Inexpensive, easy to build projects

everyday electronics

FEB. 76
30p

Electronic WATCHDOG

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- FIELD STRENGTH METER
- TWO-TONE OSCILLATOR

4 EXCITING PROJECTS

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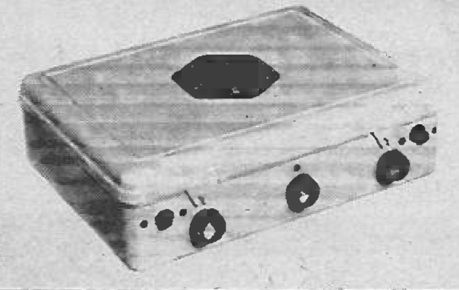
ENTERTAINMENT
-in Electronics

RADIO EXCHANGE LTD.

ALL PRICES INCLUDE VAT

NEW EDU-KIT MAJOR

Completely Solderless Construction Kit. Build these projects without soldering iron or solder



- ★ 4 Transistor Earpiece Radio.
- ★ Signal Tracer.
- ★ Signal Injector.
- ★ Transistor Tester NPN-PNP.
- ★ 4 Transistor Push Pull Amplifier.
- ★ 5 Transistor Push Pull Amplifier.
- ★ 7 Transistor Loudspeaker Radio MW/LW.
- ★ 5 Transistor Short Wave Radio.
- ★ Electronic Metronome
- ★ Electronic Noise Generator.
- ★ Batteryless Crystal Radio.
- ★ One Transistor Radio.
- ★ 2 Transistor Regenerative Radio.
- ★ 3 Transistor Regenerative Radio.
- ★ Audible Continuity Tester.
- ★ Sensitive Pre-Amplifier.

Components Include: 24 Resistors ● 21 Capacitors ● 10 Transistors ● 3½" Loud-speaker ● Earpiece ● Mica Baseboard ● 3 12-way connectors ● 2 Volume controls ● 2 Slider Switches ● 1 Tuning Condenser ● 3 Knobs ● Ready Wound MW/LW/SW Coils ● Ferrite Rod ● 6½ yards of wire ● 1 Yard of sleeving etc. ● Complete kit of parts including construction plans.

Total Building Costs £9·99 P & P 65p

ELECTRONIC CONSTRUCTION KITS

ECK 2

Self Contained Multi-Band V.H.F. Receiver Kit. 8 Transistors and 3 Diodes. Push/Pull output. 3" Loudspeaker, Gain Control. Superb 9 section swivel ratchet and retractable chrome plated telescopic aerial, V.H.F. Tuning Capacitor. Resistors, Capacitors, Transistors, etc. Will receive T.V. Sound, Public Service Band, Aircraft, V.H.F. Local Stations, etc. Operates from a 9 Volt P.P.7 Battery (not supplied with kit)

Complete kit of parts including construction plans **£7·95** P.P. and Ins. 55p.

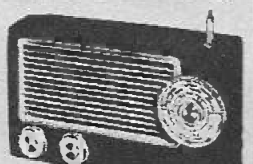
ECK 4

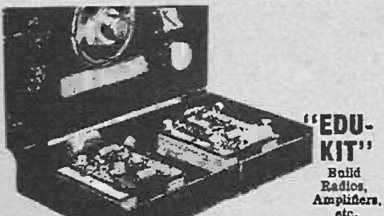
7 Transistors, 6 tuneable wavebands, MW, LW, Trawler Band, 3 Short Wave Bands. Receiver Kit. With 5" × 3" Loudspeaker. Push/Pull output stage, Gain Control, and Rotary Switch. 7 Transistors and 4 Diodes. 6 section chrome-plated telescopic aerial. 8" Sensitive Ready Wound Ferrite Rod Aerial. Tuning Capacitor, Resistors, Capacitors, etc. Operates from a 9 Volt P.P. 7 Battery (not supplied with kit). Complete kit of parts including construction plans **£7·25** P.P. and Ins. 55p.

TRANS EIGHT

8 Transistors and 3 Diodes, 6 Tunable Wavebands: MW, LW, SW1, SW2, SW3 and Trawler Band. Sensitive Ferrite rod aerial for MW and LW. 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 x 5½ x 2½in approx. Push pull output. Battery economiser switch for extended battery life. Ample power to drive a larger speaker. Complete kit of parts including construction plans. P.P. & Ins. 55p

Total Building Costs **£6·99**
(Overseas Seamail P. & P. £2·50)





"EDU-KIT"

Build Radios, Amplifiers, etc.

Five units to construct

Components include: Tuner Condenser: 2 Volume Controls: 2 Slider Switches: Fine Tone 3" Moving Coil Speaker: Terminal Strip: Ferrite Rod Aerial: Battery Clips: 4 Tag Boards: 10 Transistors: 4 Diodes: Resistors: Capacitors: Three ¼" Knobs. Units once constructed are detachable from Master Unit, enabling them to be stored for future use. Ideal for Schools, Educational Authorities and all those interested in radio construction.
Complete kit of parts including construction plans.
P.P. & Ins. 55p.
(Overseas Seamail P. & P. £3·40)

Total Building Costs **£6·99**

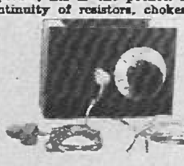
NEW EVERYDAY 6

6 Transistors and 3 diodes. Powered by 9 volt battery. Ferrite rod aerial 3" loudspeaker, etc., MW/LW coverage. Push Pull output. Complete kit of parts including construction plans.

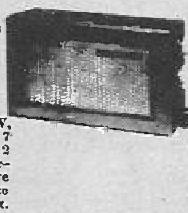
Total Building Costs **£5·50** P.P. & Ins. 50p. (Overseas Seamail P. & P. £2·30)

NEW JIFFY TESTER

Easy to build and operate, fits in the pocket. A quick checker for continuity of resistors, chokes, diodes, transistors, circuit wiring (not mains) and loud-speakers. Complete with earpiece, jack plug and socket resistors, capacitors, components, etc. Complete kit of parts including construction plans.



Total Building Costs **£3·15**
P.P. & Ins. 30p. (Overseas Seamail P. & P. £1·70)



POCKET FIVE

NOW WITH 3" LOUDSPEAKER
3 Tunable wavebands. MW, LW and Trawler Band 7 stages, 5 transistors and 2 diodes, super-sensitive ferrite rod aerial attractive black and gold case. Size 5½" x 1¼" x 3½" approx. Complete kit of parts including construction plans.
P.P. & Ins. 45p
(Overseas Seamail P. & P. £2·30)

Total Building Costs **£3·99**

VHF AIR CONVERTOR KIT

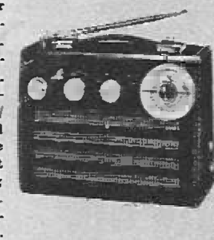
Build this Converter Kit and receive the Aircraft Band by placing it by the side of a radio tuned to Medium Wave or the Long Wave Band and operating as shown in the instructions supplied free with all parts. Uses a retractable chrome plated telescopic aerial, Gain Control, V. H. F. Tuning Capacitor, Transistor, etc.

All Parts including Case and Plans. **£4·35** P.P. and Ins. 40p

ROAMER TEN MARK 2

With VHF including aircraft

Now with free earpiece and switched socket. 10 Transistors. Latest 5" × 3" Loudspeaker. 9 Tuneable Wavebands, MW1, MW2, LW, SW1, SW2, SW3, TrawlerBand, VHF and Local Stations also Aircraft Band. Built in Ferrite Rod Aerial for MW/LW. Chrome plated 6 section Telescopic Aerial, can be angled and rotated for peak short wave and VHF listening. Push/Pull output using 600mW Transistors. Car Aerial Socket 10 Transistors plus 3 Diodes. Ganged Tuning Condenser with VHF section. Separate coil for Aircraft Band. Volume on/off. Wave Change and tone Controls. Attractive Case in rich Chestnut shade with gold blocking Size 9" × 7" × 4". Easy to follow instructions and diagrams.



Total Building Costs **£11·87** P.P. and Ins. 65p

RADIO EXCHANGE LTD.

TO RADIO EXCHANGE LTD., 61A HIGH STREET, BEDFORD MK40 1SA. Tel: 0234 52367. REG NO. 788372
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Minimum order 75p.

GREAT WINTER SALE!

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74 SERIES TTL IC's

Type	Quantity 1 £ p	100 £ p	Type	Quantity 1 £ p	100 £ p	Type	Quantity 1 £ p	100 £ p
7400	0·08	0·07	7448	0·70	0·68	74122	0·42	0·40
7401	0·12	0·09	7450	0·12	0·10	74123	0·58	0·50
7402	0·10	0·09	7451	0·12	0·10	74141	0·62	0·60
7403	0·12	0·09	7453	0·12	0·10	74145	0·70	0·65
7404	0·10	0·09	7454	0·12	0·10	74150	1·30	1·25
7405	0·10	0·09	7460	0·12	0·10	74151	0·65	0·60
7406	0·28	0·25	7470	0·26	0·24	74153	0·65	0·60
7407	0·28	0·25	7472	0·22	0·20	74154	1·30	1·25
7408	0·14	0·10	7473	0·26	0·22	74155	0·65	0·60
7409	0·14	0·10	7474	0·27	0·23	74156	0·65	0·60
7410	0·08	0·07	7475	0·44	0·40	74157	0·90	0·80
7411	0·20	0·18	7476	0·28	0·25	74160	0·95	0·85
7412	0·20	0·18	7480	0·40	0·35	74161	0·95	0·85
7413	0·26	0·25	7481	0·95	0·90	74162	0·95	0·85
7416	0·28	0·25	7482	0·72	0·62	74163	0·95	0·85
7417	0·27	0·24	7483	0·80	0·68	74164	1·20	1·10
7420	0·10	0·09	7484	0·85	0·80	74165	1·20	1·10
7422	0·25	0·23	7485	1·20	0·95	74166	1·20	1·10
7423	0·26	0·24	7486	0·30	0·25	74174	1·00	0·90
7425	0·26	0·24	7489	2·70	2·50	74175	0·95	0·85
7426	0·26	0·24	7490	0·38	0·32	74176	1·00	0·95
7427	0·26	0·24	7491	0·60	0·50	74177	1·00	0·95
7428	0·36	0·34	7492	0·43	0·35	74180	1·00	0·95
7430	0·12	0·10	7493	0·38	0·35	74181	2·00	1·80
7432	0·25	0·22	7494	0·45	0·40	74182	1·00	0·90
7433	0·35	0·32	7495	0·58	0·50	74184	1·50	1·40
7437	0·25	0·22	7496	0·68	0·63	74190	1·40	1·30
7438	0·25	0·22	74100	1·00	0·90	74191	1·40	1·30
7440	0·12	0·10	74101	0·30	0·25	74192	1·10	1·00
7441	0·64	0·58	74105	0·30	0·25	74193	1·10	1·00
7442	0·60	0·52	74107	0·30	0·25	74194	1·00	0·95
7443	0·95	0·90	74110	0·50	0·45	74195	0·75	0·70
7444	0·95	0·90	74111	0·80	0·75	74196	1·00	0·95
7445	0·75	0·55	74118	0·90	0·82	74197	1·00	0·95
7446	0·95	0·85	74119	1·30	1·20	74198	1·90	1·80
7447	0·68	0·65	74121	0·26	0·25	74199	1·80	1·70

Devices may be mixed to qualify for quantity price. (TTL 74 series only) data is available for the above series of I.C.'s in booklet form. Price 35p.

I.C. SOCKETS

BPS8 **9p.** BPS14 **10p.** BPS16 **11p.**

LINEAR IC

741P 8PIN **20p.**

TIMERS

NE555 **42p.** DUAL NE556 **85p.**

TRANSISTORS

Type	Price
AC128	10p
AC153K	18p
AC176K	20p
AC153/176K MP	38p
AC187K	20p
AC188K	18p
AC187K/188K MP	38p
OC71	9p
BC107	6p
BC108	6p
BC109	6p
BC118	8p
BC154	20p
BC147	8p
BC148	8p
BC149	10p
BC157	12p
BC158	10p
BC159	10p
BC169C	7p
BC170	5p
BC171	5p
BC172	5p
BC182 L & K	10p
BC183	10p
BC184	12p
BC212 L & K	10p
BC213	10p
BC214	12p
BC251	6p
BC327	12p
BC328	12p
BC337	11p
BC338	11p
BF115	10p
BF167	10p
BF173	10p
BF198	12p
BF199	12p
BF194	9p
BF195	9p
BF196	11p
BF197	11p
BF257	22p

Type	Price
BF258	26p
BF259	30p
BFX29	18p
BFX84	15p
BFX85	20p
BFX86	16p
BFY50	15p
BFY51	15p
BFX52	15p
BFY53	14p
2N696	10p
2N697	11p
2N706	6p
2N706A	6p
2N708	7p
2N1613	15p
2N1711	15p
2N1893	18p
2N2217	15p
2N2218	14p
2N2218A	15p
2N2219	14p
2N2219A	15p
2N2221	14p
2N2221A	15p
2N2222	14p
2N2222A	15p
2N2369	12p
2N2369A	12p
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2N2906A	12p
2N2907	11p
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2N3703	8p
2N3704	9p
2N3705	8p
2N3706	8p
2N3707	7p
2N3708	7p
2N3709	7p
2N3710	7p
2N3711	7p

F.E.T.
2N3819 12p

Type	Price
2N3903	8p
2N3904	8p
2N3905	9p
2N3906	9p
2N4058	8p
2N4059	8p
2N4060	9p
2N4061	9p
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UT46 = TIS43 20p

Type	Price
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ZTX500	8p
ZTX107	5p
ZTX108	5p
ZTX109	5p

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Type	Price
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OA47	5p
OA85-OA81	5p
OA91	5p
OA200/BAX13	5p
OA202/BAX16	5p
IN914	4p

Type	Price
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IN4001	3p
IN4002	4p
IN4003	4p
IN4004	5p
IN4005	5p
IN4006	6p
IN4007	7p

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Fitted with Phase Lock-loop

★ FET Input Stage
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★ Switched AFC
★ Multi turn pre-sets
★ LED Stereo Indicator

Typical Specification:
Sensitivity 3μ volts
Stereo separation 30db
Supply required 20-30v at 90 Ma max

OUR PRICE ONLY

£19.95

The 450 Tuner provides instant programme selection at the touch of a button ensuring accurate tuning of 4 pre-selected stations, any of which may be altered as often as you choose, by simply changing the settings of the pre-set controls.
Used with your existing audio equipment or with the BI-KITS **STEREO** 30 or the **MK60** Kit etc. Alternatively the **PS12** can be used if no suitable supply is available, together with the Transformer **T461**.
The S450 is supplied fully built, tested and aligned. The unit is easily installed using the simple instructions supplied.

STEREO PRE-AMPLIFIER

PA 100

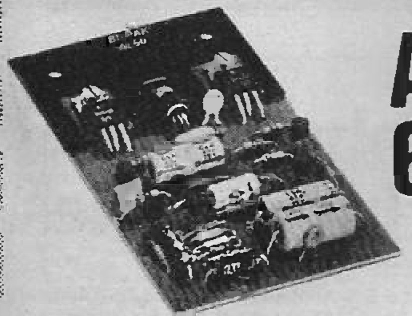
A top quality stereo pre-amplifier and tone control unit. The six push-button selector switch provides a choice of inputs together with two really effective filters for high and low frequencies, plus tape output.

Frequency Response + 1dB 20Hz-20KHz.
Sensitivity of inputs:
1. Tape Input 100mV into 100k ohms
2. Radio Tuner 100mV into 100k ohms
3. Magnetic P.U. 3mV into 50k ohms

P.U. input equalises to R1AA curve within 1dB from 20Hz to 20kHz. Supply 20-35V at 20mA. Dimensions—2[illegible]mm × [illegible]mm × 35mm.

OUR PRICE **£13.50**

MK60 AUDIO KIT: *Comprising: 2 × SPM80, 1 × BTM80, 1 × PA100, 1 front panel and knobs. 1 Kit of parts to include on/off switch, neon indicator, stereo headphone sockets plus instruction booklet.* **COMPLETE PRICE** *£27·55 plus 62p postage.*
TEAK 60 AUDIO KIT: *Comprising: Teak veneered cabinet size 16¾" × 11½" × 3½", other parts include aluminium chassis, heatsink and front panel bracket plus back panel and appropriate sockets etc.* **KIT PRICE** *£9·20 plus 62p postage.*



AL 60

VAT ADD 25%

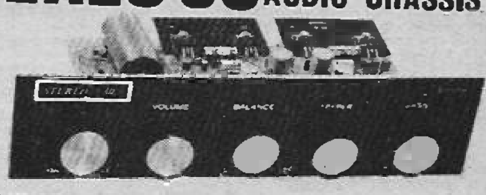
25 Watts (RMS)

● Max Heat Sink temp. 90C. ● Frequency response 20Hz to 100kHz. ● Distortion better than 0·1 at 1kHz. ● Supply voltage 15-50v. ● Thermal Feedback. ● Latest Design Improvements. ● Load—3, 4, 5, or 16ohms. ● Signal to noise ratio 80db. ● Overall size 63mm. 105mm. 13mm.

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

ONLY £3.95

STEREO 30 COMPLETE AUDIO CHASSIS



7 + 7 WATTS R.M.S.
The Stereo 30 comprises a complete stereo pre-amplifier, power amplifiers and power supply. This, with only the addition of a transformer or overwind will produce a high quality audio unit suitable for use with a wide range of inputs i.e. high quality ceramic pick-up, stereo tuner, stereo tape deck etc. Simple to install, capable of producing really first class results, this unit is supplied with full instructions, black front panel, knobs, mains switch, fuse and fuse holder and universal mounting brackets enabling it to be installed in a record plinth, cabinets of your own construction or the cabinet available. Ideal for the beginner or the advanced constructor who requires Hi-Fi performance with a minimum of installation difficulty (can be installed in 30 mins.).

TRANSFORMER £2·45 plus 62p p & p.
TEAK CASE £3·65 plus 62p p & p.

£15.75 *P & P 45p*

Stabilized Power Supply Type SPM80

SPM80 is especially designed to power 2 of the AL60 Amplifiers, up to 15 watts (r.m.s.) per channel simultaneously. With the addition of the Mains Transformer **BMT80**, the unit will provide outputs of up to 1·5A at 35V. Size: 63mm, 105mm, 30mm. Incorporating short circuit protection.

INPUT VOLTAGE	33-40V. A.C.
OUTPUT VOLTAGE	33V. D.C. Nominal
OUTPUT CURRENT	10mA-1·5 amps
OVERLEAD CURRENT	1·7 amps approx.
DIMENSIONS	105mm × 63mm × 30mm
TRANSFORMER BMT80	£2·60 + 62p postage

£3.00

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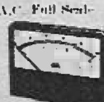
Handy boxes for construction projects. Moulded extrusion rails for P.C. or chassis panels. Fitted with 1mm front panels.

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

3 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 — 65p + 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 75p 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 2½" × 2½" × 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

LOW PRICE TRANSISTORS

BF303B—15p TIP42A—75p
AC142K—25p OC75—22p
BC149B 15p AA129—6p
Plus 25% VAT

IC EXTRACTION TOOL

Saves damage to valuable ICs.
Only 40p + 8% VAT

ANTEX SOLDERING IRONS AND SPARES

X25 25 watt	£2·99
X25 Spare Element	£1·47
X25 Spare Bits No. 50, 51, 52	44p each
C240/2 15 watt	£2·99
C240/2 Spare Element	£1·20
C240/2 Spare Bits No. 2, 3, 6	32p each
ST3. Soldering Iron Stand suitable for all models	£1·10

Plus 8% VAT

ALUMINIUM BOXES

Metal Project Boxes give your work a professional finish.

	L	W	H	Price
AB7	2¼	5¼	1½	54p
AB8	4	4	1½	68p
AB9	4	2¼	1½	54p
AB10	4	5¼	1½	68p
AB11	4	2½	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

SCOOP PURCHASE AM—FM STEREO TUNER

We supply an AM. FM. Stereo tuner fully wired and aligned on a 6" × 4" × 1¼" Printed board, plus the ferrite aerial and a switch which you connect following our complete instructions. Now you only need a 9/12 Volt DC supply and you can feed this tuner into any stereo amplifier.
Fantastic Value at £7·00 + 25% VAT.

LOW VOLTAGE STEREO AMPLIFIER

8 Transistor Stereo Amplifier with volume, bass, balance and tone controls. Approx. 3 watts into 8 ohms per channel. Needs 9/12 volt D.C. supply and is complete on a 2½" x 7½" printed board ideal for domestic record players, etc. A bargain at £5 + 25% VAT.

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 = 58p
10% discount on ten or more cassettes of one type Plus 8% VAT

U.K. CARR. 50p unless otherwise stated

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) AFC Switching Tape record and playback facilities. Dimensions 18½" x 9" 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.

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Stereo headphones supplied with every complete order.

LEWIS radio EE/2/76 100 CHASE SIDE SOUTHGATE LONDON N14 5PL Telephones: 01-882-1644

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BRITISH NATIONAL RADIO & ELECTRONICS SCHOOL, Dept EEC 26
P.O.Box 156, Jersey, Channel Islands.

NAME ______________________________

ADDRESS ______________________________

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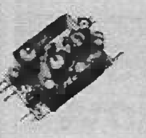
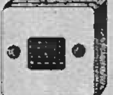
MULLARD AUDIO AMPLIFIERS

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 convenient way to stop and start an operation. Requires only a pair of wires to the normal switch. In bakelite box, normal switch-plate size. 1 amp model £3·75.
VAT and Postage 50p.

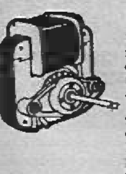
MAINS TRANSISTOR PACK

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 and Postage 60p.

SOUND TO LIGHT UNIT

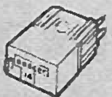
Add colour or white light to your amplifier. Will operate 1, 2 or 3 lamps (maximum 450w). Unit in Box all ready to work. £7·95 plus 95p VAT and postage.

MAINS MOTOR



Precision made—as used in record decks and tape 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.

6 DIGIT COUNTER

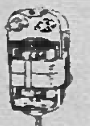


Made by famous American Company. Operated by 24v DC or by mains through resistor. 19/16" × 1" × 2¼" deep. 80p. Post & VAT 20p each.

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 15,000 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.

BATTERY CHARGER

Famous Atlas in metal case with meter, output leads terminated by crocodile clips. For 6 or 12V charging simply by changing plug on front panel. Ready built new and still in makers original packing.
£2·95, plus Post & VAT.

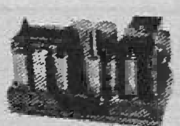
AMMETERS

Ideal for chargers, etc. 2" sq. full vision—0-8 amp 95p. 1½" *round* 0-2 amp 55p. 0·3 amp 65p. 0·4 amp 75p.

RELAY BARGAIN

Type 600 relay, 2 changeover one open and one closed contact. Twin 500 ohm coils make this suitable for closing off DC 6v, DC 12v, DC 24v or AC mains using resistor and rectifier. 40p each. Resistor and rectifier 20p extra.
Post and VAT 20p.

AUDIO AMPLIFIER

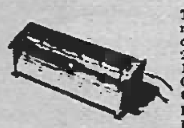


Part of the famous Rediffune background music system, secondhand, but believed in good order. However, no guarantee; we are selling for spares value only. These are 6 valve amplifiers, the output valves are 2 × EL 84 in push/pull, complete with mains transformer, rectifier and ample smoothing equipment. The mains transformer alone, today would cost at least £4. Size is 9½" × 5¼" × 4¼". Price only £2·00 + postage and VAT £1·50.

TWIN OUTPUT POWER PACKS

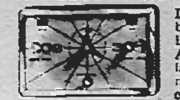
These have two separately R.C. smooth outputs so can operate two battery radios on a stereo amp without cross modulation (they will of course operate one radio-tape-cassette-calculator in fact any battery appliance and will save their cost in a few months.) Specs: Full wave rectification, double insulated mains transformer—total enclosed in hard P.V.C. case—three core mains lead—terminal output. When ordering please state output voltage 4½v, 6v, 7½v, 9v, 12v or 24v—price £3·95 post and VAT included.

TANGENTIAL HEATER UNIT



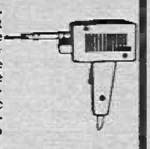
This heater unit is most efficient, and quiet running. Is as fitted in Hoover and blower heaters costing £15 and more. Comprises motor, impeller, 2kW element and 1kW element allowing switching 1, 2 and 3kW and with thermal safety cut-out. Can be fitted into any metal line case or cabinet. Only needs 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.

15A ELECTRICAL PROGRAMMER



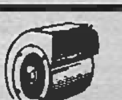
Learn in your sleep: Have radio playing and kettle boiling as you wake—switch on lights to ward off intruders—have a warm house to come home to. All these and many other things you can do if you invest in an electrical programmer. Clock by famous maker with 15 amp. on/off switch. Switch-on time can be 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.

THIS MONTHS SNIP



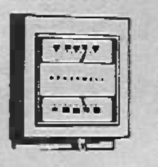
YOUR TIME is the most precious thing you have. Do you waste it waiting for the soldering iron to heat up? You can be soldering in a few seconds with the E.T.P. Soldering Gun which we offer at a specially keen price. It is in fact this months snip. A well made lightweight unit with flash lamp to illuminate the work. Has 100 watt double insulated mains Transformer and is built into a shockproof Thermo-plastic case. Suitable for 240 volt, 50c.p.s. This comes complete with 5 spare tips and is offered at a special snip price £2·75 plus 85p Post & VAT.

CENTRIFUGAL FAN



Mains operated, turbo blower type. Pressed steel housing contains motor and impeller. Motor is 1/10th h.p. giving considerable air flow but virtually no noise. Approx. dimensions 10½" × 4½".
£9·50 plus Post & VAT.

THERMOSTAT WITH THERMOMETER



Made by Honeywell for normal air temperatures 40-80 F. (5-25 C.). This is a precision instrument with a differential which can be adjusted to better than 1·5 F. A mercury switch breaks on temp. rise. Elegently styled and encased in an ivory plastic case with clear plastic windows, thermometer above and switch setting scale below—size approx. 3·8 in. × 3·2 in. × 1·4 in. deep—can be mounted on conduit box or directly on wall. Price £2·25 plus 50p Post & VAT.

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.

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 × 10in £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 cenral 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.

TERMS: Where order is under £5 please add 30p surcharge to offset packing expenses.

J. BULL (ELECTRICAL) LTD.

(Dept. E.E.), 103 TAMWORTH ROAD, CROYDON CRO IXX

YOU MAY BE IN TIME

For a valve volt-meter at £7·50—a signal generator at £8·50, an oscilloscope at £12·50 — a frequency standard at £19·50 as these and many other good buys were offered in our December Advanced Advertising News. Send S.A.E. for a copy today.

Subscribers received this list at least a month ago chances are best buys will have been snapped up so whilst writing why not send £1·25 and receive the next issues in advance.

Below are some of the items in our December News Letter.

Cannon plug, 37 pin with flex grip. *Ditto* socket also with flex grip. £2 per pair + 16p Post 20p+2p.
Shaded Pole Motor, 1¼" stack, 50 watt, made by famous American Company, these rotate at 260 rpm for 220/240 mains, good length of ⅜" spindle. Price £1·50 + 12p. Post 25p + 2p.
O.C.P. 70 photo transistor by Mullard, very popular for circuits such as infra-red burglar alarms, smoke detectors, etc. A big buy enables us to offer at the very favourable price of 25p each + 2p. or 5 for £1 + 8p.
6 digit mechanical counter, made by famous American Company, operated by 24v DC or by AC mains through resistor, 1⅛" × 1". 2¼" deep. 80p + 6p. Post 12p + 1p.
Component boards, mainly ex computer, these contain many useful parts and represent fantastic value at 5 for £1 + 8p. We guarantee the 5 would be different. You would receive IC's, etc., variable controls, altogether about 250 components, some transistors with long leads and so are easy to remove and re-use. Post 50p + 4p
½ meg pot with switch, a popular size with standard ¼" spindle, available at bargain price of 5 for £1 + 25p. Post 40p + 10p.
Microswitch bargain, made by Pye, Honeywell, Burgess and similar first-class makers especially for the Post Office, in fact they have been fitted to Post Office equipment which was never put into use. They are a change-over microswitch with 10 amp contacts offered at the very low price of 20 for £1 + 8p. Post 40p + 3p.
Impulse clocks, 10" diameter, white face and large clear hands. These require two low voltage pulse per minute to give correct time. Really beautiful clock, price only £5 + 40p each. Post £1 + 8p.
Screened sleeving, may help with hum problems 4mm—10p per metre.
Photo electric kit, comprises all the parts to make an infra-red burglar alarm or broken beam counter, etc. Kit comprises relay, photo cell, transistors, resistors and all parts. With circuit diagram. £1·50 + 12p. Post 20p + 2p.
EHT transformers 7·5 KV 50mA. These extremely well-made enclosed in metal box and bitumen filled with waterproof lid intended originally for neon signs. Price £16·50 + £1·32. Post £1·25 + 10p.
Thin connecting wire, 500 metre drums, 7 stranded copper core p.v.c. covered available in 10 different colours. Price £4·50 per 500 metre drum + 36p. Post £1·25 + 10p per drum.
Short duration time switches, precision made, some by Seimens, others by equally good firms, mostly fitted with Crouzet motors. Model 1, switch on/off time adjustable from ¼ second to 5 seconds by ¼ second intervals. Model 2, up to 20 seconds in 1 second intervals, and Model 3 up to 60 seconds in 2½ second intervals. These are all ex computers, believed to be perfect, any not so would be exchanged. Price £2·50 + 20p. Post 15p + 1p.
Instrument motor by Potter of America. A 24v DC motor but with a field winding suitable for 50 volts, presumably to permit additional speed control. Motor rated a tenth horsepower, although the quoted 9 amps armature current would indicate rather more than this; also the size and look of the motor would, in our opinion, put it at above ¼ horsepower. Has a splined ⅜" diameter shaft; was made for computer use. Price £5 + 40p. Carriage £1 + 8p.
Anti frost thermostat. The normal refrigerator type thermostat, switches off as the temperature falls and so is not suitable for anti frost devices. However, we have amongst our range of thermostats the ice stat—this switches on as the temperature falls and is set to switch on just above freezing point. It is a skeleton stat so would require boxing, but the price is modest at 90p + 7p.
2 speaker bargains. 8" × 5" elliptical 12 ohms so useable on any circuit between 8 and 15 ohms, 5 watts rating. Price £1·20 + 30p. Post 35p + 3p. 5" × 2", 30 ohms, a small but useful speaker for those special applications. Price 80p + 20p. Post 20p + 5p.
Emergency light, works from the mains but automatically switches to battery should the mains fail, so the point is never without light. Uses a PP9 or similar battery. Price £6 + 48p. Post 60p + 5p.
Instrument bargains. The instruments described below are all believed to be complete and in working order, but at the very low price we are offering them we have not tested any of them, so really these are bargains for callers who can inspect before buying. However, if you are prepared to take a chance, then we will send these to you by carrier, so after the price of each instrument we are quoting the estimated carriage charge. All the instruments are of highest quality used by very famous firm in their laboratories. They are all for normal mains working.
Marconi TF 867 standard signal generator, range 15 KC/S to 30 MC/S in 11 bands calibration accuracy "+" or "−" 1%. Price £19·50 + £1·56. Carriage £10 + 80p.
Marconi valve volt meter TF 1041, more than a volt meter, this is in fact a valve multi range meter for covering AC and DC volts up to 1000 and ohms up to 500 megs. Price £12·50 + £1. Carriage £2 + 16p.

Now...the most exciting Sinclair kit ever

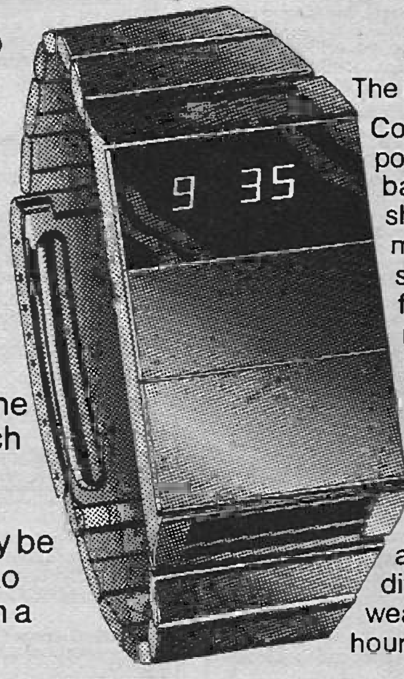
The Black Watch kit

At £17.95, it's

★ **practical** – easily built by anyone in an evening's straightforward assembly.

★ **complete** – right down to strap and batteries.

★ **guaranteed.** A correctly-assembled watch is guaranteed for a year. It works as soon as you put the batteries in. On a built watch we guarantee an accuracy within a second a day – but building it yourself you may be able to adjust the trimmer to achieve an accuracy within a second a week.



The Black Watch by Sinclair is unique.

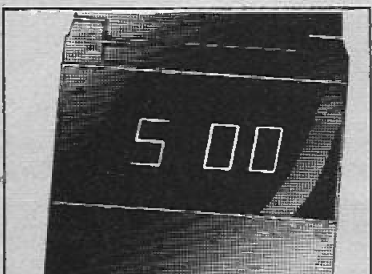
Controlled by a quartz crystal... powered by two hearing aid batteries...using bright red LEDs to show hours and minutes and minutes and seconds...it's also styled in the cool prestige Sinclair fashion: no knobs, no buttons, no flash.

The Black Watch kit is unique, too. It's rational – Sinclair have reduced the separate components to just four.

It's simple – anybody who can use a soldering iron can assemble a Black Watch without difficulty. From opening the kit to wearing the watch is a couple of hours' work.

The special features of The Black Watch

Smooth, chunky, matt-black case, with black strap. (Black stainless-steel bracelet available as extra – see order form.)



Large, bright, red display – easily read at night.
Touch-and-see case – no unprofessional buttons.

Runs on two hearing-aid batteries (supplied). Change your batteries yourself – no expensive jeweller's service.

The Black Watch – using the unique Sinclair-designed state-of-the-art IC.

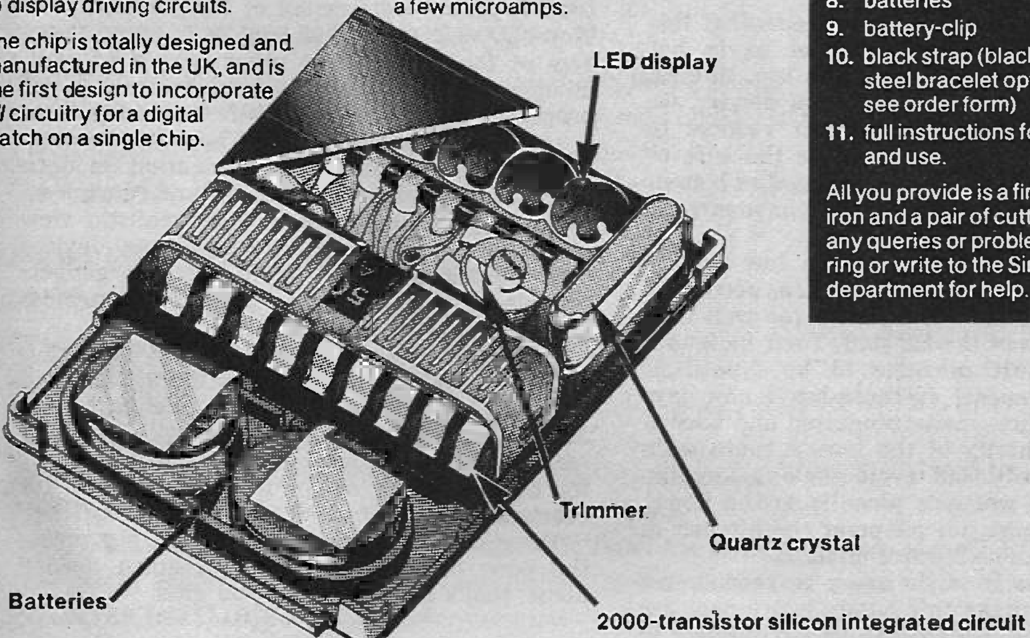
The chip...
The heart of the Black Watch is a unique IC designed by Sinclair and custom-built for them using state-of-the-art technology – integrated injection logic.

This chip of silicon measures only 3 mm x 3 mm and contains over 2000 transistors. The circuit includes

a) reference oscillator
b) divider chain
c) decoder circuits
d) display inhibit circuits
e) display driving circuits.

The chip is totally designed and manufactured in the UK, and is the first design to incorporate *all* circuitry for a digital watch on a single chip.

...and how it works
A crystal-controlled reference is used to drive a chain of 15 binary dividers which reduce the frequency from 32,768 Hz to 1 Hz. This accurate signal is then counted into units of seconds, minutes, and hours, and on request the stored information is processed by the decoders and display drivers to feed the four 7-segment LED displays. When the display is not in operation, special power-saving circuits on the chip reduce current consumption to only a few microamps.



Complete kit £17.95!

The kit contains

1. printed circuit board
2. unique Sinclair-designed IC
3. encapsulated quartz crystal
4. trimmer
5. capacitor
6. LED display
7. 2-part case with window in position
8. batteries
9. battery-clip
10. black strap (black stainless-steel bracelet optional extra – see order form)
11. full instructions for building and use.

All you provide is a fine soldering iron and a pair of cutters. If you've any queries or problems in building, ring or write to the Sinclair service department for help.

Take advantage of this no-risks, money-back offer today!
The Sinclair Black Watch is fully guaranteed. Return your kit within 10 days and we'll refund your money without question. All parts are tested and checked before despatch – and correctly-assembled watches are guaranteed for one year. Simply fill in the FREEPOST order form and post it – today!

Price in kit form: £17.95 (inc. black strap, VAT, p&p).

sinclair

Sinclair Radionics Ltd, London Road, St Ives, Huntingdon, Cambs., PE17 4HJ. Tel: St Ives (0480) 64646.
Reg. no: 699483 England. VAT Reg. no: 213 8170 88.

To: Sinclair Radionics Ltd, FREEPOST, St Ives, Huntingdon, Cambs., PE17 4BR.

Please send me .... (qty) Sinclair Black Watch kit(s) at £17.95 (inc. black strap, VAT, p&p). Total £ ....

.... (qty) black stainless-steel bracelet(s) at £2.00 (inc. VAT, p&p). ....

* I enclose cheque for £.............................., made out to Sinclair Radionics Ltd and crossed.

* Please debit my *Barclaycard/Access/American Express account number

....

Name ____________________

Address ____________________

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____________________ EE/2

Please print. FREEPOST – no stamp required. *Delete as required

everyday electronics

PROJECTS THEORY..

A MATTER OF GENDER

Talk of boiling liquids; it now seems that this month's cover could possibly land us in hot water with Women's Lib if not the law. In view of this currently sensitive matter of gender, we certainly must avoid advising our readers to build the Boiling Liquid Alarm for the wife or for mum. This might me misconstrued as blatant sex discrimination. It's no joke. We have already seen the danger signals.

A remark made on this page a few months ago referring to the kitchen as a peculiarly feminine domain did not go down too well with female members of the EE staff. Their indignant reaction we must presume to be typical of womenfolk in general. In these brave new days of female equality—now recognised and backed by the full authority of the law—a mere male must tread warily and avoid making any imputation that a woman's place is in the home, and certainly must not pin-point the kitchen as her particular and exclusive domain.

So, natural as it might seem to recommend our readers to make this handy instrument for a female relative, we have to be circumspect in this matter and not risk invoking the Sex Discrimination Act!

Leaving aside this sensitive and emotional area, there is in fact another perfectly sound reason for avoiding any differentiation in matters of gender when discussing electronics. Though still mainly a male field of interest (that is purely a statement of fact, honest, your Worship) electronics has won over many members of the fair sex. No other branch of technology can have as large a female involvement, proportionally, as the electronics industry. Now it appears girls and women in appreciable numbers are discovering the fascination modern electronics can offer as a hobby. And (dare it be said) they usually have a more realistic view concerning helpful and labour saving devices for domestic use. Many simple electronic gadgets capable of being built by amateurs, regardless of sex, come into this field.

Any woman having witnessed the disastrous results of the male in action in the kitchen will instantly welcome this month's Boiling Liquid Alarm. Some of our fair readers will assuredly see the wisdom of making this device not merely for their husband or for dad but, in fact, for everyone to use.

Those cover pictures? Oh, we were just giving the poor male ego a bit of a much needed boost, that's all. Believe us you girls.

Fred Bennett.

Our March issue will be published on Friday, February 20

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. 5 NO. 2 FEBRUARY 1976

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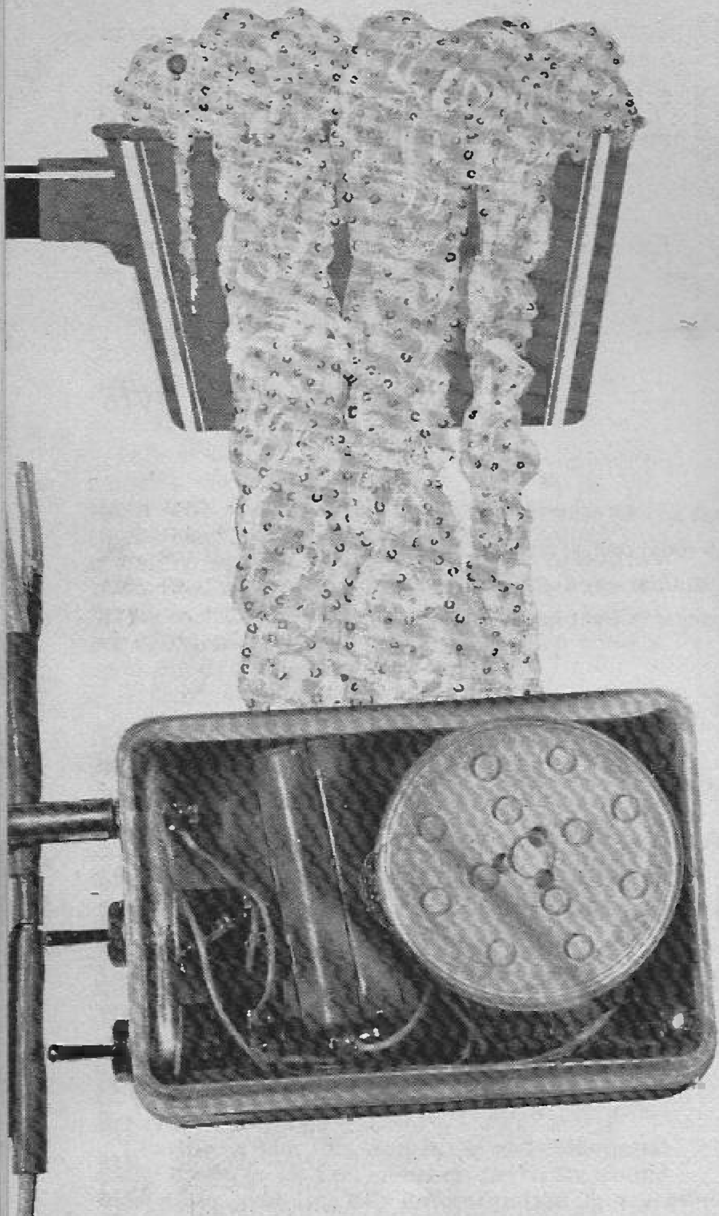
Binders for volumes 1 to 5 (state which) and indexes for volume 1 and 2 available for £1·85 and 30p respectively, including postage, from Binding Department, Carlton House, Great Queen Street, London, WC2E 9PR.



BOILING LIQUID ALARM

By P. J. TYRRELL

THE unit described in this article was designed after much cursing and elbow grease as a result of leaving pans of milk on the cooker and promptly forgetting about them. This device provides an audible warning at the onset of boiling of either water or milk. It requires no electrical connection to the cooker or mains, being battery powered and using a submersible temperature probe.

CIRCUIT OPERATION

The circuit of the alarm is shown in Fig. 1. It is built around an NE555 integrated circuit and an ordinary silicon diode. The diode is mounted in the probe tip and acts as the actual temperature sensor. The forward voltage variation with temperature change of the diode, normally a nuisance in most diode applications, is fully exploited in this circuit. The NE555 is connected as an astable multi-vibrator and drives the earphone or speaker to give an audio tone.

When the temperature of the diode increases the current into the base of TR1 decreases, turning it off. The voltage at pin 4 of IC1 rises enabling it to oscillate freely.

Potentiometer VR1 permits the trigger temperature to be correctly set while S2 gives switching for milk/water and a battery test facility. In position 2, R1 and R2 are in circuit and the unit will trigger when the probe approaches the boiling point of milk. In position 3, R1 and R2 are shorted out and the unit now triggers at the boiling point of water. With S2 in position 1 the probe is shorted out and IC1 oscillates freely.

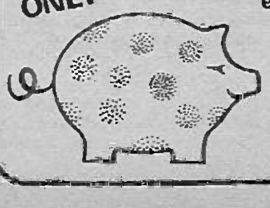
CONSTRUCTIONAL DETAILS

Most of the components are mounted on a small piece of 0·1 inch matrix Veroboard, 20 holes long by 12 strips wide. If the constructor has little experience in soldering it is recommended that a more spacious layout is adopted, necessitating a bigger piece of board and a larger box. Also IC1 can be mounted in a socket if desired. The component layout and the track breaks required are shown in Fig. 2. The holes for mounting VR1 should be drilled to suit the particular component available.

The prototype unit used a small 45mm

FOR GUIDANCE ONLY

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



£2.00
excluding case

*Based on prices prevailing at time of going to press

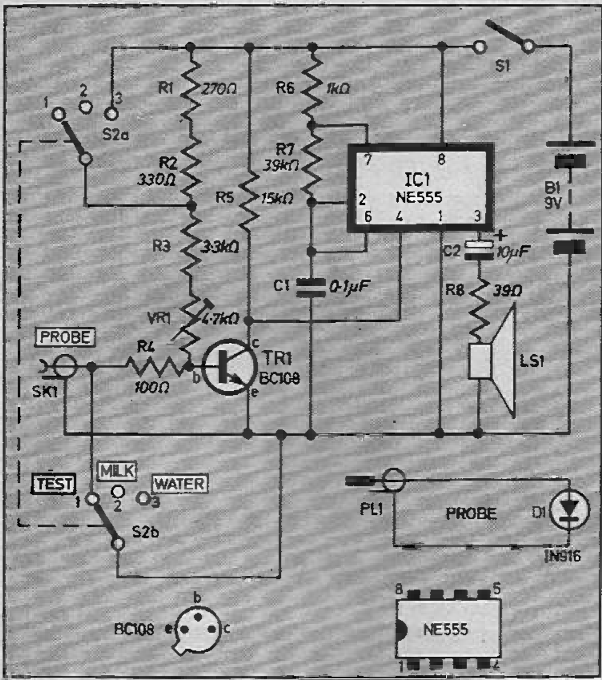


Fig. 1. Complete circuit diagram of the Boiling Liquid Alarm.

Components....

Resistors

R1	270Ω
R2	330Ω
R3	3·3kΩ
R4	100Ω
R5	15kΩ
R6	1kΩ
R7	39kΩ
R8	39Ω

All ¼ watt ± 5% carbon

SEE SHOP TALK

Capacitors

C1	0·1μF 100V polyester
C2	10μF elect. 25V

Semiconductors

IC1	NE555 integrated circuit timer
TR1	BC108 silicon *npn*
D1	IN916 silicon diode

Miscellaneous

LS1	20 to 100Ω telephone earpiece or loudspeaker
S1	single-pole on/off switch
S2	2 pole 3 way switch
SK1 and PL1	sub miniature jack plug and socket
VR1	4·7kΩ miniature preset potentiometer

Plastic box; battery connector; Veroboard, 0·1 inch matrix, 20 holes by 12 strips; Veropins; connecting wire etc.

diameter telephone earpiece for LS1 although a high impedence (20 to 100 ohms) speaker may be adopted instead. A plastic soap box was at hand and this provided an admirable housing for the alarm, although there is of course no reason why a metal container should not be used.

Veroboard wiring up is also shown in Fig. 2. Pieces of cardboard were used in the prototype to insulate the battery case from the switch terminals and the Veroboard from the back of LS1.

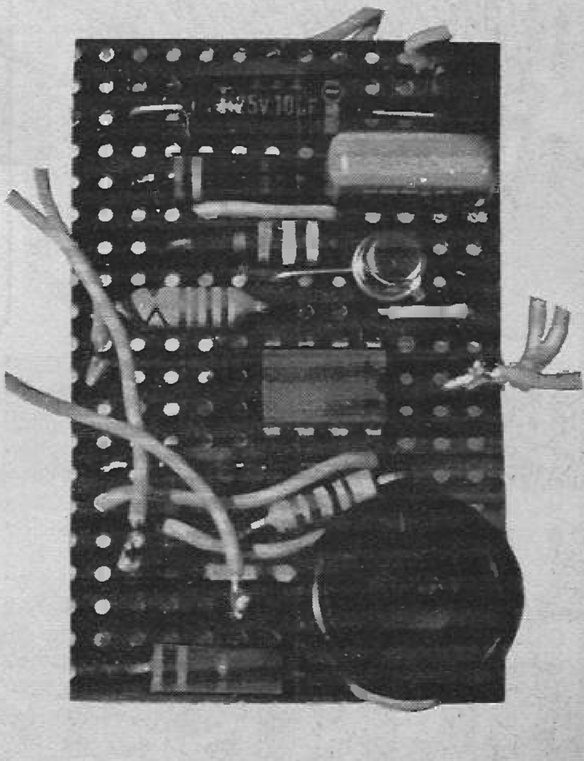
Lastly 2 strips of magnetic rubber were stuck to the underside of the box permitting the unit to be easily secured to a cooker top.

PROBE CONSTRUCTION

The encapsulation of the diode is shown in Fig. 3, this provides a waterproof probe. The aluminium can (about 12mm long by 6 mm diameter) was obtained from an old transistor (OC81, OC200 etc.). A crocodile clip was fixed to the supporting wires to permit the probe to be clipped to edge of a saucepan.

SETTING UP

With the probe plugged in and S2 set to "water" (position 3) the unit should be switched on. If a meter is available the current consump-

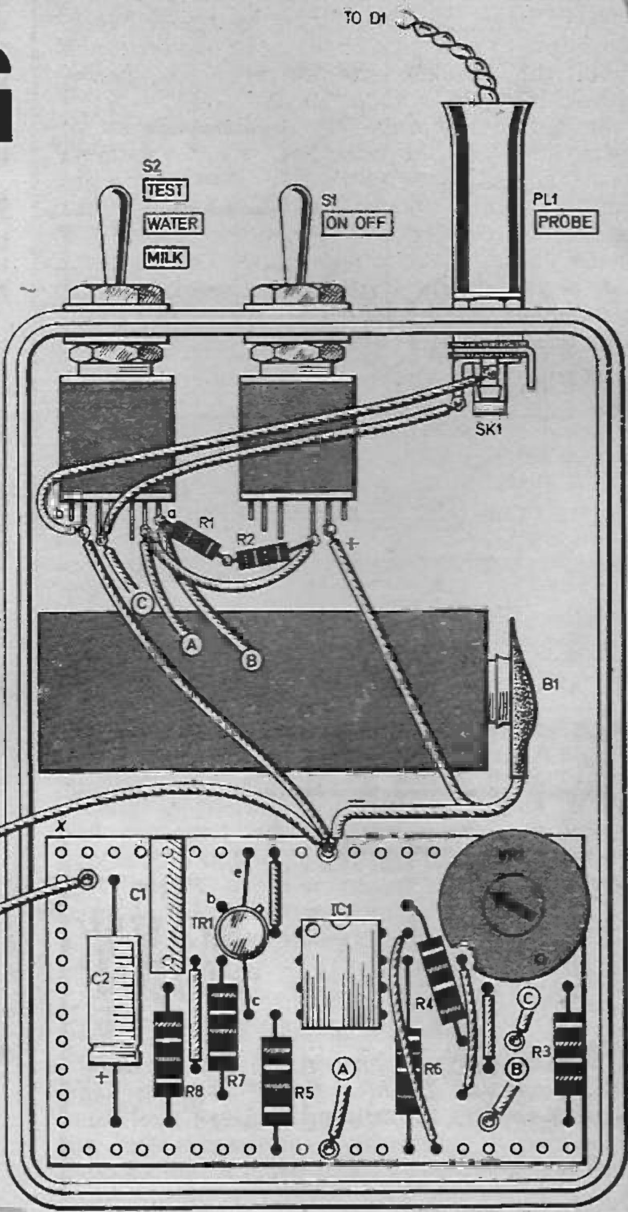


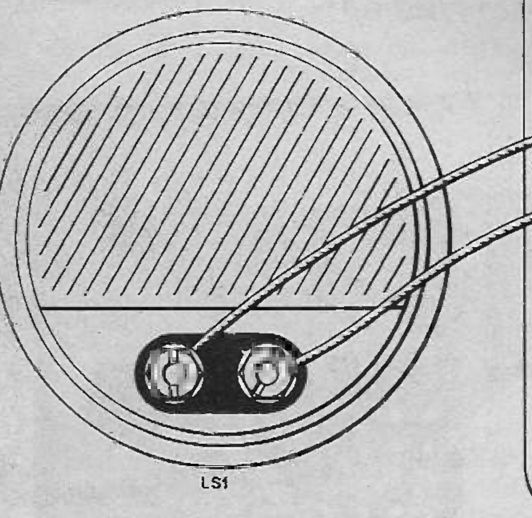
Photograph of the completed prototype component board.

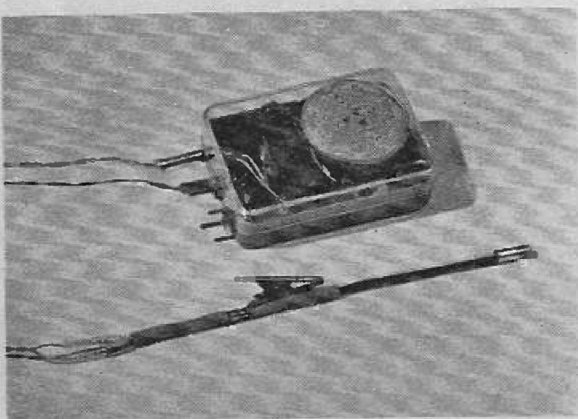
BOILING LIQUID ALARM

Fig. 2. Layout and wiring of the Veroboard and complete wiring up details of the unit.

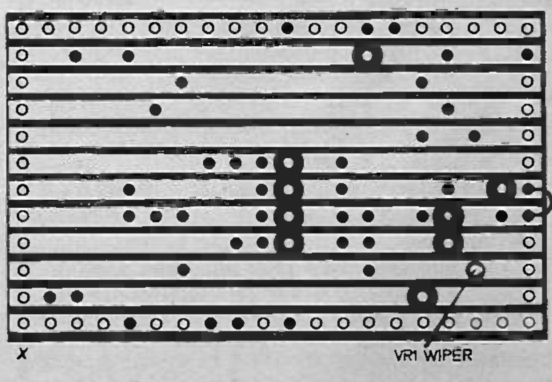
A photograph of the completed unit is shown below.







◎=VEROPINS



tion can be measured; it should be around 15mA at this stage, S2 should now be set to "test" (position 1) and an audible tone should sound from the speaker—the current consumption should increase to about 30mA.

Immerse the probe tip in about 25mm of water in a pan and heat. Set VR1 to minimum resistance and wait until the water approaches boiling point. Rotate VR1 until the alarm sounds. Now allow the water to cool a little and then reheat it. As it approaches boiling point the alarm should trigger; if not adjust VR1 accordingly. If the alarm fails to trigger with VR1 at maximum resistance and the water boiling it may be found that the diode has been connected the wrong way around.

Now try out the alarm on a pan of milk (setting S2 to position 2). If there is any discrepancy in the milk/water settings VR1 can be set to give a compromise, or R1 altered to compensate.

MODIFICATIONS

If the unit is required to trigger at some lower temperature R1 or R2 can be increased in value. Also the output tone can be increased/decreased in frequency by decreasing/increasing the value C1. ▣

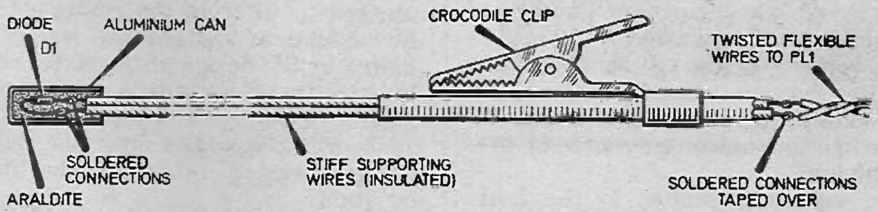
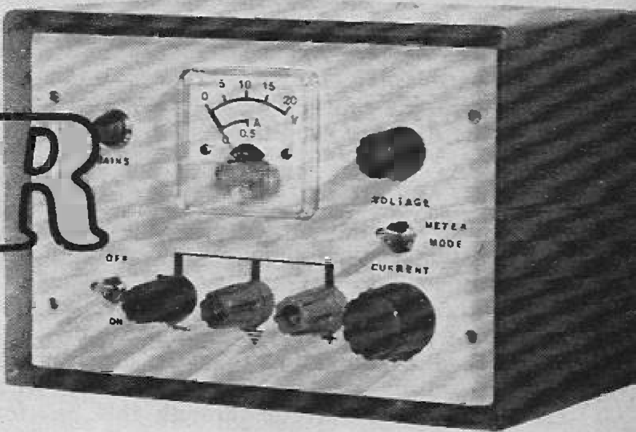


Fig. 3. Showing the construction of the temperature sensor probe.

ABOUT POWER SUPPLIES



Explains circuit action and limitations of stabilised power supplies

By J. SMITH

THIS short article will explain the difference between constant voltage, constant current and current limit as applied to power supplies. It will also introduce the readers to another feature found in power supplies, "crowbar protection".

CONSTANT VOLTAGE

The principles of a modern constant voltage power supply are shown in Fig. 1. A high voltage d.c. source is fed through a series regulator to the output. The series regulator is designed to drop a voltage proportional to its control voltage. The regulator is usually designed to vary the voltage at the output terminals from 0 volts to within a volt or so of the high d.c. voltage.

A constant output voltage is achieved by comparing the *output* voltage with a *reference* voltage in the difference amplifier. With this arrangement any change in load or output voltage is sensed by the difference amplifier, which then produces a compensating control voltage to correct the change. Thus the output voltage remains constant regardless of changes in load or mains supplies.

In practice constant voltage supplies have

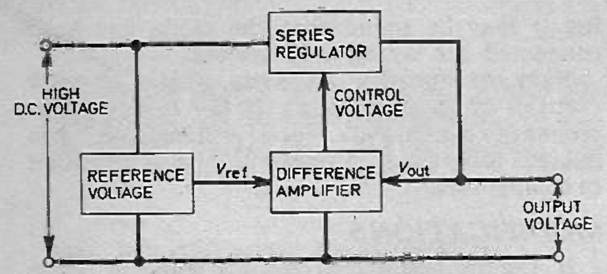


Fig. 1. Block diagram of a constant voltage power supply.

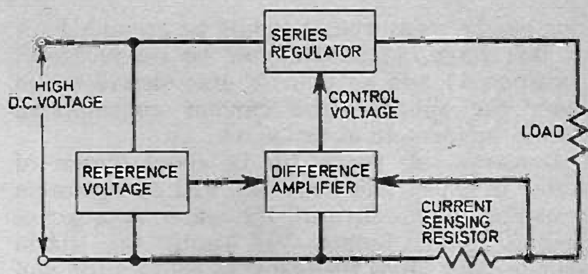


Fig. 2. Block diagram of a constant current power supply.

some very definite limitations which must be allowed for, these are: current limitation, voltage limitation, mains limitation.

A constant voltage across a short circuit requires infinite current, clearly impossible. Therefore all power supplies are limited, in their design, to the amount of current they are capable of supplying.

The high d.c. voltage is limited by the dissipation capabilities of the series regulator. When the power supply is set to its minimum output voltage and maximum current, the series regulator has to dissipate the voltage dropped across it. Therefore the design is limited to give a maximum d.c. voltage at the output terminals.

Finally if the mains voltage drops so will the high d.c. voltage, so the designer puts a limit on the permissible mains variation. This enables him to design a supply capable of compensating for all the specified conditions.

CONSTANT CURRENT

A constant current supply would work in the fashion shown in Fig. 2. It has a series regulator, differential amplifier and reference voltage in common with the constant voltage supply, but its method of operation is quite different. A current sensing resistor is fitted in *series* with the load. If the current through this resistor changes, the voltage across it changes. This change is sensed by the difference amplifier which produces a control voltage to compensate for the change. By this means the *voltage across the sensing resistor* is held constant thereby keeping the current through it constant. If the load (in series with the current sensing resistor) changes then the supply will change its *voltage* output in order to maintain a constant current.

As with the constant voltage supply so the constant current supply has identical limitations. To maintain constant current in an open circuit requires infinite voltage, but the supply is only capable of giving a certain maximum. This maximum output voltage puts an automatic limit to the highest value of load resistor through which the supply can keep a constant current flowing.

The actual constant current setting may be changed by altering the reference resistor, but the amount of current the supply can give is limited by the design of the series regulator. The designer therefore puts a maximum limit to the amount of current the supply can give. As with the constant voltage supply the designer works within specified limits to the mains supply variation.

To summarise so far: A constant voltage supply strives to keep a fixed voltage across its output terminals and will vary its *current* to maintain this voltage when the load is changed. Conversely a constant current power supply will vary its *voltage* in order to maintain current flowing in the load.

CURRENT LIMIT

The most common type power supply is the "constant voltage" supply, which as we have seen is limited by dissipation in the series regulator to the amount of current it can supply. If a constant voltage supply is shorted accidently it will quickly burn out the series regulator unless some form of protection, such as a fuse, is provided.

Modern supplies provide this protection by limiting the amount of current the supply is capable of giving. The circuits which achieve this approximate to constant current supplies under certain conditions, but the supply is not a constant current supply in normal use (a circuit using this type of limit is discussed later).

CROWBAR PROTECTION

Some supplies are fitted with "crowbar protection". This is a circuit arrangement used with fixed voltage supplies which senses an over-voltage (fault) capable of damaging the transistor circuits the supply is driving. When an over voltage is sensed a silicon controlled rectifier (thyristor) is fired and shorts across the output terminals. The thyristor will take a very heavy current until a fuse blows. This heavy short circuit current capability of the system gives rise to the name "crowbar".

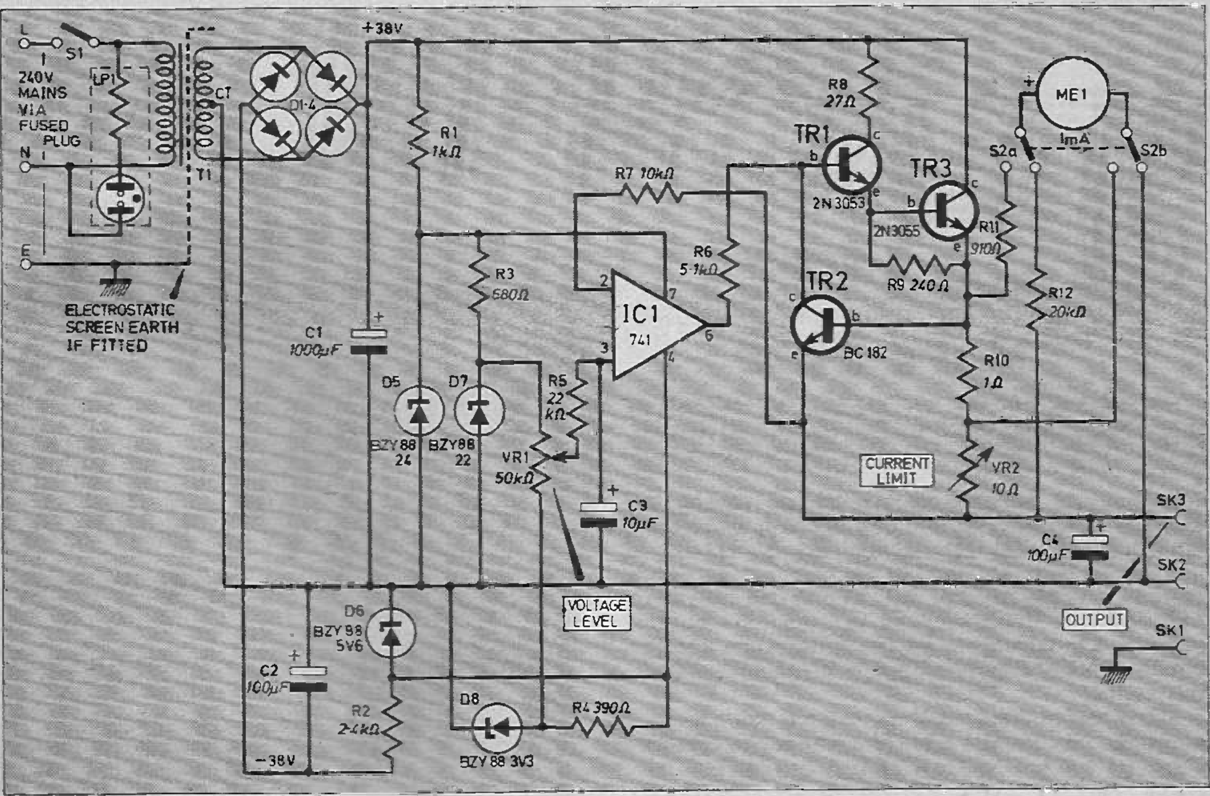


Fig. 3. Typical circuit diagram of a constant voltage supply with current limit.

SUPPLY CIRCUIT

The circuit reproduced in Fig. 3 is of the power supply published in our February '74 issue. This circuit does not have crowbar protection but it does have current limit to protect the series regulator.

The series regulator comprises TR1, TR3 and their associated components with the control voltage input fed to R6. The series regulator may be tested (with IC1 removed) by connecting a voltage between R6 and earth. The output terminals should take up a potential a volt or so less than this voltage. If this control voltage is varied the output should follow. The current limit comprises a sensing resistor R10 and VR2 connected to the base of TR2. When an excessive output current flows TR2 conducts, thereby robbing TR1 of its base current.

When a short circuit occurs across the power supply output terminals, TR1 is robbed of most of its base current and the output current limited to 0·5A or so. The precise limit will depend upon the particular components used, but it may be adjusted to 0·5A by selecting an appropriate value for R6. Thus, under short circuit, or near short circuit conditions the supply behaves in a similar manner to a constant current supply. However, under normal conditions the supply is constant voltage.

To summarise, the supply will give 0 to 20 volts at 0·5A with VR2 turned to its maximum. If the load exceeds 0·5A the supply automatically changes to its current limit mode of operation. Similarly with smaller loads the current limit will come into operation if VR2 is turned down. Thus there is interaction between the voltage and current under certain conditions and users must ensure that they know these conditions.

With VR2 at its maximum, loads of up to 0·5A will not bring the current limit into operation. However, if VR2 is turned to its minimum position, the supply will only function normally with loads of less than 50mA. Once these currents are exceeded the supply switches to its current limit mode, behaving like a constant current supply by giving a *varying* output voltage.

Readers will no doubt be interested to hear of a completely new type of power supply design now being used for professional electronic equipment which overcomes the dissipation problem of series regulators. This new supply called a "switching supply" is smaller and more efficient than the conventional supplies described here, and has the additional advantage of tolerating a much wider variation in mains voltage. Needless to say, they are very much more complicated than the conventional designs in current use. ▣

TEACH-IN 76

By A.P. STEPHENSON

Part Five

5.1 THE DIODE

A diode is a component which possesses the property of allowing current flow in *one direction only*. Most of the varieties manufactured resemble resistors in appearance but instead of the colour code bands there is a single band or spot at one end called the **cathode**; the unmarked end is called the **anode**, see Fig. 5.1a which shows the appearance and the circuit symbol and photograph of diodes used in this series.

The arrow of the symbol indicates the direction of conventional current, i.e. only from anode to cathode.

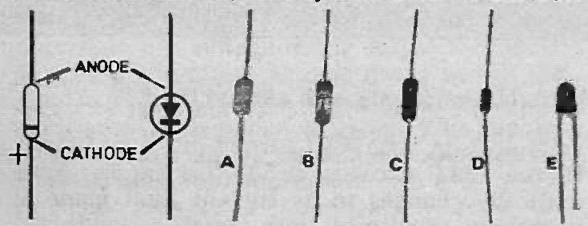


Fig. 5.1a. Schematic and circuit symbol of a diode. Photograph shows diodes used in this series (A) rectifier (B) point contact germanium (C) general purpose silicon (D) Zener (E) l.e.d.

To illustrate the one way only behaviour see Fig. 5.1b. Apart from the one way only property, a diode does not obey Ohm's law when it is passing current. If the voltage across a diode is doubled, the current, instead of doubling, will rise enormously. If the diode is made of silicon (and most of them are nowadays) current will only become appreciable when there is 0.6 volts across it.

The current will rise at an enormous rate for even slight increases of voltage above this figure—in fact 1 volt is sometimes sufficient to destroy a small diode. For this reason it is necessary to include a resistor in series with a diode to limit the current flow to safe limits. *Never* place a diode straight across a battery—unless you are a sadist.

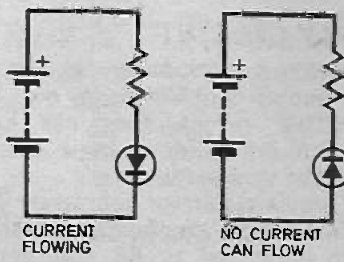


Fig. 5.1b. A simple circuit to illustrate the uni-direction property of a diode.

5.2 THE DIODE GRAPH AND CALCULATIONS

The complete behaviour of a silicon diode can be shown very simply by means of the graph shown in Fig. 5.2a. This graph shows:

(a) Even when the applied voltage is the "right way round" (known as **forward volts** or **forward bias**) no appreciable current flows until about 0·6 volts is reached.

(b) The current rises rapidly for even small rises of voltage above 0·6 volts.

(c) When the voltage across the diode is the "wrong way round" (known as **reverse volts** or **reverse bias**) negligable current will flow unless the voltage reaches a value called **reverse avalanche** voltage. Very heavy current will flow if this voltage is reached. Note that the reverse voltage axis of the graph is not the same scale as that of the forward voltage. The reverse avalanche will normally be at least 50 volts but could beas high as 400 volts, depending on the type of diode.

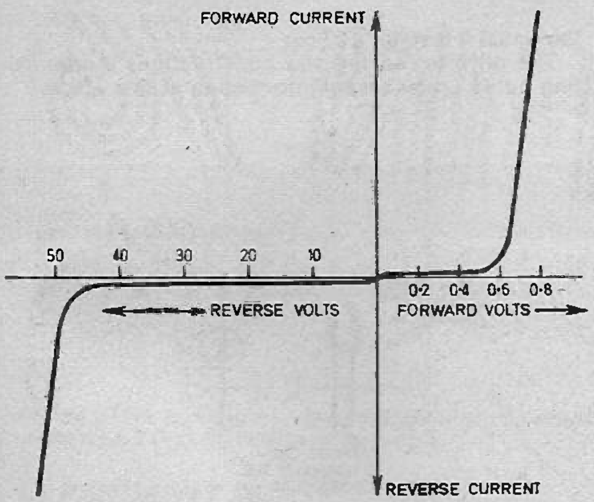


Fig. 5.2a. Graph showing forward and reverse characteristics for a silicon diode.

Since a diode with forward bias doesn't obey Ohm's law, there is little point in asking what is its resistance? A diode has a resistance but it is not a constant value and useless for circuit calculations. What is useful is the 0·6 volts drop which can be taken as a reasonable approximation; Fig. 5.2b shows how to treat the diode in circuit calculations.

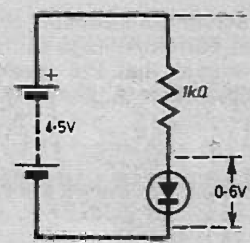


Fig. 5.2bA forward biased diode "drops" 0·6 volts.

$$\text{Current flowing in circuit} = \frac{(4{\cdot}5 - 0{\cdot}6)\text{ volts}}{1\text{ kilohm}}$$
$$= 3{\cdot}9 \text{ milliamps}$$

The silicon diode has been the standard general purpose diode for some years. The first semiconductor diodes were made of germanium which differed in two ways from silicon.

(a) Germanium "leaks" badly. (Some current flows even with reverse bias.)
(b) The forward volts volts drop is about 0.2 volts instead of 0·6 volts for silicon.

5.3 USE OF DIODES

Our prime source of power so far has been the battery which delivers a reasonably constant voltage of fixed polarity known as **d.c.** (meaning direct current). The domestic mains electricity supply on the other hand is **a.c.** (meaning alternating current) and unlike the battery, delivers a voltage which is continuously *reversing* its polarity fifty times a second!

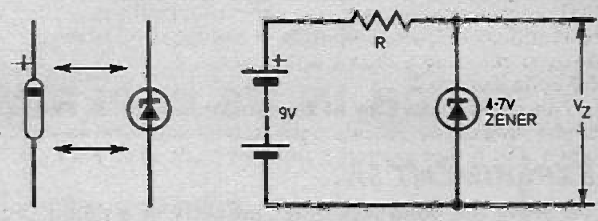
To convert a.c. to d.c. all that is needed is a diode to prevent the current reversing and certain smoothing components (which are dealt with later in the series). Such diodes are called **rectifiers** and may often pass currents of many amperes.

Apart from this, diodes are used abundently in many areas of electronics, sometimes simply to drop about 0·6 volts.

5.4 THE ZENER DIODE

Zener diodes are used to prevent a voltage from changing, i.e. to provide a constant voltage drop, voltage reference, etc. For example, if we wished to maintain 4·7 volts across two points in a circuit, a 4·7 volt Zener diode could be used. Unlike normal diodes, Zeners are used with reverse bias sufficient to cause **avalanche breakdown**. The circuit symbol, physical appearance and correct operating polarity are shown in Figs. 5.4a and b.

The circuit shows up an important point—the battery voltage must be greater than the Zener voltage otherwise the Zener diode could never avalanche or "strike" as it is sometimes called. Once the Zener diode has struck, the voltage across it remains locked at 4·7 volts (approximately) even if we change the value of *R* or increase or decrease the battery voltage within reasonable limits. Thus if we reduce *R*, more current will flow through the Zener, but it will still maintain nearly the same 4·7 volts across it. Although the 4·7 volt Zener has been used as the example, manufacturers produce a whole range of Zeners with different striking voltages up to over 100 volts, and different power ratings.



(a) (b)

Fig. 5.4a. Shows the circuit symbol and appearance of a Zener diode (b) correct polarity to ensure Zener action.

For example, a Zener may be quoted as 6·8 volts, 300 milliwatts. The power rating indirectly specifies the maximum permissible current which in this case is given by:

$$I = \frac{P}{V} = \frac{300\text{ milliwatts}}{6{\cdot}8\text{ volts}}$$
$$= 44 \text{ milliamps}$$

The actual construction of a Zener and also the graph of current/voltage is no different to a normal diode, except that the reverse avalanche point is precisely stated. A Zener with forward bias drops the usual 0·6 volts.

The physics (behind the construction) is interesting but is unnecessary information at this stage.

5.5 LIGHT EMITTING DIODES

Semiconductor diodes always send out some form of radiation when they are forward biased. Normal silicon diodes have no useful radiation but special diodes currently made from a material called gallium phosphide emit visible radiation when passing current. Diodes manufactured to exploit this property are called **light emitting diodes** (l.e.d.s.) and are becoming very popular as panel lights, as general on/off indicators and, perhaps most important of all to form the numerical displays in computers and hand calculators.

Light emitting diodes must not be dismissed under the heading of "just another little light bulb". Normal lamps are crude inefficient devices which squander most of their energy as heat with a little light as a sort of by-product.

The light from an l.e.d. is relatively pure and only slightly contaminated by heat, which means extremely low power consumption. For example, a typical "pea lamp" suitable for on/off indication consumes at least 40 milliamps at 4 or 6 volts. An equally typical l.e.d. would give sufficient indication off about 5mA at 1 volt, a power saving in the order of 40 to 1. Typical appearance and circuit symbol are shown in Fig. 5.5a.

Two vital rules apply to the operation of the l.e.d.'s:

(a) They must be operated the correct way round, i.e. cathode must be held negative with respect to the anode. Three or four volts reverse bias is normally lethal.

(b) Like any other diode, never place them straight across a battery, even a 1·5 volt battery could kill them. They must have a series resistance to limit the current.

The value of the resistance depends on how much light you want but must never be lower than a certain minimum, dictated by the manufacturers maximum current rating. For example the TIL209 has a maximum current rating of 40 milliamps continuous. If we use say a 4·5 volt battery, the series resistance must have a minimum value given by:

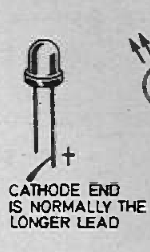


Fig. 5.5a. Shows physical appearance of a common light emitting diode oval circuit symbol. Sometimes the cathode is marked with a spot on the body.

$$R = \frac{\text{Battery voltage} - \text{Diode voltage drop}}{\text{Maximum permissible current}}$$

The diode voltage drop can be taken as 2 volts in most cases, so in our example:

$$R = \frac{(4\cdot5 - 2)\text{ volts}}{40\text{ milliamps}} = 62\cdot5\text{ ohms}$$

However it is seldom necessary or wise to run "full-out". A faint, but still quite visible, glow would be apparent at a current of 1 milliamp, that is with $R = 2\cdot5$ kilohms.

The percentage of gallium phosphide present in the device determines the colour of the radiated light, the available colours including red, orange, yellow and green.

Another advantage of the l.e.d. is the enormous speed at which the light can be turned on or off, less than one microsecond is not unusual.

TEACH-IN '76 EXPERIMENTS AND EXERCISES

EXPERIMENT 5A

To prove the "one way only" property of a diode.

PROCEDURE

1. Assemble the components on the Circuit Deck as shown in Fig. 5A.2. Compare with the theoretical circuit of Fig. 5A.1. Because the diode is forward biased, the lamp should glow.

2. Remove the diode and replace it the other way round. The lamp does not glow as current cannot flow through the lamp due to the reverse biased diode.

Note: No current limiting "resistor" is incorporated in the circuit as the bulb fulfils this function.

Question

Assuming the battery was changed to 9 volts, what value series resistor should be used to ensure that the lamp is still operating within its voltage rating?

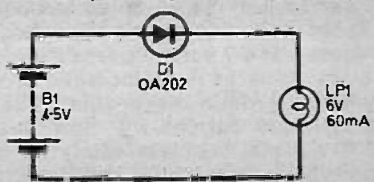


Fig. 5A.1. The theoretical circuit diagram to illustrate the "one way" property of a diode.

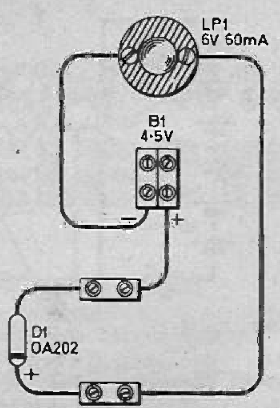


Fig. 5A.2. The layout of the component and wiring up details on the Circuit Deck for experiment 5A.

EXPERIMENT 5B

To show that the diode voltage is fairly constant in spite of large current variation.

PROCEDURE

1. Assemble the components as shown in Fig. 5B.1 leaving the 1 kilohm potentiometer fully anticlockwise.
2. With the meter set for 1 volt, measure the voltage across the diode. You should obtain a reading of between 0·6 and 0·7 volts.
3. Now slowly rotate the potentiometer control and note the meter reading rises by only a small amount. With the control fully advanced the reading will still be low, around 1 volt.

CONCLUSION

The minimum current flowing is given by:

$$I = \frac{(9 - \text{voltage across diode})\ \text{volts}}{1{\cdot}2\ \text{kilohms}}$$

$= 7$mA (approximately)

The maximum current flowing is given by

$$I = \frac{(9 - \text{voltage across diode})\ \text{volts}}{0{\cdot}2\ \text{kilohms}}$$

$= 40$mA (approximately)

The current through the diode has increased by about 600 percent, but the voltage across the diode has changed very little.

Repeat the experiment using the 25 kilohm and 2 megohm potentiometers. Your calculations should confirm even more strongly the diode's disregard for Ohm's law.

Question

If the diode is reversed, the voltage across it would be 9 volts irrespective of the potentiometer setting. Why is this?

EXPERIMENT 5C

To show how a Zener diode can "lock" or stabilize a voltage.

PROCEDURE

1. Assemble the components on the Circuit Deck as detailed in Fig. 5C.1. Leave switch S1 off and the 1 kilohm potentiometer fully anticlockwise. Before switching on ensure that the Zener is connected in the correct way around.
2. With S1 on, measure the voltage across the Zener diode, V_{OUT}, with the voltmeter plugged to the 5 volt range. Slowly advance the potentiometer control in a clockwise direction; V_{OUT} will rise smoothly towards 4·7 volts because the Zener is not conducting until this value is reached. For V_{IN} above 4·7 volts V_{OUT} will start to "lock" and will rise only slightly, even when the potentiometer is fully clockwise.

CONCLUSION

Although V_{IN} changed from 4·7 volts to 18 volts, the Zener voltage V_{OUT} has only changed by half a volt or so. The so called "control ratio" of the circuit is given by:

$$\frac{\text{change of } V_{IN}}{\text{change of } V_{OUT}} = \frac{(18 - 4{\cdot}7)\ \text{volts}}{(\max V_{OUT} - 4{\cdot}7)\ \text{volts}}$$

Example

If the maximum V_{OUT} was 5 volts, the control ratio

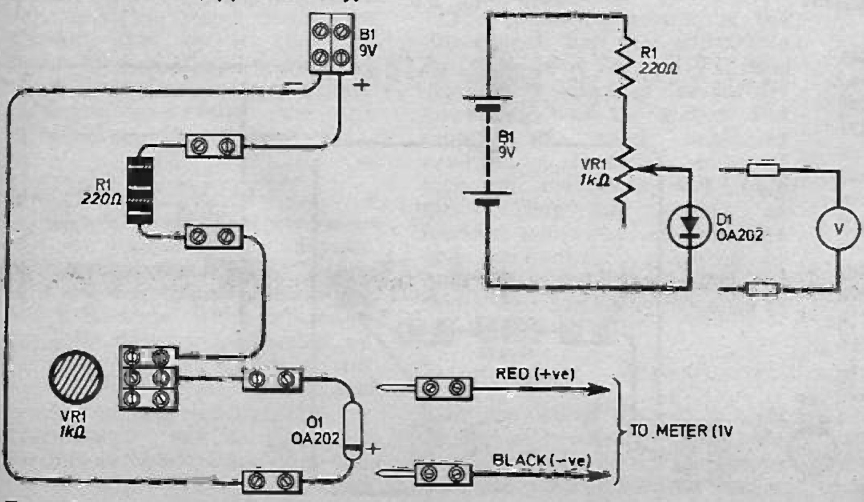


Fig. 5B1. Component layout on the Circuit Deck and complete wiring up details for experiment 5B. Also shown is the theoretical circuit diagram.

is equal to $\frac{(18-4{\cdot}7)}{(5-4{\cdot}7)}$

=44 (approx.). Don't expect the Zener to be exactly 4·7 volts, remember, all components have tolerance.

3. Repeat the above experiment procedure but now with the Zener diode reversed (i.e. in the forward biased mode, and observe that the Zener behaves as a normal diode "locking" at about 0·6 volts).

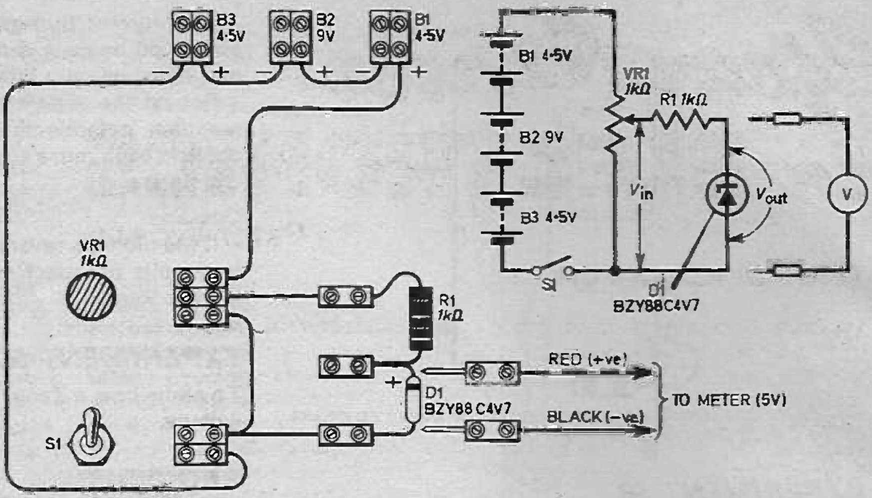


Fig. 5C.1. Shows the layout and wiring up of the components on the Circuit Deck, together with the theoretical circuit diagram for experiment 5C.

EXPERIMENT 5D

To investigate the light emitting diode.

PROCEDURE

1. Connect up the components on the Circuit Deck as shown in Fig. 5D.1. Take great care that the l.e.d. is the correct way round noting that the shorter lead is the anode and must go to the positive terminal of the battery.

2. Commence with the 25 kilohm potentiometer fully anticlockwise and rotate slowly until you can just see the l.e.d. glowing. Calculate how much resistance is in series with the l.e.d. by noting the percentage rotation of the control relative to 25 kilohms.

3. Calculate the minimum glow current from:

$$I=\frac{\text{battery voltage − voltage dropped across l.e.d.}}{\text{total resistance in series with l.e.d.}}$$

$$=\frac{9-2}{R_t}$$

where R_t includes the 220 ohm series limiting resistor.

4. Now advance the potentiometer fully clockwise, note the brilliance and calculate the current.

Don't reverse the diode to prove it won't work backwards because it won't — ever again!

EXERCISES

5.1 A simple diode is usually marked with a spot or coloured band at one end and will not pass "forward current" unless this end is held ——— with respect to the other end. Fill in the blank.

5.2 A diode is in series with a 2 kilohm resistor and a 9 volt battery and is passing current. Calculate the aproximate current expected.

5.3 What assumption was necessary in order to answer question 5.2.

5.4 If a diode was passing a very large forward current would we still expect a drop of 0.6 volts.

Answers

5.1 Negative. 5.2 4.2 milliamps. 5.3 The diode drops about 0·6 volts. 5.4 No. The drop could be a volt or more Refer to graph of Fig. 5.2a.

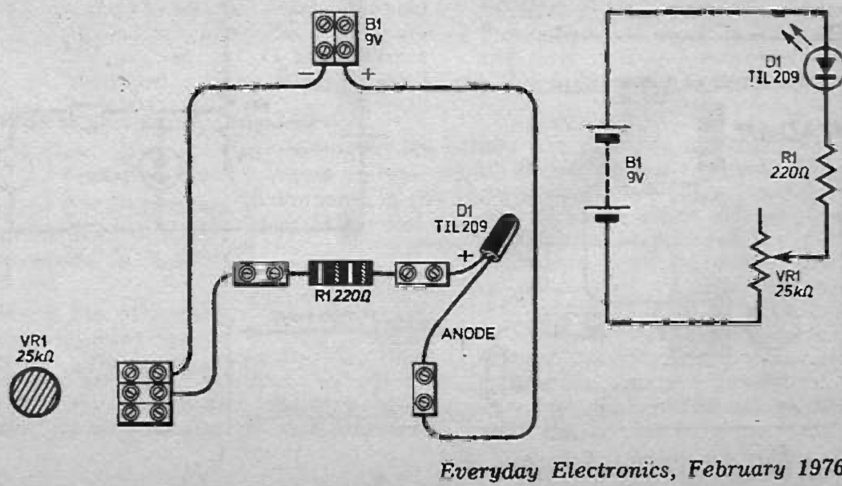


Fig. 5D.1. Component layout and wiring up details for experiment 5D with circuit diagram

Your Career in ELECTRONICS

By Peter Verwig

THE ROYAL AIR FORCE

When Britain was faced with possible annihilation, as was the case in the critical days leading up to the start of the 1939-45 war and during the first years of the struggle itself, the level of technical innovation and the speed of its implementation accelerated tremendously. And nowhere more spectacularly and with such demonstrable success as in air defence. One is reminded of Samuel Johnson who said on September 19, 1777, "Depend upon it, Sir, when a man knows he is to be hanged in a fortnight, it concentrates his mind wonderfully".

The earlier 1914-18 war was the forcing ground for the technology of the flying machine. At the beginning of that war the aeroplane was little more than a mechanical novelty. By the end, the technology of flight was such that the foundation for the development of civil and commercial aviation has been substantially completed. The process was repeated in the 1939-45 war but on a far broader technological front.

The design of aircraft and engines saw continuous improvement and even completely new innovations such as the jet engine which, in later years, was to supersede the piston engine on all but light aircraft. But the main distinguishing feature of the 1939-45 from its predecessor a generation earlier was the introduction of electronics.

RADAR

The key development was radar and the trigger for its ultimate development was a paper "Detection and Location of Aircraft by Radio Methods" which arrived at the Air Ministry in London on February 12, 1935. Its author was Robert Watson-Watt, the Superintendant of the National Physical Laboratory's Radio Research Station at Ditton Park, just outside Slough. Within a few days a demonstration was arranged, the object of which was to prove that electromagnetic energy would be reflected from an aircraft and could be detected by suitable equipment.

The experiment was one of supreme simplicity, and used the BBC short wave broadcast transmitter at Daventry which had a power of 10kW and radiated in a beam of 30 degrees at an inclination of 10 degrees above the horizon. To prove the point an aircraft would fly through the beam and it was hoped that signals reflected from the aircraft would be received on specially adapted equipment which would neutralize the direct transmission from Daventry and display only the signal reflected from the aircraft.

On the morning of February 26, 1935, a Heyford twin-engined bomber of the Wireless and Electrical Flight took off from the Royal Aircraft Establishment, Farnborough, and flew a prearranged course in the Daventry area. The aircraft was detected by the receiver at ranges of up to 10 miles and radar in its most embryonic form had arrived. The receiver used in the historic equipment eventually found a home in the Science Museum, South Kensington.

The practical outcome of the experiment was that £10,000 (a laughable sum by today's standards) was allocated for further development of the system. But from this small beginning emerged a fantastic series of technical inventions and, once the fighting had started, an intricate game of electronic move and counter-move practiced by both sides and then called the Radio War, and today is known as Electronic Warfare.

OUTCOME

By the end of the war a great electronics industry had been built up much broader in scope than the pre-war industry which, apart from a few innovations such as radio-therapy in medicine, was mainly concerned with radio communications, essentially the building of receivers and transmitters for professional or entertainment purposes. The mainstream of effort during the war had become directed to signal processing and display, and the generation of powerful signals at microwave frequencies almost undreamt of in the 1930s.

The realisation that the electron could be manipulated effectively for purposes other than "wireless communication" led to new branches of technology such as the electronic computer and industrial automation.

The war-time experience, however, created something else entirely new. It brought about, reluctantly at first and then with growing impetus, a partnership between the air arm and the scientific establishment which has continued to the present day. The Royal Air Force, youngest of the British armed services, was unemcumbered by centuries of tradition. It was uninhibited and therefore able to seize on new ideas which would improve its efficiency.

In the post-war years one might have imagined that the pace of technical development would have slowed. Events decreed otherwise. The Cold War of the '50s demanded continued military preparedness in conventional weapons, and the great new field of space flight, if anything, accelerated research and the introduction of novel techniques. The past two decades have ushered in the transistor, the integrated circuit, the miniature airborne computer.

The aerospace industry was responsible for all the advances in high packing density of electronic components leading first to miniaturisation, and then to microminiaturisation, so that today powerful electronic equipment that would have completely filled the largest bomber of the 1939-45 era can be packaged for stowage in the smallest fighter aircraft.

In a world which remains disfigured by conflict and the threat of conflict a substantial defence force is the best guarantee of peace and security—at least until universal disarmament, a dream which has never been realised and probably never will be.

Raymond Baxter, TV commentator, takes his seat in a two-seater Harrier VTOL aircraft at the Farnborough Air Show. RAF Harrier squadrons are deployed in Germany.

GOOD ENOUGH?

As we have seen, the aerospace industry has been the father of technical innovation and it follows naturally that if your interests are in technology at the highest level, in many cases at the very frontiers of science, then the Royal Air Force is a career goal well worth pursuing—if you are good enough!

Yes—if you are good enough. Look at it this way. In the early days of aviation people built flying machines and then added equipment to them—machine guns, bombs, cameras, almost as an afterthought. Today's military aircraft are designed from the start as a complete weapons system. At the time of the Battle of Britain the key British aircraft were the Hurricane and Spitfire, each costing about £20,000 ready to fly.

Sydney Camm, responsible for the design of the Hurricane, was chief designer at Hawker from 1925 until his death in 1966. During this period he originated 52 aircraft types, an average of more than one a year. Nowadays it takes huge teams of designers typically ten years from putting pencil to paper to getting a new aircraft type into squadron service. And the cost per aircraft with full avionics and weapons fit is nearer £2 million than £20,000 and often considerably more.

In short, today's military aircraft is far too complex and, for that matter, far too valuable to be entrusted to the amateur, however gifted. Moreover, operational conditions have changed. Aircraft fly within an air defence complex in which all movements, friendly and otherwise, are detected by radar, and evaluated by electronic computer which determines the most effective counter-measures.

An efficient ground back-up is equally important, operationally, as the airborne component. What was once an art has now become a science. And although there is still opportunity for the exercise of individual skill and initiative, air defence today is far more of a team effort by specialists.

How can you become one of these specialists—one of the electronic trades elite in the Royal Air Force of the late 1970's and through the 1980's? Naturally, if the RAF is to spend thousands of pounds on your initial technical training and then re-training you at various stages of your career, you need to be young at the start and willing to stay with the Service for a long time, normally for 12 years or nine years plus three years on reserve, with the further possibility of staying on for a total of a 22-year career which carries a pension.

APPRENTICESHIP

If you are still at school you should consider an RAF

A RAF Nimrod maritime reconnaissance aircraft overflying a warship of the Soviet Union. The Nimrod carries an exceptionally heavy load of electronics equipment.

apprenticeship or cadetship. You must be medically fit and be a British subject or a citizen of the Republic of Ireland. There are some exceptions on nationality and residence requirements, so if in doubt on whether you qualify on these grounds your nearest RAF Careers Information Office (there are over 70 of these throughout the United Kingdom) will give you advice.

The apprentice technician trades in electronics are Electronic Technician (Navigational Instruments) and Electronic Technician (Air Communications/Air Radar). The age limits are normally 16-18½ years and in exceptional cases up to 21. You need four 'O' level GCE passes or equivalent which must include mathematics, a specified science or other technical subject plus two other subjects.

Again, you can get advice from RAF Careers Offices. Pay a visit to your nearest office and have a chat with the serving officers and NCOs on duty there. They will ask you questions but you, in turn, will be able to question them because it is just as important that the RAF will suit you as that you should suit the RAF.

If you decide to go ahead with your application for an apprenticeship you will undergo a series of verbal and written aptitude and intelligence tests followed by two private interviews. After the second interview you will be told whether you have been accepted and your parents will receive an official letter of confirmation. But you may well have second thoughts. Is this really the life for you? After all, it is a big decision for a young man to take and the Royal Air Force understands this. So you may withdraw your application at any time until you have been actually attested.

TRAINING

If your decision is still to go ahead, then, after basic recruit training, you move on to No. 2 School of Technical Training, RAF Cosford, which is near Wolverhampton, where you will be trained for up to three years with general grounding in electronic engineering and specific training in chosen fields. The courses are both theoretical and practical and include instruction on the equipment you will encounter when your training has been completed.

Your term of service starts when you are 18 or at the age of entry, whichever is the later. As well as plenty of free time for sports and other recreation you will be entitled to six weeks leave a year on full pay and four free travel warrants.

If you are too old to join as an apprentice there is a direct entry scheme for adults provided you have the basic educational qualifications and, if you already have some practical experience as an electronics technician, this is all to the good. After recruit training you will be sent on a single intensive course of study of up to 18 months and on completion emerge in one of four electronic fitter categories, Air Radar, Ground Communications, Air Communications, or Navigational Instruments.

The pay in specialist trades is comparable with that in the equivalent trade in ordinary civilian life but as an airman (or airwoman) you will be bound by service regulations and may be posted to any location, home or overseas, where you are needed. To most airmen this is not a handicap but a first-class method of travel and a beneficial broadening of experience.

GRADUATES

The RAF has a special welcome for graduates. If we look at the RAF from a business viewpoint it is a large, complex, technology-orientated organisation with a pay-roll of some 100,000 people and an expenditure of some £2 million per day. A "firm" of this size needs a lot of management and because of the nature of the "firm" it demands management skills every bit as good as in general commerce and industry and, in some areas, greatly superior skills. It is well worth while to try for commissioned rank and while you may be accepted with a minimum of five 'O' level passes you stand a much better chance if you read for a degree. And the RAF will help you to get one.

If you are a sixth-former staying on for 'A' levels you may be fortunate to win a Royal Air Force scholarship which will lead to a Cadetship. The scholarship carries a grant towards the cost of staying on at school to obtain the qualifications necessary to enter a degree course. If you already have these qualifications an RAF Cadetship will bring you an income while reading for a degree and the RAF also pays all tuition and examination fees. If you already have a degree you can still join under the scheme provided you are 22 years of age or under or, in exceptional circumstances, up to the age of 24.

PROMOTION

With an interest in electronics you would naturally opt for the Engineering Branch and as your career develops there are opportunities for further specialist training to second degree standard and other courses will be on staff training and management training. As a highly professional organisation the RAF today has no use for the "old boy" network. You get promotion from Pilot Officer to Flight Lieutenant on "time". After that, all the way up from Squadron Leader to Air Chief Marshall, promotion is entirely on merit.

As an Engineering Officer you may find yourself in the later stages of your career working on research and development interpreting the RAF's needs to equipment manufacturers and influencing their designs.

Whatever the rank to which you may aspire in an Air Force career you will be handling the newest technologies and be well equipped, technically, to continue your profession in civilian employment when you have left the RAF. And while you are serving you have job security and job satisfaction as well as having the rather special additional satisfaction of playing your part in keeping the peace.

That Sonic Bomber Game you made for the children—here's a list of things they bombed that you'll have to replace.

FIELD STRENGTH METER

By R.A. PENFOLD

Provides visual indication of radio control transmitter output

SOME form of field strength monitor is an extremely useful adjunct to a radio control link. It is really the only sure way of knowing if one is obtaining the maximum possible output from the transmitter, and thus also obtaining the maximum reliable range. It is an extremely useful piece of equipment even if the transmitter is a relatively simple one, such as that described in the January issue of EVERYDAY ELECTRONICS. But when using more complicated transmitters where there are oscillator, output stage, and possibly aerial loading coils to be adjusted, such a unit is virtually indispensable.

The monitor can easily be miniaturised, and the prototype has external dimensions of only

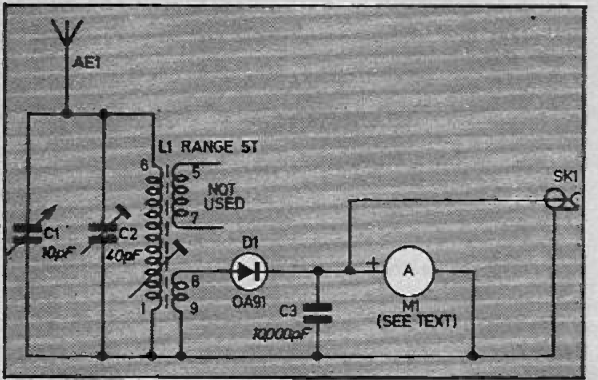


Fig. 1. Complete circuit diagram of the Field Strength Meter.

about 77×51×25mm, excluding the aerial and control knob. The unit is thus completely portable.

A passive circuit is used, and therefore no batteries or running costs are involved. This results in a less sensitive circuit than is possible when employing active (amplifying) devices, but the circuit is, nevertheless, sensitive enough for use with low power transmitters.

CIRCUIT OPERATION

Basically the circuit consists of a tuned circuit (L1, C1 and C2) feeding a diode detector D1, which in turn feeds a moving coil meter. The circuit diagram of the unit is shown in Fig. 1.

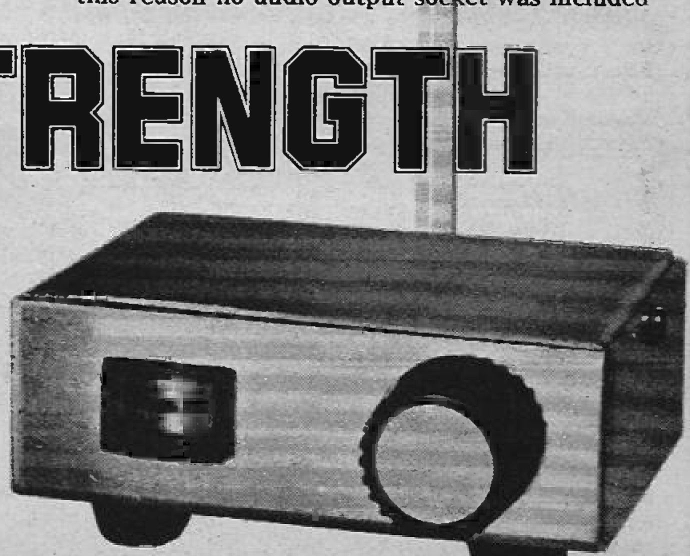
The aerial is coupled directly to the tuned winding of L1, which can be tuned over the entire 27MHz radio control band by means of C1; C2 is adjusted to give C1 approximately the correct frequency coverage, although the setting of this is not too critical, as C1 provides a degree of excess frequency coverage.

Signals in the tuned circuit are at a high impedance, and must be fed to the detector via a low impedance coupling winding in order to provide an efficient coupling, and to prevent excessive damping of the tuned circuit. A ready made Denco Range 5T blue coil is used for L1. The third winding on the ready made coil is unused in the circuit.

The detector diode D1, removes the negative going r.f. half cycles, but permits the positive going ones to pass. The remaining half cycles are smoothed to a positive d.c. signal by C3, and it is this d.c. signal that operates the meter.

Obviously, the stronger the signals received by the aerial, the larger the signal which is induced into the tuned circuit, and the greater the deflection of the meter. The meter thus presents an indication of the field strength produced by any radio control transmitter operating in the proximity.

A jack socket can be connected across the meter terminals, and if a crystal earpiece is plugged into this, any audio signal modulated onto the carrier of the monitored transmitter will be reproduced by the earpiece. Many simple radio control receivers include this feature, including the one described in the November 1975 issue of EVERYDAY ELECTRONICS, and for this reason no audio output socket was included



Components....

Capacitors
C1 10pF air-spaced variable (Jackson C804)
C2 40pF ceramic trimmer
C3 10nF type C280

Miscellaneous
D1 OA91 or similar germanium diode
M1 250μA or less moving coil meter
L1 Transistor useage coil type Denco Blue range 5T
AE1 Telescopic aerial with swivel base approx. 685mm long
SK1 3·5mm jack socket (if required)
Case to suit; control knob; insulated wire; solder

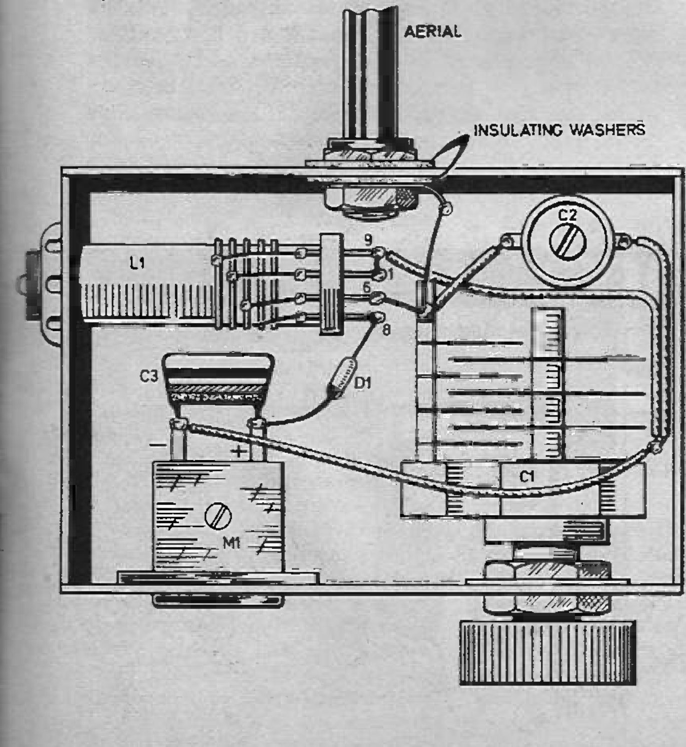
SEE SHOP TALK

on the prototype unit, although one is shown on the circuit diagram for completeness.

CONSTRUCTION

Virtually any small case will make a suitable housing for the monitor. The prototype is contained in a ready made aluminium box type AB12, with a modified lid.

The layout and wiring up of the unit is shown in Fig. 2, but as the unit is passive, the exact layout is not critical. However, when wiring up any r.f. circuit it is advisable to keep the connecting wires as short and direct as possible. This point should be borne in mind if a different layout is adopted.



If a metal case is used, the aerial, must be insulated from the case. This can be achieved by drilling its mounting hole slightly over size, and using rigid insulating washers either side of the hole with the aerial positioned so that it is not in direct contact with the case when the mounting nut is tightened. A continuity tester or ohmmeter should be used to check that the aerial is in fact insulated from the case, but this must be done before pins 1 and 6 of L1 are wired up, as the aerial connects to the case through this winding.

The coil has an OBA threaded portion at the top, and comes complete with a plastic fixing nut, and these are used to secure the coil to the side of the case. Do not tighten the nut to more than finger tightness, as the plastic screw thread is easily sheared.

Since the meter is only required to give a relative indication of the field strength, the type of scale fitted is irrelevant, and an inexpensive level or battery condition type meter is suitable, provided it has a sensitivity of 250 micoamps f.s.d. or less (e.g. 100μA or 50μA).

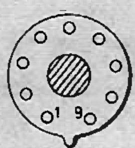
It is well worth shopping around when buying one of these meters as there are extremely wide variations in prices.

The fact that this type of meter is very robust and is not easily damaged by overloads is a very useful feature in this particular application.

An ordinary type panel meter can be used if preferred, but will need a larger case, and has only one real advantage, that of being easier to read. Whatever type of meter is used, the greater its sensitivity the better.

The cut-out for the meter in the case can be

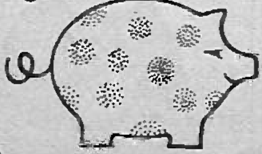
Fig. 2. Layout and wiring of the Field Strength Meter. Socket SK1 is not shown but this is simply wired across M1 if desired.



L1 BASE

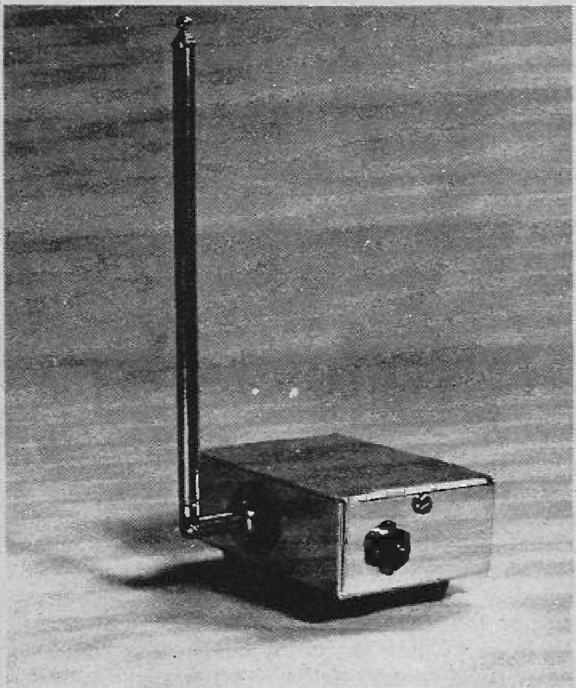
FOR GUIDANCE ONLY

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



£4.20

*Based on prices prevailing at time of going to press



made using a fretsaw or a miniature round file. Miniature level meters are not always intended for normal screw fixing, and can be mounted by either being made a tight push fit into the cut-out, or by being glued into position.

When all the large components have been mounted, the unit is wired up using insulated leads. Be sure to connect D1 and the meter the correct way round.

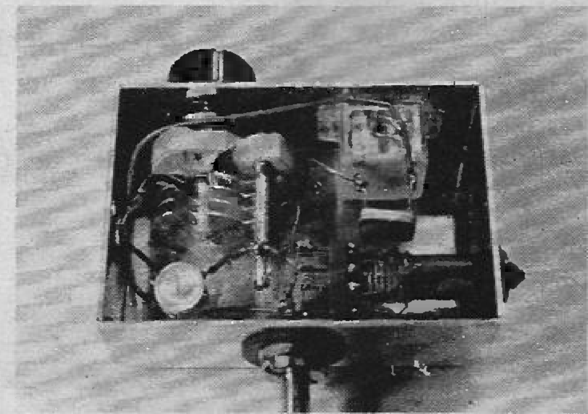
ADJUSTMENT

Screw the core of L1 right down so that virtually none of the metal screw thread protrudes from the top of the coil. Place an operating 27MHz band radio control transmitter in the proximity of the monitor, with each aerial extended and parallel to each other. Set C1 at about half way, and then adjust C2 for peak reading on the meter.

If necessary, move the two units further apart, or partially collapse the monitor's aerial in order to prevent the meter from being overloaded. If, on the other hand, a tighter coupling is necessary, move the two units closer together.

It should then be possible to tune the monitor to any frequency in the 27MHz radio control band of 26·96 to 27·28MHz, and the unit is ready for use. When operating the monitor, always tune it as accurately as possible to the transmitter's frequency (by adjusting C1 for peak reading on the meter).

It may be found easier to make transmitter adjustments with the transmitter in a horizontal rather than a vertical position, and this can be achieved by simply laying the transmitter on the workbench, and swivelling the monitor's aerial into a horizontal position, roughly parallel to the transmitter's aerial. ■



JACK PLUG & FAMILY...

New products and component buying for constructional projects

SHOP TALK

By Mike Kenward

BY the time you read this the 1975/76 Faraday Lecture Tour will be well under way—unfortunately we did not receive information on the lecture in time for it to be useful to those readers in the Cardiff, Bristol and Sheffield areas but the following synopsis of the lecture—arranged annually by the IEE together with dates and venues should be of interest to a large proportion of our readers.

The lecture is entitled The Entertaining Electron and is presented by F. Howard Steele FCGI, BSc(Eng), CEng., FIEE, FIERE, Director of Engineering, Independent Broadcasting Authority. A special stage is used which includes quadraphonic sound and big screen colour television projection to display the various filmed and other sequences used for demonstration. Although only two lecturers are on stage at one time over a dozen other people are actively involved in each presentation backstage, controlling lights, balancing sounds, preparing demonstrations, operating the cameras, managing the stage and actually producing the various electronic displays.

The lecture largely ignores wires, resistors, semiconductors and the like. Instead it concentrates on the true marvels of television. The way it makes use of the human eye and brain; the way it processes information for transmission and reassembles it again in your own home; the way it makes use of the three primary colours to produce a near approximation on a little glass screen of the hues in which the world is painted. The way television programmes are made, and the way that technology is changing. But it never ignores the fact that the real star of television, as in all electronic systems, is Faraday's electron. For us it is of course, The Entertaining Electron.

Lecture Dates, Times and Places

Birmingham The Town Hall
26-27 January 1976 E MAE
London The New London Theatre
3, 4, 5, 6 February 1976
E MAE ME MA
Exeter The Great Hall, Exeter University 26 February 1976
AE
Bradford St Georges Hall
9 March 1976 AE
Nottingham The Albert Hall
11 March 1976 AE
Liverpool Philharmonic Hall
19 March 1976 AE
Manchester Free Trade Hall
22-23 March 1976 E AE
Glasgow The Kelvin Hall
21 April 1976
Edinburgh The Usher Hall
23 April 1976 AE
Newcastle The Newcastle City Hall 27 April 1976 AE
Portsmouth The Guildhall
4 May 1976 MAE

M=*Morning* **A**=*Afternoon*
E=*Evening*

The lecture will also visit Belfast and Dublin. Dates for these two venues have yet to be fixed. Tickets for the lecture are free and are available from Mrs. B. Newman, IEE, Savoy Place, London WC2R 0BL. The lecture lasts approximately 1¼ hours.

Changing the subject slightly, before we cover component buying for projects in this issue, we have still been unable to include a review of the Sinclair Black Watch Kit but they assure us a kit is on its way so the review should appear next month.

Two Tone Audio Oscillator

Another straightforward project the *Two Tone Audio Oscillator* provides a good volume output not unlike a police car siren—with modifications available as given in the text. None of the parts should be difficult to get—we suggest the use of a holder for the i.c. No case details have been given since it is likely that readers will wish to fit the unit in a variety of places to suit its application. If a case is required any small plastic one will do and a variety are available.

Field Strength Meter

The most important point to watch when buying components for the *Field Strength Meter* is that the meter itself is the correct type and that it is bought at the right price, about £1·50 to £2·00. None of the remaining parts should cause any problem, however if they are not available from your local shop try contacting one of the larger suppliers who advertise in our pages. If necessary Denco can supply their coil direct, they are at 357-9 Old Road, Clacton-on-Sea, Essex.

Boiling Liquid Alarm

One or two of the components for the *Boiling Liquid Alarm* may prove difficult to get in some areas, once again the answer is to try one of the larger mail order suppliers who advertise in our pages; a few catalogues will overcome most of the problems.

Recourse to larger suppliers may be necessary for the 555 timer—although this is now a very popular device—for the 30 to 100 ohm loudspeaker or telephone earpiece, and possibly for the double-pole three-way switch, if this is to be a miniature type as used in the prototype.

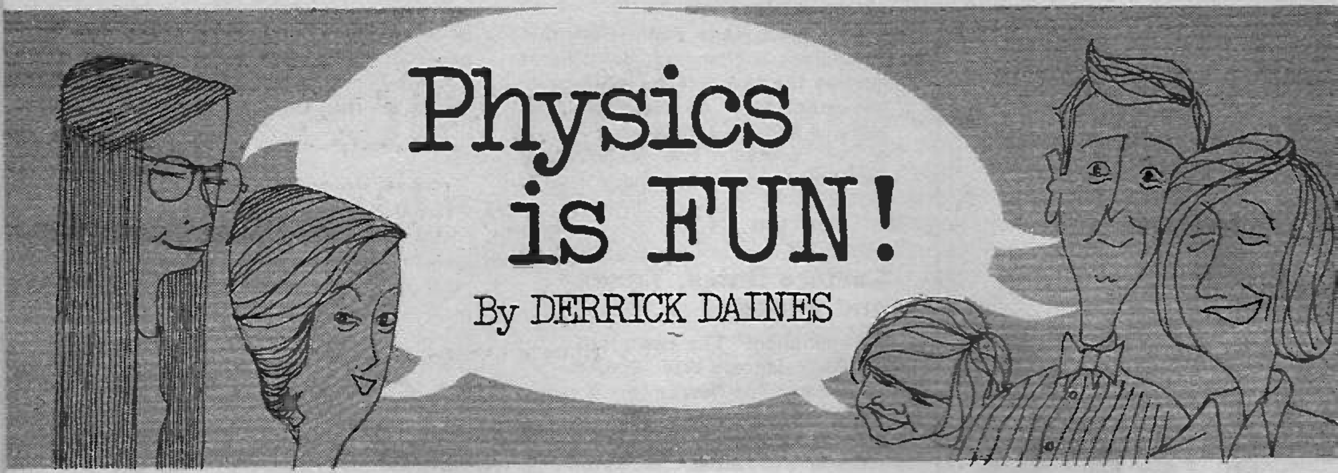
Electronic Watchdog

Basically speaking no buying problems for parts used in the *Electronic Watchdog*, apart from repeating what has been said above.

Such things as pressure mats are advertised from time to time and we believe J. Bull who advertise in our pages have a stock of them. Bells or other warning devices, if used, can be purchased from most electrical shops, the type will obviously depend on its use and the supply available.

Kits

One final word although it may seem obvious to most readers we **do not supply components or kits** for projects in this magazine. Constructors must buy all the parts from the various suppliers, a good selection of whom advertise in our pages.



Physics is FUN!

By DERRICK DAINES

TAKING STOCK

THIS series has been running now for twenty months and this is as good a time as any to pause and take a look back, as well as forwards. We have done a lot of experimentation on magnetism and static electricity as well as some work on capacitors and electrolysis. On the way, we glanced at a simple cell battery and recently we have been finding out that any two dissimilar metals will make a battery.

What single idea binds all this work together? I think that the one outstanding point is this: that magnetism, static electricity, current flow and chemistry are all inter-related. We may take examples of any one of the four and produce any other!

By the appropriate technique we can for example produce a chemical change from (say) static electricity, or produce current flow from magnetism. Much of the research into theory and techniques in the laboratories of the world can be summarised as finding yet more ways of changing one of these forms of energy into others.

Now energy can take many forms and is not simply confined to the four that I have mentioned. Light, heat and sound are three more forms of energy with particular interest to electronic enthusiasts and in the coming months we shall be looking at some experiments connected with all of these; changing them into electricity and vice-versa; interchanging them; intermodulating them; playing around and having fun.

Experiments will continue to play the major role in this series, but there will be more things to make. Next month for example, I will show you how to make a useful circuit-breaker, while coming up soon after that will be full instructions on making a Van de Graaf Generator.

Another of our fun projects will be the ever-popular but harmless shocking coil. Then there's meters, bells, motors, receivers—oh, and a whole lot of other things, so stay with us and learn the fun way!

YOUR FAVOURITE EXPERIMENT

One of my fondest memories relates to a group of children to whom I was demonstrating that a flame uses up air. It's a well-known and very simple experiment in which you put a candle inside a jar that is up-turned in a saucer of water (Fig. 1). The water of course rises up inside the jar to take the place of the oxygen that is consumed.

I had performed this experiment many times, but for these children it was the first time, and they did not know what to expect. When the denouement of the experiment was reached there was a great spontaneous roar of amazed delight—a happy sound that always brings a smile to this tired old face whenever I remember it. It is for this reason that that particular experiment—although so simple—is my favourite one.

So what has this got to do with electronics, or even this column? Well, it is by way of introducing an invitation to all of our readers—and we know that many thousands follow this column.

I would like you all to jot down on paper the details of what is YOUR favourite experiment. Keep it as brief as possible, add a sketch if necessary and an explanation why it is your favourite.

It doesn't matter if you are a schoolboy or a University Don; an apprentice or a technician; whoever you are, we would like to hear from you, so please—do write. *A reward will be made for every letter published.*

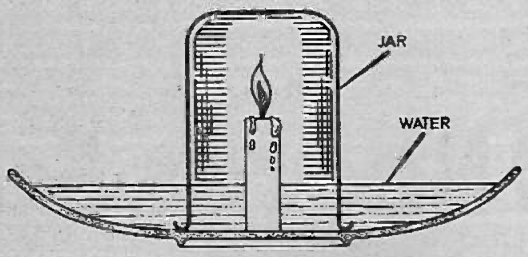
We will not be looking for frightfully difficult experiments, or anything connected with the more abstruse aspects of electronics—although there is no reason why you should not submit such an experiment if you wish—but we will be on the look-out for those that use simple apparatus. To summarise: (1) *keep it simple* (2) *use simple apparatus* (3) *explain how to do it, what will happen* (4) *add a sketch if you wish, and* (5) *explain simply why it is your favourite.*

HOW TO DEFLECT ELECTRONS

I have not left much room for experiments this month, so the two I shall describe are very simple and closely related.

For the first, take your ordinary permanent magnet and while your television set is switched on and giving a good picture, put the magnet in close proximity to the screen. In the region of the magnet the picture will be distorted.

Now for the second experiment. Spread a piece of tinfoil over the top of a 100 watt electric light bulb. Charge an electroscope as fully as possible by vigorously



Physics is FUN!

Fig. 1. Simple burning candle experiment.

rubbing a glass plate and touching the electroscope with it. Now connect the electroscope to the tinfoil by means of a thin wire. (Fig. 2). The leaves of the electroscope will remain open, but the instant that the lamp is switched on, they will collapse. (A home-made electroscope was described in *Physics Is Fun* November 1974.)

Take my word for it that rubbing the glass plate will charge the electroscope with *positive* electricity. Therefore, when the lamp is switched on, the hot filament must give off *negative* particles, called electrons. These fly across space to the positively-charged foil. But here is an anomaly — (summat odd!) — it seems that we must think of positive charge as being the *absence* of electrons and a negative charge as being an *excess* of electrons, and this is indeed the modern way of looking at it.

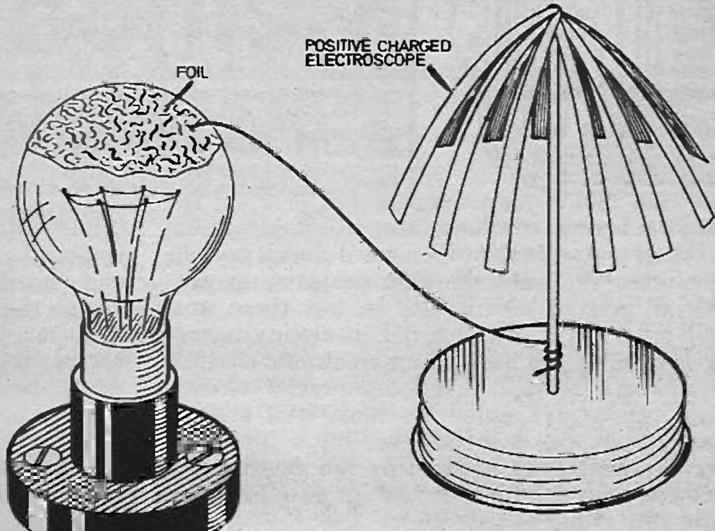


Fig. 2. Electroscope and light bulb to demonstrate electron polarity.

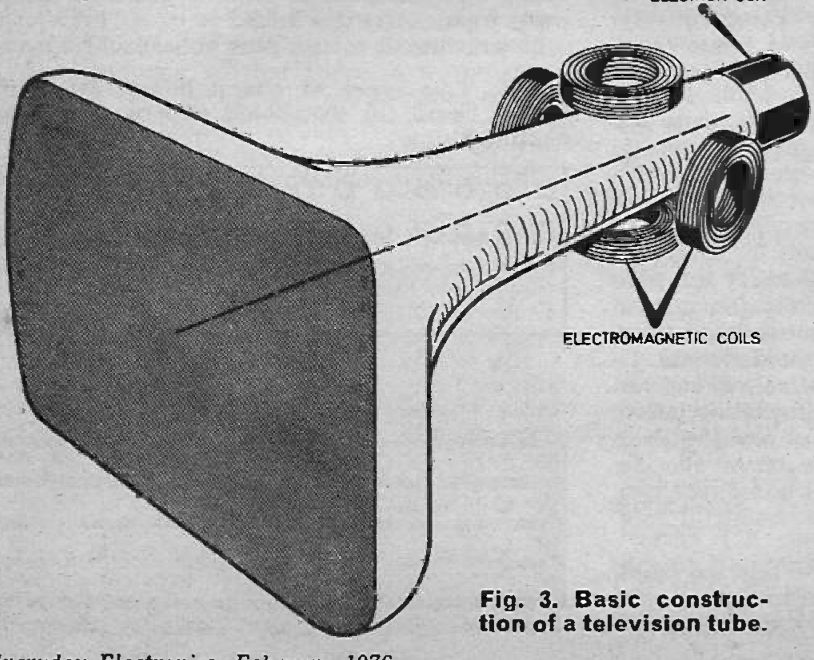
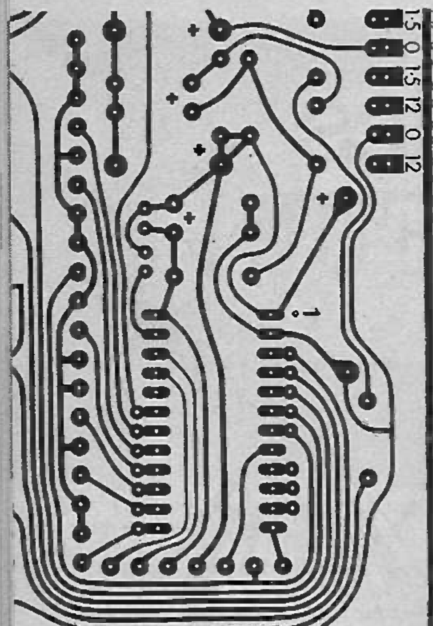


Fig. 3. Basic construction of a television tube.

The connection between the two experiments? It's like this— electrons in their flight can be deflected by a magnetic field. In a TV tube there is a 'gun' firing a constant stream of electrons at the screen. (Fig. 3). When they strike the coated surface they make the material glow momentarily. To deflect the stream to make a sensible picture, magnetic coils are arranged in pairs, N and S, E and W, but the addition of our hand-held magnet deflects them locally even more, hence, the distorted picture.



A Guide to Circuit Boards & Construction Methods

By MIKE HUGHES

FOR the benefit of this article we would rather keep to a wide definition for a circuit board. More often than not the title conjures up pictures of printed circuit boards, but there are many other ways in which flat insulating board can be used as the basis of an electronic circuit.

There are a number of commercial circuit wiring boards available—the most well known being Veroboard—but there are other forms of assembly which can be used by the amateur to good effect and which do not cost a lot (tag strips and group boards etc).

In complicated projects there is nothing better than a genuine printed circuit board but at first sight it might be felt that these are outside the scope of the amateur to make at home. This is not necessarily true—it is a comparatively simple job to make certain types of printed layout without recourse to very specialised equipment.

In this article we shall try to explain the ins and outs of applying the various circuit wiring techniques.

PLAIN MATRIX BOARD

Probably at least seven out of every ten projects printed in these pages calls for matrix board, of one form or another so we had better start by describing this constructional method.

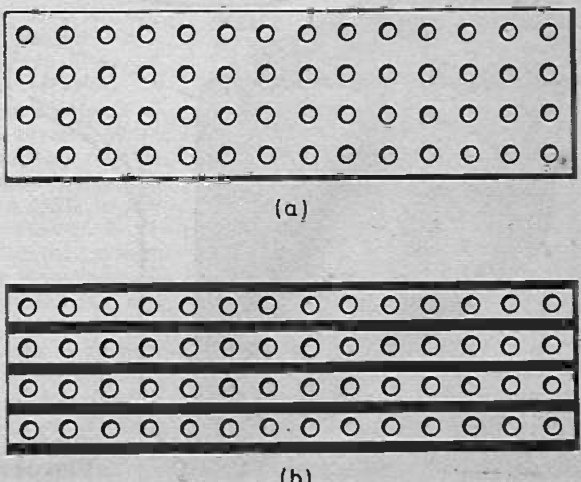
This type of circuit board is available in various forms. Basically it is a sheet of insulating board (resin bonded paper) which is covered with a matrix of holes. These holes are set on specific pitches for the different types of board; the two most common matrix pitches being 0·15in (3·8mm) and 0·1in (2·54mm).

Special pins can be inserted into selected holes and the components are soldered to the top side of the pins while the bottom ends are interconnected with tinned copper wire—giving something like a point to point wired printed circuit board. With a bit of skill one can usually design the underside interconnecting of the pins so that none of the wires have to cross each other; this makes for greater simplicity in wiring because one can use un-insulated wire.

Some project designers will specify the use of this type of Veroboard (which incidentally is the trade name of Vero Electronics) which does not have copper strips on it. It is sometimes called "unclad or plain matrix board" which is, probably, a better title because it does not constantly infringe a single manufacturer's trade name. There are other makes of insulated circuit board (RS Components have a brand of their own) which carry pin holes.

If you intend to use pins you should ensure

Fig. 1. Two types of circuit board; (a) plain matrix board (b) Veroboard with copper connecting strips.



(a) (b)

that you get the correct sized pin for the make of board you purchase—there are slight differences!

You can, of course, use unclad matrix board without pins by inserting the component leads through the holes and simply soldering the leads together on the other side. This is certainly a cheaper way of going about the job but it usually ends up rather unsightly and none of the components ever seem to be rigidly held in place. This is apart from the fact that it becomes very difficult to replace a single component without half the circuit falling apart!

COPPER CLAD BOARD

The board we have just described is probably not as common as copper clad Veroboard. The board most frequently called for in projects has strips of pure copper bonded on one face of the board to coincide with rows of holes (Fig. 1). The pitch of the copper strips can again be 0·1in or 0·15in and very often it is important that you follow the designer's specification because in his layout he might be relying on the standard hole pitch to mount certain special components (integrated circuits, etc).

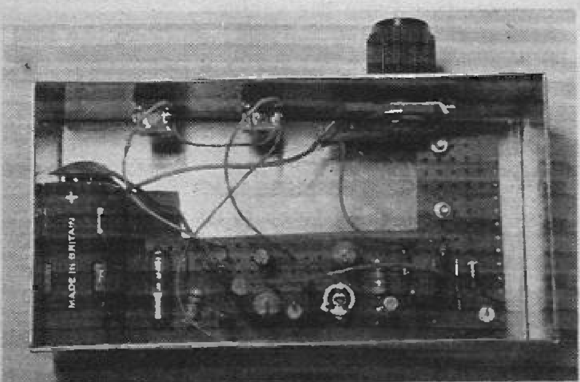
If you are a beginner and the design seems fairly simple without too many miniature components, you would always be advised to start with the larger pitch Veroboard as its use calls for slightly less soldering skill.

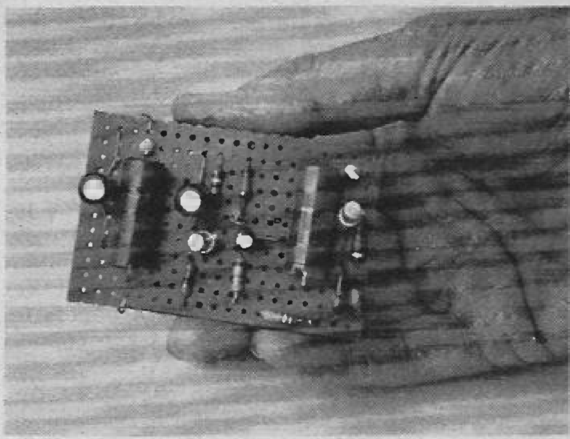
COMPONENT LAYOUT

Producing a neat design on clad Veroboard is very difficult and this is one of its biggest drawbacks. To make best use of the board one has to use the copper strips like printed circuit board connections but as they only run in one direction great care has to be taken in the original design to arrange, as far as possible, for the components to be positioned so that there is a minimum amount of "jumpering" (the use of tinned copper wire to bridge from one copper strip to another).

One may wish to break a conductor strip to isolate one group of connections from another.

A neat finished project employing Veroboard.





Typical appearance of a circuit wired on Veroboard. The use of a file on the edges of the bare board would have given a better finished appearance.

This is easily done (as will be explained later) but is a very obvious source of trouble when one is copying a design from the pages of a magazine—it is all too easy to leave out one or two breaks of the wiring by mistake!

BONDING

One can be forgiven if one thinks that the copper foil and the insulated board are bonded together by some magic glue which gives 100 per cent perfect adhesion but it should be remembered that there is no such glue available and there is always a tendency for the clad Veroboard to "de-laminate" when subjected to high temperatures and stresses—this is most likely to happen during the soldering operation and is much more likely to happen if you have broken the copper strip near the soldered connection. For that reason it is not advisable to make soldered connections immediately adjacent to conductor break points—sometimes it is essential to do this, but if so you should take great care that you do not overheat the job.

Likewise you should avoid making soldered connections too close to the edge of the board where the strip stops.

Because of the fragile nature of the bonding between the copper strips and the insulated board, you should not expect the foil to act as a mechanical support for bulky components—e.g. transformers or large electrolytic capacitors. If you have to insert any of these they should be bolted down as well as having their connections soldered.

BRIDGES

From the constructor's point of view the biggest hazard, when using clad Veroboard, is the high possibility of getting solder blobs bridging from one conductor strip to the next.

This is usually caused by inexperienced soldering or dirt on the board which causes the solder to "ball up". When a large ball of solder is formed is very easily flops over on to the next strip.

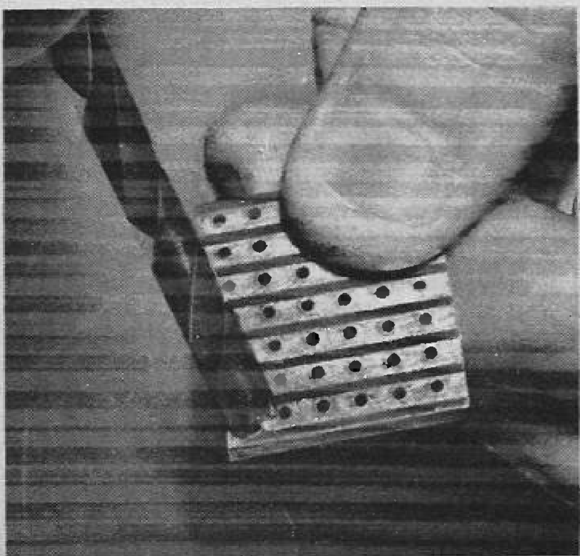
If you start off with a clean board, clean component leads, the right solder and a good soldering iron at the right temperature you can carry out your soldering with the minimum amount of solder and hence totally prevent the possibility of "strip bridging".

The simplest way to "un-bridge" a gap is to turn the board upside down so that the copper side is pointing downwards and then very carefully touch the solder blob with the tip of the soldering iron (from which all the excess solder has been removed). This method sometimes fails if there is a lot of charred flux or dirt in the vicinity of the bridge; what you should do in these circumstances is remove as much of the solder as possible by the above method but then use a sharp knife and scrape down between the conductor strips until there are no foreign particles to be seen.

CUTTING AND DRILLING

When cutting clad Veroboard to size you should use a very fine blade hacksaw and work from the copper clad side—this stops the sawing action from ripping the copper away from the board. If you are cutting across the strips there is a possibility that you might leave one or two straggly ends of copper short circuiting the strips. To prevent this you should file or sandpaper a fine bevel down the copper side edge of the cut.

Method of breaking the copper strip with a drill bit held in the hand.



Always finish off mechanical work on the board before you start electronic assembly i.e. make sure that you have drilled all the fixing holes and have removed copper from any areas where it is not required.

To break a conductor strip at a single point you can use the special Vero "Spot Face Cutter" which is rather like a simple hand held end mill —the spike on it should be inserted into the hole where the break is to occur and with a reasonable amount of pressure the tool is turned and it neatly cuts away a circular piece of the foil.

To save the cost of this special tool you can use a 6mm bit hand held (do not use a drill brace). A twiddle or two with the bit centred on the hole in question will have more or less the same effect, but be careful not to press too hard otherwise you might start drilling through the board! After having removed material at break points always check that there are no small pieces of swarf shorting tracks together!

INSERTING PINS

Whether you use clad or unclad Veroboard, or, for that matter, make up your own board by drilling holes in insulating board, you may require to use pins to support components or take lead out wires. As we have previously said, you must make sure that you have the correct diameter pins for the holes—ideally the nose of the pin should just enter the hole but the splined bulk of the pin should not go through the hole. The trick is to push the splined portion of the pin half way through the hole so that it is held tightly in place by friction.

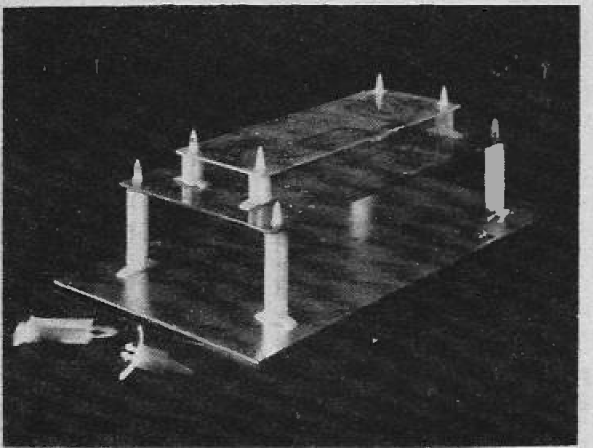
It is almost impossible to do this without a tool of some sort. Again Vero Electronics supply a special tool for inserting their own pins but quite honestly it is so simple that anyone could quickly make one up at home in a few minutes. All you need is a hole (the diameter of the pin) drilled in the end of a 3mm diameter steel rod. The depth of the hole should be just under half the length of the pins you intend to use so that when the tool is used to push the pin into the hole just over half goes into the hole and the rest, when the tool is removed, is left protruding from the surface.

Rather than bother with a handle on the tool you can use it with the aid of a hammer if you support the board over the jaws of a metal vice.

FIXING HOLES AND MOUNTING

When planning the position of fixing holes in copper clad Veroboard you must remember that the nuts and washers which will be used might extend over several conductor strips and this could give rise to short circuits, so it is just as well to remove all copper in the vicinity of the mounting holes.

If you have high voltages on the board it is



The Ilex mounting pillar's used to hold two printed circuit boards.

a wise move to remove as much copper as possible from surrounding areas to prevent the possibility of arcing or tracking.

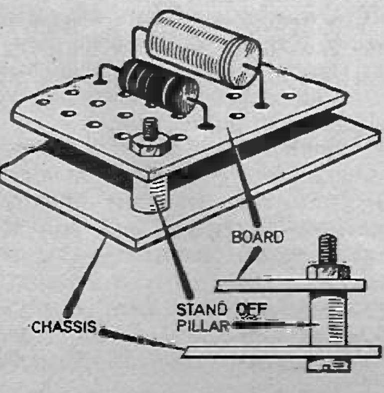
When mounting the board into a cabinet you must use stand off spacers to keep a gap between the soldering and the cabinet (this gap should be at least 6mm). If you do not have spacers you can get the same effect by using a number of nuts on a long bolt, see Fig. 2.

From time to time readers suggest novel ways of fixing boards into cabinets and a particularly good method which sticks in the author's mind involves the use of plastic binding strips (as used to hold office reports together). These could be glued or screwed into position and used for high density vertical packing of boards. The advantage of this method is that the boards are so easily removable, simply by sliding them out of the plastic grips.

TAG BOARD

One must not forget the comparatively old type of board which is still very much available under the name of tag board or group board, Fig 3. This is a piece of insulating resin bonded

Fig. 2. Mounting a circuit board using spacers and screws.



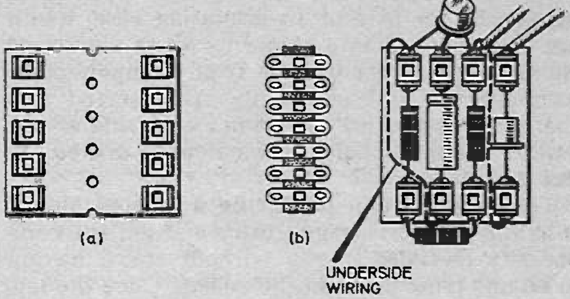


Fig. 3 (a and b). Two types of tagboard often used for construction. Also shown is a typical component layout.

paper with solder tags riveted down each edge. It can be obtained in various widths, various pitches and there is the option of different sorts of solder tags. Although we imply various types are available you will probably find that your local supplier will only carry one or two alternative styles.

The wider type is very useful because there is usually enough space between the rows of tags to drill holes for potentiometers, switches or other components which need mechanical support. Although not very practical for larger projects this type of board can save an awful lot of headaches for the smaller constructional job—particularly those which are wired up for experimental purposes rather than "for keeps".

PRINTED CIRCUIT BOARD

These days one finds it difficult to keep clear of projects requiring printed circuits. Although in Everyday Electronics we tend to avoid calling up printed circuit layouts, there are occasions when they can be used to advantage—an obvious example is in producing a keyboard for a stylus type of organ.

Apart from providing a much neater assembly for an electronic circuit there is a terrific satisfaction to be obtained from designing your own printed board or even simply copying someone elses design straight from the magazine. The art of converting a pen and ink drawing on paper into an etching on metal is a fascination in itself and, who knows, if you get good at printed circuit work you may find yourself starting into yet another hobby, photo-engraving!

In the following paragraphs we shall describe a few ways by which you can make your own etched circuit boards but before you embark on any of the suggested ways please take heed of the warning that the process requires the use of chemicals which could be harmful to health if taken internally or splashed on the skin or in the eyes, so we do not recommend that youngsters be allowed to experiment unless closely supervised by an adult who fully understands the various warnings.

A printed circuit is a thin layer of copper foil, bonded to one side of an insulating base, which has been etched into shape to route electronic signals around the circuit from component to component. The components are inserted into the board from the non-copper clad side of the board through holes which are drilled in strategic places.

The major art in producing a printed circuit is in the original design, to try and get the components laid out neatly without there having to be any cross overs in the wiring. Once the layout has been decided upon (usually as a sketch on a piece of paper) it has to be transferred to the copper.

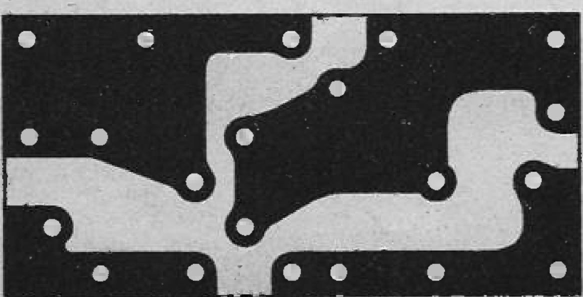
BOARD MATERIAL

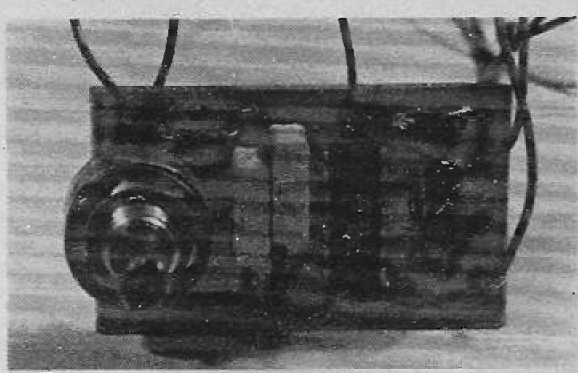
To start with you need a piece of plain copper clad laminate. This is an insulating board with a continuous layer of copper bonded all over one surface. It is possible to obtain double sided laminate (with copper on both surfaces) but we do not recommend you embark on this sort of material as it is difficult to use (even for specialists!).

The insulating base of the board is usually resin bonded paper or epoxy bonded glass fibre. The latter is much stronger than the paper boards but, as you might expect, is somewhat more expensive. Unless glass boards are specified you can use either type of base material. Apart from being mechanically stronger there is less tendency for the glass boards to delaminate when soldering and they have rather better electrical insulation properties.

The thickness of the copper foil has a relevance to the maximum current that a given width of track will carry but for most amateur applications this is not a factor that need be worried about unduly as most projects involve only low currents. Thicknesses of foil range from about 25 microns to 75 microns (1 micron equals one millionth of an inch). Generally speaking you can reckon that a 4mm wide strip to 25 micron foil will carry a current of up to 5 amps and a similar width strip of 75 micron foil up to 15 amps.

Fig. 4. Appearance of the printed circuit board showing masked areas of copper.





Photograph of a finished unit using printed circuit board.

ETCHANT RESIST

To produce the conductor pattern in the copper all that is necessary is for you to put an etchant resistant film over the areas of copper which you wish to keep on the board (Fig 4), and when this is done you remove the rest of the copper in a suitable etching bath. We recommend ferric chloride solution as being one of the least hazardous etchants but more will be said about this later.

The most difficult choice you have to make is which type of resist you will use. Some are easy to use but limit the accuracy of your work while others are neater and produce a better finish but require rather more skill in applying and there is, of course the ultimate method which uses photographic techniques. The latter method will probably be outside the scope of most of our readers so we shall not go into details of the true photo-etching method.

Probably the easiest to use in the first attempts at making a printed circuit board is ladies' nail varnish. It may need diluting a little with thinners if you wish to get fine detail but avoid over diluting as you will impair its resist capabilities. Use a very fine brush and make sure that you cover the areas you wish to protect with a good thick layer of varnish. You should leave the varnish to go really hard before attempting to etch.

Alternatively you might prefer to make use of one of the fibre tipped resist pens which are now readily available from advertisers in this magazine. These can be used just like a normal felt tipped pen but wherever you draw a line you will be protecting the copper from the eventual attack from ferric chloride.

The only problem with this type of pen (one type is called a Dalo pen) is when it comes to filling in large areas; firstly it is difficult to get an even coverage over an area and secondly there is a good chance that the pen will run out on you half way through! To overcome this use the pen to go round the edges to get a good sharp resolution and then use nail varnish to fill in the large areas.

USING FABLON

A method that will produce very clean sharp edges to a layout but requires a bit more skill entails the use of Fablon. A piece of white self-adhesive film should be stuck to the copper surface of the board and the design drawn on it in pencil. All one then has to do is use a sharp artists' knife and cut round the perimeters of the copper areas to remain, removing the Fablon from the rest of the surface. The material that is left acts as a very good resist and the knife cuts round the edges give the appearance of very high resolution when the circuit is finally etched.

No doubt experimenters will come up with other possible resists but it should be remembered that whatever is used should be capable of fairly easy removal (either with a solvent or by gentle abrasion) after etching has been completed.

FERRIC CHLORIDE SOLUTION

You should next obtain or make up a solution of ferric chloride suitable for etching copper. If you are not chemically inclined you should have a word with your local pharmacist who will probably oblige by making up a suitable strength solution. Alternatively you can make up your own if you obtain some hydrated ferric chloride crystals. This looks more like fudge than crystals and should be crushed up very finely before trying to dissolve it. This material is poisonous when wet it is rather harmful to the skin and has the nasty habit of staining everything with which it comes into contact a bright yellow colour. The wet crystals also make nasty stains on "stainless steel" working surfaces and draining boards so make sure you thoroughly rinse down any such surfaces with plenty of water if you happen to drop any.

You should use plastic or glass vessels to mix and store the solution which should be made up to be quite strong. The actual proportions are by no means critical but it is advisable to make the solution as strong as possible if you want the etching process to be reasonably quick. We suggest you start by mixing about 100 grams of hydrated ferric chloride into 100 millilitres of warm tap water; stir thoroughly and when all has dissolved try and dissolve a further 50 grams.

As the solution becomes stronger it will be more difficult to get the remaining ferric chloride into solution. As soon as you notice this difficulty occurring do not bother to add any more solid material.

When making up the solution we suggest you use rubber gloves to protect your hands and it is essential that you use gloves during the etching process as you may have to dip your fingers into the solution.

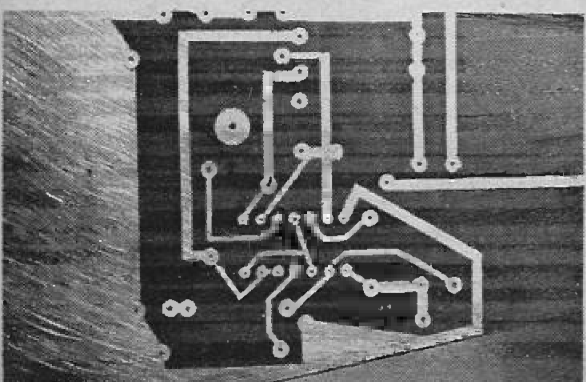


Fig. 5. Illustration of part of a printed circuit board after etching.

ETCHING TECHNIQUE

To carry out the etching you should preferably warm up the solution and pour it into a plastic photographic dish or any flat bottomed glass dish. The board to be etched should be slid (copper side up) under the surface of the solution and the surface gently stroked backwards and forwards with a wad of cotton wool.

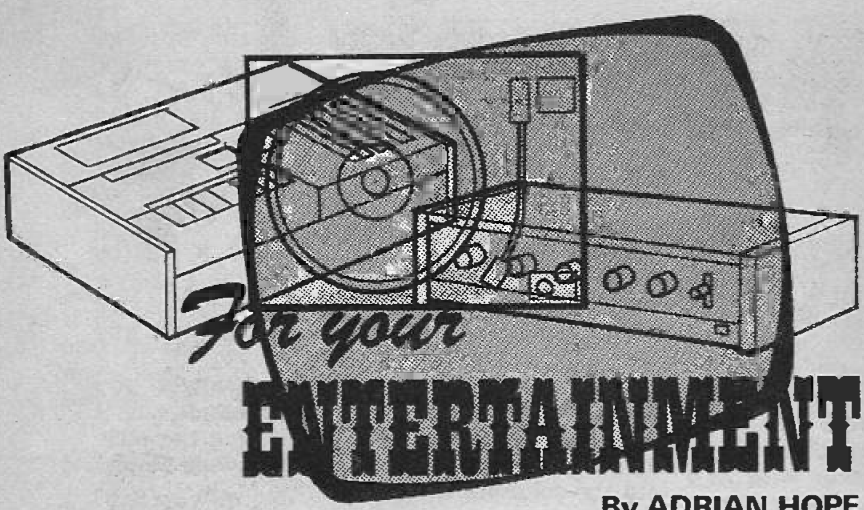
The process of etching with ferric chloride is not the normal acid erosion one expects. The process is one of replacement where the copper reacts with the ferric chloride to form copper chloride and the iron in the ferric chloride is deposited as a fine sludge on the surface of the copper. Brushing the surface with cotton wool removes this sludge and exposes a fresh surface of copper. The board after etching is shown in Fig. 5.

It is difficult to say how long the etching process will take but be prepared for it to go on for five or ten minutes. Should it take longer you either have to warm the solution up a bit or increase its strength. You can use the same solution several times but remember that it will gradually get weaker and there comes a point when you just have to discard it as the etching time becomes too protracted.

When etching is completed, rinse the board well and then remove the resist by using nail varnish remover (if you used nail varnish in the first instance). Gently abrading with fine wire wool will remove other forms of resist, e.g. Dalo pen markings, and will help remove any traces of stickiness that may be left after stripping off the Fablon if you used the last method.

It only remains to drill holes for the component leads, and the printed circuit board is complete.

A 1/32 inch or comparable size drill should be used to drill the holes. The board should be clamped down, drilled from the copper side and only a small length of the drill should protrude from the chuck to avoid breakages. ■



By ADRIAN HOPE

RECENTLY we looked at the, as yet, largely unrecognised problems of thyristor interference to medium and long wave radio and mains intercoms. In fact thyristor controls are odd things in more ways than this. As explained, they work by chopping up the mains wave form so that only a part of each half cycle gets through to the load. Thus the frequency stays the same, but there is more or less energy in the wave form and thus more or less power available for the load.

It follows that (until the power is reduced to zero or thereabouts) a thyristor control should have no effect on a synchronous motor because its speed is governed by the supply frequency. But have you ever tried using a full wave thyristor control on a shaded pole synchronous motor, such as a fan? If you haven't, give it a try and surprise yourself. The chances are that you will find the thyristor control gives smooth variation of the motor speed, from more or less zero r.p.m. right up to full speed. I still haven't worked out a really satisfactory reason why, but doubtless a reader somewhere will be able to enlighten me!

Speaker Testing

A fairly elaborate test with which I was involved recently brought some interesting audio morals and lessons to light. The requirement was to check how a particular bass and treble unit behaved together in a loudspeaker cabinet with a trial crossover uuit. The combination as a whole sounded good, but, in an effort to qualify results, we rigged a precision test.

An elaborate oscillator was used to produce a string of steady sine wave tones over the full audio frequency range, and these tones were fed to a high quality, high power amplifier (Yamaha CA1000) to drive the speaker combination. To check that the speaker was receiving constant power at all frequencies, a twin beam oscilloscope was also fed by the amplifier, with one beam set to display the sine wave and the other set as a rail to define a constant, power level.

The sound level of each tone reproduced by the speaker was read with a Castle CS17A precision sound level meter (using the C scale and with necessary additional corrections made to convert its readings to the linear scale). I mention these details simply to show that the test was conducted carefully, rather than casually. But, as it turned out, we might just as well have been casual, and the reasons why serve as a warning to anyone who pontificates in ignorance on how a loudspeaker "sounds" to them.

Environment

Because constant sine wave tones were used in a domestic room (rather than an anechoic chamber) standing waves built up at some frequencies. As a result the meter could be persuaded to read almost anything we wanted simply by moving it slightly to one side or another, into and out of the nodes of the standing wave.

Even the movement of people in the room, well away from the meter, produced substantial differences in its readout. Moreover, at low frequencies, traffic noise in the street outside made measurements impossible, and the same thing happened at high frequencies. Also a massive dip in the speaker's apparent bass response around 60-80Hz suggested that bass was being soaked up, probably by a wall cavity or stair well. Not surprisingly, the final results were wholly unusable as a guide to the performance of the speaker combination under test.

To be usable, the tests would have to be re-run in a sound-proof anechoic chamber using pink noise or gliding tones. But think about the significance of that last remark. When you or I listen to music at home, we do so under just those circumstances under which our failed test was run. And modern music contains plenty of steady tones for instance from guitars and electronic instruments. So what you hear from a loudspeaker in a domestic environment depends far more on factors like the position of the loudspeaker and the listener in the room than many people imagine.

It is a brave, or more likely foolish, man who will listen to a domestic hi-fi loudspeaker setup and condemn it for audible peaks and dips at some frequencies. So next time you feel tempted to criticise a system for being "thin in the base" or "squawky in the mid range", or "shrill at the top" think hard before you open your mouth, because you may well end up putting your foot in it.

Digital Timer

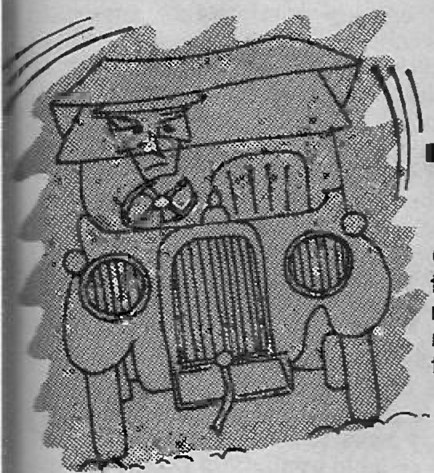
Here's a final thought for the month. The electronic world is now knee-deep in digital clocks such as desk-top or wall timepieces, alarm clocks or radio alarm clocks. But so far no one seems to have marketed what would be far more use than all the other types put together — namely a time switch with digital readout and controls.

The necessary technology must already all be available, because a digital alarm clock or radio works in this way. So will some enterprising manufacturer please string the necessary chips and components together and market a time switch that is accurate, not to the nearest five minutes, like some of the mechanical ones, but to the nearest second.

Next Month!

BITE INDICATOR

A fisherman's aid; rest your rod, put the line through the contacts on the unit and sit back and relax. When you get a bite an audible alarm will tell you immediately.



Tachometer

Old or new, your car could profit from this simple to build electronic rev. counter. Uses a 270 degree meter to provide a professional finish.

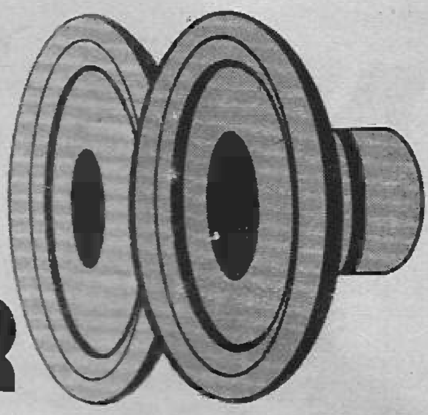
Phone Bell Repeater

If you work in your garage, shed, garden or even parts of the house where you cannot hear the phone ringing, this simple project will overcome the problem.

everyday electronics

MARCH ISSUE
ON SALE FRIDAY,
FEBRUARY 20

TWO TONE AUDIO OSCILLATOR



By G. C. GOOCH

A versatile audio oscillator for a variety of applications.

THE device to be described is built around an inexpensive digital integrated circuit, which together with a few additional components makes a simple but versatile two tone oscillator suitable for a variety of applications, e.g. door "bell", intercom call tone generator, alarm circuit for electronic digital clocks, klaxon horn for model fire engines, trains. etc., or even as an excess voltage alarm.

OSCILLATOR CIRCUIT

The circuit, shown in Fig. 1, is built around an SN7413 dual 4 input NAND Schmitt trigger, one Schmitt wired as a switchable frequency audio multivibrator and the other as a low frequency tone switching circuit.

The audio multivibrator has two timing networks C1/R1 and C2/R2. When running, the frequency of operation is determined largely by the C1/R1 combination until it is rendered inoperative by the tone switching circuit holding the appropriate gate input positive at which time C2/R2 will take over as timing components at a lower frequency.

At switch on, C1 and C2 (connected to separate inputs of Schmitt A) will be at zero voltage (logic 0) and the output will be at logic 1, allowing both capacitors to begin charging through their respective resistors. Capacitor C1 will charge to logic 1 first because of its lower capacitance.

No change will occur in the output until C2 rises to 1 as well (NAND action) when the output will switch to 0 and both capacitors will begin to discharge. Capacitor C1 will discharge to logic 0 which will switch the output before C2 can drop below the logic 1 level. The capacitors will then both begin charging again.

It will be seen that once charged C2 will remain at the logic 1 level and will have no effect on operation until C1 is held positive by the switching circuit which will allow C2 to drop to 0 and then continue to control oscillation in the same way as C1 although at a lower frequency.

The tone switching multivibrator is unusual in that the charging current for the timing capacitor C3 is derived entirely from the i.c. input. Diode D2 prevents any charging of this capacitor through R3 but allows it to discharge normally after the Schmitt output drops to 0. This arrangement gives the lowest possible operating frequency for a given size capacitor, consistent with a fairly even mark/space ratio.

The diode D1 isolates the audio oscillator stage from the switching circuit until the switch output goes high.

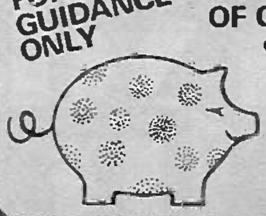
COMPONENT VALUES

No difficulty has been experienced by the author in the use of 470 ohm resistors for R1, R2 and R3 but it is possible that with some i.c.s these resistors may have to be lowered slightly in value to ensure reliable oscillation. Do not use values lower than necessary.

With the component values given, tones of approximately 650Hz and 950Hz with a switching speed of 1Hz will be generated. The pitch of either tone can be raised or lowered by using smaller or larger capacitors respectively for C1 or C2 or raised by increasing the resistors R1 or R2. The amount by which these resistors can be modified is dependent on the characteristics of the particular i.c. used, a typical maximum is around 1 kilohm.

FOR GUIDANCE ONLY

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



£2.00

*Based on prices prevailing at time of going to press

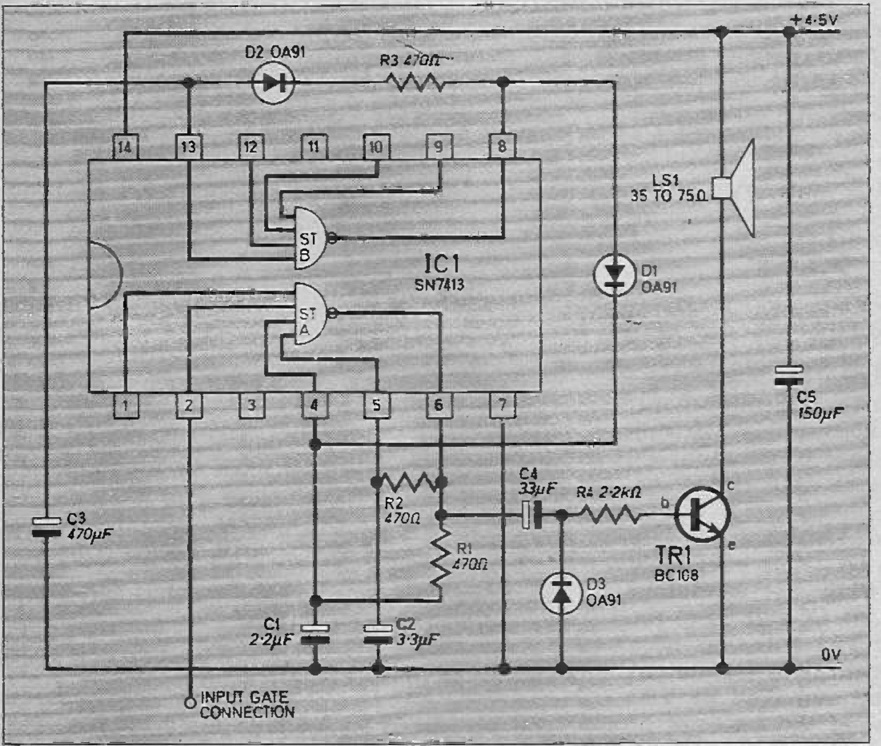


Fig. 1. Circuit diagram of the Two Tone Audio Oscillator

MARK TO SPACE

If the value of C3 is reduced to around 100μF a warble effect will be produced. This will be found preferable in applications requiring short bursts of operation. e.g., door bell circuit, etc.

Components....

Resistors

R1	470Ω
R2	470Ω
R3	470Ω
R4	2·2kΩ
R5	see text
R6	see text

All ¼W ± 10% carbon

SEE SHOP TALK

Capacitors

C1	2·2μF elect. 6V
C2	3·3μF elect. 6V
C3	470μF elect. 6V
C4	33μF elect. 6V
C5	150μF elect. 6V

Semiconductors

D1-D4	OA91 or similar germanium diodes (4 off—see text)
TR1	BC108 silicon *npn*
IC1	SN7413 dual 4 input NAND Schmitt

Miscellaneous

LS1 35 to 75 ohm miniature loudspeaker
Veroboard 10 strips by 24 holes by 0·1 inch matrix, 14 pin d.i.l. i.c. socket, 4·5V type 1289 battery, connecting wire, any small plastic case if required.

The discharge resistor R3 in the switching circuit is chosen to give an even mark/space ratio to the switching waveform, and may need slight alteration in value to achieve this end. It may also be necessary to reduce the value of this component to ensure correct working of the switching circuit. In this event the mark/space ratio may be restored at the expense of higher frequency working by connecting a suitable resistor (typically 10 to 20 kilohms) between the positive end of C3 and the positive supply line. In this case the frequency may be reduced to the former value by increasing the capacitance of C3.

Incidentally, if capacitor C1 and resistor R1 are removed and a jumper wire used to replace diode D2, the circuit will operate as a single tone "bleeper".

The oscillator may be switched on and off either by switching the supply current or by taking one of the unused inputs of Schmitt A to a logic 1 or 0 source and leaving the supply line permanently connected. The latter method will be found the most convenient if the unit is to be used in connection with digital circuits or as an excess voltage alarm as will be described later.

OUTPUT STAGE

The output stage is designed to draw no power until the oscillator is working. This keeps the quiescent current in applications utilising the gated input mode of switching to a minimum (approximately 14mA).

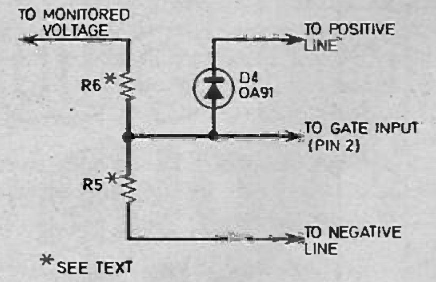


Fig. 2. Input gate circuit for an excess voltage alarm.

Under "off" conditions the output of Schmitt A will be high which would result in the continual saturation of the output transistor if C4 was not included in the circuit to block the d.c. path from the i.c. output.

At the commencement of oscillation the output drops and the charge on C4 is effectively shorted by D3. The following rise in output voltage is then transferred via C4 and R4 to the base of TR1. The input to TR1 will thus be a train of positive pulses identical to the output from the i.c., which will be amplified by TR1 and fed to the loudspeaker at the collector of this transistor.

If the on/off switch is included in the power supply lead, C4 and D3 may be omitted and the free end of R4 connected directly to the i.c.

If a higher power output is required any appropriate amplifier with an input impedance of 2 kilohms or greater can be connected directly to the i.c. output and the existing output stage may be dispensed with.

EXCESS VOLTAGE ALARM

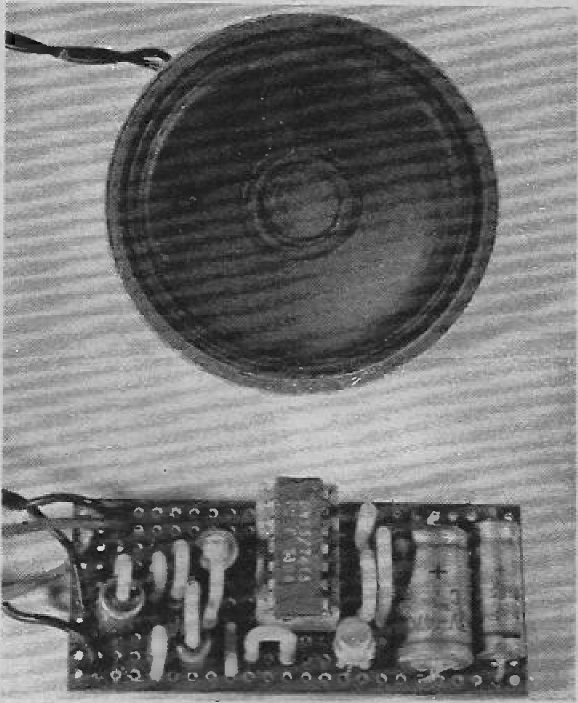
As oscillation can be initiated by a positive voltage applied to an input that is normally held at a low potential, it follows that if a voltage divider is connected across that input (see Fig. 2) any voltage in excess of a predetermined level can be made to give an audible warning. Diode D4 is to prevent the maximum gate input voltage being exceeded by clamping the gate input to the positive line.

The values of the divider resistors are best found experimentally, resistor R5 being just low enough to prevent oscillation and R6 to give the required voltage detection. Considerable differences in value will be found with different i.c.s and preset potentiometers may be used to advantage.

Voltages much below 5 volts cannot be detected by this arrangement.

CONSTRUCTION

The prototype was constructed on a piece of 0·1 inch matrix Veroboard 10 strips by 24 holes. The layout of components is in no way critical

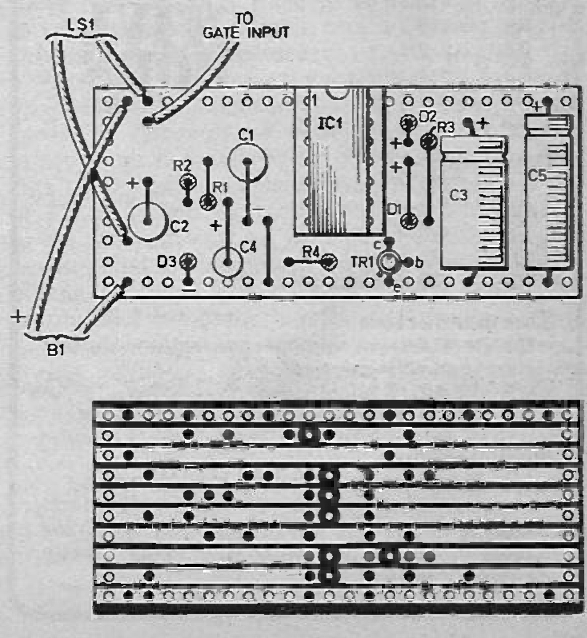


Photograph of the completed unit.

but a suggested layout is shown in Fig. 3. The use of an i.c. socket is recommended but is not essential if care is taken during soldering and a heat shunt is used on the i.c. pins. Care must also be taken while making all solder connections, not only to prevent damage to the components but also to the copper strip which can be detached from the board by excess heat.

All components are mounted vertically, with the exception of C3 and C5, on the plain side

Fig. 3. Layout and wiring of the components mounted on the Veroboard.



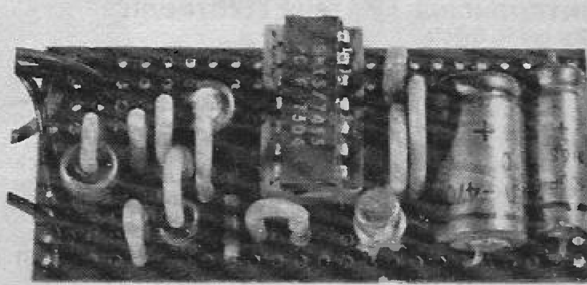
of the board and solder connections made as required on the copper strip side. The necessary breaks can be made in the copper strips either with a special spot face cutter, a 5mm twist drill or even a sharp craft knife.

It will be seen that in the suggested layout one of the unused Schmitt inputs (pin 1) is connected to the positive supply instead of left floating as in the circuit diagram. This is done simply because pin 1 is over the positive supply strip and as a gate input taken to the positive line has the same effect as if left floating, no change in performance will be made. Pins 11 and 4 are also connected together but this will have no effect because pin 11 is not connected internally to the i.c.

The recommended supply voltage for the i.c. (5V) should not be exceeded by more than a few per cent and operation from a 4·5 volt supply will be quite satisfactory. Battery operation from a type 1289 battery will therefore be very straightforward.

Although all the capacitors in the circuit are shown as 6 volt components, due to the lack of availability of low capacitance/low voltage electrolytic capacitors, components with a much higher working voltage may have to be used especially for C1 and C2.

The input gate connection may be used with the circuit of Fig. 2 or left disconnected if the supply line is switched. ▣



Photograph of the Veroboard layout.

SOMETIMES when I write this article I have to remember the approximate date that you will be reading it. This one is a case in point, because you will be reading it (I hope) in January 1976, and therefore it would be timely to wish you all a happy and prosperous 1976. At first I did think of writing to tell you what your new year's resolutions should be, but apart from suggesting that you read Uncle Paul's articles every month without fail, and that you should all write to the editor and tell him how much you enjoy them, I could think of nothing else to say, and I was up the creek, no paddle and four hundred words still to go.

This started me thinking about filling up space, and by natural progression, I came round to thinking that in the modern world, space is at a premium. How fortunate it is that in the electronics world everything is getting smaller and smaller. You lucky people! I say that quite seriously, because in the last fifteen years the diminution of all components has been unbelievable.

Let me cite a few examples: twenty years ago all our resistors were one watt (never less) and were about 35mm by 8mm. They were in fact capable of carrying a 100 per cent overload and would therefore be classified today as two watts. The constructor of that era would have to stock a selection of these and there was nothing smaller he could use.

A sixteen microfarad electrolytic capacitor measured 115 by 30 mm and today's equivalent measures 10 by 8 mm. It is only fair to add that the first one would carry 500 volts and the second only 40 volts, but who needs 500 volts d.c. today? I am sure you are all familiar with valves, and so there is no need for me to make a comparison in size with transistors. Coils in screened cans have shrunk from about 40 x 40 x 100 mm to 10 mm cubes. Perhaps the item that has changed the least is the air spaced variable capacitor, which is understandable as the size is dependent on the air gap.

It can be fun to see what our fathers had to contend with, although it means a visit to the Science Museum. Coils were about 45 by 10 cm and capacitors were large glass jars covered in tin foil, in fact the early units of capacitance were known as "jars" not farads.

Valves were, I believe, about the size of 150 watt lamps. However, let us look forward, instead of backwards, and rejoice in our good fortune. Instead of needing a large room for our hobby, which few families can spare, we only need the occasional use of the kitchen table. Already i.c.'s have once more dramatically reduced sizes, and it seems we may soon have to do all our constructing under a magnifying glass, a prospect us older generation cannot view with equanimity, but for the rest of my readers 1976 and beyond looks truly exciting.

Happy constructing in the coming months.

BOOK REVIEWS

INTRODUCING AMATEUR ELECTRONICS
By Ian R. Sinclair
Published by Fountain Press, Argus Books Limited, Station Road, Kings Langley, Hertfordshire, England.
Size 79 pages, 21·5 x 14 cm approx.
PRICE £1·25

A good book for those interested in getting a quick start in understanding simple transistor circuits and also in basic techniques such as soldering. The greater part of this easy to read book is taken up with basic theory and the operation of simple circuit blocks.

This is not a book that will show you how to build various projects, but it will give a good background to the subject and is suitable for the complete novice. However, I feel it could have been much more helpful had the "Bare Essentials" chapter been expanded to give more information on basic construction techniques.

Well illustrated and laid out but, like most of the electronics books, rather expensive for its size.

M.K.

ELECTRONIC TEST EQUIPMENT
By Harry T. Kitchen.
Published by Fountain Press, Argus Books Ltd.
Size 200 pages, 22cm x 14cm.
Price £4·50

This book is the work of an enthusiast who draws upon his extensive practical experience as a designer and constructor to impart to his readers basic facts about instruments and sound advice concerning their selection and use.

The book starts off with moving coil meters and provides a thorough treatment of principles of operation and practical aspects of extending ranges through the use of shunts and multipliers. Then the following kinds of electronic instruments are covered: electronic meters, a.f. oscillators, r.f. oscillators, attenuators, and oscilloscopes. The explanations of electronic circuitry are somewhat sketchy and often assume a theoretical knowledge level higher than that of the kind of reader this book is chiefly aimed at. But in matters of handling and usage, the book serves as a good introduction to the various kinds of instruments commonly encountered or likely to be needed, and points out their merits and demerits and brings out quite clearly the essential factors that must be taken into account when considering their purchase and use.

Representative examples of commercial instruments are mentioned with perceptive comments based upon the author's own practical experience as a user. The author's enthusiasm for his subject is conveyed through the matey tone of his writing, and clear evidence of his own practical involvement is provided by several home made instruments referred to.

F.E.B.

READERS' LETTERS

Guitar Shocks

As a newcomer to electronics I am writing to your magazine in the hope of some advice.

Just recently I have been putting together an "effects unit" consisting of Waa Waa, Phaser, Ring Modulator, etc., for use with my electric guitar. The power to the modules used needs to be 9 volts or 12 volts (it makes no difference) and all are wired negative to earth. Not wishing to use batteries I want to use some kind of mains driven power supply. I was contemplating using the 9 volt power supply that Sinclair sell for use with their calculators, partly because of its small size which is necessary to my needs and also because it doesn't generate much heat even after long usage, until I read your June '73 project on the *Mini Organ* and the bit about some battery eliminators not being isolated from the mains and possibly dangerous.

If I am correct in assuming this, I am holding part of a potentially dangerous circuit, i.e., the strings on my guitar which, via the bridge, is connected to the circuitry of the instrument. I don't want anything to go wrong! In view of this I would be very grateful if you could suggest a power supply available that could be built into my unit. Also will the power supply I use need to be earthed? If so then I envisage earth hum loops and was told it is safe to disconnect one of the mains earths either from the unit or main amplifier. Is this safe? I thank you for your time.

R. T. Axon
Southport.

The thing to check is that the supply or "battery eliminator" employs a double wound transformer to provide complete isolation from the mains—this can be done by contacting the manufacturer or distributor. If a supply is constructed a double wound transformer must be used.

The circuit can be earthed through the connecting lead to the amplifier to avoid hum loops, but this means that the unit is not earthed until the lead is connected and that the lead must be kept in good condition. The obvious dangers with this type of arrangement can be overcome by connecting the d.c. supply to the effects unit via the same plug as used for the output to the amplifier.

Ventilated Postman!

May I through your columns appeal to your readers for help, or pose a challenge to circuit designers who may read this.

In my job as a postman, there is one continual threat to my safety—dogs! The latest sport it seems is to stand on one's doorstep and laugh as "Rover" provides extra ventilation to the postman's uniform. The public love it—so do the dogs! Needless to say, I don't. I seek a deterrent.

I want to build a "magic box" which will oscillate at a frequency disliked by dogs (but not to harm them) and will keep a vicious dog away from the user. Similarly this must be a fairly simple device. It would certainly be a golden asset to me, and my colleagues. If anyone knows of such a circuit, or where I could get more information, I would be interested to hear of it.

Many thanks for your excellent magazine. I hope you can help by printing this letter.

P. D. Hobday,
S.Devon.

We sympathise with you and other postmen and hope that dog owners who read this will take note and keep their "best friend" under control when the postman is around.

We regret that we are unable to help you with the "magic box" you need, perhaps other readers can and will let us know. (How about a chain-Mail uniform?)

TEACH-IN 76 Matters Arising

CIRCUIT DECKS

We recently published a note concerning the supply of *Teach In 76* Circuit Decks by Mr. B. H. Malme, "Newhaven", Mill Lane, East Runton, Cromer, NR27 9PH. Mr. Malme tells us that he has sold well over 100 decks and kits but that he is now forced to omit the base panel in order to keep to the original price, this is due to cost increases.

We would like to point out that the deck is not constructed in exactly the same way as that shown in the October '75 issue but that it is quite suitable for the purpose, and at £2·80, varnished and inclusive of postage etc., is very reasonably priced (the kit is £1·75 ready to assemble). Supply of the deck may take a few weeks due to delays in delivery by BRS Parcels Ltd.

COLOUR CODE

I am writing this letter to you to ask for your help, my problem is that I do not understand the reading of resistor values by the colour code. My problem is how do you get the points in the values like a 1·8kΩ and how do you not mistake it for a 18kΩ resistor; also if you had a box of unknown resistors how would you know or find out if they were ¼W carbon or ½W and so on.

R. Chick
Newcastle-upon-Tyne 4

The number of noughts on the end of the resistor value and thus the placing of the decimal point in kilohm and megohm values is determined by the third band. Thus red red red=2200 or 2·2kΩ.

The wattage of the resistor can only be determined by knowing its form of construction and its physical size—you will get to know this in time.

ELECTRONIC WATCH-DOG

By O. N. BISHOP

WATCHDOG snoozes peacefully all day, consuming a current of only 1·5 milliamps. With his one eye he watches darkness come in the evening, and the brightening sky of dawn. The day may be sunny or dull, yet he never stirs. But if there is some rapid change in the scene, perhaps a person walks by, or an object is taken from his view, or a light is shone on him, then the Electronic Watchdog springs instantly into action, giving out a loud whine!

Don't be deceived . . . "he" may look asleep but the slightest movement will arouse "him"

OPERATION

Most light-triggered devices are set to operate at a definite light level. They switch on room lights at dusk, or sound an alarm when a beam of light is interrupted by an intruder. The light beam must come from a constant light source; if daylight or room lights are used the alarm is triggered at dusk or when the room lights are switched off. Even a cloud over the sun can set off the alarm.

The Electronic Watchdog is different because it does not simply rely on light *level*. It is not triggered by slow changes of light such as occur at dusk or dawn, or when clouds pass by. It responds only to rapid changes, such as might occur when a person passes between it and a window or a room lamp, or when a torch is shone on it at night—or even a single match struck a few feet away.

The device responds to many kinds of movement in its vicinity, for a moving person or object nearly always causes an alteration in the balance of light and shade sufficient to trigger the circuit. It can look out for intruders, spot the car headlamps of expected guests, or keep guard on almost any object. It can even be used in a game of skill, as described later.

LIGHT DETECTOR

The unit uses a light-dependent resistor, or photoconductive cell (PCC1) wired in series with a resistor to make a potential dividing chain, see Fig. 1.

FOR GUIDANCE ONLY

ESTIMATED COST* OF COMPONENTS
including V.A.T.
£4.20
excluding case

*Based on prices prevailing at time of going to press

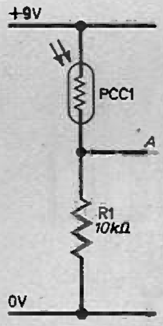


Fig. 1. Potential divider circuit.

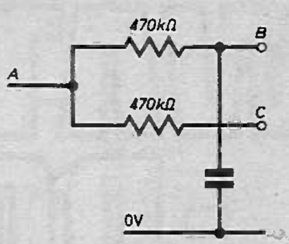


Fig. 2. Basic response circuit.

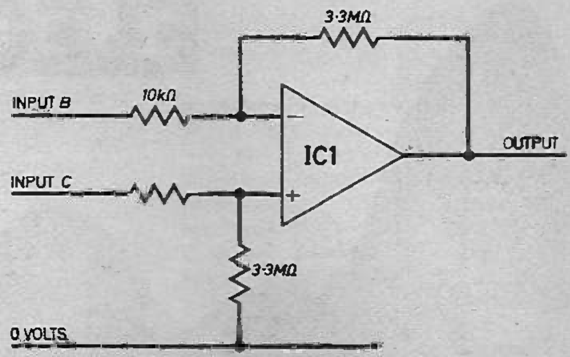


Fig. 3. Differential amplifier circuit.

As light intensity increases, the resistance of PCC1 decreases, and the voltage at point *A* therefore increases. Voltage at *A* is about 0·1 volts in darkness, and rises to about 8·5 volts in bright sunshine.

The next stage in the circuit is designed to respond to *rapid* changes in this voltage, even though these changes may be relatively small—of the order of 0·05 volts.

If the voltage at *A* (Fig. 2) rises there are corresponding rises at *B* and *C*. Voltage at *C* rises virtually at once, but the rise at *B* is delayed.

For the voltage at *B* to increase, the charge on the capacitor must be increased, and this can only occur by current flowing from *A* through the high value resistor. This takes an appreciable time. The voltage at *B* rises more slowly than that at *C*; the result is that, for a short period after *A* has risen, the voltage is higher at *C* than it is at *B*. If *A* changes slowly, the charging capacitor more-or-less keeps pace with the rise in voltage, and *C* is only slightly higher than *B*. If *A* rises rapidly, the lag at *B* produces a bigger difference between *B* and *C*. The more rapidly *A* rises, the bigger the difference between *B* and *C*.

DIFFERENTIAL AMPLIFIER

Next we have to detect and amplify these voltage differences. To do this we use an operational amplifier connected as a differential amplifier, as shown in Fig. 3. Whenever the voltages at the two inputs are equal (zero difference), the output voltage of the amplifier is zero. If input voltage at *C* is greater than input voltage at *B*, the output voltage is greater than zero. In other words, the output voltage is proportional to the difference between the input voltages. Note that it does not matter what the voltages are; if *B* is 1·1V and *C* is 1·2V (difference is 0·1 volts) or if *B* is 6·75V and *C* is 6·85V (difference is still 0·1 volts) we get the same output from the amplifier. If *B* and *C* are both equally low in dim light or both equally high in bright light, this has no effect on the output of the amplifier, which remains at zero. It is only when a rapid increase of light occurs, and *A* rises, causing *C* to be greater than *B*, that the output of the amplifier increases.

The gain of the amplifier is 330 with the resistor values shown in Fig. 3. This means that the output voltage is 330 times the difference between input voltages (subject to a maximum of about 7 volts, set by the voltage supply of the circuit). So to get an output of 1·5 volts, which is what is required to trigger the next stage, the difference between the inputs need be only 1·5/330 volts, which is less than 50 millivolts. This explains the high sensitivity of the device.

Consider what happens as light intensity falls. In brief, the reverse of the above occurs. Voltage at *A* drops, the capacitor discharges. This takes time, so for a period, *B* is higher than *C*. The difference between *C* and *B* is negative, and the output of the amplifier is negative (less than zero volts). Though it is possible to devise a circuit which is triggered by a negative-going output, it is easier to make one that is triggered by a positive-going output. The circuit used in the Electronic Watchdog responds only to positive going outputs, and this simplification is no great loss, for usually a movement in the vicinity of PCC1 will produce both decreases and increases of light intensity—often many fluctuations in succession—and the alarm will be triggered.

TRIGGER CIRCUIT

The "trigger circuit" can be seen on the complete circuit diagram shown in Fig. 4. The output of IC1 passes through a resistor to the gate of the thyristor, CSR1.

No current passes from the anode to the cathode until the gate is made more positive than the cathode. This happens when the amplifier output exceeds about 1·5 volts. After this has occurred, current will continue to flow through CSR1 even when the amplifier output returns to zero, or becomes negative. The effect of the thyristor operation is that on a positive

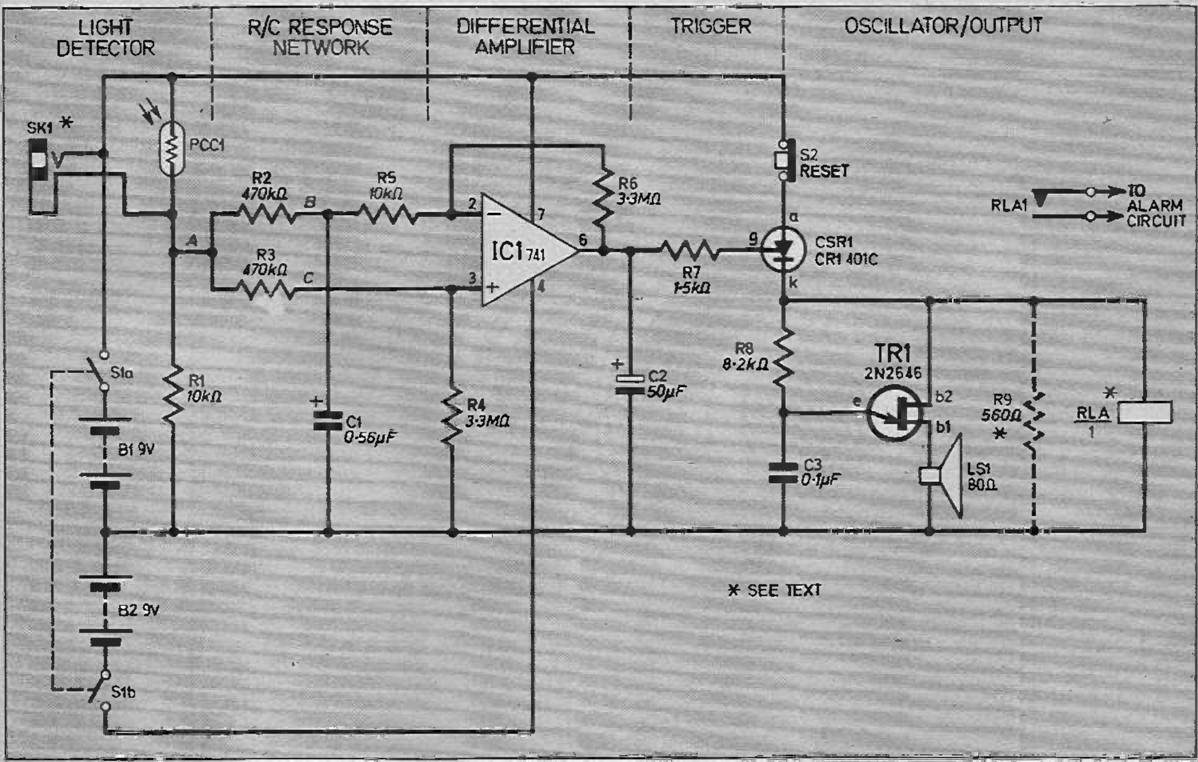


Fig. 4. Complete circuit diagram of the Electronic Watchdog.

output from the amplifier, current to the oscillator (and relay) is switched on, and continues to flow until the circuit is broken by pressing the reset button, S2 (thereby turning off CSR1. Once the alarm is triggered it will sound until it is reset.

Note that power supply to the oscillator is provided only *after* triggering, so saving current and allowing the unit to be run for long periods without exhausting the batteries.

OSCILLATOR

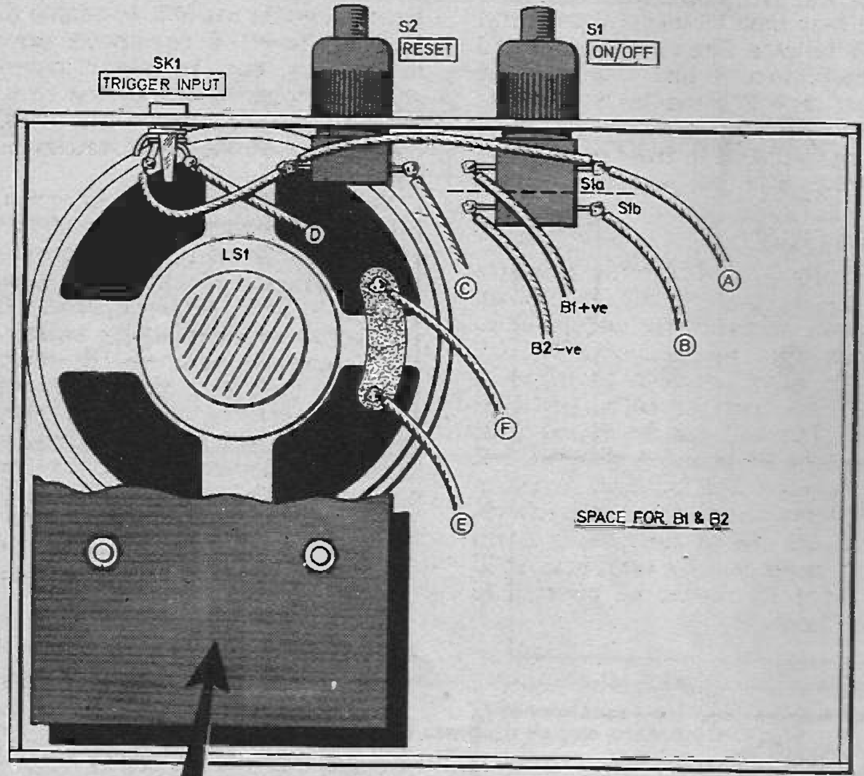
The oscillator is built around a unijunction transistor, TR1. The resistance between b2 and b1 is about 9·1 kilohms, allowing little current to flow through the loudspeaker. Instead, current flows through R8 and charges C3. When the latter has charged to about 7 volts there is a "breakdown" between the emitter and the base of the transistor. A burst of current flows through the emitter, through the base to b1, and then through the loudspeaker. This flows, discharging the capacitor, until the voltage at the emitter has fallen to about 2·5 volts. The flow then stops and the capacitor recharges again. The charging and discharging occurs several hundred times a second, the rate depending upon values of R8 and C3, and the intermittent current through the loudspeaker produces the required alarm tone.

CONSTRUCTION

The Veroboard layout is shown in Fig. 5; the copper strips need to be cut between the opposite pins of the IC1, but not elsewhere. As wiring proceeds, make temporary connections to the Veropins for testing purposes. All voltage measurements are made with the negative terminal of the testmeter connected to the 0 volt line (bottom strip of board). First mount PCC1 and R1; check that the voltage at their junction is almost nil in darkness, and rises to about 8·5 volts in bright sunshine. Then wire up the resistor-capacitor network, and check variation of voltages at the upper ends of R2 and R3.

You will not be able to check if one lags behind the other until IC1 is connected, so mount this next not forgetting its feedback resistor R6. Then check its output voltage. Place your hand over PCC1. Output should go negative (below zero on your test-meter), but after about a second return to zero. When you remove your hand quickly it will swing up to 3 or 4 volts, then fall quickly to zero. See how little the voltage increases if you move your hand away slowly!

Next assemble the oscillator (R8, R9, TR1, C3). Connect the loudspeaker temporarily and wire the b2 connection of TR2 temporarily to the plus 9 volt supply. The oscillator should now work.



ELECTRONIC WATCHDOG

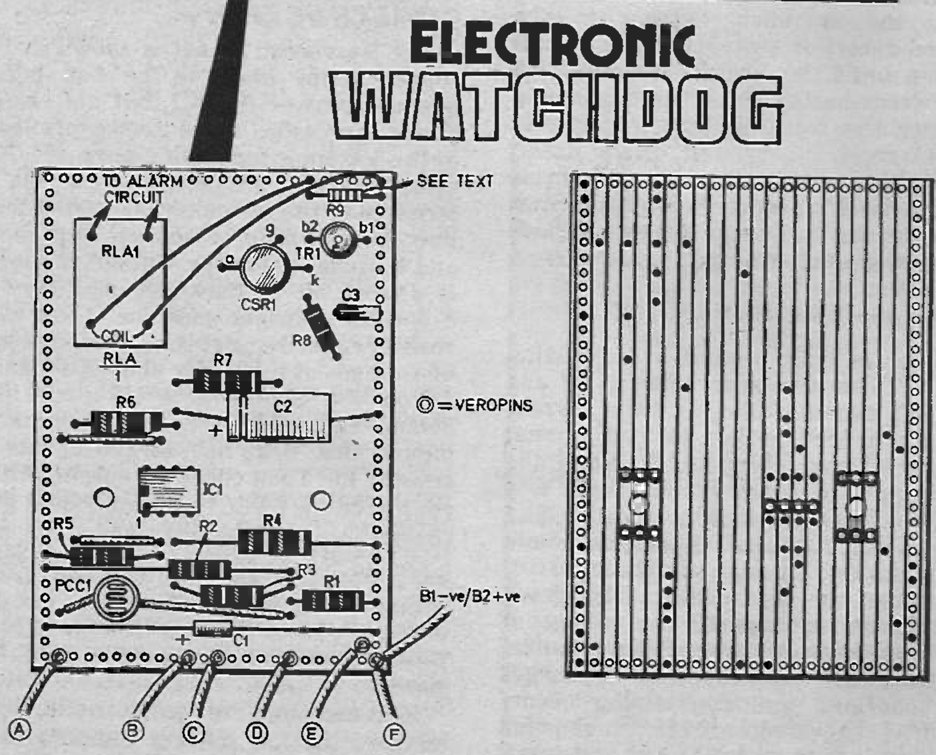


Fig. 5. Layout and wiring of the complete unit.

If you like, you can adjust the pitch of the note by altering R8, but if you alter it by too much the oscillator will not function.

Finally mount C2, R7, CSR1 and the reset button. The unit may then be given its final test before fixing it in its case. The board is mounted with PCC1 at the bottom, in line with a hole in the case, so that it will come to be close to whatever surface the unit is stood on. Thus, small objects may be placed in front of the hole, and if they are taken away the alarm will sound.

RELAY OPERATION

To obtain a really loud alarm the thyristor is wired to a relay, as shown in Fig. 4. This can be additional to the oscillator or instead of it. In the latter case, you can then omit R8, C3, TR1 and LS1. The relay can then be wired to switch on an electric bell (or bells) when its coil is energised. The bell can be driven from a heavy-duty battery or a mains-powered bell transformer. If required the bell and its power supply can be at some distance from the Watchdog, where the alarm can be more easily heard and is safe from tampering by the intruder. If a relay is not fitted R9 should be inserted to ensure thyristor "latching".

Components....

Resistors

R1	10kΩ	R6	3·3MΩ
R2	470kΩ	R7	1·5kΩ
R3	470kΩ	R8	8·2kΩ
R4	3·3MΩ	R9	560Ω
R5	10kΩ		

All ¼W ±10% carbon

SEE SHOP TALK

Capacitors

- C1 0·56μF tantalum or polystyrene
- C2 50μF elect. 12V
- C3 0·1μF plastic or paper

Semiconductors

- PCC1 ORP12 or similar photocell
- IC1 741 op. amp i.c.
- TR1 2N2646 unijunction
- CSR1 CR1 401C or any 50 p.i.v. 1A thyristor

Miscellaneous

- SK1 miniature jack socket and plug to suit
- S1 d.p.s.t. toggle switch
- S2 s.p. push to break pushbutton
- B1, B2 9V PP6 (2 off)
- LS1 35 to100 ohm loudspeaker
- RLA1 185Ω 6-12V relay with normally open contacts (rated as required) Type MH2 or similar
- 6BA fixings, Veroboard 34 holes by 24 strips, case 150 x 110 x 40mm, connecting wire

The relay can also be used for switching on (or off) any other electrically powered devices such as lamps, motors, audio equipment, model locomotives or cars, or projectors. The relay switch contacts are able to handle mains current, so mains-powered equipment can be switched in this way. But the inexperienced constructor should beware of attempting this, for there is not only the chance of accidental damage to components but also the serious risk of electric shock.

Those who have some experience of wiring relays into mains circuits will be able to find many applications for the Electronic Watchdog. It can be used to switch on a porch light or garage light in response to the headlamps of an approaching car. It can switch off the radio when someone picks up the telephone. It can be used by infirm persons or operate many electrical devices such as a bedside lamp, a radio, or a room heater. In these applications it must be remembered that the device will only trigger the switch once—the reverse condition has to be obtained by pressing the reset button. Thus the main applications for this device are where once-only switching is required—alarm systems and fail-safe systems.

EXTERNAL PROBES

Additional photoconductive cells may be connected in parallel with PCC1. Increase in light intensity on any one (or more) of these causes a change of voltage which triggers the circuit. Although the prototype was made with the photocell inside to give a compact device, it might be essential to have one or more external cells, connected via SK1. When the alarm sounds an intruder could quickly switch it off, but if the cell or cells are unobtrusively located around the house, and the rest of the circuit is in some place where it can be heard (bedroom, kitchen, office) there is less chance of interference.

For other purposes the internal photocell is more convenient—the unit can be placed so that it is "looking" down the drive to watch for the milkman, or to detect an approaching car. It can be put on the ground to sound when the cat comes in. If the unit is placed hole downward, it is a game of skill to lift it so slowly that the alarm is not triggered.

The device can also be adapted to concentrate on distant events. A small pocket lens can be arranged (either permanently in a tube, or temporarily) to focus the image of more distant areas onto the photocell. The light from a match bursting into flame will trigger the device at a distance of over 2 metres if a pocket lens is used to catch and concentrate the light. This works not only in darkness, but also in a well-lit room.

Another type of probe is the pressure—sensitive resistor. This is a spongy plastic which is conductive and is manufactured in small slabs between two metal plates. It comes in many shapes and sizes, and all seem to work well as external probes. When the plastic is compressed, its resistance decreases, and the circuit is triggered. Even a brief and light touch is enough. Such resistors placed under carpets and in other strategic positions can be used to detect all manner of movements. These resistors can be connected in parallel with photocells, via SK1, to give a complete detection system.

One final point—the Electronic Watchdog responds best to rapid *changes* in light, so as far as possible illumination in the area should be contrasty. Well-diffused lighting such as that from large windows, or fluorescent tubes tends to dispel shadows and makes for less change of light intensity. The watchdog does not need a lot of light; a small window or a single lamp bulb will give greater lighting contrast. ◘

DOWN TO EARTH

By GEORGE HYLTON

THE CHRISTIE BRIDGE

Last year (1975) marked the centenary of the death of Charles Wheatstone, inventor of the concertina. Knowledgeable readers may have heard the name in connection with a rather different gadget, the Wheatstone Bridge. Forget it. The bridge was (as Wheatstone himself freely acknowledged) the invention of another chap, called Christie. Wheatstone took it and used it for the resistance measurements which he needed to make in the course of the electrical work which made him rich and famous—work on telegraph systems, magneto generators, and submarine cables.

Somewhere along the line he found time to invent amusements like the concertina and the stereoscope. He even invented a kind of linear motor, though it lay forgotten in a cupboard in King's College, London, until 1973, and in the meantime various other people had re-invented it.

That's by way of introduction to the subject of measuring bridges, which I've been asked by more than one reader to explain. These Victorian electrical engineers are a good starting point. They had a solid, down-to-earth approach which I admire. Having few instruments, they substituted thought, and came up with the right answers. Let's have a look at the back-to-first-principles sort of thinking which might have led to the development of the "Wheatstone" bridge.

In the early days, there were no voltmeters, ammeters or ohmmeters. The beginnings of the meter go back to the discovery, by the Danish physicist Oersted, that the flow of current in a wire deflects a compass needle placed near the wire. By coiling the wire (to increase the magnetic field) the effect is strengthened. Oersted was a friend of Wheatstone and it's interesting to note that Wheatstone's early telegraphs used deflected magnetic needles like compass needles.

The deflected-needle idea can be worked up into a system for measuring current, an ammeter, in other words. The moving-iron meter, as it was eventually called, is still used, though it has largely given place to the more sensitive and convenient (but harder to make) moving coil meter. One of the great problems in the early days was that it was hard to calibrate meters, that is, to give them an accurate scale. To do this you need precisely known currents. The way to get an accurate current is to apply a known voltage to a known resistance. Too bad, if you don't have accurate voltages and you are trying to find out how to measure resistance.

The Wheatstone bridge gets round all these problems. It uses the meter, not as a current *measurer*, but merely as a current *indicator*, to show whether there is some current flowing, or none. It doesn't need an accurately known voltage. In its simplest form, its accuracy as a comparator of resistances depends, not on having accurate electrical standards, but merely an accurate measurement of *length*.

In its earliest form (what Wheatstone called "Mr. Christie's arrangement of wires") straight lengths of copper wire were used as standard resistances. The very first bridge was for comparing two nearly equal resistances. I'll cheat a bit and go straight on to more versatile kind of bridge actually developed later.

BRIDGE PRINCIPLE

One way of understanding the bridge principle is to begin with a simpler circuit (Fig. 1). This has a battery and two resistances in series. The same current passes through each resistance. Common sense tells you that if the resistances are identi-

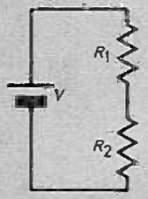


Fig. 1.

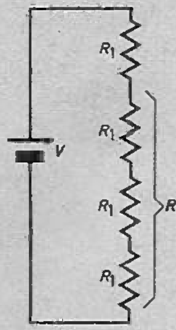


Fig. 2.

Fig. 3.

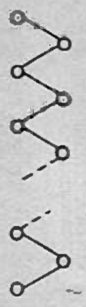


Fig. 4.

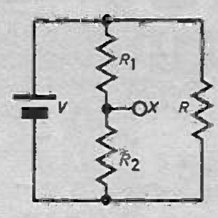


Fig. 5.

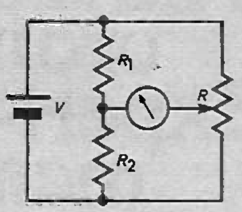


Fig. 6.

Figs. 1 to 6. Showing the circuit arrangements to find resistance ratios and the derivation of the Wheatstone (Christie's) Bridge. Fig. 4 is the arrangement of nails and wire used to form a resistance.

cal, the voltage across one is the same as the voltage across the other. Also, if $R1=R2$ the two resistances behave like one resistance equal to $2R1$. What if they are not equal?

If $R2=3R1$, then $R2$ could be replaced by three resistances as in Fig. 2. It is clear that one quarter of the voltage must appear across each "*R1*." The three "*R1*" that make up *R2* get $\frac{3}{4}$ of *V*, and *R1* gets $\frac{1}{4}$; *R2* gets three times the voltage *R1* gets. **The ratio of the voltages is the same as the ratio of the resistances.** Note that though the actual voltages increase or decrease as *V* increases or decreases the *ratio* is always the same. It is independent of *V*.

Now, if *R1* were a standard resistance, and *R2* an unknown resistance, you could use this circuit to compare the two, so long as you could measure the voltages across each. Thus if *R2* dropped 7 times the voltage that *R1* dropped, *R2* must be $7R1$. Unfortunately, in Wheatstone's day there were no accurate voltmeters. So the problem was to measure the ratio *without* measuring the voltages.

This is the apparently impossible problem which the pioneers set about solving. Looking back, we may guess that they did it in two stages.

RESISTANCES

The first was to forget about *R1* and *R2* and construct a chain of equal resistances (Fig. 3). This can be done very easily by measuring lots of equal lengths of resistance wire. In practice, it was often done by knocking two staggered rows of equally spaced copper nails into a wooden board and threading the wire tightly from one nail to another (Fig. 4). This gives a zig-zag with each zig or zag of equal resistance. (Now you know how the circuit symbol for resistance came into being!)

By analogy with Fig. 2 you can see that by comparing one part of this chain of resistances with the remainder you can get many different ratios. In principle, by using enough nails to make enough zig-zags you can get as many ratios as you like, all known with a high degree of precision, so long as the resistance wire is uniform and the nails are in the right places.

The next stage in the problem is how to use all these known ratios as a yardstick for measuring unknown ones. Remember, we need to compare the unknown *R2* with the standard *R1*.

The first step is to connect the zig-zag *R* across the same battery (Fig. 5). There must be some point on *R* where the voltage has been dropped by exactly the same amount as by *R1*. That is, there must be a possible tapping point on *R* whose voltage is the same as at point *X*. Now, if you can find this tapping point, you have also found the ratio of *R2* to *R1*, because this must be the same as the ratio of the lower part of *R* (below the top) to the upper part, and you know what that is from the number of zig-zags.

All that is needed, therefore, is some means of finding, by trial and error, the tapping point on *R* where the voltage is the same as at *X*. Now the clever bit. If you do find this point, and connect it to *X*, **no current will flow through the connection**. This is simply because there is no voltage difference between the two points.

To find this no-current tapping all you need do is connect the current indicator such as a moving-iron meter as in Fig. 6 and try various tappings until you get the one where no current is registered. The meter helps you because if you tap too high up on *R* the pointer needle is deflected one way, and if too low, the other way.

I use the word "tap" advisedly. Old moving-iron current indicators were not only insensitive, but poorly damped. Given a kick of current, the needle swung to and fro for a long time before settling down. This was put to good use. By tapping the connection to *R* in time to the swing of the needle each tap reinforced the previous one, giving greatly increased sensitivity, at the expense of time and effort. The old engineers had plenty of both.

I think it would be an instructive school project (in both physics and carpentry) to remake one of these early types of bridge, right down to the meter (which was usually called a galvanometer, by the way) and see how well it works.

The Extra-ordinary Experi-ments of Professor Ernest Eversure

by Anthony John Bassett

THE Prof. had shown how the *Breakdown Voltage Tester* can help to distinguish components which generate a lot of noise, and those which generate only a little and also how it can give some guidance on the voltage levels at which most noise is produced.

"I notice there is a terminal on the tester for connection of an oscilloscope," observed Bob. "Is it really necessary to use an oscilloscope with the tester?"

OSCILLOSCOPE

"No, Bob, it is not. The tester is enormously useful without an oscilloscope, but if you do connect an oscilloscope in addition to the built-in milliameter and the multimeter, the usefulness of the equipment is increased even more."

The Prof. connected the input terminals of an oscilloscope to the appropriate terminals on the tester by means of a length of low noise co-axial cable with the inner wire connected to the oscilloscope terminal on the tester and the outer braid connected to the earth terminal. He returned the "test voltage" control on the tester to zero, and switched on both instruments.

When the oscilloscope had warmed up and a green line appeared on the screen he adjusted the sensitivity control on the oscilloscope so that when he gradually rotated the voltage control on the tester, the oscilloscope trace, after making a rapid vertical movement, returned to its previous position in the middle of the screen.

The Prof. continued to increase the voltage and as he did so, the line on the oscilloscope tube appeared to become broader and by adjusting the horizontal frequency and synchronization controls the Prof. caused a sawtooth triangular wave form to appear on the screen (Fig. 1). Bob noticed that alternate peaks of the sawtooth were at different heights on the screen.

"This is due to the voltage doubler circuit used in the tester to generate the h.t. voltage," the Prof. explained, "and because the h.t. smoothing in the tester is not perfect a sawtooth ripple remains on the h.t. voltage supply. As well as seeing it on the oscilloscope, you can hear this as an audio output by means of an audio amplifier connected to the scope terminals, or by means of a sensitive crystal earpiece."

The Prof. connected a crystal earpiece in parallel with the oscilloscope input terminals, and this reduced the amplitude of the sawtooth waveform displayed on the screen but without much effect on the waveshape. Bob could hear a low hum coming from the earpiece.

AMPLIFIER

"I can hardly wait," Bob said excitedly, "to see the effect of breakdown voltage on the trace on the screen, and to hear the results. If we connect an audio amplifier in place of the crystal earpiece then maybe we can hear the sound effects produced by voltage breakdown. Can we use one of the class A amplifiers which I built recently Prof.?"

"Yes, Bob. It should be possible to use almost any audio amplifier but the class A amplifier you built would be a good choice for two reasons. Firstly, because it runs from a battery, there should be no problem with mains earth loops and secondly, because it is a class A design there is no chance of cross over distortion or heavy dissipation due to charge storage effects if we encounter any frequencies much above the audio range. Whichever amplifier you use, however, it is best to connect a high value resistor in series with the input to avoid loading the

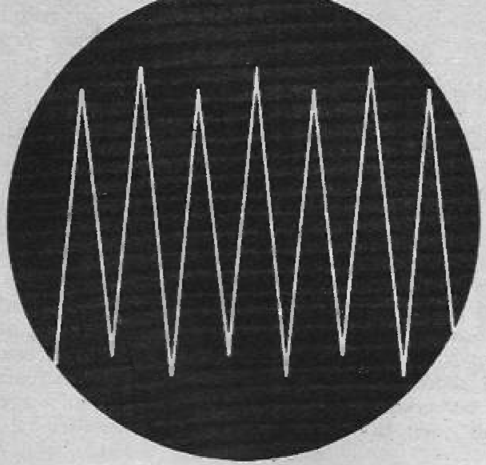


Fig. 1. The sawtooth triangular waveform produced by the tester.

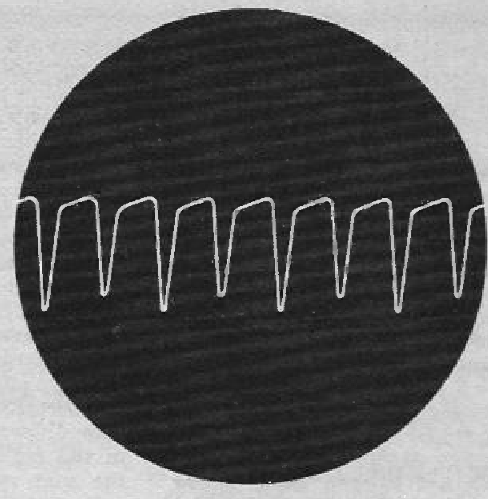


Fig. 2. The distorted waveform produced with the neon in circuit.

input of the oscilloscope."

Bob connected his amplifier to the scope terminals in place of the crystal earphone and with a 470 kilohm resistor in series with the input, this had very little effect on the oscilloscope trace. But when he switched on the amplifier and turned up the volume control the buzz from the sawtooth waveform could be heard clearly from the loudspeaker.

"The amplitude of the sawtooth waveform is so low that it does not interfere substantially with the breakdown voltage measurements," the Prof. informed Bob, "and the other audio effects can be heard superimposed upon it. We will see during the course of our experiments just how useful it is to have this sawtooth waveform upon the steady 'pedestal' of an adjustable d.c. voltage. Let us start with a few tests on some simple two terminal components then later we can advance on to the three terminal devices such as transistors and thyristors."

NEONS

The Prof. brought a small wire-ended neon from amongst his stock of components and inserted its leads into the c and e sockets of the transistor holder. He turned up the test voltage slowly, and as he did so the triangular trace on the oscilloscope gradually increased in amplitude and the sound from the speaker became louder. Bob turned down the volume to prevent overloading of the amplifier. The voltage was now approaching 60 volts and the Prof. warned Bob that this was near to the firing voltage of the neon bulb. "Soon we should see something happen, Bob, as most neons of this type fire at a voltage of around 60 to 90 volts. I have heard of some neons which will light up at only 30 volts but these are exceptional."

As he turned the voltage up to about 74 volts there was a slight pop from the loudspeaker and Bob could see that the neon had lit up, with an orange glow around one of its electrodes. The reading on the multimeter had fallen to about 65 volts and the milliameter showed that a small current was being consumed by the neon, about 100μA.

The waveform on the oscilloscope now showed a large reduction in amplitude and was no longer a clean sawtooth shape. It had become both distorted and reduced in amplitude (Fig. 2).

"This is because the neon, once it begins to conduct, acts as a low impedance so that as well as conducting a d.c. current, it shunts some of the sawtooth waveforms," the Prof. explained. "So now you can see how a neon tube can be used as a switch controlled by a d.c. voltage. Notice how much quieter the sound from the loudspeaker becomes when the neon conducts."

NEON SWITCH

Bob rotated the voltage control back and forth, and as he did so noticed how the trace on the oscilloscope and the sound from the speaker were affected as the neon lit and extinguished.

"This phenomenon has proved to be very useful in electronic music and for sound effects." The Prof. continued. "Neons have been used in electronic organs and similar instruments not only to generate tones, but also to route them through the complex circuitry of the instruments in response to d.c. voltages, introduced when the organist plays the instrument. This has simplified the keyboard arrangements considerably.

Now although neons are being replaced by solid state devices and especially by integrated circuits in electronic organs and musical instruments they are still very interesting to work with and it is easily possible to obtain some quite surprising sound effects from neons with fairly simple circuitry. The *Breakdown Voltage Tester* comes in as very useful here, as it enables us to select neon bulbs whose breakdown voltages match each other closely.

The extinguishing voltage can also be measured by turning down the test voltage to the point at which the neon just becomes extinguished."

Now Bob began to adjust the test voltage with the neon lit, and as he approached the voltage at which the neon would extinguish he noticed some very interesting effects on the waveform and some rather peculiar sounds from the loudspeaker. He tried several different neon bulbs, and whilst the effects were similar, there were noticeable differences between them, both on the oscilloscope screen and in the sounds from the loudspeaker.

"Prof.," called Bob, "this is very peculiar. As I turn the test voltage gradually down towards the point where the neon extinguishes, the sawtooth waveform appears to do somersaults on the oscilloscope screen and it becomes covered in small ripples. at the same time a very peculiar sound comes from the loudspeaker and the effect is different with each neon I try. It even changes if I reverse the wires of an individual neon."

"Ah, yes," explained the Prof., "these effects and their variations are due to a combination of the properties of the neon gas in each bulb, and to the surface texture and geometry of the electrodes."

PARASITIC OSCILLATION

"Whenever the current through the neon and the voltage across it approach closely the conditions where it is about to become extinguished the negative resistance characteristics of the device become enhanced and this tends to produce parasitic oscillations which are the sounds you can hear from the loudspeaker.

This negative resistance property also has the effect of exaggerating the differences between individual neons so that slight differences in gas pressure or composition and minute differences in surface texture of the electrodes make a considerable difference to the behaviour in the circuit from one neon to the next.

Because these effects also change as the neon ages, and are also sensitive to the type of use or treatment that each neon receives, each neon may be regarded as a different individual whose character changes throughout its useful life until it goes out of specification or becomes blackened and useless.

Whilst its performance remains within certain limits it may be employed as a mass produced article for a huge variety of purposes involving light emission, waveform operation, switching voltage regulation and protection and many other uses. So that in addition to the neon tubes you see used for advertisements and the small neons used as indicator lamps there are all sorts of other neon tubes which are manufactured for special purposes, some having over 20 electrodes."

"It seems, Prof. as though the humble little neon bulb, to which we tend to pay very little attention deserves a lot more study," remarked Bob enthusiastically.

"Oh, yes!" the Prof. agreed, "and there is another device more recently brought into common use which is also very interesting. It gives out light at much lower voltages than are necessary to fire a neon bulb and is a solid state type semiconductor device. I am referring of course to the family of devices known as light emitting diodes. The *Breakdown Voltage Tester* can be used for some interesting experiments on these and on other types of diode.

Next Month: Bob and the Prof. experiment with various diodes.

BOOK REVIEWS

ABC OF HI-FI

By John Earl
Published by Fountain Press, Argus Books Ltd.
Size 168 pages, 22cm x 14cm.
Price £3·75

The subject matter is grouped in chapters devoted to the familiar regions of amplifiers, loudspeakers, programme sources and signals, radio tuners, recording and replay, and sound and room acoustics; with another chapter devoted to "quadraphony". Within these chapters individual items are alphabetically arranged, with helpful cross references. Treatment varies in length from a sentence or so defining some expression or quality etc., to a page or more where the subject merits fuller descriptive treatment. There are many diagrams and photographs to illustrate the text.

The immediate and obvious usefulness of this book is as a ready source of reference for all audiophiles. As a "continuous read", the newcomer to hi-fi could find this an easy and agreeable way to acquire an overall appreciation of what actually is involved in sound production systems.

D.D.R.

RADIO CONSTRUCTION FOR AMATEURS

By R. H. Warring
Published by Pitman Publishing Ltd., Pitman House, 39 Parker St., London, WC2B 5PB.
Size 120 pages, 22 x 14 cm approx.
PRICE £2·50

A well known technical author and a book that lives up to his but perhaps not "its" name. From basic radio principles we are quickly led through crystal sets to a combined theory and practice section on tuned circuits followed by amplifier and general theory sections, taking up the first half of the book.

The remaining 60 odd pages are devoted to the description of various radio circuits with three chapters—"TRF Receivers", "Regenerative and Reflex Receivers", and "Superhets"—followed by an excellent section on components with good illustrations and descriptions for those who are new to the hobby.

The two final chapters are very brief and deal with "Circuit Construction", and "F.E.T.S and I.C.S" and if any criticism can be levelled at this book it is that these final chapters are too short. I do feel that most readers with little experience in construction would require more instruction in the techniques, and some construction diagrams for the various receivers discussed in earlier chapters. For this reason I feel that the title may be rather misleading, since no construction drawings are shown for anything other than crystal sets. The section on "F.E.T.S and I.C.S" cover only four pages and is hardly worthwhile.

M.K.

FROM BI-PRE-PAK

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Not only is this Stirling Sound's best audio amplifier yet; it rightfully qualifies as one of the best of its kind yet made available to constructors. Intended above all for high-fidelity, the characteristics of the SS.125 are such that it can be used in many other applications where dependability is the prime consideration. The SS.125 integrates well with other S.S. units as well as those of other manufacturers. Incorporates new circuitry using a complimentary long-tailed pair input and full complementary output circuits to give lab standards of performance.

OUTPUT	25 watts R.M.S. into 8 Ω using 50V 22 watts R.M.S. into 4 Ω using 33V *(Low imp. not less than 4 Ω)*
DISTORTION	Less than 0·05% at all power levels (From 10Hz to 10KHz)
FREQUENCY RESPONSE	± 1dB 15 Hz to 30 KHz (4 Ω) ± 1dB 10 Hz to 30 HKz (8 Ω)
HIGH Z INPUT	100 Kohms (40dB gain/100x)
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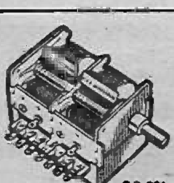

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SS.201	Tuner front end. Ganged, geared variable tuning, 88—108MHz. A.F.C. facility	£5·00
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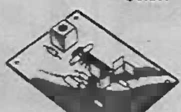
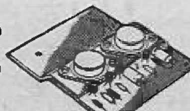


SS.202

SS.203



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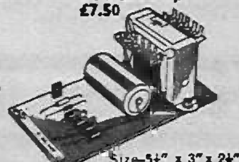

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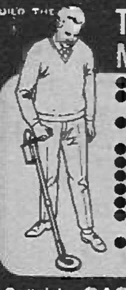

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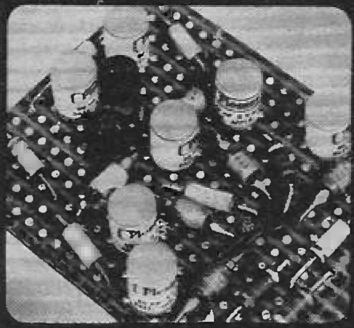

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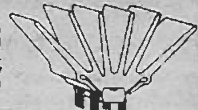

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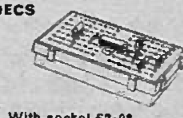

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