next month: We shall examine the behaviour of parallel circuit. Some new experiments will be given and the basic theory will be taken a step further. A summary of the results of this month's experiments will also be given.

Test No. 1

The purpose of this test is to build a series circuit using the 100 ohm potentiometer (VR1) as a variable resistor, together with a 6 volt 60 mA bulb, one 4·5 volt battery and a switch. The layout is shown in Fig. 1.4a and the corresponding schematic in Fig. 1.4b. Note that only two of the three tags on the 100 ohm potentiometer and the switch are actually used. The remaining tag on each component is not connected to any other point. In each case the centre tag and one of the two outer tags is used.



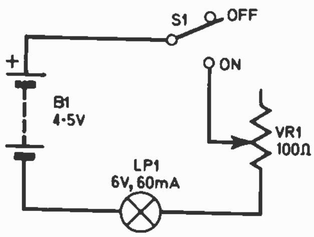


Fig. 1.4a (above). Basic layout on the Tutor Board for the first test.

Fig. 1.4b. Schematic diagram of Fig. 1.4a.

The relative position of the switch toggle for ON and OFF is dependent on which outer tag is used. Similarly for the potentiometer, the relative position of the spindle or knob for maximum and minimum resistance will depend on the choice of outer tag as before.

Observe the operation of these two components very carefully so that their action is fully understood. For example, the switch is ON when the toggle points towards the end tag actually in use. When the toggle points towards the unused end tag the switch is off. Work out a similar rule for the resistance of the 100 ohm potentiometer.

It is always desirable to check any circuit before connecting the battery or other power source and this habit is worth cultivating. If the bulb does not light it is most likely that a poor connection has been made.

The strands of wire should be twisted together and can be folded back to double the thickness when only one wire per hole is required in the terminal block. Do not overtighten the screws as this will fracture the strands very quickly. The terminal blocks can be used to join two or more wires, or wires and component leads, together. A few minutes practice will soon indicate the amount of screw pressure required.

When this first test has been completed, dismantle the Tutor Board wiring and proceed to Test No. 2. Never leave a battery connected to any circuit for longer than is necessary. Always move the switch to the OFF position when a circuit is not in use as this will ensure long life from the batteries.

Test No. 2

Set up the voltmeter circuit with the series 100 kilohm ± 2 per cent resistor and two test prods. Use a black lead for the meter negative terminal (marked −) and a red lead for the connection to the 100 kilohm resistor (refer to Fig. 1.5). Check the voltage of each battery, paying special attention to the correct polarity of the leads (red lead to battery positive terminal, black lead to battery negative terminal).

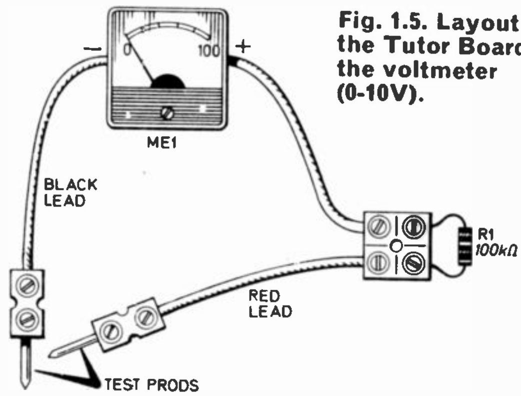


Fig. 1.5. Layout on the Tutor Board for the voltmeter (0-10V).

Mark each battery with the measured voltage. (Nominal voltage is 4·5V, but will be higher when the battery is first purchased.) Subsequent checks of battery voltage will show lower voltage readings as the battery becomes exhausted. Leave the voltmeter set up and proceed to next test.

Test No. 3

Devise your own Tutor Board layout and then set up the circuit shown schematically in Fig. 1.6. Operate the switch to the on position and set the 5 kilohm potentiometer (VR2) for maximum resistance using the principles covered in Test No. 1. Check for current flow by measuring the voltage across the 1 kilohm resistor. (Red lead to switch end of resistor. A zero reading indicates faulty circuit wiring or switch in wrong position).

Measure the voltage between the potentiometer end of the 1 kilohm resistor, furthest away from the switch, and the junction of the two batteries. (Black lead to the batteries.) A reading of about 3 volts should be obtained (30 on the meter scale). Whilst observing the meter adjust the 5 kilohm potentiometer until the meter reads zero. For equal battery voltages this occurs when the variable potentiometer resistance is equal to 1 kilohm.

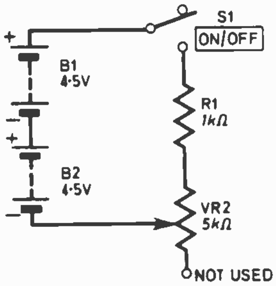


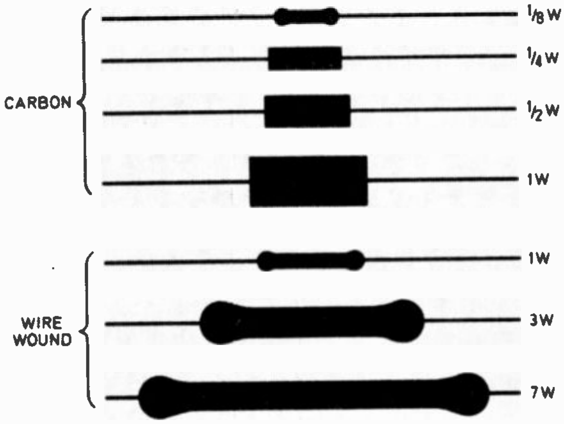
Fig. 1.6. Schematic diagram of the circuit used in test 2.

Without disturbing the potentiometer setting measure the voltage difference across the variable potentiometer and across the 1 kilohm resistor. These should be about equal if the battery voltages are similar. Switch off and dismantle all wiring. Replace the shorting lead across the meter terminals for protection.

Study the results of all tests and try to explain to your own satisfaction what is happening in each test, particularly Test No. 3. If you feel it will help you, try making a few notes about each test in a notebook. In particular try to work out what each test has taught you!

DATA CHART

The following information on resistor wattages was unfortunately omitted from the Data Chart enclosed in this issue.



Ruminations

By Sensor

Weather or Not

The holiday season will be almost over by the time this piece is published. But before we all take up our work again it is worth while recalling the part played by electronics in improving weather forecasting. Accurate forecasting depends upon the collection of an enormous amount of data from a very wide area, and the rapid processing of this data, together with a few facts and maybe some inspired guesses.

Electronics is involved in almost every aspect of weather forecasting but its greatest contribution has been the electronic computer. A prodigous quantity of data can be processed by the computer in a very short time and thus an up-to-date and accurate forecast can be made available, via radio or telephone, to all who may have need of it.

Unfortunately, little progress has been made in controlling the weather; gales, typhoons and hurricanes have no beneficial effects, and while it is very useful to know where and when they are likely to occur, we would be far better off without them! One can foresee that our cities may, in the future, have a controlled environment in a manner rather like that described by H. G. Wells in his book "The Sleeper Awakes." I suppose that it would only rain at night (only people up to no good, and policemen, are out at night!) and storms would be unknown.

Theoretically, there would seem to be no great problem in covering an entire city with a transparent dome and equipping the area with the necessary air conditioning plant, but the practical problems would be enormous. Modern electronics would find no difficulty in providing the sensing and control equipment for such a project, apart from the sheer size of such an undertaking.

Perhaps the inhabitants of such a city would read with wonder of the great freeze-up of 1963 or the floods of 1973. But there is some cosy satisfaction to be felt when indoors with the rain beating against the windows and the wind howling round the house. And what of the free firework display (son et lumiere) provided by a good thunderstorm?

I think that I prefer to take the weather as it comes; always provided that the weather forecasters can give me some idea of what to expect. If the weather were controlled what on earth would we talk about?

AUDIO Voltmeter

BY F.C.JUDD

Approximate cost of components including V.A.T.
£6·75 plus case

Measures a.c. voltages over a large frequency range—useful instrument for the audio enthusiast.

ONE of the most valuable test instruments for audio work is the Audio Voltmeter, so called because it will read alternating voltages over a wide range of frequencies and is sensitive enough to read very small audio signals of down to one millivolt or less. It is basically a bridge rectifier system, the rectifier being used to convert alternating voltage to d.c. in order to drive the meter movement.

To be able to read very small voltages, the bridge rectifier and meter is preceded by an amplifier. Wide frequency response is achieved by careful design of the amplifier section and by the use of negative feedback.

RANGES

The meter described in this article operates over five ranges as follows:

Range 1 0 to 10 millivolts (mV)
Range 2 0 to 100 millivolts
Range 3 0 to 1 volt
Range 4 0 to 10 volts
Range 5 0 to 100 volts

It has a high input impedance of approximately one megohm, which is essential to prevent the meter "loading" the circuit to which it is connected and so produce errors in reading. The meter has a wide, flat frequency response from 10Hz to over 100,000Hz (±1dB).

Some ways of using the meter will be explained later but before describing the circuit and construction, readers should note that although the circuit may not look too complicated, this project is not one for absolute beginners to tackle. Those who feel capable of building the instrument however, will, providing construction, specified components and wiring etc., are strictly adhered to, find it a worthwhile item of test gear and moreover one with reasonable accuracy.

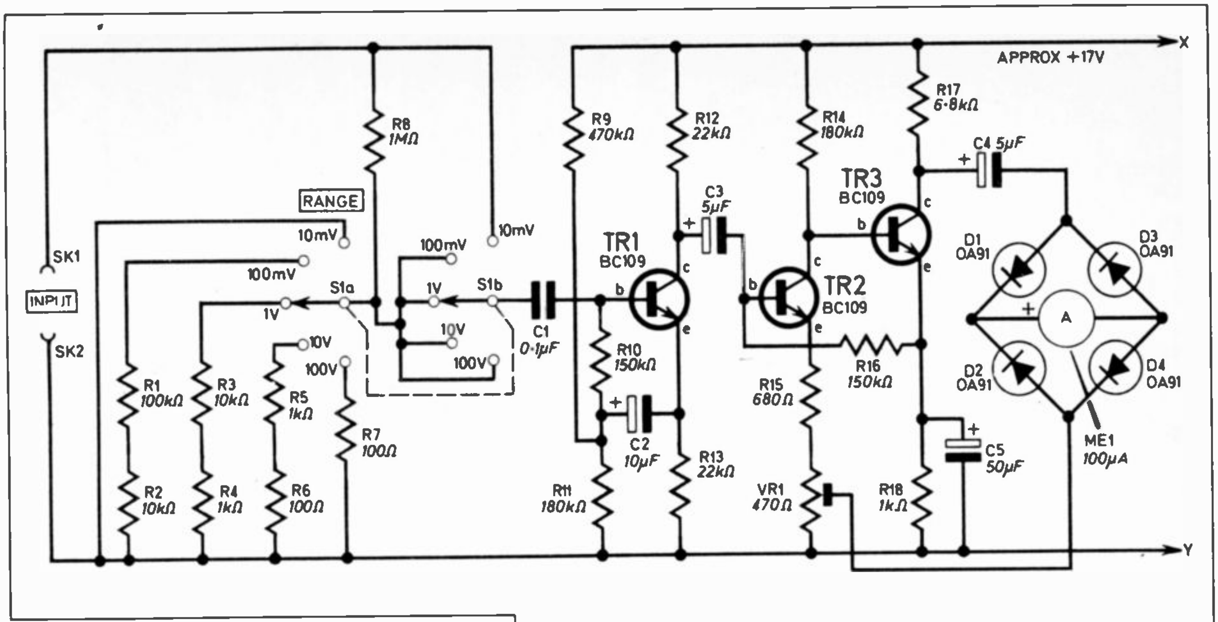
It can be used for measuring the signal level going into and out of a pre-amplifier, the gain of an amplifier, the output power from amplifiers designed to deliver power and of course for generally checking newly built audio equipment. One other instrument is required to do all this and that is an audio signal generator, which is also not difficult to construct and a possible subject for an E.E. project.

THE CIRCUIT

The Audio Voltmeter circuit is shown in Fig. 1 and reading as is usual in circuitry, from left to right, begins with the input, followed by the attenuator network which consists of S1a and S1b (ganged 5 way wafer switches) and resistors R1 to R8. The "impedance" of the network which is also the input impedance of the meter, is about one megohm and more or less determined by the main leg of the attenuator network R8.

In the 10mV, or most sensitive range, R8 is switched direct to earth so no attenuation occurs. For the 100mV range an attenuator factor of 10 is provided by R8 in series with R1 and R2. The 1V, 10V and 100V ranges are achieved in the same way but by attenuation factors of 100, 1,000, 10,000 and 100,000. The values of the network are not precise but do allow the use of standard value resistors and a readout accuracy from the meter of ±5 per cent which is about average for a low cost audio voltmeter.

The output from the attenuator is fed to TR1



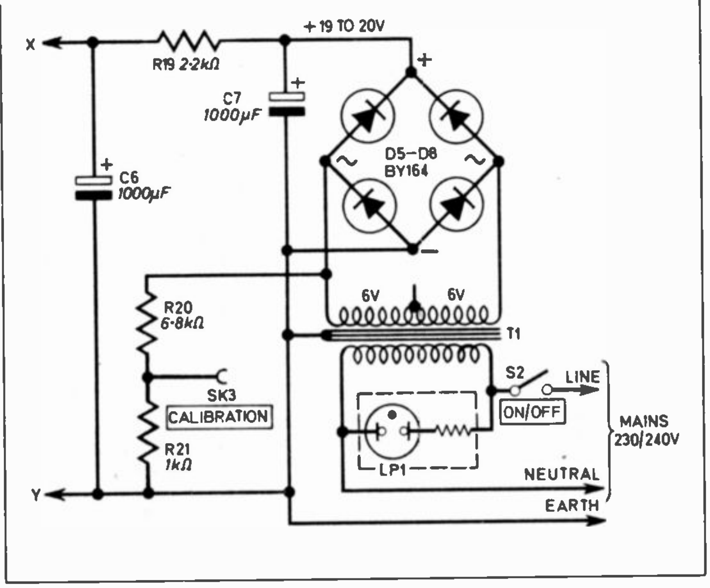


Fig. 1. The complete circuit diagram of the Audio Voltmeter with built in power supply.

which is a special amplifier stage with a high impedance input so as not to shunt the high impedance of the attenuator itself. Transistors TR2 and TR3 are a conventional signal amplifier to further boost the signal so that it will drive the meter via the bridge rectifier network consisting of D1, D2, D3 and D4.

In order to achieve a wide frequency response one arm of the bridge is coupled back to the emitter of TR2 via the preset potentiometer VR1. This not only provides negative feedback, and an aid to wide frequency response but also the means of "self-calibrating" the finished meter. This is why a portion of the 50Hz voltage from the secondary of the mains transformer T1 is tapped off from R20 and R21. This voltage is brought out to a socket on the front panel and is used in conjunction with VR1 to set the meter calibration. The amplitude of the 50Hz signal at the calibration socket (SK3) is 1V, give or take a few millivolts, but more of this later.

The remainder of the circuit is the power supply consisting of T1 which supplies 12V a.c. to the bridge rectifier (D5-D8) which, in turn feeds pulsating d.c. to the smoothing components C7, R19 and C6. The supply rail to the amplifier at the junction of C6/R19 should be about 17 volts.

CONSTRUCTION

The prototype shown in the photographs was built into a case measuring approximately 222 × 130 × 125 mm made from Lektrokit parts, however any similar sized metal case could be used but a **metal case it must be.**

The circuitry is assembled on plain Veroboard as in Fig. 2 and this is attached, when wired, to the front panel by means of small angle brackets (Fig. 3). The meter may be any good quality 100 micro-amp, moving coil type with the usual 90 degree scale calibrated in 10 divisions each sub-divided by 10 or 5.

The front panel layout is shown in Fig. 4, note that the input terminals (one red and one black) and calibration socket, are insulated from the panel. The black terminal (earth) is only earthed at the circuit board common negative/earth line; the metal case is also earthed to the common negative supply rail.

When the circuit wiring is completed check if possible the supply rail voltage at the junction of C6/R19. This should be approximately 17 volts. Short circuit the input terminals and switch to the 10mV range to ensure that the meter is reading zero.

Note: Immediately after switching on the meter will read for a moment or two and then drop back to zero. Allow a few seconds for it to settle before using.

If the range switch is left in the 10 or 100mV position and the short circuit from the input terminals removed, the meter will usually read because of 50Hz hum pickup. Remember at low millivolt ranges it is effectively a high gain amplifier with a response down to 10Hz.

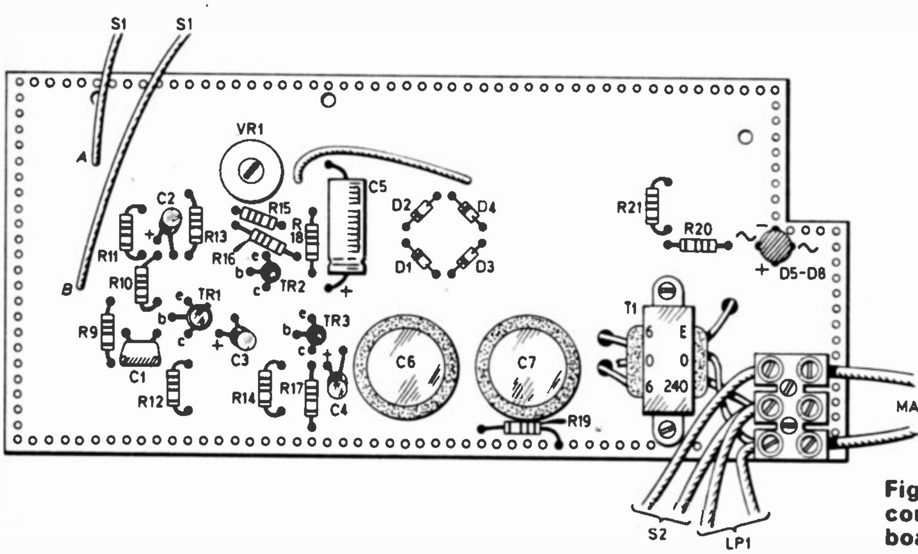
For calibration the meter and circuit must be out of the case so as to get at the pre-set VR1. Couple the calibration socket to the red or live input terminal and switch to the 1 volt range. Adjust VR1 until the pointer of the meter reads exactly full scale—10 on the meter or 1 volt. The meter is now calibrated and can be fitted into its case.

DECIBEL MEASUREMENT

Voltage (and current and power) can be expressed in decibels and it is usual to include a scale for decibels on audio voltmeters. This is useful when checking gain and/or plotting the frequency response of an amplifier. A full decibel scale, as normally found on audio voltmeters, is shown beneath the regular voltage scale in Fig. 4a.

With very large meter scales the full scale can usually be included but on small meters, such as the one specified for this project, it is better to use the part scale as in Fig. 4b otherwise the divisions are too cramped together at the higher or minus dB readings i.e., between −5 and −10dB. For practical purposes the +2dB down to −5dB scale with divisions of 1dB, is sufficient anyway.

The point of 0dB is based on 0·755 volts, the reference of which is a power of 1 milliwatt into 600 ohms. Normally the power level holds for any impedance but the voltage only for 600



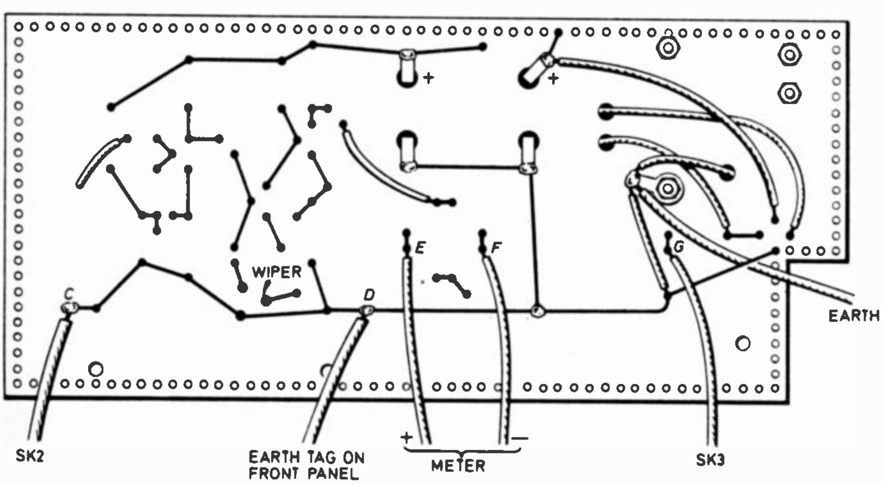


Fig. 2. The layout of the components on the Veroboard topside and the interconnection details below the board.

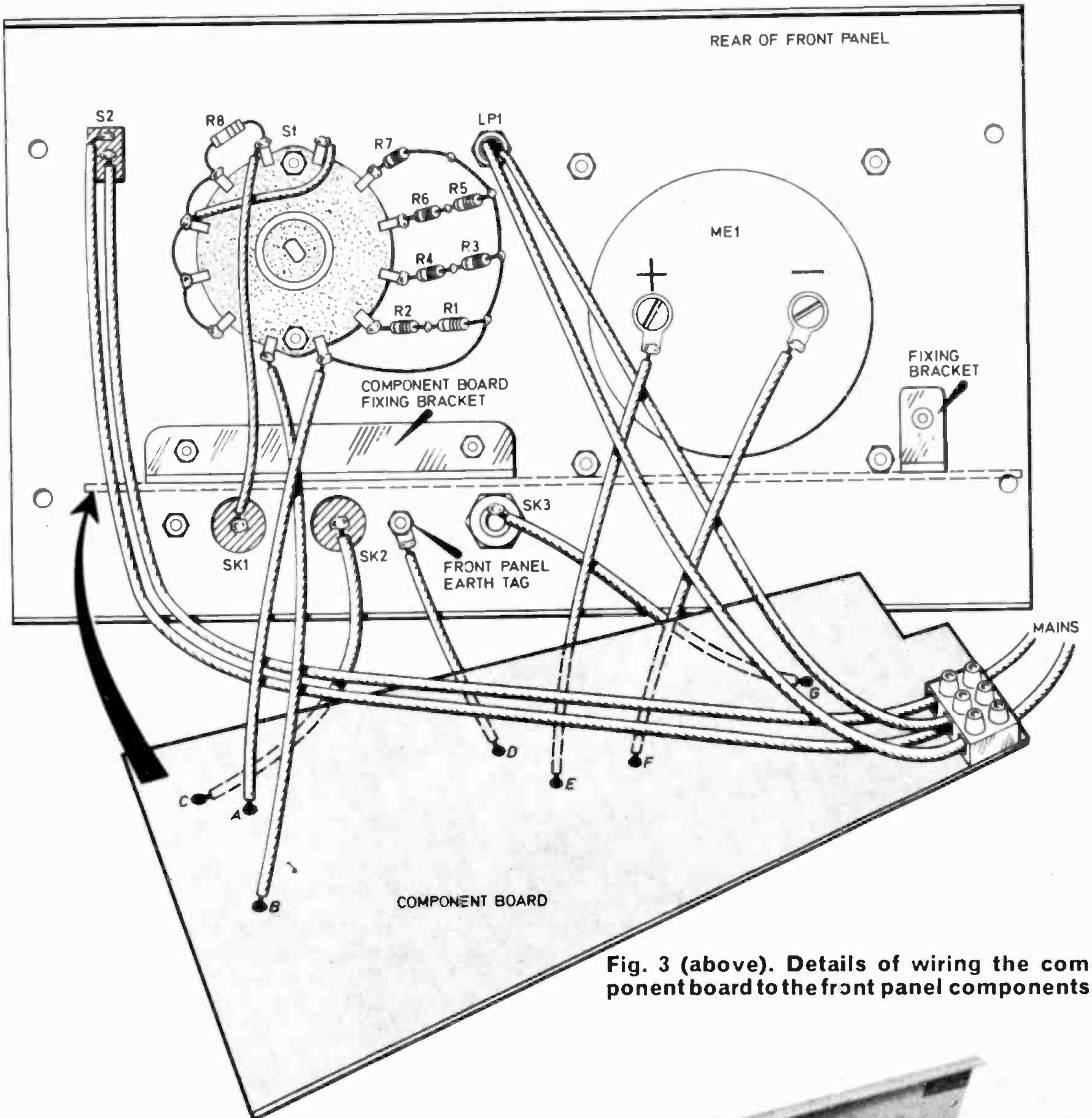


Fig. 3 (above). Details of wiring the component board to the front panel components.

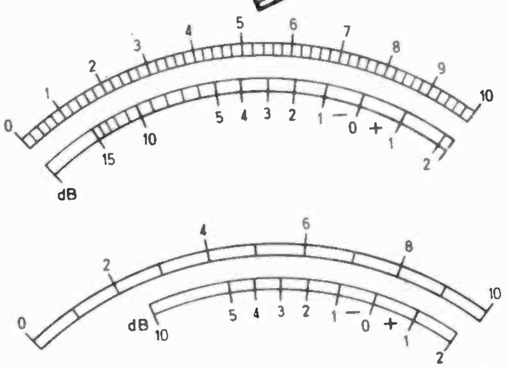
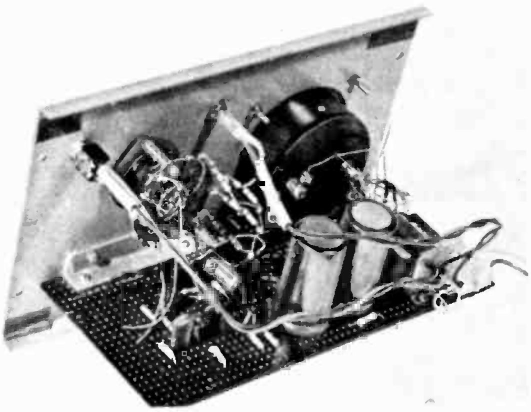


Fig. 4. Voltage and decibel scales for the unit, see text.



Photograph of coupled board and front panel.

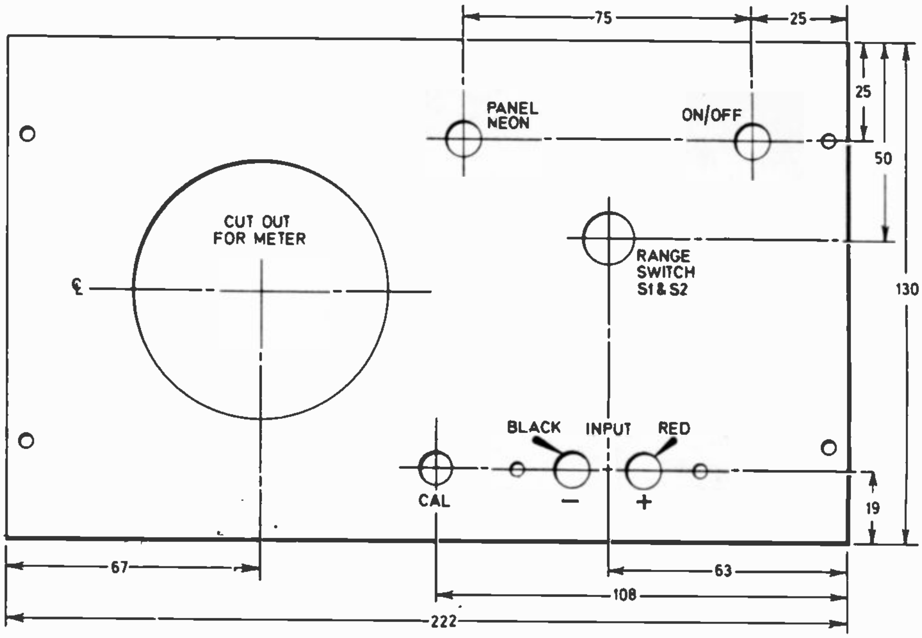


Fig. 4. Drilling and meter cut-out details for the front panel. The meter cut-out should be made to suit meter used.

Components....

SEE SHOP TALK

Resistors

R1	100kΩ	R8	1MΩ	R15	680Ω
R2	10kΩ	R9	470kΩ	R16	150kΩ
R3	10kΩ	R10	150kΩ	R17	6·8kΩ
R4	1kΩ	R11	180kΩ	R18	1kΩ
R5	1kΩ	R12	22kΩ	R19	2·2kΩ
R6	100Ω	R13	22kΩ	R20	6·8kΩ
R7	100Ω	R14	180kΩ	R21	1kΩ

All ¼W ±5% carbon

Capacitors

C1	0·1μF	C5	50μF elect. 15V
C2	10μFd elect. 15V	C6	1000μF elect. 25V
C3	5μF elect. 15V	C7	1000μF elect. 25V
C4	5μF elect. 15V		

Semiconductors

TR1, 2, 3 BC109 silicon *npn* (3 off)
D1, 2, 3, 4 OA91 or similar (4 off)
D5-D8 BY164 or any 50 p.i.v. 500mA bridge rectifier

Miscellaneous

SK1, 2 Single spring loaded terminals (one red one black) or terminal block (2 way)
SK3 Insulated panel socket
S1 Double pole 5 way wafer switch
S2 S.p.s.t. toggle switch
VR1 470Ω skeleton preset
ME1 100μA moving coil meter approx 3in square
T1 240V primary, 6-0-6V 100mA secondary (Eagle MT6 type)
LP1 Panel neon indicator incorporating dropper resistor.
Metal case approximately 222 x 130 x 125mm, knob for S1, plain perforated Veroboard 203 x 95mm x 0·15inch matrix, mains lead and 3 pin plug.

ohms. However, for practical use the dB scale can be used directly for determining gain or loss when dealing with voltage only and providing the impedance of the circuit at which the measurement is being made is not changed during the measurement.

For example, a signal amplifier may be delivering 0·775 volts, as read on the meter (which is 0dB). If the gain of the amplifier was increased by 2dB then the output voltage would be increased to 0·975.

In plotting the frequency response of an amplifier the signal level out is adjusted (by the volume control or input signal level) to read 0dB on the audio voltmeter. If the amplifier has a flat response from say 20 to 10,000Hz the meter will read 0dB over that frequency range. As the response falls away at either end of the flat part of the frequency range, so the meter readings fall accordingly and the amount in decibels by which it falls can be noted.

DECIBEL SCALE

Those who wish to put a decibel scale directly on the meter will have to remove the meter cover and then very carefully remove the scale plate itself. The scale can now be drawn with Indian ink (a compass and fine nib pen will be required) and the dB figures marked as shown in Fig. 4b.

The prototype was checked against a high grade laboratory audio voltmeter and accuracy was found to be within ±5 per cent on any range.

SEMICONDUCTORS

FIVE THE TRANSISTOR

J.B. DANCE M.Sc.

This month's article in the Semiconductor series continues with transistor types and explains the manufacture of planar devices; also discussed are types of encapsulation.

ALLOY JUNCTION GERMANIUM POWER TRANSISTORS

Power transistors must be able to dissipate the heat generated in their collector, so the small types of construction discussed previously are unsuitable. The collector must be in good thermal contact with the external metal base of the device.

This external base must be designed so that it can be bolted onto a piece of metal which serves to dissipate the heat. The transistor is kept cooler if the metal is blackened, since black surfaces radiate more heat than bright surfaces for the same temperature difference.

A thin mica washer may be placed between the transistor and the heat sink, although this washer will inevitably result in a slight increase in the working temperature of the transistor.

It is best to coat the mounting base of the transistor (and the mica washer, if used) with silicon grease so that good thermal contact is established. Special silicon compounds which conduct heat better than ordinary silicon grease are available and can be used with advantage.

The construction of a typical germanium alloy junction transistor is shown in Fig. 5.1.

The OC35 is a typical general purpose transistor of this type. It can dissipate 30W if the mounting base of the transistor is kept at a temperature of not more than 45°C.

The V_{ceo} rating is 48V at collector currents of up to 0·5A and 32V at collector currents up to 6A. The value of h_{fe} is in the range 25 to 75 at 1A.

The OC36 is a high voltage version of the OC35, whilst the OC29 is a higher gain type (with an h_{fe} of 45 to 130 at 1A). All of these transistors have a cut off frequency of around 250kHz.

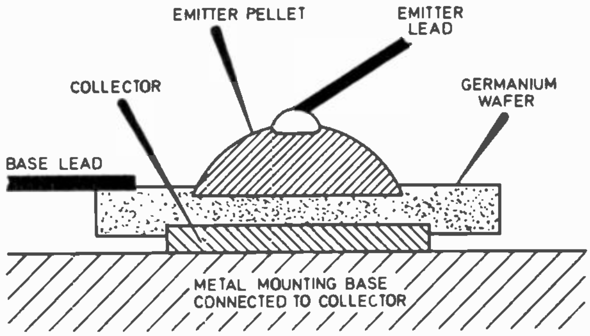


Fig. 5.1. The construction of a typical germanium alloy junction power transistor.

The OC22 to OC24 range has a higher cut off frequency (2·0 to 2·5MHz), but the power dissipation must be limited to 15W.

All of these transistors have a diamond shaped base of the TO-3 type shown in Fig. 5.2.

No similar *npn* germanium power transistors are generally available.

Table 5.1: Germanium PNP Power Transistors

Device	V_{cbo} (V)	V_{ceo} (V)	$I_{c\,max}$ (A)	$P_{t\,max}$ (W)	h_{fe}	f_T (MHz)	Application
OC20	−100	−75	8·0	30	25–75	0·25	High Voltage
OC22	−47	−24	1·0	15	150	2·0	General purpose, high frequency
OC23	−55	−24	1·0	15	150	2·5	Power Switch
OC24	−40	−24	1·0	15	150	2·5	Power Switch
OC25	−40	−40	4·0	22·5	15–80	0·25	General purpose power transistor
OC28	−80	−60	8·0	30	20–55	0·25	High voltage, especially suitable for d.c. converter
OC29	−60	−32	8·0	30	45–130	0·25	High gain power transistor
OC35	−60	−32	8·0	30	25–75	0·25	General purpose power transistor
OC36	−80	−32	8·0	30	30–110	0·25	High voltage power transistor

Table 5.2: PNP Silicon Alloy Junction Transistors

Device	V_{cbo} (V)	V_{ebo} (V)	$P_{t\,max}$ (MW)	h_{fe}	f_T (MHz)	Remarks
OC200	−25	−25	100	20	1·0	Low gain
OC201	−25	−25	100	30	4·0	
OC202	−15	−15	100	70	4·0	Medium gain
OC203	−60	−60	100	15	1·0	High voltage
OC204	−32	−32	125	24	1·5	Medium voltage
OC205	−60	−60	125	24	1·5	High voltage
OC206	−32	−24	125	40	2·0	
BCZ11	−30	−25	100	25–60	1·5	

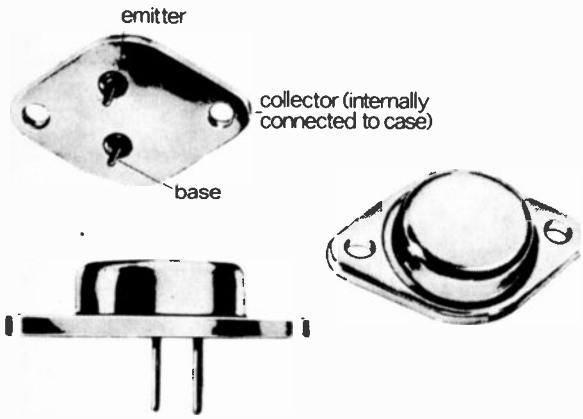


Fig. 5.2. The TO-3 encapsulation showing lead-out details.

SILICON ALLOY JUNCTION TYPES

The early silicon transistors were made by an alloy junction technique similar to that used for manufacturing germanium transistors.

These techniques resulted in the production of transistors such as the OC200 to OC206 which are a *pnp* series with cut off frequencies in the range 1 to 4MHz and values of h_{fe} in the range 20 (for the OC200) to 70 (for the OC202).

The V_{ceo} rating varies from −15V for the OC202 to −60V for the OC203 and OC206. The BCZ11 is another transistor of this type.

This range of tranistors is encapsulated in the small metal envelope of Fig. 4.7 (last month) with a red spot near the collector.

SILICON PLANAR DEVICES

The silicon planar process has made possible the mass production of the very high performance transistors which are available today.

The present trend is for silicon planar devices to displace most of the earlier germanium devices in almost all applications.

The planar process cannot be used to produce germanium devices, although it can be employed to manufacture other silicon devices, such as diodes.

The diagrams of Fig. 5.3 show some of the processes involved in the manufacture of a silicon planar *npn* transistor.

An *n*-type slice of silicon of about 2·5 cm diameter is heated in oxygen so that a layer of silicon oxide is formed all over it. A drop of photosensitive material is placed on top of the slice and the latter is spun so that the photosensitive material forms an even layer of the desired thickness.

The slice is then covered by a "base mask", which is a photographic negative containing a pattern, the opaque parts of which are in the positions of the bases of the hundreds or thousands of transistors which are to be made from the silicon slice.

The slice is then put under an ultra-violet light. The parts of the photosensitive material which receive the radiation are hardened and become fixed in position, but the other parts are easily washed away.

The slices are treated with acid which removes the oxide layer at the points where the photosensitive layer has been washed away.

Each of the positions in the silicon slice where a transistor is to be formed now has the type of cross section shown in Fig. 5.3b.

After cleaning, the slice is treated with a *p*-type material and heated so that the latter diffuses to the required depth. An oxide layer is then formed over the whole surface. The cross section of a single part of the disc is now as in Fig. 5.3c.

A photosensitive material is then used with a new mask (the emitter mask) and holes in the oxide layer are formed in positions which are to be treated with an *n*-type impurity (Fig. 5.3d).

Afterwards an *n*-type material is allowed to diffuse in to form the emitter and an oxide layer is formed over the whole surface (Fig. 5.3e).

CONTACTS

A further photosensitive layer is applied and a mask used to produce gaps in the oxide layer over the small parts of the base and emitter where the contacts can be fitted (Fig. 5.3f). A thin layer of aluminium is then deposited over the whole surface and, by means of a fourth mask, the aluminium is removed from all parts except where it is required to form the base

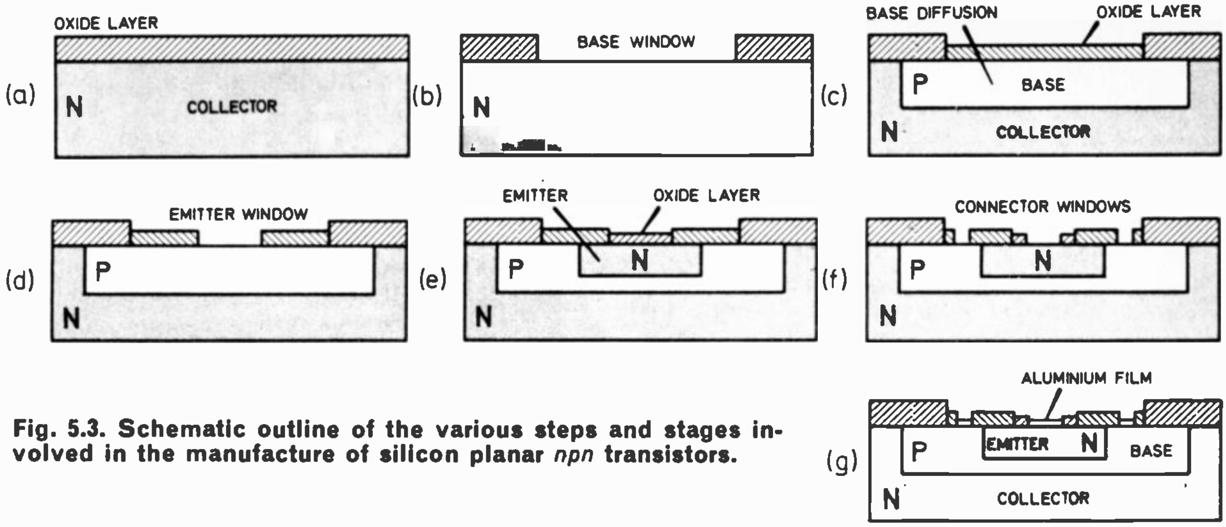


Fig. 5.3. Schematic outline of the various steps and stages involved in the manufacture of silicon planar *npn* transistors.

and emitter contacts.

Each transistor now has the general form shown in Fig. 5·3g.

The transistors on each slice are now briefly tested, separated, and the good ones encapsulated. Finally each device is thoroughly tested.

The manufacture of silicon planar *pnp* transistors is very similar. In expitaxial planar transistor manufacture, a lightly doped thin layer of silicon is used on a more heavily doped substrate. The transistor is formed within the thin layer.

LOW CURRENT PLANAR TYPES

Low current transistors operating with collector currents (I_c) of 1mA or less, are used in low level circuits where one may require a low noise transistor.

Typical *npn* transistors of this type are the BC107 (V_{ceo}=45V), the BC108 (V_{ceo}=20V), and the low noise BC109.

Electrically equivalent types in an epoxy encapsulation are the BC147, BC148 and BC149.

The 2N929 and the higher gain, low noise 2N930 are similar *npn* types (V_{ceo}=45V). Another similar type is the 2N2483 and the higher gain 2N2484 (minimum value of h_{fe}=250 at I_c=1mA) which have V_{ceo} equal to 60V and which may be used at values of I_c as low as 1μA.

In the S.G.S. range, one may mention the epoxy encapsulated C450 and the BFY76 and BFY77. Other *npn* types are the 2S501 to 2S503

Table 5.3: Low Level Silicon Planar Transistors

Device	V_{cbo} (V)	V_{ebo} (V)	$I_{c\ max}$ (mA)	$P_{t\ max}$ (mW)	h_{fe}	f_T (MHz)	Remarks
npn							
BC107	50	45	100	300	125–500	300	TO-18
BC108	30	20	100	300	125–500	300	TO-18
BC109	30	20	100	300	240–900	300	Low noise, TO-18
BC147	50	45	100	220	125–500	300	Lockfit
BC148	30	20	100	220	125–500	300	Lockfit
BC149	30	20	100	220	125–500	300	Low noise, Lockfit
2N929	45	45	30	300	100–350	50	TO-18
2N930	45	45	30	300	200–600	50	Low noise, TO-18
2N2483	60	60	—	360	>175	60	High voltage, TO-18
2N2484	60	60	—	360	>250	60	Low noise, high voltage, TO-18
BC184L	45	30	200	300	>250	150	Silect
pnp							
BC157	−50	−45	100	220	75–260	130	Lockfit
BC158	−30	−25	100	220	75–260	130	Lockfit
BC159	−25	−20	100	220	125–500	130	Low noise, Lockfit
BFX37	−60	−60	50	360	70–300	40	High voltage, Low noise, TO-18
2N2604	−60	−45	30	400	40–120	30	High voltage, TO-46
2N2605	−60	−45	30	400	100–130	30	High voltage, Low noise, TO-46

(Texas) and the ZTX114 "E line" Ferranti type.

Similar types of low current high gain *pnp* transistors are available. For example, the Texas 2N2605, the Mullard BC157 to BC159 series and the BFX37.

MEDIUM CURRENT PLANAR TYPES

The number of planar transistors for use in the 10 - 200mA range is very numerous and most designers choose from a few types with which they are especially familiar.

Common examples of such transistors are the economical types 2N2926 (International General Electric) and the ZTX300 (Ferranti) in epoxy encapsulation, whilst amongst the metal cased types there are C111E (S.G.S.), the 2N696, 2N697, 2N1613, 2N1711, 2N3053, etc.

Most of these have f_T values around 50MHz, but one may select one of the 2N2217 to 2N2219 series if one requires a 250MHz f_T. The BFY50 to BFY53 series offer a higher value of I_c (1A) than most of the other small types.

In the *pnp* medium current types, one may use the 2N1131 or 2N1132 which have an f_T around 50MHz.

The common 2N2904 to 2N2907A series offer an f_T value of 200MHz and are rather similar in performance to the 2N2217 *npn* series.

Of the epoxy encapsulated *pnp* types, one may mention the 2N3702/2N3703 with an f_T of 100MHz.

HIGH FREQUENCY TYPES

Various silicon planar transistors are available for the u.h.f. region. One of the best known is the BFY90 (minimum f_T=1000MHz). Other *npn* types are the 2N3570 (minimum f_T= 1500MHz) and the S.G.S. BFY78.

The 2N3662/2N3663 (Int. Gen. Electric) are examples of transistors designed for u.h.f. tuners, whilst the Mullard BF200 (f_T=270MHz) is intended for use in v.h.f. tuners.

Various *pnp* high frequency amplifiers are available, but their operating frequency is not normally quite so high as some of the *npn* types. An example is the BFX48 (S.G.S.).

HIGH VOLTAGE

In some applications a transistor capable of controlling a high voltage is required; for example, in the control of neon filled numerical indicator tubes.

The S.G.S. *npn* type C407 is one of the best known (with a V_{ceo} rating of 120V). The ZTX341 and ZTX342 (Ferranti) have V_{ceo} ratings of 100 and 120V respectively and are also intended for driving numerical indicator tubes.

The S.G.S. V765 is a *pnp* type with a 120V V_{ceo} rating.

SWITCHING

Many of the transistors aleady mentioned (both silicon and germanium types) are also used for switching applications. In particular, the *npn* 2N2217 series and the *pnp* 2N2904 series are, widely used for medium current switching.

However, many silicon transistors especially designed for switching applications are now available. Some of the best known are the *npn* 2N706 and 2N708 for moderate speeds and the 2N709 for very fast switching.

The TIS45 (Texas) is similar to the 2N708, but is in a plastic encapsulation. Another fast general purpose switch is the S.G.S. type P346A.

Special types of ultra fast switch, such as the Motorola 2N3960 with f_T=1800MHz, are available, but lie outside the scope of this article.

Table 5.4: Medium Current Silicon Planar Transistors

Device	V_{cbo} (V)	V_{ebo} (V)	I_{cmax} (mA)	$P_{t\ max}$ (mW)	h_{fe}	f_T (MHz)	Encapsulation
npn							
BFY50	80	35	1000	800	>30	60	TO-5
BFY51	60	30	1000	800	>40	50	TO-5
BFY52	40	20	1000	800	>60	50	TO-5
2N696	60	40	—	600	20–60	40	TO-5
2N697	60	40	—	600	120–150	40	TO-5
2N1613	75	30	—	800	40–120	60	TO-5
2N1711	75	30	—	800	100–300	70	TO-5
2N2217	60	30	800	800	20–60	250	TO-5
2N2218	60	30	800	800	40–120	250	TO-5
2N2219	60	30	800	800	100–300	250	TO-5
2N2219A	75	40	800	800	100–300	300	TO-5
2N3053	60	40	700	5000	50–250	100	TO-5
pnp							
2N1131	−50	−35	600	600	20–45	50	TO-5
2N1132	−50	−35	600	600	90–150	60	TO-5
2N2904	−60	−40	600	600	40–120	200	TO-5
2N2905	−60	−40	600	600	100–300	200	TO-5
2N2905A	−60	−60	600	600	100–300	200	TO-5

ENCAPSULATION

Silicon planar transistors are available in quite a number of types of encapsulation.

A very common encapsulation for both silicon and germanium transistors is the TO-5 type shown in Fig. 5.4. The diameter of the main part of the metal body of the device is about 8·15 mm. One of the electrodes (normally the collector) is often internally connected to the metal body.

Another very common form of encapsulation for small transistors is known as the TO-18 type.

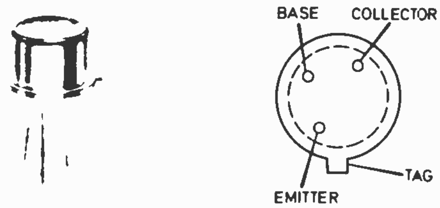


Fig. 5.4. Details of the TO-5 type encapsulation.

This is a metal encapsulation of the same form as the TO-5, but considerably smaller, the diameter of the main part of the body being about 4·8 mm.

The connections are almost invariably as shown in Fig. 5.4, but other devices (such as field effect transistors) are produced in the same types of encapsulation. Some types of electrically similar transistors are available in both the TO-5 and TO-18 types of encapsulation, but the maximum permissible dissipation of the TO-5 type is usually about double that of the TO-18 type.

A further variation of the TO-18 type is the TO-72 encapsulation in which a fourth lead (often connected to the metal case of the device) is present so that the four leads of the base are at the corners of a square. The TO-46 is even smaller than the TO-18, but has the same general type of base connections.

PLASTIC TYPES

A number of the manufacturers have developed their own type of epoxy (black plastic) encapsulation.

The S.G.S. and Fairchild companies employ epoxy forms which are somewhat similar to the TO-18 and TO-5 types, but the top is rounded off. The base connections are similar to the metal types.

Texas Instruments employ a form called "Silect" in many economical devices. This form, shown in Fig. 5.5a, is also used for field effect transistors.

The Ferranti 'E-line' is shown in Fig. 5.5c, whilst the International General Electric epoxy encapsulation is shown in Fig 5.5b.

HIGH POWER SILICON TYPES

The most commonly used high power silicon transistor is almost certainly the *npn* 2N3055. This can dissipate up to 115W, has a minimum f_T of 1MHz and a current gain of 20 to 70 at $I_c = 4A$.

In general its ratings are well above those of germanium power transistors, since the silicon material can operate at a much higher temperature. The encapsulation is as shown in Fig. 5.2.

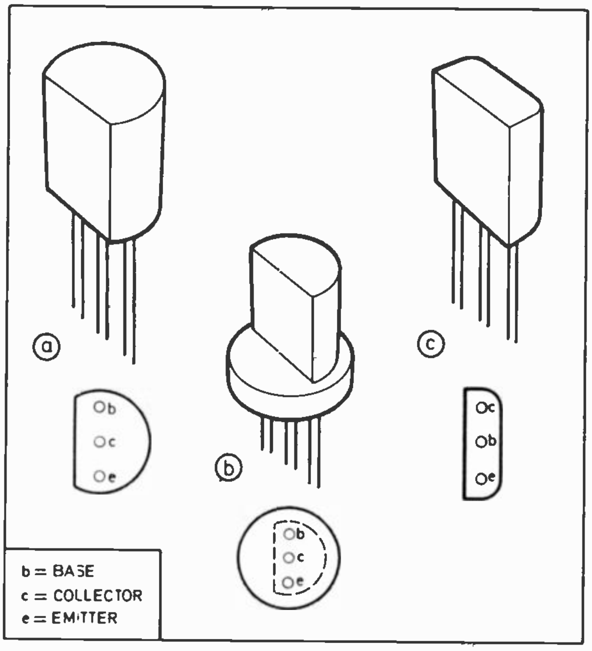


Fig. 5.5. Various common found types of encapsulation.

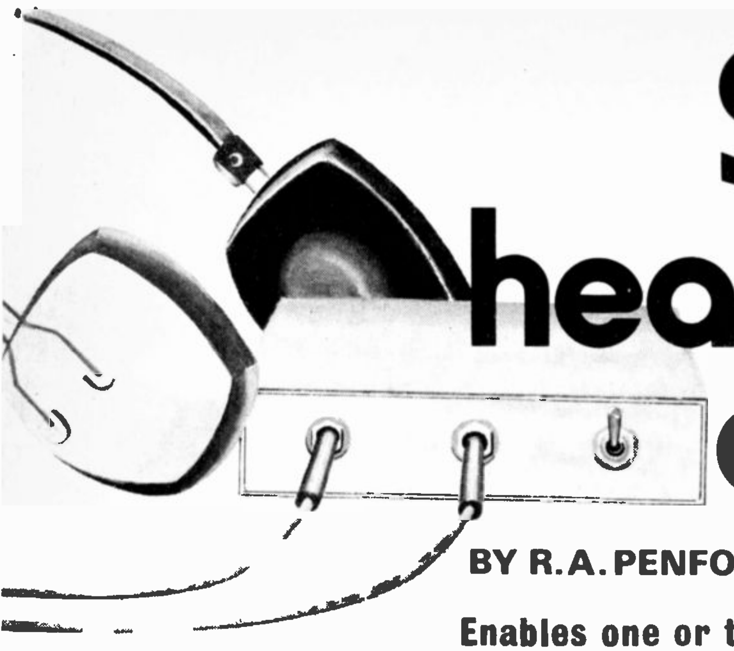
For some purposes the *npn* RCA type 40250 is suitable. This is in a smaller case (known as TO-66) which also has a "diamond" shape. The maximum dissipation is 29W and it is cheaper than the 2N3055. Another *npn* type is the 2N3054 which has a 25W maximum dissipation.

Various *npn* planar high power transistors are available, such as the Mullard BD121 (45W, $f_T = 95$MHz) and the BD123 (45W, $f_T = 85$MHz, $V_{ceo} = 60$V) and the S.G.S. BD117 which is intended for high power audio amplifiers.

The number of *pnp* high power transistors is more limited than that of the *npn* types, but they find application in power amplifiers in conjunction with *npn* types.

Special power transistors are available for use at radio frequencies.

Next Month: Testing transistors.



Stereo headphone adaptor

BY R.A.PENFOLD

Enables one or two sets of stereo headphones to be used with an amplifier.

DESPITE the popularity of stereo headphones, a large number of stereo amplifiers, and record players, have no provision for using headphones. It is, however, a simple matter to construct an adaptor to enable the use of headphones.

SENSITIVITY

It is not really practical to connect the phones straight across the speaker terminals, as the sensitivity of a pair of headphones is of course much greater than that of a pair of speakers. It would therefore be necessary to have the volume control set almost at minimum.

This results in excessive hum, and noise, as the general noise level of an amplifier is usually expressed as *minus* a certain number of dB compared with the maximum output of the amplifier. This could be for example, −60dB, which means that the noise level is one thousandth of the level of the full output of the amplifier.

When using speakers the amplifier would be used at something approaching full output, and a noise level as low as this would be virtually inaudible. If headphones were in use, the output from the amplifier would, in all probability, never be more than say, one hundredth of the maximum output of the amplifier. This means that the required signal at its peak would only be ten times stronger than the noise level, and this would obviously be very unsatisfactory.

Also, due to crossover distortion, some amplifiers have a lower output quality at low output levels, than they do at higher output levels. This would be the result when headphones were in use.

ATTENUATOR

In order to enable headphones to be used with the volume control set higher, an attenuator is required. The circuit of a simple attenuator is shown in Fig. 1.

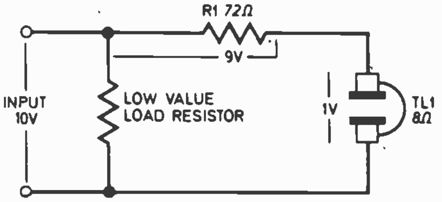


Fig. 1. The circuit of a simple attenuator to explain the theory used in the prototype.

The load resistor is *not* part of the attenuator, but forms a suitable low impedance load for the amplifier. The 72 ohm resistor, R1, and the headphone itself form the attenuator.

The input voltage from the amplifier (10 volts in this example) will be shared across the resistor and the headphone in proportion to their resistance. In this case they have a total resistance of 80 ohms (72 ohms + 8 ohms in series).

The headphone constitutes one tenth of this resistance, and will have one tenth of the input

Approximate cost of components including V.A.T.

£1·85 plus case

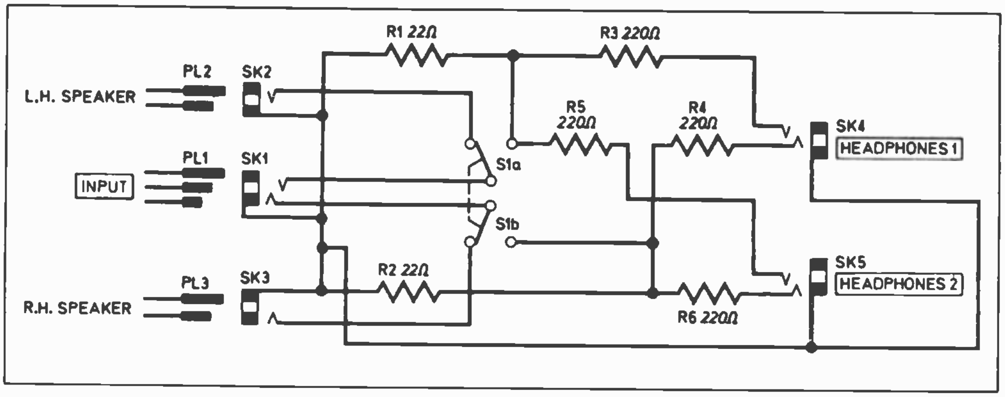


Fig. 2. The complete circuit diagram of the Stereo Headphone Adaptor.

voltage across it, the other nine tenths appearing across the 72 ohm resistor. The simple formula for calculating the attenuation factor of a circuit such as this is $(R1 + R_{TL1})/R_{TL1}$. Thus in the circuit of Fig. 1 we have an attenuation factor = $(72 + 8)/8 = 10$.

Using this circuit, the headphone has only one tenth of the sensitivity it would have without it, and would therefore require ten times the output voltage from the amplifier. This would result in the noise level being reduced by a factor of ten.

PRACTICAL CIRCUIT

The complete circuit diagram of the Stereo Headphone Adaptor is shown in Fig. 2. The input to the adaptor (from the speaker outlets of the amplifier) is through SK1, a stereo jack socket, which is connected to the double-pole two-way switch S1. The latter enables the headphones to be used (via the attenuator) in one position, and the loudspeakers in the other via SK2 and SK3, the output sockets to the loudspeakers.

The unit can therefore drive one, or two pairs of headphones, or can be switched for ordinary loudspeaker use.

Resistors R3, R4, R5, and R6 are the attenuator resistors, two for each pair of headphones (one for each earphone). If only one pair of headphones are likely to be used, SK5, R5, and R6 can be omitted; resistors R1, and R2 are the load resistors.

As the circuit stands it is suitable for use with almost any modern *transformerless* amplifier, as these work well with a wide variety of output impedances, and the value of the load resistors is therefore not too critical. With the values shown two to four watts will be developed across R1, and R2 at normal listening levels. With the majority of amplifiers, distortion is at its lowest at around this output level, and a good low noise level is obtained.

CONSTRUCTION

The prototype unit was constructed in an aluminium case, see Fig. 3, and straightforward point to point wiring as employed as shown in Fig. 4.

First of all make the metal case as shown in Fig. 3 and make the cut-outs for the various sockets and switch. With this done fit the latter in position on the lid is indicated.

The wiring up of the components should be somewhat easier if it is carried out in the following order:

(1) Connect and solder the leads from the speaker sockets SK1 and SK2 using sleeved wire.

(2) Using stout tinned copper wire connect and solder together all the earth terminals on the sockets.

(3) With sleeved wire connect and solder the two leads from SK1 to S1.

(4) Wire in R1 and R2 followed by R3, R4, R5, and R6.

Thoroughly check out the wiring, and when satisfied that it is correct the case may be fixed together and the sockets and switch positions marked, with Letraset for example, so they may be identified.

A double length of twin cable is required to connect the unit to the amplifier or record player with which it is to be used; the length of the wire will depend on the relative positions of the unit and amplifier.

This lead should have, at one end, two suitable plugs which connect into the amplifier loudspeaker sockets, and a stereo jack plug at the other end, Fig. 5.

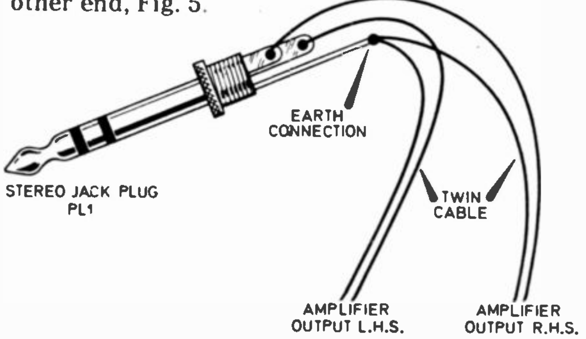


Fig. 5. Wiring details of the input jack plug, PL1.

Stereo headphone adaptor

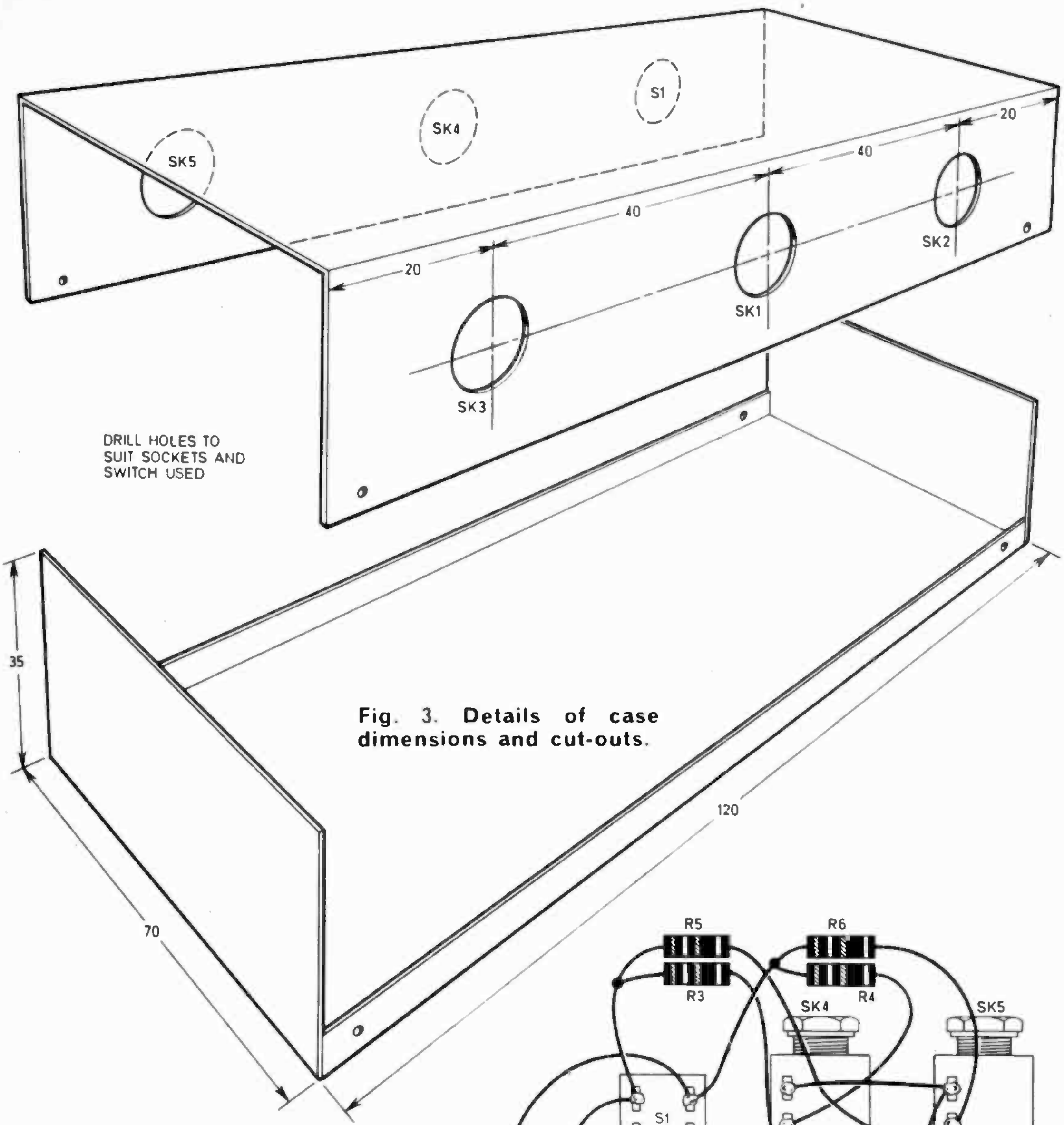


Fig. 3. Details of case dimensions and cut-outs.

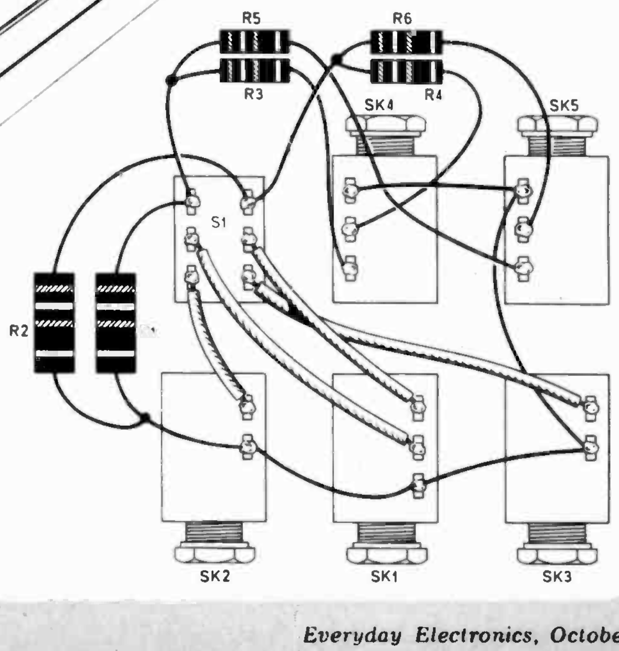


Fig. 4. The complete wiring up details for the unit. All sockets and switch are mounted on the lid of case before commencing wiring up.

Components....

Resistors

R1 22Ω 5W
R2 22Ω 5W
R3 220Ω
R4 220Ω ¼ watt carbon
R5 220Ω +10%
R6 220Ω

SEE SHOP TALK

Sockets

SK1 stereo jack socket
SK2 standard jack socket
SK3 standard jack socket
SK4 stereo jack socket
SK5 stereo jack socket

Miscellaneous

PL1 stereo jack plug
PL2 standard jack plug
PL3 standard jack plug
S1 Double-pole double-throw toggle; Small metal case (see text); stout copper wire; insulated wire; length of twin cable.

MODIFICATIONS

Sensitivities of different makes, and models of headphones do tend to vary slightly. If when the unit is in use it is found to be impossible to obtain sufficient volume, or R1, and R2 are found to be overheating (these are intended to operate at quite high temperatures, but should not seriously discolour, or smoke), R3, R4, R5, and R6 should be reduced in value, to about 82 ohms.

If the unit is to be used with an amplifier which uses an output transformer, it will be necessary to alter the values of all the resistors. Table 1 gives suitable resistor values for use with this type of amplifier, for the usual output impedances quoted by manufacturers.

Table 1: Component changes necessary when using an amplifier with transformer output.

Speaker Impedance (ohms)	R1, R2 (ohms)	R3 to R6 (ohms)	R3 to R6 (ohms)
3	3·3 5W	68	33
8	10 5W	100	47
15	18 5W	150	68

Note: the final column with values for R3 to R6 is for use with low sensitivity headphones.

As in the standard circuit, it is possible that R1 and R2 may overheat, or there will be a lack of volume. Thus in the table, suitable values for R3-R6 are shown in the last column for this eventuality.

Should there be any doubt as to whether or not the amplifier is a transformerless type or not, this can be ascertained by tracing back the speaker leads from the output sockets to see if these emanate from a transformer. If the amplifier is a valve type, it will certainly use an output transformer.

IN USE

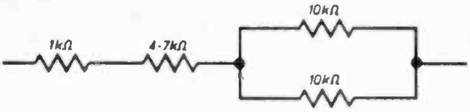
The Stereo Headphone Adaptor has been designed to be situated by the listeners armchair so that a set of headphones (or two sets) may be conveniently switched in without the listener needing to stir from his armchair whilst transferring from speakers to headphones.

What do you know?

RESISTORS

(1) There are two well known formulae for calculating the total resistance of a number of resistors in (a) parallel (b) series, can you write these down?

(2) Calculate the total resistance of the following network.



(3) (a) State Ohm's law and write down the equation relating voltage, current and resistance. (b) What current will flow in a 100 ohm resistor connected across a 6V battery? (c) the power in watts (P) is related to voltage (V) and current (I) by the equation P = VI. Calculate the power dissipated in the resistor in (b). What wattage resistor would you use?.

ANSWERS

(1) (a) $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots + \ldots$

(b) $R_T = R_1 + R_2 + R_3 + \ldots + \ldots$

(2) The two resistors in parallel yield a total resistance of 5 kilohm; this is in series with the other two giving a total resistance of (1 + 4·7 + 5) kilohms which equals 10·7 kilohms.

(3) (a) Ohm's law states that the current (I) flowing in a circuit is directly proportional to the voltage (V) across the circuit; V = I × R, where R is the circuit resistance.

(b) Using Ohm's law, $I = \frac{6}{100} = 0{\cdot}06A = 60mA$.

(c) P = (6 × 0·06) watts = 0·36 watts. You would use the nearest standard value *above* this, i.e. ½ watt.

DOWN TO EARTH

By GEORGE HYLTON

"My amplifier has an input resistance of 20 kilohms and is fully loaded by an input of 5 millivolts r.m.s. I wish to use a crystal pickup with it. The manufacturers' data for the pickup says that it is correctly matched and equalised when it is loaded with 100 kilohms. The output is given as 100 millivolts peak. How can I adapt the pickup to the amplifier?"

This problem really has two parts. First, the amplifier's input-signal requirement is given in *r.m.s.* (root mean square) millivolts, while the pickup output is in *peak* millivolts. These are not directly comparable. Secondly, there is the real problem of whether the pickup can be matched to the amplifier.

The required amplifier input voltage (for full output) is 5 millivolts r.m.s., and it can be taken that this specification refers to sine-wave signals. In this case, the peak voltage is about 1·4 times the r.m.s. voltage, so 5 millivolts r.m.s. corresponds to 7 millivolts peak. From now on we'll work in peak voltages and forget the r.m.s. ones.

THE MATCHING PROBLEM

We have to make sure that whatever matching arrangement we make doesn't reduce the voltage at the amplifier input terminals to less than the 7 millivolts needed for full output. At the same time the pickup must "see" a load of 100 kilohms.

The simplest possible arrangement is shown in Fig. 1. Here a resistance R_s is put in series with the input impedance R_i of the amplifier. To match the pickup, (R_s+R_i) must total 100 kilohms. Since R_i is 20 kilohms, it follows that R_s must be 80 kilohms. (In practice it would be all right to use the nearest standard value, 82 kilohms, since the matching isn't very critical in this sort of circuit).

The question is, will adding 80 kilohm, which must absorb some of the output of the pickup, leave at least the required 7 millivolts at the amplifier input?

In Fig. 1, R_s and R_i form a potential divider. Since R_s is four times R_i it must absorb four times as much voltage as R_i. In other words, four-fifths of the pickup voltage is wasted in R_s and the remaining one-fifth appears at the amplifier input. So the amplifier gets one-fifth of 100 millivolts, or 20 millivolts, which is comfortably greater than the required 7 millivolts but not so enormous as to overload the input stage of the amplifier (most amplifier inputs are designed to accept a 20dB overload, and in the present case the overload is roughly 10dB, which is the decibel equivalent of a threefold increase in voltage).

In this case, then, the simple matching arrangement works well. Unfortunately, it is not possible to match any pickup (or other signal source) to any amplifier in this way. For example, if the pickup in question had had an output of only 20 millivolts, then the amplifier would have received only 4 millivolts, which is not enough to give full power output. In such a case, extra amplification is needed, or a high input impedance buffer stage before the amplifier. If the pickup had an output of 500 millivolts the amplifier would be in danger of being overloaded and some extra attenuation would have to be put between it and the pickup.

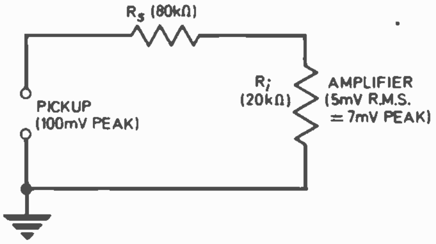


Fig. 1. A very simple form of attenuator/matching circuit.

MATCHING CRITERION

To check whether a particular combination of pickup and amplifier will work with this simple matching arrangement, calculate this *Matching Criterion*:

$$\left(\frac{\text{Pickup output (mV)}}{\text{Amplifier input (mV)}}\right) \times \left(\frac{\text{Amplifier input resistance}}{\text{Required pickup load resistance}}\right)$$

If this comes to more than unity, the system will work. If it comes to more than 10, there may be a danger of overloading the input stage (this doesn't apply if there is a volume control before the input stage). If less than unity, either more amplification or more input impedance with the same amplification is needed.

In calculating the *Matching Criterion,* both voltages must be in millivolts and both resistances (or impedances) in kilohms. The criterion also applies to matching signal sources other than pickups.

Occasionally, a pickup or some other signal-source may produce far too much output and be in danger of overloading the amplifier which it drives. To avoid overloading the preamplifier it is necessary to attenuate the signal while at the same time presenting the pickup with the correct load.

Taking the figure of 500 millivolts for the pickup output, but keeping the load at 100 kilohm as before, how can we reduce the input to the amplifier without at the same time presenting the wrong load to the pickup? The simplest answer is to connect a resistance in parallel with R_i, thus bringing down the effective input impedance of the amplifier. To preserve the required 100 kilohm, R_s must be increased, and this, together with the reduced input impedance, causes the desired attenuation of the signal.

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RESISTORS
½W Iskra high stability carbon film—very low noise—capless construction.
⅓W Mullard CR25 carbon film—very small body size 7·5 x 2·5 mm.
¼W 2% ELECTROSIL TR5.

Power watts	Tolerance	Range	Values available	Price 1–99	Price 100+
½	5%	4·7 Ω–2·2M Ω	E24	1p	0·8p
⅓	10%	3·3M Ω–10M Ω	E12	1p	0·8p
¼	2%	10 Ω–1M Ω	E24	3·5p	3p
[illegible]	10%	1 Ω–3·9 Ω	E12	1p	0·8p
[illegible]	5%	4·7 Ω–1M Ω	E12	1p	0·8p
4	10%	1 Ω–10 Ω	E12	6p	5·5p

Quantity price applies for any selection. Ignore fractions on total order.

DEVELOPMENT PACK
0·5 watt 5% Iskra resistors 5 off each value 4·7 Ω to 1M Ω.
E12 pack 325 resistors **£2·40**. E24 pack 650 resistors **£4·70**.

POTENTIOMETERS
Carbon track 5k Ω to 2M Ω, log or linear (log ½W, lin ¼W).
Single, **12p**. Dual gang (stereo), **40p**. Single D.P. switch, **24p**.

SKELETON PRESET POTENTIOMETERS
Linear: 100, 250, 500 Ω and decades to 5M Ω. Horizontal or vertical P.C. mounting (0·1 matrix).
Sub-miniature 0·1W, **5p** each. Miniature 0·25W, **7p** each.

TRANSISTORS

AC107	15p	AF126	20p	BF115	25p	OC42	12p	SN3707	12p
AC126	12p	AF139	32p	BF173	20p	OC44	12p	2N3708	10p
AC127	15p	AF178	32p	BF177	28p	OC45	12p	2N3709	11p
AC128	15p	AF180	40p	BF178	32p	OC70	12p	2N3710	11p
AC131	12p	AF181	40p	BF179	32p	OC71	12p	2N3711	11p
AC132	12p	BC107	12p	BF180	32p	OC72	12p	2N3819	32p
AC176	15p	BC108	12p	BF181	32p	OC81	21p	2N4062	12p
AC187	22p	BC109	12p	BF194	14p	OC82D	12p	2N4286	20p
AC188	22p	BC147	12p	BF195	14p	2N2646	60p	2N4289	20p
AD140	50p	BC148	12p	BF197	15p	2N2904	20p	40360	35p
AD149	45p	BC149	12p	BF200	32p	2N2926	10p	40361	35p
AD161	33p	BC157	14p	BFY50	20p	2N3054	58p	40362	40p
AD162	36p	BC158	14p	BFY51	20p	2N3055	60p	40408	40p
AF14	20p	BC159	14p	BFY52	20p	2N3702	13p	2TX108	15p
AF115	20p	BC187	22p	BUY105	225p	2N3703	12p	ZTX300	15p
AF116	20p	BD131	75p	OC26	45p	2N3704	13p	ZTX302	20p
AF117	20p	BD132	25p	OC28	50p	2N3705	12p	ETX500	15p
AF118	38p	BD133	75p	OC35	50p	2N3706	11p	EXT503	20p

ZENER DIODES
400mW 5% 3·3V to 30V, **12p**.

WIRE WOUND POTS.
3W, 10, 25, 50 Ω and decades to 100k Ω, **35p**.

DIODES

RECTIFIER

BY127	1250V	1A	12p
BZY10	800V	6A	25p
BZY13	200V	6A	20p
1N4001	50V	1A	7p
1N4004	400V	1A	8p
1N4007	1000V	1A	10p

SIGNAL

OA85	7p
OA90	5p
OA91	5p
OA202	7p
1N4148	5p
BA114	8p

BRUSHED ALUMINIUM PANELS
12in x 6in, **25p**; 12in x 2½in, **10p**; 9in x 2in, 7p

SLIDER POTENTIOMETERS
86mm x 9mm x 16mm, length of track 59mm.
SINGLE 10K, 25K, 100K log. or lin. **40p.**
DUAL GANG, 10K + 10K etc. log. or lin. 60p.
KNOB FOR ABOVE, 12p.
FRONT PANEL, 65p.
18 Gauge panel 12in x 4in with slots cut for use with slider pots. Grey or matt black finish complete with fixings for 4 pots.

THERMISTORS

VA1055S	15p
VA1066S	15p
VA1077	15p
R53	£1·35

THYRISTORS

2N5060	50V	0·8A	30p
2N5064	200V	0·8A	47p
106F	50V	4A	40p
106D	400V	4A	55p

MULLARD POLYESTER CAPACITORS C296 SERIES
400V: 0·001µF, 0·0015µF, 0·0022µF, 0·0033µF, 0·0047µF, **2½p**. 0·0068µF, 0·01µF, 0·015µF, 0·022µF, 0·033µF, **3p**. 0·047µF, 0·068µF, 0·1µF, **4p**. 0·15µF, **6p**. 0·22µF, **7½p**. 0·33µF, **11p**. 0·47µF, **13p**.
160V: 0·01µF, 0·015µF, 0·022µF, 0·033µF, 0·047µF, 0·068µF, **3p**. 0·1µF, **3½p**. 0·15µF, **4½p**. 0·22µF, **5p**. 0·33µF, **6p**. 0·47µF, **7½p**. 0·68µF, **11p**. 1·0µF, **13p**.

MULLARD POLYESTER CAPACITORS C280 SERIES
250V P.C. mounting: 0·01µF, 0·015µF, 0·022µF, **3p**. 0·033µF, 0·047µF, 0·068µF, **3½p**. 0·1µF, **4p**. 0·15µF, 0·22µF, **5p**. 0·33µF, **6½p**. 0·47µF, **8½p**. 0·68µF, **11p**. 1·0µF, **13p**. 1·5µF, **20p**. 2·2µF, **24p**.

MYLAR FILM CAPACITORS 100V
0·001µF, 0·002µF, 0·005µF, 0·01µF, 0·02µF, **2½p**. 0·04µF, 0·05µF, 0·068µF, 0·1µF, **3½p**.

CERAMIC DISC CAPACITORS
100pF to 10,000pF, **2p** each.

ELECTROLYTIC CAPACITORS
(KF/v) 1/63, 1·5/63, 2·2/63, 3·3/63, 4·7/63, 6·8/40, 6·8/63, 10/25, 10/63, 15/16, 15/40, 15/63, 22/10, 22/25, 22/63, 33/6·3, 33/16, 33/40, 47/4, 47/10, 47/25, 47/40, 68/6·3, 68/16, 100/4, 100/10, 100/25, 150/6·3, 150/10, 220/4, 220/6·3, 220/16, 330/4, **6p**. 47/63, 100/40, 150/25, 220/25, 330/10, 470/6·3 **7p**. 68/63, 150/40, 220/40, 330/16, 1000/4, **10p**, 470/10, 680/6·3 **11p**. 100/63, 150/63, 220/63, 1000/10, **12p**. 470/25, 680/16, 1500/6·3 **13p** 470/40, 680/25, 1000/16, 1500/10, 2200/6·3, **18p**. 330/63, 680/40, 1000/25, 1500/16, 2200/10, 3300/6·3, 4700/4 **21p**.

SOLID TANTALUM BEAD CAPACITORS — 12p

0·1µF	35V	2·2µF	35V	22µF	16V
0·22µF	35V	4·7µF	35V	33µF	10V
0·47µF	35V	6·8µF	25V	47µF	6·3V
1·0µF	35V	10µF	25V	100µF	3V

VEROBOARD

	0.1	0.15
2½ x 3¾	22p	16p
2½ x 5	24p	24p
3¾ x 3¾	24p	24p
3¾ x 5	27p	27p
17 x 2½	75p	57½p
17 x 3¾	100p	78p
17 x 5 (plain)	—	82p
17 x 3¾ (plain)	—	60p
17 x 2½ (plain)	—	42p
2½ x 5 (plain)	—	12p
2½ x 3¾ (plain)	—	11p
Pin insertion tool	52p	52p
Spot face cutter	42p	42p
Pkt. 50 pins	20p	20p

JACK PLUGS AND SOCKETS

Standard screened	18p	2·5mm insulated	8p
Standard insulated	12p	3·5mm insulated	8p
Stereo screened	35p	3·5mm screened	13p
Standard socket	15p	2·5mm socket	8p
Stereo socket	18p	3·5mm socket	8p

D.I.N. PLUGS AND SOCKETS
2 pin, 3 pin, 5 pin 180°, 5 pin 240°, 6 pin
Plug 12p. Socket 8p.
4 way screened cable, **15p**/metre.
6 way screened cable, **22p**/metre.

BATTERY ELIMINATOR — £1.50
9V mains power supply. Same size as PP9 battery.

LARGE (CAN) ELECTROLYTICS

1600µF	64V	74p	2500µF	64V	80p	4500µF	16V	50p
2500µF	40V	74p	2800µF	100V	£2·60	4500µF	25V	£1·68
2500µF	50V	58p	3200µF	16V	50p	5000µF	50V	£1·10

HIGH VOLTAGE TUBULAR CAPACITORS—1,000 VOLT

0·01µF	10p	0·047µF	13p	0·22µF	20p
0·022µF	12p	0·1µF	13p	0·47µF	22p

POLYSTYRENE CAPACITORS 160V 2½%
10pF to 1,000pF E12 Series Values, **4p** each.

SMOKE AND COMBUSTIBLE GAS DETECTOR—GDI
The GDI is the world's first semiconductor that can convert a concentration of gas or smoke into an electrical signal. The sensor decreases its electrical resistance when it absorbs deoxidizing or combustible gases such as hydrogen, carbon monoxide, methane, propane, alcohol, North Sea gas, as well as carbon-dust containing air or smoke. This decrease is usually large enough to be utilized without amplification. Full details and circuits are supplied with each detector.
Detector GDI, **£2.** Kit of parts for detectors including GDI and P.C. board but excluding case. Mains operated detector **£5·20.** 12 or 24V battery operated audible alarm **£7·30.** As above for PP9 battery, **£6·40.**

PRINTED BOARD MARKER — 97p
Draw the planned circuit onto a copper laminate board with the P.C. Pen, allow to dry, and immerse the board in the etchant. On removal the circuit remains in high relief.

LARGE RANGE ITT/TEXAS IC's NOW IN STOCK

PRICES ARE CALCULATED ON TOTAL NUMBER ORDERED REGARDLESS OF MIX

	1–11 p	12–24 p	25–99 p	100+ p
7400	18	16	14	13
7401	18	16	14	13
7402	18	16	14	13
7403	18	16	14	13
7404	20	18	16	14
7405	20	18	16	14
7406	50	45	40	35
7407	56	50	44	38
7408	36	30	27	23
7409	36	30	27	33
7410	18	16	14	13
7411	23	21	20	18
7412	36	30	27	23
7413	34	28	26	22
7416	45	43	39	34
7420	18	16	14	13
7421	36	30	27	23
7426	32	29	23	20
7430	20	18	16	14
7432	40	36	32	28
7440	20	18	16	14
7441	80	75	70	65
7442	80	75	70	65
7443	125	120	115	115
7447	175	165	150	120

	1–11 p	12–24 p	25–99 p	100+ p
7448	185	175	170	165
7450	18	16	14	13
7451	18	16	14	13
7453	18	16	14	13
7454	18	16	14	13
7460	18	16	14	13
7470	30	28	25	24
7472	30	28	27	23
7473	40	38	36	30
7474	40	36	32	28
7475	55	52	50	49
7476	40	36	32	30
7480	100	95	90	85
7481	125	115	110	105
7482	100	96	90	85
7483	100	97	95	92
7484	120	115	110	105
7485	250	245	240	230
7486	45	42	37	33
7490	75	67	60	52
7491A	100	92	85	79
7492	75	70	65	60
7493	75	68	60	52
7494	95	90	85	80
7495	105	100	95	90
7496	100	95	90	85
74100	250	240	235	230

	1–11 p	12–24 p	25–99 p	100+ p
74118	100	82	73	64
74121	43	40	38	36
74141	100	95	90	85
74145	150	140	135	130
74150	330	280	250	220
74151	110	100	95	89
74153	120	110	105	95
74154	200	180	170	160
74155	150	120	100	86
74156	130	120	100	96
74180	155	136	112	105
74190	195	190	185	180
74191	195	190	185	180
74192	200	190	180	164
74193	200	180	170	150
74196	200	190	180	170
74197	200	195	180	170

LINEAR IC's

709	14 pin DIL	40p
741	8 pin DIL	40p
741	14 pin DIL	38p
723	14 pin DIL	95p
747	14 pin DIL	85p
748	8 pin DIL	45p
DIL sockets	14 pin and 16 pin	16p

IN [e] NEXT MONTH

THE 4 BAND T.R.F. RECEIVER

A radio capable of receiving short wave amateur and shipping transmissions as well as the normal medium wave band

GAS alarm

A simple alarm for the detection of combustible gases and vapours and smoke

THREE BY THREE GAME

An addition to any game using a dice, or a novel game for two players

EXTRA INSIDE

8 PAGE SUPPLEMENT

ON CONSTRUCTIONAL METHODS

ALL IN THE NOVEMBER ISSUE OF

everyday electronics

On Sale Friday, September 21

SHOP TALK

By Mike Kenward

We appear to have overlooked the supply problem concerning one major component used last month. The CA3046 integrated circuit, used in the *Train Controller*, is not particularly easy to get hold of, but one large supplier of semiconductors does list it—A. Marshal and Son, their address can be found on their advertisement elsewhere in this issue.

Lamp Dimmer

To get to the supply problems likely to occur when buying for this month's projects we will first look at the *Lamp Dimmer*. Most components for this project will cause few problems, but it might be as well to shop around before buying the diac and triac as prices vary widely.

Some firms sell these items in pairs and this is probably a good way of buying them. The case and other mechanical parts should be available from most electrical shops.

Audio Millivoltmeter

The case used on the prototype *Audio Millivoltmeter* is a good case for this piece of test gear but is rather expensive (about £2·50). This case is made from Lektrokit parts available from Home Radio.

The meter used can be any type of the approximate size quoted (provided the range is correct) and there are a number of reasonably priced types available from advertisers. The transformer specified should preferably be used since the calibration voltage is likely to be more accurate with one particular type.

Headphone Adaptor

The only component likely to be difficult to get for the *Stereo Headphone Adaptor* is the case. A design for a home model case is shown in the article but any small metal or plastic case could be used.

All the other components are readily available.

Tutor Board

We hope that some of our advertisers will be supplying a full kit of parts for the *Tutor Board* and the first six parts of *Teach-In '74*. We have taken the unusual step of informing advertisers of the necessary components so that they can help you by selling them all in one kit.

Just one point, the last Teach-In series also used a small moving coil meter and the demand was so heavy that all the stocks were exhausted; we hope this will not happen this time as the suppliers have been warned.

If the meter does become unavailable similar types should be sought. The size is not that critical but we suggest you do not use one very much smaller than the original.

Another point if you are buying the parts individually make sure you get R.S. Components connector blocks—this is because of the method of fixing them used.

Readers' Bright Ideas; any idea that is published will be awarded payment according to its merit. The ideas have not been proved by us.

I have often spent many hours sorting through a box of resistors to find the values I need, so I have come up with the following idea. Obtain a polystyrene ceiling tile and divide it into many parts using a felt-tipped pen and number these sections with resistor values, preferably in ascending order. The resistors can then be placed in their respective sections by inserting one wire end into the tile. It is then an easy matter to find the required value resistor.

P. D. Turner,
Woodbridge, Suffolk.

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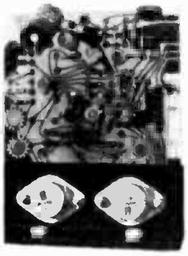


New Versions using 3A 'Plastic Power' Driver Transistors Now Available. To meet demand, we have included a more powerful module in our well-established and proven range. These power amplifiers are carefully assembled, tested and guaranteed. They offer superb value for reliability and versatility.

SA35 35 watts RMS. Uses 7 transistors and 7 diodes Carr. paid. **£4·45**

A NEW ADDITION IS THE

SA50 at £5·65

Carr. paid. A rugged, well built unit, capable of 50 watts R.M.S. out, with all the advantages of Saxon Amplifier design and quality. Ready now.

SA100 makes an ideal unit in disco assemblies. A real glutton for work. **£10·90**
Reliable, tough and compact. 11 transistors, 6 diodes. Carr. paid.

BRIEF SPEC. FOR ALL THREE MODULES

All modules incorporate OPEN AND SHORT CIRCUIT PROTECTION, plus proof against over-dissipation and faulty inductive loads in the SA.100.

Freq. response	15–40,000 Hz ± 1dB
Distortion	0·2% at 1 kHz
Loads	4 to 16 ohms
Quiescent current	15 mA
Noise	Better than −75 dB
Supply voltage	SA35 25–45 volts SA50/SA100 40–70 volts
Size	4½" x 4" x 1" (SA100) 4" x 3" x 1" (SA35/SA50)

Circuits, connecting instruction and application data are supplied free with all modules.

POWER SUPPLIES FOR THE SA25/35 & SA100 AUDIO MODULES

PU45	Unstabilized supply for 2 SA25/35	£4·90
PU70	Unstabilized supply for one or two SA100	£7·75 carr. 40p
PS45	Stabilized module for 2 SA25's or two SA35's	£3·50 carr. free
MT45	Transformer for above, heavy duty	£2·85 carr. 20p
MT30	Transformer for unstabilized supply complete with rectifier diodes mounted	£3·50 carr. 20p
PS70	Stabilized supply module for one or two SA100's	£4·90 carr. free
MT70	Transformer for PS70	£4·90 carr. 40p

ALL MODULES ARE BUILT ON GLASS FIBRE P.C. BOARD AND SUPPLIED FULLY TESTED

TWO NEW PA/MIXER CONTROL UNITS

Using grouped pairs of inputs and outputs (high Z and low Z inputs) with individual bass, treble and volume controls on each pair plus master control. These low-noise units will feed all makes of amplifiers, making them ideal for clubs, discos etc. Standard jack sockets. Compact design. In strong metal cases. All units guaranteed for 3 years.

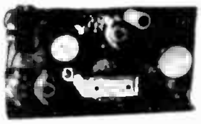
- **M.4H** 4 high Z, 4 low Z inputs, 4 sets of controls. Case 14" × 8" × 2½" Carr. pd. **£18·50** + V.A.T.
- **M.6HL** Case 18" × 8" × 2½" 12 inputs (6 high Z, 6 low Z). Carr. pd. **£27·50** + V.A.T.
- Channel section modules, for building your own mixer. Gain—16 x (24dB). Tone controls—18dB swing. Carr. pd. £3·50 + V.A.T.

SAXON CONTROL UNITS

Mono (as shown) Carr. 20p. **£6·50**
Stereo. Carr. 30p. **£15·80**

Two decks, and full headphone monitoring. The unit is mains operated and measures 17½" x 3" x 4" deep and is finished with a smart white on black facia. The controls are: Left/Right deck fader, volume, bass, treble, Headphone Selector and volume. Microphone volume, bass, treble, mains on/off.
COMPARABLE TO UNITS AT OVER TWICE THE PRICE. (N.B.—Stereo only has mic input.)

120 WATT HEAVY DUTY MODULE



Rugged class A driver stage, this module will run from all our mixers, etc., and most other makes. Delivers 120 watts into an eight ohm load and employs 4 TO3 can (115 watt) output transistors. These are the modules where extra power is demanded.

Power output	120 watts into 8 ohms
Freq. response	20-20,000 HZ ± 2dB
Input sensitivity	200 mV into 10K
Construction	Fibreglass board
Size	8" x 4" x 4" (5" with supply)

Low distortion parallel push-pull output stage.

Module only (Carr. 20p) **£13·90**
Module & power supply (Carr. 40p) **£18·95**
160 watt version with power supply (Carr. 50p) ~~£27·90~~ **£27·50**

SOUND AND LIGHT UNITS

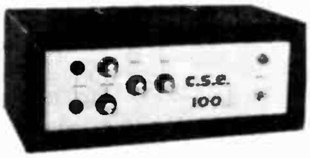
Our popular 3 channel model handles up to 3KW (3000 watts) of lighting and incorporates versatile sound control arrangement to enable professional standards to be achieved. Both units are excellent examples of Saxon quality and value.

3 CHANNEL UNIT
Includes bass, middle and treble as well as master controls. 2 amplifier sockets eliminate need for split leads. Up to 3KW lighting load. Smartly finished steel case. Carr. 30p. **£19·75**

SINGLE CHANNEL UNIT
Operates from 5 to 100 watt amplifiers. Supplied for bass note operation, is easily adapted for treble or mid-range at a cost of about 5p. Carr. pd. **£8·90**

COMPLETE AMPLIFIERS

CSE 100. £34·90 carr. free



This versatile unit is now available in a black vynide case and so represents even better value than ever delivering speech and music powers of up to 100 watts RMS and continuous signal outputs of 70 watts. Two individually controlled inputs with wide range bass and treble controls.

SAXON 100 £48·50 carr. free

With an RMS output of 120 watts speech and music, 100 watts continuous power, four individually controlled FET input stages and wide range bass and treble controls, this amplifier has established itself as a unit offering quality and reliability at low cost.

600 Watt 3 colour Ligh Boxes Smart Rexine finish £15 carr free.

LOUDSPEAKERS British made bargains!!
12" 25 watt 8/15 ohms £5·95 carr. 30p. 15" 50 watt 8/15 ohm £14·50 carr. 50p.
12" 40 watt 15,000 gauss magnet system 8/15 ohm £11·50 carr. 40p.

A.K.G. MICROPHONES
D11 OHL IDEAL DISCO MIKE ONLY £8·45 (rrp £11·00).

Prices quoted do NOT include V.A.T. 10% must be added on to total value of order for V.A.T.

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Smoothing Capacitors

When designing a mains power supply for transistor circuits you use a large value electrolytic capacitor. How do you arrive at the value for this and is it very critical?

The general rule is to make the capacitor as large as possible (or as one can afford) however there is a slightly more scientific answer. If you assume full wave rectification the capacitor has to smooth out what is, effectively, a 100Hz waveform. This pulsating waveform is constantly trying to fill the capacitor with charge (if you consider it like a bucket) and in the absence of any current being drawn from the capacitor this happens quite quickly and once it is fully charged there is no further ripple across its terminals.

As soon as you connect to an external circuit, charge will be drawn from the capacitor—hopefully at a lower rate than it is being fed in. The crux of the problem is to make sure that the rectifying circuit can keep the capacitor filled with charge more easily than the external circuit can draw it.

If you consider the external circuit to be a box having impedance (forget what the function of the circuit actually is) we must make sure that the impedance of the charge circuit is very much less than the impedance of the external circuit. This means that the reactance of the smoothing capacitor must be very low at a frequency of 100Hz. If the external circuit has a high impedance (e.g. it draws only a milliamp or two) we can afford to use a low value capacitor for smoothing (a few hundred micro-farad which does not have an exceptionally low reactance) but if we need to supply several hundred milliamps we must reduce the reactance of the capacitor proportionally (to perhaps several thousand micro-farads). The values are not very critical provided you are in the right order of magnitude but there is a hidden snag—if the capacitor is too large there might be a big current surge at switch on as it charges up for the first time and this surge—in badly designed circuits—can sometimes destroy the rectifiers!

Impedance

I thought that impedance was dependent on frequency and yet you often talk about input impedances without mentioning the frequency you are considering. My amplifier specification even says "Input impedance: 1 megohm" but it does not mention frequency. This does not seem to make sense!

When dealing with audio amplifiers there is a standard frequency that is used as the basis for calculating impedances; this has been chosen to be approximately in the peak of the human ear's frequency response — 1kHz. Whenever we talk about input impedance or impedance matching in amplifiers we are assuming that a frequency of 1kHz is being used. Once you know this you can calculate impedances for other frequencies.

There is an exception (to prove the rule?) loudspeakers' impedances are usually quoted for a frequency of 400Hz.

Impedance Variation

I assume that it is possible to increase or reduce the impedance of a loudspeaker merely by connecting a resistor in series or in parallel with it but is this permissible and what effects would be evident?

It is perfectly permissible to do this—provided you carry out your series (or parallel) calculation correctly. For example you can increase the impedance of a 3 ohm loudspeaker to about 8 ohms by putting a 5 ohm resistor in series with it. This would make it safe to connect to an amplifier with a restriction of 8 ohms "output impedance" but you will sacrifice a lot of power—over half the power would be dissipated by the resistor and the volume will be considerably reduced.

It is a handy "stop gap" technique for initially checking a circuit before you buy the correct loudspeaker but is not to be recommended as good practice!

Reversed Transistors

Why must you not connect transistors the wrong way round—by that I mean swop collectors for emitters. In an *npn* transistor both collector and emitter are made of *n* type material and the structure is a sort of sandwich so why on earth can't you reverse the connections without "dire" results.

Your description of the structure of an *npn* transistor is correct and we agree that it does seem strange that the device is not reversible. The reason lies behind the fact that although you have the sandwich structure there are differences in the doping levels of the silicon forming the collector and emitter regions respectively. Emitter doping is very much greater than that in the collector—this is necessary to improve the "emitter efficiency" which controls the gain and frequency characteristics of the device. A side effect of this high level doping is to reduce the reverse emitter base breakdown voltage (to typically 5 or 6 volts).

In normal circuits we take great care to ensure that for an *npn* transistor the base can never go more than about 5V negative with respect to the emitter for this very reason. When a transistor is in a correctly operating circuit the base is usually at a much more negative voltage than the collector—often there can be 7 or 8 volts difference and the collector base junction is always in a reverse biased condition. If you connect your transistor the wrong way round you will be applying these 7 or 8 volts across the emitter base junction which has a reverse limit of 5 volts and this is why the device might be destroyed.

A point of interest is that provided the breakdown current is limited you can sometimes get away with it! If the supply voltage is less than the emitter base reverse breakdown voltage there will be no danger of damaging the transistor but your circuit will still not work as you do not get the true emitter efficiency that is required and the effective gain of the device—when operating the wrong way round—is in the order of 1·1.

Mono to Stereo

I have a mono cassette tape recorder which I want to modify to give me stereo playback. Is there any simple way to do this.

Theoretically it is possible to convert your device for stereo replay but if you are a beginner we feel that this might prove to be a very difficult operation. Not only is it difficult but you might have considerable difficulty getting the right parts and obtaining a reasonable balance between the two channels.

Your recorder will be fitted with a mono head which imprints the recorded signal as a magnetic pattern on a $\frac{1}{16}$ inch wide track of the cassette tape. To operate in stereo two tracks—containing left hand and right hand information—have to be recorded within this $\frac{1}{16}$ inch width, so firstly you have to change the head to one which has two electromagnetic cores. Problem number one is to locate a head that will mechanically fit your deck—because of the miniature nature of modern recorders getting one to exactly fit will be difficult! You then have to mechanically line up the head so that is exactly corresponds to the two tracks we have mentioned.

Assuming you are able to do this you then have to make a high gain audio amplifier which will operate from the very low signals that are derived from the tape when playing back. There are many amplifiers which are capable of doing this and you would have no problem in that respect unless you tried to get the signal from the extra channel to exactly match the quality from the existing one. The only satisfactory way to do this is to start from scratch and build two identical playback amplifiers and feed these from the signals from the double track heads.

The answer would thus seem to be "don't modify but start from scratch" and to do that you need to be reasonably experienced—circuits for stereo tape recorders appear from time to time in our sister magazine Practical Electronics to which we hope you will progress as you get more confident in handling complex circuits.

Using Veroboard

I have read—somewhere—that Veroboard is not recommended for use in radio circuits why is this?

In some radios it is true that Veroboard can give problems. Because of the very close proximity of the conducting strips you can get parasitic capacitive coupling between stages and this can affect tuning and in some instances cause the circuit to be unstable and oscillate. In our designs we are very much aware of this problem and will only specify Veroboard in non critical applications.

Transformer Addition

Can I step up the output of my 1 watt transistor amplifier by putting a transformer between it and the loudspeaker.

No! The output of the amplifier is designed to match the impedance of a loudspeaker to give optimum power coupling. By putting in a transformer you will upset this coupling and at best will get slightly less power output. At worst you might damage the output transistors of your amplifier. Remember a transformer does not give **power** transformation—only voltages and currents are changed and always at the expense of each other.

Thyristor Check

Is there any "quick and easy" way of checking if a thyristor is working?

The following method will check if a thyristor is working but it will not check whether it is capable of withstanding higher voltages or for that matter will not show any leakage current problems which might be encountered when operating at normal mains voltages.

Use a 9V battery and a 6V 150mA bulb in series with the anode/cathode circuit of the thyristor under test. The bulb should be between the anode and the positive terminal of the battery; the cathode goes straight to the negative terminal. The bulb should not light up. Now, with an extra lead and a 100 ohm resistor in series, connect from the positive battery terminal to the gate connection of the thyristor momentarily. The bulb should light up and stay alight even though you remove the connection to the gate.

Momentarily disconnect the main circuit and reconnect and the bulb should go out and stay out. This test should work for most thyristors available but one ought to say that there are a few devices around which need more gate current than this simple circuit can provide.

Dissipation

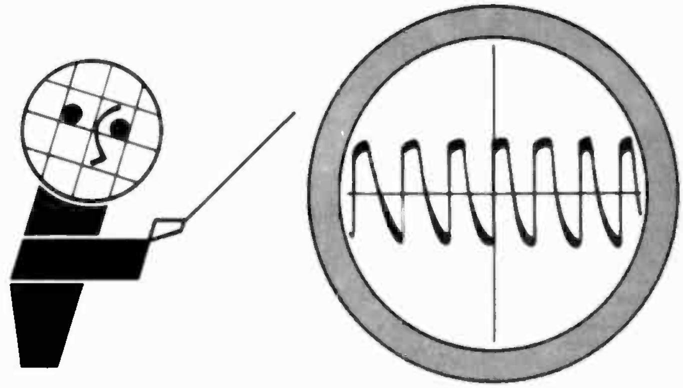
When I made your *Cassette Power Supply* (car version) it worked fine for about ten minutes and then TR2 blew. Admittedly I was not using the Philips unit as specified but as it worked for a bit and the current drawn was within the transistor's rating why should it "go" after a period of time.

The problem is that too much power is being dissipated in TR2. In this case the current rating is not the most important parameter of the transistor. Although the specification for it says it will pass up to 1 amp without damage you have to remember that the power dissipated within it is given by the voltage drop across it multiplied by the current going through it at the time and the product of these must not exceed 0·8 watts. It is likely you are exceeding this maximum power and the effect would be for the transistor to get hotter and hotter until something "goes" inside. The solution is to get the heat out faster than it is being generated and to do this might be necessary to go to a higher power dissipation transistor. A common device which is more than adequate would be a 2N3055.

look! electronics really mastered

...practical
...visual
...exciting!

no previous knowledge
no unnecessary theory
no "maths"



RAPY

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step by step, we take you through all the fundamentals of electronics and show how easily the subject can be mastered. Write for the free brochure now which explains our system.

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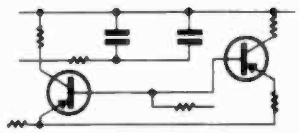
You learn how to build an oscilloscope which remains your property. With it, you will become familiar with all the components used in electronics.

2/ READ, DRAW AND UNDERSTAND CIRCUIT DIAGRAMS



as used currently in the various fields of electronics.

3/ CARRY OUT OVER 40 EXPERIMENTS ON BASIC ELECTRONIC CIRCUITS & SEE HOW THEY WORK, including:

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This new style course will enable anyone to really understand electronics by a modern, practical and visual method—no maths, and a minimum of theory—no previous knowledge required. It will also enable anyone to understand how to test, service and maintain all types of electronic equipment, radio and TV receivers, etc.

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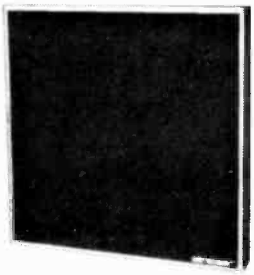
the world's most advanced high fidelity modules

Q.16 high fidelity loudspeaker



The Q 16 employs original and by now well proven acoustic principles in which a special driver assembly is meticulously matched to a uniquely designed cabinet. In performance it comfortably stands comparison with very much more expensive loudspeakers. A solid teak surround is used with a special all-over cellular black foam front chosen both for its appearance and ability to pass all audio frequencies without masking.

Specifications
Construction: A sealed seamless sound or pressure chamber is used with internal baffle, and special high flux driver
Loading: Up to 14 watts RMS, into 8 ohms
Frequency response: From 60 to 16,000 Hz
Size and styling: 248 mm square x 120 mm deep (9¾" x 4¾") with neat pedestal base.

£7.70 +V.A.T. 77p

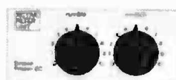
Stereo 60 pre-amp/control unit

Designed specifically for Project 60 systems, the Stereo 60 is equally suitable with any high quality power amplifier. Silicon epitaxial planar transistors used throughout ensure high signal-to-noise ratio and excellent tracking between channels. Input selection is by press buttons, with accurate equalisation on all input channels. The unit is easy to mount.

SPECIFICATIONS—Input sensitivities: Radio – up to 3mV. Mag p.u. 3mV: correct to R.I.A.A. curve ±1dB 20 to 25,000Hz Ceramic p.u. – up to 3mV: Aux – up to 3mV. **Output:** 250mV. **Signal to noise ratio:** better than 70dB. **Channel matching:** within 1dB. **Tone controls:** TREBLE +12 to —12dB at 10KHz: BASS +12 to —12dB at 100Hz. **Front panel:** brushed aluminium with black knobs and controls. **Size:** 66 x 40 x 207mm.

Built, tested and guaranteed. **£9.98** +V.A.T. 99p

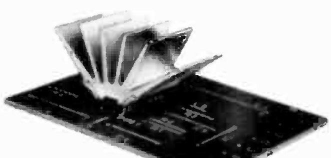
AFU filter unit



For use between Stereo 60 and two Z 30's or Z 50's in stereo formation. Cut off frequencies are continuously variable, with 12dB/octave cut in the rejection band. Two stages of filtering – rumble (high pass) and scratch (low pass). Amplitude and phase distortion are negligible. Supply voltage needed – 15–35V. H.F. cut-off (– 3dB) 28KHz to 5KHz: L.F. (– 3dB) 25Hz to 100Hz. For Project 60 or any good stereo system. Built, tested and guaranteed

£5.98 +V.A.T. 59p

Super IC.12 Integrated circuit high fidelity amplifier



Having introduced Integrated Circuits to hi-fi constructors with the IC.10, which was the first time an IC had ever been made available for such purposes, we followed it with an even more efficient version, the Super IC.12. This needs very few external resistors and capacitors to make an exceedingly efficient high fidelity amplifier for pick-up, F.M. radio or small P.A. set up etc. The free 40 page manual supplied details many other applications which this remarkable IC make possible. The Super IC.12 is the equivalent of a 22 transistor circuit contained within a 16 lead DIL package, and the finned heat sink is sufficient for all likely requirements. The Super IC.12 is also compatible with those Project 60 modules which would be used with the Z.50 and Z.30 amplifiers. Complete with free manual and printed circuit board.

SPECIFICATIONS
Output power: 6 watts RMS continuous (12 watts peak) into 6–8 Ω. **Frequency Response:** 5Hz to 100KHz±1dB. **Total Harmonic Distortion:** less than 1%. (Typical 0.1%) at all output powers and frequencies in the audio band (28V). **Load Impedance:** 3 to 15 ohms. **Input Impedance:** 250 Kohms nominal. **Power Gain:** 90dB (1,000,000,000 times) after feedback. **Supply Voltage:** 6 to 28V. **Quiescent current:** 8mA at 28V. **Size:** 22 x 45 x 28mm including pins and heat sink.
Manual available separately 15p post free

With FREE printed circuit board and 40 page manual.
£2.98 +V.A.T. 29p Post free

Project 605

the simple way to build a Project 60 system without soldering

For the many audio enthusiasts anxious to build to high standards without too many involvements, there could be nothing better or simpler than Project 605. It offers the advantages of Project 60 and is absolutely complete down to the last piece of wire cut to length. Whilst not as powerful as assemblies using Z.50 power amplifiers, we know from experience that there are many for whom the specifications of Project 605 are ideal, particularly in relation to the environment in which it is required to be used. In Project 605 you have everything necessary to build a versatile Project 60 thirty watt high fidelity amplifier system suitable for all domestic requirements. The convenient pack includes two Z.30 power amplifiers, a Stereo 60 pre-amp control unit and the special Masterlink unit to and from which all input and output connections are made. For power a PZ.5 is provided. Building is particularly easy since all necessary leads are supplied colour coded, cut to length and terminated by contact clips which connect firmly to the modules. There is absolutely no soldering to be done. Complete with comprehensive, easy to follow instructions manual.

£29.95 + V.A.T. £2.99 Post free

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KITS FOR PREVIOUS PROJECTS

Unless otherwise stated, kits contain electronic parts only. The case and special items can be obtained locally. Also batteries are not included. Kits may be returned for refund if construction has not been started. We reserve the right to substitute components should deliveries be protracted so as to avoid undue delay.

If reprint of data is required add 10p

HOME SENTINEL. "Ward off the unwanted intruder"—No elaborate setting up or wiring required. Kit of parts £4·35.
"SNAP" INDICATOR. Press your button first and your opponent is blocked also suitable for Quiz games and reaction testing. Kit of parts £1·10.
RECORD PLAYER. Good quality at a reasonable price—good enough for classical records and pop. Kit of parts £6·10.
WINDSCREEN WIPER CONTROL. Wet dirty road—Drizzle—Fog—Smeared screen—Scraping wipers—combat these with add-on wiper control. Kit of parts £2·50.
FUZZ BOX. Add weird and interesting effects to guitar playing with this solid state Fuzz box. Kit of parts £2·50.
PHOTOGRAPHIC COLOUR TEMPERATURE METER. Must for colour photographer get the colours right gives quick indication of filters necessary for correction in any light. Can be used with natural or Studio lighting. Kit of parts £3·58.
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RAIN WARNING ALARM. Keep your washing dry with this automatic alarm device. Kit £2·20.
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SIMPLE CALCULATOR. Teaching aid for multiplication—can be used for quick checks. Kit £3·10.
POWER SUPPLY UNIT. Just right for testing low voltage circuits—a simple stabilised supply providing 0-16 volts D.C. continuously variable. Kit £5·20.
METAL LOCATOR. A simple easy to construct self-contained metal locator giving a meter indication of buried metal. Kit £5·00.
AUDIO TONE GENERATOR. Makes electronic music—covers range from 50—2000 hz. Specifically designed for use with tape recorder. Kit £3·25.
LIGHT TO SOUND CONVERTER. Produces an audio tone—the frequency of which is dependent on the light level. Kit £2·15.
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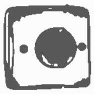
ELECTRONOME. Electronic Metronome with pulse frequency continuously variable from 40—225 beats per minute. Kit £2·15.
THROUGH LENS LIGHT METER. A simple light meter for use with single lens reflex camera. Kit £4·35.
MEDIUM AND LONG WAVE RADIO TUNER. A simple radio tuner for use with almost any amplifier. Kit £3·25.
INFRA RED BURGLAR ALARM. Uses an invisible, reflected beam to detect intruders when beam is intercepted—a power output is switched on for up to one minute. Kit £4·35.
CASSETTE TAPE POWER SUPPLIES. Two units to power a cassette tape player or recorder one from the mains. Price £2·50. Two from the car battery—price £1·40.
REACTOMATIC. A reaction testing game that can also be a quiz answering indicator. Kit £3·30.
ELECTRONIC MOUSE TRAP. A humane mouse trap—catches them alive so that you can release them in the park. Kit £3·35.
TRANSISTOR TESTER. A rapid tester for checking most transistors—tests transistors in an oscillator circuit and gives audible indication of goodness. Kit £2·15.
BIT SAVER. Prolongs life of soldering iron bit—prevents pitting. Kit £1·95.
ICE WARNING DEVICE. A device that can be set to indicate 'ice' conditions or similar temperature levels. Kit £1·55.
AUDIO COLOUR UNIT. Add a colour dimension to your audio equipment. This unit will modulate three lamps in accord with Bass—middle and treble notes of any music. Kit of parts £7·20.
U.H.F. T.V. AERIAL. A simple aerial for U.H.F. to reception on your band could improve your reception immensely. Kit £1·65.
DAMP LOCATOR. Easily carried in your pocket this little unit gives visible indication of damp. Kit £1·25.
ENLARGER & EXPOSURE METER. For D.I.Y. photographer £5·00.
EGG TIMER. Simple timer with audible warning. £4·15.

MULLARD UNILEX

This D.I.Y. Stereo Amplifier is still available complete at £7·00 for the four Mullard Modules, or Modules can be bought separately as follows: —4 watt amplifier module (2 required) Mullard Ref. No. E.P.9000—£1·60 each.
Pre amp module Mullard Ref. No. E.P.9001—£1·96 each.
Power module—Mullard Ref. No. E.P.9002—£2·58 each.
Central panel parts with escutcheon and ally faced knobs—£2·85

SPECIAL OFFER the complete Unilex with control panel and 2 matching speakers. **£14**

THYRISTOR LIGHT DIMMER



Domestic model for any lamp up to 250 watt. Mounted on switch plate to fit in place of standard switch. Virtually no radio interferences. Price £2·95. Industrial model 5 amp module with control knob £3 30.

DISTRIBUTION PANELS

Just what you need for work bench or lab. 4 × 13 amp sockets in metal box to take standard 13 amp fused plugs and on/off switch with neon warning light. Supplied complete with 6 feet of flex cable. Wired up ready to work. £2·50 plus 23p P. & I

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Miniature mains driven blower centrifugal type blower unit by Woods. Powerful but specially built for quiet running—driven by cushioned induction motor with specially built low noise bearings. Overall size 4½" × 4½" × 4". When mounted by flange, air is blown into the equipment but to suck air out, mount it from centre using clamp. Ideal for cooling electrical equipment or fitting into a cooker hood, film drying cabinet or for removing flux smoke when soldering etc. etc. A real bargain at £2·05.

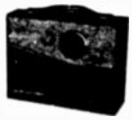
TEACH-IN '74

SOLID STATE DIMMER
STEREO HEADPHONE ADAPTOR

To receive parts for these and other feature projects send the quoted approximate amounts and any cash adjustment can be made later.

GOOD COMPANION

We can now offer these again in i.c. version using Ferranti ZN414 and Mullard AF Modules 1172. Excellent tone wood cabinet. Cabinet size approx. 11in wide × 8in. high × 3in. deep. Complete assembly instructions £5·75 plus 25p post and ins.



MIGHTY MIDGET

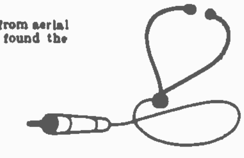
Probably the tiniest possible radio, as described in Practical Wireless, January '73. All electronic parts £2·20 post paid.

DRILL CONTROLLER
NEW IKW MODEL

Electronically changes speed from approximately 16 revs. to maximum. Full power at all speeds by finger-tip control. Kit includes all parts, case, everything and full instructions. £1·65 plus 13p post and insurance. Made up model also available. £2·50 plus 13p post & p.

RADIO STETHOSCOPE

Easiest way to fault find—traces signal from aerial to speaker—when signal stops you've found the fault. Use it on Radio, TV amplifier, anything — complete kit comprises two special transistors and all parts including probe tube and crystal earpiece. £2·20—twin stethoset instead of earpiece 83p extra—post and ins. 20p.



MULLARD AUDIO AMPLIFIERS

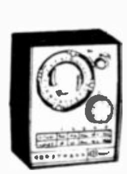
All in module form, each ready built complete with heat sinks and connection tags, data supplied.
Model 1153 500m watt power output 83p.
Model 1172 750m watt power output 94p.
Model EP9000 4 watt power output £1·66.
EP9001 Stereo preamp £2.
10% discount if 10 per type or more ordered.

HORTSMAN 24 HOUR TIME SWITCH

With 6 position programmer. When fitted to hot water systems this could programme as follows:—

Programme	Hot Water	Central Heating
0	Off	Off
1	Twice daily	Off
2	All day	Off
2	Twice daily	Twice daily
4	All day	All day
5	Continuously	Continuously

Suitable of course, to programme other than central heating and hot water, for instance, programme upstairs and downstairs electric heating or heating and cooling or taped music and radio. In fact there is no limit to the versatility of this Programmer. Mains operated—Size 3" × 3" × 2" deep as illustrated but less case. Price £3·50 each.



KITS FOR PREVIOUS PROJECTS CONT. FROM LEFT HAND COL.

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NIGHT LIGHT SWITCH. A simple control to dim a lamp. Kit £1·10.
GENERAL PURPOSE AMPLIFIER. An audio amplifier of reasonable quality for use with radio tuners—audio oscillators, record decks—electric guitars, etc. Kit £4·90.
HOME INTERCOM. Keep in touch with this simple, easily connected good quality two way intercom. Kit £4·00
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MINI ORGAN. A three octave, stylus operated organ—neatly and simply constructed on a printed circuit board. Kit £4 75.
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CASSETTE AMPLIFIER. Boosts the output from cassette tape recorders and transistor radios. Kit £4·50.
AUDIO SIGNAL MIXER. Where you want to mix speech and music, and to fade them in and out—no tape enthusiast should be without this. Kit £3·90
AUTO FAN. A thermostatic control for car engine fan, gives quicker warming up time, etc. Kit £2·35
SLAVE FLASH. Photos taken with a single flash have a "flat" appearance a second flash correctly positioned overcomes this. This unit enables a second (or third) flash to be automatically triggered. Kit £1 85.
ELECTRONIC DOORBELL. Not in fact a bell but an electronic circuit that produces an unusual sound when the button is pressed. Kit £4·00.
WAA WAA. Add another sound dimension to your guitar or organ. Kit £1 50.
I.C. RADIO. A fantastic personal radio uses a special I.E., is small, easy to build, yet gives excellent results. Kit £3·10.
AQUARIUM THERMOSTAT. A very sensitive electronic thermostat. Can also be used for other applications requiring fine control of temperature Kit £2·85.
TRAIN CONTROLLER. With most control there is considerable loss of power on low speeds— this unit overcomes this problem and makes slow speed realistic. Kit £3·15.

RECORD PLAYBACK HEADS (TRUVOX)

Individual prices of these are:—
2 track record playback heads 50p each.
4 track record playback heads 72p each.
Erase heads are also available separately.—
2 track 33p – 4 track 55p

AC CONDENSERS

In addition to the normal uses as motor starters, power factor correction etc. These make very good voltage droppers for working low voltage appliances from mains. The voltage working quoted is AC and condensers are usually suitable for working on DC at 2½ times the quoted AC voltage.

1·5 mfd 400v 28p	5 mfd 570v 66p	8 mfd 440v 88p
2 mfd 440v 33p	6·25 mfd 250v 55p	12 mfd 250v 77p
3·4 mfd 440v 44p		15 mfd 250v 88p
3·5 mfd 250v 33p	8 mfd 250v 55p	20 mfd 275v 99p

TINIEST AUDIO UNIT

Although only the same size as an Oxo cube these are completely self contained and comprise microphone, 3 transistor amplifier with volume control and battery compartment and finally a dynamic earpiece. All in a plastic case. Made by Ardent (Sold, we believe at over £50 each). These are really hearing aids complete except for the ear tube but we are not selling these as hearing aids only for the micro midget parts they contain Believed to be in perfect working order but not tested. Price £5·50 each.

MAINS MOTOR

Precision made—as used in record decks and tape recorders—ideal also for extractor fan, blower, heaters, etc. New and perfect. Snip at 65p Postage 20p for first one then 10p for each one ordered.
1" stackmotor 94p.
1½" stackmotor £1·10.

NEED A SPECIAL SWITCH

Double Leaf Contact. Very slight pressure closes both contacts. 8p each 10 for 60p. Plastic pushrod suitable for operating. 6p each. 10 for 54p.

8" · 5" P.M. SPEAKER. 15 ohm—£1·50. This is a good quality speaker by a famous maker High flux ideal for use with our Mullard 4 watt amplifier.
3 GANG TUNING CONDENSERS. 500pf each section ideal for transmitter or communications receiver. 61p.
16 TRACK TAPE HEAD for ½" or 1" tape. This is a brass encased tape head and measures approx ½" × ½" × ½". Resistance is approx. 20-0-20 ohms. These heads are beautifully made but we have no technical data, also have only a limited quantity. Price £5·50 each or 10 for £50.

TERMS:—10% discount if ten of an item ordered, send postage where quoted—other items, post free if order for these over £6·00 otherwise add 20p.

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The largest selection

EX COMPUTER BOARDS
Packed with transistors, diodes, capacitors and resistors—COMPONENT VALUE £1·50. 3 for ONLY 55p + p & p 30p
SPECIAL. As above PLUS Power Transistors ONLY 55p each + p & p 15p
STABILISED POWER MODULES
Complete with circuit diagrams, etc. 99p each + p & p 15p
PAXOLINE BOARDS 7½ × 9" approx. 4 for 30p + p & p 20p.

FIBRE-GLASS PRINTED CIRCUIT BOARDS
16½ × 4" approx. 2 for 55p

DECON-DALO 33pC Marker
Etch resistant printed circuit marker pen 90p each

VEROBOARDS
Packs containing approx., 50sq. ins. various sizes, all ·1 matric 55p

REPANCO CHOKES & COILS
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CH1. 2·5mH 25p CH2. 5·0mH 25p
CH3. 7·5mH 25p CH4. 10mH 25p
CH5. 1·5mH 25p
COILS
DRX1 Crystal set 56p DRR2 Dual range 45p

COIL FORMERS & CORES
NORMAN ¼" Cores & Formers 7p
⅜" Cores & Formers 8p

SWITCHES
DP/DT Toggle 25p SP/ST Toggle 18p

FUSES
1¼" and 20mm. 100mA, 200mA, 250mA, 500mA, 1A, 1·5A, 2A
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EARPHONES
Crystal 2·5mm plug 33p
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8 ohms 2·5mm plug 22p
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DYNAMIC MICROPHONES
B1223. 200 ohms plus on/off switch and 2·5mm and 3·5mm plugs £1·60

3-WAY STEREO HEAD-PHONE JUNCTION BOX
H1012 £1·87

2-WAY CROSSOVER NETWORK
K4007. 80 ohms Imp. Insertion loss 3dB £1·21

SELECTED RESISTORS
R1. Our mix, ¼ watt carbon—50 for 55p

CAR STEREO SPEAKERS
(Angled) £3·85 per pair.

BI-PAK
CATALOGUE AND LISTS
Send S.A.E. and 10p.

INSTRUMENT CASES

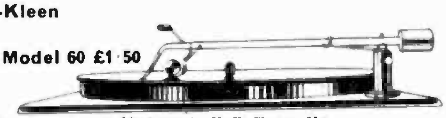
(Black Vinyl covered)

No.	Length		Width		Height	Price
BV1	8"	×	5½"	×	2"	90p
BV2	11"	×	6"	×	3"	£1·20

ALUMINIUM BOXES

BA1	5¼"	×	2¼"	×	1½"	42p
BA2	4"	×	4"	×	1½"	41p
BA3	4"	×	2¼"	×	1½"	41p
BA4	5¼"	×	4"	×	1½"	47p
BA5	4"	×	2½"	×	2"	41p
BA6	3"	×	2"	×	1"	34p
BA7	7"	×	5"	×	2½"	66p
BA8	8"	×	6"	×	3"	84p
BA9	6"	×	4"	×	2"	54p

BIB HI-FI ACCESSORIES
De Luxe Groov-Kleen
Model 42 £1·84
Chrome Finish Model 60 £1·50



Ref. 36A. Record/Stylus Cleaning Kit 28p
Ref. 43. Record Care Kit £2·35
Ref. 31. Cassette Head Cleaner 54p
Ref. 32. Tape editing Kit £1·54
Model 9. Wire Stripper/Cutter 83p
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Ref. 34. Cassette Case £1·27
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Model G. 18 watt £2·15
SK2. Soldering Kit £2·86
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22SWG 7oz 82p. 18SWG 22ft 28p
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ANTEX BITS and ELEMENTS

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102	For model CN240 3/32"	28p
102	For model CN240 3/16"	28p
1100	For model CCN240 3/32"	28p
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1020	For model G240 3/32"	28p
1021	For model G240 1/8"	28p
1022	For model G240 3/16"	28p
50	For model X25 3/32"	37p
51	For model X25 1/8"	37p
52	For model X25 3/16"	37p

ELEMENTS
ECN 240 £1·16 ECCN 240 £1·16
EG 240 £1·16 EX 25 £1·16

ANTEX HEAT SINKS 10p

V.A.T. included in all prices. Please add 10p P. & P. (U.K. only). Overseas orders—please add extra for postage.

NEW COMPONENT PAK BARGAINS

Pack No.	Qty.	Description	Price
C1	250	Resistors mixed values approx. count by weight	0·55
C2	200	Capacitors mixed values approx. count by weight	0·55
C3	50	Precision Resistors ·1%, ·01% mixed values	0·55
C4	75	⅛th W Resistors mixed preferred values	0·55
C5	5	Pieces assorted Ferrite Rods	0·55
C6	2	Tuning Gangs, MW/LW VHF	0·55
C7	1	Pack Wire 50 metres assorted colours	0·55
C8	10	Reed Switches	0·55
C9	3	Micro Switches	0·55
C10	15	Assorted Pots & Pre-Sets	0·55
C11	5	Jack Sockets 3 × 3·5m 2 × Standard Switch Type	0·55
C12	40	Paper Condensers preferred types mixed values	0·55
C13	20	Electrolytics Trans. types	0·55
C14	1	Pack assorted Hardware—Nuts/Bolts, Grommets etc.	0·55
C15	4	Mains Toggle Switches, 2 Amp D/P	0·55
C16	20	Assorted Tag strips & Panels	0·55
C17	10	Assorted Control Knobs	0·55
C18	4	Rotary Wave Change Switches	0·55
C19	3	Relays 6—24V Operating	0·55
C20	4	Sheets Copper Laminate approx. 10" × 7"	0·55

PLUGS AND SOCKETS
SOCKETS

PS 35 DIN	2 Pin (Speaker)	0·06
PS 36 DIN	3 Pin	0·10
PS 37 DIN	5 Pin 180°	0·10
PS 38 DIN	5 Pin 240°	0·10
PS 39	Jack 2·5mm Switched	0·09
PS 40	Jack 3·5mm Switched	0·10
PS 41	Jack ¼" Switched	0·17
PS 42	Jack Stereo Switched	0·26
PS 43	Phono Single	0·06
PS 44	Phono Double	0·10
PS 45	Car Aerial	0·09
PS 46	Co-Axial Surface	0·09
PS 47	Co-Axial Flush	0·14

INLINE SOCKETS

PS 21	D.I.N. 2 Pin (Speaker)	0·13
PS 22	D.I.N. 3 Pin	0·17
OS 23	D.I.N. 5 Pin 180°	0·17
PS 24	D.I.N. 5 Pin 240°	0·17
PS 25	Jack 2·5mm Plastic	0·10
PS 26	Jack 3·5mm Plastic	0·12
PS 27	Jack ¼" Plastic	0·24
PS 28	Jack ¼" Screened	0·28
PS 29	Jack Stereo Plastic	0·22
PS 30	Jack Stereo Screened	0·32
PS 31	Phono Screened	0·14
PS 32	Car Aerial	0·15
PS 33	Co-Axial	0·17

PLUGS

PS 1	D.I.N. 2 Pin (Speaker)	0·11
PS 2	D.I.N. 3 Pin	0·12
PS 3	D.I.N. 4 Pin	0·15
PS 4	D.I.N. 5 Pin 180°	0·14
PS 5	D.I.N. 5 Pin 240°	0·15
PS 6	D.I.N. 6 Pin	0·15
PS 7	S.I.N. 7 Pin	0·15
PS 8	Jack 2·5mm Screened	0·10
PS 9	Jack 3·5mm Plastic	0·09
PS 10	Jack 3·5mm Screened	0·12
PS 11	Jack ¼" Plastic	0·13
PS 12	Jack ¼" Screened	0·18
PS 13	Jack Stereo Screened	0·29
PS 14	Phono	0·06
PS 15	Car Aerial	0·15
PS 16	Co-Axial	0·10

CABLES

CP 1	Single Lapped Screen	0·06
CP 2	Twin Common Screen	0·08
CP 3	Stereo Screened	0·08
CP 4	Four Core Common Screen	0·23
CP 5	Four Core Individually Screened	0·30
CP 6	Microphone Fully Braided Cable	0·10
CP 7	Three Core Mains Cable	0·07
CP 8	Twin Oval Mains Cable	0·06
CP 9	Speaker Cable	0·04
CP 10	Low Loss Co-Axial	0·10

CARBON POTENTIOMETERS
Log and Lin
4·7K, 10K, 22K, 47K, 100K, 220K, 470K, 1M, 2M

VC 1	Single less Switch	0·14
VC 2	Single D.P. Switch	0·26
VC 3	Tandem Less Switch	0·44
VC 4	1K Lin Less Switch	0·14
VC 5	100K Log anti-Log	0·14

HORIZONTAL CARBON PRESETS
0·1 watt 0·06 each
100, 220, 470, 1K, 2·2K, 4·7K, 10K, 22K, 4K7, 100K, 220K, 470K, 1M, 2M, 4·7M

BOOK BARGAIN BUNDLE
8 Books comprising
2 Transistor Equivalent Books
1 Radio and Electronic Colour Code and Data Chart
1 Radio Valve Guide PLUS
3 other Constructional books on Receivers, FM Tuners, etc.
Also 1 General Constructional book
Value £3 Our Price £2 10p p & p

BP1	Handbook of Transistor Equivalents and Substitutes	40p
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BP3	Handbook of Tested Transistor Circuits	40p
BP4	International Handbook of the Worlds Short Wave, Medium and Long Wave Radio Stations and FM/TV Listings	35p
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BP7	Radio & Electronic Colour Codes and Data Chart	15p
BP8	Sound and Loudspeaker Manual	50p
BP9	38 Practical Tested Diode Circuits for the Home Constructor	35p
BP11	Practical Transistor Novelty Circuits	40p
129	Universal Gram-Motor Speed Indicator	8p
138	How to make FM & TV Aerials, Bands 1, 2 and 3	18p
141	Radio Servicing for Amateurs	20p
146	High Fidelity Loudspeaker Enclosures	37p
156	Transistor Circuits Manual No.1	15p
160	Coil Design & Constructional Manual	30p
161	Radio, TV and Electronics Data Book	25p
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175	Transistor Test Equipment and Servicing Manual	25p
176	Transistor Audio Amplifier Manual	40p
177	Modern Transistor Circuits for Beginners	40p
178	A Comprehensive Radio Valve Guide, Book 5	30p
183	How to Receive Foreign TV Programmes on your set by simple modifications	32p
185	Tested Shortwave Receiver Cuircuits using MAT's	30p
187	The TSL Mark '4' Valved FM Tuner and its construction	20p
196	Reactance-Frequency Chart for Audio & RF use	15p
	Resistor Colour Code Disc Calculator	10p

CARTRIDGES
ACOS GP91-1SC. 200mV at 1·2cms/sec £1·16
ACOS GP93-1. 280mV at 1cm/sec £1·65
ACOS GP96-1. 100mV at 1cm/sec £2·65
TTC J-2005. Crystal/Hi Output 95p
TTC J-20 10C Crystal/Hi Output Compatible £1·10
TTC J-200 CS Stereo/Hi Output £1·60
TTC J-2105 Ceramic/Med. Output £1·64

CARBON FILM RESISTORS
The E12 Range of Carbon Film Resistors, 1/8th watt available in PAKS of 50 pieces, assorted into the following groups:—
R1 50 Mixed 100 ohms–820 ohms 40p
R2 50 Mixed 1K ohms–8·2K ohms 40p
R3 50 Mixed 10K ohms–82K ohms 40p
R4 50 Mixed 100K ohms–1 Meg. ohms 40p
THESE ARE UNBEATABLE PRICES—LESS THAN 1p EACH INCL. V.A.T.

BI-PAK SUPERIOR QUALITY LOW - NOISE CASSETTES
C60, 32p C90, 41p C120, 52p

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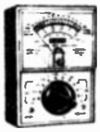
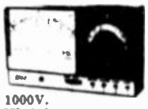
18 BALDOCK ST., WARE, Herts. (A10)
Open Mon.–Thurs. 9.15–6 p.m. Sat. 9.15–5.30. Late Night Shopping until 7 Fri. Tel. 61593

GWS G.W.SMITH&CO(RADIO)LTD

AUDIOTRONIC MODEL ATM.1

Top value 1000 o.p.v. pocket multimeter. Ranges: 0/10/50/250/1000v. AC and DC. DC Current 0-1mA/100mA. Resistance 0/150k ohms. Decibels −10 to +22dB. Size 90 × 60 × 28mm. Complete with test leads. £2·50. Post 15p.

LT601 MULTIMETER

New style 20,000 o.p.v. pocket multimeter. 5/25/50/250/500 / 2500 V. D.C. 10 / 50 / 100 / 500 / 1000V. A.C. 50μA / 250mA. 6K / 6 meg ohms. −20 to + 22 dB. £5·75. Post 20p.

MODEL TH-12

20,000 o.p.v. Overload protection. Slide switch selector 0 / ·25 / 2·5 / 10 / 50 / 250 / 1000V. D.C. 0 / 10 / 50 / 250 / 1000V. A.C. 0 / 50μA / 25 / 250mA. D.C. 0 / 3K / 30K / 300K / 3 meg − 20 to + 50dB £4·97. Post 15p.

RUSSIAN 22 RANGE MULTIMETER

Model U437 10,000 o.p.v. A first class versatile instrument manufactured in U.S.S.R. to the highest standards. Ranges: 2·5/10/50/250/500/1000v D.C. 2·5/10/50/250/500/1000v A.C. DC Current 100wA/1/10/100mA/1A. Resistance 300 ohms/3/30/300K/3m Ω. Complete with batteries, test leads, instructions and sturdy steel carrying case. OUR PRICE £4·95. P. & P. 25p

MODEL PL436

20k Ω/Volt D.C. 8k Ω/Volt AC. Mirror scale. ·6/3/12/30/120/600 V D.C. 3/30/120/600 V A.C. 50/600μA/60/600 mA. 10/100K/1 Meg/10 Meg Ω −20 to +46db. £6·97. P. & P. 12p.

MODEL 500

30,000 O.P.V. with overload protection mirror scale 0/·5/2·5/10/25/100/250/500/1,000v. D.C. 0/2·5/10/25/100/250/500/1,000V. A.C. 0/50μA/5/50/500mA. 12 amp. D.C. 0/60/K/6 Meg./60 Meg Ω £9·95. Post paid. Leather Case £1·75

U4312 MULTIMETER

Extremely sturdy instrument for general electrical use. 667 o.p.v. 0/·3/1·5/7·5/30/60/150/300/600/900 VDC and 75mV. 0/·3/1·5/7·5/30/60/150/300/600/900 VAC. 0/300μA/1·5/6/15/60/150/600MA/1·5/6 AMP. D.C. 0/1·5/6/15/60/150/600MA/1·5/6 AMP. AC. 0/200 Ω/3K/30K Ω. Accuracy DC 1%. AC 1·5%. Knife edge pointer, mirror scale. Complete with sturdy metal carrying case, leads and instructions. £9·75. P. & P. 25p.

HIOKI MODEL 700X

100,000 O.P.V. Overload protection. Mirror scale. ·3/·6/1·2/1·5/3/6/12/30/60/120/300/600/1200V DC 1·5/3/6/12/30/60/150/300/600 1200 V. A.C. 15/30μA/3/6/30/60/150/300mA 6/12 AMP. DC. 2K/200K/2 Meg/20 Meg ohm −20 to +63dB. £13·50. P. & P. 20p

MODEL C-7080 EN

Giant 6" mirror scale. 20,000 o.p.v. 0 / ·25 / 1 / 2·5 / 10 / 50 / 250 / 1000 / 5000V. D.C. 0 / 2·5 / 10 / 50 / 250 / 1000 / 5000V. A.C. 0 / 50μA / 1 / 10 / 100 / 500mA / 10 amp. D.C. 0 / 2K / 200K / 20 meg − 20 to + 50 dB. £13·95. Post 35p.

All prices are subject to 10% VAT

370 WTR MULTI-METER

Features A.C. current ranges. 20,000 o.p.v. 0/·5/2·5/10/50/250/500 1000 V. D.C. 0/2·5/10/50/250/500/1000V AC 0/50uA/1/10/100mA/1/10 Amp D.C. 0/100mA/1/10 Amp AC 0/5K/50K/500K/5 MEG/ 50 MEG. −20 +62db. £15. P. & P. 25p.

KAMODEN 72.200 MULTITESTER

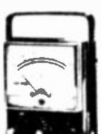
High sensitivity tester. 200,000 o.p.v. Overload protection. Mirror scale. Ranges: 0 / ·06 / ·3 / 3 / 30 / 120 / 600 / 1200V. D.C. 0 / 3 / 12 / 60 / 300 / 11,200V. A.C. 0 / 6μA / 1·2mA / 120mA / 600mA / 12A. D.C. 0 / 12A. A.C. −20 to +63dB. 0 / 2K / 200K / 2 meg / 200 meg ohms. £16·95. Post 30p.

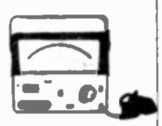
TMK LAB TESTER.

100,000 O.P.V. 6½in. Scale Buzzer Short Circuit Check. Sensitivity: 100,000 O.P.V. D.C. 5K/Volt A.C. D.C. Volts: ·5, 2·5, 10, 50, 250, 1,000 V. A.C. Volts: 3, 10, 25, 50, 250, 500, 1,000V. D.C. Current: 10, 100μA, 10, 100, 500mA, 2·5, 10 amp. Resistance: 1K, 10K, 100K, 10MEG, 100MEG Ω. Decibels: −10 to +49 db. Plastic Case with Carrying Handle. Size: 7½in. × 6¾in. × 3¼in. £18·95. P. & P. 25p.

Model S-100TR MULTIMETER/TRANSISTOR TESTER

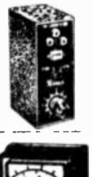
100,000 o.p.v. mirror scale/overload protection. 0/·12/·6/3/12/30/120/600 V DC. 0/6/30/120/600. V AC. 0/12/600μA/ 12/300mA/12 AMP DC. 0/10 K/1 MEG/100MEG. −20 to +50db. 0·01−2 MFD. Transistor tester measures Alpha, beta and Ico. Complete with batteries, instructions and leads. £13·50. P/P 25p.

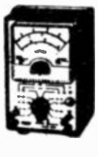
KAMODEN HM.350 TRANSISTOR TESTER

High quality instrument to test Reverse Leak current and DC current. Amplification factor of NPN, PNP, transistors, diodes, SCR's etc. 4" × 4¾" clear scale meter. Operates from internal batteries. Complete with instructions, leads and carrying handle. £12·50. Post 30p.

MODEL 449A IN CIRCUIT TRANSISTOR TESTER

Checks true A.C. beta in / out. Checks Icbo. Checks diodes in / out. Checks SCR, etc. Beta H1 10 − 500, LO 2 − 50. Icbo 0-5000μA. 220/240 V A.C. operation £17·50. Post 25p.

LB3 TRANSISTOR TESTER

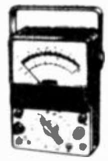
Tests ICO and B. PNP / NPN. Operates from 9v battery. Complete with all instructions, etc. £3·95. P. & P. 20p.

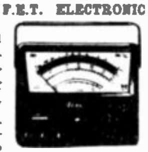
LB4 TRANSISTOR TESTER

Tests PNP or NPN transistors. Audio indication. Operates on two 1·5v batteries. Complete with all instructions, etc. £4·50. P. & P. 20p.

TE-40 HIGH SENSITIVITY A.C. VOLTMETER

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

TE-65 VALVE VOLTMETER

28 ranges. D.C. volts 1·5–1,500v. A.C. volts 1·5–1,500v. Resistance up to 1,000 megohms. 200/240v. A.C. operation. Complete with probe and instructions. £17·50. P. & P. 30p. Additional probes available: R.F. £2·12½; H.V. £2·50.

KAMODEN HM. 720B F.E.T. V.O.M.

Input impedance 10 meg ohms. Ranges: 0 / ·25 / 1 / 2·5 / 10 / 50 / 250 / 1000V. D.C. 0 / 2·5 / 10 / 50 / 250 1000V. A.C. 0 / 25μA / 2·5 / 25 / 250 MA D.C. − 20 to + 62dB 0 / 5K / 50K / 500K / 5meg 500meg ohms. £14·95. Post 30p

TMK MODEL 117 F.E.T. ELECTRONIC VOLTMETER

Battery operated, 11 meg input, 26 ranges. Large 4½" mirror scale. Size 5¼" × 4¾" × 2¼". DC VOLTS 0·3–1200V AC VOLTS 3–300V RMS. 8·0–800V P-P. DC CURRENT ·12–12MA. Resistance up to 2000M ohm. Decibels −20 to + 51dB. Complete with leads/instructions. £17·50. P. & P. 20p.

MODEL L-55 FET V.O.M.

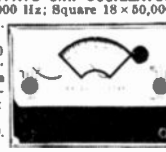
Input impedance 10 meg ohms. 0 / ·3 / 1·2 / 6 / 30 / 120 / 600V. D.C. 0 / 3 / 12 / 60 / 120 / 600V. A.C. 0 / 120μA / 120mA D.C. 0 / 1K / 100K / 10 meg /100 meg ohms £15·97. Post 15p.

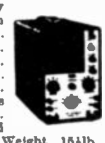
KAMODEN HMG-500 INSULATION RESISTANCE TESTER

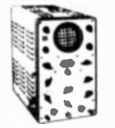
Range 0–1000 Megohms. 500 Volt. Battery operated. Wide range clear meter 4½" × 4". Complete with deluxe carrying case, batteries, instructions. £19·95. Post 30p

MODEL U4311 SUB-STANDARD MULTI-RANGE VOLT AMMETER

Sensitivity 330 ohms/Volt AC and DC. Accuracy 5% D.C. 1% AC. Scale length 165mm. 0/300/750μA/1·5 / 3 / 7·5 / 15 / 30 / 75 / 150 / 300 / 750mA / 1·5 / 3 / 7·5AMP DC 0 / 3 / 7·5 / 15 / 30 / 75 / 150 / 300 / 750mA / 1·5 / 3 / 7·5 AMP AC 0 / 75 / 150 / 300 / 750mV / 1·5 / 3 / 7·5 / 15 / 30 / 75 / 150 / 300 / 750V DC 0/750mV / 1·5 / 3 / 7·5 / 15 / 30 / 75 / 150 / 300 /750V AC. Automatic cut out. Supplied complete with test leads, manual and test certificates. £49·00. Post 50p.

BELCO AF-5A SOLID STATE SINE SQUARE WAVE C.R. OSCILLATOR
Sine 18 × 200,000 Hz; Square 18 × 50,000 Hz

Output max. + 10 dB. (10 K ohms) Operation internal batteries Attractive 2-tone case 7½" × 5" × 2". Price £17·50. Carr. 17½p.

TO-3 PORTABLE OSCILLOSCOPE

3in. tube, Y amp. Sensitivity 0·1v p-p/CM. Bandwidth 1·5 cps–1·5 MHz. Input imp. 2 meg Ω 25pF X amp. sensitivity 0·9v. p-p/CM. Bandwidth 1·5cps–800kHz. Input imp. 2 meg Ω 20pF. Time base. 5 ranges 10 cps 300 kHz. Synchronization. Internal/external. Illuminated scale 140 × 215 × 330 mm. Weight 15½lb. 220/240V. A.C. Supplied brand new with handbook. £52 50. Carr. 50p.

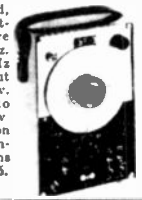
CI-5 PULSE OSCILLOSCOPE

For display of pulsed and periodic waveforms in electronic circuits. VERT. AMP. Bandwidth 10MHz. Sensitivity at 100KHz VRMS/mm. ·1-25; HOR. AMP. Bandwidth 500KHz. Sensitivity at 100KHz. V RMS/mm. ·3-25; Preset triggered sweep 1-3,000usec.; free running 20-200,000Hz in nine ranges. Calibrator pips. 220 × 360 × 430mm. 115-230V. AC operation. £39 00. Carr. paid.

RUSSIAN CI-16 DOUBLE BEAM OSCILLOSCOPE

5 mc/s Pass Band. Separate Y1 and Y2 amplifiers. Rectangular 5in. × 4in. C.R.T. Calibrated triggered sweep from ·2 u/sec. to 100 milli-sec. per cm. Free running time base 50 c/s-1 mc/s. Built-in time base calibrator and amplitude calibrator. Supplied complete with all accessories and instruction manual £87. Carr. Paid.

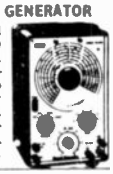
MODEL AT201 DECADE ATTENUATOR

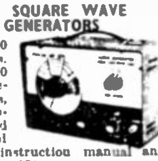
Frequency range 0–200KHz. Attenuator 0–111db. 0·1db step. Impedance 600 ohms. Max. input power 30dbm. Size 180 × 90 × 55mm. £12·50. Post 37p.

ARF-300 AF/RF SIGNAL GENERATOR

All transistorised, compact, fully portable. AF sine wave 18 Hz to 220 KHz. AF square wave 18 Hz to 100 KHz. Output sine / square 10v. P-P. RF 100 KHz to 200 MHz. Output 1v maximum. Operation 220/240v. AC. Complete with instructions and leads. £29·95. Post 50p.

MODEL TE.15 GRID DIP METER

Transistorised. Operates as Grid Dip, Oscillator, Absorption Wave Meter and Oscillating Detector. Frequency range 440Kc/s–280Mc/s in 6 coils. 500μA Meter. 9V battery operation. Size 180 × 80 × 40mm. £15·00. Post 20p.

TE-20D RF SIGNAL GENERATOR

Accurate wide range signal generator covering 120 Kc/s 500 Mc/s on 6 bands. Directly calibrated Variable R.F. attenuator, audio output. Xtal socket for calibration. 220/240V. A.C. Brand new with instructions £17·50. Carr. 37p. Size 140 × 215 × 170 mm.

TE22 SINE SQUARE WAVE AUDIO GENERATORS

Sine: 20cps to 200 kc/s on 4 bands. Square: 20cps to 30 kc/s. Output impedance 5,000 ohms, 200/250V. A.C. operation. Supplied brand new and guaranteed with instruction manual and leads. £17·50. Carr. 37½p.

AUTO TRANSFORMERS
0/115/250V. Step up or step down. Fully shrouded.

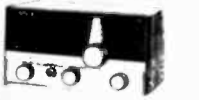
80 W	£2·35	P. & P. 18p
150 W	£3·00	P. & P. 18p
300 W	£4·00	P. & P. 23p
500 W	£5·80	P. & P. 33p
1000 W	£8·25	P. & P. 38p
1500 W	£11 25	P. & P. 43p
2250 W	£19·00	P. & P. 50p
5000 W	£40·00	P. & P. £1

MCA. 220 AUTOMATIC VOLTAGE STABILISER

Input 98 125 VAC or 176, 250VAC. Output 120VAC or 240VAC. 200VA rating. £11·97. Carr. 50p.

GWS G.W.SMITH & CO (RADIO) LTD

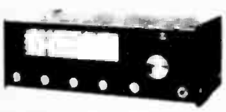
UNR 30 RECEIVER



4 Bands covering 550 kc/s-30 mc/s B.F.O. Built-in Speaker 220/240 v. A.C. Brand new with instructions.

Our Price **£15·75** Carr. 37p

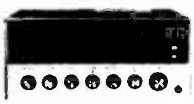
UR-1A RECEIVER



4 Bands covering 550 kc/s-30 mc/s. FET, S Meter. Variable BFO for SSB. Built-in Speaker, Bandspread, Sensitivity Control. 220/240 v. A.C. or 12 v. D.C. 12½in. x 4½in. x 7in. Brand new with instructions.

Our Price **£25·00** Carr. 37p

SKYWOOD CX203 RECEIVER



Solid state, 5 bands covering 200-420 KHz and ·55 to 30 MHz. Illuminated slide rule dial. Bandspread. Aerial tuning. BFO, AVC, ANL, "S" meter, AM/CW/SS B. Integrated speaker and phone socket. 220/240 v. A.C. or 12 v. D.C. Size 325 x 266 x 150 mm. Complete with instructions and circuit.

Our Price **£32·50** Carr. 50p

LAFAYETTE HA-600 RECEIVER

General coverage 150-400 kc/s, 550 kc/s-30 mc/s, FET front end, 2 mech. filters, product detector, variable B.F.O., noise limiter, S Meter Bandspread. RF Gain. 15in. x 9½in. x 8½in. 18 lb. 220/240 v. A.C. or 12 v. D.C. Brand new with instructions.

Our Price **£50·00** Carr. 50p

TRIO 9R59DS RECEIVER

4 bands covering 550 kc/s to 30 mc/s continuous and electrical bandspread on 10, 15, 20, 40 and 80 metres. 8 valve plus 7 diode circuit. 4/8 ohm output and phone jack. SSB-CW, ANL, Variable BFO. S meter. Sep. bandspread dial. IF frequency 445 kc/s, audio output 1·5w. Variable RF and AF gain controls 115/250 v. A.C. Size: 7in. x 13in. x 10in. with instruction manual.

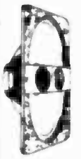
Our Price **£49·50** Carr. Paid.

FULL RANGE OF TRIO STOCKED

GWS

ALSO SEE PREVIOUS PAGES

EMI LOUDSPEAKERS



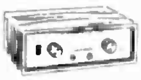
Model 350. 13" x 8" with single tweeter/crossover. 20-20,000 Hz. 15 watt RMS. Available 8 or 15 ohms. £7·25 each. P. & P. 37p. Model 450. 13" x 8" with twin tweeter/crossover. 55-13,000 Hz. 8 watt RMS. Available 8 or 15 ohms. £3·62 each. P. & P. 25p.

SPECIAL OFFER ! STEREO SPEAKERS

Matched pair of stereo bookshelf speakers. Deluxe teak veneered finish. Size 14½" x 9" x 7½". 8 ohms. 8 watt RMS. 16 watt peak. Complete with DIN lead.

Our Price **£12·95** Carr. 50p

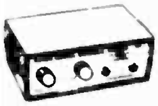
HA-10 STEREO HEADPHONE AMPLIFIER



All silicon transistor amplifier operates from magnetic, ceramic or tuner inputs with twin stereo headphone outputs and separate volume controls for each channel. Operates from 9v battery. Inputs 5MU/100MU. Output 50MW.

Our Price **£6·97** P. & P. 15p

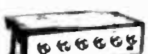
1021 STEREO LISTENING STATION



For balancing and gain selection of loudspeakers with additional facility for stereo headphone switching. 2 gain controls, speaker on-off slide switch, stereo headphone sockets. 6" x 4" x 2½".

Our Price **£2·25** P. & P. 15p

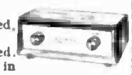
MP7 MIXER PREAMPLIFIER



5 microphone inputs each with individual gain controls enabling complete mixing facilities. Battery operated. 9½" x 5" x 3". Inputs Mics: 3 x 3mV 50K; 2 x 3mV 600 ohm. Phono meg. 4mV 50K. Phono ceramic 100mV 1 meg. Output 250mV 100K.

Our Price **£8·97** P. & P. 20p

EA.41 REVERBERATION AMPLIFIER



Self contained, transistorised, battery operated. Simply plug in microphone, guitar, etc., and output into your amplifier. Volume control, depth of reverberation control. Beautiful walnut cabinet. 7½ x 3 x 4½in.

Our Price **£7·50** P. & P. 15p

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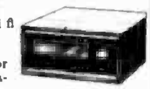
ACD.660 Stereo Cassette Deck

A beautifully styled 4 track stereo deck with an outstanding specification offered at a remarkably low price. Incorporates a host of features including switchable noise filter normal/chrome tape selector, twin VU meter, slider record/playback level controls, front panel headphone socket, recording indicator lamp, phono/Din line input sockets, 3.5mm mike input sockets etc. etc. Frequency response 100-8KHz (100-12KHz Cr02) S/N-45dB. Crosstalk 45dB. Separation-35dB. Noise limiter-6dB at 10KHz. Complete with phono connecting leads.

OUR PRICE **£39·50** Carr. & Ins.50p

AHP-8D 8 Track Stereo Tape Deck



Can be used with most hi fi amplifiers. Push button track selector and illuminated track indicators. Attractive cabinet with black and silver trim. Output level 750mV. AC 220/240v.

OUR PRICE **£11·95** P. & P. 50p.

AHP-8A 8 Track Stereo Tape Player

Incorporates built in amplifiers giving 2½ + 2½ watts rms output. Push button track selector, illuminated track indicators, slider controls for volume, balance and tone. Attractive cabinet with black and silver trim. Output impedance 8 ohms. AC 220/240v.

OUR PRICE **£17·25** P. & P. 50p.

Stereo Headphones

LSH.20 Individual volume controls Stereo mono switch. 8 ohms. 40-19,000 Hz. £3·50 P & P 30p

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LSH.60 3" speaker units. 8 ohms. 20-20,000 Hz. Complete with zipped carrying case. £8·50 P. & P. 30p

LQH.400 4-channel dynamic headphones. Each earpiece has 4 drive units. 4-32 ohms. 20-20,000 Hz. £9·95 P. & P. 30p

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Reduce tape hiss by 3dB at 600Hz, 6dB at 1200Hz and 10dB for all frequencies above 3000Hz. Size 16¾" x 8" x 3¼". AC 200/250v

PROCESS FOUR
For use with semi-professional tape recorders. Freq. res. 30Hz-20KHz ± 2dB. S/N better than 70dB. Full source tape monitoring. Record/Replay metering. Switchable multiplex filter. Supplied with test tape.

Our Price **£50·00** P & P 50p

PROCESS TWO
For use with cassette and tape recorders. Freq. res. 30Hz-20KHz ± 2dB. Off tape monitoring. Switchable multiplex filter. Two Dolby calibration meters. S/N better than 70dB. Supplied with test cassette or tape as required.

Our Price **£34·50** P & P 50p

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Portable twin track mono recorder with automatic recording level control. Built in speaker. Earpiece socket. Input for radio or record player. Fast forward and rewind. Output 500mW. AC 220/240v or 6v DC operation. Complete with remote control microphone, mains lead, earpiece and batteries.

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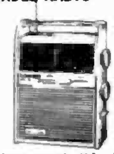
AMR-900 GLOBAL AM/FM PORTABLE RADIO

10 wavebands covering AM: 535-1605 kHz, LW: 150-380 kHz, MB 1·6-4·00 MHz, SW1: 4·0-8 MHz, SW2: 8·0-1·6 MHz, SW3: 16-24 MHz, PSB1: 30-50 MHz, PSB2: 148-174 MHz, FM 88-108 MHz, AIR: 108-136 MHz. Features time zone map and timing dial. Large clear scale. Telescopic aerial and built in aerial. AFC or FM. 6" x 4" speaker and personal earpiece. Battery/mains operation. Size: 345 x 133 x 305mm.

OUR PRICE **£36·00** P. & P. 50p.

AR.1000 SPORTSMAN AM/FM PORTABLE RADIO



5 wavebands covering AM 535-1065KHz. FM 88-108MHz. AIR 108-135MHz. PB 147-174MHz. WB 162. 5MHz. Large horizontal slide dial with logging scale. Slider volume and squelch controls. 7 section telescopic aerial for FM and built in ferrite bar for AM. AFC. 3in. speaker. Earpiece socket. Green leatherette covered cabinet with metal side panels. Size 152 x 79 x 219mm. Battery/mains operation.

OUR PRICE **£11·50** P. & P. 35p.

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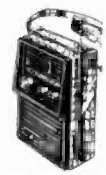

5 wavebands covering MW 535-1605KHz and FM 88-175MHz. All transistor. Battery or mains operation. Built in aerial and 8 section telescopic aerial. Complete with batteries, shoulder strap and earpiece.

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Push button tuning of one LW and five MW stations of your choice. 12v pos. or neg. earth. Complete with speaker, mounting brackets and instructions.

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12v neg. earth. Slider controls for Volume, Tone and Balance. Channel selector button with red pilot lamp, with speakers, mounting brackets and instructions.

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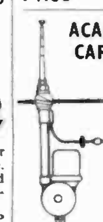

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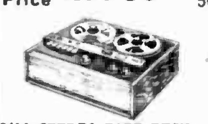

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Now built and used by thousands of satisfied customers. Features slim design overall size in cabinet 15½" x 2¾" x 6⅛". 6-IC's, 10 transistors, stabilisers Gardners low field transformer. Fibre Glass PC Panel, complete chassis work. Now available built and tested as well as in kit form. HIGH QUALITY & STABILITY ARE PREDOMINATE FEATURES — DEVELOPED BY TEXAS ENGINEERS FOR PERFORMANCE, RELIABILITY AND EASE OF CONSTRUCTION. FACILITIES. On/off switch indicator, headphones socket, separate treble, bass, volume and balance controls, scratch and rumble filters, mono/stereo switch, input selector: Mag. P.U., Radio Tuner, Aux. Can be altered for Mic., Tape, Tape-head, etc. Constructional details Ref. No. 21 30p. Distributed by Henry's throughout UK. FREE—Teak cabinet with complete kit. Kit price **£28·50** (+VAT+50p carr/packing) or built and tested **£35·00** (+VAT + 50p carr/packing) as illustrated.

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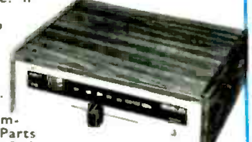
A completely new high stability stereo FM tuner Features variable capacity diode tuning, stabiliser power supply, IC Decoder, high gain low noise. IF stages. LED indicators. Tuning meter, AFC, easy to construct and use. Mains operated. Slim modern design with fibre glass PC, teak cabinet, etc. Available as a kit to build or ready built. Overall size 8" x 2½" x 6½". Produced to give high performance with a realistic price. (Parts list and constructional details Ref. No. 5 30p). Henry's are sole distributors UK and Europe.



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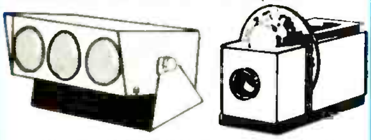

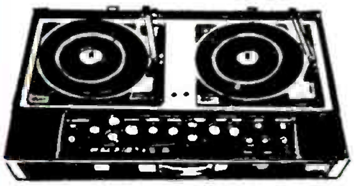

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Axcent 100	30 watt		8 ohms	£4·90
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