PARFITT

Inexpensive, easy to build projects

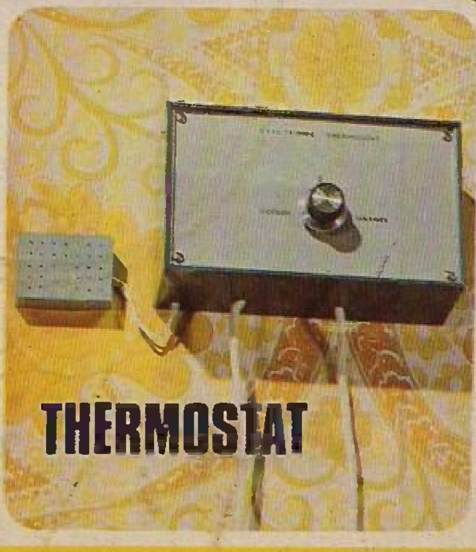
everyday electronics

JUNE 75

25p

This issue includes
INDEX for Vol. 3

...WHITE LINE FOLLOWER... WHITE LINE FOLLOWER... WHITE LINE FOLLOWER...



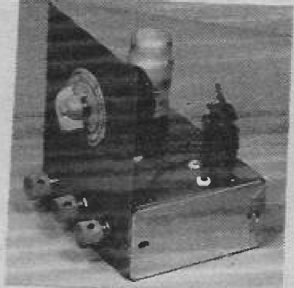
HOME RADIO (Components) LTD., Dept. EE, 234-240 London Road, Mitcham, CR4 3HD. Phone 01-648 8422

For Prices see Supplement

HOME RADIO (COMPONENTS) LTD.

CONSTRUCTIONAL KITS—*Continued*

KT4B. Radiokit No. 4B. A unique one valve model with world-wide range. Continuous coverage from approx. 10 metres to 47 metres, this covers the usual long-distance broadcasts. Band spread tuning. This set which was designed by us, uses only the finest components. Jackson and Wavemaster capacitors, Wearite P. Coils and Mazda valves. Great fun both to build and to use. Under favourable atmospheric conditions you will be able to hear such far off places as Moscow, Australia and America.



KT4B

AN ETCHING KIT

KT 253. Etching Kit. An ideal kit for the Constructor wishing to Etch his own Circuits. All essentials and detailed Instructions included in every Kit.

KT253

Contents:—

(1) Plastic Dish.
(2) Suitable pieces of copper clad board.
(3) Laminate cutter.
(4) Ferric Chloride.
(4A) Large Plastic Spoon.
(5) Decon Etch resist pen (An alternative may be supplied if this is not available). If at any time items are not available the kit will be supplied minus these articles and the price adjusted accordingly.
(6) Instructions (4 Pages).

94

ETCHING MATERIALS LISTED ON PAGE 95

Recently I've been telling you just why I've been a customer of Home Radio Components for so long. I've given special emphasis to their superb catalogue, and now its time to show you a typical page. The problem is . . . which one? There are 240 to choose from—for example, 17 pages of capacitors, 6 of resistors, 10 of switches and 8 of stylii. These are run-of-the-mill things, but here's a page that's specially interesting . . . page 94, showing a Short Wave Kit and an Etching Kit.

The managing director of Home Radio Components tells me there's quite a story behind these items. Briefly, Home Radio Components always listed a S.W. Kit, but eventually the firm making them ceased trading so H.R.C. decided to produce their own. When they looked around for an Etching Kit they were unable to find any at a sensible price, so again they said "Right, we'll make our own!" Sounds simple, but the managing director told me that if you produce any kit within 12 months of deciding to go ahead you're doing very well. "As for the problems of producing an Etching Kit," he said, "I could write a book about it!"

Incidentally, if you want to order either of these kits the prices are:

KT4B. S.W. Kit £4·75 plus VAT, plus 35p for p & p.
KT253 Etching Kit £3·75 plus VAT, plus 35p for p & p.

In any case, you'll surely want to study all the other pages in this famous catalogue. There are getting on for 2,000 illustrations by the way. Simply send the coupon below, with cheque or PO for 98p (65p plus 33p for post, packing and insurance). The catalogue contains 14 vouchers, each worth 5p when used as directed, so you can soon recover 70 pence of your investment. You just can't go wrong!

65p.

plus 33p POST AND PACKING

Send off the coupon today.

The price of 98p applies only to customers in the U.K and to BFPO Addresses.

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SPECIAL RESISTOR KITS (Prices include post & packing)

10E12 ¼W KIT: 10 of each E12 value, 22 ohms—1M, a total of 570 (CARBON FILM 5%), £3·85 net
10E12 ½W KIT: 10 of each E12 value, 22 ohms—1M, a total of 570 (CARBON FILM 5%), £3·95 net
25E12 ¼W KIT: 25 of each E12 value, 22 ohms—1M, a total of 1425 (CARBON FILM 5%), £9·00 net
25E12 ½W KIT: 25 of each E12 value, 22 ohms—1M, a total of 1425 (CARBON FILM 5%), £9·00 net
5 ⅛W KIT: 5 of each E12 value, 10 ohms—1M, a total of 305 (METAL FILM 5%), £3·45 net
DUE TO CURRENT WORLD SHORTAGES, RESISTOR KITS MAY TEMPORARILY CONTAIN WATTAGE OR VALUE SUBSTITUTIONS.

MULLARD POLYESTER CAPACITORS C280 SERIES

250V P.C. Mounting: 0·01µF, 0·015µF, 0·022µF, 0·033µF, 0·047µF, 3½p. 0·068µF, 0·1µF, 4½p. 0·15µF, 5p. 0·22µF, 6p. 0·33µF, 8p. 0·47µF, 10p. 0·68µF, 13p. 1µF, 16p. 1·5µF, 24p. 2·2µF, 27p.

MULLARD POLYESTER CAPACITORS C296 SERIES

400V: 0·001µF, 0·0015µF, 0·0022µF, 0·0033µF, 0·0047µF, 3p. 0·0068µF, 0·01µF, 0·015µF, 0·022µF, 0·033µF, 3½p. 0·047µF, 0·068µF, 0·1µF, 4½p. 0·15µF, 7p. 0·22µF, 9p. 0·33µF, 13p. 0·47µF, 15p.
160V: 0·01µF, 0·015µF, 0·022µF, 3½p. 0·047µF, 0·068µF, 4p. 0·1µF, 4½p. 0·15µF, 5½p. 0·22µF, 6p. 0·33µF, 7p. 0·47µF, 9p. 0·68µF, 13p. 1µF, 15p.

MINIATURE CERAMIC PLATE CAPACITORS

50V: (pF) 22, 27, 33, 39, 47, 56, 68, 82, 100, 120, 150, 180, 220, 270, 330, 390, 470, 560, 680, 820, 1K, 1K5, 2K2, 3K3, 4K7, 6K8, (µF) 0·01, 0·015, 0·022, 0·033, 0·047, 2½p. each. 0·1, 30V, 5p.

POLYSTYRENE CAPACITORS 160V 5%

(pF) 10, 15, 22, 33, 47, 68, 100, 150, 220, 330, 470, 680, 1000, 1500, 2200, 3300, 4700, 6800, 10,000, 4½p.

RESISTORS

CF—High Stab Carbon Film, 5% MF—High Stab Metal Film, 5%.

W.	Type	Range	1–99	100–499	500–999	1000+	Size mm
⅛	CF	22–1M	1	0·80	0·65	0·60	2·4x7·5
¼	CF	22-2M2	1	0·80	0·65	0·60	3·9x10·5
½	CF	22-1M	1	0·80	0·65	0·60	5·5x16
⅛	MF	10-2M7	2	1·7	1·4	1·2	3x7
½	MF	10-2M2	2	1·6	1·3	1·1	4·2x10·8
1	MF	10-10M	3	1·98	1·81	1·65	6·6x13
2	MF	10-10M	4·5	3·52	3·08	2·75	8x17·5

For value mixing prices, please refer to our catalogue. (price in pence each)
VALUES AVAILABLE—E12 Series only. (Net prices above 100.)

PRESET SKELETON POTENTIOMETERS

MINIATURE 0·25W Vertical or horizontal 7p each 1K, 2K2, 4K7, 10K, etc. up to 1M Ω
SUB-MIN 0·05W Vertical, 100 Ω to 220K Ω 7p each

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LEIGHTON BUZZARD, BEDS.
Tel. Leighton Buzzard 2316 (Std. Code 05253)
CATALOGUE No. 4—20p

Miniature Mullard Electrolytics

1·0µF	63V	7p	68µF	63V	14p
1·5µF	63V	7p	100µF	10V	7p
2·2µF	63V	7p	100µF	25V	7p
3·3µF	63V	7p	100µF	63V	17p
4·7µF	63V	7p	150µF	16V	7p
6·8µF	63V	7p	150µF	63V	17p
10µF	25V	7p	220µF	6·4V	7p
10µF	63V	7p	220µF	10V	7p
15µF	16V	7p	220µF	16V	8p
15µF	63V	7p	220µF	63V	25p
16µF	40V	7p	330µF	16V	14p
22µF	25V	7p	330µF	63V	28p
22µF	63V	7p	470µF	6·4V	8p
32µF	10V	7p	470µF	40V	25p
33µF	16V	7p	680µF	16V	17p
33µF	40V	7p	680µF	40V	28p
47µF	10V	7p	1000µF	16V	25p
47µF	25V	7p	1000µF	25V	28p
47µF	63V	8p	1500µF	6·4	17p
68µF	16V	7p	1500µF	16V	28p
			2200µF	10V	28p
			3300µF	6·4	28p

VEROBOARD	0·1	0·15
2½ x 5"	36p	36p
2½ x 3¾"	33p	25p
3¾ x 5"	42p	46p
3¾ x 3¾"	36p	36p
2½ x 1"	10p	9p
2½ x 5" (Plain)	—	19p
2½ x 3¾" (Plain)	—	16p
5 x 3¾" (Plain)	—	29p
Insertion tool	73p	73p
Track Cutter	56p	56p
Pins, Pkt. 50	22p	22p

TRANSISTORS

AC127	21p	BC212L	13p
AC128	22p	BC213L	13p
BC107	12p	BC214L	18p
BC108	12p	OC44	19p
BC109	13p	OC71	13p
BC148	13p	OC81	17p
BC149	13p	OC170	29p
BC182L	13p	TIS43	34p
BC183L	13p	2N2926	13p
BC184L	14p	2N3702	14p

POTENTIOMETERS

Carbon Track 5K Ω to 2M Ω, log or lin. Single, 17½p Dual Gang 43p. Log Single with switch 28p
Slider Pots. 10K, 100K, 500K, 30mm, 34p, 45mm, 47p, 60mm, 55p.

DIODES	
IN4001	6½p
IN4002	7½p
IN4003	9p
IN4004	9½p
IN4005	12p
IN4006	14p
IN914	7p
IN916	7p
BA100	10p
OA5	42p
OA47	9p
OA81	11p
OA200	8p

PLUGS	
DIN 2 Pin	12p
3 Pin	13p
5 Pin 180°	16p
Std. Jack	20p
2.5mm Jack	13p
Phono	7p
SOCKETS	
DIN 2 Pin	10p
3 Pin	10p
5 Pin 180°	12p
Std. Jack	18p
2.5mm Jack	13p
Phono	7p

ELECTROLYTIC CAPACITORS. Tubular & Large Cans (uF/V): 1/25, 2/25, 4/25, 4·7/10, 5/25, 8/25, 10/10, 10/50, 16/25, 22/63, 25/25, 25/50, 32/25, 50/25, 100/10, 100/25, 7p. 50/50, 8p. 100/50, 200/25, 10p. 250/50, 18p. 500/10, 8p. 500/25, 17p. 500/50, 25p. 1000/10, 17p. 1000/25, 25p. 1000/50, 40p. 2000/10, 20p. 1000/100 90p. 2000/25, 30p. 2000/100, 95p. 2500/25, 38p. 2500/50, 68p. 3000/50, 80p. 5000/25, 69p. 5000/50, £1·20.

HI-VOLT: 8/350, 23p. 16/350 35p. 32/350, 38p. 50/250, 27p. 100/100, 27p. 100/250, 40p. 32/500, 46p. 16 + 32 + 32/350, 65p.

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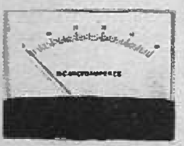
STOP PRESS
Our Retail Shop in now open in North St., Leighton Buzzard

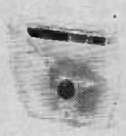
Screened Wire, Metre	7p
Twin Screened Wire, Metre	13p
Stereo Screened Wire, Metre	13p
Connecting Wire, All colours, Metre	2½p
Neon Bulb, 90V Wire Ended	5 for 25p
Panel Neon, 240V Red, Amber, Clear	21p

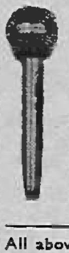
5E12 ½W METAL FILM. 5 each Value 10Ω-1M. Total of 305 £3·75. NET



4½in x 3¼in METER. 30µA, 50µA or 100µA, £3·85. P. & P. 11p.

TAPE RECORDER LEVEL METER
500µA, 70p
P. & P. 5p.





CARDIOID DYNAMIC MICROPHONE
Model UD-130. Frequency response 50–15,000c/s. Impedance Dual 50K and 600 ohms, £6·55. P. & P. 11p.

42 x 42mm METERS 100µA, 500µA, 1mA, 500mA **£2·76**, 11p P. & P.

60 x 45mm METERS 50µA, 100µA, 500µA and 1mA **VU METER £2·92**, 11p P. & P.

EDGEWISE METERS, 90mm x 34mm, 1mA £3·40, 11p P. & P.

MULTI-METER
Model ITI-2
20,000 ohm/volt, £6·90.
P. & P. 15p.

3 WATT STEREO AMPLIFIER
1½W PER CHANNEL
£4·30. P. & P. 10p.

All above prices include 8% V.A.T. LARGE S.A.E. for List No. 11. Special prices for quantity quoted on request.

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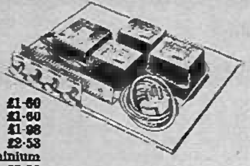
NEW ITEMS THIS MONTH

The bargains in this column are just some of the items which appeared in the April supplement to our catalogue. You can receive this catalogue and the next 12 supplements by sending £1.

Miniature microswitch with roller, Cherry ref. no. E62, size approx. ½" long × ½" high × ⅛" thick with steel roller on ⅜" long actuating lever. **25p each.**
Triac, ex unused computer American "GE" ref. no. SC 40D, this is a 600v 12 amp triac. A snip at £1·40.
Rectifier, American "GE", 100v 10 amp. 65p each.
Computer condensers, American made Sangamo, their type DCM: 21,500 mfd, 35v DC working with mounting clip and terminal sockets. Price £1 each + 25p post.
Reel to reel tapes, pre-recorded with classic and light music, new in perspex type storage box. 10 different titles (our assortment). £5 the lot, which makes them worth buying even if you do not like the music recorded on them. Please add 30p post. 50 all different £25.
Multi-voltage transformer 13 watts, an extremely versatile transformer and it is quite surprising the number of different voltages which may be obtained by using its two windings or parts of these windings in assisting or opposing modes. In addition to these, such voltages as 20-0-20 or 25-0-25 or 130-0-130 may be obtained. The two secondary windings are (1) 50v tapped at 30v and (2) 260v tapped at 240, 220, 200 and 130. Special snip price, only £1 + 30p post.
Ring main cable. Springtime is the time for alterations at home and if you are contemplating any lighting or heating alterations, then note we have good quality ring main cable 13 amp twin and earth, price 15p per metre, cut to your length, or £11·75 per 100 metres + £1 post.
Ditto for lighting. 12p per metre, cut to your length, or £7·75 per 100 metres. Also for ring mains etc. we have junction boxes at 14p each, 13 amp ring main sockets, flush mounting, white, at 40p each, brown at 25p each or brown switched at 30p each. 13 amp 2 gang sockets, brown, unswitched, at 60p each. 5 amp 3 pin sockets, white at 25p each, switched 30p. White spur boxes 20p each—white spur with 13 amp socket 50p.
3KW tangential heaters. We have had a further small delivery of these and can once again supply. Price, a little up unfortunately, now £4·80 + 60p post. Control switch 55p. Knob for same 25p.
Break-down unit, contains a whole range of most useful parts some of which are as follows—66 silicon diodes equivalent OA91. 68 resistors, mostly ½ watt 5% covering a wide range of values. 4 × ·1 mfd 400v condensers. 15 × ·01 mfd 100v condensers. 2 RF chokes. 8 × B9 valve holders. 1 × 4H choke. 1 × 115v transformer. 1 boxed unit containing 4 delay lines. Tag panels, trimmer condensers, suppressors, all mounted up on a useful chassis sized approx. 9" × 5" × 7". Offered at only 75p—the 66 diodes would cost at least 10 times this amount, so this is obviously a snip not to be missed. Post and packing 60p.
Waterproof 3 core leads for lawn mowers etc., new colour code, 5A rating, this is a perfectly standard pvc circular flex which will cost you 15p per metre in you local shop. Offered at the special price of £1·85 per 25 metre length + 30p post. Fix a 13 amp socket to a cable drum, wind this lead round it and terminate with a 3 amp rubber covered plug (available, price 40p) and you have a very useful extension lead.
Acquarium thermostat, in a sealed glass tube, but adjustable over the tropical fish range. Price £1 each.
Computer boards with ICs. We guarantee each board have at least 15 ICs, the boards are in tip top condition, as far as we know they were never put into service. Price 75p each.
Computer cooling fans, the famous Plannair, these are a six bladed 4½" fan rotating at approx. 3000 revs per minute, in a die cast case sized approx. 5" square with 4 fixing holes and cable entry box. Now new, but any not in perfect working order would be replaced. Price £3 each + 30p post.
Double-ended mains motors, special snip this month! It has a normal induction motor, not high powered but quite suitable for operating a fan in a heater or cooker hood or similar. This has the advantage that having a spindle from each end thus any fan blade should be right. Another feature is that this has 4 mounting feet. Special price, only 55p each.
Slot meter. Another special bargain this month because of its high and useful breakdown value is the slot meter. (a) It is in a useful box with lock, size approx. 8" × 3" × 4" (b) it has a Sangamo motor of 1 rev per hour which the makers price is in excess of £3 (c) it has 3 digit counter and (d) it has a coin switch mechanism. Undoubtedly an unrepeatable bargain at £2 + 30p post.
High power battery motor, 12v operated, strong enough to power a motor mower, go-cart or similar. Speed easily variable. These motors can also be used as a brake for any rotating machine, simply by coupling the spindle to the machine and short-circuiting the windings by a variable resistance, price £2·50.
Transistor type 2N3055, thoroughly checked, for high gain, suitable for fluorescent lighting in verters etc. 45p each.
Relay "elasta" Swiss made with watchmaker's precision, 1600 ohm coil operates heavy duty gold or silver contacts, one set changeover and two other sets open or relay closing. A really high-class relay, supplied in a transparent plastic box which can be used as a dust cover. Do not miss this bargain at 55p.
2 circuit toggle switch normal panel mounting through ½" hole, one circuit changeover, the other circuit simply on-off. 20p each.

MULLARD UNILEX STEREO. SYSTEM



There is no doubt that it is a good system, we believe that for the money it is without comparison. We demonstrate gladly at our Tamworth Road depot. Prices of the individual items for this:

1 Unilex Amplifier	Ref. EP.9000	£1·60
1 Unilex Amplifier	Ref. EP.9000	£1·60
1 Unilex Pre-Amp	Ref. EP.9001	£1·98
1 Unilex Power Unit	Ref. EP.9002	£2·53
1 Control panel kit with spun aluminium faced knobs		£3·80

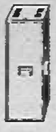
Pair of 15 ohm speakers made by Goodmans are also available if required, price £3·30 the pair. No extra postage if ordered with the above, otherwise add 25p.

SPECIAL PRICES TO COLLEGES AND INSTITUTIONS WISHING TO INCLUDE THIS KIT IN THEIR CURRICULUM.

SMITHS CENTRAL HEATING CONTROLLER

Push button gives 10 variations as follows:—(1) continuous hot water and continuous central heating (2) continuous hot water but central heating off at night (3) continuous hot water but central heating on only for 2 periods during the day (4) hot water and central heating both on but day time only (5) hot water all day but central heating only for 2 periods during the day (6) hot water and central heating on for 2 periods during the day time only—then for summer time use with central heating off (7) hot water continuous (8) hot water day time only (9) hot water twice daily (10) everything off. A handsome looking unit with 24 hour movement and the switches and other parts necessary to select the desired programme of heating. Supplied complete with wiring diagram. Originally sold, we believe, at over £15—we offer these, while stocks last, at £5·95 each, post 30p.

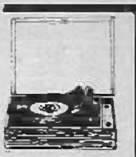
WALL THERMOSTATS



Wall mounting and in a handsome plastic case. (Cream and beige). Adjustable by slider (lockable) and may be set to control temperatures from around freezing through to 30°C. The slide panel is engraved and indicates (frost), (warm), (very warm), etc. The thermostat will control heaters, etc., up to 15 amp at normal mains voltage and is ideal for living room, bedroom and greenhouse, etc. Price £1·65. Don't miss this.

THIS MONTH'S SNIP

Latest BSR Record Changer with ceramic Stereo Cartridge £8·95 andif purchased at the same time teak veneered wooden plinth and Perspex cover for only £4·00 instead of £4·95 P.&P. £1 on one or both items.

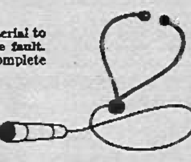


TRANSISTOR ASSISTED CAR IGNITION

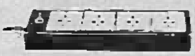
This system which has proved to be efficient and reliable, was described in the April *Wireless World*. We can supply kit of parts. Price £5·56 plus 30p post. When ordering please state whether for positive or negative systems.

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 stetho-set instead of earpiece 88p extra post and ins. 20p.



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. £2·75 plus 40p P. & P.

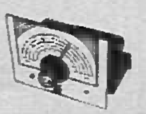
WHITE LINE FOLLOWER MULTIMETER SENSITER

I.C. THERMOSTAT

To quickly receive parts to construct these projects simply send the estimated cost as shown—any price adjustments can be made later.

SHORTWAVE CRYSTAL SET

Although this uses no battery it gives really amazing results. You will receive an amazing assortment of stations over the 19, 25, 31, 39 metre bands-Kit contains chassis front panel and all the parts, £1·25—crystal earphone 50p.



INSTANT START FLUORESCENT LIGHTING BARGAINS

Starterless control gear, complete with tube ends and tube clips for window lighting, signs, fascias, etc. 4 ft. 40 w. £1·50; 5 ft. 65w. £1·60; 5 ft. 80w. £1·75; 6 ft. 80w. £1·95; and for pairs as follows:—twin 2 ft. 20w. £2·55; twin 3 ft. 30w. £2·75; twin 4 ft. 40w. £2·95; twin 5 ft. 65w. £3·25; twin 5 ft. 80w. £3·95; twin 8 ft. 125w. £4·50. These are about one half of maker's current prices and can't be repeated once stocks are cleared. Please add 30p per piece to cover postage or carriage.

MAINS TRANSFORMERS

All standard 230-250 volt primaries.

		£ p
1v	1 amp (special)	1·75
2·4v	5 amp ..	·85
6·3v	2 amp ..	1·00
6·3v	3 amp ..	1·50
9v	1 amp ..	·95
9v	3·5 amp ..	1·95
12v	1½ amp ..	1·50
12v	1 amp ..	1·00
6·5v-0-6·5v	1 amp ..	1·35
18v	1 amp ..	1·25
20v	½ amp ..	1·00
24v	1 amp ..	1·50
24v	3 amp ..	3·50
12·0-12v	50mA ..	1·20
6-0-6v	50mA ..	1·20
8-0-8v	½ amp ..	1·25
18-0-18v	2 amps ..	3·50
25v	1½ amp ..	1·95
50v 2 amp & 6·3v ..	1 amp ..	4·50
60v 5 amp & 5v ..	1 amp ..	7·50
27v	8 amp ..	4·50
30v	37 amp ..	22·00
80v tapped 75v & 70v	4 amp ..	5·50
230v-60mA & 6·3v ..	1·5 amps	1·75
275-0-275v at 90mA & 6·4v	3 amps ..	2·25
EHT Transformer 5000v 23mA	(intermittent)	5·50
Charger Transformers		
6v and 12v	2 amps ..	1·25
6v and 12v	3 amps ..	2·25
6v and 12v	5 amps ..	3·50

DEDUCT 10% IF YOU ORDER 10 OR MORE OF ONE TYPE, ADD 35p PER TRANSFORMER IF NOT COLLECTING.

RELAY BARGAIN

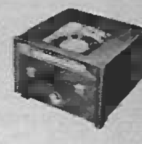
Type 600 relay, 2 changeover one open and one closed contact. Twin 500 ohm coils make this suitable or closing off DC 6v, DC 12v, DC 24v or AC mains using resistor and rectifier. 33p each. Resistor and rectifier 20p extra.

BLACK LIGHT

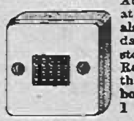
As used in discotheques and for stage effects, etc. Virtually no white light appears until the rays impinge on luminous paint or white shirts, etc. We offer 12" 8w tubes complete with starter, choke, lamp-holders and starter-holder. Price £2·75 + 30p post. Tubes only £2 + 30p post.

TAPE DECK

In metal case with carrying handle, heavy fly wheel and capstan drive. Tape speed 3¾. Mains operated on metal platform with tape head and guide. Not new but guaranteed good working order. Price £1·95 plus £1 post and insurance.



LIGHT SWITCH



Automatically switches on lights at dusk and off at dawn. Can also be used where light and dark is a convenient way to stop and start an operation. Requires only a pair of wires to the normal switch. In bakelite box, normal switch-plate size. 1 amp model £2·95.

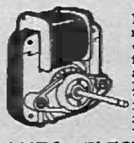
MAINS TRANSISTOR POWER PACK

Designed to operate transistor sets and amplifiers. Adjustable output 6v., 9v., 12 volts for up to 500mA (class B working). Takes the place of any of the following batteries: PP1, PP3, PP4, PP6, PP7, PP9 and others. Kit comprises: main transformer rectifier, smoothing and load resistor, condensers and instructions. Real snip at only £1·20.

SOUND TO LIGHT UNIT

Add colour or white light to your amplifier. Will operate 1, 2 or 3 lamps (maximum 450w). Unit in Box all ready to work. £7·95 plus 95p VAT and postage.

MAINS MOTOR



Precision made—as used in record decks and tape recorders—ideal also for extractor fans, blower, heaters, etc. New and perfect. Snip at 75p Postage 20p for first one the 10p for each one ordered.
1" stackmotor £1·04.
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with dashboard control switch—fully extendable to 40in or fully retractable. Suitable for 12V positive or negative earth. Supplied complete with fitting instructions and ready wired dashboard switch. £6·95 plus 45p post and insurance.

TERMS:—
ADD V.A.T.
Send postage where quoted—other items, post free if order for these items is £6·00, otherwise add 45p.

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500μF 50v. Elect. 10p each

DECON-DALO 33PC Marker
Etch resistant printed circuit marker pen 99p each

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

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RF Chokes
CH1. 2·5mH 29p CH2. 5·0mH 30p
CH3. 7·5mH 31p CH4. 10mH 33p
CH5. 1·5mH 28p
COILS
DRX1 Crystal set 31p DRR2 Dual range 45p

COIL FORMERS & CORES
NORMAN ¼" Cores & Formers 8p
⅜" Cores & Formers 10p

SWITCHES
DP/DT Toggle 36p SP/ST Toggle 30p

FUSES
1¼" and 20mm. 100mA, 200mA, 250mA, 500mA, 1A, 1·5A, 2A
QUICK-BLOW 5p ea.

EARPHONES
Crystal 2·5mm plug 42p
Crystal 3·5mm plug 42p
8 ohms 2·5mm plug 22p
8 ohms 3·5mm plug 22p

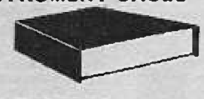
DYNAMIC MICROPHONES
B1223. 200 ohms plus on/off switch and 2·5mm and 3·5mm plugs £1·85

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

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

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

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

INSTRUMENT CASES


(Black Vinyl covered)

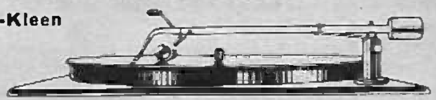
No.	Length		Width		Height	Price
BV1	8"	×	5¼"	×	2"	£1·35
BV2	11"	×	6"	×	3"	£1·75

ALUMINIUM BOXES

BA1	5¼"	×	2¼"	×	1½"	49p
BA2	4"	×	4"	×	1½"	49p
BA3	4"	×	2¼"	×	1½"	49p
BA4	5¼"	×	4"	×	1½"	58p
BA5	4"	×	2½"	×	2"	49p
BA6	3"	×	2"	×	1"	42p
BA7	7"	×	5"	×	2½"	85p
BA8	8"	×	6"	×	3"	£1·10
BA9	6"	×	4"	×	2"	70p

P & P 15p on each box

BIB HI-FI ACCESSORIES
De Luxe Groov-Kleen
Model 42 £1·95
Chrome Finish
Model 60 £1·50



Ref. B Stylus & Turntable Cleaning Kit 34p
Ref. 36A. Record/Stylus Cleaning Kit 33p
Ref. 43. Record Care Kit £2·42
Ref. 31. Cassette Head Cleaner 58p
Ref. 32. Tape editing Kit £1·68
Model 9. Wire Stripper/Cutter 83p
Ref. 46. Spirit level 62p
Ref. P. Hi-Fi Cleaner 31p
Ref. 32A. Stylus Balance £1·37
Ref. J. Tape Head Cleaning Kit 62p
Ref. 56. Hi-Fi Stereo Hints & Tips 42p
Ref. 45. Auto changer groove cleaner £1·08

ANTEX SOLDERING IRONS
X25. 25 watt £2·05
CCN 240. 15 watt £2·48
Model G. 18 watt £2·26
SK2. Soldering Kit £3·25
STANDS: ST3, Suitable for all models £1
SOLDER: 18SWG Multicore 7oz £1·61
22SWG 7oz £1·61. 18SWG 22ft 51p
22SWG Tube 33p

ANTEX BITS and ELEMENTS

Bits No.		
102	For model CN240 3/32"	42p
104	For model CN240 3/16"	42p
1100	For model CCN240 3/32"	42p
1101	For model CCN240 3/8"	42p
1102	For model CCN240 ¼"	42p
1020	For model G240 3/32"	42p
1021	For model G240 1/8"	42p
1022	For model G240 3/16"	42p
50	For model X25 3/32"	48p
51	For model X25 1/8"	48p
52	For model X25 3/16"	48p

ELEMENTS
ECN 240 £1·30 ECCN 240 £1·32
EG 240 £1·07 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	200	Resistors mixed values approx. count by weight	0·54
C2	150	Capacitors mixed values approx. count by weight	0·54
C3	50	Precision Resistors 1%. 2% mixed values	0·54
C4	75	⅛th W Resistors mixed preferred values	0·54
C5	5	Pieces assorted Ferrite Rods	0·54
C6	2	Tuning Gangs, MW/LW VHF	0·54
C7	1	Pack Wire 50 metres assorted colours	0·54
C8	10	Reed Switches	0·54
C9	3	Micro Switches	0·54
C10	15	Assorted Pots & Pre-Sets	0·54
C11	5	Jack Sockets 3 × 3·5m 2 × Standard Switch Type	0·54
C12	30	Paper Condensers preferred types mixed values	0·54
C13	20	Electrolytics Trans. types	0·54
C14	1	Pack assorted Hardware—Nuts/Bolts, Grommets etc.	0·54
C15	5	Mains Slide Switches	0·54
C16	20	Assorted Tag strips & Panels	0·54
C17	10	Assorted Control Knobs	0·54
C18	4	Rotary Wave Change Switches	0·54
C19	2	Relays 6—24V Operating	0·54
C20		Sheets of Copper Laminate to make approx. 200 sq. ins	0·54

PLUGS AND SOCKETS

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°	0·16
PS 5	D.I.N. 5 Pin 240°	0·16
PS 6	D.I.N. 6 Pin	0·17
PS 7	S.I.N. 7 Pin	0·18
PS 8	Jack 2·5mm Screened	0·18
PS 9	Jack 3·5mm Plastic	0·12
PS 10	Jack 3·5mm Screened	0·18
PS 11	Jack ¼" Plastic	0·15
PS 12	Jack ¼" Screened	0·22
PS 13	Jack Stereo Screened	0·36
PS 14	Phono	0·10
PS 15	Car Aerial	0·22
PS 16	Co-Axial	0·15
INLINE SOCKETS		
PS 21	D.I.N. 2 Pin (Speaker)	0·14
PS 22	D.I.N. 3 Pin	0·20
PS 23	D.I.N. 5 Pin 180°	0·20
PS 24	D.I.N. 5 Pin 240°	0·20
PS 25	Jack 2·5mm Plastic	0·16
PS 26	Jack 3·5mm Plastic	0·16
PS 27	Jack ¼" Plastic	0·30
PS 28	Jack ¼" Screened	0·35
PS 29	Jack Stereo Plastic	0·30
PS 30	Jack Stereo Screened	0·38
PS 31	Phono Screened	0·18
PS 32	Car Aerial	0·22
PS 33	Co-Axial	0·22
SOCKETS		
PS 35	D.I.N. 2 Pin (Speaker)	0·08
PS 36	D.I.N. 3 Pin	0·11
PS 37	D.I.N. 5 Pin 180°	0·11
PS 38	D.I.N. 5 Pin 240°	0·11
PS 39	Jack 2·5mm Switched	0·12
PS 40	Jack 3·5mm Switched	0·12
PS 41	Jack ¼" Switched	0·20
PS 42	Jack Stereo Switched	0·30
PS 43	Phono Single	0·08
PS 44	Phono Double	0·10
PS 46	Co-Axial Surface	0·10
PS 47	Co-Axial Flush	0·20

LEADS
LS 1 Speaker lead 2 pin D.I.N. plug to open ends approx. 3 metres long (coded) 0·20

CABLES

CP 1	Single Lapped Screen	0·07
CP 2	Twin Common Screen	0·11
CP 3	Stereo Screened	0·12
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	0·09
CP 8	Twin Oval Mains Cable	0·07
CP 9	Speaker Cable	0·05
CP 10	Low Loss Co-Axial	0·18

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

VC 1	Single less Switch	0·15
VC 2	Single D.P. Switch	0·28
VC 3	Tandem Less Switch	0·46
VC 4	1K Lin Less Switch	0·15
VC 5	100K Log anti-Log	0·46

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

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The wonder bond which works in seconds—bond plastic, rubber, metals, transistors, components permanently immediately!
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Takes 6, HP7's complete with terminal, clip and lead. **34p.**

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Transistors – Germ. and Silicon Rectifiers – Diodes – Triacs – Thyristors – I.C's and Zeners ALL NEW AND CODED.
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7" EP. 15¼" x 7" x 8". (50 records) £2·10
12" LP. 13¼" x 7½" x 12¼". (50 records) £2·95

CASSETTE CASES £1·30
Holds 12. 10" x 3¼" x 5". Lock & Handle.

8-TRACK CARTRIDGE CASES
Holds 14, 13" x 5" x 6" £1·95
Holds 24, 13¾" x 8" x 5¼" £2·70.
Both with lock and handle.

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REPANCO TRANSFORMERS
240v. Primary. Secondary voltages available from selected tappings 4v, 7v, 8v, 10v, 14v, 15v, 17v, 19v, 21v, 25v, 31v, 33v, 40, 50 and 25v-0-25v.

Type	Amps.	Price	P & P
MT50/½	½	£1·93	45p
MT50/1	1	£2·42	48p
MT50/2	2	£3·30	60p

CARTRIDGES
ACOS
GP91-1SC 200mV at 1·2cm/sec £1·35
GP93-1 280mV at 1cm/sec £1·85
GP96-1 100mV at 1cm/sec £2·80
TTC
J-2005 Crystal/Hi Output £1·05
J-2010C " " " Compatible £1·20
J-2006S Stereo/Hi Output £1·75
J-2105 Ceramic/Med Output £1·85
J-2203 Magnetic 5mV/5cm/sec, including stylus £4·95
J-2203S Replacement stylus for above £3·00
AT-55 Audio-technica magnetic cartridge 4mV/5cm/sec £3·30

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 50p
R2 50 Mixed 1K ohms–8·2K ohms 50p
R3 50 Mixed 10K ohms–82K ohms 50p
R4 50 Mixed 100K ohms–1 Meg. ohms 50p
THESE ARE UNBEATABLE PRICES—JUST 1p EACH INCL. V.A.T.

BI-PAK SUPERIOR QUALITY LOW - NOISE CASSETTES
C60, 36p C90, 48p C120, 60p

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BI-PAK *QUALITY* COMES TO AUDIO!

AL10/AL20/AL30 AUDIO AMPLIFIER MODULES

The AL10, AL20 and AL30 units are similar in their appearance and in their general specification. However, careful selection of the plastic power devices has resulted in a range of output powers from 3 to 10 watts R.M.S.
The versatility of their design makes them ideal for use in record players, tape recorders, stereo amplifiers and cassette and cartridge tape players in the car and at home.

Parameter	Conditions	Performance
HARMONIC DISTORTION	Po = 3 WATTS f = 1KHz	0·25%
LOAD IMPEDANCE	—	8–16 Ω
INPUT IMPEDANCE	f=1KHz	100 k Ω
FREQUENCY RESPONSE ± 3dB	Po=2 WATTS	50 Hz – 25KHz
SENSITIVITY for RATED O/P	Vs=25V. Rl=8 Ω f=1KHz	75mV. RMS
DIMENSIONS	—	3" × 2¼" × 1"

The above table relates to the AL10, AL20 and AL30 modules. The following table outlines the differences in their working conditions.

Parameter	AL10	AL20	AL30
Maximum Supply Voltage	25	30	30
Power output for 2% T.H.D. (RL = 8 Ω f = 1 KHz)	3 watts RMS Min.	5 watts RMS Min.	10 watts RMS Min.

AUDIO AMPLIFIER MODULES

AL 10.	3 watts	RMS	£2·50
AL 20.	5 watts	RMS	£2·85
AL 30.	10 watts	RMS	£3·20

PRE-AMPLIFIERS

PA 12. (Use with AL10, AL20 & AL30) £4·35
PA 100. (Use with AL60) £12·15

POWER SUPPLIES

PS 12. (Use with AL10, AL20, AL30) 95p
SPM 80. (Use with AL60) £3·25
FRONT PANELS F.P. 12 with Knobs £1·10

TRANSFORMERS

T461 (Use with AL10) £1·60 P & P 22p
T538 (Use with AL20, AL30) £2·30 P & P 22p
BMT80 (Use with AL60) £2·75 P & P 37p

PA 12. PRE-AMPLIFIER SPECIFICATION

The PA 12 pre-amplifier has been designed to match into most budget stereo systems. It is compatible with the AL 10, AL 20 and AL 30 audio power amplifiers and it can be supplied from their associated power supplies. There are two stereo inputs, one has been designed for use with *Ceramic cartridges while the auxiliary input will suit most †Magnetic cartridges. Full details are given in the specification table. The four controls are, from left to right: Volume and on/off switch, balance, bass and treble. Size 152mm × 84mm × 35mm.

Frequency response—20Hz – 50KHz (–3dB)
Bass control—± 12dB at 60Hz
Treble control—± 14dB at 14KHz
*Input 1. Impedance 1 Meg. ohm
Sensitivity 300mV
†Input 2. Impedance 30 K ohms
Sensitivity 4mV

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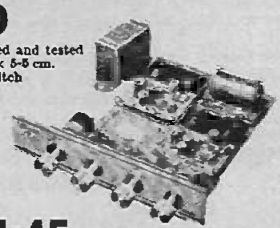
ALL PRICES INCLUDE V.A.T.

The STEREO 20



The 'Stereo 20' amplifier is mounted, ready wired and tested on a one-piece chassis measuring 20 cm × 14 cm × 5·5 cm. This compact unit comes complete with on/off switch volume control, balance, bass and treble controls, Transformer, Power supply and Power amps. Attractively printed front panel and matching control knobs. The 'Stereo 20' has been designed to fit into most turntable plinths without interfering with the mechanism or alternatively, into a separate cabinet. Output power 20w peak. Input 1 (Cer.) 300mV into 1M. Freq. res. 25Hz-25kHz. Input 2 (Aux.) 4mV into 30K. Harmonic distortion. Bass control ±12dB at 60Hz typically 0·25% at 1 watt. Treble con. ±14dB at 14kHz.

£14·45 p. & p. 45p.

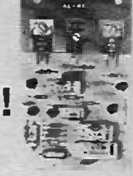
TC20 TEAK VENEERED CABINET

For Stereo 20 (front board undrilled) size 10½" x 8¼" x 3", £3·95, plus 45p postage

SHP80 STEREO HEADPHONES

4-16 ohms impedance. Frequency response 20 to 20,000Hz Stereo/mono switch and vol ume controls £4·95

NOW WE GIVE YOU 50w PEAK (25w R.M.S.) *PLUS* THERMAL PROTECTION! The *NEW* AL60 Hi-Fi Audio Amplifier FOR ONLY £4.25



- Max Heat Sink temp. 90°c.
- Frequency Response 20Hz to 100KHz
- Distortion better than 0·1% at 0·1KHz
- Supply voltage 15-50 volts
- Thermal Feedback
- Latest Design Improvements
- Load—3, 4, 8 or 16 ohms
- Signal to noise ratio 80dB
- Overall size 63mm × 105mm × 13mm

Especially designed to a strict specification. Only the finest components have been used and the latest solid state circuitry incorporated in this powerful little amplifier which should satisfy the most critical A.F enthusiast.

STABILISED POWER MODULE SPM80

SPM80 is especially designed to power 2 of the AL60 Amplifiers, up to 15 watt (r.m.s.) per channel simultaneously. This module embodies the latest components and circuit techniques incorporating complete short circuit protection. With the addition of the Maine Transformer BMT80, the unit will provide outputs of up to 1·5 amps at 35 volts. Size: 63mm × 105mm × 30mm.
These units enable you to build Audio Systems of the highest quality at a hitherto unobtainable price. Also ideal for many other applications including:—Disco Systems, Public Address Intercom Units, etc. Handbook available 10p **PRICE £3·25**

TRANSFORMER BMT80 £2·75 p. & p. 40p

STEREO PRE-AMPLIFIER TYPE PA100

Built to a specification and NOT a price, and yet still the greatest value on the market, the PA100 stereo pre-amplifier has been conceived from the latest circuit techniques. Designed for use with the AL50 power amplifier system, this quality made unit incorporates no less than eight silicon planar transistors, two of these are specially selected low noise NPN devices for use in the input stages.
Three switched stereo inputs, and rumble and scratch filters are features of the PA100 which also has a STEREO/MONO switch, volume, balance and continuously-variable bass and treble controls.

SPECIFICATION

Frequency Response	20Hz – 20KHz ± 1dB
Harmonic Distortion	better than 0·1%
Inputs: 1. Tape Head	3·25 mV into 50K Ω
2. Radio, Tuner	75 mV into 50K Ω
3. Magnetic P.U.	3 mV into 50K Ω

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

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

ONLY £14·25

MK 60 AUDIO KIT

Comprising: 2 x AL60, 1 x SPM80, 1 x BTM80, 1 x PA 100, 1 front panel, 1 kit of parts to include on-off switch, neon indicator, stereo headphone sockets plus instruction booklets. Complete Price: £29·75 plus 45p postage

TEAK 60 AUDIO KIT

Comprising: Teak veneered cabinet size 16¾" x 11½" x 3½", other parts include aluminium chassis, heatsink and front panel bracket, plus back panel and appropriate sockets etc. Kit price: £9.95 plus 45p postage

Giro No. 388-7006
Please send all orders direct to warehouse and despatch department.

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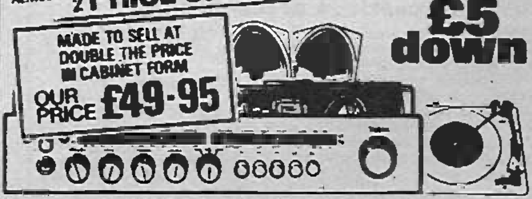

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PROJECTS THEORY...

FAULT FINDING

For the electronics constructor, one of life's little thrills comes with every initial switching on of a completed project. Will it, or won't it—a moment of anxiety before reassuring evidence is forthcoming, denoting that all is well.

But what if silence, or complete inactivity, is all one is rewarded with after power has been applied? A state of affairs that is not at all uncommon—and not the experience of novices alone, let it be made clear! Impatient fiddling with connections, a rapid visual examination of the whole assembly with the desperate hope that by luck or chance the defective part or connection will reveal itself or, if one is extra lucky, the fault will miraculously become cured.

Every seasoned constructor must have performed this ritual more times than he cares to remember.

But what if this initial check fails to bring life to the assembled circuit? This in fact becomes the moment when the men are sorted from the boys, as the saying goes. Logic now takes over and a careful and reasoned approach is made to the matter. The circuit is tested systematically stage by stage until the offending component or connection is traced and the appropriate remedy then effected.

To carry out a logical fault-finding procedure requires a good understanding of fundamentals, and of course at least some appreciation of how the particular circuit operates. Admittedly electronic green fingers do exist, and some folk who have but little formal knowledge of theoretical matters often are able to track down the source of trouble in a most uncanny way. This knack or intuition is a valuable asset, but obviously it is better to have a sounder base from which to operate.

Also, by contrast, there are those who are well conversant with circuit theory yet have quite a bother when it comes to dealing with real-life problems in a practical electronic assembly.

The title of one of this month's features, *It's Not My Fault!* may cause a wry smile or two. But it's an expression that is all too painfully familiar. With the aid of this article and others to follow, we hope it will become less commonplace in future.

MAIDEN VOYAGE

We have always maintained that sex discrimination has no place in our hobby. Nor has it in professional electronics. Nice to see a young lady featured in the careers article this month. Good luck Radio Officer Meryl. Guess you will have set many other gals athinking!

Fred Bennett.

Our July issue will be published on Friday, June 20

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VOL. 4 NO. 6 JUNE 1975

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

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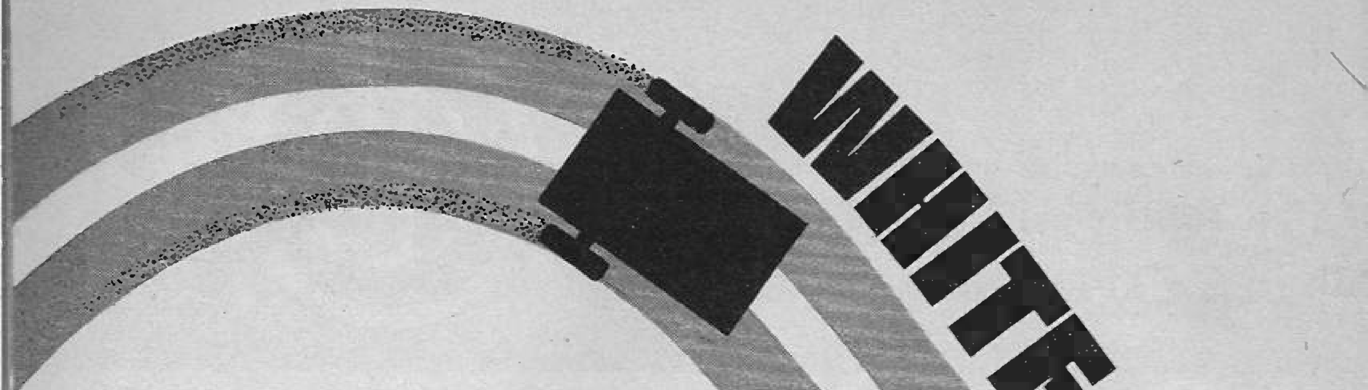
Next Month

AUTOMATIC GARAGE DOORS

See PAGE 325



WHITE LINE

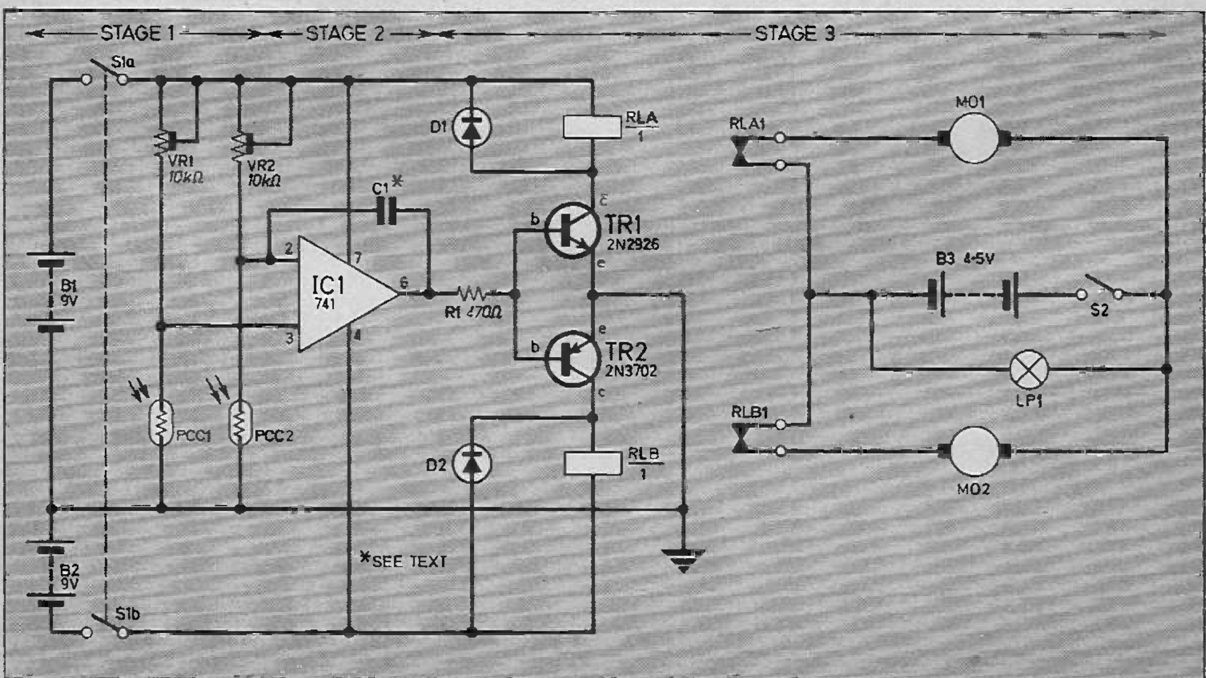
A novel electronic motorised vehicle that will follow a white line.

ELECTRONIC control systems are incorporated in a greater part of the technology which influences most of us every day of our lives; for instance, control systems using electronics are vital to the safety of air, sea and rail transportation systems. And the efforts of the home constructor are, in no small way, bringing the benefits of electronic control circuitry into the car and home.

For example, the electronics hobbyist is making use of readily obtainable semiconductor devices to build circuits providing improved control of the functions of his car; and in the home he is using electronics for humidity and temperature control, the automatic opening of doors, for the control of gain and noise in hi fi systems, etc.

The White Line Follower described in this article illustrates admirably the function of a control system known as a "servomechanism" incorporating the elements of command, amplification, work and feedback. Two photocells mounted side-by-side "look at" the white line and provide the command signal when they "see" a difference of illumination.

Fig. 2. The complete circuit diagram of the White Line Follower.



An operational amplifier (op. amp.) detects this differential command signal and via current buffer transistors and relays amplifies this signal to operate two electric motors connected to drive wheels. These motors provide the feedback essential for the vehicle to take corrective action in order to maintain equal illumination of the photocells. Thus the vehicle is compelled to follow the white line.

THE CIRCUIT

The general-purpose integrated circuit operational amplifier—the "741" type—is well suited to this application. Those of you who have used this i.c. will know that it has two input terminals, an inverting input and a non-inverting input. As shown in Fig 1, these terminals are, respectively, pins 2 and 3 for the 8-pin d.i.l. version.

The 741 is operated with a dual, or double-ended, power supply, which means that pin 7 is connected to the positive terminal and pin 4 to the negative terminal of two series-connected batteries, the common terminal being connected to ground or "earth" in the circuit. The input voltages V_1 and V_2 and the output voltage V_{out} are measured relative to this connection.

The arrangement shown in Fig. 1 acts as a difference amplifier since it is the difference (V_1-V_2) of voltage which is amplified by the op. amp. and appears at the output terminal.

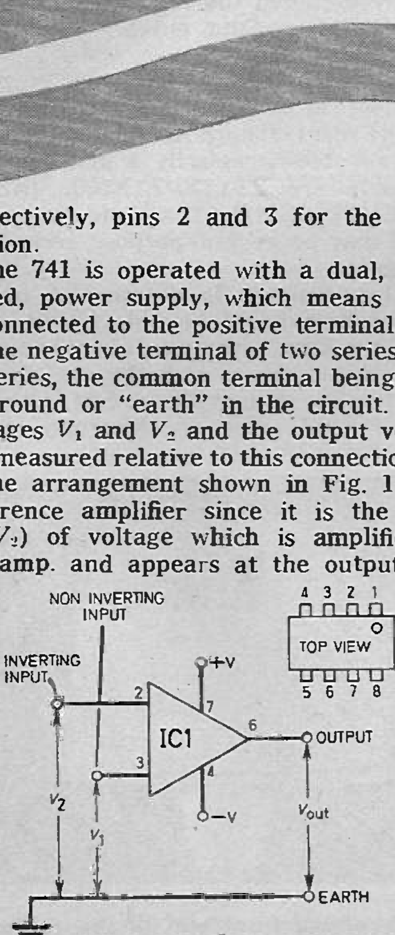


Fig. 1. Details of the 741 i.c.

If V_1 is greater (more positive) than V_2, the output voltage is positive with respect to earth, and if V_2 is greater than V_1, the output voltage is negative with respect to earth. This is the secret of operation of the White Line Follower: the output voltage swings from almost $+V$ to almost $-V$ as (V_1-V_2) changes from a positive difference to a negative difference.

Due to the very high gain (at least 10,000) of the op. amp., the output voltage saturates at the negative and positive supply voltages for very small differences in voltage across the input terminals.

Now take a look at the complete control circuit shown in Fig 2. This circuit is divided into three stages in order to understand its operation better. We have already seen the operation of stage 2, the op. amp's. part in amplifying the voltage difference between pins 2 and 3.

FOLLOWER

By MALCOLM PLANT

In stage 1 of the circuit, two light-sensitive voltage dividers VR1/PCC1 and VR2/PCC2, provide the changing voltages at the input terminals. Assuming that VR1 and VR2 have equal resistances, and photocells PCC1 and PCC2 have identical electrical characteristics, equal illumination of the photocells will make V_1 equal to V_2 so that there is no voltage difference to be amplified and, consequently, the output voltage is zero.

Now if PCC1 is illuminated less strongly than PCC2, its resistance is higher than that of PCC2, V_1 is greater than V_2 giving a positive voltage at the output. And if PCC1 is illuminated more strongly than PCC2, V_2 becomes greater than V_1, and the output voltage is negative. The

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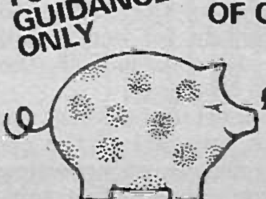

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*Based on prices prevailing at time of going to press changing illumination of the photocells is brought about by the vehicle attempting to follow the white line marked out on the floor.

FINAL STAGE

Stage 3 consists of a *npn/pnp* pair of transistors, TR1 and TR2, which act as solid-state switches, sensing the polarity of the output voltage from the op. amp. and controlling the action of the relays in their collector circuits. Notice that a normally-closed contact on each relay is connected to the motor circuits so that if the output voltage is zero, both transistors are off and the vehicle moves on a straight course.

If PCC1 is less strongly illuminated than PCC2, the output voltage goes positive, TR1 switches on, the normally-closed contact of RLA opens and motor 1 switches off while motor 2 stays on. If we now have the situation where PCC1 is less strongly illuminated than PCC2 the vehicle will be caused to veer to the left of the line. To bring the vehicle back on course, with both motors driving and both photocells equally illuminated, requires the circuit to behave in the way just explained.

You will be able to work out that if the vehicle swings to the right, PCC2 picks up less light than PCC1, and motor 2 switches off to bring the vehicle back on course.

Thus the control circuit incorporates an opto-electronic element (stages 1 and 2) and an electromechanical element (stage 3). These stages make up what is known as a "servo-system" having the elements of "command", "amplification", "work" and "feedback" previously mentioned.

For the White Line Follower, the "command" is originated by the photocells "picking up" light from the white line, the "amplification" is produced by the op. amp. and transistors acting as current buffers, the "work" is done by the motors which drive the vehicle back on course when required, and the "feedback" is accomplished by the motors effectively adjusting the illumination of the photocells until the light levels are equal.

FEEDBACK CONTROL

There is one modification to the circuit of the control system which is well advised: the op. amp. is operated "open loop" that is, with no signal being fed back from the output to the input terminals. Consequently, the op. amp. provides a very high gain causing the motors to switch on and off very rapidly for very small changes in the relative illumination of the photocells.

A resistor could be connected between the output and inverting input terminal of the op. amp. in order to reduce the gain by providing negative feedback. However, an effective solution to the problem of eliminating spurious switching of the relays for small changes of illumination, as well as switching caused by the voltage spikes generated by the operation of the relays and motors, is to connect a small-value capacitor (C1) between pins 2 and 6. This capacitor has the following effect.

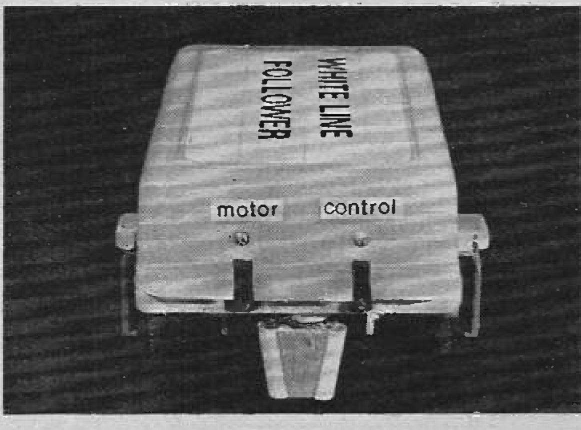
A sharply rising positive voltage at pin 6 (caused by the voltage at pin 3 rising just above that at pin 2) is transmitted by (C1) to the inverting input and tends to lower the difference of voltage between pins 2 and 3. Similarly, a sharply rising negative output voltage (caused by the voltage at pin 2 rising just above that at pin 3) is transmitted by (C1) to have the same effect on the input voltage difference. A value for C1 of about 0·01µF was found suitable but its optimum value can be chosen by experiment.

CIRCUIT ASSEMBLY

The chassis for the prototype vehicle was a piece of 15 x 20 mm 5-ply under which was mounted the independently-controlled driving motors and wheels. Also mounted underneath the chassis were the two photocells and the lamp to illuminate the white line. On top of the chassis were mounted the relays, batteries and switches as well as the circuit mounted on Veroboard (Fig. 3).

The components to be mounted on Veroboard are shown in Fig. 4. Note that the transistors may be any general-purpose medium current *npn/pnp* pair, not necessarily a matched pair. Suitable pairs are ZTX330/ZTX500, 2N2926/2N3702, BC182L/BC212L. The protective diodes D1 and D2 may be general-purpose germanium or silicon types.

The battery voltage is determined by the motors used but should be able to drive the motors and the lamp with ease. It is necessary to gear down the motor so that the vehicle does not "lose" the line by moving too fast. Although rather costly and large, 6V Meccano motors



Photograph of the front end of the prototype showing photocell and lamp arrangement.

WHITE LINE FOLLOWER

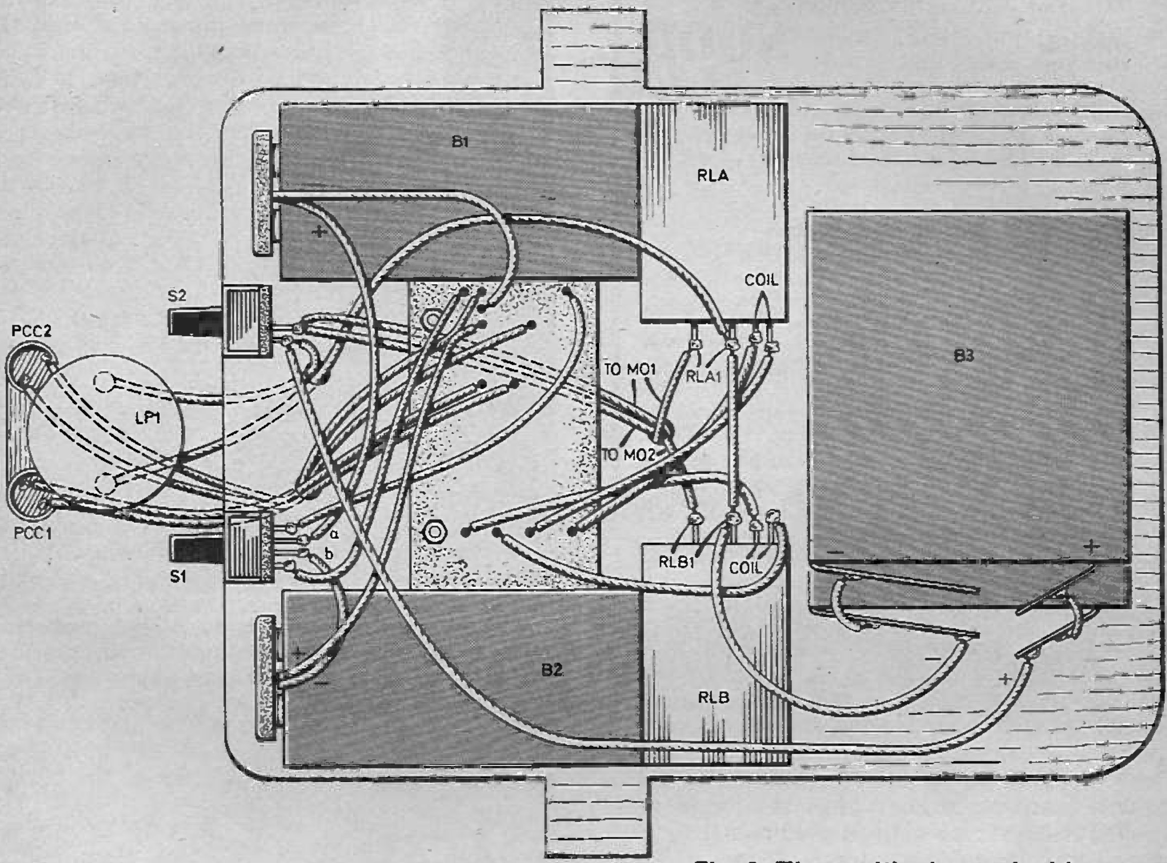


Fig. 3. The positioning and wiring up of the components mounted on the top side of the chassis.

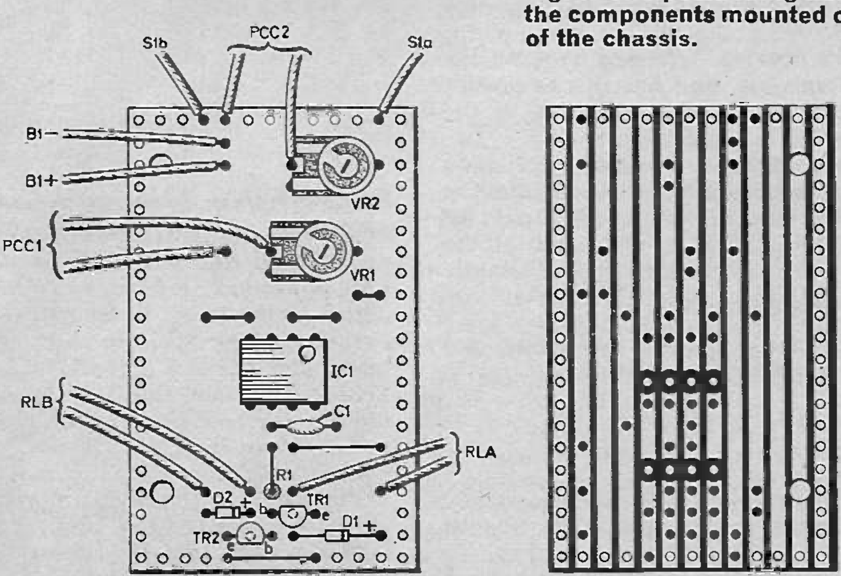


Fig. 4. The layout of the components on the Veroboard, wiring details and breaks to be made along the copper strips on the underside of the board.

Components....

Resistor
R1 470Ω ¼W ±10% carbon

SEE SHOP TALK

Capacitor
C1 0·01μF—see text

Semiconductors

PCC1, 2	miniature photoconductive cell (light dependent resistor)—2 off
TR1	2N2926 silicon *npn*
TR2	2N3702 silicon *pnp*
IC1	741 8-pin d.i.l. op. amp.
D1, 2	OA91 or similar diode (2 off)

Miscellaneous
VR1, 2 10kΩ miniature skeleton presets (2 off)
RLA, RLB 6 to 12V 180Ω or greater relay with one set of normally closed contacts (2 off)
LP1 3·5V 100mA lamp and batten mounting holder
S1 d.p.s.t. toggle or slider switch
S2 s.p.s.t. toggle or slider switch
MO1; MO2 Orbit 605 d.c. motor with 40 to 1 worm gears to fit spindle and axles (2 sets)
B1, B2 9V PP6 battery and clips (2 off)
B3 4·5V (two 1289 types in parallel)
Veroboard 22 holes x 10 strips, 0·1 inch matrix. Materials for chassis and gear mounting, two rubber tyred wheels approx 40mm diameter, castor wheel, tubes to hold PCC1 and PCC2 approx 25mm long, plastic food box for "case", wood and 4BA fixings etc.

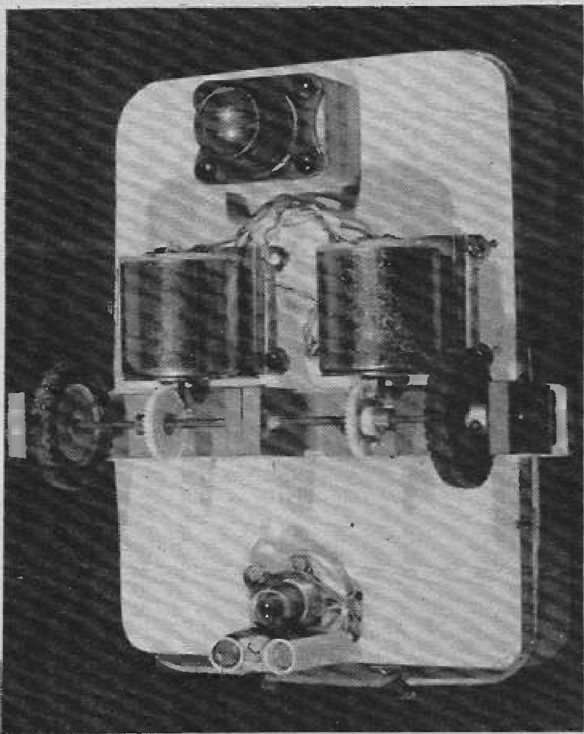
could be used since they have selectable gear ratios. The prototype vehicle used two Orbit 605 motors and nylon wormgears. Using a 4·5V battery the vehicle moves forward at a suitable speed.

As the motors provide a varying load on B3, the lamp brightens and dims but this behaviour does not adversely affect the operation of the vehicle.

The photocells and the lamp need positioning carefully. The lamp should not illuminate the photocells directly and the photocells should be housed in short lengths of tubing, open at the "viewing" end and preferably angled slightly towards each other so as to be "looking at" the same part of the white line. Ideally, some adjustment should be allowed for positioning the lamp and photocells after the vehicle is assembled.

MECHANICS

Mechanical construction of the vehicle should be kept as simple as possible; "U" Shaped brackets made from strips of aluminium can be used to mount the axles and wheels, with p.v.c. sleeving pushed over the ends of the axles to keep them in position. The height of the axles must be correct so that the gears mesh properly.



Photograph of the underside of the prototype showing motors and gearing fixings, photcell and lamp set up, and ball type castor.

The prototype unit used a ball-type castor as the third wheel but any small castor will suit and this can be mounted directly on the chassis or on a block to achieve the correct height. The lamp holder and a balsa block to secure the photocells to are mounted at the other end of the vehicle by two wood screws. The photocells in their protective tubes may be fixed to the block with glue or insulation tape.

Finally, a plastic food box can be cut to a size and inverted over the chassis to finish the unit.

PREPARING THE VEHICLE

Set VR1 and VR2 towards the high resistance end of their tracks. With S1 on and S2 off, shield the photocells individually and observe the action of the relay. Refer to Figs 2, 3 and 4 and ensure that as PCC1 is shielded, RLA is energised, and as PCC2 is shielded RLB is energised. Switch on S2 and the lamp should light and the motors move. Make sure they are both driving in the same direction. If not, interchange the connections to the offending motor.

Mark out on the floor a narrow white line of strips of paper or chalk and set the vehicle over it. Make sure that the ambient lighting is not too strong and the contrast between the floor and line not too low. Make slight adjustments to VR1 and VR2 until the vehicle moves along the line without tending to veer off it. ■

for your Entertainment...

By Adrian Hope

THE British Car industry is in a pretty poor financial state. Apart from strikes and price increases, it suffers because some foreign cars have a far better reputation for reliability. A friend recently drew my attention to something that sums up why some people just do not want to buy British. He owns an expensive, large British car which uses an electrical relay system to control functions such as ignition, horn, windscreen wiper and so on. The idea is to let heavy duty relays control these functions, the relays being operated by light duty switches on the dashboard. This would be all very well if the relays were really heavy duty. But when the ignition relay burnt out we took it apart and found it to be virtually nothing more than a coil of wire and a few pieces of bent tin.

A replacement was listed at £3, for which money any reader of the adverts in this or related magazines could buy himself two or three precision made relays of equivalent electrical rating. But of course the chances of finding an electrical equivalent of the right size and matching connections are virtually nil.

BURNT OUT

In the event, the local auto spares depot was out of stock of the relays. They had what appeared to be an exact equivalent, but it was actually intended for use in the horn rather than the ignition circuit. In desperation this was bought and fitted, but within a few minutes of use it burnt out.

We striped it down and found it was of the same, tinny construction as the original. What's more, even though it cost as much as the ignition relay, the coil was wound with only half the turns that would be necessary to carry a constant current. This is why it had burnt out when used in the ignition rather than the horn circuit.

So here we have a car manufacturer who is so desperate to cut corners that he will actually wind a relay coil short, on the assumption that no one will blow their horn long enough to burn it out. And the manufacturer doesn't even pass on the cash saving to the customer.

Remember that this is not a cheap car, it's a prestige export. And if it is used in a country where horn blowing is a national hobby or if it is fitted with a burglar alarm that leaves the horn blasting to signal an attempt at theft, a relay will bnrn out.

I'll bet this isn't the only example of its kind, and it makes me fear for our future. If that instance typifies widespread industrial attitudes, we haven't a hope in Europe.

CALCULATION

On a lighter note here's a lovely way to amaze your friends with a calculator—or if you're a gambling man, win a few bets (provided of course that the people you are gambling with don't also read this magazine).

On most, if not all calculators the numbers on the keyboard are arranged in a 3 x 3 square as follows:

7	8	9
4	5	6
1	2	3

Punch out the three numbers of the top line in any order (say, 7,8,9). Then punch out the three numbers of the middle line, also in any order (say 6,5,4). Now press the minus sign on a chain flow machine or the plus sign on a reverse logic machine. Next, punch out the numbers of the middle and bottom rows in the same order as you punched out the numbers of the top and middle rows (in our example, you must punch out 4,5.6 and 3,2,1).

Finally on a chain flow logic machine press the equals key and, on a reverse logic machine, press the minus equals key. The answer will always be 333333, whatever order you originally chose to punch the numbers, and thus whatever numbers you punched in.

Now mystify your freinds even further. Clear the calculator and do the same things using vertical columns. Take the left hand column and punch out the three numbers in any order (say 1,4,7). Now punch out the numbers of the centre column in any order (say 2,5,8). Now, as before, enter minus (if you have a chain flow calculator) or plus (if you are using a reverse flow machine). Next punch out the numbers of the centre and right columns in the same order as the left and centre columns (in this example, 2,5,8 and 3,6,9).

Now read out the answer by pressing the equals key on a chain flow machine or the minus equals key on a reverse logic machine. Whatever order you choose to press the numbers in, and thus whatever numbers you put in, the answer will always be 111111.

Now try the same tricks, but moving right to left and bottom to top instead of left to right and top to bottom. Of course it's not magic, the layout of the keys always pnts a difference of 1 or 3 between adjacent keys, depending on which direction you are moving in. But it certainly seems like magic to all but the most dedicated calculator buff.

FINAL WORD!

But the final word on calculators must come from a fourteen-year-old reader from Luton. He points out that if you alter the decimal places in my little sum for getting a calculator to talk ($1\cdot1601\times4\div6$ and invert the display) you get a very different answer. Shift the decimal places so that the sum becomes $11601\times 40\div6$ and read out the answer upside down!

IT'S NOT MY FAULT!

By P. ALLCOCK

An introduction to basic fault finding techniques.

FROM time to time we receive letters from readers who have built up a circuit . . . "exactly as described in the article" . . . only to find that nothing happens when the darned thing is turned on. Often in desperation these projects will be put (or thrown!) on one side, simply because the fault cannot be found.

It is not that the original design is faulty or suspect, or that insufficient constructional details have been given in the article—it is simply a case of not being able to anticipate or allow for all the possible errors and faults that might occur without using up an excessive amount of magazine space for each project.

The guide lines in this article will help to illustrate typical faults and show how to locate and identify them. In this way, we can help readers interested in the project used for illustrating the points and also show some of the fault-finding techniques that might be applied to other circuits.

For this exercise we have selected the *Egg Timer* project which was described in E.E. May 1974. Obvously it helps if the constructor understands how the circuit is supposed to work but with practice it is often possible to diagnose faulty circuit operation without understanding all the finer circuit details.

The *Egg Timer* breaks down into three units or parts, the unijunction timing circuit, the bistable and the tone oscillator (Fig. 1), each of these individual parts are often found in other circuits and so the fault finding information is not just applicable to one circuit.

If necessary, each of these parts can be tested as a separate entity to see if they operate correctly "on their own", but for the moment let us assume we have built the complete circuit and have just found that "nothing" happens. What do we do first.

CONSTRUCTION CHECK

With all home constructed equipment it usually pays to check the circuit wiring and soldering, leads and connections of transistors, diodes and polarised capacitors very carefully. "But I have checked it" you might say. Well, check it again, section by section and pay particular attention to the following (all too common) pitfalls:

1. Leads reversed for "outermost" connections of transistors—especally those with all leads in one line (see later comments re. TR1).

2. Reversed polarity of diode connections. Positive (cathode) end usually has a line or band marking. It is good practice to check diodes with a meter for correct polarity before use—sometimes the marking can be incorrect.

Checking, also locates faulty items before they cause damage to other components. This is especially important when re-using components from other projects or using components salvaged from scrap circuit boards.

Note that the voltage polarity of most test meters is opposite to that indicated (by terminal colour or marking) when used on resistance or ohms ranges. If in doubt check by testing a good diode.

3. Check all polarised capacitors—the positive side must be joined to that part of the circuit which is the most positive. In your own designs, if in doubt, check the voltage polarity with a voltmeter (with the capacitor disconnected).

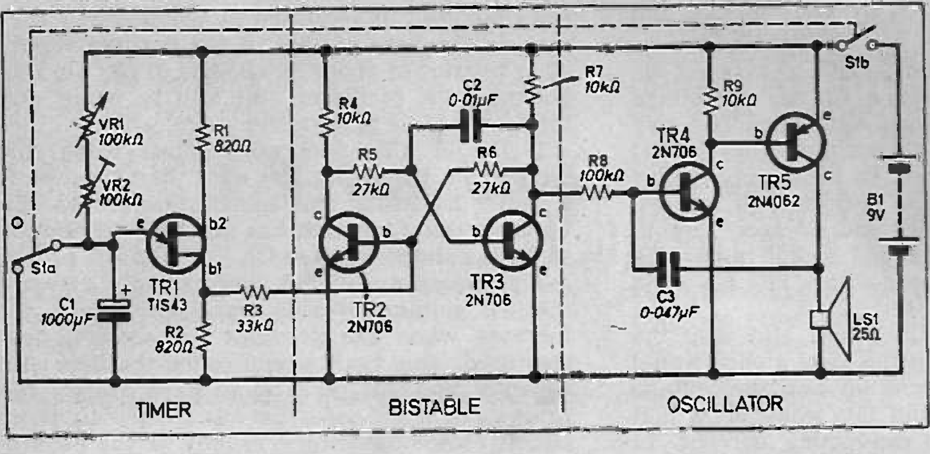


Fig. 1. The circuit diagram of the *Egg Timer*, which is used to illustrate typical faults and methods of fault finding.

4. Check the connections, especially soldered and screw terminal joints and watch out for small "slivers" of solder between copper tracks on Veroboard and printed circuit boards.

5. If the circuit operates from batteries check their condition on load. A temporary load can be provided by connecting a resistor across the battery whilst observing the voltmeter reading.

The resistor value should be chosen to draw a current of about 20 to 50mA. Thus a resistance of say 20 to 50 ohms for every "battery volt" is about right. Low capacity "pen cells" can be tested at the lower current whilst "radio type" batteries should be tested at the higher current level. Excessive voltage reduction on load indicates an exhausted unit.

6. Check that metal cases on panels do not contact parts of the circuit other than those intended. Watch out for metal cased transistors which often have the case joined to the collector lead internally.

When you are quite satisfied with the visual and physical checks, if the circuit still fails to operate when switched on, it is necessary to try some electrical tests. The nature of these tests will depend on the circuit details, so let us return to our *Egg Timer* and consider what can be done in this case.

INITIAL CHECKS

From the description given in the article it is obvious that the end of the timed interval is indicated by the tone from the oscillator. If no tone appears after a reasonable time it might be that the oscillator unit is not responding to the changeover of the bistable (which causes a positive voltage at TR3 collector). Alternatively, perhaps the bistable is not changing over when the timer tells it to! Or perhaps the timer itself is not working. How can we tell?

One way is to start at some convenient midpoint in the system and see if the circuit operation is correct "up to that point." This assumes that there is a logical sequence or "flow" to the circuit operation and this is indeed the case with the *Egg Timer*. We can check the voltage at TR3 collector to see if this transistor is turned "on" or "off".

If the transistor is on the voltage between c and e will be very small, perhaps 200mV. By shorting the base to the emitter we can test TR3 to see if it will turn off. The transistor should remain off when the short circuit is removed and the oscillator should operate. If this occurs the fault most likely lies earlier in the operating sequence although it is quite possible to have more than one fault at a time!

Notice that the short circuit applied between b and e of TR3 cannot cause any harm in this circuit, due to the presence of R5 and R4, which limit the current flow via the short circuit. Before using this "dodge" always examine the circuit carefully and avoid joining the base to the collector or transistor case by mistake as this may cause damage to the transistor.

OSCILLATOR

Our next move obviously depends on the outcome of this test. If the oscillator fails to give any sound there is most likely a fault in the oscillator section if the test shows that TR3 does turn off. Under these conditions (and assuming only one fault) it is quite likely that the bistable does in fact operate at the end of the timing period and this can easily be checked by watching the voltmeter, connected across c and e of TR3. A sudden increase in voltage should occur when the bistable changes state.

Lets assume that we suspect our oscillator and the rest of the circuit appears to function correctly—what is our next step to be. Can we check the transistors in the oscillator section. Certainly we can take voltage measurements across the collector-emitter connections of TR4 and TR5. With TR3 on, both TR4 and TR5 should be off. The voltage across c-e for each transistor should therefore be about 9 volts (see Table 1).

It is assumed here that a reasonable testmeter of 20 kilohms/volt sensitivity is available—without this, serious attempts at fault finding will be difficult in most cases.

By allowing (or forcing) TR3 to turn off we should be able to detect a change in voltage across TR4. If this does not occur then TR4 may be faulty, R8 may be open circuit (dry joint!) or C3 may be short circuit. By measuring the b-e voltage of TR4 when TR3 is turned off, we can check for R8 open circuit and C3 short circuit. If C3 is suspect its removal should allow the normal 0·6 volts to appear across TR4 b-e when TR3 is off.

An open circuit in C3 would also stop the oscillator working but in this case a click would be heard when TR3 turns off and the voltage measurements on TR4 and TR5 would show that these transistors were conducting current. In fact with this fault the current in TR5 could rise to a "steady" value of some 300mV (limited by the speaker resistance of 25 ohms if TR5 turns fully on). A faulty R8 (or C3) could be checked by component substitution.

One other possibility in the oscillator is that the loudspeaker or its wiring might be open circuit. This could be checked by the testmeter on "ohms" and would also show up due to the absence of voltage across TR5 (c-e) when TR3 was on and TR4 was off.

In some cases the oscillator may work without R9 connected since TR4 can still receive collector current via the base-emitter junction of TR5. From a design point of view it might have been better to have limited the current flow in this part of the circuit by a resistor between the collector of TR4 and the base of TR5.

Well that just about covers the possibilities for oscillator faults, lets go back to the TR3 test and assume that the oscillator did operate when TR3 was forced to turn off.

BISTABLE

Obviously we must go back one step in the operating sequence and check that the bistable section is operating correctly. Since the changeover of the bistable is initiated by a positive-going pulse from base 1 of the unijunction we can simulate this condition by momentarily connecting the base of TR2 to the positive supply via a resistor of about 33 kilohms. If the bistable operates, the oscillator note will be heard and the fault will lie in the timer stage.

If the bistable does not operate using this method of triggering the most likely cause is a faulty transistor and substitution checks can be used. One fault that has not been mentioned so far is a short circuit in C2.

This would make TR3 "permanently on" and the c-e voltage of this transistor would not increase when the previous b-e shorting test was used. This fault would cause the base and collector voltages for TR3 to have exactly the same value if the capacitor was completely short circuit (some capacitors, usually of the electrolytic variety, can develop excess leakage without becoming fully short-circuit).

TIMER

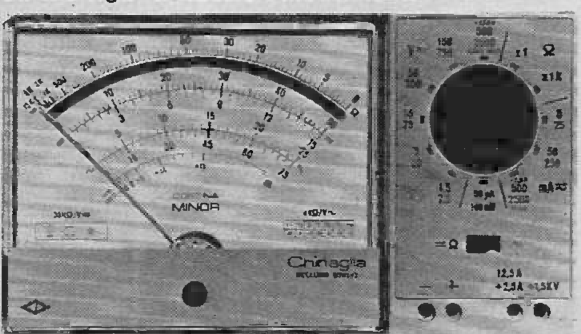
If the bistable section operates correctly the fault must be in the timer stage and here the two most likely sources of trouble are the 1,000μF capacitor and the transistor. Re-check the transistor connections first, since this device has different lead markings to the more usual *npn/pnp* bipolar transistors. The lead arrangement used in the layout of the board may not be the same as the transistor lead-out arrangement and the leads may "change-over" positions. Make sure the leads do not short together.

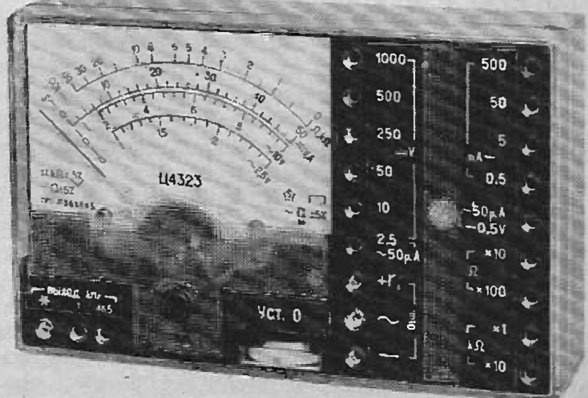
If the wiring is correct the quickest way to check the transistor is to disconnect C1. When the unit is switched on the oscillator should sound immediately since the time-delay is missing. If this test works replace capacitor C1 with a new component which must have low leakage (correct polarity is also important).

If no sound is obtained with C1 removed check the preset VR2 for an open circuit at the wiper contact. If this is in order a replacement TR1 should be tried.

An alternative method of checking the timer stage transistor TR1 is to replace C1 with a

Two illustrations of the type of meter required for fault finding. Below, the Chinaglia Minor and on the right a Russian instrument.





capacitor of about $0{\cdot}047\mu F$. If the loudspeaker is temporarily connected across R2 a tone should be heard if the transistor is working, and variation of the time control VR1 should alter the frequency of this tone. Note that only one lead of the loudspeaker need be removed for this test since the other lead is already common to R2.

VOLTAGES

The voltage readings obtained from the prototype *Egg Timer* circuit are given in Table 1 below:

Table I

All readings in volts (20 kΩ/V meter on 5V or 15V range)

TR1			TR2			TR3			TR4			TR5		
b1	e	b2	e	b	c	e	b	c	e	b	c	e	b	c
1·4	—	7·5	0	0·6	6·3	0	0·7	0·1	0	0	8·8	0	8·8	9·0
(0·8)				(0·4)	(6·6)									

From these readings it can be seen that TR2 is on the verge of conduction due to the rather high voltage present across R2. This voltage, attenuated by the potential divider action of R3 and R6, gives a V_{BE} of 0·6 volts for TR2 and if a transistor with a high current gain is used this could cause TR2 to conduct to such an extent that the bistable operation would be affected.

If trouble is experienced from this aspect, resistor R2 can be reduced to 470Ω which will give the voltage readings shown in brackets. Do not forget to recalibrate the unit after this circuit change as R2 affects the switching voltage level for the unijunction circuit. (It should perhaps be mentioned at this point that the voltage across R2 depends on the interbase resistance R_{BB}, of the unijunction and this can vary between samples over a range of about 2:1. The voltage of 1·4V is about the maximum that can occur when R_{BB} is at its lower limit. The slight rise in the collector voltage of TR2 when R2 is reduced to 470Ω is evidence of the slight conduction that occurred with the prototype unit.)

These notes should help to point out some of the tests and methods that can be applied. It is usually helpful to measure and record the voltages on each transistor, since these can often throw light on possible wiring or component faults and it is hoped to cover this topic more fully in a future article.

If one of your projects fails to work correctly why not have a go at fault finding—the effort will invariable be rewarded and the challenge can be very stimulating. The best way to learn fault finding is to experience it first hand. ▣

...Counter Intelligence

BY PAUL YOUNG

A retailer discusses component supply matters.

THE other morning as I took my usual constitutional stroll down the half mile street where my premises are situated, what a lamentable sight met my eyes. At least ten shops were closed or in the process of closing down. In the evening having taken enough money to buy myself an orange, I went across the road to my favourite fruiterers and asked Doreen for one of her best Jaffas. Doreen has been selling me oranges for nearly thirty years so when she said, "I am closing down," I looked at my watch and said, "Its a bit early for you, isn't it?" She said, "I mean for good."

I was so surprised, I questioned her further and she summed it up in a few words, "I am fed up with working for the landlord and the Government. What with rent, rates and V.A.T. the whole thing has become a nightmare."

Before you say "What's all this to do with electronic components?", let me hasten to enlighten you. The majority of your component suppliers, are the equivalent of the little man with the corner shop. Now, I am not saying you will not get good service from the big suppliers, because this would not be true, but when establishments get too large the man at the top is too far removed from you, the customer, and those at the bottom probably do not care anyway. This soon becomes apparent if you have a complaint.

With the large firm, you may well suffer the frustration of interminable delay, while your complaint is passed to different departments. With the small man, he knows he must deal with it personally and as speedily as possible. The small man has to give good service, because so often, it is all he has to offer.

This brings me to the main point. It became apparent to me many years ago that what the small man lacks, is buying power. In many cases, when you can talk of buying in thousands, prices shrink dramatically. This enables the supplier to offer substantial reductions in prices and still make a reasonable margin of profit.

I then started to reason, that if several of us got together, with each of us buying one or two items in large quantities, and all sharing in the purchases, we could in time cover the whole field of components and start to contain prices, even perhaps to bring prices down! Thus, was born the idea of a consortium of retailers forming a buying group for the purchases of electronic components, the first of its kind and therefore called Group One.

The group has been active for about four years now, and has had many successes. We have about twenty-five members but if we had more, we could cover a wider field which would be to your advantage and ours. In the past I have tried to assist you, with suggestions on the purchase of your components, now is your chance to return the compliment. Next time you buy a few parts from your local man, ask him if he is a member of Group One. If he is not, explain the advantages to him and to you. If he is interested in joining ask him to drop a line to Paul Young, care of EVERYDAY ELECTRONICS.

Your Career in ELECTRONICS

By Peter Verwig

A career in electronics is an exciting prospect! Month by month our contributor Peter Verwig will explain what working in electronics is all about, how to prepare yourself for a rewarding career, and the job opportunities available in the world's fastest growing industry.

THE PROFESSIONAL INSTITUTIONS

LAST month we discussed qualifications and advised our readers to aim high. This month we take a closer look at the professional institutions and, again, you are urged to aim high.

Do not confuse a professional institution with a trade union. The latter is an organisation largely concerned with pay and working conditions. The professional institution is a learned society with quite different aims. And whereas entry to a trade union is comparatively easy (indeed, in some firms where the "closed shop" is in operation membership is compulsory), you will have to demonstrate to the council of a professional institution that you are worthy of election.

I.E.E.

By far the oldest of the institutions serving the professional electrical and electronics engineer is the Institution of Electrical Engineers (I.E.E.) which came into being long before the word electronics was coined. In the early days the I.E.E. membership was composed almost entirely of power engineers. Men who were fascinated by the theory and practice of generation of electric power, of its distribution by cable and its conversion to other forms of energy.

This was essentially heavy current engineering and many years were to elapse before electronics was considered to be a subject worthy of consideration. But such has been the impact of electronics in recent years that the I.E.E. is now recognised as being one of the world's premier institutions for the electronics engineer.

OTHER INSTITUTIONS

As mentioned in the first article, it was the rapid spread of radio broadcasting in the 1920's and 1930's that saw the birth of the electronics industry. This new-fangled science appealed very little to the power men in the I.E.E. and so radio engineering pioneers pooled together their common interests and formed the Institution of Radio Engineers, not at that time in 1925 as a rival body to the I.E.E., but because there was no appropriate home for them anywhere else.

The I.R.E. prospered and was incorporated by Royal Charter in 1961 and has also changed its name to the Institution of Electronic and Radio Engineers (I.E.R.E.), thus broadening its scope of activities.

Today both institutions operate in friendly rivalry and frequently co-operate in joint meetings. From time to time there have been rumours of a merger being discussed, or even about to happen, but today they still retain their separate identities.

In 1965 two new institutions were formed especially to cater for technician engineers. The entry qualifications for these are less exacting than those for the senior institutions where university degree standard is required for corporate membership. The equivalent technician institution of the I.E.E. is the Institution of Electrical and Electronic Technician Engineers (I.E.E.T.E.) and that of the I.E.R.E. is the Society of Electronic and Radio Technicians (S.E.R.T.). In both cases they operate quite separately and autonomously.

Which to join? There are clearly some advantages in size of membership. Big institutions are generally richer and more powerful and this certainly applies to the I.E.E. and the I.E.E.T.E. But of course a substantial part of their total membership consists of electrical engineers.

If you happen to be professionally engaged in electronic control of electrical power systems it could well be that you might welcome rubbing shoulders with and talking to electrical engineers and then the I.E.E. or I.E.E.T.E. would be the better choice. But if your interests lie in, say, radio communications then the I.E.R.E. or S.E.R.T. may be more suitable.

ENTRY QUALIFICATIONS

The best course of action is to write to the secretaries for details of entry qualifications, grading structures, and facilities offered. The addresses are given in the panel.

As mentioned last month, your goal should be to reach professional status and get your name on the composite register of the Engineers Registration Board (E.R.B.) set up under the Royal Charter of the Council of Engineering Institutions. You can only get your name on the Register through membership of a professional institution.

To get the top rating of Chartered Engineer you will need to work towards corporate membership of the I.E.E. or I.E.R.E. The Technician Engineer and Technician designation can be obtained through the I.E.E.T.E. or S.E.R.T. once you have reached the appropriate grade of membership.

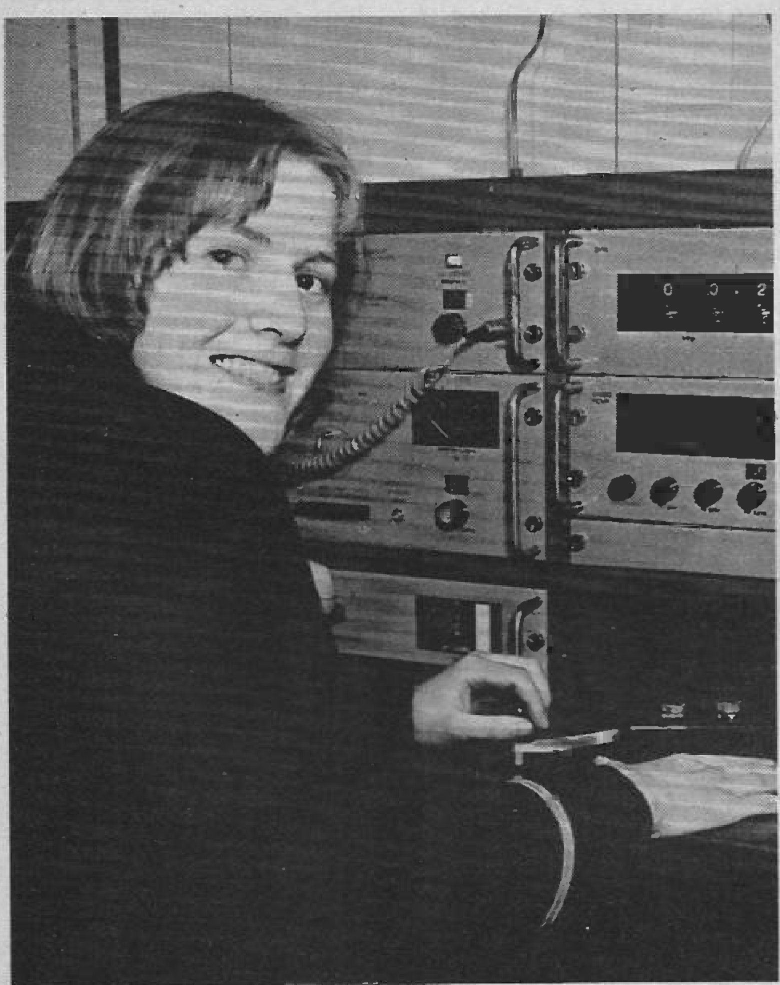
STUDENT MEMBERSHIP

You don't need to have a whole dossier of qualifications to join a professional institution. Study the membership regulations and see where you can fit in. For those just starting on their training there are student grades of membership with appropriately reduced fees.

The only qualifications needed for the student member of S.E.R.T. are that the applicant must be over 16 years of age and that he or she must be pursuing a regular course of further education approved by the council and which will satisfy the requirements for eventual admission to a higher grade. In S.E.R.T. you can remain a student member for five years while carrying on with your studies.

Naturally, the qualifications for student membership of the I.E.E. and I.E.R.E. are more stringent, the latter for example calling for a G.C.E. in five subjects (one being English) with two at "A" level and these preferably in mathematics and physics. But not having these does not necessarily debar you from entry because there are other qualifications which you may have which may be considered by the council as suitable.

If you have already been working as a technician but haven't yet bothered to advance yourself academically you can still join a professional institution in a non-corporate grade. For example you can become an associate in S.E.R.T. if you are over 21 and have a minimum of three years experience at work.



It's her world, too. Eighteen year old Meryl Swannack puts to sea as a radio officer having obtained the Ministry of Posts and Telegraphs certificate and taken the Department of Trade radar course. She is the first lady in the seagoing staff of Kelvin Hughes. After experience at sea she can study further to become an electronics officer capable of maintaining all the electronic navigation equipment on a ship as well as radio equipment.

BENEFITS

What are the benefits of membership? Institutional journals and news letters let you know what is going on through technical articles and professional news. There are conferences and meetings you can attend and, of course, the opportunity of meeting like-minded people, your fellow professionals either in London or at the many events held in the regions.

As your career advances you climb the ladder of membership up to fellow although this may yet be a long way ahead. The S.E.R.T. regulations lay down that to be elected a fellow you must be 30 years of age, have qualifications acceptable for registration as a technician engineer, have ten years experience in the profession (which can include time spent training) and have served five of these years in a position of superior responsibility.

The main thing to remember is that there is a world of difference between just having a job in electronics and having a well-defined set of goals in a professional career structure. Membership of one of the institutions helps self-development and opens up new opportunities.

Next month we shall examine what is involved in an apprenticeship and what life as an apprentice is really like.

Addresses: In all cases apply to the secretary:

The Institution of Electrical Engineers,
Savoy Place,
London, WC2R 0BL.

Institution of Electronic and Radio Engineers,
8-9 Bedford Square,
London, WC1B 3RG.

The Institution of Electrical and Electronics Technician Engineers,
2 Savoy Hill,
London, WC2R 0BS.

The Society of Radio and Electronic Engineers,
8-10 Charing Cross Road,
London, WC2H 0HP.

READERS' LETTERS

Bored

We have been following your magazine since it started and have had generally no complaints. But we couldn't help noticing lately the repetition of some of your projects. For instance, after browsing through the magazines we have collected, we came up with this; so far you have published projects of three rain alarms, three security systems, two ice warning alarms, three reaction testers and four windscreen wiper controls. We think it is about time you pulled your socks up and got some more varied projects.

Bored Kiwis,
Malcolm Landett,
New Zealand.

Yes in the $3^1{}_2$ years E.E. has been published we have provided details for three rain alarms—all different, one with an oscillator output, one with an automatic cut out at night and one very simple design with electromechanical output device.

The three security systems have again all been different, one was simply a light controlled switch, one was an infra-red beam and one a wired system, in fact all three could be put to good use in one house. Two ice warning alarms have been published one using transistors the other with an i.c. The three reaction testers were again all different—a very simple design, a design with timed start lamp and a reaction timer.

As far as the wiper controls go we have only published three designs, all different and one was for a wash/wipe and could be used with either of the other two.

We are pleased that you have taken E.E. since it was first published (two of the projects you mention were in the first issue), but you must realise that we do cater for beginners in electronics and we are continually getting new readers who are interested in these useful and simple designs; we have also published about 125 other designs. If you have some suggestions for projects we have not yet covered, and they are not too complex in nature, we would be pleased to hear of them.

Transmitters

As your magazines are for beginners, and I am one, I wondered if you could help me out of a serious quandary, whether or not to buy a kit for a "walkie talkie". My problem is that I have often seen these advertised and underneath it says "not licencable in U.K.", so would you please tell me how I stand in regard to the law on "walkie talkies", and would I have to take the transmitter exam to use one?

R. J. Scholefield,
Halifax.

We must advise you that the use of transmitting apparatus (other than for radio control on special bands) is prohibited in this country, except by those persons who have passed the appropriate examination and have obtained an amateur transmitting licence from the Home Office.

It is true that certain "walkie talkies" are advertised, but this in no way permits an individual to use these without the necessary licence.

If you are interested in becoming a radio amateur, we suggest you get in touch with the following: Radio Regulation Dept., Waterloo Bridge House, Waterloo Road, London, SE8UA. We suggest also that you contact the Radio Society of Great Britain, 35 Doughty Street, London WC1N 2AE.

Modules, I.C'S and Discrete

I am 12 and I buy Everyday Electronics monthly. I agree with Paul Young (*Counter Intelligence*) on modules and i.c's in the April 1975 issue.

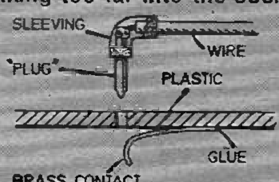
The more I can construct myself the better, the i.c's are best employed in miniature instruments such as pocket calculators where it is more important to get it as small as possible.

Richard Ferries,
Bromsgrove,
Worcestershire.

Whilst planning a logic patch-board, I realized that the cost of plugs and sockets would be approximately four times the price of components to go into the device.

By drilling a hole in suitably thick plastic or other material and bending a piece of springy brass as shown, an acceptable socket is formed. Note the glue should be well away from the hole.

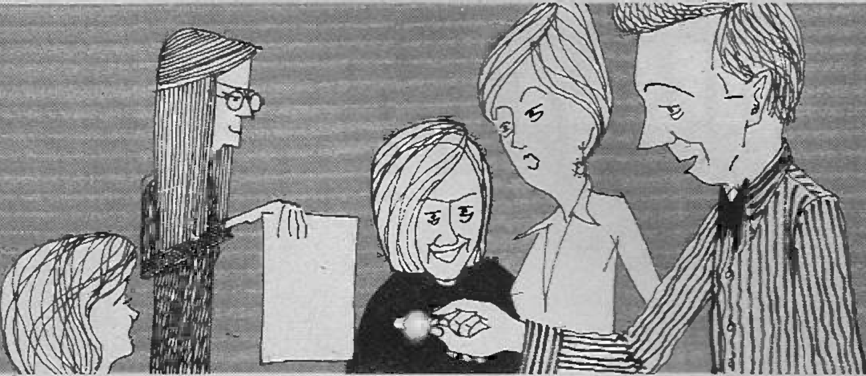
A matching plug is made by removing the head from a nail and filing a groove in it to solder the wire to. A piece of sleeving over the joint serves to hide the joint and to form a "stop" to avoid the plug sinking too far into the socket.



P. Gooderham,
Middlesborough

Physics is FUN!

By Derrick DAINES



LIGHTING A NEON LAMP WITH STATIC

Previously we have said that a static charge is usually of very high voltage. Now a neon lamp, of the small encapsulated type (see Fig. 1), frequently has a striking voltage—that is, the voltage at which it comes on—of 60 to 90 volts, depending upon the type.

The lamp has two small wires called electrodes connected to a metal cap at each end. These electrodes are enclosed in a glass tube, but do not touch each other so that when a voltage is applied the current does not flow through a continuous wire as in a tungsten lamp, but leaps across a gap, through a rarified gas. The action of the electrons passing through the gas makes it glow. If the reader does not already have a miniature neon lamp in his possession, the type used in neon screwdrivers, it is strongly recommended that he buy one. They are very cheap and incidentally is the first item we have recommended buying for this series.

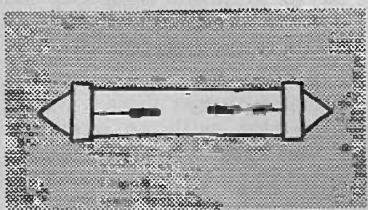


Fig. 1. Shows the type of neon lamp used in the experiment.

Rub a plastic film vigorously with a woollen cloth and then holding it by one hand, hold the neon lamp by *one cap* in the other hand and slowly bring it up to the film. It will be found that at certain points the lamp will glow for a brief instant before going out again. The points will increase in number as the lamp is brought towards the film, as in Figure 2, where the glow-points are numbered 1 to 4.

What happens is that the contact held in the hand is effectively earthed, so the free-cap passes through zones of electricity planes parallel to the film. As the cap reaches each of these in turn, the striking voltage of 90 volts is reached or exceeded and the lamp lights. However, the free electrons around the points numbered flow through the lamp so quickly that the voltage quickly drops and the lamp goes out.

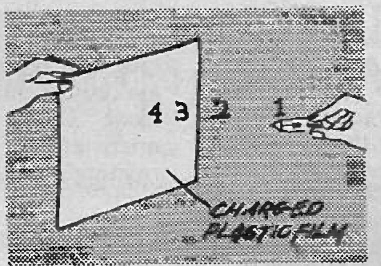


Fig. 2. Bringing up the neon lamp to a charged plastic film will cause the neon to flash as it passes through "zones" marked 1 to 4.

Repeat the experiment and notice carefully that only one of the two electrodes inside the capsule actually glows. Experiment will show that this is caused by a negative electric field, and it seems that we must think about electric fields sweeping out into space in just the same way that we think about magnetic fields.

The reader might have wondered, whilst vigorously rubbing his plastic film, if there is not an easier method, whether it can be mechanised. The answer is yes, it can be.

A chap called van de Graff invented just such a machine in 1931 and there have been various models made based upon the same principle of rubbing two substances together, usually at high speed.

At a later date, I will describe how the reader may make one for himself, but if he is particularly interested there are one or two distributors who advertise in Everyday Electronics and Practical Electronics, (Boffin Projects, for example), who offer various devices for high-voltage experiments.

The reader may rest assured on two points—if it is a van de Graaff generator that is advertised, it is simply a motor-driven armature rubbing two materials together, and although some thousands of volts are available, these of themselves are not lethal or even dangerous *if used with care*, as this month's experiments have shown.

A typical van de Graaff generator is shown in Figure 3.

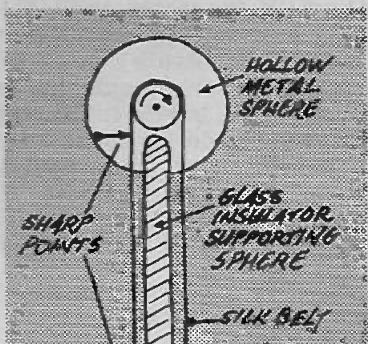
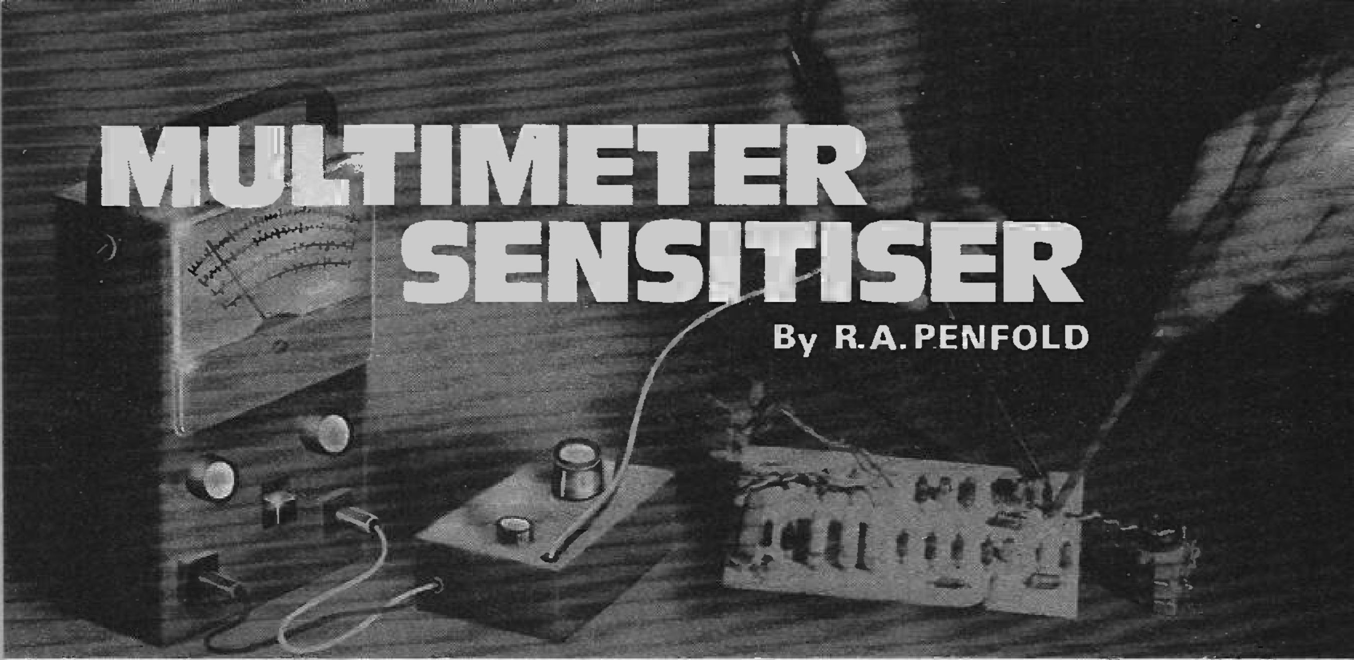


Fig. 3. The basic details of a van de Graaff machine for producing very high voltages.



MULTIMETER SENSITISER

By R.A. PENFOLD

A simple unit to increase the input impedance of a multimeter.

Now that modern silicon transistors have largely superseded the earlier germanium types, there is a tendency to use ever smaller operating currents in contemporary circuit design. Many of the transistors in general use today operate quite satisfactorily at collector currents as low as 10 microamps, and in low noise circuits often are used at such low currents. The input current to the base of the transistor is of course only a fraction of the collector current, and is often less than 1 microamp.

An ordinary multimeter with a sensitivity of 20 kilohms/volt requires an input current of 50 microamps to give full scale deflection (f.s.d.) of the meter, and is therefore unsuitable for taking voltage measurements in "low operating current" circuitry.

Consider for example, the fairly typical audio stage shown in Fig. 1. The base potential of the BC169C should be about 0·6 to 0·7 volts, and if a multimeter set to read 1V f.s.d. was connected between its base terminal and the negative supply, it might reasonably be expected to give a reading of about this figure. Assuming that the meter has a sensitivity of about 20kΩ/V, it will in fact give a reading of virtually zero.

This is because the meter needs 50 microamps to produce f.s.d., and therefore on the 1 volt range will require 30 to 35 micro amps to give a reading of 0·6 to 0·7V. Since the meter is connected to the positive supply via the 2·7 megohm base bias resistor, this will limit the maximum current flow to the meter to little more than 2 microamps ($6V/2{\cdot}7M\Omega = 2{\cdot}22$ micro amps), and obviously a totally inaccurate reading is obtained.

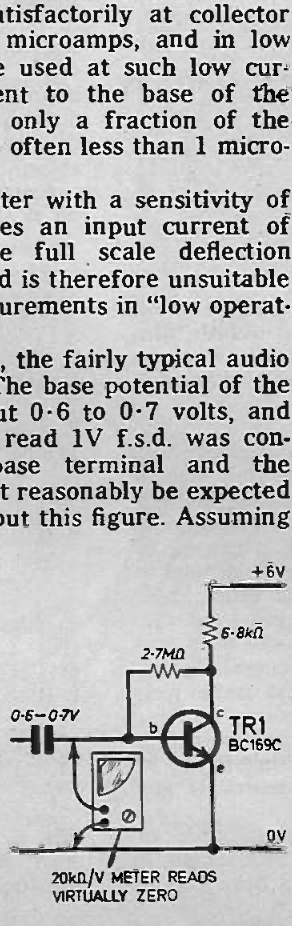


Fig. 1. An ordinary 20kΩ/V meter is unsuitable for voltage measurements where only a few microamps flow in the measured circuit.

ELECTRONIC VOLTMETER

For this kind of voltage measurement where only a very limited drive current is available, an electronic voltmeter of some kind is required. This type of device has an amplifier added ahead of the meter to boost the input impedance, so that a far smaller input current is required to produce f.s.d. on the meter.

The circuit diagram of a simple device which can be used in conjunction with an ordinary 20kΩ/V multimeter, or one of the popular dual range instruments, when switched to their 50 microamp range is shown in Fig. 2.

FOR GUIDANCE ONLY

ESTIMATED COST* OF COMPONENTS including V.A.T.

£2.50 excluding case

*Based on prices prevailing at time of going to press

everyday electronics

VOLUME 3 INDEX

JANUARY 1974 TO DECEMBER 1974

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CONSTRUCTIONAL PROJECTS

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SPECIAL FEATURES

SPECIAL SERIES

SPECIAL INSERTS

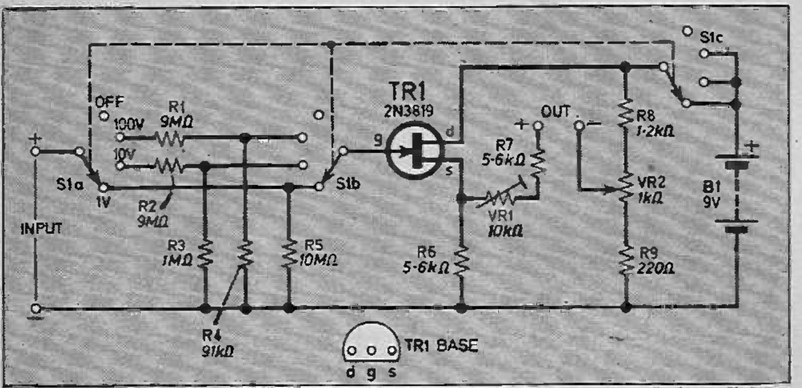

Fig. 2. Circuit diagram of the complete Multimeter Sensitiser.

It provides three voltage ranges, these being 0 to 1, 10, and 100 volts, and the input impedance is approximately 10 megohms on all ranges. This corresponds to a sensitivity of 10MΩ/V on the 1V range, 1MΩ/V on the 10V range, and 100kΩ/V on the 100V range.

HOW IT WORKS

The unit is based on a simple bridge circuit, one side of the bridge being formed by TR1 and R6, and the other side by R8 plus the upper part of VR2, and R9 plus the lower part of VR2. With no input voltage present, VR2 is adjusted so that there is the same voltage at its slider as appears at the source of TR1. The multimeter is connected between these two points via VR1 and R7, and will therefore indicate any unbalance in the bridge circuit, which with no input is zero.

Transistor TR1 has either R3, R4, or R5 as its gate bias resistor, depending on which range S1 is switched to. When an input voltage is connected TR1 turns harder on, and the voltage at its source increases. This unbalances the bridge, and the degree of unbalance, which is proportional to the input voltage, is indicated by the meter.

Preset VR1 is adjusted to give the unit a basic sensitivity of 1V f.s.d. On the 10V range the potential divider action of R2 and R3 reduces the sensitivity to the required level, and R1 and R4 perform a similar function on the 100V range.

Transistor TR1 is used in the grounded source mode, and therefore has 100 per cent negative feedback, resulting in it having a voltage gain of slightly less than unity. This gives the circuit excellent linearity, and means that as the gain of the unit is virtually unaffected by changes in supply potential, an unstabilised supply can be used.

Apart from being the range switch, S1 also functions as the on/off switch, position 1 being the off position.

Components....

Resistors

R1	9MΩ (see text)	R6	5·6kΩ
R2	9MΩ (see text)	R7	5·6kΩ
R3	1MΩ ±2%	R8	1·2kΩ
R4	91kΩ ±2%	R9	220Ω
R5	10MΩ		

All ± 5% ¼W except where stated

Potentiometers

VR1 10kΩ miniature skeleton preset
VR2 1kΩ lin. carbon

Transistor

TR1 2N3819 *n* channel f.e.t.

SEE **SHOP TALK**

Miscellaneous

S1 3 pole 4 way rotary switch
B1 9V PP3 battery and clips
Veroboard 14 holes by 15 strips, crocodile clips (insulated type 1 red and 1 black), test prods and leads, small case—see text, connecting wire, knobs for VR2 and S1.

WIRING

Most of the components are mounted on a small 0·1 inch matrix Veroboard having 14 holes by 15 copper strips. This is shown in Fig. 3, where all other wiring of the unit is also shown.

Start by mounting and connecting the components which are fitted to the Veroboard panel, leaving TR1 until last. Then wire R1 and R2 to the range switch; 9 megohm resistors are not available, and so these are made by connecting any combination of resistors in series which totals 9 megohms. For instance, on the prototype R1 consists of a 3 megohm, a 2·7 megohm and a 3·3 megohm in series, and R2 consists of two 1·5 megohm, a 2·7 megohm, and a 3·3 megohm in series. These resistors should have tolerances of ±5 per cent or better.

Now using five short lengths of heavy gauge insulated wire, connect up the leads between the component panel and S1. As the component panel is quite small this will provide it with a quite rigid mounting, and no further mounting should be required. Finally, connect up the remaining wiring using insulated leads.

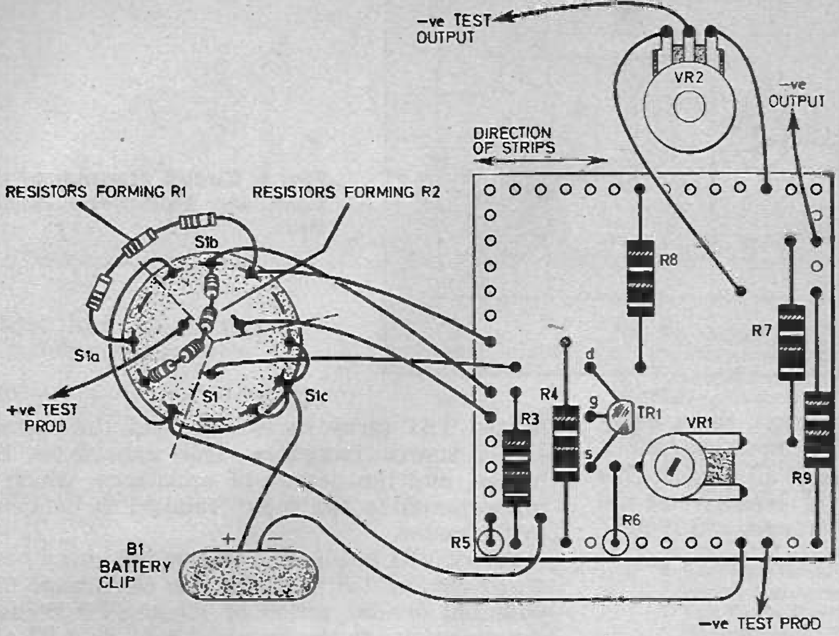

Fig. 3. Layout and wiring of the Veroboard and associated components for the sensitiser. There are no breaks in the copper strips.

CASE

The prototype is housed in a home made plywood box with inside dimensions of approximately 90 x 50 x 50mm. Any box of a similar size, provided it is not significantly smaller, can be used. Several suitable commercially made cases are available.

The general layout used on the prototype is with VR2 mounted on the left-hand side of the front panel, with S1 towards the centre, and the battery on the extreme right-hand side of the case. The component panel is positioned behind VR2.

A hole is drilled at a convenient point on the front panel, and is fitted with a grommet. This is used as an exit for the test leads. The plugs at the ends of the test leads are removed to enable direct soldered connection to the rest of the circuit. A second hole is drilled and fitted with a grommet, and is used as an exit for the two output leads. These are terminated in small coloured crocodile clips which connect to the test prods of the multimeter.

ADJUSTMENT

Before turning the unit on, adjust both VR1 and VR2 almost fully anticlockwise. Before connecting the multimeter to the output of the unit, use it to measure the battery voltage of the PP3 used to power the sensitiser, and make a note of the exact reading obtained. The sensitiser should be turned on while this reading is taken.

Now switch the meter to the 50 microamp range, connect it to the unit being careful to observe the correct polarity, and immediately zero the meter using VR2. With the unit switched to the 10 volt range connect the positive test prod to the battery positive terminal, and adjust VR1 to give a reading which is identical to that obtained when the multimeter alone was used to measure the battery voltage.

The unit is then ready for use. Before making a measurement with the unit always ensure that the meter is properly zeroed, by adjusting VR2 if necessary. ▣

PLEASE TAKE NOTE

In the *Modula 3 Stereo Amplifier* (March 1975) Fig. 11 page 131 the junctions between the wipers of VR4/104 and VR3/103 must be changed around at the VR3/103 end.

In *Shop Talk* (May 1975) under the Warning Winker paragraph, when referring to the "arrow head" of the diode sign we mean the bar end of the symbol.

In the *MW/LW Tuner* (May 1975) two C7's are shown in both Fig. 2 and Fig. 5. These can both be 0·01μF disc ceramic types.

ELECTRONIC THERMOSTAT

By MICHAEL J. HOLT

THE circuit to be described is a sensitive integrated circuit thermostat able to control wall heaters, electric bar fires and the like, retaining the ambient temperature stable within a very narrow temperature range about a set value. It utilises an operational amplifier to achieve high sensitivity while retaining low cost.

CIRCUIT DESCRIPTION

The circuit diagram of the electronic thermostat is shown in Fig. 1 and uses a very common operational amplifier type 741C.

Resistor R1 together with Zener diode D1 produces a stable reference voltage of 5·6 volts which is tapped to produce a potential for inputting to the inverting input of IC1. A 5·6 volt Zener is important since this is the voltage value that changes least with temperature. This is necessary because the circuit has to detect a temperature change of a fraction of a degree using a thermal sensitive resistor RTH1, and the reference voltage must not interfere with the detection circuitry otherwise the thermostat will not switch reliably.

Preset potentiometers VR1 and VR2 and variable potentiometer VR1 set the potential at the inverting input (pin 4) to IC1 while R2 together with thermistor RTH1 set the potential at the non-inverting input (pin 5). As RTH1 resistance varies with temperature, so the potential at the non-inverting input changes.

The 741C has a very high gain, around 200,000, so that a difference in potential between the inputs of more than a fraction of a millivolt results in the output being close to the potential of one or other of the supply rails. Hence when the voltage at one input crosses that at the other, the output of the 741 effectively switches from one supply rail to the other. In this sense the 741 is working as a comparator.

Thus when VR1 and VR2 have been set so that the inputs are at the same potential at the required temperature, any change from this temperature causes the 741 output to switch. The circuit is so designed that the output rises in potential when the temperature falls. This causes transistor TR1 to conduct, energising the relay which in turn energises the heater being used.

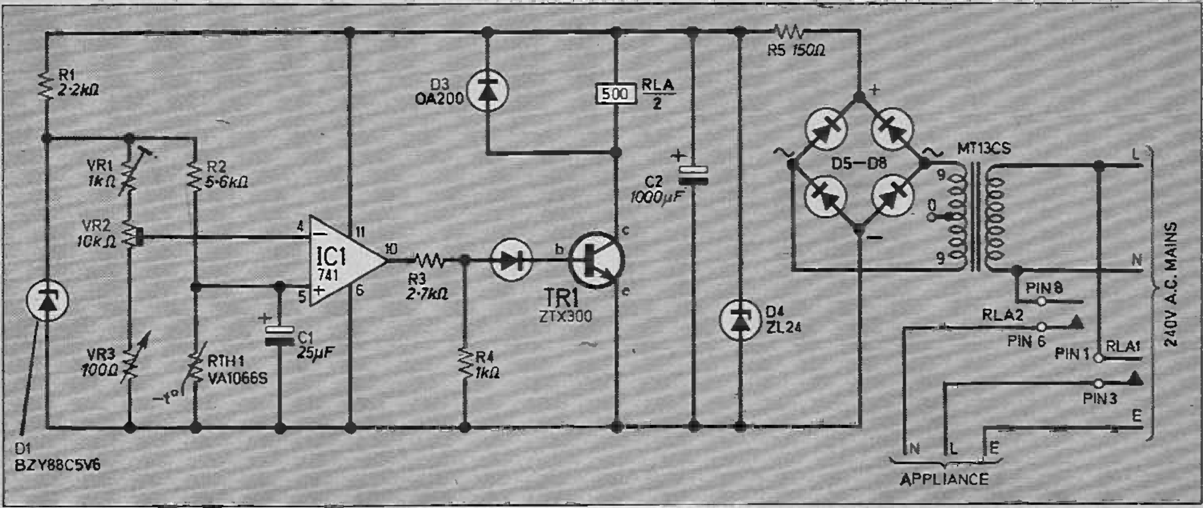

Fig. 1. The circuit diagram of the Electronic Thermostat.

When the temperature has risen slightly above the chosen temperature the 741 output falls, TR1 turns off, the relay drops out, switching off the heater.

The circuit sensitivity is such that the 741 will switch with a temperature change of less than 0·1 degree Fahrenheit, but thermal lag effects reduce the performance slightly so that the room temperature fluctuates by approximately 0·3 degrees Fahrenheit. This is considerably more sensitive than bi-metal thermostats.

Preset VR1 is actually used as a fine control while VR2 is a coarse adjustment; VR3 is a control brought out to the front panel for slight alteration in temperature to suit personal choice and provides a degree variation of about 2 to 3 Fahrenheit degrees.

Capacitor C1 is an anti-hum component which shorts away any a.c. picked up by the thermistor and its leads. This is necessary since the thermistor will more than likely be mounted close to the case.

The power supply section is a conventional bridge rectifier type giving full-wave rectification. Resistor R5 and Zener diode D4 holds the supply voltage to the rest of the circuitry steady at 24 volts.

CONSTRUCTION

The circuit is built on 0·1in matrix Veroboard, two panels size 19 strips by 35 holes; one holds

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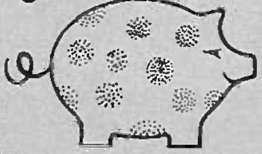
ESTIMATED COST* OF COMPONENTS including V.A.T.



£7.25 excluding case

*Based on prices prevailing at time of going to press

Components....

SEE SHOP TALK

Resistors

R1	2·2kΩ
R2	5·6kΩ
R3	2·7kΩ
R4	1kΩ
R5	150Ω

All ¼W carbon ± 10%

Potentiometers

VR1	1kΩ subminiature skeleton preset
VR2	10kΩ subminiature skeleton preset
VR3	100kΩ carbon linear

Capacitors

C1	25μF 25V elect.
C2	1000μF 50V elect.

Semiconductors

TR1	ZTX300 silicon *npn*
IC1	operational amplifier type 741C 14-pin d.i.l.
D1	BZY88C5V6 Zener diode 5·6V 400mW
D2	OA200
D3	OA200
D4	ZL24 Zener diode 24V 1·5W
D5-D8	B1/05 ½A 50V bridge rectifier
RTH1	VA1066S thermistor

Miscellaneous

T1 MT13CS (Douglas) mains/9-0-9 volt 100mA secondary

RLA 8-pin plug-in relay 24V d.c. coil resistance 475 ohms with two sets of changeover contacts rated at 10A each (Doram type 348-784)

Veroboard: 0·1in. matrix 19 strips by 35 holes (2 off); Paxolin sheet 90 x 50mm; octal base for RLA; 10 amp 5-way terminal block; 14-pin d.i.l. socket for IC1; case—Zippy type P3 (Henrys Radio); knob; connecting wire; mains 3-core cable to suit appliance used.

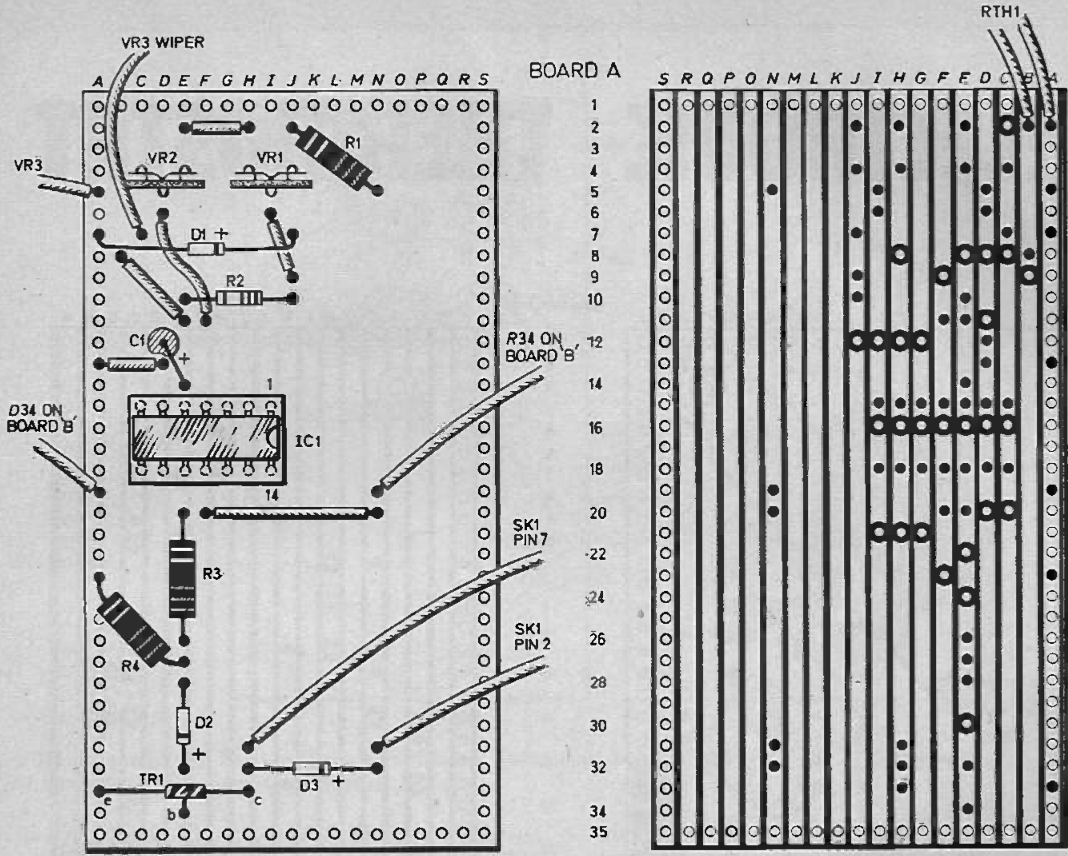


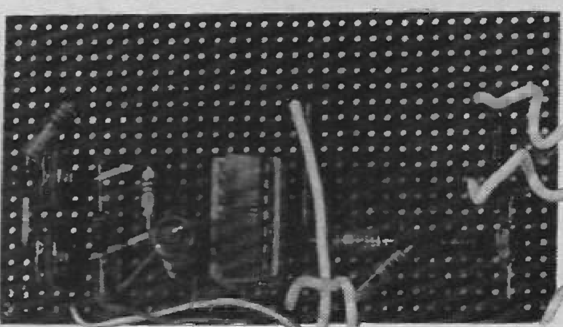
Fig.2. Layout of the components and wiring-up details of board A.

the main thermostat circuitry, board A, and the other holds the power supply, board B. The relay is mounted on a separate piece of Paxolin sheet, board C, the same size as the Veroboard panels. The three boards were all mounted in a Zippy case type P3 which is slotted to take the panels used and provides an attractive compact case. This case is not critical and may be changed to suit individual requirements.

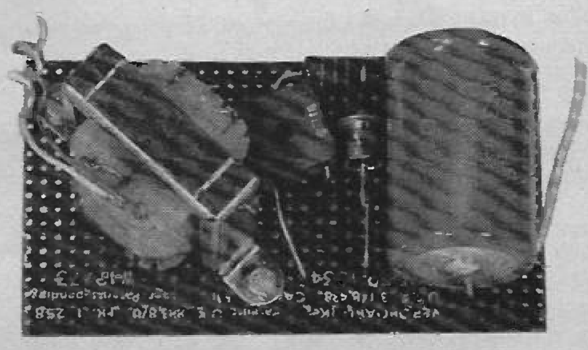
Begin construction by cutting the two Veroboard panels to size and making the breaks along the copper strips on the underside. The layout of the components on board A is shown in Fig. 2. Note that a 14-pin d.i.l. socket is used to mount IC1. Position and solder the i.c. socket followed by the capacitor, resistors, potentiometers and link wires. Solder the semiconductors in place last of all and use a heatshunt when soldering to avoid damage to these devices from the hot soldering iron. Pay special attention to the diode polarities.

The layout of the components for board B is shown in Fig. 3. The transformer used in the prototype had short stub lead-out wires protruding from the underside. These are to be soldered to the board through the holes specified in Fig. 3. Ensure that the bridge rectifier (D5 to D8) is connected in the right way round.

With reference to Fig. 4, prepare the piece of Paxolin (board C) to accept the relay socket SK1

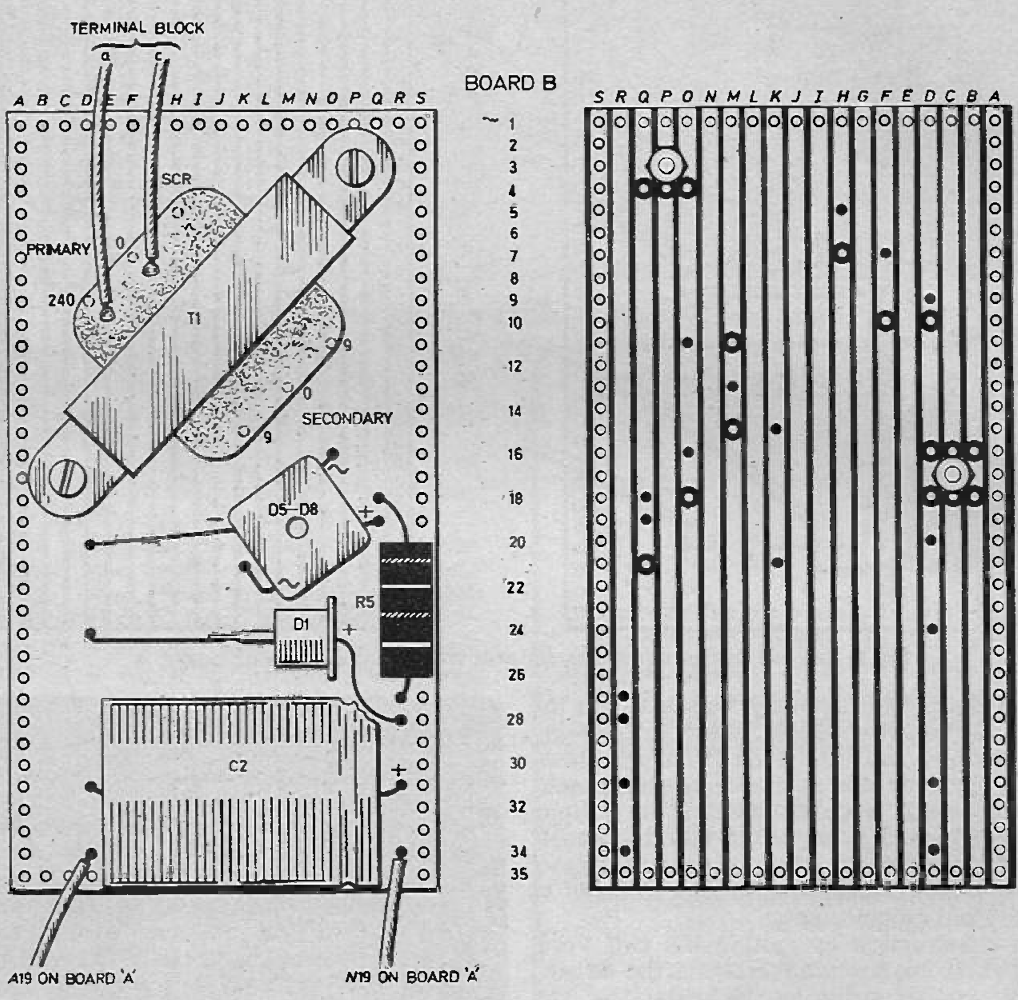


Photograph of the prototype board A.



Board B of the prototype thermostat.

ELECTRONIC THERMOSTAT



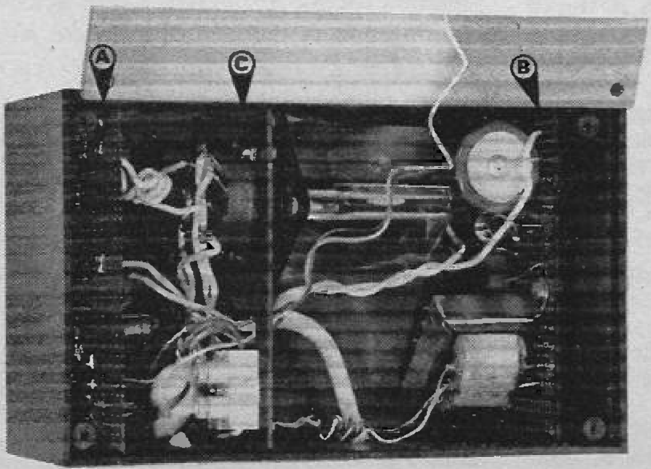


Fig.3. (above). The layout of the components on board B and details of wiring to the other boards.

Photograph (left) of the prototype showing positions of the three boards within the case.

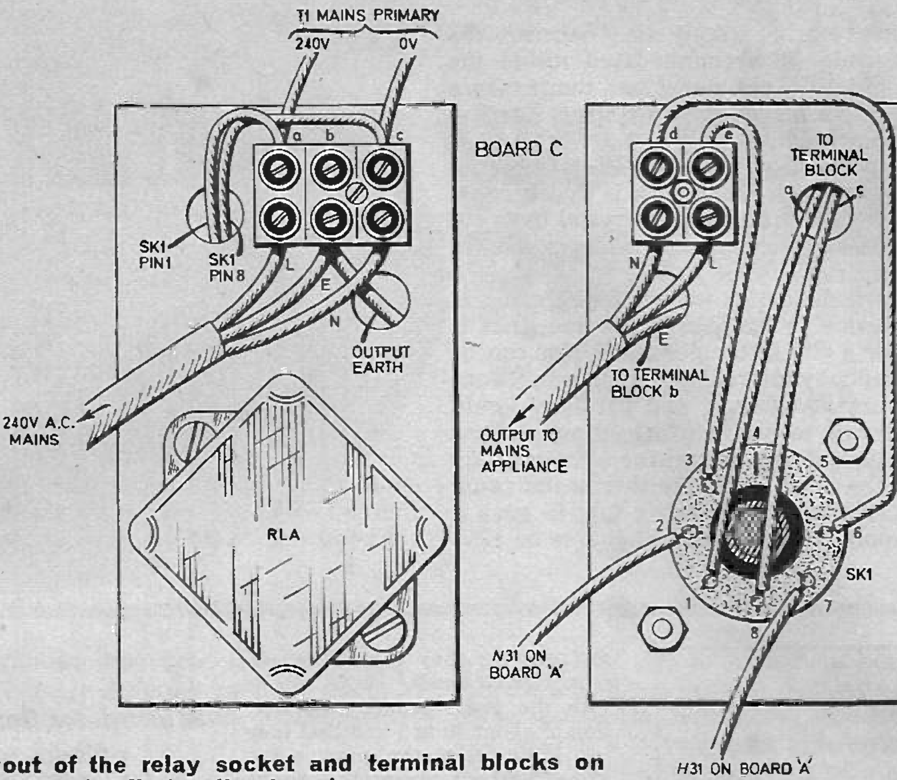


Fig.4. The layout of the relay socket and terminal blocks on board C and wiring details to other boards.

and the terminal blocks, and drill the two holes for feeding through the flying leads. Secure SK1 and the terminal blocks and wire up the three boards as indicated, keeping in mind their relative positions within the case. Next secure the control potentiometer VR3 to the front panel and conect up as shown.

The thermistor is connected to the main board by a pair of wires fed through the side of the case; solder the wires to the board before soldering the thermistor to the wires. Place the boards in the slots in the case as shown in photograph and then feed the external wires through holes drilled in the side of the case. The thermistor can be mounted on a small piece of Veroboard, and for the sake of neatness and protection, housed in a small aerated box.

All mains leads should be of adequate gauge for the heater being used, and should, for safety, be connected using screw connector blocks as shown.

SENSOR POSITION

The thermistor being the temperature sensitive element must be positioned carefully. It should ideally be fixed at 1 metre from the floor, and at least 1 metre away from any doors and windows. It also must not be too close to the heater, preferably some 2 to 3 metres away. It is because of the importance of positioning that the thermistor is mounted outside the case on wire leads, so that it can be correctly located while placing the thermostat case in the most convenient position. The leads to the sensor could be any length up to about 3 metres.

SETTING UP

The thermostat is easily set up once the thermistor has been correctly positioned. If the ambient temperature is below the required temperature, adjust VR2 until the device just switches on, leaving VR1 at the centre of its travel. When the required temperature is reached, trim VR2 and then VR1 until the circuit is just on its switching threshold with the front control VR3 at the centre of its travel. The thermostat is now set up.

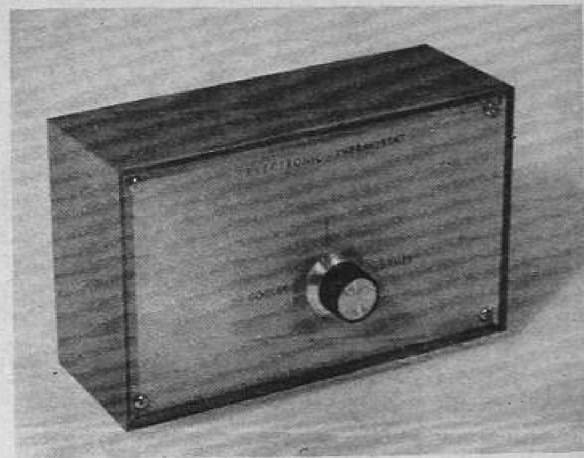
OTHER APPLICATIONS

Although originally designed to control a 500 watt wall heater the thermostat is able to serve in a wide variety of other applications. It could in fact operate without alteration over a temperature range of about −50 to +120 degrees Fahrenheit simply by adjusting VR2, so that it could handle a number of special purpose applications.

It could be utilised in a heated greenhouse, perhaps retaining the temperature considerably above that outside as may be required for tropical plants. It may interest amateur photographers who use the standard do-it-yourself photographer's dishwarmer—a 40 watt light bulb mounted in a biscuit tin—because the thermistor could be accommodated inside the tin and would hold the developer temperature accurately stable, as is often required, particularly for colour work.

Another possibility perhaps of interest to those concerned with radio work is that it could be used to control a home-built crystal oven for a frequency standard, probably using a smaller relay in such a case.

There is a modification which can be made to allow the device to operate in reverse, that is switch *on* for a *rise* in temperature. This can be achieved simply by interchanging all connections to the 741 inputs (pins 4 and 5). This would allow the device to detect overheating perhaps in a car engine; if the thermistor were suitably attached to the head block, the thermostat could be used to switch on an electric fan. In such a case the supply voltage would of course be 12V, but this will not affect the operation of the circuit except that the relay should be a 6 to 12V type of coil resistance greater than 150 ohms.



New products and component buying for constructional projects

SHOP TALK

By Mike Kenward

WHAT next? The Mickey Math is now with us and the makers claim it is being distributed as an educational aid and also as an executive gift (one wonders just what these executives do with all their gifts). The Mickey Math is simply a normal calculator fitted in an enlarged case with a large picture of Mickey Mouse on the case.

The Mickey Math is distributed by Decimo, already well known for calculators and costs £17·50 plus V.A.T.

White Line Follower

Some unusual parts are needed for the *White Line Follower*, in particular the gears, motors, axles and wheels; they can all be obtained from model shops. Make sure the gears provide a reduction of about 40 to 1 and that they will fit on the motor spindles and axles. Battery mounting on the prototype unit was achieved using double sided Sellotape.

As far as the "electronic components" go the relays and photocells are the only parts that need some explanation. The relays can be any small type that will work from 9V, have a coil resistance of at least that specified—greater is in order—and have one set of normally closed contacts. The photocells can be any of the cadmium sulphide photo conductive type—the smaller the better. We suggest you go for some fairly small ones that are relatively cheap.

Electronic Thermostat

One or two parts for the *Electronic Thermostat* may be hard to find. They are not unusual but if the wiring of the prototype is to be followed particular types must be obtained. The relay is a Doram type with plug in base; if other types are used the wiring and pin connections may need altering. The transformer is a Douglas type with printed circuit pin connections—others of the correct specification could be used but the wiring of the mounting board will need alteration.

The transformer (type MT 13CS) is available from Barrie Electronics, 3 The Minories, London EC3N 1BJ. Price, including post, packing and V.A.T. is £1·74.

Multimeter Sensitiser

No problems when buying for the multimeter sensitiser, all the parts should be readily available. Test probes and leads can be purchased from most shops and a variety are usually available. The case for the project can be home made from wood or any suitably sized plastic box could be used—we suggest you go for a fairly strong one as it may get a great deal of use.

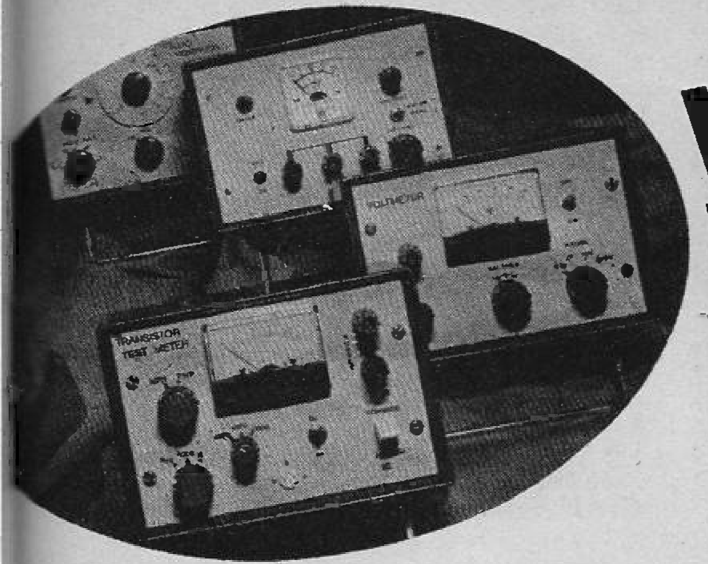
Catalogues

We have recently received some new catalogues; Home Radio have once again produced their high quality comprehensive catalogue containing 244 pages size 290×200mm approx. and listing over 6,000 items. Cost 65p plus 33p post and packing. Each catalogue contains 70p worth of vouchers when used as directed.

Doram have produced a catalogue amendment leaflet (No. 2) dated March 24, 1975, and a new price list, dated April 1, 1975, to complement their catalogue—price 25p including post and packing. The cost of this catalogue is refunded when an order for £5 or more (plus V.A.T.) is placed.

Prices

Will readers please note that prices quoted in this issue may be subject to alteration arising from the new Budget proposals.



Workshop Practice

By MIKE HUGHES M.I.E.R.E

PART THREE

A Professional Finish

WE CONTINUE on the same theme as last month, namely covering cabinets and in particular wooden cabinets and loudspeaker coverings.

WOODEN CABINETS

You can use paint or plastic film on wooden cases but you have to be a little bit more careful. First, ensure that the wood is thoroughly sanded and then dusted off. When painting, go through all the steps we recommend for metal cases except that you can usually forget about the first coat of primer. Two coats of undercoat should be applied instead but you must rub down the surface between these coats as the first will raise the grain. Provided you do this rubbing down carefully you can get a surface that looks no different from that obtained on metal. An advantage with wood is that you can easily fill any nasty chips or cracks with one of the proprietary filling compounds before the undercoat operation.

Remember that when you have bolts going through a piece of plywood there is a tendency for the heads to sink into the wood if you are going to tighten the nuts hard. To avoid this happening use ample sized washers under the screw heads.

Whether working on wood or metal always try to use chromium plated screws for outside surfaces, they cost a little more and are a bit more difficult to obtain but they make all the difference to the appearance of the finished job.

COVERING WOOD

Applying self adhesive plastic film to wood is a little more difficult because it will not stick (for long periods) to the rough surface of normally sanded wood. The only exception to this is the finished side of hardboard but even then there is a problem because nothing on earth will make it stick to the reverse side when you do any returns. The only satisfactory solution is to paint the wood first, just as we have described, and then apply the film.

Of course you do not have to be quite so fussy about the painted finish but it must be glossy to get the best adhesion. You must not expect the film to hide any cracks or lumps and bumps in your woodwork, if anything their presence will be emphasised through the film so make sure you do any filling that is necessary before painting.

VENEER

When dealing with wooden cabinets one of the best looking finishes is a real wood veneer. This has the advantage of not only looking good but it can hide a multitude of sins. It is a little more tricky to do properly than the forgoing methods but all in all it is a somewhat quicker operation with the do-it-yourself aids that are now available. There are numerous types of veneer available and they come in all sorts of finish from Birds Eye Maple to Teak and, probably the cheapest, Sapele Mahogany.

You can buy veneer with an already plastic treated finished surface with a strengthening backing—one such brand is called "Rollwood". This is particularly easy to use because it will not chip or splinter, can be bent round corners and needs no polishing operation to finish it off.

Alternatively you can get a straightforward veneer which has an iron-on glue deposited on the back surface. This, again is easy to apply but you have to be careful at edges to prevent the veneer splitting down the grain when you do the trimming. Cheapest of all is raw veneer.

If you choose Rollwood or ordinary veneer you must supply your own adhesive for bonding it to your cabinet. Without doubt the best adhesive to use is one of the impact varieties like Evo-stick.

When using this make sure that you have a very even layer on both the reverse surface of the veneer and the surface of the cabinet. There should be no areas left uncoated as these will give rise to airblisters in the finished job. At the same time do not apply too much adhesive as you will not get a strong bond. Provided you follow the manufacturers recommendations correctly you should have no trouble getting a good bond but make sure that you burnish down the edges well to prevent any tendency to lift off.

With iron-on veneers make sure you have the iron set at the right temperature by testing it on a few scraps first before starting on the main job. Ideally the glue should flow and stay soft for about 5 or 10 seconds before it cools down sufficiently to set. During the setting period you must remember to apply pressure to the veneer to prevent air bubbles forming. This can be a bit of a problem when using large areas, therefore it is best to start the ironing operation at the centre of the job and work out towards the edges in a methodical manner. Again pay special attention to the edges!

TRIMMING AND SANDING VENEER

You can obtain some extremely professional looking finishes with veneer including inlay effects at edges, but this technique ought to be left until you gain a bit of experience in handling the material.

When trimming the edges make sure that you use a sharp knife and trim in the direction of the grain of the veneer to avoid digging the knife into the edge of your cabinet. Finish off the edges with fine sandpaper held on a wooden block. Finally stick edging strip on any exposed edges and trim these down in like manner.

Unless you have used a ready finished veneer you must now use the finest sandpaper you can get and gently rub down each surface *along the grain* to get a silk-like finish. Be careful at corners that you do not sand through the veneer to the underlying wood.

WAXING AND VARNISHING

There are various methods of finishing off a wood veneer surface. The author prefers a dull gloss finish, as obtained by waxing. Before applying the wax it is a good idea to feed the grain with an oil such as teak oil (it does no harm applying this to mahogany or other dark woods). This should be rubbed in liberally and allowed to dry. If you run your fingers over the surface you will find that the grain has lifted slightly so it is then a good idea to give the surfaces another very gentle sanding and then follow this with a liberal polishing with any household wax. The more you polish the better the colour of the wood and the more attractive the finish.

Perhaps one of the reasons why the author prefers this method is that once the first few operations have been carried out the rest can be left to the wife to be incorporated into the normal round of domestic chores!

A higher gloss finish can be obtained by using polyurethane varnish but this should *not* be applied to teak veneer as the natural oils in the teak prevent the varnish setting properly. To get the best gloss finish you should apply one layer of ordinary varnish, let it dry thoroughly and then rub it down with fine sandpaper and then apply a further coat. Three or four coats applied in this way will produce a mirror-like finish.

LOUDSPEAKER COVERING

It is worth mentioning how to handle loudspeaker grill material. This could be of the expanded metal variety, Tygan or cloth. Each has its own problems in fixing. Probably the easiest to handle is the expanded metal as it is usually fixed by glueing with epoxy resin to the inside surface of the final box or can be held in place over the same screws which fix the loudspeaker (being sandwiched between the loudspeaker and the inside of the case).

Tygan is the proprietory name for plastic loudspeaker material—woven out of plastic threads. It is extremely attractive and enhances the outside appearance of an enclosure tremendously. It is usually applied over the whole front surface of a loudspeaker obscuring the aperture. This makes it easy to apply because you simply stick it over the whole of the front panel *before* the panel is inserted into the enclosure.

Before sticking it you should paint the front of the panel black so that there is no chance of seeing the loudspeaker aperture through the materials. Evo-stick is probably the best adhesive to hold Tygan into place but you must return the material round the edges of the panel to hold it securely. Once the Tygan is stuck there is a very nice little trick which helps get rid of the wrinkles over the aperture. By warming it up in front of an electric fire the material has the property of shrinking slightly and it will pull itself taught—another reason for returning it round the edges of the panel.

Finally you can use loudspeaker fabric in exactly the same way as Tygan (don't forget to paint the surface of the panel black) but you should use Copydex or a similar non-staining adhesive and you have to do the best you can about getting rid of creases, but be careful not to overstretch the material.

To be continued

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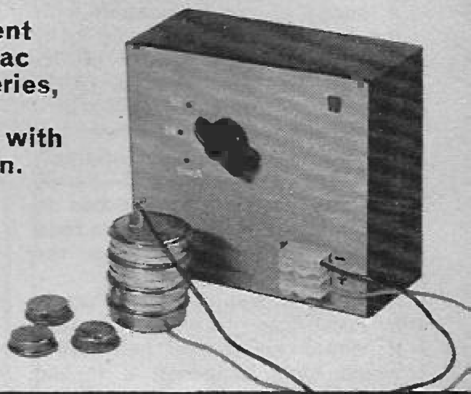
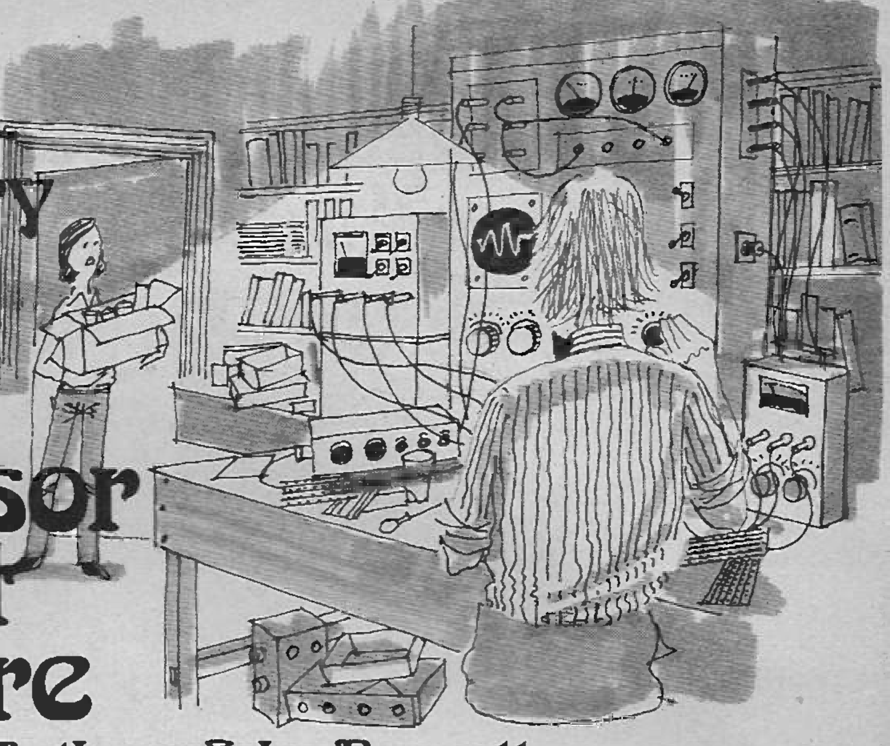


everyday electronics

JULY ISSUE ON SALE FRIDAY JUNE 20

The Extra-ordinary Experi-ments of Professor Ernest Eversure



by Anthony John Bassett

Professor Ernest Eversure, or the Prof. as his friends call him, has been experimenting in electronics for more years than anyone can remember and we thought that you might like to hear of, and perhaps repeat, some of his extraordinary experiments. Anthony J. Bassett recounts some of these experiments every month so why not follow the Prof's work and learn along with young Bob, his friend.

As the "foaming robot" approached the Prof., Bob could hear the sounds of the clicking and whistling noises it made, as a means of communication with the Prof. Bob warily moved away as the foaming mass slowly approached, but the Prof. called out and told him to stand still.

"It will not quite reach the point where you are standing", he reassured Bob, and surely enough, the mass approached to within a few inches of Bob's feet, then slowly drew back in the direction whence it came.

Bob was astounded. "What is it, Prof? How did you know that it would not reach me? What would have happened if it had reached me?"

"My experimental liquid-state amplifier must have bubbled over" remarked the Prof. "But in accordance with the law of conservation of energy, I knew that there was insufficient available energy to expand the foaming mass to reach the point where you stood."

With a few more clicks and whistles, the Prof. gave further instructions to the robot, which made its way to one of the workbenches and returned with a strange device of metal tubing and flexible plastic hosepipe. It connected one of the tubes to a water tap and turned on.

The device sprayed the mass of bubbles with fine jets of water, and simultaneously sucked it up by means of a venturi activated by a stream of cold water, then dumped the mess down the drain! The Prof. could see that the lab. would soon be clean and in good order once again.

Meanwhile Bob had been deep in thought.

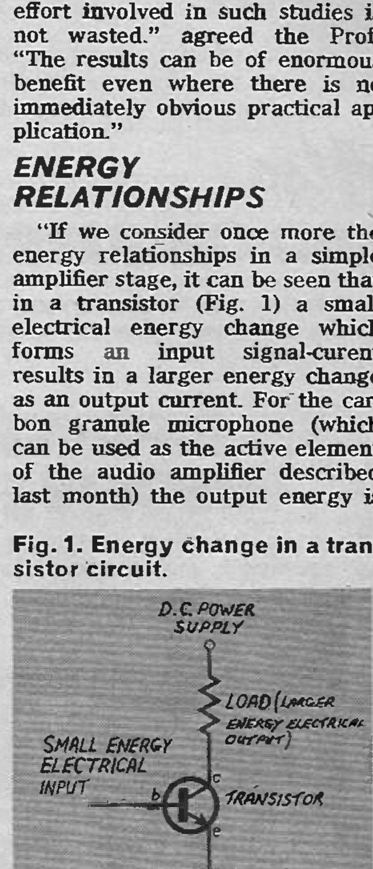
"Prof.," he said, "Because you know about the law of conservation of energy, and so many other scientific things, you were able to predict that the foam would not reach me. I wish I knew a lot more about all these things—transistors, electronics, energy. It would be possible for me to build all sorts of helpful devices—and even to invent a few, maybe, like you do!"

"I am sure that the time and effort involved in such studies is not wasted." agreed the Prof. "The results can be of enormous benefit even where there is no immediately obvious practical application."

ENERGY RELATIONSHIPS

"If we consider once more the energy relationships in a simple amplifier stage, it can be seen that in a transistor (Fig. 1) a small electrical energy change which forms an input signal-curent results in a larger energy change as an output current. For the carbon granule microphone (which can be used as the active element of the audio amplifier described last month) the output energy is

Fig. 1. Energy change in a transistor circuit.



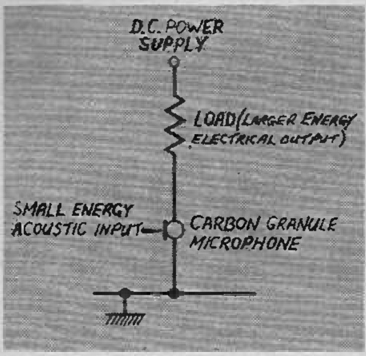


Fig. 2. Energy change in a circuit powered by a carbon microphone.

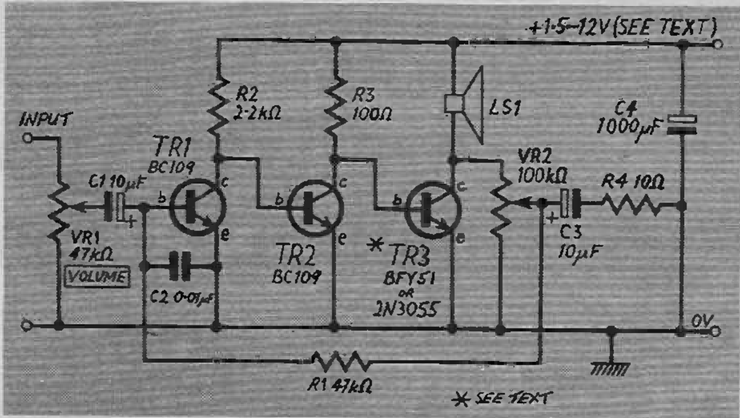


Fig. 3. An experimental class A amplifier.

provided in similar form, but the input energy required by this device is in the form of mechanical or acoustic vibrations." (Fig. 2).

"I see" said Bob, "Amplifiers in effect convert a small energy input signal into a large energy output signal which is a replica or a reflection of the input."

"Yes" replied the Prof., "and the power rating of the amplifier is a guide to the rate at which the output energy can be delivered to the load."

The Prof. drew another circuit diagram (Fig. 3).

"I know that you are wanting to experiment with amplifiers, and I think that this should interest you, Bob. It is a three-transistor class A amplifier with the transistors directly coupled to each other like those which you drew earlier (Fig. 3 last month). The loudspeaker is directly connected to the collector of TR3 so that when the resistance of TR3 varies, it allows varying amounts of current to pass through the loudspeaker and sounds are produced accordingly.

Almost any loudspeaker of 3, 8 or 15 ohms can be used, and one from an old T.V. or radio should be suitable. The speaker is connected so that the red spot or + sign connects to the battery positive when the switch is on. If there is no red dot or + sign on the loudspeaker, connect it so that when the switch is turned on the speaker cone moves slightly outwards."

"When a signal reaches the input transistor TR1 through VR1 and C1, the resistance of TR1 varies slightly. This causes a bigger variation in the resistance of TR2, followed in turn by an even greater variation in the resistance of TR3, which will produce an audible output from the loudspeaker. By adjustment of VR2 the operating current of TR3 is varied, and VR2 should be adjusted to a point as near to the negative line as possible, consistent with clear sound output from the speaker. If only very low volume is wanted, a very low setting can be used, which gives a lower operating current. This helps to conserve the battery."

Bob collected together the necessary components. He smeared the case of TR3 with silicone grease and fitted a push-on heat-sink. He then mounted the transistors, resistors and capacitors on a piece of perforated board, and connected the battery, on/off switch, loudspeaker, volume control VR1, and an input-socket by means of flexible wires to give the circuit of Fig. 3. He used screened wires to the volume control in order to avoid interference.

After adjusting VR1 to give minimum volume, and VR2 to give minimum bias, it only remained to connect a source of audio signal to the input to test the amplifier, and to adjust the bias control VR2 for correct operation.

"The amplifier may be used to amplify a microphone, record-player deck, tape recorder or cassette deck, or with your musical note-generator or electric kazoo. It may be used to amplify almost any audio signal of sufficient amplitude." remarked the Prof.

Bob connected the musical note-selector which he had made earlier, to the input of the amplifier, and soon the sounds of melodies and glissando sound-effects could be heard in the laboratory. Next he connected an electric guitar, then a series of other sources of sound-signal to the input as Prof. had suggested.

POWER

"Before I install this amplifier into a cabinet", Bob asked, "I wonder whether there is anything I can do to improve its performance? It is quite suitable as a small amplifier, and for most purposes it is reasonably loud and clear. But I wonder whether there are some simple modifications which I could do at low cost?"

"What do you have in mind?" asked the Prof.

" I wondered whether it would be possible to use two speakers instead of one," remarked Bob, "and connect the extra speaker whenever I need more volume. Also, could I get more volume by using a bigger battery? Can we do a few experiments with this amplifier to find the answers to these questions?"

"Yes", replied the Prof. "I think a few experiments with this circuit would be well worthwhile, as I am sure that we can increase the output from the amplifier and learn a few things at the same time."

"Firstly, if you increase the power output of this class A design in any way, it will become more expensive to use because of battery costs. So although running costs are not high, they could become quite a lot higher unless you changed the circuit slightly to enable a rechargeable battery to be used. We can try using a 6 volt lantern battery or a 6 volt motorcycle battery; and we might even try a 12 volt car

battery. That could make it quite a lot louder! But I think that modifications will become necessary if we wish to operate at over 6 volts, or to use several loudspeakers."

Bob decided to start with a low voltage and work up. He found that with a 1·5 volt dry-cell he could connect 2 or 3 three ohm loudspeakers together to the terminals of the amplifier, but after a few minutes the sound faded and became distorted. The battery he was using was not a fresh one, however, and when he tried a new battery the sound was a lot better.

"If you continue to use a large number of speakers of only 3 ohms," observed the Prof., "The battery will not last for very long. However, an equal number of 8 ohm speakers will enable the battery to last approximately twice as long, and 15-ohm speakers would enable the battery to last even longer."

Still using the 1·5-volt dry-cell, Bob connected a pair of low-impedance headphones in place of the speakers, and found that the unit made a fine headphone amplifier. Then he changed back to the loudspeakers and replaced the single dry cell with a 3 volt cycle front-lamp battery.

Before switching on again, he was careful to turn VR2 to lowest bias, so that the bias could be reset to suit the new voltage. He noticed that the sound output could be made considerably louder with the 3 volt supply than when he had been using only 1·5 volts.

"Will it be all right to use a 4·5 volt or a 6-volt battery now, Prof.?" he asked.

MODIFICATIONS

"If you use either a smaller number of loudspeakers, or speakers of higher impedance in ohms, so that TR3 does not overheat, then you will only need to adjust the bias control again to operate the amplifier successfully.

If you go above 6 volts, it will be necessary to alter R3, and I would suggest using a 220 ohm wirewound 2·5 watt resistor. Also, it may be necessary to replace TR3 with a transistor capable of handling higher current and power dissipation. This would depend upon the speakers you use, and the bias setting."

Bob drilled some holes in a piece of 16 s.w.g. aluminium about 50 sq. cm. in area and bolted a 2N3055 transistor into place on it, using a small quantity of silicone grease for good heat transfer. He replaced R3 with a 220 ohm 2·5 watt w.w. resistor as the Prof. had suggested. Now he readjusted the bias control VR2 to zero, connected a 6 volt battery and switched on. He found that two or three 3 ohm speakers could be used, and the volume from each speaker was now considerably greater than before.

"It is loud enough now" remarked Bob, "to use for a small party, or to have a few friends around to listen!"

The Prof. agreed. "The output from the amplifier is quite powerful now—and I would not advise the use of headphones without a series resistor to cut down the power. Also, if you touch the heat sink, you will notice that TR3 is now quite warm. This is all right as it will operate at quite a high temperature. But it is a sign that a larger heat sink would be beneficial if we boost the output power of the amplifier much more!"

"I would like to try using a 12 volt car battery" remarked Bob. While he fitted a larger heat sink, the Prof. pursed his lips and emitted a series of clicks and whistles. A series of answering signals came from another part of the laboratory, and a few minutes later, the Prof's experimental robot came into view, carefully clutching a 12-volt car battery. Being very careful not to short-circuit the battery with his metal arms or body, he set it down on the bench near to where Bob was working. Next to the battery he deposited a set of red and black connecting leads with crocodile clips attached.

Turning the bias control to zero setting, Bob connected a single 15 ohm speaker to the amplifier, then connected the 12 volt battery. He adjusted the bias control once more until the music signal which he was feeding to the input came through loud and clear.

Now the music was so much louder that Bob found that it had attracted a small audience. From different parts of the laboratory the Prof. and his experimental robot came and stood beside Bob as he made adjustments to the controls.

"I see that you have used a larger speaker now that the amplifier is being operated from 12 volts," remarked the Prof. "That is a very wise precaution, as the speaker coil may be required to dissipate several watts under normal working conditions, and if VR2 were incorrectly adjusted the dissipation could exceed 10 watts, which would be enough to damage some speakers.

If you decide to try the amplifier with an 8 ohm speaker at this voltage, it would be necessary to either use an even more powerful speaker, or to exercise care when adjusting VR2, so that excess current does not flow in the speaker coil."

The Prof. listened carefully to the amplifier.

"It is Paul's birthday soon," he remarked, "And I think I heard him mention that he would like a 12 volt amplifier for use in his car!"

The Prof's experimental robot had also been listening carefully to the amplifier. Soon the Prof. and the robot were engaged in what appeared to Bob to be a lively conversation in a special code of clicks and whistles.

"What was all that about, Prof.?" he asked when they had finished.

"The robot was giving me a list of the distortion figures at various frequencies and degrees of intermodulation which he has deduced by listening to the equipment just now. It may sound just fine to we h u m a n s—but apparently it's not quite up to the robot's high standard."

"The robot is sensitive to the technical quality of the sound reproduction, but we are sensitive to the qualities of the music which is being reproduced."

"Talk about ironic! He was going to buy the components for his Lighting-up Warning and got pinched for having no lights on."

DOWN TO EARTH

By GEORGE HYLTON

METER SENSITIVITY AGAIN

MR. EBRAHIM ALI writes from Bahrein with a question which often puzzles newcomers to electronics. (To be fair, it must be said that it would puzzle a lot of old hands as well, if they stopped to think about it.) It's just this: *"What do makers of multimeters mean when they quote the sensitivity in 'ohms per volt'?"*

This question was dealt with in an earlier *Down to Earth* (November, 1973, page 615) but I welcome the opportunity to have another go at it, both for the benefit of new readers and for the chance of exploring it from a rather different angle. In the earlier article I made the point that ohms per volt is really not much more than a roundabout way of stating the amount of current which has to flow through a voltmeter to move the pointer from zero to maximum on the scale; e.g., if the meter has a sensitivity of 1000 ohms per volt the current for full-scale deflec- is 1mA. (To find the current, divide the full-scale volts by the ohms: 1V/1000 ohms=1mA.)

The only reason for quoting ohms per volt is that it gives a quick way of working out the resistance of a voltmeter when set to a particular voltage range. Thus a meter of 20 kilohms/volt has a resistance of 20 kilohms on its 1V range, 200 kilohms on its 10V range, and so on. This resistance has an effect on the circuit being measured, and knowing it helps you to see whether the effect is serious and if necessary to allow for it.

VERY SIMPLE CASE

To take a very simple case, suppose you want to use your voltmeter to test a dry battery. If your meter is 20 kilohms/volt and you set it to a 10V range to check a 9V battery, the meter resistance is 200 kilohms. To read 9V, the meter will draw only 45 microamps. But the battery, in actual service, will usually have to deliver a lot more than this, and the voltage will then fall.

A more realistic test will be to put the battery in its equipment, switch on, and check the voltage on load.

This is one of the few cases where the meter is too sensitive for the job. Usually it isn't sensitive enough. The reason is easily seen from a practical measurement (Fig. 1). Here the flow of collector current I_c sets up a volts drop across R_c ($V=I_cR_c$ by Ohm's law). When the meter is connected, the meter resistance R_m is in parallel with R_c and part of I_c is now diverted through R_m. The result is to reduce V. So the meter indicates something less than the "true" voltage.

LOADING ERROR

To take a simple case, if $R_m=R_c$, then half the current is diverted through the meter and the voltage reading is 50 per cent low. Clearly, if the error is to be small, R_m should be much greater than R_c so that only a small portion of I_c is diverted. Ideally, R_m should be infinite, then there would be no such "meter loading error", but this ideal is approached only by electronic voltmeters. With ordinary multimeters there is always some error. The question is, is it serious?

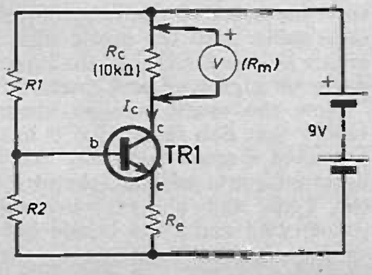


Fig. 1. Measuring the voltage across the collector load of a simple amplifier.

SIMPLE RULE

Well, to take another case, if R_m is 100 times R_c common sense tells you that only about one-hundredth of the current is diverted through the meter. The error can't be more than one-hundredth, i.e. 1 per cent, which is usually quite negligible.

The trouble is that, even with a sensitive meter of 20 kilohms/volt or more there are still plenty of cases where the meter resistance is a good deal less than 100 times the circuit resistance. Can you allow for this? That is, can you estimate the error? Yes, and the rule is quite simple. If the meter resistance is *ten* times the circuit resistance then the meter reads low by one *eleventh*, and so on.

Thus if R_c were 10 kilohms and R_m 200 kilohms, which makes $R_c/R_m=1/20$, the error would be 1/21 of the reading. The error fraction has a number at the bottom which is always one more than the resistance fraction. In symbols, if the "true" voltage is called V_o and the meter reading V_m, then:

$$V_o=V_m\ (1+R_c/R_m)$$

This says that to find the true voltage you add to the indicated voltage the *resistance fraction* times the indicated voltage.

In Fig. 1, suppose R_c is 10 kilohms, and the meter is 20 kilohms/volt, set to its 10V range, and the meter reads 5V. What's the true voltage?

First, work out R_m. At 20 kilohms/volt and 10V, $R_m=10\times20=200$ kilohms. So $V_o=5\ (1+10/200)=5{\cdot}25$ V. Not a very serious error. But if the meter sensitivity had been only 2 kilohms/volt the true voltage would have been 7·5V for a 5V indicated voltage, quite a serious error in this particular case.

REDUCING ERROR

To reduce the loading error you can switch to a higher voltage range. Changing from a 10V range to a 100V range multiplies the meter resistance by 10. The price you have to pay is a much smaller pointer deflection, making it hard to read the voltage accurately, but sometimes the price is worth paying.

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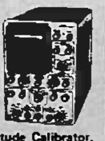

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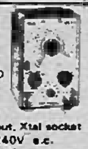

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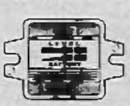

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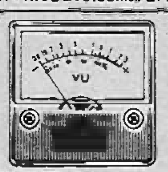

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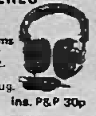

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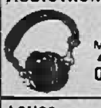

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7½ 7½ watts rms. Inputs for magnetic phono, tuner, tape and aux. Separate base, treble, balance and volume controls. Headphone socket. Teak case. Unrepeatable offer.

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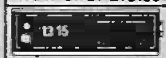
SUPERB QUALITY LOW PRICES

AUDIOTRONIC DIGITAL CLOCK RADIOS

ADC22 24-hour clock radio, covering MW/FM wavebands. 180-minute sleep timer. timer. Choice of Grey or White cabinet.

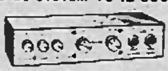
NOW ONLY £13.95 Ins. P & P £1



ADC33 Deluxe 24-hour clock radio covering MW/FM wavebands. 180-minute sleep timer. Buzzer alarm. Tone control.

NOW ONLY £15.95 Ins. P & P £1

SPECIAL OFFER! CONVERT YOUR STEREO SYSTEM TO 4D SOUND



This clever unit enables you to add 4D sound to your existing system. Complete with simple connection details. Use this converter (together with 2 extra speakers) to achieve the fantastic 4D quadrophonic sound! The effect of being immersed within the music becomes a thrilling new experience (2 year guarentee).

OUR PRICE £3.95 Ins. P&P 50p

FM TUNER CHASSIS

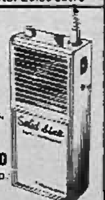
6 transistor high quality tuner. Size only 153 x 101 x 63mm 3 IF stages. Double tuned discriminator. Ample output to feed most amplifiers. Operates on 9V battery. Covers 88—108MHz. Ready built, ready for use. Fantastic value for money.

OUR PRICE £8.95 Ins. P&P 20p

Stereo Multiplex Adaptor £5.95 extra

WALKIE TALKIES

SKYFON NV7
Super low cost transmitter/receivers. 100MW with call buzzer and on/off volume control. 7 transistors. Telescopic rod antenna.



OUR PRICE £31.50 per PAIR Ins. P.&P 50p.

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POCKET CALCULATOR 'TECO TE8053'

8 digit, 4 function.
List price £10.50.

OUR PRICE £8.95

P&P Ins. 25p

SINCLAIR CALCULATORS *LOWEST PRICES EVER!*

SINCLAIR CAMBRIDGE
8 digit, Constant, DC only. List Price £12.95
OUR PRICE £11.00 P&P Ins. 25p

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SINCLAIR EXECUTIVE MEMORY 8 digit, Constant, Memory, DC only. List Price £24.95
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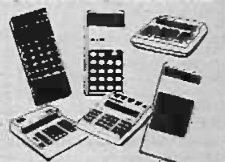
OXFORD 100 4 function. (DC.)
Mains adaptor optional extra. List Price £12.95
OUR PRICE £11.00 P&P Ins. 25p

OXFORD 200 4 function plus Memory and Percentage (DC). Mains adaptor optional extra. List Price £19.95
OUR PRICE £16.95 P&P Ins. 25p

OXFORD 300 Scientific
(Available late March.) (DC). Mains adaptor optional extra. List Price £29.95
OUR PRICE £25.50 P&P Ins. 25p

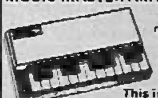
OXFORD MAINS ADAPTOR
OUR PRICE £2.95
optional extra

ELECTRONIC CALCULATORS



We carry a tremendous range of both pocket and desk calculators from as little as £8.45
Owing to the demand it is not possible to include them in this advertisement, so send for our latest price list or call into any branch.

MINIATURE ORGAN MUSIC MASTER AM100



Spanning nearly two octaves, including semi-tones. This instrument will give hours of enjoyment to all the family. Beautifully finished. The Keyboard range can be adjusted to be in tune with any instrument. Operates from internal 9V battery. Fitted with on/off switch, vibrato switch, earphone socket and external 9V D.C. socket. Size 229mm x 127mm x 64mm

OUR PRICE £7.95 Ins. P&P 50p.

HANIMEX HDC 1900 DIGITAL ALARM CLOCK

240V operation with large clear numbers, night light and 'snooze' switch. Attractively finished in white and silver.

OUR PRICE £7.50 Ins. P&P £1.00

SINCLAIR Project 80 Modules

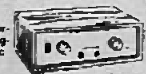
Z40 Power Amp.	£4.50	Ins. P & P 15p
Z60 Power Amp.	£5.40	Ins. P & P 15p
Stereo 80 Pre-Amp.	£13.95	Ins. P & P 15p
Active Filter Unit	£7.45	Ins. P & P 15p
FM Tuner	£10.50	Ins. P & P 15p
Stereo Decoder	£6.75	Ins. P & P 15p
PZ5 Power Supply	£3.75	Ins. P & P 30p
PZ6 Power Supply	£6.75	Ins. P & P 30p
PZ8 Power Supply	£6.35	Ins. P & P 30p
Transformer for PZ8	£4.05	Ins. P & P 50p

AUDIOTRONIC LOW NOISE CASSETTES

TYPE	5	10	25
C60	£1.57	£3.00	£7.08
C90	£2.24	£4.25	£10.00
C120	£2.73	£5.17	£12.24

Ins. P&P 3p each.
10 and over Post Free

AUDIOTRONIC AHA101 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: 5mV and 100mV. OUTPUT: 50mV per channel.

OUR PRICE £8.50 Ins. P&P 30p

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WE ARE STOCKISTS AT Oxford Street, 42 & 257 Tottenham Court Road, 34 Lisle Street, 152, Fleet Street, 311 Edgware Road, CROYDON BIRMINGHAM KINGSTON LEICESTER NORTHAMPTON SOUTHEND TUNBRIDGE WELLS WOLVERHAMPTON branches, or by Mail Order.

All kits are complete with comprehensive easy to follow instructions and covered by full guarantee.

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AF25 Mixer	£3.29
AF30 Mono pre-amplifier	£3.20
AF35 Emitter amplifier	£2.42
AF80 0.5W mic. amplifier	£4.86
AF305 Intercom	£7.63
AF310 2 Mono Amplifier	£7.55
M160 Multi-vibrator	£2.18
M1302 Transistor tester	£8.33
M191 VU Meter	£5.37
M192 Stereo balance meter	£5.93
LF380 Quadraphonic device.	£ 8.42
AT5 Automatic light control	£3.75
AT30 Photo cell switch unit	£6.68
AT50 400W triac light dimmer/speed control	£5.18
AT56 2,200W triac light dimmer/speed control	£6.75
AT60 1 channel light control	£10.82
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GU330 Tremolo unit	£8.10
HF61 Diode detector	£3.67
HF65 FM transmitter	£3.21
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HF310 FM tuner	£16.32
HF325 Deluxe FM tuner	£26.33
HF330 Decoder (HF310/325)	£10.55
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GP304 Circuit board	£5.33
HF380 lw/vhf aerial amplifier	£6.02
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NT300 Stabilised p. supply	£13.16
NT310 Power Supply 240 V AC or 2 x 18 V D.C. at 2 amps	£5.84
NT305 Voltage converter	£5.64
NT315 Power supply 240V AC to 4,5/15V DC, 500mA	£12.06

Amateur Electronics by Josty-Kit, the professional book for the amateur—covers the subject from basic principals to advanced electronic techniques. Complete with circuit board for AE1 to AE10 listed below.

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Ins. P&P 25p plus VAT.

AE1 100mW output stage	£1.55
AE2 Pre-amplifier	£1.32
AE3 Diode receiver	£2.06
AE4 Flasher	£1.26
AE5 Astable multi-vibrator	£1.14
AE6 Monostable multi-vibrator	£1.11
AE7 RC generator	£1.08
AE8 Bass filter	£1.06
AE9 Treble filter	£1.05
AE10 CCIR filter	£1.05

Also see previous page

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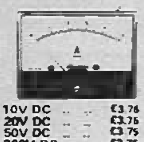
CLEAR PLASTIC MODEL SD640
Size: 85 x 64mm

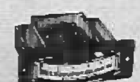


50uA	£3.90	10V DC	£3.75
100uA	£3.85	20V DC	£3.75
200uA	£3.80	50V DC	£3.75
500uA	£3.75	300V DC	£3.75
50-0-50uA	£3.85	15V AC	£3.85
100-0-100uA	£3.80	300V AC	£3.85
1mA	£3.75	VU Meter	£4.00
5mA	£3.75		
10mA	£3.75		
50mA	£3.75		
100mA	£3.75		
500mA	£3.75		
1A DC	£3.75		
5A DC	£3.75		
10A DC	£3.75		
5V DC	£3.75		

CLEAR PLASTIC MODEL SW100
Size: 100 x 80mm

50uA	£4.70	150V AC	£4.65
100uA	£4.60	300V AC	£4.65
500uA	£4.40	VU Meter	£5.00
50-0-50uA	£4.60		
100-0-100uA	£4.55		
1mA	£4.40		
1A DC	£4.40		
5A DC	£4.40		
20V DC	£4.40		
50V DC	£4.40		
300V DC	£4.40		

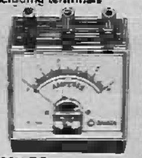
EDGWISE MODEL PE70
Size: 90 x 34mm



50uA	£4.25
100uA	£4.20
200uA	£4.15
500uA	£4.00
50-0-50uA	£4.20
100-0-100uA	£4.15
1mA	£3.95
300V AC	£4.05
VU Meter	£4.40

MODEL ED107 EDUCATIONAL METER
Size: 100 x 90 x 150mm including terminals

A range of high quality moving coil instruments ideal for school experiments and other bench applications. 3" mirror scale. The meter movement is easily accessible to demonstrate internal working.



50uA	£8.70	20V DC	£7.80
100uA	£8.10	50V DC	£7.80
50-0-50uA	£8.10	300V DC	£7.80
1mA	£7.80	500mA/5A DC	£8.80
1-0-1mA	£7.80	5V/50V DC	£8.80
1A DC	£7.80	5V/15V DC	£8.80
5A DC	£7.80	1/5A DC	£8.80
5V DC	£7.80		
10V DC	£7.80		
15V DC	£7.80		

CLEAR PLASTIC MODEL MR 85P
Size: 120 x 110mm

50uA	£5.60	300V DC	£5.40
100uA	£5.55	15V AC	£5.45
200uA	£5.50	300V AC	£5.45
500uA	£5.40	S Meter 1mA	£5.35
50-0-50uA	£5.55	VU Meter	£5.70
100-0-100uA	£5.50	1A AC	• £5.35 •
500-0-500uA	£5.35	5A AC	• £5.35 •
1mA	£5.35	10A AC	• £5.35 •
1-0-1mA	£5.35	20A AC	• £5.35 •
5mA	£5.35	30A AC	• £5.35 •
10mA	£5.35		
50mA	£5.35		
100mA	£5.35		
500mA	£5.35		
1A DC	£5.35		
5A DC	£5.35		
15A DC	£5.35		
30A DC	£5.55		
10V DC	£5.35		
20V DC	£5.35		
50V DC	£5.35		
150V DC	£5.35		

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MW1-6 60 x 60 mm £6.50 P & P 15p
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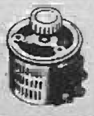
YAMABISHI VARIABLE VOLTAGE TRANSFORMERS

Excellent quality at low cost. Input: 230V 50/60Hz. Output 0–260V.
MODEL S260 BENCH MOUNTING

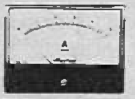


		Ins. P&P
1A	£8.50	50p
5A	£15.00	50p
8A	£22.50	£1.00
10A	£27.50	£1.00
12A	£30.00	£1.00
20A	£70.00	£1.50
25A	£75.00	£1.50
40A	£85.00	£1.50

ALL PRICES EXCLUDE VAT

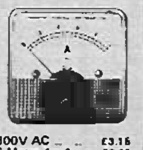
*Items with asterisk are Moving Iron type, all others are Moving Coil

CLEAR PLASTIC MODEL SD830
Size: 110 x 83mm



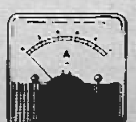
50uA	£4.40	10V DC	£4.20
100uA	£4.35	20V DC	£4.20
200uA	£4.30	50V DC	£4.20
500uA	£4.25	300V DC	£4.20
50-0-50uA	£4.35	15V AC	£4.30
100-0-100uA	£4.30	300V AC	£4.30
1mA	£4.20	VU Meter	£4.50
5mA	£4.20		
10mA	£4.20		
50mA	£4.20		
100mA	£4.20		
500mA	£4.20		
1A DC	£4.20		
5A DC	£4.20		
10A DC	£4.20		
5V DC	£4.20		

CLEAR PLASTIC MODEL MR 45P
Size: 50 x 50mm



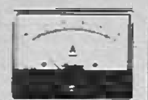
50uA	£3.30	300V AC	£3.15
100uA	£3.25	S Meter 1mA	£3.05
200uA	£3.20	VU Meter	£3.50
500uA	£3.10	1A AC	• £3.05 •
50-0-50uA	£3.25	5A AC	• £3.05 •
100-0-100uA	£3.20	10A AC	• £3.05 •
500-0-500uA	£3.05	20A AC	• £3.05 •
1mA	£3.05	30A AC	• £3.05 •
5mA	£3.05		
10mA	£3.05		
50mA	£3.05		
100mA	£3.05		
500mA	£3.05		
1A DC	£3.05		
5A DC	£3.05		
10V DC	£3.05		
20V DC	£3.05		
50V DC	£3.05		
300V DC	£3.05		
15V AC	£3.15		

CLEAR PLASTIC MODEL MR 38P
Size: 42 x 42mm



50uA	£3.20	20V DC	£2.85
100uA	£3.15	50V DC	£2.85
200uA	£3.10	100V DC	£2.85
500uA	£2.90	150V DC	£2.90
50-0-50uA	£3.15	300V DC	£2.90
100-0-100uA	£3.10	500V DC	£2.95
500-0-500uA	£2.85	750V DC	£2.95
1mA	£2.85	15V AC	£2.95
1-0-1mA	£2.85	50V AC	£2.95
2mA	£2.85	150V AC	£2.95
5mA	£2.85	300V AC	£2.95
10mA	£2.85	500V AC	£3.10
20mA	£2.85	S Meter 1mA	£2.85
50mA	£2.85	VU Meter	£3.30
100mA	£2.85		
150mA	£2.85		
200mA	£2.85		
300mA	£2.85		
500mA	£2.85		
750mA	£2.85		
1A DC	£2.85		
2A DC	£2.85		
5A DC	£2.85		
10A DC	£2.85		
3V DC	£2.85		
10V DC	£2.85		
15V DC	£2.85		

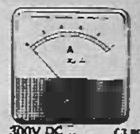
CLEAR PLASTIC MODEL SO460
Size: 59 x 46mm



50uA	£3.60	10V DC	£3.40
100uA	£3.55	20V DC	£3.40
200uA	£3.50	50V DC	£3.40
500uA	£3.45	300V DC	£3.40
50-0-50uA	£3.55	15V AC	£3.55
100-0-100uA	£3.50	300V AC	£3.55
1mA	£3.40	VU Meter	£3.75
5mA	£3.40		
10mA	£3.40		
50mA	£3.40		
100mA	£3.40		
500mA	£3.40		
1A DC	£3.40		
5A DC	£3.40		
10A DC	£3.40		
5V DC	£3.40		

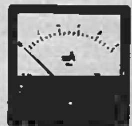
INSURANCE POSTAGE & PACKING 15p

CLEAR PLASTIC MODEL MR 65P
Size: 86 x 78mm



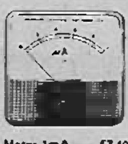
50uA	£4.05	300V DC	£3.80
100uA	£3.95	15V AC	£3.90
200uA	£3.90	50V AC	£3.90
500uA	£3.85	150V AC	£3.90
50-0-50uA	£3.95	300V AC	£3.90
100-0-100uA	£3.90	500V AC	£4.00
500-0-500uA	£3.80	S Meter 1mA	£3.90
1mA	£3.80	VU Meter	£4.20
1-0-1mA	£3.80	1A AC	• £3.80 •
5mA	£3.80	5A AC	• £3.80 •
10mA	£3.80	10A AC	• £3.80 •
50mA	£3.80	20A AC	• £3.80 •
100mA	£3.80	30A AC	• £3.80 •
500mA	£3.80	50mA AC	• £3.80 •
1A DC	£3.80	100mA AC	• £3.80 •
5A DC	£3.80	200mA AC	• £3.80 •
10A DC	£3.80	500mA AC	• £3.80 •
15A DC	£3.80		
20A DC	£3.90		
30A DC	£3.95		
50A DC	£4.15		
5V DC	£3.80		
10V DC	£3.80		
15V DC	£3.80		
20V DC	£3.80		
50V DC	£3.80		
150V DC	£3.80		

BAKELITE MODEL S80 Enlarged Window
Size: 80 x 80mm



50uA	£4.60
100uA	£4.55
500uA	£4.30
50-0-50uA	£4.55
100-0-100uA	£4.50
1mA	£4.30
1A DC	£4.30
5A DC	£4.30
20V DC	£4.30
50V DC	£4.30
300V DC	£4.30
300V AC	£4.40
VU Meter	£4.80

CLEAR PLASTIC MODEL MR 52P
Size: 60 x 60mm



50uA	£3.80	S Meter 1mA	£3.40
100uA	£3.60	VU Meter	£3.90
500uA	£3.45	1A AC	• £3.40 •
50-0-50uA	£3.60	5A AC	• £3.40 •
100-0-100uA	£3.45	10A AC	• £3.40 •
1mA	£3.40	20A AC	• £3.40 •
5mA	£3.40	30A AC	• £3.40 •
10mA	£3.40		
50mA	£3.40		
100mA	£3.40		
500mA	£3.40		
1A DC	£3.40		
5A DC	£3.40		
10V DC	£3.40		
20V DC	£3.40		
50V DC	£3.40		
300V DC	£3.40		
15V AC	£3.50		
300V AC	£3.50		

BAKELITE MODEL MR 65 Size: 80 x 80mm

25uA	£5.40	300V DC	£3.90
50uA	£4.10	30V AC	• £3.70 •
100uA	£4.05	50V AC	• £3.70 •
500uA	£3.75	150V AC	• £3.70 •
50-0-50uA	£4.05	300V AC	• £3.70 •
100-0-100uA	£4.00	500V AC	• £3.70 •
500-0-500uA	£3.70	VU Meter	£4.20
1mA	£3.70	1A AC	• £3.70 •
1-0-1mA	£3.70	5A AC	• £3.70 •
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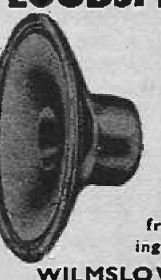

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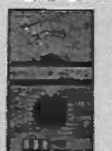

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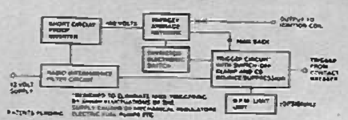

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