Inexpensive, easy to build projects

everyday electronics

OCT. 75
30p

CRESCENT RADIO LTD.

11-15 & 17 MAYES ROAD, LONDON N22 6TL
(also) 13 SOUTH MALL, EDMONTON, N.9

MAIL ORDER DEPT.
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ABS PLASTIC BOXES

Handy boxes for construction projects. Moulded extrusion rails for P.C. or chassis panels. Fitted with 1mm front panels.

1005 – 105mm × 73mm × 45mm – 55p.
1006 – 150mm × 74mm × 47mm = 72p.
1007 – 185mm × 124mm × 60mm = £1.28
1021 – 106mm × 74mm × 45mm – 55p.
(sloping front) Plus 8% VAT

CLEAR PLASTIC PANEL METERS

Size 59mm × 46mm × 35mm these meters require a 38mm hole for mounting.

ME6 – 0 to 50 micro amp Full Scale
ME7 – 0 to 100 micro amp " "
ME8 – 0 to 500 micro amp " "
ME9 – 0 to 1m/a " "
ME10 – 0 to 5m/a " "
ME11 – 0 to 10m/a " "
ME12 – 0 to 50m/a " "
ME13 – 0 to 100m/a " "
ME14 – 0 to 500m/a " "
ME15 – 0 to 1 amp " "
ME16 – 0 to 50 volts
ME17 – 0 to 300 volts A.C. Full Scale
ME18 – "S" Meter
ME19 = "VU" Meter
OUR PRICE £3·00
Plus 8% VAT

LOW VOLTAGE AMPLIFIER

5 transistor amplifier complete with volume control, is suitable for 9V d.c. and a.c. supplies. Will give about 1W at 8 ohm output. With high IMP input this amplifier will work as a record player, baby alarm, etc., amplifier. **£2·00**
Plus 25% VAT

P.C. ETCHING KIT

This kit contains all that the constructor will need to etch the circuits of his own design.
Contents—Plastic etching dish. Sample copper clad board. Laminate Cutter. 1 lb Ferric Chloride. Large Plastic Spoon. Etch Resist Pen. Full Etching Instructions.
Complete and Big Kit Value at £3·75p + 8% VAT.

FERRIC CHLORIDE

Anhydrous ferric chloride in double sealed one pound pld packs.
OUR PRICE — 50p + PP + 8% per lb.

3 KILOWATTS PSYCHEDELIC LIGHT CONTROL UNIT

Three Channel: Bass—Middle—Treble. Each channel has its own sensitivity control. Just connect the input of this unit to the loudspeaker terminals of an amplifier, and connect three 250V up to 1000W lamps to the output terminals of the unit, and you produce a fascinating sound-light display. (All guaranteed.)
£18·50 plus 38p P. & P.
Plus 8% VAT

POWER PACKS

PP1 Switched 3, 4½, 6, 7½, 9 and 12 volt @ 500 m/a, with on/off switch and pilot light. Size – 130 mm x 55 mm x 75 mm ONLY = £4·00
PP2 Switched 6-7½-9 volt Battery Eliminator. Approx size 2¼" × 2¼" × 3½". Ideal for cassette recorders. £3·25 each.
PP3 Car converter. From 12v Pos. or Neg to = 6-7½-9 volt. Easy to fit and transistor regulated £3·90 each.
Plus 8% VAT

10 INCH 8 OHM DUAL CONE L/S

Manufactured by "ELAC" to a very high standard these loudspeakers are a real bargain.
Spec: Size = 10" Dual Cone
Power – 10 Watts
Frequency = 40-12000Hz
IMP = 8 Ohm
Our Price £3·75 Plus 25% VAT

WIRE WOUND VARIABLE CONTROL

250Ohm approx diameter = 1 inch long Standard spindle only 25p each.
Plus 25% VAT

ALUMINIUM BOXES

Metal Project Boxes give your work a professional finish.

	L	W	H	Price
AB7	2¼	5¼	1¼	54p
AB8	4	4	1¼	63p
AB9	4	2¼	1½	54p
AB10	4	5¼	1¼	63p
AB11	4	2¼	2	54p
AB12	3	2	1	45p
AB13	6	4	2	69p
AB14	7	5	2½	84p
AB15	8	6	3	99p
AB16	10	7	3	£1·35
AB17	10	4½	3	£1·02
AB18	12	5	3	£1·20
AB19	12	8	3	£1·50

All size are approx and in inches.
Plus 8% VAT

BARGAIN PROJECT BOX

A plastic box with moulded extrusion rails for PC or Chassis panels with metal front plate fitted with four screws (all supplied)
An ideal box to give a small project a professional finish.
SIZE (internal) 81mm x 51mm x 28mm.
OUR PRICE 40p Plus 8% VAT

TELESCOPIC AERIAL

Nine section fully swiveling telescopic aerial with 4BA single bolt fixing or two hole fixing bracket. Fully extended — 43". Fully closed — 7".
Our Price — 50p + P/P + VAT @ 8%

CABLELESS SOLDERING IRON WAHL "ISO-TIP"

★ Completely Portable
★ Solders up to 150 joints per charge
★ Re-charges in its own stand
★ Fine tip for all types of soldering
★ Only 8" long and weighs just 6 ozs.
Our Price £9·75. Plus 8% VAT
(Spare bits are available)

12-0-12 VOLT 500m/a 240 VOLT PRIMARY TRANSFORMER

approx. size = 60mm × 40mm × 50mm. Fixing centres—75mm.
A REAL BARGAIN AT £1·20 each.
Plus 8% VAT

LOW NOISE LOW PRICE CASSETTES

Good quality tape in well made screw type cassettes.
Presented in single plastic cases.
C60 = 31p
C90 – 42p
C120 = 53p
10% discount on ten or more cassettes of one type Plus 8% VAT

U.K. CARR. 20p unless otherwise stated	Send 30p for a CRESCENT CATALOGUE	All prices are excluding VAT. Please add to each item the VAT rate indicated to all orders

QUALITY* STEREO SOUND

ALMOST ½ PRICE OFFER! SOLENT AUDIO SYSTEM **£5·95 down**

*Stereo Tuner Amplifier chassis with AM/FM radio covering long medium short and Stereo FM wavebands. Separate Base and Treble controls. 30 watts total power output (frequency response 25-20,00 Hz) Tape record and playback facilities. Dimensions 18" x 8½" x 3½". The very latest BSR automatic record deck with cue and pause control. Two matching elliptical speaker units.

Order early limited stocks available cash price £59·95. Credit Sale £5·95 deposit 9 monthly payments of £7·00 (Total Credit price £68·95). P. & P. £3·00. Send £8·95 today.

Chassis only available for cash at £42·00.

Full 12 months Guarantee.

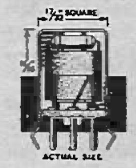
CALLERS WELCOME.

Stereo headphones supplied with every complete order.

LEWIS radio EE/10/75 100 CHASE SIDE SOUTHGATE LONDON N14 5PL Telephone: 01-882-1644

DENCO (CLACTON) LTD.

357-8-9 OLD RD., CLACTON-ON-SEA ESSEX. CO15 3RH



Our components are chosen by technical authors and constructors throughout the world, for their performance and reliability, every coil being inspected twice plus a final test and near spot-on alignment.

General catalogue showing full product range 28p, post paid. Please enclose S.A.E. with all other enquiries.

TRADE ENQUIRIES WELCOME

PLEASE MENTION

EVERYDAY ELECTRONICS

WHEN REPLYING TO ADVERTISEMENTS

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The Publishers of *Everyday Electronics* are members of the Periodical Publishers Association which has given an undertaking to the Director General of Fair Trading to refund moneys sent by readers in response to mail order advertisements, placed by mail order traders, who fail to supply goods or refund moneys owing to liquidation or bankruptcy. This arrangement does not apply to any failure to supply goods advertised in a catalogue or in a direct mail solicitation.

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For the purpose of this scheme, mail order advertising is defined as:—

'Direct response advertisements, display or postal bargains where cash had to be sent in advance of goods being delivered.' Classified and catalogue mail order advertising are excluded.

RECORD PLAYBACK TAPE HEADS

Individual prices of these are:
2 track record playback heads 75p each.
4 track record playback heads £1·10 each.
Erase heads are also available separately—
2 track 50p—4 track 85p.
MV metal mounting shields 60p each.
2 track heads already fixed on heavy mounting plate with shield £1.85. ALL PLUS 25% VAT

DRILL CONTROLLER

Electronically changes speed from approximately 10 revs. to maximum. Full power at all speeds by finger-tip control. Kit includes all parts, case, everything and full instructions. £2·50 plus 45p post & VAT. Made up model also available.

NEED A SPECIAL SWITCH

Double Leaf Contact. Very slight pressure closes both contacts 12p each. Plastic pushrod suitable for operating. 10p each. 10 for 68p.

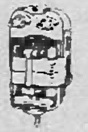
1 R.P.M. MOTOR+GEAR BOX

Made by the famous Chamberlain & Hookham Ltd. These could be made to drive clock or similar. Really robust reliable unit. Price £1·50 + 30p Post & VAT

MINIATURE WAFER SWITCHES

2 pole, 2 way—4 pole, 2 way—3 pole, 3 way—4 pole, 3 way—2 pole, 4 way—3 pole, 4 way—2 pole 6 way—1 pole, 12 way. All at 38p + 15p post & VAT each.

MULTI-SPEED MOTOR



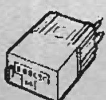
Six speeds are available 500, 850 and 1,100 r.p.m. and 8,000, 12,000 and 15,500 r.p.m. Shaft is ¼ in. diameter and approximately 1 in. long. 230/240v. Its speed may be further controlled with the use of our Thyristor controller. Very powerful and useful motor size approx. 2 in. dia. × 5 in. long. Price £1·40+45p post & VAT.

SLIDE SWITCHES

Slide Switch. 2-pole changeover panel mounting by two 6B.A. screws. Size approx. 1in. × ⅜in rated 250V lamp. 15p+7p post & VAT.

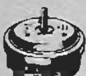
Sub Miniature Slide Switch. DPDT 19mm (¾in approx.) between fixing centres. 28p+9p post & VAT each or 10 for £1·90. SP Change over spring return 250V 1 amp. 25p+8p post & VAT.

6 DIGIT COUNTER



Resettable. 440 ohm coil up to 25 impulses per second. Ex-equipment but guaranteed perfect. £3·30+40p Post & VAT each.
4 digit counter as specified for telephone charge calculator 93p.

PRESSURE SWITCH



Containing a 15 amp change over switch operated by a diaphragm which in turn is operated by air pressure through a small metal tube. The operating pressure is adjustable but is set to operate in approx. 10in. of water. These are quite low pressure devices and can in fact be operated simply by blowing into the inlet tube. Original use was for washing machine to turn off water when tub has reached correct level but no doubt has many other applications £2·10 each+25p post & VAT.

TELESCOPIC AERIAL

for portable, car radio or transmitter. Chrome plated—six sections, extends from 7½ to 47in. 50p+15p Post & VAT. KNUCKLED MODEL FOR F.M. 80p+17p Post & VAT.

LIGHT DIMMER KIT

For dimming up to 250w without heat sink or 750w with heat sink. This comprises quadrac variable control potentiometer, condenser, resistors, tag strip for mounting and data. Price £1·95+30p Post & VAT.

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. 40p each. Resistor and rectifier 20p extra.. and Post VAT 20p.

TERMS

CASH DISCOUNTS

25% on order over £500, 20% over £100, 15% £50, 10% £30.

SMALL ORDERS

Please add 30p if order under £5.

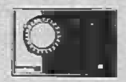
LARGE ORDERS

Deduct discounts as follows: £30-£50 deduce 10%: £60-£100 deduce 15%; £100-£499 deduce 20%: over £500 deduce 25%.

SWITCH TRIGGER MATS

So thin is undetectable under carpet but will switch on with slightest pressure. For burglar alarms, shop doors, etc.
24in × 18in £1 90. Post & VAT 30p.
13in × 9in £1·50. Post & VAT 25p

SMITHS CENTRAL HEATING CONTROLLER

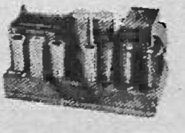


Push button gives 10 variations as follows:—(1) continuous hot water and continuous central heating (2) continuous hot water but central heating off at night (3) continuous hot water but central heating on only for 2 periods during the day (4) hot water and central heating both on but day time only (5) 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 £6·95 each. VAT & Postage 85p each.

WALL THERMOSTATS (SMITHS)

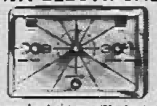
Wall mounting and in a handsome plastic case. (Cream and beige). Adjustable by slider (lockable) and may be set to control temperatures from around freezing through to 50°C. The slide panel is engraved and indicates (frost), (warm), (very warm), etc. The thermostat will control heaters, etc., up to 15 amp at normal mains voltage and is ideal for living room, bedroom and greenhouse, etc. Price £1·95. VAT & Postage 30p. Don't miss this.

AUDIO AMPLIFIER



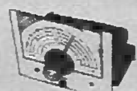
Part of the famous Redltune background music system, secondhand, but believed in good order. However, no guarantee; we are selling for spares value only. These are 6 valve amplifiers, the output valves are 2 × EL 84 in push/pull, complete with mains transformer, rectifier and ample smoothing equipment. The mains transformer alone, today would cost at least £4. Size is 9½" × 5½" × 4½". Price only £2·00 + postage and VAT £1·50.

15A ELECTRICAL PROGRAMMER



Learn in your sleep: Have radio playing and kettle boiling as you awake—switch on lights to ward off intruders—have a warm house to come home to. All these and many other things you can do if you invest in an electrical programmer. Clock by famous maker with 15 amp. on/off switch. Switch-on time can be set anywhere to stay on up to 6 hours. Independent 60 minute memory jogger. A beautiful unit. Price £2·95. VAT & Postage 60p, or with glass front, chrome bezel, £1·50 extra.

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, £1·50—crystal earphone 55p, VAT & Postage 75p.

THIS MONTH'S SNIP

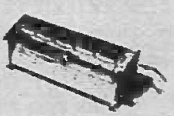
Smiths 24 hr. timer heart, really the "Autoset" without its plastic case. This is a 24 hr. twice on, twice off, clock switch which will repeat until reprogrammed. Switches rated at 15 amps. Limited supplies—£3.95 VAT & post 55p. each.

12 VOLT 1½ AMP POWER PACK

This comprises double-wound 230/240V mains transformer with full wave rectifier and 2000 mfd smoothing. Price £3·75 plus VAT and Post £1.

Heavy Duty Mains Power Pack. Output voltage adjustable from 15–40V in steps—maximum load 250W—that is from 6 amp at 40V to 15 amp at 15V. This really is a high power heavy duty unit with dozens of workshop uses. Output voltage adjustment is very quick—simply interchange push on leads. Silicon rectifiers and smoothing by 3·000mF. Price £10·50 plus £25 VAT & post.

TANGENTIAL HEATER UNIT



This heater unit is most efficient, and quiet running. Is as fitted in Hoover and blower heaters costing £15 and more. Comprises motor, impeller. 2kW element and 1kW element allowing switching 1, 2 and 3kW and with thermal safety cut-out. Can be fitted into any metal line case or cabinet. Only needs control switch. £5·82 plus VAT & post £1. 2kW Model as above except 2kW £4·25 plus VAT & post 75p. Don't miss this. Control Switch 44p. P. & P. 40p.

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. £1·90; 5 ft. 65w. £2·00; 5 ft. 80w. £2·20; 6 ft. 80w. £2·45; and for pairs as follows:—twin 2 ft. 20w. £2·55; twin 3 ft. 30w. £3·55; twin 4 ft. 40w. £3·25; twin 5 ft. 65w. £3·25; twin 5 ft. 80w. £3·95; twin 8 ft. 125w. £5·75. 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 and 8% VAT.

J. BULL (ELECTRICAL) LTD.

(Dept. E.E.), 103 TAMWORTH ROAD, CROYDON CRO 1XX

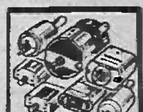
MAINS TRANSFORMERS

All standard 230-250 volt primaries.

		£ p
1v	1 amp (special)	1·75
2·4v	5 amp	·85
6·3v	2 amp	1·25
6·3v	3 amp	1·75
9v	1 amp	·95
9v	3·5 amp	2·50
12v	1½ amp	1·50
12v	1 amp	1·00
6·5v-0-6 5v	1 amp	1·50
18v	1 amp	1·50
24v	2 amp	2·25
24v	3 amp	3·50
12·0-12v	50mA	1·20
6-0-6v	50mA	1·20
8-0-8v	½ amp	1·50
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	1·50
6v and 12v	3 amps	2·25
6v and 12v	5 amps	3·50

Add 30p per piece to cover postage and VAT 25%.

ONLY £1·50 FOR SEVEN ELECTRIC MOTORS



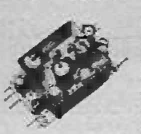
7 powerful batt. motors as used in racing cars & power models. Output & types vary for use in hundreds of different projects—Tools, toys, models, etc. All brand new reversible & for 1½-12v. batts. Wiring diag. inc. VAT & Post 40p. FREE plan for min. power station.

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 9" 6w tubes complete with starter, choke, lamp-holders and starter-holder. Price £2·75+30p post. Tubes only £2. Post & VAT 50p.

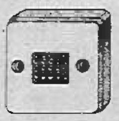
MULLARD AUDIO AMPLIFIERS

All in module form, each ready built complete with heat sinks and connection tags, data supplied.



Model 1153 500mW power output £1·10+40p post & VAT.
Model 1172 1W. power output £1·35+45p post & VAT.
Model EP9000 4 watt power output £2·40+50p post & VAT.
EP 9001 twin channel or stereo pre amp. £2·50+50p post & VAT.

LIGHT SWITCH

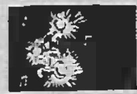


Automatically switches on lights at dusk and off at dawn. Can also be used where light and dark is a convienent way to stop and start an operation. Requires only a pair of wires to the normal switch. In bakelite box, normal switch-plate size. 1 amp model £3·75. VAT and Postage 50p.

MAINS TRANSISTOR PACK

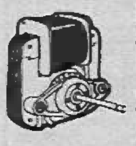
Designed to operate transistor sets and amplifiers. Adjustable output 6v., 9v., 12 volts for up to 500mA (class B working). Takes the place of any of the following batteries: PP1, PP3, PP4, PP6, PP7, PP9 and others. Kit comprises: main transformer rectifier, smoothing and load resistor condensers and instructions. Real snip at only £1·50. VAT & Postage 60p.

SOUND TO LIGHT UNIT



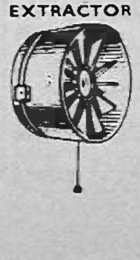
Add colour or white light to your amplifier. Will operate 1, 2 or 3 lamps (maximum 450w). Unit in Box all ready to work. £7·95 plus 95p VAT and postage.

MAINS MOTOR



Precision made—as used in record decks and tapes recorders—ideal also for extractor fans, blower, heaters, etc. New and perfect. Snip at 95p+VAT & Postage 20p. Postage 20p for first one then 10p for each one ordered.
1" stackmotor £1·25+VAT & postage 25p. 1½" stackmotor £1·50+VAT & Postage 30p.

EXTRACTOR FAN



Cleans the air at the rate of 10,000 cubic ft. per hour. Suitable for kitchens, bathrooms, factories, changing rooms, etc., it's so quiet it can hardly be heard. Compact, 5¾" casing with 5½" fan blades. Kit comprises motor, fan blades sheet steel casing, pull switch, mains connector and fixing brackets. £4·25 VAT & Postage £1·50.

BI-PAK SEMICONDUCTORS

COMPONENTS

CARBON RESISTOR PAKS

These Paks contain a range of Carbon Resistors, assorted into the following groups:

R1	50	Mixed	100 ohms–820 ohms 1/8th W.	0·60
R2	50	Mixed	1K ohms–8·2K ohms 1/8th W.	0·60
R3	50	Mixed	10K ohms–82K ohms 1/8th W.	0·60
R4	50	Mixed	100K ohms–820K ohms 1/8th W.	0·60
R5	30	Mixed	100 ohms–820 ohms ¼ W.	0·60
R6	30	Mixed	1K ohms–8·2K ohms ¼ W.	0·60
R7	30	Mixed	10K ohms–82K ohms ¼ W.	0·60
R8	30	Mixed	100K ohms–820K ohms ¼ W.	0·60

THESE ARE UNREPEATABLE PRICES

LOW COST CAPACITORS

500	µF	50V Elect	0·09 each
·01	µF	400V	0·03 each

REPANCO CHOKES & COILS

RF Chokes	CH1	2·5mH	0·27
	CH3	7·5mH	0·29
	CH5	1·5mH	0·26
	CH2	5·0mH	0·28
	CH4	10mH	0·31

COILS DRX1 Crystal set 0·29 DRR2 Dual range 0·42

CARBON POTENTIOMETERS

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

VC 1	Single Less Switch	0·14
VC 2	Single D.P. Switch	0·26
VC 3	Tandem Less Switch	0·43
VC 4	1K Less Switch	0·14
VC 5	100K Log anti-Log	0·43

HORIZONTAL CARBON PRESETS

0·1 Watt 0·06 each
100, 220, 470, 1K, 2·2K, 4·7K, 10K, 22K, 47K, 100K, 220K, 470K, 1M, 2M, 4·7M.

REPANCO TRANSFORMERS

240V. Primary. Secondary voltages available from selected tappings 4V, 7V, 8V, 10V, 40V, 50V and 25V-0-25V.

Type	Amps	Price	P & P
MT50/½	½	£1·79	0·45p
MT50/1	1	£2·24	0·48p
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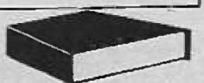
CP 6	Microphone Fully Braided Cable	★0·11
CP 7	Three Core Mains Cable	★0·11
CP 8	Twin Oval Mains Cable	★0·08
CP 9	Speaker Cable	★0·06
CP 10	Low Loss Co-Axial	★0·14

INSTRUMENT CASES



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No.	Length		Width		Height	Price
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BV2	11"	×	6"	×	3"	★£1·62
BV3	6"	×	4½"	×	1¾"	0·92
BV4	9"	×	5¼"	×	2¼"	£1·39

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BA4	5¼"	×	4"	×	1½"	★0·54
BA5	4"	×	2¼"	×	2"	★0·45
BA6	3"	×	2"	×	1"	★0·39
BA7	7"	×	5"	×	2½"	★0·79
BA8	8"	×	6"	×	3"	★£1·03
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(Each complete with ½" deep lid & screws)

PLEASE ADD 20p POSTAGE AND PACKING FOR EACH BOX.

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C2	150	Capacitors mixed values approx. count by weight	0·60
C3	50	Precision Resistors mixed values	0·60
C4	75	1/8th width Resistors mixed preferred values	0·60
C5	5	Pieces assorted Ferrite Rods	0·60
C6	2	Tuning Gangs, MW/LW VHF	0·60
C7	1	Pak Wire 50 metres assorted colours	★0·60
C8	10	Reed Switches	0·60
C9	3	Micro Switches	0·60
C10	15	Assorted Pots & Pre-Sets	0·60
C11	5	Jack Sockets 3 × 3·5m, 2 × standard Switch Type	0·60
C12	30	Paper Condensers preferred types mixed values	0·60
C13	20	Electrolytics Trans. types	0·60
C14	1	Pack assorted Hardware—Nuts/Bolts, Grommets, etc.	★0·60
C15	5	Mains Slide Switches, 2 Amp	0·60
C16	20	Assorted Tag Strips & Panels	0·60
C17	10	Assorted Control Knobs	0·60
C18	4	Rotary Wave Change Switches	0·60
C19	2	Relays 6-24V Operating	0·60
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J	Tape head cleaning kit	★68p
P	Hi-Fi cleaner	★30p
9	Wire stripper/Cutter	★94p
31	Cassette head cleaner	★58p
32	Tape editing kit	★£1·64
32A	Stylus balance	★£1·24
36A	Record stylus cleaning kit	★32p
42	De Luxe Groov-Kleen	★£1·84
43	Record care kit	★£2·68
45	Auto changer groove cleaner	★98p
46	Spirit level	★68p
56	Hi-Fi stereo hints & tips	★38p
60	Chrome finish as above	★£1·72

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X25. 25 watt	★£2·45
Model G. 18 watt	★£2·70
CCN 240. 15 watt	★£2·90
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102 for model CN240 3/32"	★42p
104 for model CN240 3/16"	★42p
1100 for model CCN240 3/32"	★42p
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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"	★44p
51 for model X25 1/8"	★44p
52 for model X25 3/16"	★44p

ELEMENTS

Model ECN 240	★£1·10
Model EG 240	★£1·35
Model ECCN 240	★£1·55
Model EX 25	★£1·20

SOLDERING IRON STAND

ST3 Suitable for all models	★£1·10
Antex heat shunt	★10p

PLUGS

		Price
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PS 2	D.I.N. 3 Pin	0·11
PS 3	D.I.N. 4 Pin	0·14
PS 4	D.I.N. 5 Pin 180°	0·15
PS 5	D.I.N. 5 Pin 240°	0·15
PS 6	D.I.N. 6 Pin	0·16
PS 7	D.I.N. 7 Pin	0·17
PS 8	Jack 2·5mm Screened	0·17
PS 9	Jack 3·5mm Plastic	0·11
PS 10	Jack 3·5mm Screened	0·17
PS 11	Jack ¼" Plastic	0·14
PS 12	Jack ¼" Screened	0·20
PS 13	Jack Stereo Screened	0·33
PS 14	Phono	0·09
PS 15	Car Aerial	0·14
PS 16	Co-Axial	0·14

INLINE SOCKETS

PS 21	D.I.N. 2 Pin (Speaker)	0·13
PS 22	D.I.N. 3 Pin	0·19
PS 23	D.I.N. 5 Pin 180°	0·19
PS 24	D.I.N. 5 Pin 240°	0·19
PS 25	Jack 2·5mm Plastic	0·15
PS 26	Jack 3·5mm Plastic	0·15
PS 27	Jack ¼" Plastic	0·28
PS 28	Jack ¼" Screened	0·32
PS 29	Jack Stereo Plastic	0·28
PS 30	Jack Stereo Screened	0·35
PS 31	Phono Screened	0·17
PS 32	Car Aerial	0·20
PS 33	Co-Axial	0·20

SOCKETS

PS 35	D.I.N. 2 Pin (Speaker)	0·07
PS 36	D.I.N. 3 Pin	0·09
PS 37	D.I.N. 5 Pin 180°	0·09
PS 38	D.I.N. 5 Pin 240°	0·10
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PS 40	Jack 3·5mm Switched	0·11
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Spare container of etchant for above ★60p
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C60	★33p
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S237	5 pin DIN plug to 5 pin DIN plug mirror image length 1·5m	£1·20
S238	2 pin DIN plug to 2 pin DIN socket length 5m	68p
S268	5 pin DIN plug to 3 pin DIN plug 1 & 4 and 3 & 5 length 1·5m	£1·00
S270	2 pin DIN plug to 2 pin DIN socket length 10m	80p
S271	5 pin DIN plug to 2 phono plugs connected to pins 3 & 5 length 1·5m	70p
S275	5 pin DIN plug to 2 phono sockets connected to pins 3 & 5 length 23cm	68p
S316	5 pin DIN socket to 2 phono plugs connected to pin 3 & 5 length 23cm	68p
S404	Coiled stereo headphones extension cord extends to 7m	£1·40
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S219	5 pin DIN plug to 5 pin DIN plug length 1·5m	80p
S474	3·5mm Jack to 3·5mm Jack length 1·5m	68p
S600	5 pin DIN plug to 3·5mm Jack connected to pins 3 & 5 length 1·5m	80p
S700	5 pin DIN plug to 3·5 jack connected to pins 1 & 4 length 1·5m	80p

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PROJECTS..
THEORY....

AUTUMN REFLECTIONS

That was a very good summer, that was indeed. Anyone who didn't enjoy a fine spell during his vacation this year must have been exceptionally unlucky, or holidayed outside the UK. (Sorry, Overseas readers; it's not often we get a chance to brag about our weather!)

But now autumn's here. And autumn is a good time of any year. For there's a nip in the air and a flurry of ideas and intentions in the mind as thousands of folk concentrate upon ways to occupy those long dark evenings that loom ahead.

Evening institutes and colleges of further education offer an abundance of courses for all imaginable—and some unimaginable—subjects. Yet there will always be those who cannot for personal reasons attend places of education in the evening. Furthermore they may not wish the formal teaching or the extent and depth of treatment as provided for in many evening class syllabuses. And there are those, of course, who in any event prefer to study alone or perhaps with a fellow enthusiast in their home, at times of their own choosing.

NEW READERS START HERE

Anyone who has electronics in mind as a new subject to get started in this autumn is on a good thing, always provided she or he is reading this! For this month we launch the new beginners series entitled *Teach-In 76*. As the title may suggest, this series is in the good tradition established by previous series, vintage '72 and '74. This means that while covering the same general field and aimed at the same kind of reader, it is entirely new, and in its approach to the subject reflects the personal touch of its author.

Most important to you, new reader, is the fact that *Teach-In 76* is prepared for the absolute beginner and therefore does not assume any previous knowledge of electricity or electronics. (What's the difference? Well, that's a good question. By the time you have reached Part 4 you should know the answer.)

We hope many new readers will be joining us on this occasion. To them we say welcome—and here's to success. (Write and let us know how you get on.)

Here's to a successful, entertaining and instructive season—for all our readers, beginners and old hands alike, whatever their age or sex, and wherever they may reside.

With electronics as a hobby, there need never be a dull moment!

Fred Bennett.

Our November issue will be published on Friday, October 17

Everyday Electronics Fleetway House, Farringdon Street, London, E.C.4. Phone: *Editorial* 01-634-4452; *Advertisements* 01-634-4202.

..EASY TO CONSTRUCT
..SIMPLY EXPLAINED

VOL. 4 NO. 10 OCTOBER 1975

FREE INSIDE CIRCUIT COMPONENTS IDENTIFIED AND EXPLAINED—DATA CHART

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

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★ **BUILD YOURSELF A HAWAIIAN GUITAR**

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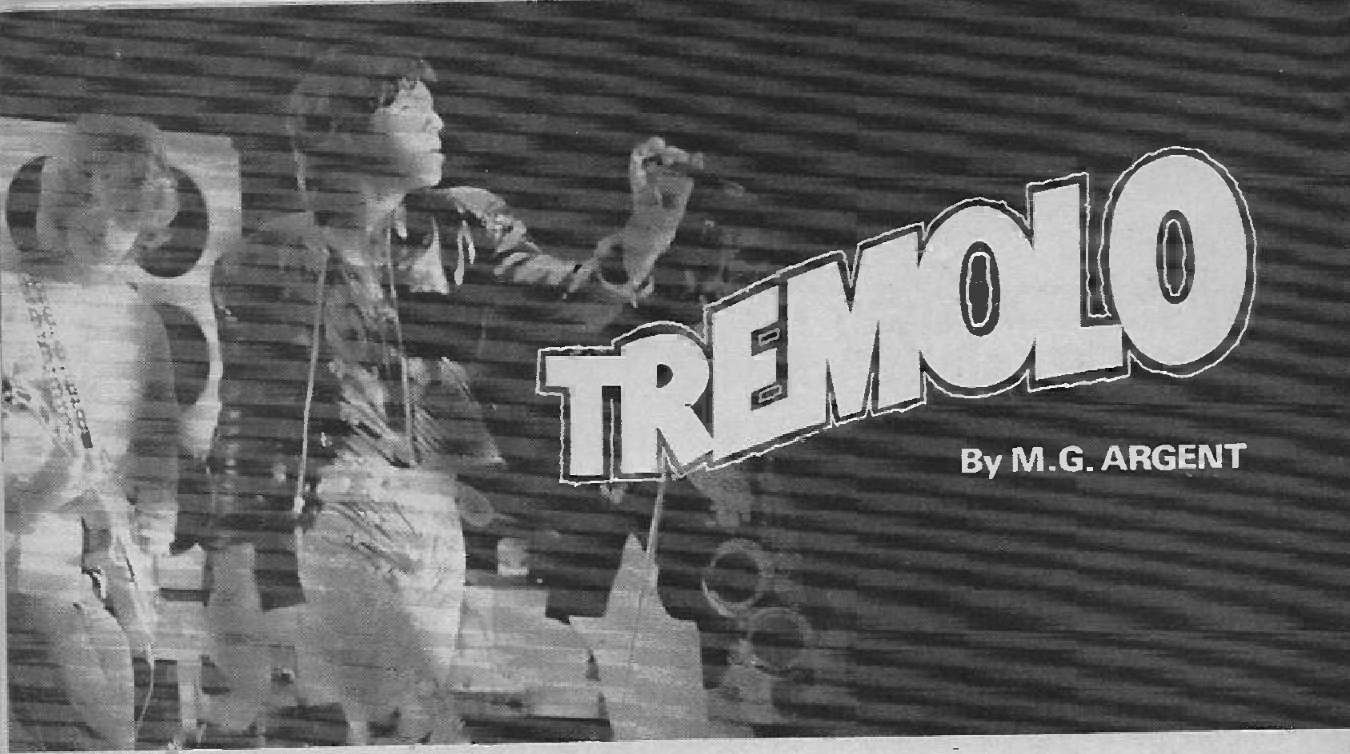
See page 539



TREMOLO

By M.G. ARGENT

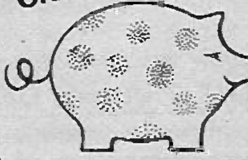
Effects unit for use with musical instruments.

ELECTRONIC effects play a large part in the sounds used by "pop groups" and dance bands. The unit described here is a tremolo unit of a more sophisticated design than most other circuits available.

The most noticeable advantage of this circuit is the lack of "thump" which is common among more simple designs. This undesirable thump can cause damage to loudspeakers; a most expensive experience.

FOR GUIDANCE ONLY

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



£3.70
excluding case

*Based on prices prevailing at time of going to press

CIRCUIT OPERATION

The complete circuit is shown in Fig. 1. Transistor TR1 and its associated circuitry forms a "twin T oscillator" providing a low frequency sine wave, the frequency of which can be varied by VR1.

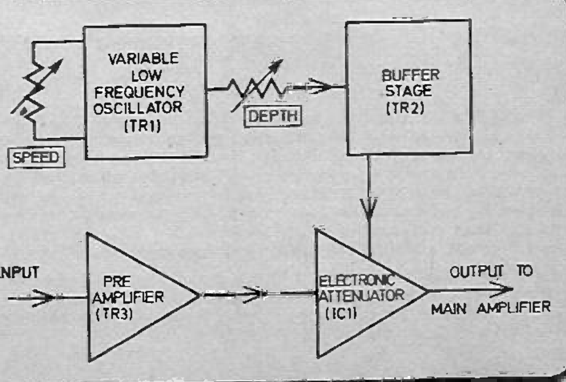
The oscillator is a phase shift design with two feedback paths formed by C1, C2, R1, R2, VR1 and R3, R4, C3, it is from these two paths that the oscillator gets its name.

The output from the oscillator is taken from the depth control VR2, which feeds the desired

HOW IT WORKS

An oscillator produces a low frequency sinewave, the frequency (VR1) and amplitude (VR2) of which can be controlled. This sinewave is fed via a buffer stage (emitter follower) to the control input of an integrated circuit electronic attenuator, thus controlling the amplitude of the signal passing through the i.c.

The output from an instrument is amplified and fed through the attenuator to the main power amplifier, it therefore can have its amplitude continuously varied in sympathy with the oscillator output.



Components....

Resistors

R1	1kΩ	R8	1·5kΩ
R2	150kΩ	R9	47kΩ
R3	150kΩ	R10	220kΩ
R4	150kΩ	R11	8·2kΩ
R5	4·7kΩ	R12	1·5kΩ
R6	150kΩ	R13	12kΩ
R7	56kΩ	R14	12kΩ

All ¼W ±10% carbon.

Potentiometers

VR1 50kΩ log. carbon with d.p.s.t. switch (S2)
VR2 5kΩ lin. carbon.

Capacitors

C1 0·47μF plastic
C2 0·47μF plastic
C3 1μF plastic
C4 0·47μF plastic
C5 10μF elect. 16V
C6 10μF elect. 16V
C7 5,000 pF ceramic or plastic
C8 10μF elect. 16V

Semiconductors

TR1 BC108 silicon *npn*
TR2 BC108 silicon *npn*
TR3 BC109 silicon *npn*
IC1 MFC6040 integrated circuit electronic attenuator (see Shop Talk)

Miscellaneous

S1 s.p.s.t. toggle or slide switch
SK1 jack socket (standard)
SK2 jack socket (standard)
PL1 jack plug (standard)
B1 9V PP3 battery and connectors
Case approx. 135 x 105 x 45mm metal or plastic; knobs 2 off; single sided plain printed circuit panel 106 x 55mm; connecting wire; screened lead etc.

SEE SHOP TALK

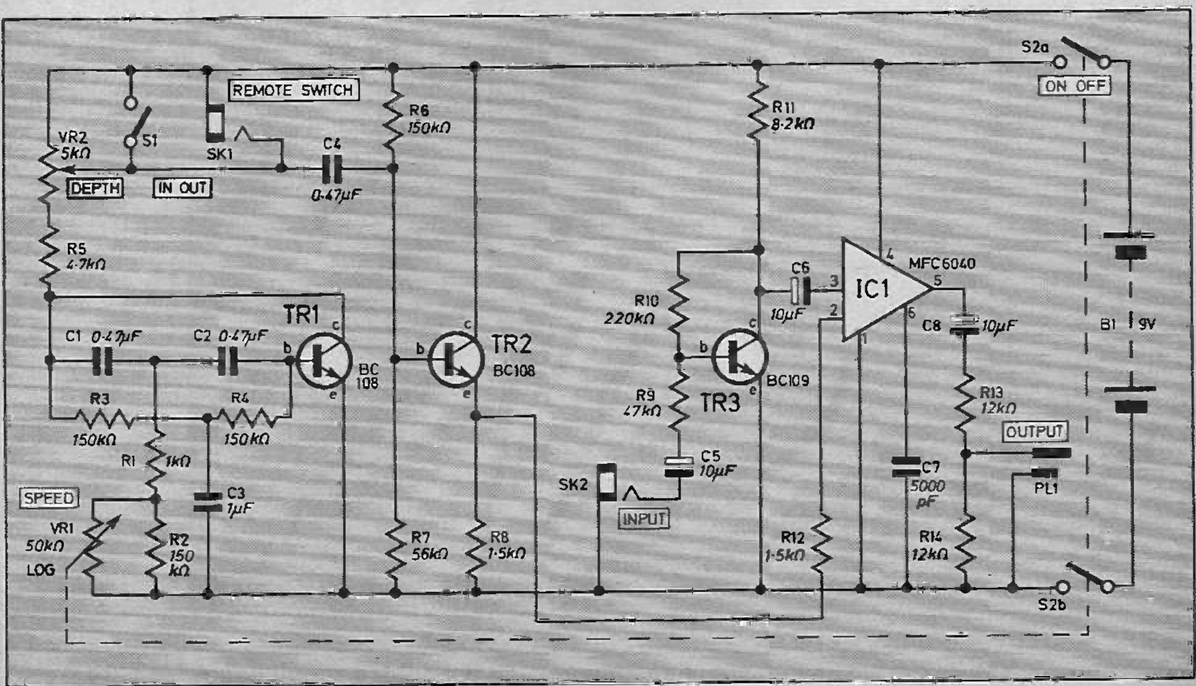
amplitude of sinewave to the emitter follower TR2. The purpose of TR2 is to lower the output impedance of the oscillator before feeding it to IC1, thus preventing IC1 from upsetting the operation of the oscillator.

Integrated circuit IC1 is an electronic attenuator the attenuation of which may be controlled by a voltage applied to pin 2. When the sine wave from TR2 is applied to pin 2 via R12 the attenuation of the circuit varies in sympathy with the sinewave.

The instrument or other signal is fed into SK1, amplified by TR3 and fed to the input of IC1. When the unit is in operation the output from IC1 will be the input modulated in amplitude by the sine wave produced by TR1 and controlled by VR1 and VR2.

A switch is provided for instant on/off (S1) of the tremolo effect, also a socket (SK1) is incorporated for a remote on/off footswitch so useful for musicians.

Fig. 1. The complete circuit diagram of the Tremolo.



TREMOLO

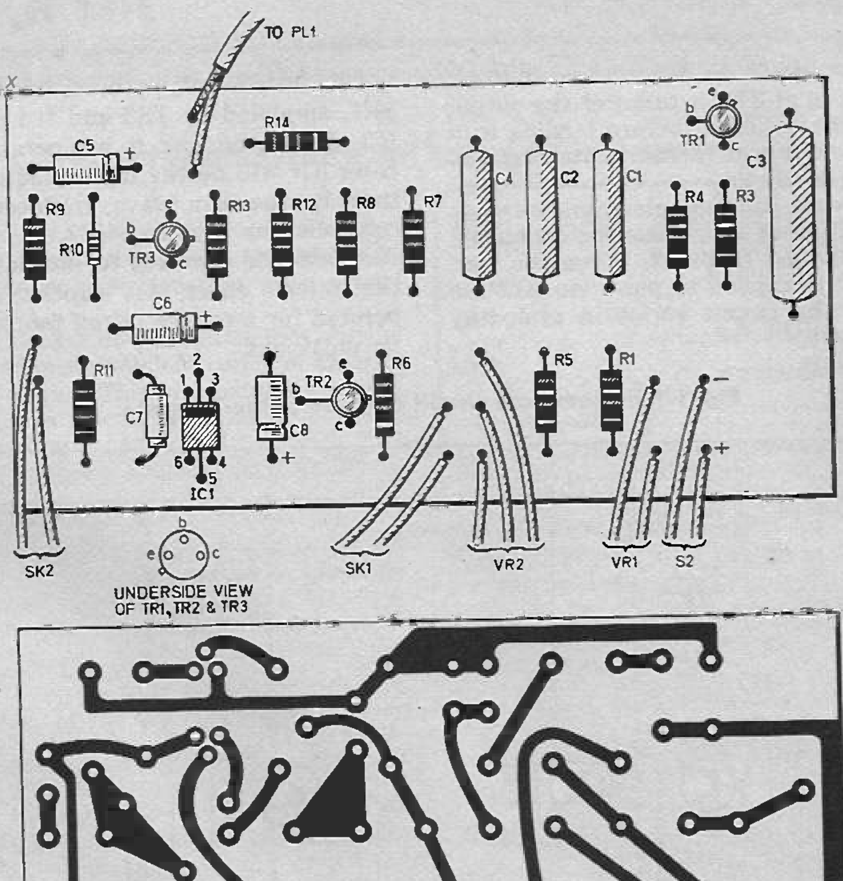


Fig. 2. Design and layout of components on the printed circuit board.

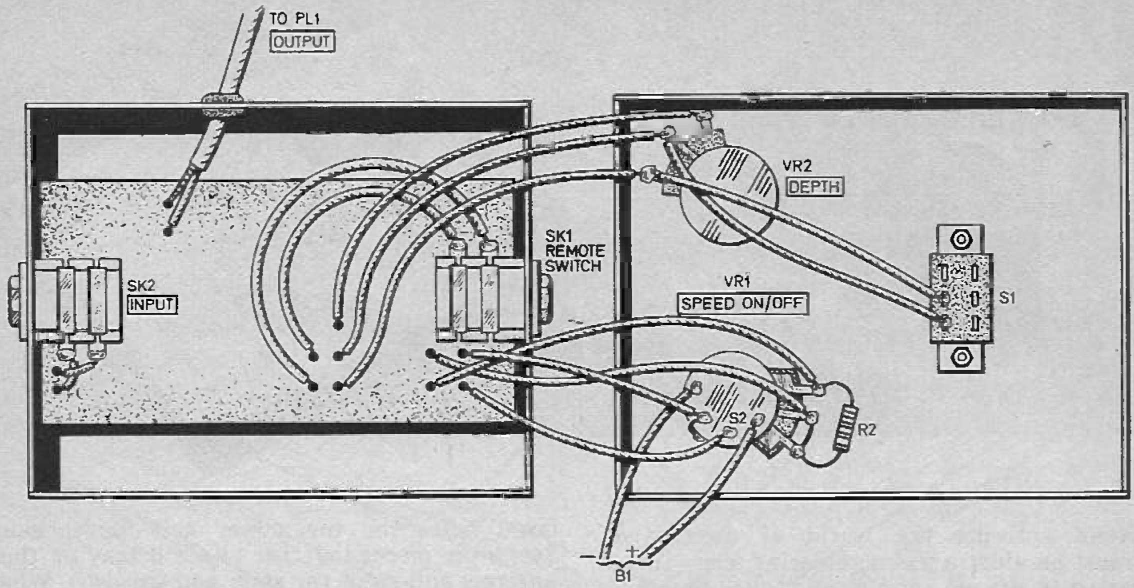


Fig. 3. Connection and wiring of the circuit board to the remaining components.

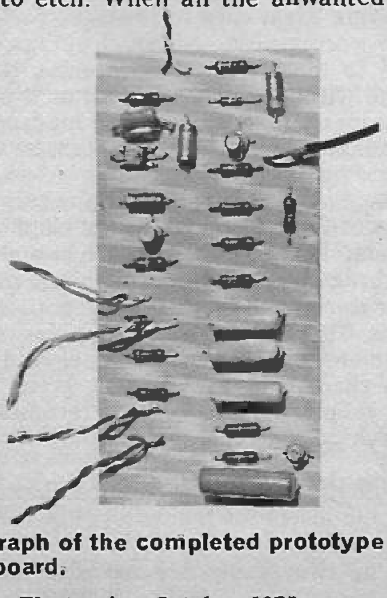
CONSTRUCTION

The prototype unit was constructed on printed circuit board—the design and component layout for this is shown full size in Fig. 2. To make the circuit board draw out the pattern on the underside on a suitable piece of plain copper clad board, the copper having been thoroughly cleaned with scouring powder and water first. This can be done by tracing the pattern shown.

Next paint over the areas shown black, to protect the copper, using nail varnish, model paint or an etch resist pen. Etch away the unwanted copper in a bath of ferric chloride—any finger marks or dirt on the copper will now become obvious as the copper under it will be difficult to etch. When all the unwanted copper is removed, clean up the board to leave the copper areas ready for soldering. Next drill the small holes in the positions indicated to take the component leads.

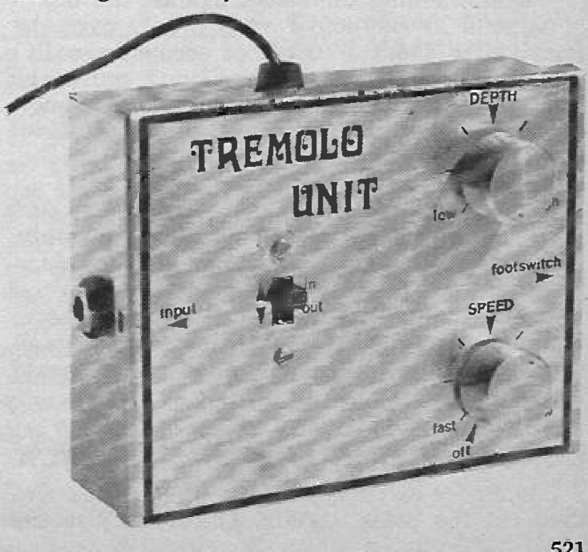
Finally insert the components as shown and solder them to the copper strips. Take care not to overheat the transistors and integrated circuit and connect these parts in last, checking the lead connections carefully.

To complete construction mount the remaining components in a suitable case (approximately 135 x 105 x 45mm) as shown in Fig. 3 and wire the board and components together. Screened lead must be used for the input and output leads. ■



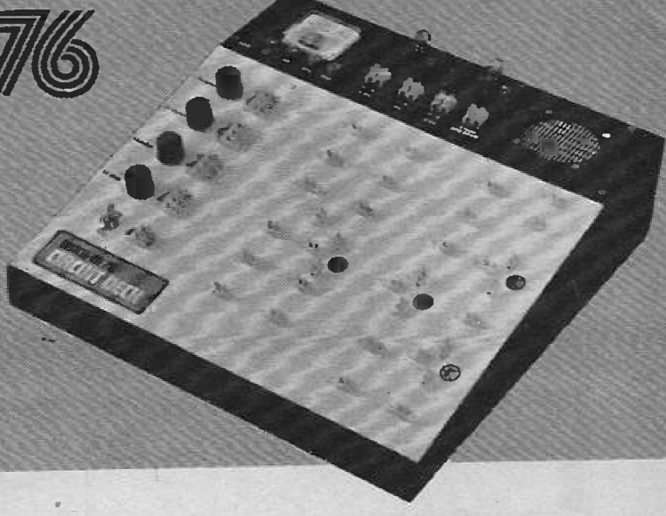
Photograph of the completed prototype printed circuit board.

Photograph of the completed prototype showing labelling on front panel.



TEACH-IN 76
CIRCUIT DECK

By A.P. STEPHENSON



ANYONE entering the world of electronics must be able to use a soldering iron. To be an expert in the art of soldering takes time but the small amount needed to construct the Circuit Deck can be attempted after a few practice trials. The best way to learn is to obtain a few feet of tinned copper wire, cut it up into 50mm lengths and solder them into a "50mm cube".

The simple tips for soldering a wire to, say, the soldering tag of a pot are as follows:

(a) When the iron is hot, hold the solder against the tip of iron until it runs smoothly over the face.

(b) Wipe the surplus off the face with a piece of rag, leaving a shiny, even appearance due to a thin solder film. (The iron is now said to be tinned ready to use.)

(c) Clean the wire and the tag with fine emery (or an india rubber) and "tin" the tag by applying the iron to the tag for a few seconds while holding the solder against the tag.

(d) Bend the wire round the tag and apply iron, again holding the solder against the tag.

As soon as the solder runs evenly over the joint (after about a couple of seconds usually) remove the iron and solder. Don't move the joint until it cools or you will have a poor, mottled looking result known as a "dry joint" (see next month for more details).

The pitfalls are:

(i) dirty wire or tags—solder will refuse to run.
(ii) Too *little* heat—solder won't run smoothly.
(iii) Too *much* heat—component may be damaged and third degree burns on the fingers!

The art mainly is to judge the happy mean. Examine the expert soldering inside a small transistor radio to see how good joints should look.

CONSTRUCTING THE CIRCUIT DECK

Commence by cutting all the wood to size and then cut the holes (as Fig. 1) cutting also the large holes for the meter and loudspeaker. Screw the pieces together to see if they fit, then unscrew and paint (or stain and varnish). When dry, screw the back, sides and the bottom permanently. Fix the three batteries on the inside of the backboard by screw-in hooks and stout elastic bands.

Drill holes (tight fit) for the five wander sockets on the meter panel (Fig. 2) and fix with a smear of glue. Glue and/or screw on the double terminal blocks for each of the three batteries and loudspeaker and also the two batten type lamp holders, using Araldite or a similar glue. Drill a small hole behind each block for wires to pass through.

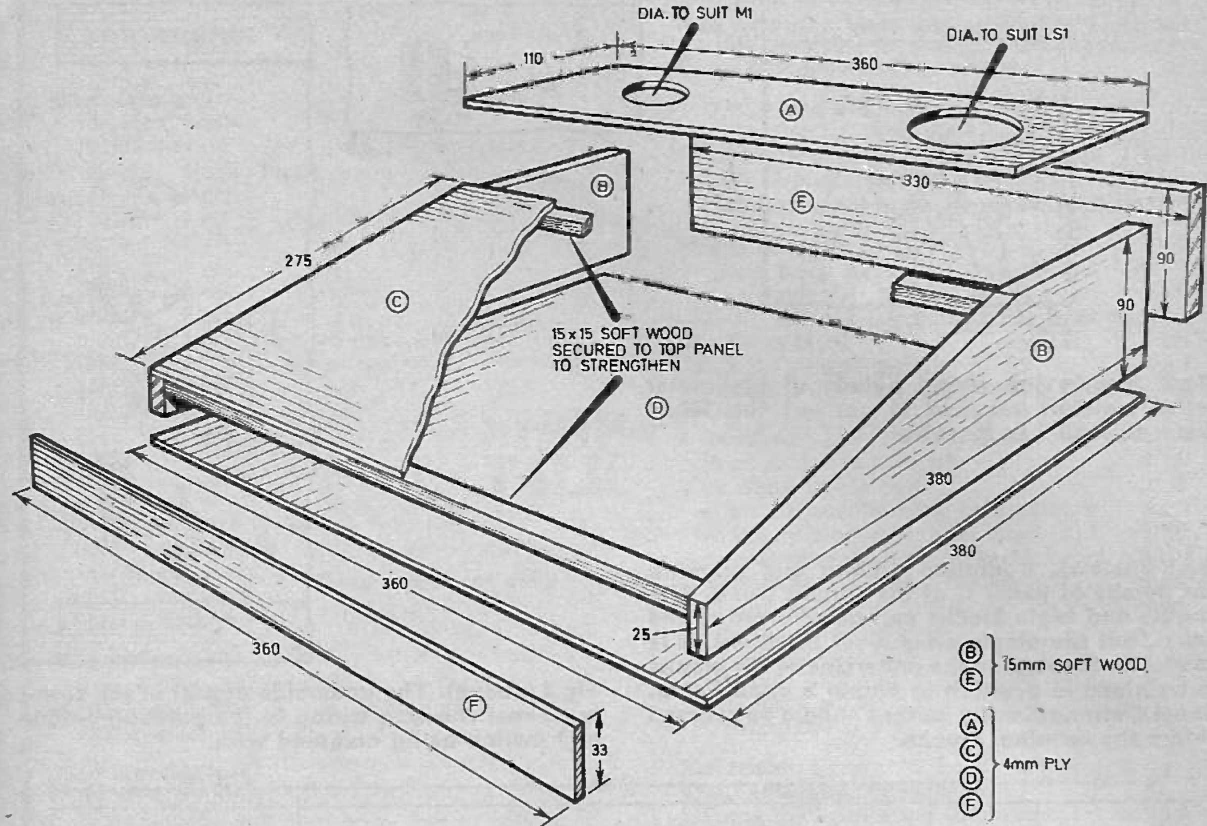
Wire up the meter resistors as in (Fig. 3) soldering the common ends of the resistors to the tag supplied with the meter. (The actual meter should be fixed afterwards.) Make very **certain of the correct resistor values and wiring and the "+" and "−" marks on the meter.**

Wire up the batteries to the terminal blocks, again taking great care to preserve positive and negative correctness. Although plugs can be obtained to mate with the batteries, it is easy to fix the wires directly with a touch of solder (and cheaper). Also wire up the loudspeaker to the terminal block. The panel can be screwed in place.

Cut the holes for the potentiometers and fix them (as in Figs. 4 and 5) on the sloping panel. Drill a small hole adjacent to each potentiometer for the three wires to pass through and solder the wires (of the colour shown) to the potentiometer terminals. Glue the three-terminal blocks for the potentiometers to the front panel and fix the wires to them (red wire to top, green wire to middle, yellow wire to bottom terminal). Glue the switch to terminal block and wire up as shown.

Glue all the remaining terminal blocks as in (Fig. 5) and insert the transistors (BC107) in the TR1, TR2 positions.

Make up two probes for use with the meter,



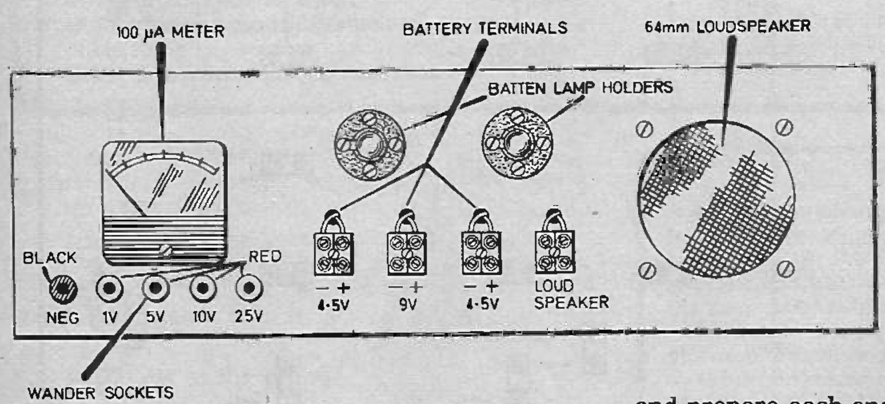


Fig.1. (above) Shows an exploded view of the Circuit Deck with details of assembly and dimensions.

Fig.2 (left). Details of the upper panel of the Circuit Deck showing layout of components.

one red and one black wire with corresponding wander plugs, and probes made from stiff wire or thin knitting needles sleeved with plastic insulation and fixed in a single connector as shown in Fig. 6.

USING THE CIRCUIT DECK

Experiments are carried out by assembling components and connecting wires, using the terminal blocks for joining them together. A set of wires should be prepared and stored inside the deck. The lengths are in no way critical and the following details are simply for guidance:

Four lengths 30cm long; 10 lengths 15cm long; 10 lengths 75mm long. Use some of each colour and prepare each end by removing about 10mm of the plastic covering with side cutting pliers or wire strippers (old hands in the game often use their teeth). Twist the bared ends tightly.

Make certain when screwing down the terminals that the screw is actually in contact with the bared wire and do not use too much force or the wire may be cut or the screw threads damaged—just enough for the wire to resist a gentle tug is right. The terminals are large enough to accept three or four wires/components and, because either end of each terminal has a screw thread, a total of eight connections can be joined together.

A word of warning, however, regarding the "special" terminals for the transistors

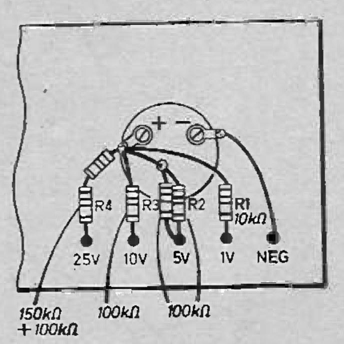


Fig.3. Shows the wiring details of the meter series resistors required to convert the 100μA meter to read 0 to 25 volts.

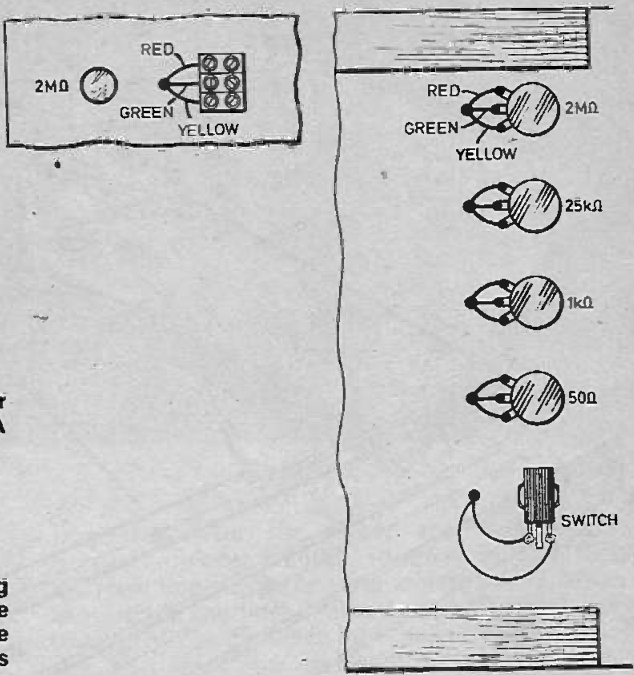
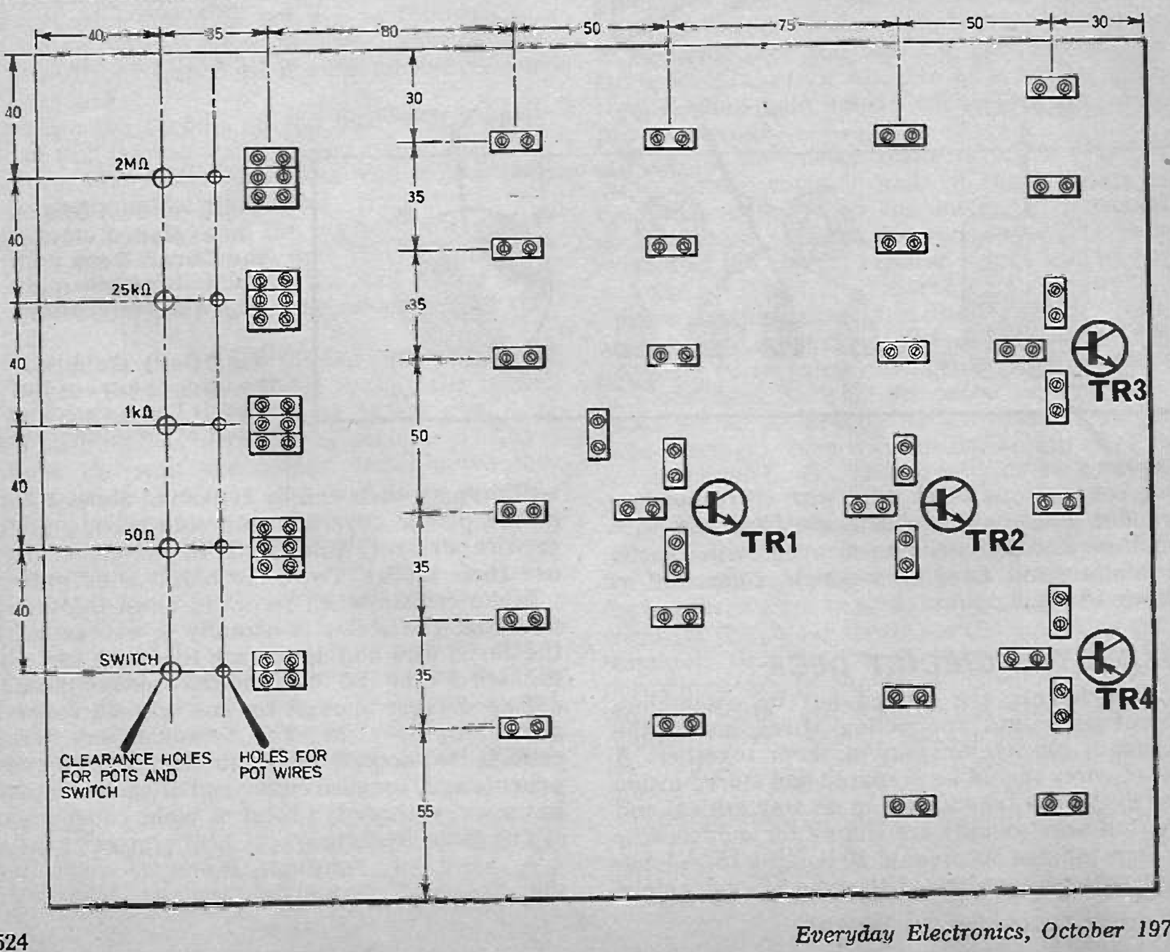


Fig.4 (above). The underside of part of the sloping panel showing wiring to the potentiometers and switch using coloured wire.

Fig.5 (below). Complete drilling and marking out details of panel C of the Circuit Deck. The double and triple blocks can be screwed to the panel, but the single ones must be glued. It is advisable to roughen the underside of the blocks to be glued in position to obtain a good fixing. Panel C strengthening battens should be secured before the terminal blocks.



Components

Resistors

10kΩ	1 off	¼W ± 2% hi-stab types for meter ranges
100kΩ	4 off	
150kΩ	1 off	
47Ω	2 off	¼W ± 5 % carbon
100Ω	2 off	
220Ω	1 off	
470Ω	1 off	
1kΩ	3 off	
2·2kΩ	2 off	
4·7kΩ	1 off	
10kΩ	2 off	
10kΩ	2 off	
147kΩ	1 off	
56kΩ	1 off	
100kΩ	2 off	
1MΩ	3 off	

Potentiometers

50Ω	wirewound	linear types 1 off each
1kΩ	carbon	
25kΩ	carbon	
2MΩ	carbon	

Capacitors

0·01μF plastic or ceramic	2 off each
100μF elect. 25V	
1000μF elect. 25V	

Semiconductors

BC107 silicon *npn*	3 off
BC177 silicon *pnp*	1 off
TIS43 unijunction or similar	1 off
1N5401 silicon diode or similar 3A 100 p.i.v. diode	4 off
OA91 or similar point contact diode	1 off

SEE
SHOP
TALK

The following parts are required to build the Circuit Deck and to carry out the experiments to be described in Teach-In 76.

OA202 or similar silicon diode	1 off
BZY88C4V7 4·7V 400mW Zener diode	1 off
TIL209 or similar light emitting diode	1 off
OCP 71 phototransistor	1 off
ORP12 or similar light dependent resistor	1 off

Miscellaneous

100μA f.s.d. d.c. meter type MR38P, MR45P or similar	1 off
30 to 80Ω moving coil loudspeaker approx. 60mm diam.	1 off
S.P.S.T. toggle switch	1 off
Friedland bell transformer, mains to 3V/5V/8V	1 off
Reed relay coil Osmor SS/12 or similar	1 off
Reed switch to suit coil	1 off
6V 60mA m.e.s. bulb	2 off
m.e.s. batten mounting bulb holders	2 off
miniature crocodile clips	2 off
wander sockets (4 red 1 black)	5 off
wander plugs (1 red 1 black)	2 off
12 way 2 amp terminal block	5 off
4·5V batteries type 126	2 off
9V battery type PP9	1 off

Flexible insulated multistrand wire approx 1 metre of each colour red, blue, green, yellow, black

Materials . . .

15 x 15mm softwood, 66cm
15mm thick softwood 90mm wide 1·1 metres long
4mm ply 36 x 80cm
Araldite or similar epoxy resin adhesive
Woodscrews 10mm x No. 8 countersunk 1 doz.

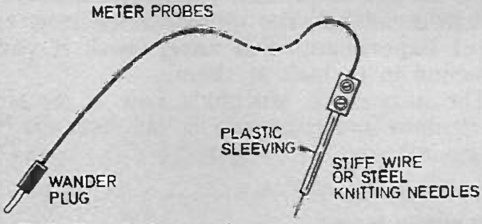


Fig. 6. Details of the probe.

battery, loudspeaker, potentiometers, etc. The ends of these terminals which hold the connections to these components should be left alone —use the other ends only, to avoid disturbance.

When performing an experiment check and double check that the connections are exactly as stated in the instructions. A good safety plan is to leave out the final battery positive connection until the check is completed. **Do not even try out the meter until you have completely understood the text on pages 526 to 530.**

Finally, do not expect high accuracy in your experiments. Because of component tolerances measured and calculated results could be substantially different. ◘

KITS

A kit containing the parts listed above (excluding materials and possibly batteries) is available from the firms given below. For the relevant addresses readers are advised to see the advertisements in this and following issues.

Although the list is fairly extensive it is stressed that none of the parts will be damaged in the experiments and **virtually all of them can be used for the construction of various permanent projects on completion of the *Teach-In 76* series.** The meter—the most expensive component—will be used for the construction of a Test Meter when the series finishes, and a design and construction details for this will be given.

Firms supplying "Teach-In 76 kits":

B.H. Component Factors Ltd.
Bi-Pak Semiconductors.

C.T. Electronics.
Crescent Radio Ltd.
Electrovalue Ltd.
Home Radio (Components) Ltd.
A. Marshall and Son (London) Ltd.

TEACH-IN 76

By A. P. STEPHENSON

Part One

ELECTRONICS is not a difficult subject providing you start at the bottom. The study of any scientific subject requires some degree of self-discipline, particularly when wrestling with the meaning behind some obscure sentence.

The trouble with writers (including the present one) is their sublime belief in the crystal clarity of every sentence they put on paper. Try hard to understand each point but do not despair if you are stuck—just leave it. Very often the light will dawn after reading on a little further.

During the progress of this series, a large number of experiments will be described to be performed on the *Circuit Deck*. Full constructional details for the latter are given on page 522. Many of the experiments will appear very simple but resist the temptation to skip. Performing experiments is a powerful aid to the understanding of theoretical points even if the only visible effect is the movement of a pointer over a meter face.

As the experiments progress you will gradually become aware of a rather sinister tendency of inanimate objects to behave in a hostile way. Don't think you alone are afflicted because this may result in orgies of self pity—it is simply a case of "Murphy's Law" which can be defined as follows:

"In any experiment, if something can go wrong it will!"

Some examples may help:

(a) If you drop a component it will roll to the least visible corner of the room and blend with the surroundings.

(b) If a wire can wriggle free from its terminal, it will.

(c) If a wire fractures it will do so in such a way as to conceal the fact.

(d) If you need nine components, only eight will be available, the ninth will be lost.

(e) Experiments will never work if you call someone in to look at them.

The answer to Murphy's Law is simple. Be meticulous and trust not in luck because it will be against you.

1.1 ELECTRIC CHARGE AND FREE ELECTRONS

Many of us find electricity an obscure subject because nothing can be seen to move. This is because extremely small particles, called **electrons,** carry the stuff (electricity) around on their backs. No one knows exactly what electricity is although its effects are well established.

The amount of electricity on each electron is called its **charge** and is always the same on every electron in the universe. This electron charge is too small to be used as a practical unit of measurement so the combined charges of a certain large number of electrons is used. The resultant unit is called the **coulomb** (C). The symbol used for the charge is "Q".

Charge *means* amount of electricity
Symbol for charge is Q
Unit of charge is the Coulomb

One coulomb happens to be equal to the combined charges of $6{\cdot}24 \times 10^{18}$ electrons, although apart from noting the enormous magnitude, there is little point in memorising this.

Electrons are present in all substances because they are parts of atoms. Atoms consist of a heavy central core called the nucleus around which electrons orbit at very high velocities. The nucleus contains relatively heavy particles called protons which like the electron carry electric charge but the opposite kind. The terms positive and negative are used to distinguish the two kinds of electricity, protons carrying the positive kind and electrons the negative.

Under normal conditions an atom has the same number of electrons as protons, i.e. the same quantity of negative and positive charge. The normal atom is therefore electrically neutral and exhibits no external electrical effects.

In certain materials, such as most of the common metals, one of the outer orbiting electrons breaks away from each atom and carries on an independent existence wandering aimlessly around in the spaces between the atoms. These are called **free electrons** and we must be grateful for their existence because the science of electronics is based upon their co-operation.

1.2 CONDUCTORS, INSULATORS AND ELECTRIC CURRENT

Any material, such as copper, containing an abundant supply of free electrons is called a good conductor because it is capable of transporting or "conducting" appreciable quantities of charge.

Materials such as glass, rubber, plastic, paper and air, are called insulators because their supply of free electrons is negligible. Wherever we wish to prevent the flow of charge, one of these insulating materials can be used. By coating copper wires with plastic, we solve the problem of guiding charges to their proper destination without fear of "short-circuits" should two wires touch each other.

The number of free electrons in copper is enormous—in fact almost every atom contributes one electron. These free electrons under the influence of normal room temperature are in a state of wild excitement, dashing around in a completely random fashion like flies over a compost heap.

If some form of persuasion is applied, the electrons will cease their random and useless movements and will start to flow in an orderly manner along the conducting path. This organised movement of charges is called an **electric current.**

The strength of the current is measured in **amperes** which is in reality the number of coulombs flowing per second.

$$\text{Current} = \frac{\text{Coulombs}}{\text{Time}}$$

One ampere is the unit of current corresponding to a flow of one coulomb per second. The symbol for current is "I" and the symbol for time is "t" so instead of the above equation in words, we may use symbols,

$$I = \frac{Q}{t}$$

Example

If the flow is 5 coulombs every second, the current is 5 amperes; if the flow is 20 coulombs every 1/10 second, the current is 200 amperes.

The question which now arises is how can we "persuade" free electrons to flow along a conductor or wire.

The answer to this lies in the fact that electrons detest each other. A strong repulsion effect exists between particles carrying the same kind of electricity which means that electrons (which carry negative electricity) will always resent being crowded together.

1.3 THE BATTERY

The normal dry battery uses chemical energy to combat this tendency for the electrons not to crowd together by sweeping electrons away from one end (called the positive terminal) and piling them up on the other end called the negative terminal.

This means that a battery just standing idly on a shelf is in a state of tension. It is not doing any work but is is potentially capable of doing some.

Suppose we were silly enough to connect a piece of wire straight across the terminal of a battery. The hordes of electrons on the negative terminal would pour into the wire, forcing the existing free electrons to rush along to the positive terminal where there was a deficit. Inside the battery, however, the chemical energy would sweep the incoming electrons back again to the negative terminal and so a continuous circulating current is maintained until the chemical energy is used up, or in popular jargon, the battery is flat.

The degree of tension or pressure in a battery is measured in a unit called the **volt.** The vast majority of modern electronic gadgets require less than 20 volts for their operation which is rather fortunate from the safety factor viewpoint. It may be advisable to mention at this point that voltages in excess of 50 volts should be considered a possible source of danger—don't touch.

There is also another hazard which it is well to avoid a possible fire risk. Never connect wires straight across a battery because not only will you ruin it in a few minutes or even seconds, but the wire and battery will get hot. The current which flows through the wire is an uncontrolled avalanche which could burn off the insulation covering.

1.4 RESISTANCE

Resistance is measured in a unit called the **ohm** and represents the opposition to the flow of current. Perfect conductors should have zero resistance and perfect insulators infinite resistance. In practice, even copper wires have some resistance, although normally small enough to ignore. An ordinary torch bulb has resistance, so does the element of an electric iron or fire.

Resistors are components which are manufactured to have some specific value of resistance in ohms (plus or minus a small tolerance). The range of values required is very wide and multiples of the unit are necessary:

The kilohm=one thousand ohms (10^3 ohms)
The megohm=one million ohms (10^6 ohms)

The symbol for the ohm is the Greek letter omega, Ω, for kilohms kΩ, for megohms MΩ, although the Ω is sometimes dropped, especially in speech.

Resistors in circuit diagrams are normally represented by the symbol shown in Fig. 1.4a, although a rectangle is not uncommon in representing a resistor.

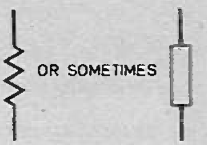


Fig. 1. 4a. Symbols used for representing a resistor in a circuit diagram.

1.5 COLOUR CODE

In the circuit diagram, the value in ohms is shown close to the circuit symbol by various ways. For example, a 4700 ohm resistor could be marked on the diagram as 4·7kΩ or sometimes as 4k7. With the exception of low value resistors of a few ohms or less, the marking on the actual resistor body is by colour code.

It is very important that you learn this by heart, because the misreading of, say a 1·8 kilohm for an 18 kilohms when experimenting could plunge a transistor into rigor mortis.

The code is detailed on the chart given free with this issue. There are one or two memory aids in circulation which help you to remember the colour code sequence. Some of the rhymes are in doubtful taste, but the example given is almost up to drawing room standard.

The catch-phrase below is used by taking the lead letter(s) of each word to give the lead letter(s) of the colour.

The colour coding on the resistor body takes the form of four (sometimes five) coloured bands—see chart. Three of the bands are spaced fairly close together and displaced towards one end. This is the end where the decoding should begin.

The first band gives the first numeral of the resistance value, the second the second numeral, and the third the multiplier. In fact the third band tells the number of noughts to add to the first two digits. The fourth band gives the tolerance. If the coding contains a fifth band, it will normally be pink in colour indicating a high stability type resistor.

Billy	**Brown**	**Revives**	**On**	**Your**	**Gin**	**But**	**Values**	**Good**	**Whiskey**
Black	**Brown**	**Red**	**Orange**	**Yellow**	**Green**	**Blue**	**Violet**	**Grey**	**White**
0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**

1.6 CIRCUIT DIAGRAMS

Before proceeding further it is advisable to learn a little about electronic circuit diagrams, taking as our first example the case of the battery, switch and two resistors, see Fig. 1.6a.

There is one obvious advantage of drawing a circuit in this way (called a pictorial diagram)—it has immediate visual impact. Unfortunately it is time consuming, demands artistic skills and becomes unwieldy if the circuit is at all complex.

Using a reasonably standardised symbolism the pictorial can be redrawn as shown in Fig. 1.6b.

NOTE:

The long thin line of the battery symbol is always the positive terminal the short fatter one is the negative terminal.

The wires are represented by straight lines, presumed to have zero resistance.

The resistors are labelled *R1*, *R2* and the third one if present would be *R3*. It is conventional to number them in numerical sequence from left to right. There is only one switch here so it is labelled S1.

This diagram is said to be a **theoretical circuit dia-**

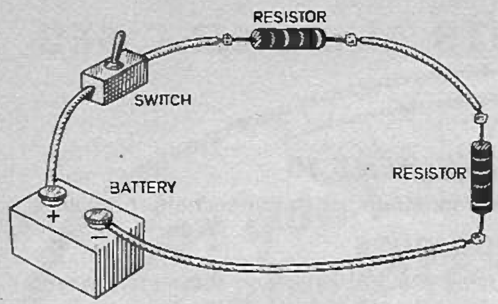


Fig. 1.6a. Pictorial diagram of the wiring up of two resistors, a switch and a battery in series.

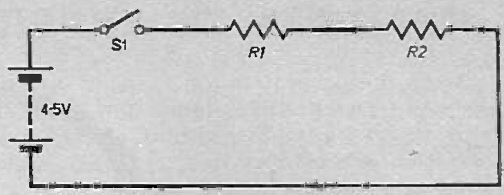


Fig. 1.6b. Theoretical circuit diagram of the pictorial diagram of Fig. 1.6a. using standard symbols.

gram and has the advantage of simplicity and uniformity. You must gradually acquire the art of "reading" a theoretical diagram so you can quickly "translate" into the actual component arrangement on the Circuit Deck. Begin by carefully studying the component list and memorise the symbols with reference to the chart given free with this issue.

1.7 OHM'S LAW

The foundation of circuit theory is the relationship between voltage, current and resistance known as Ohm's law which is stated below.

$$\textbf{Current} = \frac{\textbf{Voltage}}{\textbf{Resistance}} \quad \textbf{or in symbols } I = \frac{V}{R}$$

This relation between parameters tells us how to find the current in a circuit if we know the voltage and resistance. Notice that an increase of voltage or a decrease in resistance will increase the current, which is rather obvious if you think about it.

Consider the simple circuit of Fig. 1·7a as an example to illustrate Ohm's law.

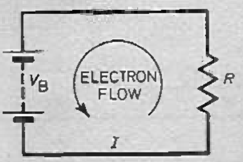


Fig. 1.7a. A simple circuit using a battery and resistor to illustrate Ohm's law.

The battery having a voltage V_B is driving current I, around the circuit which has a resistance of R ohms. The arrow is showing the direction of **electron** flow.

Examples

(a) If V_B=10 volts and R=5 ohms, then the current is, by Ohm's law, given by $I = \frac{10}{5} = 2$ amps.

(b) If V_B = 10 volts and R = 2 kilohms, then the current is $I = \frac{10}{2000} = \frac{1}{200}$ amp.

The ampere (amp) is rather a large unit in electronics so convenient submultiples are used:

The **milliamp,** (abbreviation mA)=one thousandth of an amp=10^{-3}A

The **microamp,** (abbreviation μA)=one millionth of an amp=10^{-9}A

The **nanoamp** (abbreviation nA)=one thousand millionth of an amp=10^{-9}A

To save lots of noughts in calculations on current it is useful to observe that if resistances are in kilohms the current is in milliamps. Also if resistances are in megohms, the current is in microamps.

Examples

(a) 10 volts across 5 kilohms gives 2mA current.
(b) 10 volts across 2 kilohms gives 5mA current.
(c) 20 volts across 4 megohms gives 5μA current.

There are **two** other relations implicit in Ohm's law which are obtained by juggling the equation around,

Since $I = \frac{V}{R}$, it follows that $V = IR$ and $R = \frac{V}{I}$. In fact if we know any two of the quantities we can always find the third, see examples below.

Examples

(a) If 2 amps is flowing through a 5 ohm resistor, the voltage across the resistor must be $V = 2 \times 5 = 10$ volts.

(b) If 6mA is flowing through a 7 kilohm resistor, the voltage across the resistor must be V=6mA × 7 kilohms=42 volts.

(c) If 2mA is flowing through a resistor which has 15 volts across it, then its resistance must be given by:

$$R = \frac{15\text{V}}{2\text{mA}} = 7{\cdot}5 \text{ kilohms.}$$

(d) 6 volts across a 2 megohm resistance will drive a current through it, $I = \frac{6\text{V}}{2\text{M}\Omega} = 3$ microamps.

TEACH-IN '76 EXPERIMENTS AND EXERCISES

EXPERIMENT 1A

(a) To test voltmeter and battery wiring.
(b) To gain familiarity with the technique of voltage measurement using the 25V, 10V and 5V ranges of ME1. **The 1V range must not be used in this test.**

PROCEDURE

1. With the probes plugged into the 25V meter sockets as shown in Fig. 1A.1, hold the negative probe (black) against the metal terminal of the 4·5 volt battery marked −ve and momentarily touch the +ve terminal with the positive probe (red) while keeping a sharp eye on the meter.

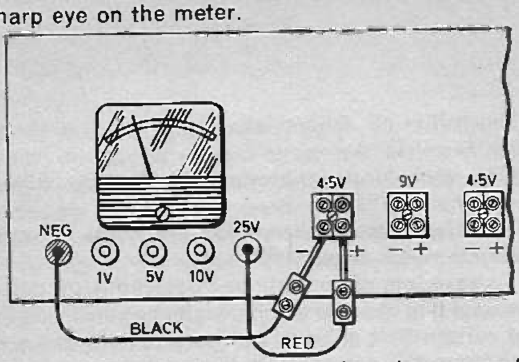


Fig. 1A.1 . Testing that the batteries have been correctly wired to the terminal blocks.

If the meter needle rushes across the entire scale, discontinue the experiment and re-examine the wiring behind the top panel—you have a fault! If the meter needle only moved a short distance, it is safe to hold the red probe long enough to take a reading. Because you are reading 4·5 volts on a meter whose full scale deflection is 25 volts, the needle should be showing nearly a fifth of full scale.
2. Now plug the red lead into the 10V meter socket and repeat the above procedure. This time the meter should read almost half full scale.
3. Repeat step 1 but this time plug the red lead into the 5V socket and check that the meter reads nearly full scale.
4. If the results so far have been satisfactory, the other 4·5 volt battery should be tested in the same manner.
5. Finally test the 9 volt battery in the same way as above but **on no account use the 5V meter socket** because the application of 9 volts to this socket could damage the meter.

Keep practising all these tests until you have gained confidence in the use of the meter and interpreting the readings.

Your meter is expensive and is easily damaged by connecting too high a battery voltage when plugged into too low a meter range. Always cultivate the habit of using the 25 volt range first and then "plug down" until the reading is about half full scale.

EXPERIMENT 1B

To demonstrate series connection of batteries.

PROCEDURE

1. Using the 10V range on the meter, measure the voltage of the two 4·5V batteries connected as shown in Fig.1B.1 The meter should read about 9 volts. This is because the two batteries are connected in series in such a way that each separate battery voltage adds to the total. (4·5V+4·5V=9V).

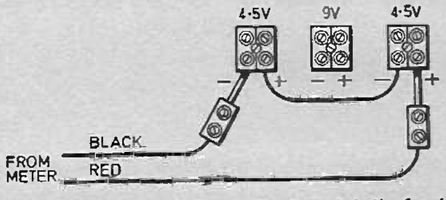


Fig. 1B.1. Wiring up and monitoring details for the two 4.5 volt batteries in series.

2. Now rewire according to Fig.1B.2. Again using the 10V range on the meter, measure the voltage at the terminals shown. This time the meter should read zero (or nearly so), because although the two batteries are still in series, they are in opposition to each other. The effective voltage is 4·5V—4·5V=0V. Any slight reading other than zero would be due to one battery having a slightly higher voltage than the other.

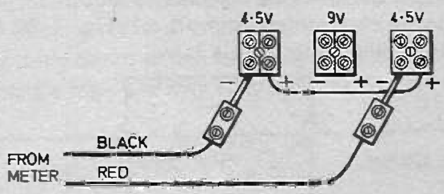


Fig. 1B.2. Wiring up and monitoring details for the two 4.5 volt batteries in parallel.

3. Now devise your own wiring to produce, first 13·5 volts and secondly 18 volts, remembering to use the meter on the 25V range.

EXERCISES

1. 1 Calculate the values left blank.
(a) V=9 volts, R=4·5 kilohms, I=——
(b) V=4·5 volts, R=1 megohm, I=——
(c) I=4 milliamps, R=2 kilohms, V=——
(d) I=2 milliamps, V=9 volts, R=——

Answers

1. 1 (a) 2 milliamps; (b) 4·5 microamps; (c) 8 volts; (d) 4·5 kilohms.

for your Entertainment...

By Adrian Hope

AMATEUR audio and hi fi enthusiasts seldom even hear about the various professional film, video and sound exhibitions that are held at least as often as the amateur exhibitions at Olympia, Harrogate and Heathrow.

By the way, I am here using the word "amateur" in the French sense—to denote an enthusiast who is involved in a subject for love rather than money. A professional, on the other hand, is essentially involved for money. But of course many professionals are amateurs as well, in that they do have a love for their job.

Professional Exhibitions

Amongst the regular professional exhibitions are those run by the AES (Audio Engineering Society), the APRS (Association of Professional Recording Studios) and the IBC (International Broadcasting Convention). Then there is the Public Address Engineers' annual get-together, and the Film and Tape Quality exhibition that is put on by the BKSTS (British Kinematograph Sound and Television Society). All these exhibitions are held in relatively small halls, usually tied to London hotels.

The general public are excluded simply because there just isn't room to accommodate them and most of the equipment on view is of professional interest only. But usually there are a couple of things of interest to us amateurs and this year's Film '75 exhibition was no exception to the general rule.

Anyone who has ever used a discharge lamp (for instance even an ultra-violet light) will know that once it has been run for a while and warmed up it cannot be switched off and then immediately switched back on again. This can be infuriating and expensive in a photographic or film studio, because if someone switches off an arc discharge light by mistake the whole studio has to wait around until the lamp vapour has cooled and its resistance has dropped sufficiently to enable the arc to be restruck.

Thorn Lighting Ltd. have now developed a 1kW compact source iodine lamp with a control unit that can blast a 25kV pulse through the hot vapour to re-fire the lamp. The pulse need only be short, so the charge store system can run happily on a 13 amp mains plug. The lamp pins have to be well spaced apart, though, to prevent the pulse jumping between the pins to avoid passing through the high resistance gas.

Don't be confused between iodine lamps as used in home movie and slide projectors, and compact source iodine lamps of the new type. The Thorn CSI lamp is an arc discharge lamp, whereas the domestic halogen lamps have a tungsten filament rather like that in an ordinary electric light bulb. The advantage of using an arc is that all the light is generated from a very small area and there is more of it usable per watt rating.

In fact a single 1kW halogen arc lamp can produce as much light as up to 15kW of filament halogen lamps. The arc lamp also lasts five times as long. Until now the disadvantage has always been not being able to switch them on and off—but as explained Thorn seem now to have licked the problem. So perhaps we shall soon start seeing halogen arc lamps in home projector equipment.

Instant Picture Film

There was also the launch in the UK of an interesting new threat to video as the "instant picture" system of the future. It is already an open secret that the Polaroid Corporation is working hard on the development of instant picture movie film but it seems likely that this will function along fairly conventional photographic lines and thus require handling in the dark.

But at Film '75 Metro Kalvar showed a new film that can be handled in daylight—just like video tape!

Raw Kalvar film stock consists of thermoplastic resin, coated on a polyester base. The resin contains a dispersion of material which is sensitive to ultra-violet light but not to normal daylight or laboratory illumination. The sensitive resin is placed in close contact with a negative to be printed and the sandwich exposed to ultra-violet light.

This produces a latent image of internal stresses in the resin, which is then developed by the application of heat.

The result is a strip of film which carries a positive image, which appears anaemically grey and low-contrast to the naked eye. However, when this grey positive film is projected onto a screen using conventional movie or slide equipment, a normal, full contrast monochrome image is produced. Whereas normal silver halide film produces black areas on the screen by blocking the passage of light, the Kalvar film produces black because areas of modified refractive index scatter the light.

Flea Market

But for me the most interesting part of the exhibition was what happened after it had finished. Having taken the Royal Lancaster Hotel for a full week, the organisers gave over some of the floor space for one day to an audio-visual "flea market".

The idea was that anyone with secondhand, or shop-soiled audio and visual equipment could come along and set up a stall, while anyone interested in picking up an audio-visual bargain could come along and do business.

So what about an "audio and electronic flea market" for a few hours after the closedown of one of the amateur audio exhibitions?

...Counter Intelligence

BY PAUL YOUNG

A retailer discusses component supply matters.

By the time these lines appear, the nights will be drawing in, and the weather will be turning a shade colder. Indoor activities will then appear more attractive than the outdoor kind, and many of you will be drawn towards electronics perhaps for the first time to fill in your leisure hours. You could not make a better choice.

Electronics today enters every phase of our lives, from the sophisticated circuitry of interstellar probes at one end, down to the microwave cooker at the other, through the entertainment provided by colour television, to the life saving medical uses such as the heart pacer. No other hobby can be as exciting or so rewarding.

When you commence, you will be following well marked paths but eventually you will reach the frontier and then you will be making your own tracks, and who knows, you may be the new Sir Robert Watson Watt or Dr. William Shockley! Electronics has the advantage that it may be started in a modest way without a great outlay of money, given the occasional use of a kitchen table and a few simple tools and the world of discovery is yours.

Let me assume for the moment you are sold on the idea. You have already made a splendid start by reading the right magazine, and I really can say with all sincerity that there is no better monthly journal for the beginner to start with. Every year it has special courses for beginners and this year is no exception. One of my pleasant labours is to instruct you in the most basic of all knowledge, how to obtain your requirements in the shape of tools and materials.

I will begin by repeating two things I have said ever since the inception of EVERYDAY ELECTRONICS. (1) You will not get all your requirements from one supplier, in fact you may well have to deal with four or five. (2) Unless you live in a large town and are extremely lucky in your location you will be dependent on mail order for many of your goods.

This brings me by natural progression to the subject of catalogues. Make these your first purchase and buy several of them. They vary in price from about 25p to 85p. The 25p catalogue is not necessarily the cheapest as it may perhaps consist of 50 pages and the 85p one perhaps 250 pages, but the number of pages are not the sole criteria by which they should be judged.

I would admit that in catalogues as in most other things, you get what you pay for, but having said that, I would counsel you to judge by the final result. You are in a fortunate position, in that most component firms are small, and they are anxious not only to get your custom initially but to keep it. This will show itself in their anxiety to put right mistakes should they occur.

Finally may I offer a few tips that will assist you with your ordering. Some of these may seem elementary but are nevertheless essential.

(1) Make sure you include your name and address, and if your long hand resembles mine, print it in block capitals. You would be surprised at the number of red faces there are, caused by customers blasting us for not sending their orders, only to be told they forgot to include their names and addresses!

(2) If you are working from a catalogue and the firm uses *catalogue numbers* you should use them also, remember it does give positive identification.

(3) If the firm provides an order form it obviously assists them if you use it.

(4) Do not order goods not listed in the catalogue.

(5) Remember the postal services are not as fast as they used to be and even if your supplier is giving a same day turn round, the delay in your letter arriving and the returning parcel, plus an intervening week-end could add up to 10 days! So be patient.

(6) Never commit the cardinal sin of writing a query on your order forms. If there is one thing that really does delay an order, this is it.

Happy constructing!

I recently had an idea that could be of interest to readers who constructed the *Ultrasonic Remote Control* (Everyday Electronics Dec. '74/Jan. '75). It is in connection with the control of a small model boat where the author of the article states that more than one transducer will be required for such application. This is my idea using one transducer:

A cone shaped piece of metal (tinplate) is held above the receiving transducer by three pieces of stiff copper wire, soldered on. The oncoming ultrasonic waves are deflected down onto the transducer regardless of the boat's position. The height of the transmitter would determine the angle of the cone.

The whole arrangement could be disguised as an air vent and would have to be on the highest part of the ship's super structure.

D. E. Heathcote, South Africa.

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

Your Career in ELECTRONICS

By Peter Verwig

A FUTURE IN VALVES

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.

IT is almost sacrilege to mention the word valve in the pages of EVERYDAY ELECTRONICS. Certainly our younger readers, educated throughout in the age of solid state, may never have handled one. And why should they? Much better to use transistors and integrated circuits in their hobby. But only 25 years ago the electronics hobbyist was stuck with valves and used them all the while—there was nothing else if you needed amplification or electronic control although there were, of course, solid state diodes and rectifiers in those days.

HISTORY

Let's take a brief look at the history of electronics. It all started in the late 19th and the early days of this century and like many discoveries and inventions the valve developed almost by accident. Dr. J. Ambrose Fleming, often described as the "father" of the electronics industry, stumbled across the diode valve partly as a result of the onset of deafness which was causing some difficulty in listening to clicks and buzzes in earphones.

Fleming remembered that 22 years earlier Edison, the pioneer of the filament electric lamp, had been worried by discolouration on the inside of the glass bulb and in searching for a cure had introduced some tin foil into the bulb envelope and had observed the phenomenon that if the foil was connected to the positive filament supply a current flowed, but if it were connected to the negative terminal of the filament supply no current flowed. In 1882 this phenomenon was of little importance and it didn't solve Edison's problem. But now, in 1904, in the early days of wireless telegraphy it was just the thing Fleming was looking for.

The decisive development, however, was due to Lee de Forest who, in a series of experiments with two-electrode valves (diodes), decided to introduce a third electrode, shaped like a grid-iron, between the cathode and anode and discovered that the "grid" was capable of exercising some control over the electron flow.

This device was patented in 1907 but again its importance was not fully grasped and although by 1912 de Forest was getting useful amplification, it was not until 1913-14 that the triode was properly exploited, technically and commercially, in professional communications.

The advent of public sound broadcasting in the 1920s saw the start of the electronics entertainment industry with the consequence that valves for receiving sets needed to be made by the thousand and ultimately by the million and generated a completely new industry.

Today the small valve industry has declined and the transistor has taken over. But don't imagine that the valve is "old hat". The early work of Fleming and de Forest still lives on in a vigorous electronic tube industry of a sophistication undreamt of by the pioneers. Fleming, who was knighted for his contribution to science in 1929, lived to the ripe old age of 95 and when he died in 1945 he had at least seen remarkable developments like TV picture tubes and the magnetron valve which, in radar, was a war-winning device.

MANUFACTURERS

For an assessment of the present state of the electronic tube industry I have taken as an example the English Electric Valve Co. Ltd. which employs over 2,000 people at Chelmsford and Maldon in Essex, and at Lincoln. It is part of the GEC Electronic Tube Co. Ltd., which unites the activities of the M-O Valve Company Ltd. based at Hammersmith, London, and EEV.

The other large manufacturers of electronic tubes in Britain are the Electronic Tube Division of EMI Electronics, based in Hayes, Middlesex and ITT's Electronic Device Division with a large plant at Paignton in Devon. Although the products designed and manufactured at these plants may be different, the type of work is essentially similar to that at EEV.

EEV has four divisions, one for each category of products. The Microwave Division produces magnetrons, klystrons and travelling wave tubes used in radar, television and sound broadcasting, professional communications and nuclear physics. Light Conversion Devices Division produces television camera tubes of a number of types and display tubes and storage tubes for radars and computers.

Power Valve Division produces heavy duty valves for application in communications, including broadcasting and industrial use. The fourth division concerns itself with gas filled tubes such as hydrogen thyratrons and gas-filled lasers. Additional activities include design and production of rectifiers, voltage stabilisers, TR cells, trigger tubes and ignitrons.

As a hobbyist engrossed in transistor technology you may find the names of some of these devices strange and some you may never have heard of before. But they are all well known to the professional electronics engineer. Look them up in an electronics dictionary or dig out information from the technical shelves of your local library. You should find them fascinating.

Apart from the TV camera tubes and electronic displays which have their own special reasons for being vacuum tube devices rather than solid state, the main distinguishing feature of the professional electron tube industry is its heavy involvement in power. Even at audio frequencies, transistors are still low power devices of the order of watts and at microwave frequencies its hard to get more than milliwatts and then only at low efficiencies.

So if we are thinking of kilowatts at any frequency the electron valve is the best buy and as frequencies rise to the u.h.f. and microwave regions it is the only buy. EEV lists an L-band magnetron with a peak power output of 5 megawatts which involves a peak anode voltage of 48 kilovolts and a peak anode current of 240 amps. I hasten to add that this very powerful device is only made to special order but it illustrates the point.

CRAFTSMANSHIP

The manufacture of electron tubes is one of the few areas in electronics where sheer craftsmanship in its traditional sense is absolutely essential. There is practically no mass production and many tubes are hand-built, mechanical as well as electrical tolerances are very tight and a variety of materials, glass, ceramics, metals, are involved.

The design and production of electron tubes demands the application of many scientific and engineering disciplines. At the top level are physicists, metallurgists, and chemists as well as electronic engineers. Nearly one person in every ten at EEV is a qualified scientist or engineer. And there are many specialisations at skilled craft level.

EEV runs apprenticeship schemes in electrical and mechanical engineering, tailored to meet different interests and different entry levels. Readers of previous articles in this series will have already encountered similar training programmes. There is a four-year craft apprenticeship, a four-year technician (C and G) scheme, a technician engineer (HNC) scheme which may be four years or accelerated to three years for ex-sixth formers, and for A-level school leavers or those with ONC or OND, a student apprenticeship leading to a university degree.

For a craft apprentice there are no specific entry qualifications. Selection is by interview and tests, and your main concern will be to demonstrate that you have good practical ability and character. There is a probationary period of six months to see how you get on before the Agreement of Apprenticeship is signed. To enter as a technician you need at least C.S.E. grade 2 passes in mathematics, physics and English language.

Entry becomes harder for technician engineer and you will need four passes at G.C.E. O level (or C.S.E. grade 1). You must have English language and mathematics, an approved science subject which may be physics, physics-with-chemistry, mechanical science or engineering science, plus one other subject.

For the accelerated electrical technician engineer course you must have completed a full two-year sixth form A level science course and obtained a pass at that level in either mathematics or physics.

VARIETY

An unusual feature of EEV and other companies in this field is the wide variety of scientific and engineering disciplines involved and so there is quite a choice of careers.

Part of the TR tube calibration and test area at EEV's Lincoln works.

EEV tell me that it is not unknown for an electrical/electronic apprentice to switch to mechanical engineering or vice-versa. Of course you are expected to make up your mind quickly because of switching college courses to suit your training programme and in general such changes take place within six months. But that is generally long enough for you to learn quite a lot about the company, its products, and its career structure, and for the company to have a fair idea of where your real interests lie.

Once you are qualified you can also switch jobs, for example, from quality assurance to tube development. It is interesting to note that all senior appointments in sales are held by qualified engineers.

The career structure at EEV is well defined with progression ladders leading up to divisional manager. How well you get on depends on your own efforts and you can interchange between progression ladders with a change in job content by acquirement of qualifications. Like all high technology professions, that of electron tube design and manufacture needs highly qualified people and it pays you handsomely to do well academically as well as professionally.

An intelligent young person with a degree can move ahead substantially and could well be an assistant manager by the mid-thirties and certainly be in a position of fair responsibility in the middle to late twenties. EEV encourage personal growth with character and personality development training as a regular and continuing part of the apprenticeship training programme and special courses and re-training in later years.

If you are too old for an apprenticeship but have good electronics knowledge there are still jobs in test and inspection for which you may be well suited. With small batch production this type of work tends to be more varied than in the ordinary factory in the electronics industry.

LADIES TOO

EEV normally takes in approaching 20 apprentices a year and somewhat more graduates. At the Apprentice Presentation Ceremony last June the Managing Director's award for the apprentice of the year went to a young lady, Kathleen Westhorp, in her third year as a trainee technician.

Another female trainee, a craft apprentice who joined EEV from Rainsford Secondary School, Chelmsford, is on record as saying her work is more pleasant than she expected, she gets a sense of pride and achievement from the work and likes being treated as an equal. Although heavily outnumbered the girls are well able to compete on equal terms with the lads.

Well over half the output of EEV goes overseas and some 600 different types of tubes and devices are listed in the latest catalogue. So, far from being "old hat", electron tubes offers a thoroughly modern career which in its specialised products is unlikely to decline.

READERS' LETTERS

Effects

I have been buying E.E. for some time. My first ever project was the *Delta Electric Guitar*. I have since bought a Vox AC30 and have made the *Fuzz Box* and the *White Noise Generator* for use with my guitar and I hope that in the future it could be possible for projects on either wah-wah or phase units to appear in the magazine, as I am interested in building one or both with the help of EVERYDAY ELECTRONICS.

Mr. S. Lister,
Wolverhampton

Short Waves

I have recently constructed the E.E. *Short Wave Receiver* as published in your March edition. Although the unit will pick up a.m. signals using a 10m aerial (and earth) I have difficulty in obtaining s.s.b. c.w. reception. By some fiddling, changing the value of C4 from 100pF to 250pF I can obtain a beat frequency and oscillation arises. I am considering changing this capacitor for a variable type, but I do not know enough about radio circuits to go too far on my own. I would be grateful if you could give me some advice as to where I may be going wrong.

A. Heason,
Dorset

To resolve c.w. or s.s.b., TR1 must be brought to the oscillating condition. This is so if a whistle is heard when tuning through an a.m. transmission. If oscillation is not obtained, the most likely cause is having C1 screwed down too far, especially if plugged into SK3.

When fine adjustment of VR1 allows the detector to be taken in or out of oscillation as described above, careful adjustment of VR1 and tuning should allow c.w. and s.s.b. to be received.

With c.w., tuning by C3 is not extremely critical as adjusting C3 will only alter the pitch. For weak c.w., VR1 is only just past the oscillation point; for strong c.w., advance VR1 a triffle more. If the c.w. is exceptionally strong, C1 must be unscrewed.

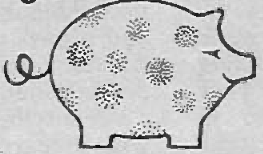
With s.s.b., adjustment is critical as adjusting C3 makes speech unintelligible or inverted. Adjustment is otherwise as for c.w., not forgetting to unscrew C1 if signals are too strong. A reduction drive could be used on C3, but is not essential with a large knob.

The 80m amateur band should furnish many c.w. and s.s.b. signals.

A miniature unit employing an integrated circuit timer to provide a delay in the switching off of the car courtesy light when the door is closed

FOR GUIDANCE ONLY

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



£1.00

*Based on prices prevailing at time of going to press

COURTESY LIGHT... DELAY

By S.A.Money

ON a cold wet wintry night, after getting into your car and closing the doors, have you had the experience of having to grope around in the darkness as you try to insert the key into the ignition switch? Modern cars are often fitted with an interior courtesy light which switches on automatically when one of the car doors is opened, but, unfortunately this light switches off again as soon as the doors are shut thus plunging the inside of the car into darkness just when a light is needed.

On a stormy winter night one naturally closes the doors as soon as possible in order to keep the unfriendly elements at bay. Wouldn't it be convenient if it could be arranged that the courtesy light would stay on for about ten seconds after the doors had been closed?

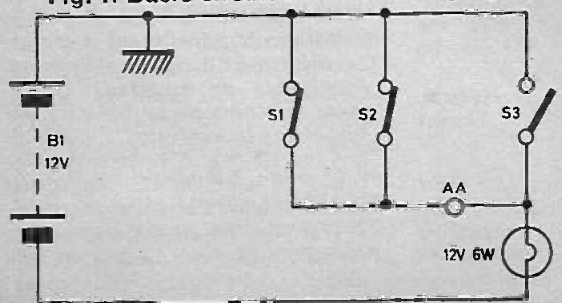
In this article a simple electronic unit is described which will delay the switch off of the interior light for some ten to fifteen seconds.

COURTESY LIGHT CIRCUIT

Let us first of all examine the basic courtesy light circuit which, for most cars, will be as shown in Fig. 1. In this circuit it is assumed that the car has a positive earth system where the positive terminal of the battery is joined to the chassis. In negative earth systems the circuit is the same but the polarity is reversed.

The two switches S1 and S2 are microswitches

Fig. 1. Basic circuit of the courtesy light.



mounted on the front door frames of the car and operated when the doors are closed. The switches are arranged to complete the circuit if either of the front doors is open. A further switch S3 is usually mounted on the interior light fitting and provides a manual override facility. When switch S3 is made the lamp will remain on irrespective of the state of the switches S1 and S2.

To fit the unit it is convenient to break into the existing car wiring at the interior light unit. To achieve a compact and reliable unit an integrated circuit is used for the time delay with a transistor switching the current through the lamp. Alternative versions of the circuit are given for positive and negative earth wiring systems.

POSITIVE EARTH CIRCUIT

The circuit for a delay unit to work with a positive earth system is given in Fig. 2.

In the average courtesy light unit the bulb is rated at 12 volts 6 watts and requires a current of about 500mA when lit. Since the output stage of the 555 integrated circuit timer used is capable of only 200mA output current it becomes necessary to use a separate transistor to switch the current through the lamp. For a positive earth system this transistor needs to be a *pnp* type.

When conducting a current of 500mA the transistor will have a collector to emitter voltage drop of about 0·8 to 1 volt. Thus the power dissipation in the transistor is about 500mW maximum. A suitable transistor for this purpose is the 2N2905 which dissipates 600mW and is in a TO5 can.

The base of the transistor is fed from the output of the 555 through a resistor R2 which limits the level of base current to a safe value.

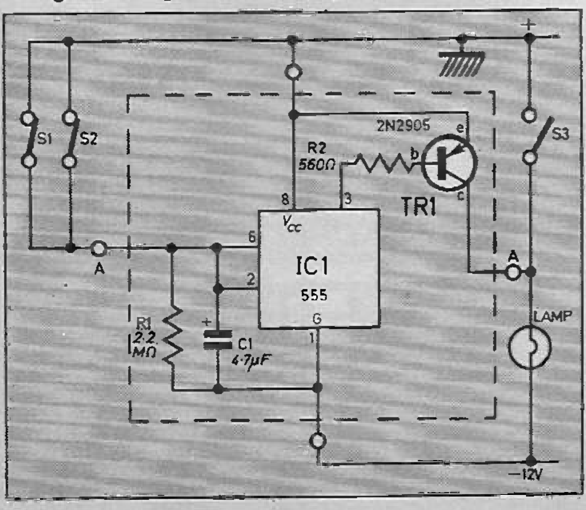
In this circuit the 555 is operated in a different mode from the normal. To turn on the transistor we need a negative pulse from the 555. Here the threshold (pin 6) and trigger (pin 2) inputs of the 555 are tied together and taken to the positive end of the parallel resistor R1 and capacitor C1. This input point for the 555 is also taken via the door switches to the +12V rail.

Now when the door switch is made the capacitor charges to the full 12 volts of the supply and is held there. This causes the comparator in the 555 to switch, resetting the internal flip-flop and taking the output voltage down to zero. Transistor TR1 turns on and the lamp lights.

When the door switch breaks the circuit the capacitor discharges through the resistor and the input voltage falls. When the input voltage reaches about +4 volts the 555 is triggered and the output rises to +12 volts thus turning off the transistor and the lamp. With the values given the delay time before the lamp turns off is 10 to 15 seconds. This delay can be increased by increasing the value of C1.

At the end of the delay period the capacitor cannot recharge unless the door switch is made again so the lamp will stay off.

Fig. 2. Delay circuit for a positive earth car.



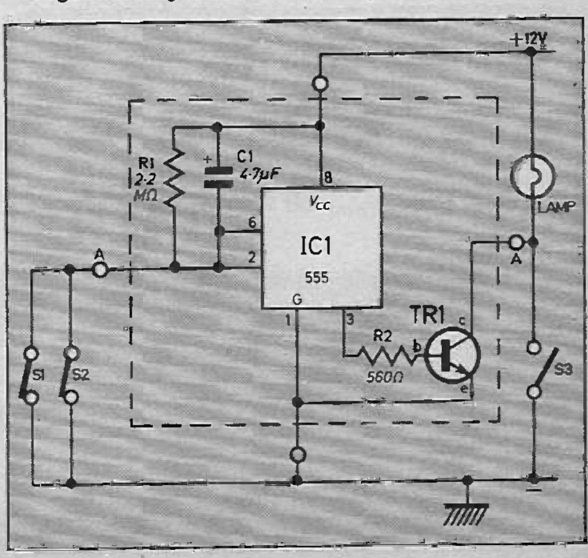
NEGATIVE EARTH CIRCUIT

In the negative earth version of the circuit shown in Fig. 3 the output transistor is of the *npn* type. The transistor used in this case is a 2N2219 which is the complementary version of the 2N2905.

Here, once again, the threshold and trigger inputs of the 555 are tied together and fed from the *RC* timing network and the door switches.

When the door switch makes it allows the capacitor to charge thus bringing the input voltage of the 555 down to zero. As the voltage falls below 4 volts the 555 is triggered and its output voltage rises to 12 volts. This causes the transistor to turn on and light the lamp.

Fig. 3. Delay circuit for a negative earth car.



When the switch breaks, the capacitor discharges through the resistor and the input voltage rises towards 12 volts. When the input reaches the reference level the 555 resets and turns off the transistor and the lamp.

CONSTRUCTION

Perhaps the most convenient method of construction is to mount the components on a small piece of Veroboard. This board should be of the 0·1 inch matrix type since this fits in with the 0·1 inch pin spacing of the 555.

Suitable layouts for the two alternative versions of the delay unit are given in Figs. 4 and 5.

A tantalum type capacitor should be used in the timing circuit. The leakage current of ordinary electrolytics is too great to give reliable operation of the circuit. The resistors are ¼ watt carbon types.

INSTALLATION

To install the unit into a car it will be necessary to break into the car wiring system at point **AA**. A convenient place at which to do this is at the interior light fitting. Usually the connections inside the fitting are made by push on type connectors. By attaching similar mating connectors to the delay unit leads it can be readily installed into the car.

The wiring connections are shown in Figs. 2 and 3. For the earth lead it is convenient to fix a solder tag to the earth lead of the delay unit and secure this tag under the earth fixing screw in the light unit.

It will be necessary to cut a small slot in the plastic cover of the light fitting to allow the delay unit leads to pass through. If the light fitting is large enough it may be possible to mount the whole delay unit inside thus avoiding the need to cut a slot into the cover.

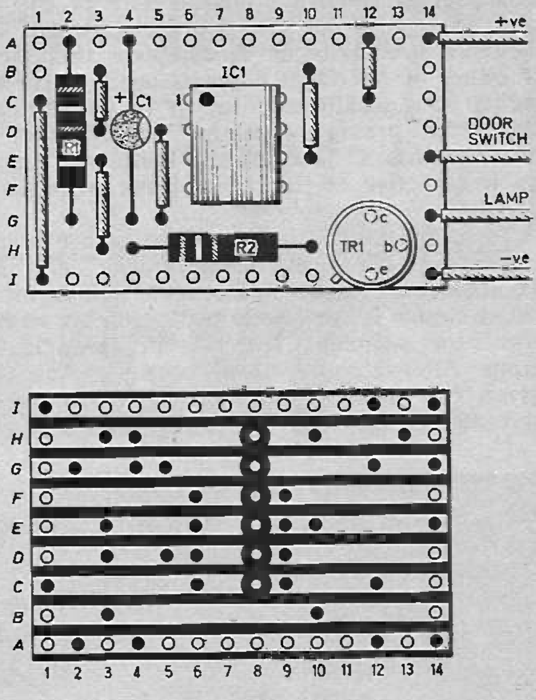
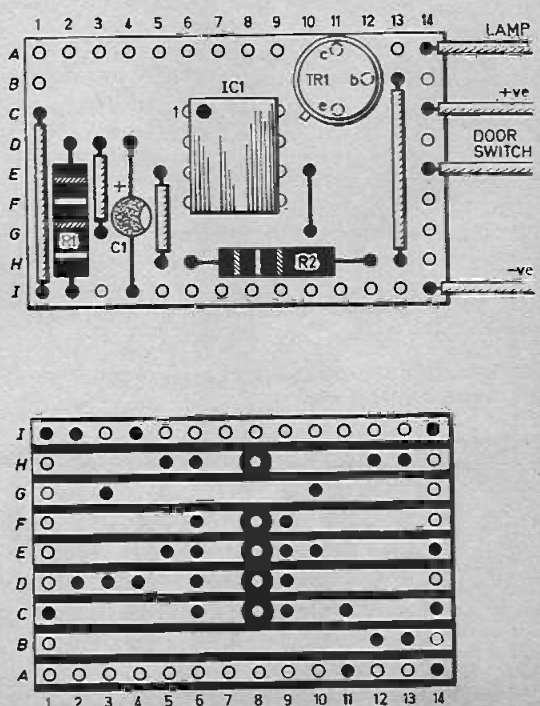


Fig. 4. The construction and wiring of the positive earth system.

Fig. 5. The construction and wiring of the negative earth system.



Components....

Resistors
R1 2·2MΩ
R2 560Ω
¼W ± 10% carbon

SEE SHOP TALK

Capacitor
C1 4·7μF tantalum bead 15V

Semiconductors
TR1 2N2905 (positive earth) silicon *pnp*
2N2219 (negative earth) silicon *npn*
IC1 555 integrated circuit timer.

Miscellaneous
Veroboard 0·1 inch matrix, 9 strips by 14 holes; connectors to suit car wiring; connecting wire.

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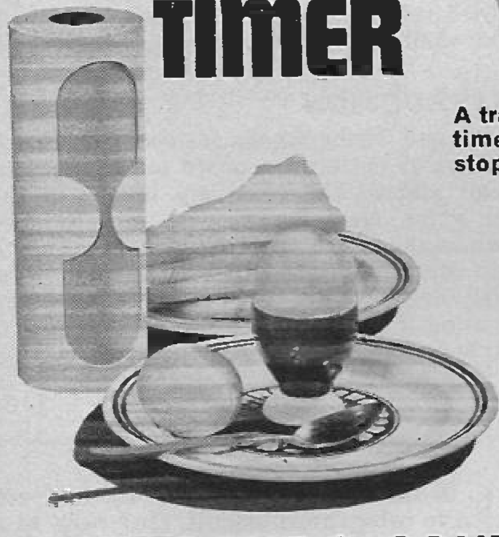

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By A. P. STEPHENSON

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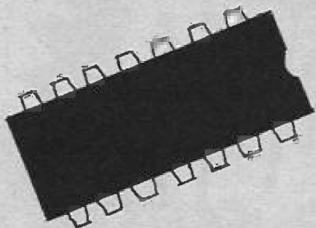


DOOR BLEEPER

By A. FREED

A simple circuit providing an interrupted tone output.

MANY circuits for electronic doorbells have been published. Few, however, are as cheap or simple as their mechanical counterpart. The circuit here uses only seven components, which are cheap and readily available, but it produces quite a complicated noise.

The sound is very noticeable even against high levels of background noise. This sound is simply an interrupted high frequency bleep.

CIRCUIT

Two capacitors and an integrated circuit are used for the two oscillators required (Fig. 1). This type of oscillator is unusual but has the advantage of simplicity. The high frequency oscillator formed by the three gates G1 to G3 feeds the loudspeaker driver transistor (TR1) directly, with a resistor (R1) to limit the base current. The second low frequency oscillator formed by G4 to G6 forces the first to stop oscillating during the negative part of its cycle. This produces the interrupted bleep. The diode (D1) used to couple the oscillators is to stop interaction.

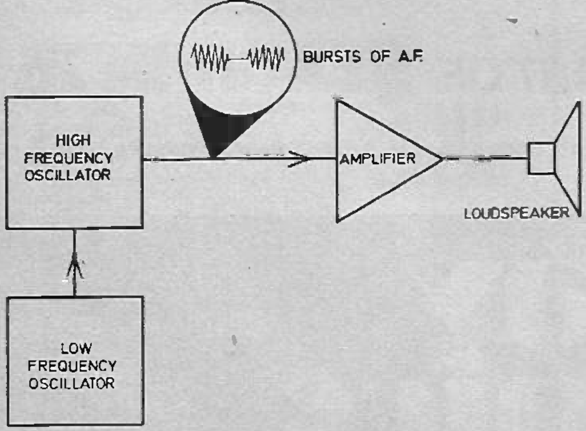
Because of capacitor tolerances, the two timing capacitors might have to be changed to produce the desired sound. A D.T.L. (diode, transistor, logic) integrated circuit has to be used in this circuit.

Any cheap medium power *pnp* transistor can be used for TR1 such as AC 128, ACY 17/19/20/21 or NKT 222/223. A small 8 ohm speaker was used in the prototype but any speaker from 3 to 16 ohms can be used. A 5 volt supply is ideal but a 4·5 volt battery is equally good, and will last the shelf life of the battery in normal use.

CONSTRUCTION

Layout and wiring details are shown in Fig. 2. Commence by cutting the board to the required size and making the necessary breaks in the copper strips. Next insert and solder the two link wires and flying leads followed by R1 and the two capacitors. Insert D1 and TR1 observing the lead identifications and solder up each lead while using a heat shunt to protect the device. Finally insert IC1 taking note of the pin identifying notch and again make the soldered connections whilst using a heat shunt.

SIMPLY



Two oscillators are made, each from half of one integrated circuit. One runs at a fairly high audible frequency the other at low frequency. The low frequency one turns the other on and off, thus producing a series of bleeps which are amplified and fed to a speaker.

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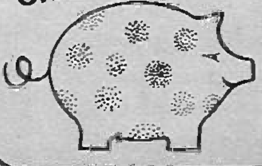
ESTIMATED COST* OF COMPONENTS
excluding V.A.T.



£1.75

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*Based on prices prevailing at time of going to press

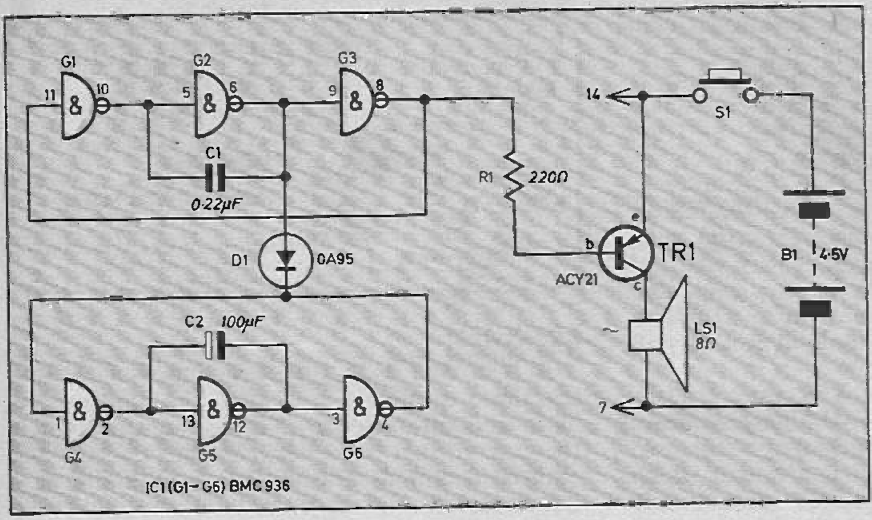
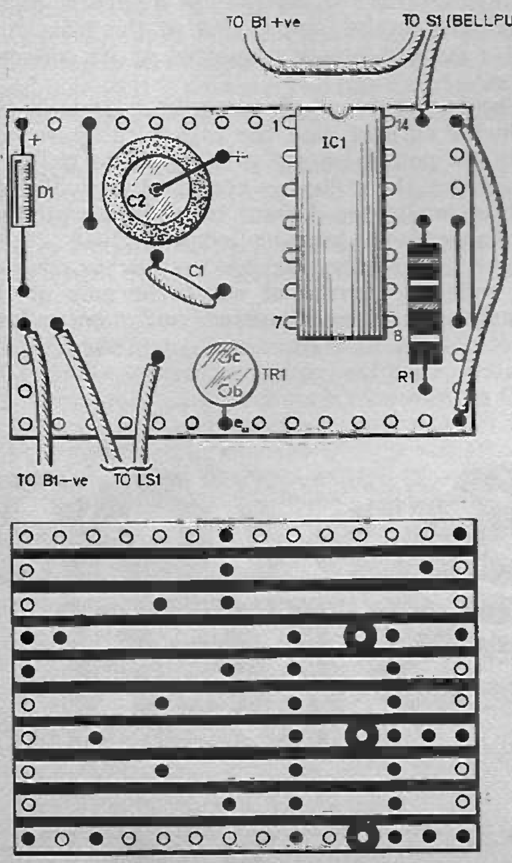


Fig.1. Circuit diagram of the Door Bleeper.

To complete the construction connect the loudspeaker, battery and bell-push and test the unit.

The prototype was built in a hemispherical plastic container; however, there are no special requirements for the case, unless it is used outside where it must be weatherproofed. There is no limit to the length of wire used to connect the doorbell switch to the circuit. ▣

Fig.2. Layout and wiring of the Door Bleeper.



Components....

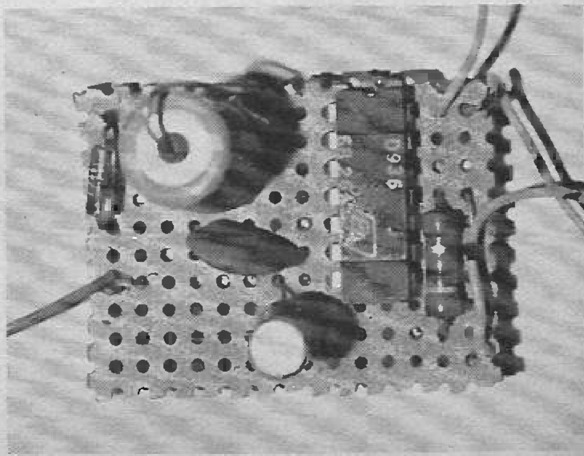
Resistor
R1 220Ω ¼W±10% carbon

Capacitors
C1 0·22μF disc ceramic
C2 100μF elect. 10V.

Semiconductors
TR1 ACY21 or similar *pnp* (see text)
IC1 BMC 936, MIC 936, DN 936, BP 936 etc. (DTL 930 series integrated circuit)
D1 OA95 or similar

Miscellaneous
LS1 3 to 16Ω miniature moving coil loudspeaker
S1 s.p.s.t. door push
B1 4·5V type 1289 battery
Veroboard 10 strips by 14 holes, 0·1inch matrix; connecting wire; case—see text.

SEE **SHOP TALK**



VIRTUALLY every electronics enthusiast will at some time or other require a test instrument which will enable him to check a suspect transistor. A transistor tester is also a valuable aid when sorting out the usable devices from the useless ones when one has a batch of the popular "untested—unmarked" transistors.

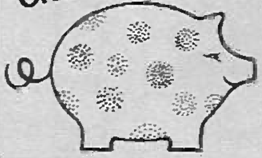
It is unfortunate that a transistor tester capable of accurately measuring even the most basic of the transistor parameters may well not be a feasible asset for many constructors, due to the rather high cost of such an instrument, considering the number of times it is likely to be required.

Very often when one wishes to test a transistor it is not necessary to have a highly accurate measurement of its gain and leakage (the two basic parameters), and a test instrument which will give some rough indication of these is perfectly adequate in the majority of cases.

The transistor tester which forms the subject of this article will enable the operator to obtain only an approximate measurement of both current gain and leakage, for *pnp* and *npn* transistors, but it will show clearly whether or not a device is usable. It can also be used to test diodes.

FOR GUIDANCE ONLY

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



£2.10
excluding case

*Based on prices prevailing at time of going to press

LEAKAGE

A transistor is a three-terminal device, and the three terminals are called the emitter, the base, and the collector. The leakage current is the current that flows between the collector and emitter terminals of the device, with the base not connected.

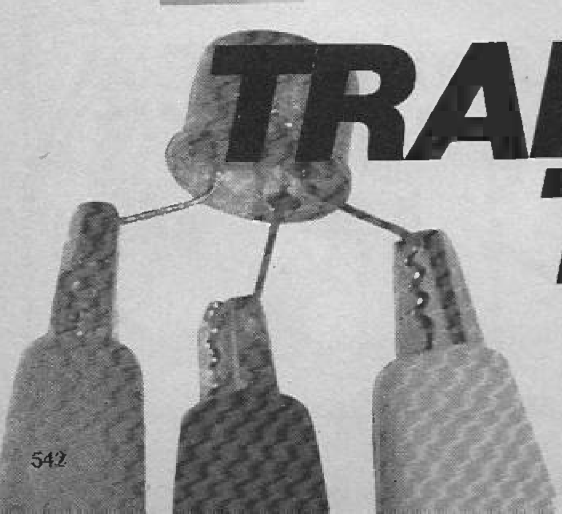
The basic test circuit for leakage is shown in Fig. 1a (*npn*) and Fig. 1b (*pnp*). As will be seen from the diagrams, the test circuit is essentially the same in each case, with the exception that the supply polarity must be reversed when testing *pnp* devices.

GAIN

The circuit for testing the d.c. current gain of a transistor (termed h_{FE}) is shown in Fig. 1c (*npn*) and Fig. 1d (*pnp*). This consists of a variable resistor in series with a current meter connected in the base circuit of the transistor, and a current meter connected in its collector circuit.

The base current of a transistor controls the collector current, and the higher the base current the potentiometer is adjusted to produce, the larger the collector current that will flow. Only a small base current is needed to produce a comparatively large collector current.

By adjusting the variable resistor to produce the collector current at which the gain of the transistor is to be measured, and then making a note of the base current, h_{FE} can then be calculated from the collector current divided by the base current ($h_{FE}=I_c/I_b$).



TRANSISTOR TESTER

By R.A.PENFOLD

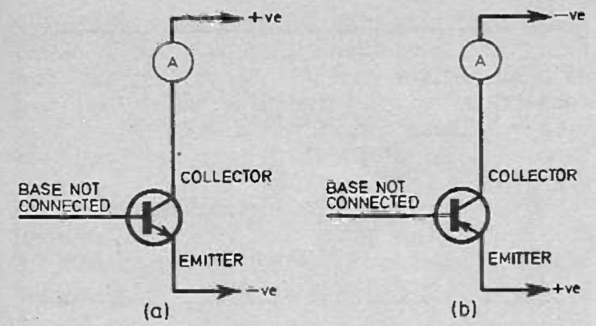


Fig. 1a and b. Test circuit for leakage for *pnp* and *npn* transistors.

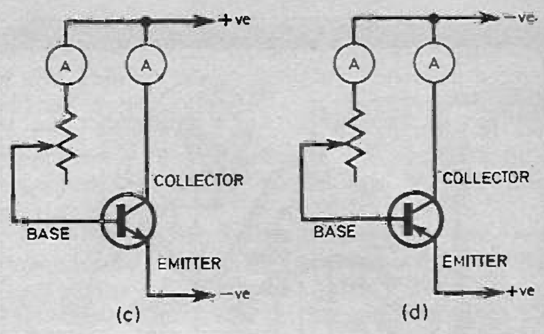


Fig. 1c and d. Test circuit for gain for *npn* and *pnp* transistors.

PRACTICAL CIRCUIT

A circuit diagram of the transistor tester is shown in Fig. 2. This is shown with an *npn* transistor being tested for gain. The basic circuits shown in Fig. 1 did not take into account that the manufacturers' brief form data for transistors gives the gain and leakage figures for various transistors at widely differing collector voltages and currents. For instance, a low noise audio transistor might have its gain specified at a collector current of 100 microamps, whereas for a v.h.f. transistor a figure of 10 or 20mA would be more likely.

A sophisticated transistor tester would have a variable supply voltage and a current meter covering several ranges, so that a wide variety of currents could be accurately measured. In a simple tester as envisaged here, this is not really feasible, and it is necessary to use a compromise operating current, 2mA being the figure adopted here.

Meters are rather expensive items, and so the circuit has been arranged to use a single inexpensive meter of the recording level or battery condition type. These are available with various full scale deflection (f.s.d.) sensitivities in the range 100-500 microamps, and any meter having a sensitivity in this range is suitable for use in this circuit. It is shunted to the required sensitivity by VR1.

Variable Resistor VR2 is used to limit the maximum collector current to approximately 2mA, which prevents both the meter and the device under test from being damaged by passing an excessive current, in the event that VR2 should happen to be adjusted towards minimum resistance when a high gain transistor is connected.

In order to avoid having to switch the polarity of the meter when switching from the *npn* to the *pnp* mode (or vice versa), the meter is fed from a fullwave bridge rectifier, formed by D1 to D4, so that it will give a positive indication from an input voltage of either polarity.

No meter is used to monitor the base current, since this is not really necessary. As the unit only measures h_{FE} at a single collector current (2mA), the variable resistor, VR2, could be directly calibrated with a value for h_{FE}, but in a simple device of this nature it can be calibrated with a random scale, as a comparative value for h_{FE} is all that is required.

The purpose of R1 is to limit the base current

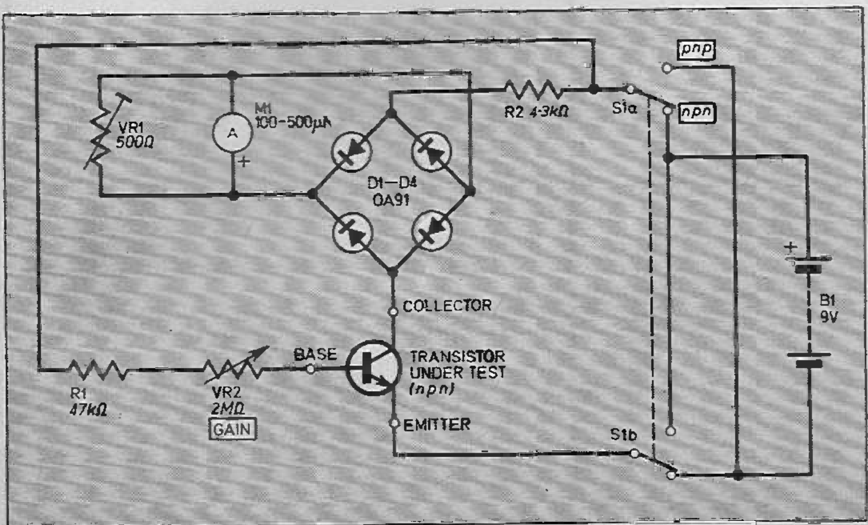


Fig. 2. Circuit diagram of the Transistor Tester.

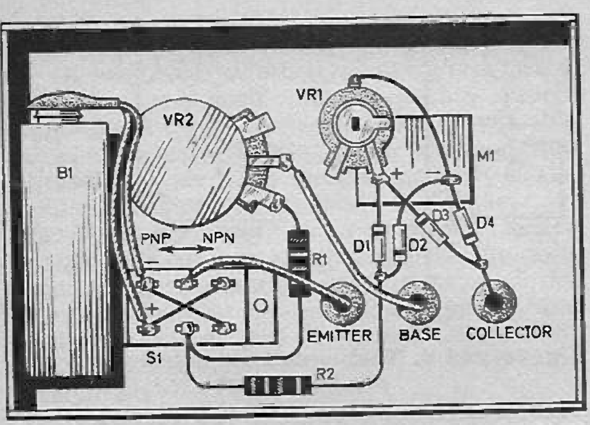


Fig. 3. Layout and wiring of the tester.

to a safe level. Switch S1 switches the supply lines to suit either an *npn* or a *pnp* device. Power is obtained from a 9 volt (PP3) battery.

CONSTRUCTION

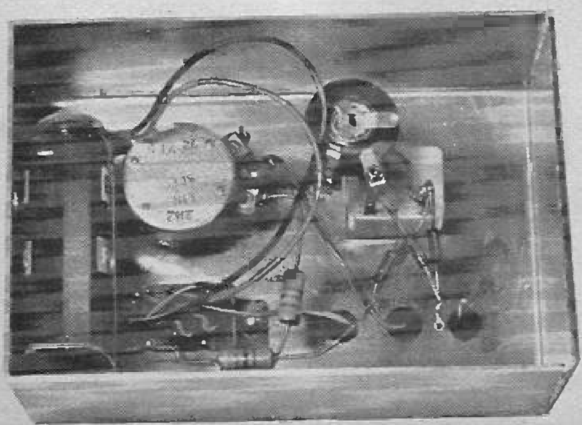
The prototype tester was housed in a home made aluminium case with external dimensions of approximately 100mm x 70mm x 40mm. At least one commercially made case of a similar size and type is available, and virtually any case of about this size should be suitable.

By referring to the photographs of the prototype unit, and to Fig. 3, the general layout of the unit can be seen. The exact layout of the front panel is not critical, but be sure to leave enough space for the battery to fit to the left of VR2 and S1 (with the tester viewed from the rear).

The large cut outs for the meter and S1 can be carefully cut using a fret or coping saw. The dimensions of these must be varied to suit the particular components employed. The type of meter used here may not have the usual screw fixing, and must then either be glued in place, or made a tight push fit into the cut out. The connections to the transistor under test are made via three crocodile clip leads, which pass through three holes in the front panel. Each hole is fitted with a small grommet.

Variable resistor VR2 requires a 10mm diameter mounting hole, and the two smaller mounting holes for S1 are 6BA clearance (No. 31 twist drill), for a standard switch.

Photograph showing the construction of the prototype unit.



WIRING

Since so few components are used, a simple point to point wiring system is utilised. All the wiring is shown in Fig. 3.

The ends of the component lead out wires and tags should all be tinned with solder prior to connections being made. Use a heat shunt when soldering the diodes, which are germanium types, and easily damaged by heat. All connecting leads, other than component leadouts, are insulated. Variable resistor VR1 is mounted on the meter in a position which enables it to be easily adjusted from the rear of the case.

ADJUSTMENT

It is only necessary to make one adjustment to the otherwise completed tester, and that is to set VR1 to give a meter sensitivity of 2mA. This is achieved by first adjusting VR1 to insert almost minimum resistance into circuit (turned virtually fully clockwise), and then short the emitter and collector test leads together; VR1 is then adjusted to produce f.s.d. of the meter. The setting up procedure is then complete.

Components....

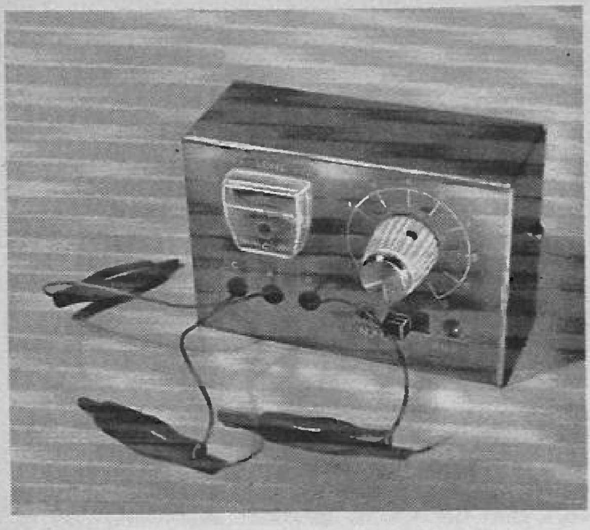
Resistors
R1 47kΩ
R2 4·3kΩ
¼W ± 10% carbon

SEE SHOP TALK

Potentiometers
VR1 500Ω skeleton prest
VR2 2MΩ (or 2·2MΩ) lin. carbon

Semiconductors
D1-D4 OA91 or similar diodes (4 off)

Miscellaneous
M1 100 to 500μA f.s.d. recording or battery level meter (see text)
S1 d.p.d.t. slide switch
B1 9V PP3 battery and connectors
Case approx. 100 x 70 x 40mm, control knob, three small grommets, three crocodile clips, connecting wire.



INTERPRETING RESULTS

Ideally a transistor should have a leakage current of zero. To test a transistor for leakage, set S1 to the appropriate position, and then connect the collector and emitter leads only.

If there is any deflection of the meter at all, this probably indicates that the device has been damaged in some way and will prove to be unreliable, that is unless the test transistor is a germanium type. These have higher leakage currents than silicon types, and a small deflection of the meter, even as much as one quarter f.s.d., is quite tolerable.

Gain is measured by connecting all three leadouts of the transistor to the test leads and adjusting VR2 as far in a clockwise direction as is necessary to produce f.s.d. of the meter (or as near f.s.d. as can be obtained allowing for a small voltage drop across the transistor).

If a scale is marked around the control knob of VR2, the reading from this will give some idea of the gain of the transistor. The base current will be approximately 4 microamps with VR2 at maximum resistance, 8 microamps at half resistance, 16 microamps at one quarter resistance, and 180 microamps at minimum resistance.

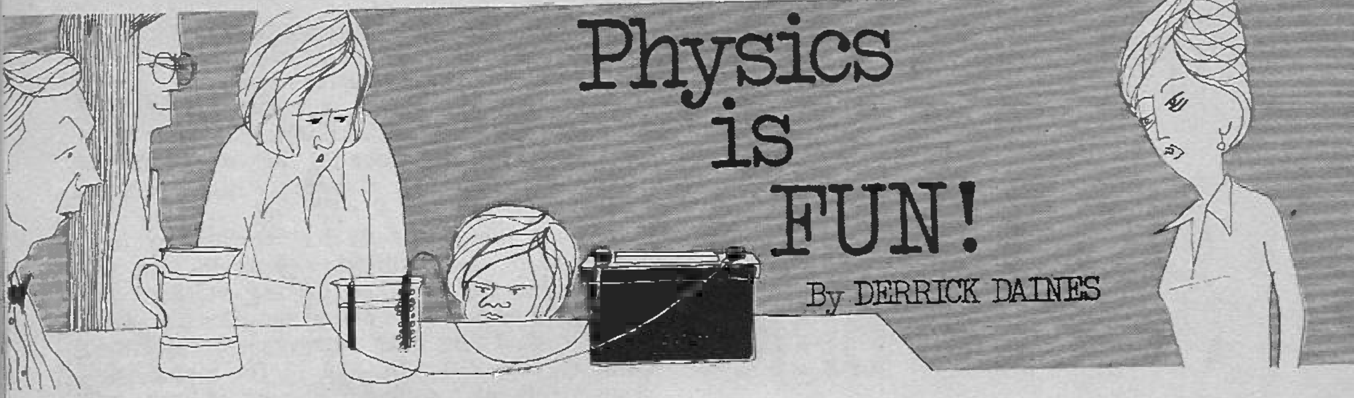
It must be stressed that these are only approximate, and will vary according to the exact value of VR2, the battery voltage, and whether it is a silicon or germanium transistor under test. These base currents correspond to gains of 500, 250, 125, and 11 for meter f.s.d. respectively, at a collector current of 2mA, and a collector potential of a fraction of a volt.

After a little experience has been gained in using the unit, it is usually quite easy to gauge whether or not a particular type of transistor has adequate current gain. When testing germanium transistors though, one must remember that if a leakage test revealed a leakage of (say) one quarter f.s.d., then the gain of the transistor will be almost one quarter less than the setting of VR2 would suggest.

TESTING DIODES

Diodes are easily tested by being connected with their cathode (the lead protruding from the end of the diode marked with a coloured band) on the collector clip, and the anode lead on the emitter clip. With S1 in the *pnp* position the meter should read virtually f.s.d., while with S1 switched to the *npn* position there should be no deflection of the meter.

No on/off switch is fitted as the unit consumes no power when the test leads are not connected. However, store the unit carefully when it is not in use, so that there is no possibility of the test clips accidentally touching one another. ■



Physics is FUN!

By DERRICK DAINES

A POLE-FINDING PAPER

A pole-finding paper is a strip that will tell us which is the positive pole of a d.c. source and which is the negative. To understand the principle involved it is first necessary to repeat our electrolysis experiment of last month but this time using a saturated salt solution.

Dissolve a tablespoonful of ordinary household salt in about half a pint of warm water and stir until no more salt will dissolve. Pour off the brine into a jar or beaker. Now take the same two electrodes that we used last month—nickel strip or thick copper wire—and immerse them in the brine at opposite sides of the jar.

Connect a d.c. source of about 9 to 12 volts such as a car battery or charger. Bubbles will form on only one of the electrodes and at the same time the strong smell of chlorine will be detected. What is happening?

Salt is composed of sodium and chlorine, while the water is of course oxygen and hydrogen. Under electrolysis, the sodium combines with the oxygen to form a precipitate that will eventually settle to the bottom. The hydrogen migrates to the cathode (negative terminal) and is there collected in bubbles. What does that leave out of the reckoning? Right—the chlorine! It migrates to the other pole and from there rises to the surface, where we can sniff it.

Now chlorine besides being a strong-smelling and powerful disinfectant, is also a bleach. If you float a few red rose petals on the surface near the anode, you will see that they quickly lose their colour. It is this principle that we can use for our pole-finding paper.

A suitable red dye can be obtained from a jar of beetroot or pickled red cabbage. A few drops added to the brine will turn it a pleasant rose colour. Under electrolysis it will be seen that the solution in the vicinity of the anode turns a pale green.

Cut some strips of blotting paper and when one needs to determine the polarity of a mystery current, a strip is first soaked in the brine/dye solution and laid on a piece of glass or plastic. The two terminals are then applied, one at each end of the paper, and of course, the end at which the rose-coloured paper turns green is the anode—the positive. The process is rather slow, but what do you expect for almost nothing?

A faster and more expensive way of making a stock of ready-made pole-finding paper is as follows. Dissolve a gram of phenolphthelein in methylated spirit and mix this with the common-salt solution. Soak the strips in this and allow them to dry. They can be stored indefinitely in this condition and when one is needed, it is simply moistened with clear water. Each strip can be used several times.

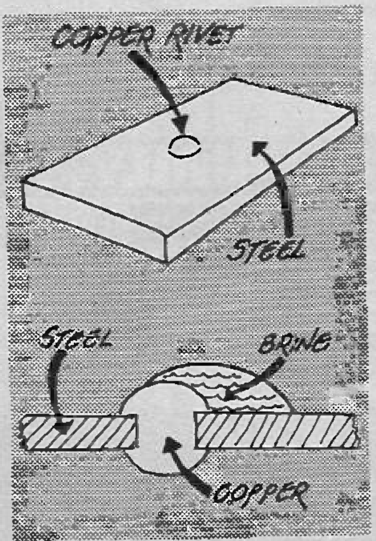


Fig. 1. A copper rivet fastened in a piece of soft iron can be used to make a "battery".

While we have the brine/phenolphthelein solution, we might explore the statement made a few months ago that any two different metals will give rise to a current if there is a weak acid between them. A brine is just as good. Make a small collection of different metals fastened in pairs, such as a copper rivet through a piece of soft iron, or a zinc nail in lead. Other combinations will no doubt occur to the reader.

Lay them flat and using a small spill as a dipper, place one or two drops of the brine/phenolphthelein solution so that they bridge the gap between the two metals (Fig. 1). A weak current will be set up and the change of colour at one side will indicate the direction.

I am not sure about this—and perhaps someone will clear it up for me—but I believe that the metal with the higher atomic number will be the cathode in each case.

Since we are using brine to initiate the electrolysis, the reader may wonder if a similar action occurs with ships. Well of course it does. Ship and aircraft builders are extremely careful in their choice of materials and fastening methods because over a period of time the electrolytic action can severely weaken the joint.

The electrolytic actions we have looked at so far decompose materials. Next month we shall see how to build up a surface by electrolysis.

New products and component buying for constructional projects

SHOP TALK

By Mike Kenward

HAVING just read Paul Young's piece about buying catalogues—and his rewarding comments about EE (*Counter Intelligence* page 532)—it is appropriate to mention a few of the recently published catalogues that have formed a small pile on the corner of my desk over the last few months. Having dug them out from beneath some readers letters, old volumes of EE and a radio control receiver—coming up next month—and blown the dust off, we have three not previously mentioned and the new Henry's (probably the most comprehensive available) is expected soon. By the time you read this perhaps they will at last have arrived from the printer!

To get to the actual catalogues they are: Doram—100 pages, plenty of good photos a new data section which is very useful and plenty of new products and kits, all priced with two VAT rates and two free amendment leaflets during the year. Should meet most of your needs at 60p per copy including postage. Doram Electronics Ltd., P.O. Box TR8, Wellington Industrial Estate, Wellington Bridge, Leeds, LS12 2UF (Tel. Leeds [0532] 34222).

Denco, now the only firm supplying ready made radio coils to the amateur constructor, produce a neat 32 page issue with plenty of good drawings and data of their coils plus switches, chassis, variable and fixed capacitors, trimming tools etc.—a must for those who enjoy building receivers. Price 28p including postage; Denco (Clacton) Ltd., 357/9 Old Road, Clacton on Sea, Essex, CO15 3RN (Tel. Clacton [0255] 22807).

Other catalogues worthy of note include Home Radio, Marshalls and Electrovalue, all advertise regularly in our pages.

An interesting new kit, but we hasten to add, perhaps not one for the new reader to build as a first project, comes from LRS Electronic Supplies. Called the Digi Dice the unit is an electronic dice—providing a seven segment filament type, random number (1 to 6) output when a button is released.

The unit basically consists of two integrated circuits plus the Minitron indicator wired with a few other components on a compact circuit board and inserted in a plastic case together with a battery. The complete kit costs £5·85 plus 15p postage from LRS Electronic Supplies, 3 Clivesway, Hinckley, Leicestershire.

Teach-In 76

A list—and it is quite extensive—of components for the whole of the *Teach-In 76* course appears in the *Circuit Deck* article. A number of firms have undertaken to supply the complete kit and no doubt they would also supply individual items should you require, or not be able to afford, the whole thing at present. Their names appear at the foot of the components list.

One point worth noting is that none of the components need be wasted—they can all be used up in various projects after the course is concluded, and no doubt by that time they will cost more to buy anyway.

Tremolo

Most of the parts for the *Tremolo* will be easily obtainable but there is a shortage of MFC6040's and this item may not be available from many suppliers. Motorola (the manufacturers) are in the process of changing the package in which the 6040 is housed and delays may occur in supply before the new type is available. The new type will be numbered MC3340P and we hope to publish details on how to fix it into the printed circuit board shown as soon as we have the information from Motorola—the new package will have 8 pins not 6 as is the case with the 6040.

Doorbell Bleeper

Only a few components are used in the *Doorbell Bleeper* and of those few only the i.c. should cause any buying problems. It is available from Bi Pak or Bi-Pre-Pak, see their advertisements for addresses etc.

Transistor Tester

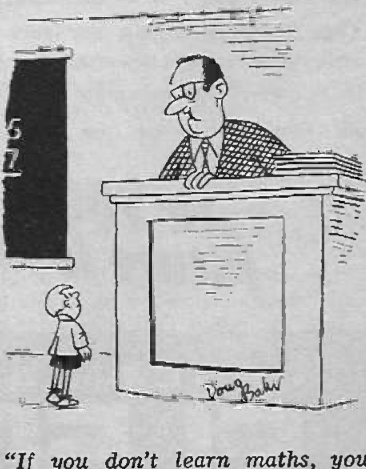
One component in the *Transistor Tester* will determine the overall cost of the unit and that component is the level meter. As stated in the article it can be one of a range of types, and prices vary from about £1·50 up to £4 or more so have a good look around before buying—those catalogues will come in handy!

The case used for the prototype was a standard aluminium one but almost any metal or plastic type will do and a home made wooden one could even be made up to save money.

Courtesy Light Delay

The only component that may not be readily available for the *Courtesy Light Delay* is the tantalum bead capacitor, most of the larger suppliers should be able to supply it but if you want to increase the capacitance to above 47μF to greatly increase the delay time you will probably have to use two or more components in parallel.

All other components should be easy to find and the i.c. is nowadays recognised as a 555 timer although this is not its full type number.



"If you don't learn maths, you won't know how to give the right money for a calculator when you leave school."

The FIELD EFFECT TRANSISTOR

By J. B. DANCE

THE common types of *npn* and *pnp* transistors are devices in which a small base *current* is used to control a much larger collector current.

The **field effect transistor**, on the other hand, is a device in which an input voltage is used to control the current flowing in the output circuit. It is therefore more like the thermionic valve in its mode of action and like the valve, has a high input impedance.

The field effect transistor, provides better isolation between the output and input than a normal transistor. It has the usual advantages of semiconductor devices, namely small size and low operating voltages and currents.

MAIN TYPES

The field effect transistors available at the present time can be divided into two main types, namely junction field effect transistors (sometimes called JFET's) and insulated gate field effect transistors (sometimes known as IGFET's). An alternative name for the IGFET is the metal-oxide-semiconductor transistor (abbreviated MOST or MOSFET).

Although the junction f.e.t. has a much higher input resistance (perhaps one thousand megohms) than ordinary *npn* or *pnp* transistors, the insulated gate f.e.t. has a still higher input resistance (perhaps one hundred million megohms). The two types of device have rather different applications.

Both junction and insulated gate f.e.t.s are normally made by the silicon planar process, but a few special types of junction f.e.t. employ germanium.

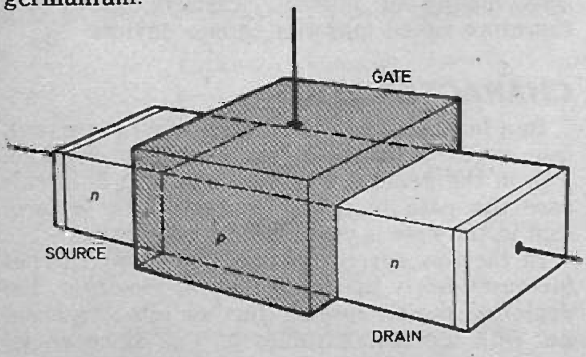


Fig. 1. Basic illustration of an *n*-channel function field effect transistor.

JUNCTION TYPES

A junction f.e.t. contains a channel of either *n*-type or *p*-type semiconductor material. A voltage applied to an electrode controls the width of this channel and hence the amount of current flowing in the channel.

The operation of the device may be illustrated by means of Fig. 1. The current to be controlled flows along an *n*-type channel from an electrode known as the **source** to an electrode known as the **drain**. The *n*-type channel is surrounded by a *p*-type material which is connected to an electrode known as the gate.

REVERSE BIAS

When the gate in Fig. 1. is made negative with respect to the other electrodes, the *pn* junction is reverse biased and a depletion region is formed between the *p*- and *n*-type materials.

As the reverse bias is increased the depletion region enters more deeply into the *n*-type channel and the part of the channel where conduction occurs is thereby narrowed. (The depletion region has a high resistance and therefore passes negligible current.)

The direct current required by the gate is very small (often less than one thousandth of a microampere), since the junction is reverse biased. This ensures that the input resistance of the gate is very high.

However, the gate-channel junction has appreciable capacitance and therefore an alternating current will pass to the gate electrode when a high frequency voltage is applied.

As shown in Fig. 2, the channel is narrower near the drain than near the source. This is

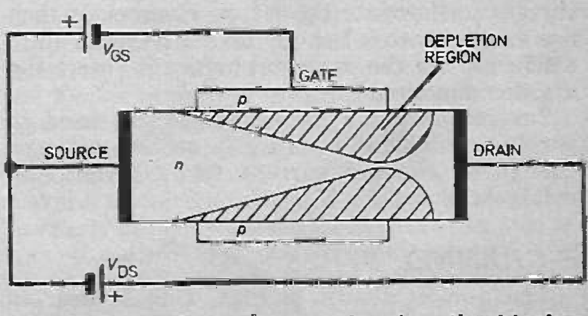


Fig. 2. An *n*-channel f.e.t. showing the biasing voltages.

because the gate-to-source voltage is less than the gate-to-drain voltage and produces a smaller field.

The gate is normally more heavily doped than the channel, since this results in the depletion layer spreading further into the channel than into the gate; optimum control of the channel current is thus obtained.

DEPLETION DEVICE

Channel current flows in a junction f.e.t. when no voltage is applied to the gate (that is, when the gate is at the same potential as the source). The device is therefore a "normally on" device.

A reverse bias applied to the gate will reduce or deplete the channel current. Junction f.e.t.s are therefore known as depletion devices or sometimes as "type A" f.e.t.s.

A very small forward voltage (which must be less than the natural junction potential) may be applied to a junction f.e.t. This will increase the channel current slightly, but the devices are normally operated only as depletion devices.

The name "field effect transistor" is derived from the change in the channel resistance which occurs when there is a change in the transverse electric field in the junction region.

STRUCTURE

The structure of a modern silicon planar junction f.e.t., the Mullard types BFW10 and BFW11, is shown in the simplified diagram of Fig. 3.

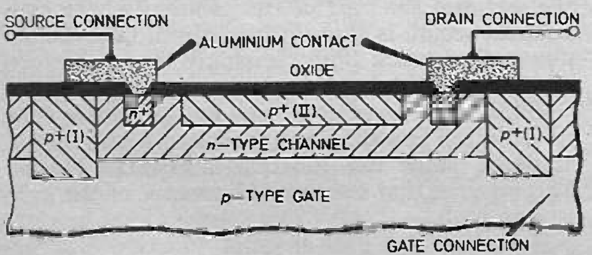


Fig. 3. The structure of a modern *n*-channel f.e.t.

Current flows from the aluminium source connection into a heavily doped material n^+. This forms a good, low resistance contact for the current to flow into the *n*-type channel. It then flows into another heavily doped material (also marked n^+ in the diagram) before it enters the drain connection.

Several of the *n*-type channels are used in parallel connection in order to achieve a larger change of channel current for a given gate voltage change.

P-CHANNEL TYPES

The devices shown in Figs. 1 to 3 have an *n*-type channel and a *p*-type gate. Another type of device, the *p*-channel junction f.e.t., employs *p*-type material in the channel and *n*-type material for the gate.

A *p*-channel device must be biased in the opposite way to *n*-channel devices. If the circuit of Fig. 2 were for a *p*-channel device, the gate would be positive and the drain negative with respect to the source. This produces the reverse bias required to keep the gate current very low.

In general, *n*-channel f.e.t.s are preferred to *p*-channel devices, since the majority carriers in the *n*-type material (electrons) have a greater mobility than the majority carriers (holes) in the *p*-type material. However both types of junction f.e.t. are readily available.

SYMBOL

The symbols for *p*-channel and *n*-channel junction f.e.t.s are shown in Fig. 4 (a) and (b). The arrow on the gate electrode shows the direction in which the gate current tends to flow.

Some types of f.e.t. have two separate gate electrodes—one on each side of the channel—which are brought out to separate external connections. The symbol used in circuits for such tetrode f.e.t.s is shown in Fig. 4(c).

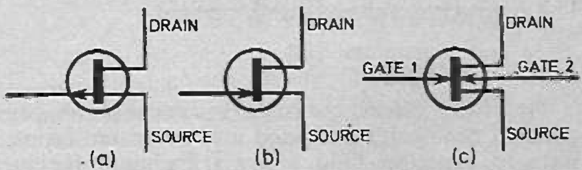


Fig. 4. Circuit symbols for junction field effect transistors.

UNIPOLAR DEVICES

In all types of f.e.t., the current is conveyed in a channel which contains either *n*-type or *p*-type material, but not both; f.e.t.s are therefore called unipolar devices to distinguish them from the ordinary "bipolar" transistors where the current flows in both *n*-type and *p*-type material during its journey from the emitter through the base to the collector.

The current flow in an f.e.t. is almost entirely by means of majority carriers, whilst the current flow in the base of a bipolar transistor consists mainly of minority carriers; f.e.t.s are therefore called majority carrier devices.

CHARACTERISTICS

In a junction f.e.t., the drain-to-source current, I_{DS}, varies with the drain to source voltage, V_{DS}, in the general way shown in Fig. 5. In this case the gate to source voltage, V_{GS}, is zero; that is, the gate is connected to the source.

In the low current region, the drain current increases fairly linearly with V_{DS}. However, the depletion region spreads further into the channel with increasing values of V_{DS}, since an increase of V_{DS} involves an increase of the drain to gate voltage when V_{GS} is zero.

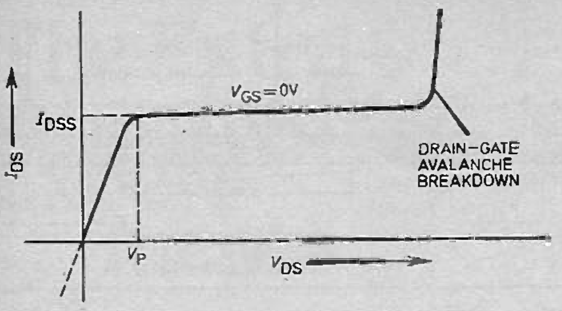


Fig. 5. Junction f.e.t. characteristic for zero gate voltage.

A point is reached at which any further increase in V_{DS} is almost balanced by an increase in the channel resistance so that I_{DS} remains almost constant. This is the horizontal portion of the curve of Fig. 5.

The minimum value of V_{DS} required for I_{DS} to become almost independent of V_{DS} is known as the **pinch-off voltage,** V_p. Any increase of V_{DS} above V_p results in the width of the narrow channel remaining almost constant, but its length increases and this increases its effective resistance.

The value of I_{DS} at the start of the horizontal part of the curve for which $V_{GS}=0$ is known as the drain saturation current, I_{DSS}, see Fig. 5.

When the value of V_{DS} is increased considerably, an avalanche breakdown of the drain to gate junction will take place. One avoids this by ensuring that the value of V_{DS} applied to the device does not exceed the maximum permissable value quoted in the manufacturer's data sheet.

The variation of I_{DS} with V_{DS} at various values of V_{GS} is shown in Fig. 6. The dotted line shows the variation of V_p with V_{GS}. The greater the reverse bias applied to the gate, the lower the value of V_p. For simplicity, the avalanche breakdowns are not shown in Fig. 6.

THE M.O.S.F.E.T.

The m.o.s.f.e.t. differs from the junction devices in that the gate electrode is a small piece of metal which is electrically isolated from the channel by a thin insulating layer of glassy silicon dioxide.

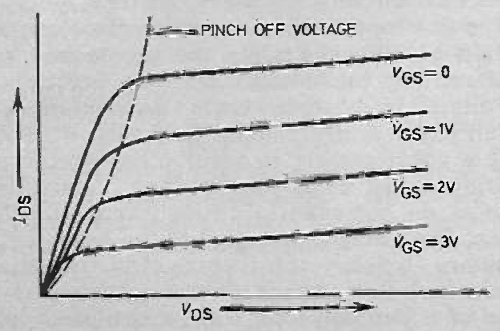


Fig. 6. Junction field effect transistor characteristics.

There are two main types of m.o.s.f.e.t. In the enhancement type, there is no conduction between the drain and the source until a voltage is applied to the gate electrode. Thus the gate voltage enhances the drain current. This type of device is sometimes referred to as a "type C" device or a "normally off" m.o.s.f.e.t.

The type B or depletion m.o.s.f.e.t. is normally conducting and application of the normal gate voltage reduces the drain current.

ENHANCEMENT M.O.S.F.E.T.

An n-channel enhancement m.o.s.f.e.t. can be made by the processes illustrated in Fig. 7.

Two heavily doped n-type regions (marked n^+ in Fig. 7) are diffused into a high resistivity p-type substrate. These n-type regions become the source and the drain connections. An oxide film is then formed over the surface to protect the junctions from any impurities which may be present.

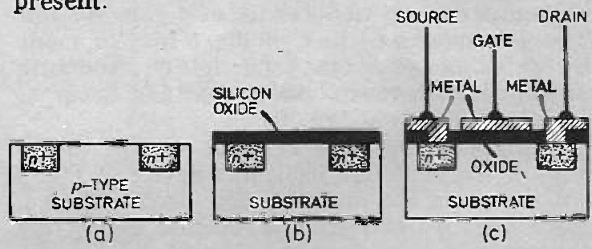


Fig. 7. Stages in the manufacture of an n-channel enhancement m.o.s.f.e.t.

As in planar transistor manufacture, holes are made through the oxide layer by the use of masks over the two n^+ regions and metal connections are deposited on them.

The metal in the centre becomes the gate. As shown in Fig. 7(c), the gate is completely separated from the device by an oxide layer.

CONDUCTION IN ENHANCEMENT TYPE

There is no conducting channel between the source and the drain when no gate voltage is applied. Any source to drain current would have to flow from n-type to p-type and back again to n-type material; it cannot do this easily in either direction, since the drain to source circuit is like two diodes connected in series in opposite directions. Very little drain current flows when no gate voltage is applied and the device is therefore normally off.

When a positive voltage is applied to the gate, however, minority carriers (electrons) in the p-type substrate will be attracted towards the gate and form an n-type channel, see Fig. 8.

An increase in the gate potential will increase the channel depth and also the concentration of electrons in the channel. These effects combine

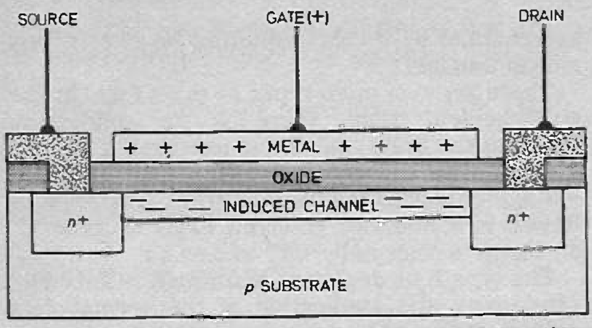


Fig. 8. An enhancement m.o.s.f.e.t. showing the induced channel formed when a positive voltage is applied to the gate electrode

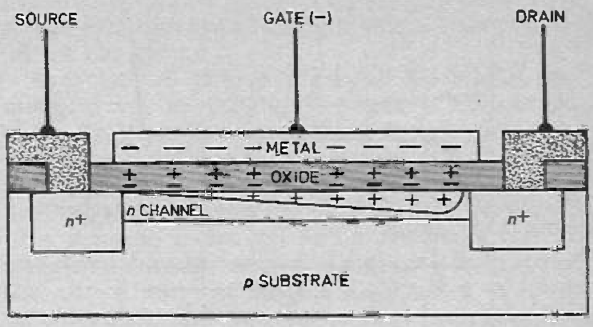


Fig. 10. The n-channel depletion m.o.s.f.e.t. with negative gate bias. Note that the n-channel is narrowed by the positive charges induced into the upper part of it.

to produce a lower resistance channel and, hence, a higher drain current. The use of high resistivity *p*-type material as the substrate results in few holes being available to combine with the electrons in the channel.

DEPLETION M.O.S.F.E.T.

In the depletion m.o.s.f.e.t. a conducting channel exists even in the absence of a gate voltage. The *n*-channel m.o.s.f.e.t. of Fig. 9 may be made by diffusing an *n*-type channel of moderate doping level between the source and drain of the structure of Fig. 7(c).

The application of a negative voltage to the gate of the depletion *n*-channel device of Fig. 9 will result in the drain current being reduced, since negative carriers are repelled away from the gate and away from the channel.

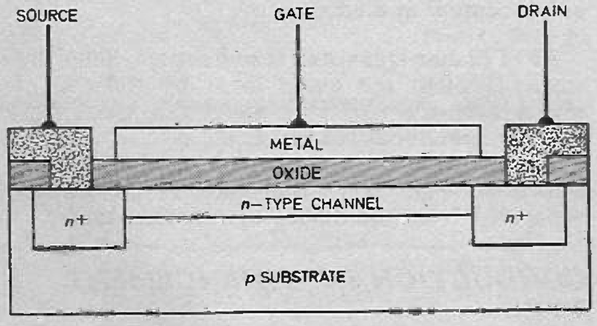


Fig. 9. The structure of an n-channel depletion m.o.s.f.e.t.

The width of the channel is reduced by an application of a negative voltage to the gate as shown in Fig. 10. The width is narrower near to the drain than near to the source, since the drain to gate voltage exceeds the drain to source voltage. The part of the channel in Fig. 10 containing positive charges no longer conducts.

Although one normally thinks of this type of m.o.s.f.e.t. as a depletion device operated by the application of a negative voltage to the gate, the application of a positive voltage to the gate will enhance the drain current. Thus the depletion m.o.s.f.e.t. can operate with a gate voltage of either polarity.

BREAKDOWN

A junction f.e.t. will show avalanche breakdown when a sufficiently high voltage is applied between the drain and gate. This breakdown will destroy the device only if so much current flows that excessive heat is developed in any part of the device.

A m.o.s.f.e.t. will break down from the gate to the channel when the applied gate voltage is sufficient to rupture the very thin layer of silicon dioxide which insulates the gate. Such a breakdown will destroy the device, since the gate will become permanently connected to the channel.

The breakdown of a m.o.s.f.e.t. can take place very easily unless suitable precautions are taken when handling and using them. For example, if a part of the electrostatic charge built up on any insulator on a dry day is transferred to the gate, the voltage developed on this electrode will probably be sufficient to puncture the oxide film. Gate potentials of thousands of volts can easily be built up in this way.

PRECAUTIONS

Before a m.o.s.f.e.t. is handled, soldered into a circuit or removed from a circuit, the electrodes of the device should be joined together with fine copper wire. The wire should first be wound around the source or drain before the gate is touched.

A soldering iron used for working on m.o.s.f.e.t. circuits should be earthed.

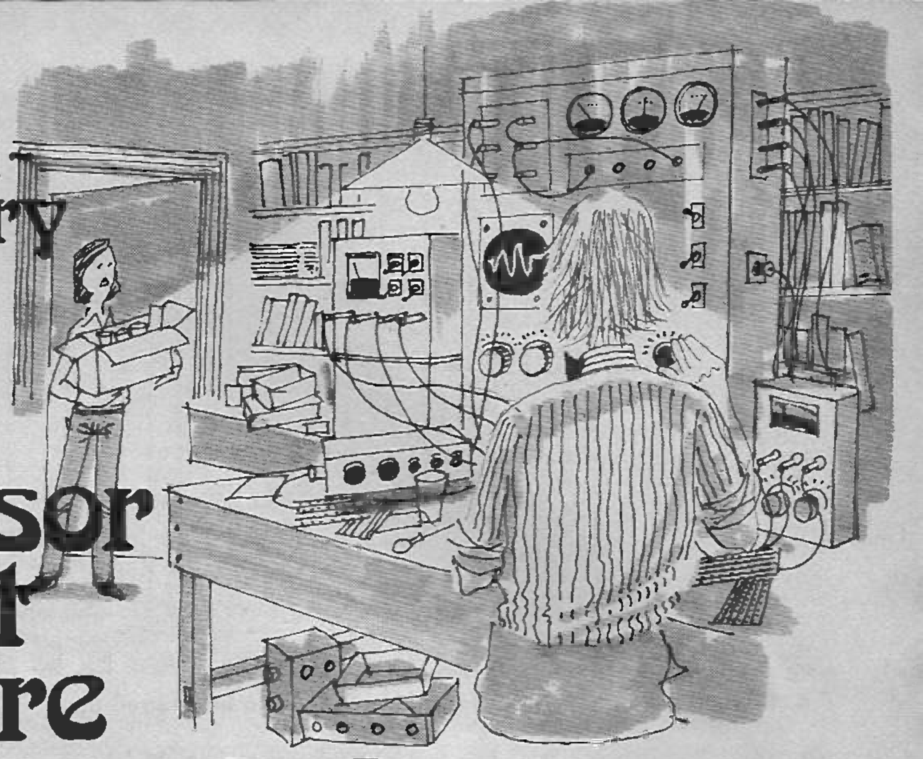
The fine copper wire connecting the electrodes should be removed after the device has been soldered into the circuit.

Failure to observe these precautions may result in the destruction of the device.

It is not necessary to observe any special precautions when using junction f.e.t.s, since these devices do not suffer from catastrophic breakdown. They may be handled in the same way as ordinary bipolar transistors. Any reasonable amount of electrostatic charge collected by the gate of a junction f.e.t. will be easily dispersed

continued on page 556

The Extra-ordinary Experiments 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.

SOMETHING STRANGE!

"Hey, Prof.!" Bob called, "there's something strange happening here! With this preset I've obtained a further improvement, but I can't very easily find the best point to set the control. There seems to be a wide range of adjustment where I'm getting good reception and the control does not seem to make much difference. Why is this?'

"This is because, Bob, you have now improved the set, to a point where strong a.g.c. action is taking place. This is *'Automatic Gain Control'*, and is a part of the circuit of most sets, designed to reduce overload when a station is received strongly. If you rotate the set until you find a point where the station is received less strongly, but still sounds clear, you should find it much easier to determine the most advantageous settings for the potentiometers."

Bob carefully rotated the set, and found that the station strength varied considerably, so that at some positions the reception was very strong, and at others the station seemed almost to disappear. He chose a position where the station was very quiet, but sounded clear.

"Why is it, Prof., that the quieter the station, the more it is spoiled by hissing noises and other interference?"

"This is another sign of a.g.c. action, Bob. As the signal becomes weaker the gain of the set is increased to compensate, and this tends to amplify and increase the interference more than when a strong signal is present. You will find that most radio textbooks explain this a.g.c. action quite clearly.

The modifications which we are doing to your set will increase its sensitivity, and this will bring in the a.g.c. action earlier, giving you clearer reception. Because the increase in noise level is not fully and directly proportional to the increase in gain, the result will be that noise level will become lower at certain levels of reception—although it will be worse on some very distant stations. But these are stations which you wouldn't receive at all clearly without the modifications."

"You mean, Prof., that I will be able to receive more stations on the set now?"

"Yes," replied the Prof., "Yet on crowded parts of the band, these will be suppressed by the a.g.c. action of the stronger stations. This gives an improvement in both senses. Where the waveband is crowded with stations, the a.g.c. action will be stronger, and this will assist slightly in removing some of the adjacent-station interference. Where the waveband is not as crowded with stations, the extra gain of the set will help you to bring in some of those more difficult stations."

Bob found that he could adjust VR2 (the replacement for R2 in Fig. 1) to a much more well-defined point, and the improvement in sensitivity was once again quite noticeable. Now he used another 10kΩ preset (VR1) as a replacement for resistor R1.

This preset appeared to be more sensitive than the other two, and at certain settings, Bob observed a strange popping sound in the loudspeaker followed by silence. By adjusting the control the station could easily be brought back, and heard quite

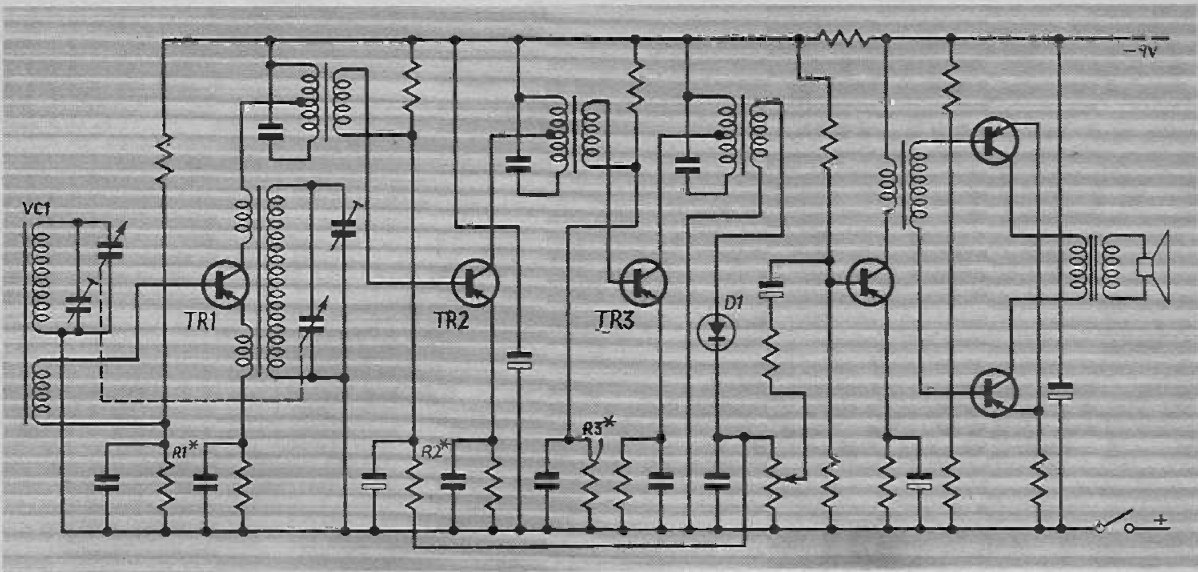


Fig. 1. Circuit diagram of the superhet receiver to be souped up.

normally. Fortunately this behaviour did not occur at a setting of the control close to that which appeared to give best reception.

"Now" said the Prof., "You could either install the presets permanently inside the cabinet of the set, or measure their values and substitute fixed resistors with values very close to what is required. You could even install printed resistors." (A method of doing this was described in the Nov '74 and Dec '74 issues of E.E.).

Bob and the Prof. began a discussion on the subject of the possible improvements which could be made, and some of the observations which the Prof. mentioned to Bob were of great interest to him.

"Whilst I was adjusting VR1," Bob told the Prof., "At some points there would be a hiss and a pop, and the station would disappear. When that happened, it usually wiped out reception on the entire waveband. But I could easily bring the reception back again, by adjusting VR1 back in the opposite direction. With another 'pop' the stations reappeared. What is the explanation for this peculiar behaviour?"

THREE FUNCTIONS

"I noticed that too," remarked the Prof., "and I think you will find that the explanation is very interesting. The transistor TR1 and its associated circuitry perform three main functions:

(1) Receive and amplify the incoming station.

(2) Oscillate at a frequency about 470kHz different from that of the incoming station.

(3) Mix the oscillation frequency with the station frequency to produce a new frequency—the 470kHz difference frequency which is passed on to TR2."

"If any of these functions should fail to occur, this would result in loss of the 470kHz signal, which is vital for operation of the remainder of the set. The main function of TR2 and TR3 is to receive the 470kHz signal from TR1, amplify it and pass it on to the detector D1, where it is converted into an a.f. signal. Without the 470kHz signal, TR2 and TR3 cannot pass any useful signal on to the rest of the set and the stations immediately disappear!"

"This is what I noticed," commented Bob wryly, "The whole lot vanished entirely with a hiss and a pop!"

"It sounds to me, Bob, as though at certain settings of the preset VR1, the oscillator ceases to operate, and this results in loss of the 470kHz 'intermediate frequency' which is essential for operation of the set.

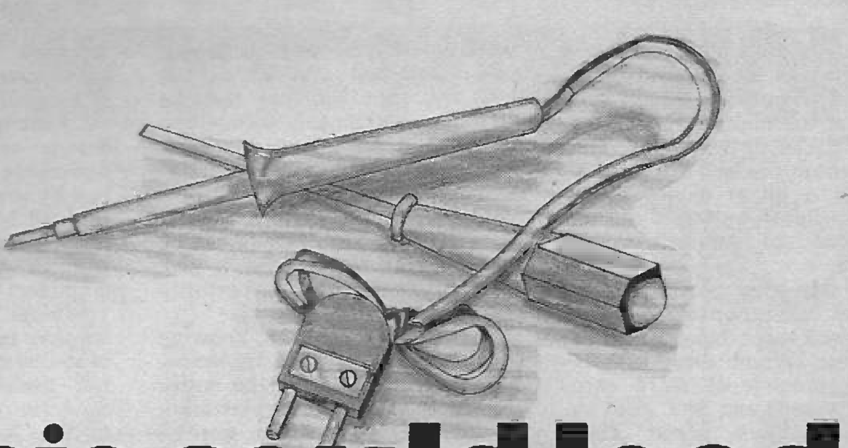
This can happen quite suddenly. First the oscillation becomes weak and erratic, resulting in the hissing sound you heard, then it suddenly ceases with a quiet pop from the speaker. As you adjust the preset VR1 back to a setting where the oscillator can operate again, it starts up suddenly. Then once again, if a station is tuned in, the 470kHz intermediate frequency reappears, and you suddenly find that you can hear stations once more. By further adjustment you can find the setting where the first transistor best receives and amplifies the signal from the incoming station.

Of course the circuit which we are considering is one of the simplest and most common of the commercially produced superhet circuits. A circuit like this occurs in most single-waveband portable receivers, and with some modifications a very similar circuit is used for two-waveband medium- and long-wave sets."

"Can a similar procedure be used on these sets too?" Bob wanted to know.

"Yes, Bob," The Prof. told him, "The adjustment to the bias on the first transistor, which is the mixer/oscillator stage, can be particularly useful on some long-wave sets. With some of these, the oscillation is much less reliable on long-wave, so that as you switch from medium- to long-wave the oscillator may stop.

With some sets the oscillator will only work on long-wave when the battery is very new, so that for continued long-wave listening you just have to keep on buying batteries much more often than should be really necessary. A common symptom of this is that stations disappear one by one, starting at the longest wavelengths on the band, because although the oscillator is not



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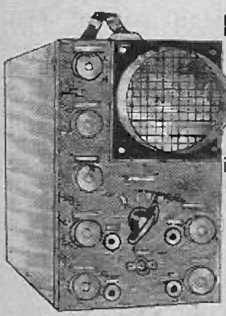

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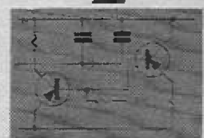

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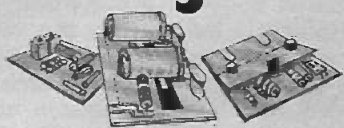

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working on the longest wavelengths, which correspond with the lowest frequencies, it will still operate at the higher frequencies even on the same waveband! Readjustment of the bias will usually cure this. A lot of money spent unnecessarily on batteries can be saved, and the set will sound better too.

So for sets with more than one waveband, alteration of the bias can be even more beneficial. But as the sets become more complicated, a great deal more care must be taken, and you need to understand more about electronics in order to be sure you do not get out of your depth in dealing with them. This could do more harm than good!" The Prof. warned Bob.

"When a radio repair engineer encounters a set where the oscillator stops on long-wave, he will generally cure it by replacing the oscillator transistor with one of higher gain. This often solves the problem. If you pick high-gain transistors, and also adjust the bias, this can improve the set even more. When this is done, the bias should be adjusted to suit each replacement transistor."

"There are so many parts in a transistor radio, Prof., that I wonder how many of them can be replaced with better parts, to give an even more superior performance?" queried Bob.

"It is a matter of knowing which parts it is worth replacing, Bob, without replacing the entire set! In many sets, for instance, the loudspeaker is of poor quality, and it may not be easy to find a replacement which would suit the cabinet. So often the best answer here is to leave the existing speaker in the set and plug a better speaker into the extension socket.

Another example of a component it is often wiser to leave is the oscillator coil, as it would be difficult to find a replacement for this, and the possibility of improvement by changing it is often quite remote.

In many sets the audio amplifier is of poor quality, and a noticeable improvement may be had by removing the transformer-coupled type of amplifier and replacing it with an integrated circuit or other directly coupled amplifier.

Where there is room for another control on the cabinet, it is sometimes possible to bring out the aerial trimmer VC1 as a separate control. This enables you to tune in each individual station more sharply, but there is a risk of r.f. instability if this is not done correctly.

So that although there are a great many improvements that may be made to the average set, the modifications which are likely to be of the most benefit for the least possible outlay, are the ones which you have just done, simply by changing three resistors!"

continued from page 552

either by non-destructive avalanche breakdown or by forward conduction.

Some m.o.s.f.e.t.s have been made with a Zener diode connected internally between their gate and source. The Zener is normally reverse biased and will break down when an excessive voltage is built up on the gate electrode. However, the use of such a diode reduces the input impedance to a value which is nearer to that of a junction f.e.t. than a normal m.o.s.f.e.t.

Another type of breakdown can also occur in a m.o.s.f.e.t. In the enhancement type, breakdown from drain to source can occur at zero gate voltage, whilst in the depletion type it can occur when the device has been cut off.

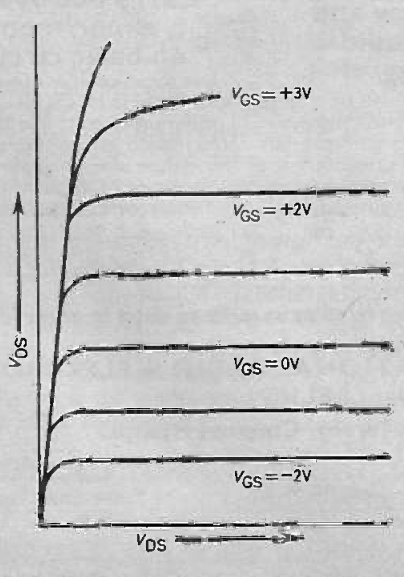

Fig. 11. Characteristics of the *n*-channel depletion m.o.s.f.e.t.

CHARACTERISTICS

The characteristics of an *n*-channel depletion m.o.s.f.e.t. are shown in Fig. 11. It can be seen that they are rather similar to those of the junction f.e.t. shown in Fig. 6, but the gate voltage of the depletion m.o.s.f.e.t. may have either polarity.

The characteristics of an *n*-channel enhancement m.o.s.f.e.t. are rather similar to those of Fig. 11; however, the negative gate voltages do not apply and the drain current is small at zero gate voltage.

The gate current of a m.o.s.f.et. is not only much less than that of a junction f.e.t., but remains very low even at moderately high temperatures.

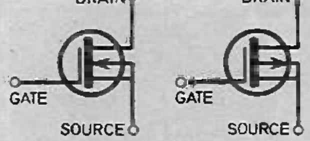

Fig. 12. Circuit symbols for m.o.s.f.e.t.s.

M.O.S.F.E.T. SYMBOL

The m.o.s.f.e.t. is often given the special circuit symbols shown in Fig. 12. These show that the gate electrode is completely insulated from the rest of the device.

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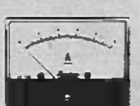

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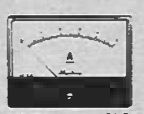

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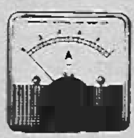
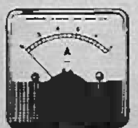
500uA	£4.55
50-0-50uA	£4.65
100-0-100uA	£4.60
1mA	£4.50
5mA	£4.50
10mA	£4.60
50mA	£4.50
100mA	£4.50
500mA	£4.50
1A DC	£4.50
5A DC	£4.60
10A DC	£4.60
5V DC	£4.50
10V DC	£4.50
20V DC	£4.50
50V DC	£4.50
300V DC	£4.50
15V DC	£4.60
300V AC	£4.60
VU Meter	£5.60

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



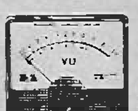
50uA	£3.55
100uA	£3.50
200uA	£3.45
500uA	£3.30
50-0-50uA	£3.50
100-0-100uA	£3.45
500-0-500uA	£3.25
1mA	£3.25
5mA	£3.25
10mA	£3.25
50mA	£3.25
100mA	£3.25
500mA	£3.25
1A DC	£3.25
5A DC	£3.25
10V DC	£3.25
20V DC	£3.25
50V DC	£3.25
300V DC	£3.25
15V AC	£3.40
300V AC	£3.40
5 Meter 1mA	£3.75
VU Meter	£4.30
1A AC	£3.25*
5A AC	£3.25*
10A AC	£3.25*
20A AC	£3.25*
30A AC	£3.25*

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



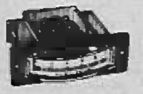
50uA	£3.45
100uA	£3.40
200uA	£3.30
500uA	£3.10
50-0-50uA	£3.40
100-0-100uA	£3.30
500-0-500uA	£3.05
1mA	£3.05
1-0-1mA	£3.05
2mA	£3.05
5mA	£3.05
10mA	£3.05
20mA	£3.05
50mA	£3.05
100mA	£3.05
150mA	£3.05
200mA	£3.05
300mA	£3.05
500mA	£3.05
750mA	£3.05
1A DC	£3.05
2A DC	£3.05
5A DC	£3.05
10A DC	£3.05
3V DC	£3.05
10V DC	£3.05
15V DC	£3.05
20V DC	£3.05
50V DC	£3.05
100V DC	£3.05
150V DC	£3.10
300V DC	£3.10
500V DC	£3.15
750V DC	£3.15
15V AC	£3.15
50V AC	£3.15
150V AC	£3.15
300V AC	£3.15
500V AC	£3.30
5 Meter 1mA	£3.50
VU Meter	£4.10

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



50uA	£6.00
100uA	£5.95
200uA	£5.90
500uA	£5.80
50-0-50uA	£5.95
100-0-100uA	£5.90
500-0-500uA	£5.85
1mA	£5.75
1-0-1mA	£5.75
5mA	£5.75
10mA	£5.75
50mA	£5.75
100mA	£5.75
500mA	£5.75
1A DC	£5.75
5A DC	£5.75
15A DC	£5.75
30A DC	£5.95
10V DC	£5.75
20V DC	£5.75
50V DC	£5.75
150V DC	£5.75
300V DC	£5.75
15V AC	£5.85
300V AC	£5.85
5 Meter 1mA	£6.65
VU Meter	£7.10
1A AC	£5.75*
5A AC	£5.75*
10A AC	£5.75*
20A AC	£5.75*
30A AC	£5.75*

EDGWISE MODEL PE70
Size: 90 x 34mm



50uA	£4.55
100uA	£4.50
200uA	£4.45
500uA	£4.30
50-0-50uA	£4.50
100-0-100uA	£4.45
1mA	£4.25
10V DC	£4.25
300V DC	£4.35
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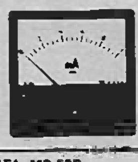
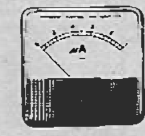
Size: 80 x 80mm



50uA	£4.95
100uA	£4.90
500uA	£4.60
50-0-50uA	£4.80
100-0-100uA	£4.85
1mA	£4.60
1A DC	£4.60
5A DC	£4.60
20V DC	£4.60
50V DC	£4.60
300V DC	£4.60
300V AC	£4.75
VU Meter	£5.95

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



50uA	£4.10
100uA	£3.85
500uA	£3.70
50-0-50uA	£3.85
100-0-100uA	£3.70
1mA	£3.65
5mA	£3.65
10mA	£3.65
50mA	£3.65
100mA	£3.65
500mA	£3.65
1A DC	£3.65
5A DC	£3.65
10V DC	£3.65
20V DC	£3.65
50V DC	£3.65
300V DC	£3.65
15V AC	£3.75
300V AC	£3.75
5 Meter 1mA	£4.20
VU Meter	£4.85
1A AC	£3.65*
5A AC	£3.65*
10A AC	£3.65*
20A AC	£3.65*
30A AC	£3.65*

BAKELITE MODEL MR 65 Size: 80 x 80mm

25uA	£5.80
50uA	£4.40
100uA	£4.35
500uA	£4.05
50-0-50uA	£4.35
100-0-100uA	£4.30
500-0-500uA	£3.95
1mA	£3.95
1-0-1mA	£3.95
5mA	£3.95
10mA	£3.95
50mA	£3.95
100mA	£3.95
500mA	£3.95
1A DC	£3.95
2A DC	£3.95
5A DC	£3.95
10A DC	£3.95
15A DC	£3.95
30A DC	£3.95
50A DC	£4.20
5V DC	£3.95
10V DC	£3.95
15V DC	£3.95
20V DC	£3.95
50V DC	£3.95
150V DC	£3.95
300V DC	£3.95
30V AC	£3.95*
50V AC	£3.95*
150V AC	£3.95*
300V AC	£3.95*
600V AC	£3.95*
VU Meter	£6.20
1A AC	£3.95*
5A AC	£3.95*
10A AC	£3.95*
20A AC	£3.95*
30A AC	£3.95*
50A AC	£3.95*
500mA AC	£3.95
50mV DC	£4.15
100mV DC	£4.15

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

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100uA	£4.25
200uA	£4.20
500uA	£4.15
50-0-50uA	£4.25
100-0-100uA	£4.20
500-0-500uA	£4.10
1mA	£4.10
1-0-1mA	£4.10
5mA	£4.10
10mA	£4.10
50mA	£4.10
100mA	£4.10
500mA	£4.10
1A DC	£4.10
5A DC	£4.10
10A DC	£4.10
15A DC	£4.10
20A DC	£4.20
30A DC	£4.25
50A DC	£4.10
5V DC	£4.10
10V DC	£4.10
15V DC	£4.10
20V DC	£4.10
50V DC	£4.10
150V DC	£4.10
300V DC	£4.10
15V DC	£4.20
50V AC	£4.20
150V AC	£4.20
300V AC	£4.20
500V AC	£4.30
5 Meter 1mA	£4.85
VU Meter	£5.20
1A AC	£4.10*
5A AC	£4.10*
10A AC	£4.10*
20A AC	£4.10*
30A AC	£4.10*
50A AC	£4.10
50mA AC	£4.10*
100mA AC	£4.10*
200mA AC	£4.10*
500mA AC	£4.10*

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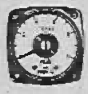

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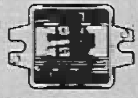

18mm × 18mm Panel mounting.
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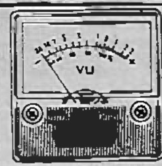

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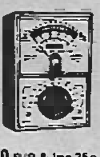

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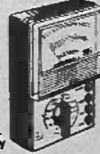

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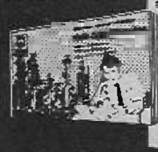

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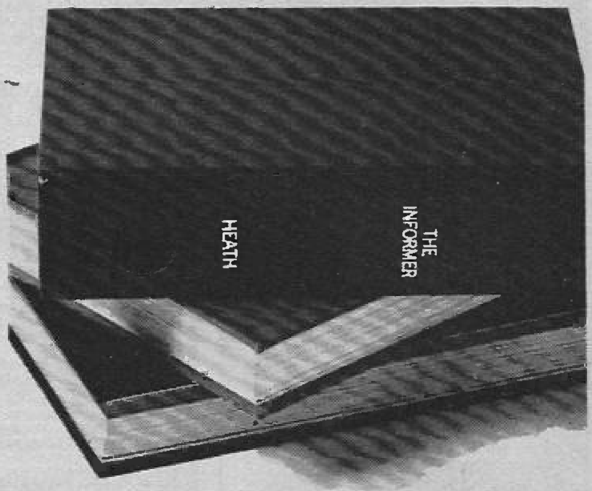

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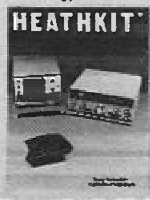

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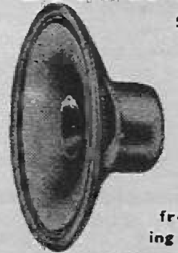

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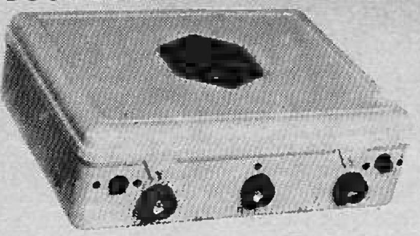

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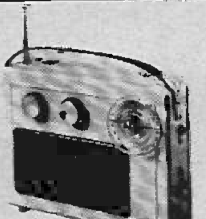

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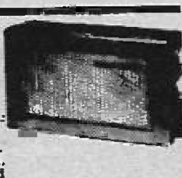

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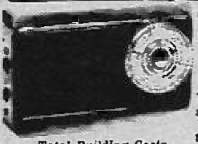

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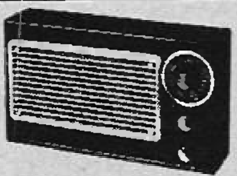

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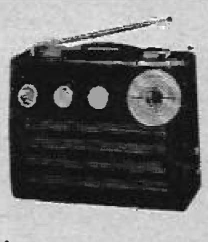

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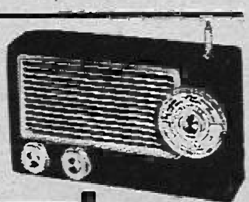
TRANS EIGHT 8 TRANSISTORS and 3 DIODES



6 Tunable Wavebands: MW. LW. SW1. SW2. SW3 and Trawler Band. Sensitive ferrite rod aerial for M.W. and L.W. Telescopic aerial for Short Waves. 3in. Speaker. 8 improved type transistors plus 3 diodes. Attractive case in black with red grille, dial and black knobs with polished metal inserts Size 9 × 5½ × 2½in. approx. Push pull output. Battery economiser switch for extended battery life. Ample power to drive a larger speaker. Parts price list and plans free with parts.

Total building costs £5·98 PP & Ins. 50p
Overseas Seamail P & P £2·50)

ROAMER SIX

CASE AND LOOKS AS TRANS-EIGHT

6 Tunable Wavebands:: MW. LW. SW1 SW2 Trawler band plus an extra Medium waveband for easier tuning of Luxembourg, etc. Sensitive ferrite rod aerial and telescopic aerial for Short Waves. 3in. Speaker 8 stages—6 transistors and 2 diodes. Attractive black case with red grille, dial and black knobs with polished metal inserts. Size 9×5½×2½in. approx. Plans and parts price list free with parts.

Total building costs £5·48 PP & Ins. 50p (Overseas Seamail P & P £2·50)

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