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FERRITE ROD AERIALS — Electronics 706
Data No. 47 For the Beginner

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Technical Queries. We regret that we are
unable to answer queries other than those
arising from articles appearing in this
magazine nor can we advise on
modifications to equipment described. We
regret that queries cannot be answered over
the telephone, they must be submitted in
writing and accompanied by a stamped ad-
dressed envelope for reply.

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Production— Web Offset.
A multiband superhet tuner, constructed using a single IC for RF/FM processing - but with all features you would expect of designs of far greater complexity. The FM section uses a three-stage ganged filter, with 2nd stage inverted feedback, with AM employing a double balanced mixer input stage, with mechanical IF filters - plus a BFO and MOSFET product detector for CW/SSB reception. We introduce the HyperFi FM IF with this package but using standard 3rif OT crystals, and we offer the pulse induction 'Sandbanks'. Now with inject and MOSFET product detector for CW/SSB reception. Styled in a matching unit to the reference series modules; complete with digital frequency readout/clock-timer hardware £99.00 + £12.37 VAT

Low power LCD means no RFI

VHF MONITOR RX WITH PLESSEY IC induction 'Sandbanks'. Now with injection and MOSFET product detector for CW/SSB reception. Styled in a matching unit to the reference series modules; complete with digital frequency readout/clock-timer hardware £99.00 + £12.37 VAT

Digital Dorchester All Band Broadcast Tuner: LW/MW/SW/SW/FM stereo

Radio and Audio Modules : The biggest range! best specs: EF5801/314 6 stage varicap tunerdetector with LO feed and varicap levels of sophistication. New SN804 inductor AGC loop on board. SN801 £17.45+£1.82 VAT - SN803 £19.75+£2.47 vat. Frequencies in 4018MHz in apporo.

CD4000 CMOS

Current news: Work continues apace on our HMOS PA kit, and by the time this is published - we expect to be about to launch the product in a style that matches the Mark III system. The unit uses separate transformers and power supplies, and includes a DC offset turning circuit combined with slow switch on using a relay. We introduced the HyperFi FM IF with this package but using standard 3rif OT crystals, and we offer the pulse induction 'Sandbanks'. Now with injection and MOSFET product detector for CW/SSB reception. Styled in a matching unit to the reference series modules; complete with digital frequency readout/clock-timer hardware £99.00 + £12.37 VAT

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STEVENSON
Electronic Components

REGULATORS
78L05 30p 7805 60p 79L05 70p 7912 80p
78L12 30p 7812 60p 79L12 70p 7915 80p
78L15 30p 7815 60p 79L05 80p LM733 35p

HARDWARE
MINIATURE TRANSFORMERS
240 Volt Primary
Secondary rated at 100mA.
Available with secondaries of:
6-0 6, 90 0 and 12-0 12, 90p each.

LOUDSPEAKERS
56mm dia. 8 ohms ... 70p
64mm dia. 8 ohms ... 75p
64mm dia. 64 ohms ... 75p
70mm dia. 8 ohms ... 100p
70mm dia. 80 ohms ... 110p

TERMINALS
Rated at 10A. Accepts 4mm plug, black, blue, green, brown and red ... 22p

SWITCHES
Subminiature toggle. Rated at 3A 250V.
SPDT 70p SPDT centre off 75p
DPDT 80p DPDT centre off 85p
Standard toggle
SPST 34p DPDT 48p
Wavechange switches.
1P12W, 2P6W, 3P4W or 4P3W all 43p ea.
Miniature switches (non-locking)
Push to make 15p Push to break 20p
Slide switches (DPDT)
Miniature 14p Standard 15p

CONTROL KNOBS
Ideal for use on mixers etc. Push on type with black base and marked position line. Cap available in red, blue, green, grey, and black. 14p

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Availability

STEVENSON
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REGULATORS
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Mail orders to: STEVENSON (Dept RE)
76 College Road, Bromley, Kent, England

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**TRANSFORMERS**

All 240VAC Primary (postage per transformer is shown after price).

- MINIATURE RANGE: 6-0.0V 60mA, 9-0.0V 75mA and 12-0.0V 80mA all 75p each (16p).
- 60mA 100mA 90p (15p).

- 0-6V, 0-5V, 0-25mA 45p.
- 0-45V, 0-0.5mA 20p.

- Miniature size transformers have no mounting bracket, 65p (15p).
- 12V 500mA 50p (22p).
- 2A 2amp 5/6p. 15-0-15V 3 amp Transformer at 2£75 (54p).
- 5/6p. 20-0-20V 2 amp £30 (54p).
- 0-12-24V 30p (2£40). £2.50.

**FETS/SCRS ETC**

Unicord ble N-channel FET similar to 2N3819 15p each. 3N140 or B6010 40p each. M203 dual matched pair of single gate mosfets in one can 40p. 2N5020 plastic TO22 SCR 100V 800mA 18p each. BX504 Opto isolators, 4 lead input red lead to photocell 25p each.

**DIODES**

IN4004 10 for 35p. IN4004 10 for 45p. IN4007 10 for 50p. BY17 10 for 75p. IN914 (numbered) 100 for £2.25.

**TRIAC/XENON PULSE TRANSFORMERS**

11:1 (gpo style) 30p. 1:1 plus 1 sub. pcb mounting 60p each.

**MICROPHONES**

ECM105 Condenser, Omni Directional. 50k Ohm, 40p each, on/off switch £2.85.

- EM506 Condenser Cardioid, Uni directional. 50k Ohm, 50p each.
- Miniature tie pin condenser microphone, 1000 Ohm impedence, 150kHz-10KHz, 15p each.
- LA-2018 500kHz-5MHz, 45p each.
- LA-2500 500kHz-5MHz, 55p each.

**TUBING**

- 2m long 1:1 OMNICALC, 100p each.
- SIMS 4936, 100p each.

**RELAYS**

Clare Elliot sub. min. sealed relay 10 x 15mm. 2 pole 0/5V, 1,250 Ohm coil, new £30. a 7923 14 pin regulator, 40p each. Reed relay, 0.1 matrix mounting, 1000 Ohm impedence, 150kHz-10KHz, 15p each.

- C016X6 500kHz-5MHz, 50p each.
- LA-2018 500kHz-5MHz, 50p each.

**MICRO SWITCHES**

- Miniature sub. min. sealed relay, 10 x 15mm, 2 pole 0/5V, 1,250 Ohm coil, new £30. a 7923 14 pin regulator, 40p each. Reed relay, 0.1 matrix mounting, 1000 Ohm impedence, 150kHz-10KHz, 15p each.
- C016X6 500kHz-5MHz, 50p each.
- LA-2018 500kHz-5MHz, 50p each.

**TOOLS**

Solder sucker, plunger type, high suction, teflon nozzle £4.75. (spare nozzle £5.65 each).

Good Quality side cutters, insulated handles, 5" £1.35.

Good Quality snub nosed pliers, insulated handles, 5" £1.35.

Antex Model C 18 watt soldering irons, 240VAC £3.60.

Antex Model MX25 25 watt soldering iron, 240VAC £4.00.

Antex ST3 iron stands, suits all above models £1.40.

Antex heat sinks 12p each.

Servisol Solder Mop 45p.

Neo-Tone Screwdrivers 8" long 40p each.

Multiplie double action 12 tags 29 x 9 x 11mm 24p.

**SWITCHES**

- Sub. miniature toggle: SPST, 15p per piece, DPDT 8 x 7 x 7mm 50p.
- DPDT centre off 12 x 11 x 9mm 75p.
- Standard button operated, 16 x 11 x 9mm £1.15.
- LOW CONSUMPTION SNAP ACTION, approx. 1 flash per second but can be varied via preset pot. 35p each.

**MICRO SWITCHES**

Standard button operated 28p, 1mm make or break, new 15p each.

Roller operated version of the latter, new 15p each. Light action micro, 3 amp make or break 35 x 20 x 7mm £1.35.

- Cherry knurled operated micro, 2 normally open, 2 normally closed, roller operated version (40 x 30 x 18mm) 25p each.

**ROCKER SWITCHES**

- 2 amp SPST, single nut mounting, various colours (red, green, blue, yellow, black) 19p each.
- 50VAC 6amp rocker (all above models) 21 x 15 x 13mm 17p each.

**TAPE HEADS**

Mono cassette £1.60.

Stereo cassette £3.40.

Standard 8 track stereo £1.75. BSR MN330, BSR SR330 £1.75.

**STEREO CASSETTE HEADS**

50VAC 6amp rocker (all above models) 21 x 15 x 13mm 17p each.

**AUTO CASSETTE HEADS**

- 722 £1.75.
- 732 £1.75.
- 772 £1.75.
- 782 £1.75.
- 792 £1.75.

**PROGRESSIVE RADIO**

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REL 779
TRADE COMPONENTS
OFFERS CORRECT AT 18/5/79 APPLICABLE TO ORDERS RECEIVED DURING JUNE.

VALVE BASES
Printed circuit B7G
Chassis B7G
Chassiss B7G-B8A
812A tube. Chassis B9A
Speaker 8" x 4" 6 ohm ideal for car radio £1.86
2 1/2" diam. 32 or 60£ 0.76
TAG STRIP — way 5p
5 x 50p or 1000 +
way 10p Single 2p
300p trimmers 35p
Car type panel low and key 86p
Transformer 9V 4A £3.78
Aluminium Knobs for 1" shaft. Approx. 2 1/2" x 1 1/2" £1.25

BOXES — Grey polystyrene 61 x 112 x 31mm, top secured by 4 self tapping screws 57p clear perspex sliding lid, 46 x 39 x 24 mm 16p.

SAPHIRE STYLM. 15 different; dual and single point, current and 18 SWG multicore solder 3-J-p foot hard to get types. My mix £2.

DIECAST ALI superior heavy gauge with sealing gasket, approx. 64 x 2 7/8" x 1 1/2" £1.85

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VARYING CONTENTS INCLUDE ZENER, GOLD BOND, TRANSISTORS AND DIODES, HIGH STAB RESISTORS, CAPACITORS, SILICON, GERMANIUM, LOW AND HIGH POWER TRANSISTORS for mains operation. Ex equipment £4.32

VARIABLE CAMM PROGRAMMER 10, 12 or 15 pole 2 way, approx. 12V d.c. (48 a.c.) or mains £1.10

3 pole jack plug to tag ends, 4ft 3 pin din to open end, 14yd, twin screened or B.C.D., or Comp. 1242 also 2p co.. £1.20

(variables too are values to numerous to list, use this price guide to work out your actual requirements 8/20, 10/20, 12/20, 22/20, 47/25. Tub. Tent 24/25

16-32/275V, 100/150V, 100-200/275V
300V, 200-20/300V £1.30 100-300-500, 16/300V £1.65

RS 100-0-100 micro amp null indicator Approx. 2" x 1" x 1" £1.86

INDICATORS
Bulgin D676 relays takes M.E.S. Bulb 38p
12 volt, or Mains light. £2.70 or inc. £3.10
R.S. Scale Print, pressure transfer sheet 12p

CAPACITOR GUIDE — maximum 500V
Up to .01 ceramic 41p. Up to .01 poly 6p .013 up to .1 poly etc. 7p, 12 up to .68 poly etc. 8p. Silver mica up to 380p 10p, then to 2,200p 13p; then to .01 mfd 21p

1/100, 6/100, 1/100, 8/100, 20/100, 40/100, 80/100, 120/100, 220/100, 470/100, 1/2μ 10p, then to .1μ £1.30

Many others and high voltage in stock.

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Open 10 a.m. till 7 p.m. Tuesday to Saturday. VAT receipts on request.
Terms: Payment with order. Telephone: 01 223 5016

JAP 4 gang min. sealed tuning condensers 40p

ELECTROLYTICS Many others in stock
Up to 10V 25V 50V 75V 100V 250V 350V 500V
MFD £83.
10 6p 7p 7p 10p 15p 18p 26p £2.32
22 8p 7p 7p 10p 15p 18p 26p £2.37
56 10p 8p 13p 15p 22p 26p £2.94
100 13p 13p 15p 22p 26p £3.69
250 13p 15p 15p 22p £1.10 £1.30
330 13p 15p 15p 22p £1.48 £1.60
1000 13p 15p 15p 22p £8.06
2000 27p 47p 59p £1.20

As values are too numerous to list, use this price guide to work out your actual requirements 8/20, 10/20, 12/20, 22/20, 47/25. Tub. Tent 24/25

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300V, 200-20/300V £1.30 100-300-500, 16/300V £1.65

RS 100-0-100 micro amp null indicator Approx. 2" x 1" x 1" £1.86

CONNECTOR STRIP
Belling Lee L1469, 4 way polystyrene. 9p each
1 1/4 glass fuses 250 ma or 3 amp (box of 12) 20p
Bulgin 8mm Jack plug and switched socket (pair) 40p
Reed Switch 28mm, body length 11p
Aluminium circuit tape, 1 x 36 yards — self adhesive. For window alarms, circuits, etc. 95p

TV MAINS DROPPERS
5 assorted multitudinous units... £7.60
100PF air-s spaced tuning capacitor... £1.30 £1.70
300PF 33 ohm capacitor... £1.60 £2.20
2 Amp Suppression Choke... £1.30 £1.70
3 x 2 1/2" x 1/2" PAXOLEINE... £4.35 £5.00
4 1/2" x 1/2" x 1/2" N/C metal clip on MES bulb Holder... £5.00 £5.60
VALVE RETAINER CLIP, adjustible... £1.50 £1.85
Sub-miniature Transistor Transformer... £5.60 £6.40
Valve type output transformer... £9.00 £10.00

POT CORES with adjuster
LA2508-LA2519 43p per pair

200V, 50/50/385V, 2+2/200V non polar, 32-32-50
100V, 100-200-60/300V £1.30 100-300-100, 16/300V £1.65

DECAY rechargeable N.C. 4500. Capacity 6V
350 1A power required, giving 16 watt 450 2A — 400 watt
RMS 8/0. £3.45

REGULATED TAPE MOTOR
Grundig 6V approx., 3" x 1/2". shock absorbing carrier, or Jap 9V, 1 1/2" diam. £1.06 £1.30
3.5mm metal stereo plug 30p
Fane 6 ohm 3 sq. heavy duty communications 1 1/2" £1.60 £1.90
RS neg. volt regulator 103, 306-099 (equiv.
MPC300) 10A, 100 watt 4-30 volt. Adjustable short circuit protection. Normally £12.50+ £15.60

Mail order 10% discount over £50. Over £100 15% discount on many items.

Automatic record cleaner. £1.30 £1.60
Trade 30 minute record. £1.20 £1.40

"Hakusan" 1/4" stereo £2.20 £2.50

D12 D.C. Variable, 500/1 500/0 100/1 100/0 £4.00 £4.50

W.35 A.C. Variable, multi-range £4.40 £5.80

DEAC rechargeable £1.90 £2.20
2 1/2 8.3mm, £1.20 £1.50

PAY A VISIT — THOUSANDS MORE ITEMS BELOW WHOLESALE PRICE. CALLERS PAY LESS ON MANY ITEMS AS PRICES INCLUDE POSTAGE. PRICES INCLUDE VAT AND ADDITIONAL DISCOUNT IN LIEU OF GUARANTEE. GOODS SENT AT CUSTOMERS RISKS UNLESS SUFFICIENT ADDED FOR REGISTRATION OR COMPENSATION FEE POST.
OFFERS CORRECT AT 18/6/79 APPLICABLE TO ORDERS RECEIVED DURING JUNE.

 VALVE BASSES

<table>
<thead>
<tr>
<th>Printed circuit B7G</th>
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<tr>
<td>Chassis B7-B7G</td>
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<tr>
<td>Shrouded chassis B7G-BBA</td>
<td>15p</td>
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<tr>
<td>B12A tube. Chas. B8A</td>
<td>13p</td>
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Speaker 6"x4" 5 ohm ideal for car radio £1.58
4 ½" diam. 30 Ω £1.78
2 ½" diam. 32 or 82 Ω £1.07

TAG STRIP - 6 way 8p
5 x 50p if 1000 +
6 way 10p Single 2p
100p if trimmers 3p

Aluminium Knobs for “J” shaft. Approx. ½" x ½" with indicator
Pack of 5 95p

BOXES — Grey polystyrene 61 x 112 x 31mm, top secured by 4 self tapping screws B7p clear perspex sliding lid, 46 x 39 x 24 mm 16p.

ABS, ribbed inside 5 mm centres for P.C.B., brass corner inserts, screw down lid, 50 x 100 x 25mm orange 65p; 80 x 150 x 50mm black 97p; 109 x 185 x 80mm black £1.82.

DIECAST ALI superior heavy gauge with sealing gasket, approx. 12V d.c. (48 a.c.) or mains’ £1.10

ENM Ltd. cased 7-digit counter 2-J- x’lf x If”

SAPPHIRE STYLUS. 15 different, dual and single point, current and

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approx. 12V d.c. (48 a.c.) or mains’ £1.10

ENM Ltd. cased 7-digit counter 2-J- x’lf x If”

VARIABLE CAMM PROGRAMMER 10, 12 or 15 pole 2way, 1 pole 2 way 10 amp oblong clip in mains £0.85; 3f’ x 2” x 1” £1.50; 3f’ x 2” x 1” £1.25.

300pF trimmers 35p

TAG STRIP—6 way 5p
300pF trimmers 35p

COMPONENTS

BDURING JUNE.

InnmMo

VARIABLE CONTENTS INCLUDE ZENER, GOLD BOND, with knob 10 for 40p

3 pin din to open end, 1 fyd, twin screened

latching 82p

5 pin din 180° to 2-phono

rocker appliance switch   38p

2 Alternating Slide

80 x 150 x 50mm

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SAPPHIRE STYLUS. 15 different, dual and single point, current and hard to get types. My mix £2.

JAP 4 gang mini. sealed tuning condensers 40p

RS Yellow Wander Plug Box of 12  40p

18 SWG multicore solder

3½ foot

SAPPHIRE STYLUS. 15 different, dual and single point, current and hard to get types. My mix £2.
**SEMI-DIODES**

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**TRANSISTORS**

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<tr>
<td>2N2222</td>
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</tr>
<tr>
<td>2N2222</td>
<td>£0.0130</td>
</tr>
<tr>
<td>2N2222</td>
<td>£0.0130</td>
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**OPTO ELECTRONICS**

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<tr>
<td>TIP33</td>
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<tr>
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**PAPER BLOCK CONNECTOR**

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<tbody>
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<td>0.25mF, 500V</td>
<td>£0.0130</td>
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<tr>
<td>0.25mF, 500V</td>
<td>£0.0130</td>
</tr>
<tr>
<td>0.25mF, 500V</td>
<td>£0.0130</td>
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<tr>
<td>0.25mF, 500V</td>
<td>£0.0130</td>
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**TV KNOB**

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<th>Price</th>
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<tbody>
<tr>
<td>Dark grey plastic for recessed shaft (quarter inch) with shaft extension</td>
<td>£0.0130</td>
</tr>
<tr>
<td>Dark grey plastic for recessed shaft (quarter inch) with shaft extension</td>
<td>£0.0130</td>
</tr>
<tr>
<td>Dark grey plastic for recessed shaft (quarter inch) with shaft extension</td>
<td>£0.0130</td>
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<tr>
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**CHASSIS SOCKETS**

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<tr>
<td>250 mfd, 400V</td>
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<tr>
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<tr>
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**SPECIAL OFFERS**

<table>
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<td>2N1613</td>
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</tr>
<tr>
<td>2N1613</td>
<td>£0.0130</td>
</tr>
<tr>
<td>2N1613</td>
<td>£0.0130</td>
</tr>
<tr>
<td>2N1613</td>
<td>£0.0130</td>
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</tbody>
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**MINIATURE E-METERS**

<table>
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<th>Value</th>
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<tbody>
<tr>
<td>200 Ah level meter, clear face. 10 x 18 mm</td>
<td>£0.0130</td>
</tr>
<tr>
<td>200 Ah level meter, clear face. 10 x 18 mm</td>
<td>£0.0130</td>
</tr>
<tr>
<td>200 Ah level meter, clear face. 10 x 18 mm</td>
<td>£0.0130</td>
</tr>
<tr>
<td>200 Ah level meter, clear face. 10 x 18 mm</td>
<td>£0.0130</td>
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</table>

**GARRARD**

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<tr>
<td>GS25T Crystal Stereo Cartridge</td>
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</tr>
<tr>
<td>Mono (Stereo compatible)</td>
<td>£0.0130</td>
</tr>
<tr>
<td>Ceramic or crystal</td>
<td>£0.0130</td>
</tr>
<tr>
<td>Ceramic or crystal</td>
<td>£0.0130</td>
</tr>
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**INTEGRATED CIRCUITS**

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</tr>
<tr>
<td>7402,7403,7404,7405,7406,7407</td>
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<tr>
<td>7402,7403,7404,7405,7406,7407</td>
<td>£0.0130</td>
</tr>
<tr>
<td>7402,7403,7404,7405,7406,7407</td>
<td>£0.0130</td>
</tr>
</tbody>
</table>

NO MORE TO ADD — Prices INCLUDE VAT and Post/Packing
**Satisfaction or your Money Back if Goods Returned within 7 Days**

**A Big New Deal**

**Panel Indicators**
- Red 30p Amber 32p Green 32p
- Clear lens red glow 22p
- All Brand New!

**Stud Diodes**
- Rated 10 amp 100V Metal Brand New
- Two for 35p

**Wirewound Resistors**
- All brand new modern types

<table>
<thead>
<tr>
<th>Value</th>
<th>Resistance</th>
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<tbody>
<tr>
<td>1.5ohm</td>
<td>5p</td>
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<td>2.0ohm</td>
<td>5p</td>
</tr>
<tr>
<td>3.0ohm</td>
<td>5p</td>
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<td>5p</td>
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<tr>
<td>5.6ohm</td>
<td>5p</td>
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<tr>
<td>6.0ohm</td>
<td>5p</td>
</tr>
<tr>
<td>5.000m</td>
<td>5p</td>
</tr>
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</table>

**Poly styrene Capacitors**
- 47pF/400V
- 60pF/350V
- 63pF/150V
- 39pF/350V
- 100pF/350V
- 307pF/125V
- 400pF/125V

**Turn capacitors**
- 250pF air spaced 40p
- 350pF ≈ 350pF approx
double gang, slow tune, air spaced 60p

**All Brand New**

**Sensitometer Scoop**
- Brand new, 7-segment, 100% functional.
- Data supplied: we don't select display colours or c.a. or c.c. types.

**Only Limited Stocks**

**Super Buy**

**Super Tested Paks**
- All modern types, carbon tracks.
- 60% long life.

**Widerband Amplifier**
- 120s FM Detector
- 50p New, with data but untested.

**Mullard Taa320**
- M.O.S. pre amp I.C.

**13 Amp Rubber Fly lead extension sockets**
- Black 40p

**Power Supply Electrolytics**
- 5% low and low.
- All brand new, with preferred leads.

**Carbon Film Resistors**
- Various types.

**Relays**
- 12v dc min new 70p

**Coaxial Connectors**
- Various types.

**4 Way Switch**
- Various types.

**Bargain Pak**
- All new and marked numbers, plastic and metal types.

**Audible Warning Device**
- Transistorised 4-12v
- Can be run from 110V
- Brand New 74p each

**Catches, Sockets**
- Low profile d.I. I.C.
- Brand New

**Films Resistors**
- Various types.

**Superme Indicators**
- Red 30p Amber 32p Green 32p
- Clear Lens red glow 22p
- All brand new!

**Electrolytic Capacitors**
- All brand new modern transistor types mostly.
- All values, voltages marked.

**ThreeBanked, One D.P. Changeover, Two D.P. Changeovers**

**Tynan Transformers**
- 4000W 350W 250W 240W 220W

**NTRO Switch**
- Miniature 2 pole 4 way 30p each

**Diode Pak**
- 50 Silicon types new only 35p

**Crystal Oscillators**
- Ten asstd types 10 x 15
- Only 60p

**Impression Trimmers**
- 10 to 100p
- Only 12p each

**Electrovanove TEL: 01-736 0868 MAIL ORDER ONLY**

**P.O. Box 191 London Sw6 2LS**

**Transistorised Inverters**
- All units ready assembled in blue exine covered aluminium cases.
- Plan bottoms, features include on/off switch, built in via 13A type plug.
- Silicon power transistors, all components used throughout.
- 12v or 24v inputs as listed — output 240v AC off load.

**Rotary Pots**
- All modern types, carbon tracks.
- 60% long life, all new

<table>
<thead>
<tr>
<th>Value</th>
<th>Type</th>
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</thead>
<tbody>
<tr>
<td>10K</td>
<td>Lin 18p</td>
</tr>
<tr>
<td>47K</td>
<td>Lin 18p</td>
</tr>
<tr>
<td>50K</td>
<td>Lin 18p</td>
</tr>
<tr>
<td>250K</td>
<td>Lin 16p</td>
</tr>
</tbody>
</table>

**Super Tested Diodes**
- Tested 20 asstd I.C.
- All sorts

**50 p I.V. amp Wire End**
- I.C.s new with data

**Wideband Amplifier**
- N.C.'s new with data but untested 18p each

**Mullard TAA320**
- M.O.S. PRE AMP I.C.

**35 Amp Fuses**
- 35 Amp Fuses

**1/4" Solid Core**
- With cores 9p

**13 Amp Plug**
- Black rubber new 38p each

**Reed Relays**
- Small types 10p each

**Reed Relay**
- Black rubber new 38p

**LED - Displays**
- Brand new, 7 segment, 100% functional.
- Data supplied: we don't select display colours or c.a. or c.c. types.

**Only Limited Stocks**

**Super Buy**

**Carbon Film Resistors**
- Various types.

**N-Cheekon FET's**
- 16p each

**Photo Transistors**
- New, un-coded 18p each

**Panel Fuseholders**
- 20amp type 30p each

**F.B.D187 transistors**
- All modern types.

**Inline Fuseholders**
- 12 fuse type 16p each

**Summer Offer**

**Please add 15p post/packing. Minimum order £1.50. Payment by cheques, postal orders etc. Overseas postage at cost. It is very helpful if you print your name and address clearly. Goods ordered now sent by return of post except where indicated.**

---

**Electrovanove TEL: 01-736 0868 MAIL ORDER ONLY**

**P.O. Box 191 London Sw6 2LS**
## EXPERIMENTER BREADBOARDS

No soldering modular breadboards, simply plug components in and out of latter and interconnect with self-adhesive nickel-silver pick off contacts. Start small and simply select boards to build breadboard of any size. Each EXP Bcreenshot has two bus-bars as an integral part of the board. If you need more than 2 buses, simply snap on 4 more bus-bars with the aid of an EXP-4B.

**EXP-325.** The ideal breadboard for 1 chip circuits. Accepts 8, 14, 16 and up to 22 pin ICs. **£1.73.**

**EXP-350.** £3.40. 270 contact points with 20-point bus-bars.

**EXP-300.** 550 contacts with 40-point bus-bars. **£6.21.**

**EXP-650** for Micro-processor. **£3.89.**

**EXP-48.** Bus bars. **£2.48.**

ALL EXP-300 Breadboards mix and match with 600 series.

### THYRISTORS

<table>
<thead>
<tr>
<th>600mA</th>
<th>To 18 Case</th>
<th>Volts No.</th>
<th>Price</th>
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</thead>
<tbody>
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<td>10 THY90/10</td>
<td>00.16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 THY90/10</td>
<td>00.22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 THY90/10</td>
<td>00.27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40 THY90/10</td>
<td>00.32</td>
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</tr>
<tr>
<td>50 THY90/10</td>
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<table>
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<th>TO 48 Case</th>
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<td>60 THTA/30</td>
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<td>70 THTA/30</td>
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<td>80 THTA/30</td>
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<tr>
<td>90 THTA/30</td>
<td>10.93</td>
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### POTentiometers

- **CARBON POTS (Linear Track)**
  - Single track with wire end terminations, 50cm plastic shaft, 10mm bulb, supplied with shake proof washer and nut. Tolerance 2% of resistance.
  - 1831 4k7 ohms £0.12
  - 1832 2k4 ohms £0.10
  - 1833 4.7k ohms £0.12
  - 1834 22k ohms £0.20
  - 1835 22k ohms £0.20
  - 1841 100k ohms £0.41
  - All at 29c each.

- **CARBON POTS (Log Track)**
  - 1842 4.7k ohms £0.12
  - 1843 10k ohms £0.13
  - 1844 22k ohms £0.20
  - 1845 4.7k ohms £0.13
  - 1846 10k ohms £0.13
  - 1847 22k ohms £0.20
  - 1848 10k ohms £0.13
  - All at 29c each.

- **DUAL CARBON POTS (Log Law)**
  - 1861 4.7k ohms £0.13
  - 1862 10k ohms £0.13
  - 1863 4.7k ohms £0.13
  - 1864 10k ohms £0.13
  - All at 29c each.

### SPECIAL VOLUME CONTROLS

- **SWITCHED POTS (Linear Track)**
  - Specification as VC2 but track having ball law.
  - 1879 4.7k ohms £0.12
  - 1880 10k ohms £0.13
  - 1881 22k ohms £0.20
  - 1882 47k ohms £0.20
  - 1883 100k ohms £0.62
  - 1884 100k ohms £0.62
  - 1885 100k ohms £0.62
  - All at 29c each.

- **DUAL CARBON LOG-ANTI-LOG POTS**
  - Track specification as dual gap pots VC3, but tracks mounted to log action.
  - 1886 100k ohms £0.62
  - 1887 100k ohms £0.62
  - 1888 100k ohms £0.62
  - All at 29c each.

### SEMICONDUCTORS

**POTS & IRONS**

- **Price**
  - £0.12 1614 24 pin DIL
  - £0.12 200 THY 10A/200
  - £0.24 1000 THY7/1000
  - £0.24 1000 THY16/1000

- **Price**
  - £0.36 200vRMS BR1/200
  - £0.36 200vRMS BR2/200

- **Price**
  - £0.49 1800 THY16A/1800
  - £0.49 1800 THY16A/1800

- **Price**
  - £0.87 2000 THY10/2000
  - £0.87 2000 THY10/2000

- **Price**
  - £0.87 1861 20A/1861
  - £0.87 1862 20A/1862

- **Price**
  - £0.41 24 pin OIL
  - £0.45 24 pin OIL

- **Price**
  - £0.62 1614

- **Price**
  - £0.67 100k ohms £0.84
  - £0.67 100k ohms £0.84

- **Price**
  - £0.91 1.3v, 2.2v, 2.7v, 3.3v, 3.9v
  - £0.91 1.3v, 2.2v, 2.7v, 3.3v, 3.9v

- **Price**
  - £0.61 VC9
  - £0.61 VC9

- **Price**
  - £0.35 VC5
  - £0.35 VC5

- **Price**
  - £0.86 200vRMS BR2/200

- **Price**
  - £0.81 IN4002 100v
  - £0.81 IN4002 100v

- **Price**
  - £0.60 1950. Iron coated bit 1/16" for 1948 iron.
  - £0.60 1950. Iron coated bit 1/16" for 1948 iron.

- **Price**
  - £0.60 1943 iron. £0.60.
  - £0.60 1943 iron. £0.60.

- **Price**
  - £0.65 200vRMS BR1/200

### REGULATORS

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<td>164</td>
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### BRIDGE RECES

- **SILICON 1 amp**
  - 15922 150v
  - 15922 150v

- **SILICON 2 amp**
  - 15922 150v
  - 15922 150v

- **SILICON 4 amp**
  - 15922 150v
  - 15922 150v

### ZENER DIODES

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<td>280</td>
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</table>

### PRINTED CIRCUIT BOARD TRANSFERS

- **PRINTED CIRCUIT BOARD TRANSFERS**
  - £0.24 200 6A 300v
  - £0.24 200 6A 300v
  - £0.24 200 6A 300v
  - £0.24 200 6A 300v
  - £0.24 200 6A 300v

### DEPT. RC7, P.O. Box 6, Ware, Herts.

COMPONENTS SHOP: 18 BALDLOCK STREET, WARE, HERTS.
Come to the Great British Electronics Bazaar

FREE!

(AND WAIT TILL YOU SEE OUR SEMINAR PROGRAMME)

The Great Big ‘Bazaar’ for the hobbyist, amateur, and small buyer.

There’s never been an event like this before.
First, the very scale of the exhibition is huge. Virtually all the companies you’re used to hearing about (and buying from) will be there. Companies like Fluke and Gould showing off their low cost multimeters; smaller but important manufacturers like Lektrokit and Chromasonics; and even the R.S.G.B. who will have a station ‘on the air’ throughout the ‘Bazaar.’

Then there are the suppliers of low-cost components and equipment. Plus almost all the journals in the business. Plus, oh, so many more interesting people catering for your needs (including computer kits!).

And you get in FREE if you send an s.a.e. (see alongside).

Our Symbol. We think it tells you just what the Bazaar is all about.

The Seminars.
If you would like to hear just what the experts have to tell you, a season ticket for three whole days can be yours for only £1.50.
Send an s.a.e. and we’ll give you all the information (just use the coupon).

Our home for three days – Alexandra Palace, where it all began. (Our seminars are sited alongside the organ – for those who know this unique hall.)

SEMINAR TICKETS
£1.50.
I’d like to sit in at your seminars. (And like a free ticket to the exhibition.) Send me full details, please, and I enclose a large-ish s.a.e.

Name: ..................................................
Address: ..................................................

Post to: The Bazaar, 34/36 High Street, Saffron Walden, Essex.

When?
Between Thursday to Saturday 28th–30th June.
You’ll be in very good company; some ten thousand enthusiasts – and over a hundred stands displaying all that you want to see.

You’ll come?
Eyes down for the appropriate coupon.

ADMISSION FREE
(or 50p on the door).
I’d like to see ‘The Bazaar’ FREE. I enclose a large-ish s.a.e. and will receive by return a ticket and full information.

Name: ..................................................
Address: ..................................................

Post to: ‘The Bazaar,’ 34-36 High Street, Saffron Walden, Essex. If you’d rather just pay 50p, go to Wood Green Tube Station and take a bus (every 3 minutes) to Alexandra Palace. We’re open 10 am–6 pm daily, Thursday to Saturday, 28th–30th June.
THREE FOR FREE FROM CSC

ELECTRONICS BY NUMBERS

LED BAR GRAPH UNIVERSAL INDICATOR

Now using EXPERIMENTOR BREADBOARDS and following the instructions in "Electronics by numbers" ANYBODY can build electronic projects. Look at the diagram and select R3; this is a resistor with a value between 120 to 270 ohm. Plug it into holes X20 and D20, now take LED 1 and plug it into holes E20 and F20. Do the same with the Diodes e.g. plug D7 into holes G7 and G10.

YOU WILL NEED

EXP. ANY EXPERIMENTOR BREADBOARD
D1 to D15 - Silicon Diodes (such as 1N914)
R1 to R6 - From 120-270 ohm resistors 1/2 watt.
LED1 to LED6 - Light emitting diodes.

LED BAR GRAPHS are replacing analogue meters as voltage-level indicators in many instances. This circuit uses the forward voltage drop of diodes to determine how many LEDs light up. Any type of diode can be used but you must use all the same type. For full working details of this circuit fill in the coupon.

If you have already built the Two-transistor Radio and the Fish‘n’cliks projects you will find that you can reuse the components from these projects to build other projects in the series.

FILL IN THE COUPON AND WE WILL SEND YOU FREE OF CHARGE FULL COPIES OF "ELECTRONICS BY NUMBERS" PROJECTS Nos 1, 2 and No 3.

PROTO-CLIP TEST CLIPS.

Brings IC leads up from crowded PC boards. Available plain or with cable with clips at one or both ends.

PC - 16 pin. £2.75.
PC - 16 pin with cable. £5.00.
PC - 16 with cable and 16 pin clips at both ends. £10.25.

CONTINENTAL SPECIALTIES CORPORATION


FILL IN COUPON & RECEIVE FREE COPY OF ELECTRONICS BY NUMBERS PROJECTS Nos 1, 2 AND 3
## OUTPUT VOLTAGE RANGE
12.6 Vdc

## OUTPUT CURRENT MAX
2.5 Amp

## LOAD REGULATION
<0.3% 0-2.2 Amp

## RIPPLE
<5mV 2.2 Amp

## DIMENSIONS (mm)
W140 x H90 x D140

## WEIGHT
1.490 Kg.

### AL.212 P

### INPUT VOLTAGE
220 V ± 10% 50-60 Hz

### OUTPUT VOLTAGE RANGE
12.6 V dc

### OUTPUT CURRENT MAX
2.5 Amp

### LOAD REGULATION
<0.3% 0-2.2 Amp

### RIPPLE
<5mV 2.2 Amp

### DIMENSIONS (mm)
W140 x H90 x D140

### WEIGHT
1.490 Kg.

### AL.315 P

### INPUT VOLTAGE
220 V ± 10% 50-60 Hz

### OUTPUT VOLTAGE RANGE
1 ± 15 Vdc

### OUTPUT CURRENT MAX
5 Amp

### LOAD REGULATION
<0.1% 0-4.5 Amp

### RIPPLE
<2mV 4.5 Amp

### DIMENSIONS (mm)
W210 x H155 x D250

### WEIGHT
5.100 Kg.

### AL.330 P

### INPUT VOLTAGE
220 V ± 10% 50-60 Hz

### OUTPUT VOLTAGE RANGE
3.4-30 Vdc

### OUTPUT CURRENT MAX
3 Amp

### LOAD REGULATION
<0.3% 0-2.8 Amp

### RIPPLE
<3mV 2.8 Amp

### DIMENSIONS (mm)
W270 x H90 x D155

### WEIGHT
4.250 Kg.

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### AL.1 P5

### INPUT VOLTAGE
220 ± 10% 50 Hz

### OUTPUT VOLTAGE RANGE
1 ± 15 Vdc

### OUTPUT CURRENT MAX
5 Amp

### LOAD REGULATION
<0.1% 0-4.5 Amp

### RIPPLE
<2mV 4.5 Amp

### DIMENSIONS (mm)
W210 x H155 x D250

### WEIGHT
5,100 Kg.

### AL.212 PS

### INPUT VOLTAGE
220 V ± 10% 50-60 Hz

### OUTPUT VOLTAGE RANGE
1 ± 15 Vdc

### OUTPUT CURRENT MAX
5 Amp

### LOAD REGULATION
<0.1% 0-4.5 Amp

### RIPPLE
<2mV 4.5 Amp

### DIMENSIONS (mm)
W210 x H155 x D250

### WEIGHT
5,100 Kg.

### AL.315 P2

### INPUT VOLTAGE
220 V ± 10% 50-60 Hz

### OUTPUT VOLTAGE RANGE
1 ± 15 Vdc

### OUTPUT CURRENT MAX
5 Amp

### LOAD REGULATION
<0.1% 0-4.5 Amp

### RIPPLE
<2mV 4.5 Amp

### DIMENSIONS (mm)
W210 x H155 x D250

### WEIGHT
5,100 Kg.

### AL.1 P5

### INPUT VOLTAGE
220 ± 10% 50 Hz

### OUTPUT VOLTAGE RANGE
1 ± 15 Vdc

### OUTPUT CURRENT MAX
5 Amp

### LOAD REGULATION
<0.1% 0-4.5 Amp

### RIPPLE
<2mV 4.5 Amp

### DIMENSIONS (mm)
W210 x H155 x D250

### WEIGHT
5,100 Kg.
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VAN KAREN PUBLISHING
5 Swan Street, Wilmslow, Cheshire
Phase Locked
200kHz Calibrator

by

R. A. Penfold

A calibrator with BBC Radio 4 accuracy

The normal type of frequency calibration oscillator consists of a crystal or very stable L-C circuit which operates at some convenient fundamental frequency such as 100kHz or 1MHz, and which has an output rich in harmonic content. The harmonics provide calibration signals on multiples of the fundamental frequency; thus a 100kHz oscillator provides calibration points at 100kHz, 200kHz, 300kHz, 400kHz and so on, usually up to at least 30MHz.

Normally, calibration generators have some form of fine frequency adjustment so that the oscillator may be "zero-beated" against a standard frequency transmission, as for example the BBC Radio 4 long wave transmission on 200kHz. The oscillator will then have a very high degree of accuracy.

This approach can be taken a stage further by having the oscillator actually locked to the standard transmission frequency, using a phase locked loop (p.l.l.) circuit. It is a fairly simple p.l.l. design locked to 200kHz which forms the basis of this article.

BASIC ARRANGEMENT

The basic arrangement used in the calibrator is shown in block diagram form in Fig. 1. A ferrite aerial picks up the BBC 200kHz signal and applies it to an r.f. amplifier employing two high gain transistors. A considerable degree of amplification is needed to bring the signal up to the level required for p.l.l. operation, particularly in areas where the Radio 4 transmission is received at poor strength. The r.f. gain is enhanced by means of positive feed-
back, and this is set up such that the r.f. amplifier is taken beyond the threshold of oscillation. By means of careful tuning, the oscillating amplifier will then itself lock onto the 200kHz signal, using an elementary form of p.i.l. operation. The result is a considerably enhanced 200kHz signal at the output of the r.f. amplifier, but this is not in itself suitable for calibration purposes since the harmonic content is low, and usable multiples of the fundamental do not extend beyond a few MHz. The amplified signal is in consequence applied to a true p.i.l. circuit, and it is the current controlled oscillator in the latter which provides the calibrator output. The p.i.l. is an NE567.

**FULL CIRCUIT**

The full circuit of the calibrator appears in Fig. 2. L1 is the tuned winding of the ferrite rod aerial, with C1 as the variable tuning capacitor. The low impedance winding, L2, couples the aerial signal to the base of the first r.f. transistor via C2. TR1 is wired as a conventional common emitter device with a resistive collector load. At the relatively low frequency of 200kHz it is possible to obtain high gain with resistive loads.

The second r.f. transistor is used in a circuit which is virtually identical, apart from the fact that a p.n.p. transistor is employed. Interstage coupling is provided by C3.
Regeneration from TR2 collector to the emitter of TR1 is provided by CX. This is simply the capacitance given by two wires positioned close to each other. In some instances the stray capacitances in the circuit will be sufficient on their own to provide the positive feedback required.

The output of the r.f. amplifier is passed via S1 and C4 to the input of the p.l.l., IC1. The functioning of the NE567 has been described in previous articles in this magazine, and so it will not be dealt with here in detail. The centre frequency determining components are R5, C7 and C9, and the last can be adjusted to give a centre frequency of 200kHz. S1 allows the NE567 input to be disconnected from the r.f. amplifier and connected to the negative supply rail in order that C9 can be adjusted to the correct setting. C4 provides d.c. blocking at the input, whilst C8 performs a similar function at the output. C5 and C6 are low pass filter components. Pin 8 is an output which goes low when lock has been achieved. This facility is not required in the present application, and no connection is made to pin 8.

C10 and C11 are supply decoupling capacitors and S1 is the on-off switch. The current consumption of the unit is approximately 16mA from a 9 volt supply, and the prototype employs a PP3 battery. The fundamental frequency output is a square wave with a nominal peak-to-peak amplitude of the order of 7.5 volts.

CONSTRUCTION

The prototype is housed in a plastic box which has approximate inside dimensions of 90 by 160 by 71 mm. This is a case type 1003, available from Goddard’s Components, 110 London Road, St. Albans, Herts, AL1 1NX. A plastic case as opposed to a metal case is essential, since a metal case would screen the ferrite rod aerial and prevent the calibrator from working. Any other plastic case of about the same size may be employed.

One of the long sides of the box is used as the front panel. S2 is mounted on the left of the front panel with S1 balancing it symmetrically on the right. The control spindle for C1 is in the centre of the panel. C1 is a 250pF trimmer with its adjusting screw removed and replaced by a “trimmer converter.” The latter consists of a length of 1/4 in. diameter rod with a section threaded 6BA at one end. This end screws into the trimmer, enabling it to be adjusted by a standard control knob passed over the 1/4 in. diameter section. The trimmer and the “trimmer converter” are both available from Home Radio (Components) Ltd.

The rear of the trimmer has a bush and nut enabling it to be secured in position, and in the calibrator the trimmer is mounted on a small home-constructed L-shaped aluminium bracket secured to the base of the box by two 6BA bolts and nuts. The bracket may be seen in the photograph of the interior of the calibrator. Its precise dimensions are not important – provided that it holds the trimmer steadily at the required height. A hole is required in the front panel of the case to allow the 1/4 in. section of the “trimmer converter” to pass through.

It would, of course, be possible to use any other variable capacitor having a maximum capacitance of the order of 250pF which is physically small enough to fit into the space available. However, the trimmer and “trimmer converter” are inexpensive, and they also have the advantage of having what is effectively a built-in slow-motion drive.

The output socket, or sockets, are mounted on the rear panel of the case. The author employed two wander plug sockets, one connecting to the negative rail and the other to C8, but a coaxial socket may alternatively be employed if desired. The box is fitted with four rubber feet at the corners of the base.

PRINTED BOARD

The remaining components are assembled on a printed circuit board, the relevant details being provided in Fig. 3, which illustrates both sides of the board actual size.

Two plastic clips hold the ferrite rod in place, and these are mounted to the board by means of two short 6BA bolts about 6 mm. long with nuts. The aerial coil, ferrite rod and mounting clips are all available from Ambit International. A mounting hole
Fig. 3. The component and copper sides of the printed board, which is reproduced actual size. Not shown in the lower view are the mounting holes for the ferrite aerial clips and for C9.

The components on the printed board are laid out with comfortable spacing.
in the board is also needed for C9.

The lead indicated “CX” in Fig. 3 is one of the leads forming the r.f. feedback capacitor. It is a single-core p.v.c. covered wire which is placed near the non-earthy lead connecting to C1. The amount of capacitance inserted into the circuit by CX is not critical and there may well be sufficient stray feedback to produce oscillation without the need for the lead from the printed board. It will probably not be necessary to twist the two leads together, although this might just be necessary in a few cases.

It is advisable not to use very much more feedback than is necessary to make the circuit oscillate, as this may make it difficult to lock the r.f. amplifier to 200kHz if only a fairly week Radio 4 signal is available. Adjustments to CX, if required, can be made during the initial setting-up process.

The completed printed circuit board is wired to the remainder of the unit before it is mounted on the underside of the plastic box lid. It is secured by two 6BA bolts and nuts, with spacing washers to keep the board underside clear of the inside surface of the lid. The ferrite aerial coil former is held in place on the underside of the plastic box lid. It is secured by two PP3 battery rests flat on the bottom of the case, and can be held in position with a small home-made aluminium clamp.

**RSGB NATIONAL AMATEUR RADIO EXHIBITION**

The RSGB’s National Amateur Radio Exhibition was held at Alexandra Palace, London, on the 11th, and 12th May, and as usual a good attendance of visitors was recorded. This venue is a good one from the point of view of space, there being plenty of room to move around and to see what is on display.

The usual Component surplus salesmen were there, in force, and new gear was on display on the well known Traders’ Stands, offering an opportunity of making comparisons between the equipment shown. Aerials and masts were also on display, which is useful in judging the actual size of these items — often difficult to do when one only has the sizes quoted in the catalogues to go by.

The RSGB had an impressive Stand, and various other organisations such as RAYNET, AMSAT-UK, RAIBC also put on interesting displays and there was of course the usual Talk-in station in operation.

One always finds something new at these exhibitions and this year it was microprocessors applied to RTTY and also a PET microprocessor on the AMSAT-UK Stand illustrating the use of this type of equipment for predicting OSCAR orbital parameters.
PROJECTS IN RADIO AND ELECTRONICS. By Ian R. Sinclair. 96 pages, 215 x 130mm. (8½ x 5in.) Published by the Butterworth Group. Price £2.25.

The author of this book will be no stranger to regular readers of Radio & Electronics Constructor who have followed his “Double Deccer” and “Tune-In To Programs” series. The same helpful and descriptive style apparent in his articles is similarly evident in “Projects in Radio and Electronics”.

Intended mainly for the beginner, the book starts with an introduction to the more common electronic components after which it proceeds to the projects themselves. There are fourteen of these and they include two receivers, a short wave converter, a bench power supply and a bench a.f. amplifier. Also to be found are simple items of test equipment such as a transistor tester, a signal injector, an electronic ohmmeter, a high resistance voltmeter and an a.c. millivoltmeter. The constructional information shows how the various circuits may be assembled on Veroboard or on any other stripboard.

The book is attractively produced with black and green illustrations having excellent registration. It should be of considerable help to anyone who intends to devote spare time to the enjoyable hobby of electronics.


The LM3900 is a quad Norton operational amplifier, the i.c. chip containing four “current-differencing” amplifiers. Unlike the more familiar operational amplifiers which have voltage inputs, the Norton amplifier functions with current inputs. Amongst its advantages are the ability to run from a single supply voltage and the fact that its output swing extremes closely approach the supply rails.

The book under review is devoted entirely to the LM3900 and the circuits in which it may be employed. These consist of audio applications, linear applications and digital applications, as well as signal generator circuits and special miscellaneous applications. The last include a squaring amplifier circuit, a peak detector and a low frequency mixer.

The text is very concise and use is made of simple mathematics wherever necessary. The book offers useful information in its particular corner of the general op-amp scene.

UNDERSTANDING ELECTRONICS. By R. H. Warring. 175 pages, 220 x 135mm. (8½ x 5½in.) Published by Lutterworth Press. Price £3.95.

We all of us have to start somewhere, and this applies just as much to electronics as to any other human activity. “Understanding Electronics” is designed for the complete newcomer who, whilst fascinated by the possibility of taking up electronics as a hobby, is discouraged at encountering a world where components in a circuit are represented by symbols having little resemblance to their actual shape and where all the currents and voltages which make the circuit function are completely invisible.

The book under review starts right at the beginning by listing the most commonly encountered electronic units, abbreviations and symbols. It then carries on to direct and alternating current, basic circuits and circuit laws, resistors, capacitors, RC circuits, coils and transformers. The text then turns to semiconductors, neon, i.e.d’s, valves and integrated circuits. Further sections in the book discuss circuit diagrams, circuit construction, printed circuits, radio and television reception, batteries and power supplies.

The whole is clearly written in a simple down to earth manner and the book represents a good primer on the subject which it covers.
NEWS... AND

LCD FREQUENCY DISPLAY FOR AM/FM AND DIRECT READING

Ambit International's range of OKI frequency counter LST includes devices for driving standard LCD units, to provide direct readout of received frequency in the LW/MW and FM bands, with a wide choice of all standard IF offsets — as well as a direct count facility.

The DFM2 unit (pictured) includes all interface electronics for the unit to be used in conjunction with virtually any/FM receiver circuitry, since the sensitivity of 5mV permits proximity coupling to the oscillator signals.

Full details from Ambit International Ltd., 2 Gresham Road, Brentwood, Essex.

SEMINARS AT GREAT BRITISH ELECTRONICS BAZAAR

A series of 14 seminars is scheduled to run in parallel with the Great British Electronics Bazaar, to be held at the Alexandra Palace on 28, 29, 30 June 1979.

Top level lecturers will talk on a very wide range of subjects. One session will deal with the theory and practical applications of microprocessors and will include demonstrations: A well-known University lecturer will be talking about "How to become a Radio Amateur"; On another occasion, a top Mullard expert will describe "Teletext for the Hobbyist"; Electronic Keyboard Instruments is another lecture to be delivered by a well-known exponent in the field: The managing director of a leading Consultancy will talk about "Professional Programming for the Amateur"; Other areas covered include "Designing and Making your own Printed Circuit Boards" — complete with a demonstration of how-to-do-it; Microcomputer Bus Systems, and Radio Technologies in the 1980s. In the exhibition hall, the Radio Society of Great Britain is to run a special Amateur Radio station with a unique call sign, and many demonstrations of building electronics circuits are planned. Tickets for the Great British Electronics Bazaar are available, free, from the organisers on receipt of a stamped addressed envelope. The address for free tickets is, The Great British Electronics Bazaar, 34-38 High Street, Saffron Walden, Essex, marking the envelope "Bazaar". Groups, Clubs or Societies requiring a number of tickets for parties can obtain all the tickets they need by writing to the above address.

TELEPHONE AMPLIFIER

SGS-ATES is currently in volume production of a linear integrated telephone speech circuit which has been developed by the company for L. M. Ericsson, one of the world's leading telephone equipment manufacturers. Only a small number of additional components is needed in the handset, as is well demonstrated by the second photograph.

The new circuit eliminates the differential transformer and automatically performs the "local effect" suppression function. It also includes a transmitting amplifier which allows the standard carbon capsule to be substituted by a moving-coil microphone or by other transducer types.

Another amplifier is used for the receiving path and the gain of both amplifying sections is automatically controlled as a function of the distance between the user and the exchange. Gain precision is better than 2dB.

The U.K. representatives of SGS-ATES are SGS-ATES (United Kingdom) Ltd., Planar House, Walton Street, Aylesbury, Bucks.

Developed by SGS-ATES for L. M. Ericsson, this telephone handset assembly incorporates electronic circuits for transmitter and receiver amplification as well as "local effect" suppression.
HAND-HELD DIGITAL MULTIMETER

The 935 LCD multimeter just announced by Data Precision has, claim Farnell International — the U.K. distributor, the lowest price tag of any high performance hand-held digital multimeter (DMM) currently available in the U.K.

Designed primarily for field use, the 935 is a full function, 3½ digit DMM with 0.1% basic accuracy. It has 29 ranges for d.c. or a.c. voltage and current and resistance measurements, including both high and low resistance excitation. Ranges, functions and hi (2.8V) and lo (250mV) ohms are selected using push button switches ergonomically designed to permit single handed operation using left or right hand, leaving the other hand free for probe use. Measurements including appropriate polarity sign and decimal points and a warning indicator for low battery voltage are displayed on a high contrast 0.5” high liquid crystal display.

The 935 is priced at £99 exc. V.A.T. U.K. mainland delivered, including test leads, battery, instruction manual, one year guarantee, certificate of conformance to NBS standards and U.S. factory final QC test report. Farnell International, who offer full repair and recalibration facilities for this and all the Data Precision range are prepared to offer substantial discounts for quantity orders and further information is available from: Farnell International Instruments Ltd., Sandbeck Way, Wetherby, West Yorkshire, LS22 4DH.

MICROELECTRONICS SYMPOSIUM ON CHIPS

"The past five years have seen a staggering reduction in cost and hence availability of microelectronic "chips". These tiny circuits seem certain to find ubiquitous application in work and leisure, bringing automation on an unprecedented scale. What are microprocessors likely to do to the existing economic structure of society? Are they really as flexible as those who fear mass unemployment say? What possible uses could they have?"

So ran the introduction to an invitation to attend a one day Symposium organised by the Norwich and Norfolk Branch of the British Association for the Advancement of Science, at the University of East Anglia, Norwich, recently.

The Chairman, Professor Sir Sam Edwards, F.R.S., in his introduction said that the B.A. still concentrated on presenting new scientific ideas to the public. He said we have to export to live and the only way we can do this, is to continue to be one of the leading countries in "high technology" and everyone must come to terms with it.

Dr. A. J. Robinson, Director of the Warren Springs Laboratory, was the first speaker, and he dealt with "Automation in Factories". He said he liked to think of a microprocessor as being much the same as a computer and doing much the same as a computer does, but at a relatively trivial cost. It was necessary that employees and management should know the possibilities of microprocessor techniques and their usage, in order that routine procedures could be taken up by these instruments, thus enabling workers to do the more interesting jobs, leaving the boring repetitive work to machines.

Lectures were also given on "Microprocessors in Transport", "Microprocessors in Education and Social Implications of Microprocessors". It was obvious from the discussion following the lectures that the application of the "new technology" in the work-a-day world will lead to much change and controversy.

IMPORTANT SERIES

Starting with our next issue, we shall be commencing one of the most important series that we have ever published.

Called the DATABUS series, the articles will describe how microprocessors work. A comprehensive and jargon-free explanation of microprocessors written specifically for the electronics enthusiast.

The remarks of Professor Sam Edwards F.R.S., as stated in our brief report on the symposium above, underline the importance of this series to all electronics enthusiasts.
The circuit described in this article is primarily intended to function as a warning device to indicate low voltage in a 12 volt car battery, but it can also be used as a voltage monitor for any equipment operating from a nominal battery supply voltage ranging from 9 to 12 volts. The circuit is not suitable for 6 volt car systems.

The unit employs two inexpensive integrated circuits and causes a green light-emitting diode to glow steadily when the battery voltage being monitored is higher than a pre-determined level. Should the battery voltage fall below that level the green l.e.d. extinguishes and a red l.e.d. flashes continually.

CIRCUIT DIAGRAM

The circuit of the voltage monitor appears in Fig. 1. In this diagram the voltage to be monitored is applied to the positive and negative supply points and can be switched on and off by S1. For reasons which are explained later, diodes D3 and D4 in the positive rail drop the voltage being checked by approximately 1.2 volts. The voltage drop across these two forward biased diodes can be assumed to be constant.

The voltage is then applied to op-amp IC1, which operates as a voltage comparator. A stabilized voltage of about 5.1 volts appears across zener diode D1 and is applied to the non-inverting input of the op-amp, whilst a proportion of the voltage across the supply rails is tapped off at the slider of pre-set potentiometer VR1 and is passed to the inverting input. When the supply voltage is high the inverting input is positive of the non-inverting input and the output of the op-amp swings negative. With a low supply voltage the op-amp inverting input is negative of the non-inverting input and the output swings positive.

A negative output from the op-amp causes the green light-emitting diode, LED1, to light up and glow continuously. It also applies a negative input to pin 1 of the CMOS quad 2-input NAND gate, IC2. The output of the gate at pin 3 is consequently high, causing the output at pin 4 to be low. As may be seen, the NAND gate associated with pins 4, 5 and 6 of IC2 is employed simply as an inverter. So also are the remaining two NAND gates associated with pins 8 to 13. When the pin 4 output is low, the pin 11 output is similarly low. No voltage is applied to the red light-emitting diode, LED2, and this is extinguished.

When the output of IC1 swings positive LED1 extinguishes and the...
input of IC2 at pin 1 is taken high. The first NAND gate can now function effectively as an inverter, with pin 3 going low when pin 2 goes high and vice versa. The first two NAND gates then commence to run as an oscillator, the oscillation frequency being controlled mainly by C1 and R5. With the component values shown, the oscillator produces a square wave at pin 4 which has a frequency slightly higher than 1Hz. The red i.e.d. lights up when the output at pin 4 is high. Since the output at pin 11 will then also be high, the i.e.d. receives additional current from this second output. Thus, the i.e.d. passes twice the current which would be available from a single NAND gate output and, in consequence, produces a brighter glow.

Summing up circuit operation so far, it can be seen that a high supply voltage causes the op-amp output to be low, whereupon the green i.e.d. is lit and the NAND gate oscillator is inhibited with the red i.e.d. extinguished, a low supply voltage results in a high op-amp output which extinguishes the green i.e.d., enables the NAND gate oscillator and produces a continual flashing of the red light-emitting diode.

Diode D2 is needed because the op-amp output, when negative, is still about 2 volts positive of the negative rail. The small voltage dropped across the diode ensures that the input to pin 1 of IC2 is taken adequately negative for CMOS functioning.

**COMPONENTS**

The components required are all readily available. The two i.e.d.'s are not specified by type numbers as there is nowadays a very wide range of suitable i.e.d.'s available to the constructor. The pre-set potentiometer may be a skeleton type of 0.1 watt rating. The pin numbers for IC1 apply to the 741 in a 14-pin d.i.l. package. If an 8-pin 741 is employed, pin 2 is the inverting input, pin 6 is the non-inverting input, pin 9 is the output, pin 4 is for negative supply and pin 7 is for positive supply. As is indicated in Fig. 1, pin 7 of the CD4011 takes its negative supply and pin 14 takes its positive supply.

The CD4011 is available in two types, one having the suffix “AE” and the other having the suffix “BE”. The “AE” type is suitable for supply voltages up to a maximum of 15 volts, whilst the “BE” type has a maximum voltage rating of 20 volts. If an “AE” i.e. is employed in the circuit for IC2, diodes D3 and D4 permit safe operation up to 16.2 volts, and this should be adequate when the unit is used to monitor the voltage of a 12 volt car battery. With a “BE” i.e.c. the two diodes are not necessary and the positive supply may be fed directly to the remainder of the circuit, as illustrated in Fig. 2. The two diodes are also not necessary if the unit is intended to monitor the voltage of a dry battery having a nominal voltage in the range of 9 to 12 volts, and in this last application IC2 may be either “AE” or “BE”. Most CD4011’s available at present should be “BE” types, but it is necessary to check this point when employing the monitor with a car battery. The suffix letters are normally marked on the case of the device.

The current drawn from a 12 volt supply is about 7mA when the green i.e.d. is lit, rising to an average of about 15mA when the red i.e.d. is flashing. These currents are negligibly low when the monitor is connected to a car battery, but it is still desirable to have an on-off switch available. This is because a continually flashing red i.e.d. could in some circumstances prove distracting to the driver. The currents drawn by the monitor are of a significant level when it is connected to a dry battery, and it needs only be switched on when it is desired to check battery voltage.

VR1 is set up by connecting the unit to a source of voltage corresponding to the minimum level that the monitored battery should have. With a 12 volt car battery this could be, say, 10.5 volts and with a 9 volt dry battery it could be 7.5 volts. These setting-up voltages can be provided by a variable voltage power supply or by an appropriate number of 1.5 volt dry cells. VR1 is then adjusted to the point at which the green i.e.d. just extinguishes, giving way to the flashing red i.e.d. No further adjustment is necessary. The monitor can be adjusted for minimum voltages down to 6 volts.

The speed of flashing may be varied by changing the value of C1. Reducing its value to 0.22µF will, for instance, increase the flashing rate to about 2Hz.

When used in a car, all the components should be fully enclosed in a plastic case with the switch and the two i.e.d.’s mounted on the front panel. Having the circuit completely insulated in this manner ensures that it can be safely connected to either a positive or a negative earth electrical system. The plastic case may be positioned at any convenient point on or near the car dashboard.

**C.S.C. APPOINT SOUTHERN AREA DISTRIBUTORS**

With effect from 1st May, Lawtronics Ltd., of 139 High Street, Edenbridge, Kent, have been appointed southern area distributors for Continental Specialists Corporation range of instruments and breadboarding equipment.

In keeping with the Lawtronics policy of offering cost effective portable test instruments, the C.S.C. range includes hand held frequency counters up to 550MHz as well as small mains powered function generators and pulse generators.

Stocks of the established C.S.C. products, i.e. logic probes and solderless breadboards, will be available for both the professional and hobby market.

This new franchise and the increased ranges from N.L.S. and Lawtronics extends the number of portable test instruments to 46, plus over 120 various digital panel meters from N.L.S.
A large number of touch switch designs have been published in recent years, and these have mainly been for the control of small d.c. loads. Such designs can be made to operate a mains powered a.c. load via a relay, but this nullifies one of the main advantages of touch switch operation: the absence of moving parts which can wear out, and the consequent high reliability.

It is possible to produce a simple mains touch switch having no mechanical switching of any kind by using a thyristor or triac as the switching element in the circuit, and employing an opto-isolator device to isolate the touch contacts (and hence also the operator) from the mains supply.

A simple design of this nature forms the subject of the present article. It has three touch contacts which are mounted close together in a line. Touching the centre contact and one of the outer contacts causes the load to be switched on, while touching the centre contact and the other outer contact results in the load being switched off again. The unit can handle load currents of up to 1 amp or, in other words, loads of up to 240 watts, with the standard U.K. mains voltage of 240 volts.

THE CIRCUIT

The complete circuit of the mains touch switch is shown in Fig. 1. This breaks down into three main
The complete assembly of mains transformer, Veroboard panel and 4-way terminal block

sections, a bistable control circuit coupled to the touch contacts, a mains power supply for the bistable, and a mains switching circuit controlling the load.

The bistable employs two of the gates in a CMOS CD4001 quad 2-input NOR gate. These are shown in Fig. 1 as Gates 1 and 2, and they each have their two inputs connected together so that they operate as inverters. Cross-coupling between the inputs and outputs is provided by R1 and R2.

When the circuit is first switched on the inputs of both Gate 1 and Gate 2 will obviously be in the low state. The outputs will therefore start to go high. However, the gates will not have identical switching speeds, and one output will go high faster than the other. There is no way of predicting which gate will have the faster operating speed, but for the sake of this explanation we will assume that it is Gate 1.

As Gate 1 output goes high it takes Gate 2 inputs high due to the coupling through R2. Gate 2 output goes low, and this low voltage state is passed to the inputs of Gate 1 by way of R1.

The circuit remains stable in this state. An alternative stable state is given when Gate 2 output and Gate 1 inputs are high, with Gate 1 output and Gate 2 inputs being low. The term “bistable” derives from the fact that the circuit has only these two stable states.

Following our assumption, Gate 1 output and the inputs of Gate 2 are high. The circuit can be changed to the alternative state by applying a finger to the “On” touch contacts. Although the skin resistance between the two contacts may be high, even up to the level of a megohm or so, this will still be much lower than the value of R2, and the inputs of Gate 2 will be taken low. Gate 2 output then goes high, causing Gate 1 output to be low. The circuit

COMPONENTS

Resistors
(All ¼ watt 5% unless otherwise stated)
R1 10MΩ, 10%
R2 10MΩ, 10%
R3 680 Ω
R4 82k Ω, 1 watt

Capacitors
C1 100μF electrolytic, 25 V.Wkg
C2 0.1μF type C280

Transformers
T1 Mains transformer, secondary 9-0-9 V at 60mA or more

Semiconductors
IC1 CD4001
TH1 thyristor, 400V at 1A (see text)
Diac BR100 or equivalent
Opto-Isolator TIL 111 or equivalent
D1 1N4002
D2 1N4002
D3 1N4004
D4 1N4004
D5 1N4004
D6 1N4004
D7 BZY88C12V

Miscellaneous
Veroboard, 0.1in. matrix
4-way terminal block (see text)
Materials for touch contacts (see text)
Mains wire, connecting wire, etc.
will therefore remain in this state when the finger is removed from the touch contacts. In practice, the “On” contacts need to be touched only momentarily to achieve the change in bistable state.

To return to the bistable to the previous state, the finger is applied to the “Off” touch contacts. This takes the inputs of Gate 1 low and the output of Gate 1 high.

The output of Gate 2 is used to drive a light-emitting diode by way of a third gate in the CD4001. This gate also has its inputs connected together and it functions as an inverting buffer stage. When the output of Gate 3 is high it causes the i.e.d. to be illuminated by way of current limiting resistor R3. When the output of Gate 2 is high, as occurs after touching the “On” contacts, the output of Gate 3 is low. In consequence, bridging the “On” touch contacts causes the i.e.d. to be unlit. Touching the “Off” contacts results in the i.e.d. being turned on.

The i.e.d. is not a discrete device but, in company with the transistor, it forms an opto-isolator. The two are encapsulated in a single light-proof housing with the illumination from the i.e.d. falling on the transistor. The latter is photosensitive and exhibits a low resistance between its emitter and collector when it is illuminated, and a very high resistance when it is not. The advantage afforded by an opto-isolator of this type is that the i.e.d. and the transistor are completely insulated from each other.

The bistable and i.e.d. circuit are powered by the very simple mains supply consisting of transformer T1, full-wave rectifier D1 and D2, and reservoir capacitor C1. The direct voltage across C1 is approximately 12 volts. The unused gate in the CD4001 has its inputs (pins 8 and 9) connected to the negative rail. No connection is made to its output at pin 10. The presence of transformer T1 ensures that there is no direct connection between the bistable and i.e.d. circuitry and the mains supply.

**MAINS SWITCHING**

The transistor in the opto-isolator cannot, of course, control a mains load directly. Instead, it controls a thyristor which appears in a conventional lamp dimmer type of circuit which is pre-set for maximum output. We shall next consider its operation when the transistor in the opto-isolator exhibits a very high resistance (as it does after the “On” contacts have been touched).

D3 to D6 form a bridge rectifier in series with the live mains feed to the load, and they cause succeeding a.c. half-cycles to be passed to the anode and cathode of the thyristor, TH1, such that the anode is always taken positive and the cathode is always taken negative. At the start of any half-cycle the voltage across the thyristor will be zero, and the thyristor will be turned off. As the half-cycle proceeds, the voltage across the thyristor rapidly increases, as also does the voltage applied to R4 and C2. The values of R4 and C2 are chosen so that the voltage across C2 lags only slightly behind that across the thyristor. At an early instant in the half-cycle the voltage across C2 will be of the order of 32 volts, whereupon the diac will trigger and present a low resistance, resulting in C2 discharging into the gate and cathode of the thyristor. The thyristor at once turns on, switching on the load by way of two of the diodes in the bridge rectifier. The thyristor remains conductive until the end of the half-cycle, when the voltage across it falls to zero. The whole process then repeats at the start of the next half-cycle.

The circuit incurs some losses in the power applied to the load: there are small forward voltage drops across the thyristor and the conducting diodes in the bridge rectifier; also, the thyristor does not switch on at the very beginning of each half-cycle. However, these combined losses are minimal and, for all practical purposes, can be considered insignificant.

In the explanation just given, the transistor in the opto-isolator has not affected circuit operation because it has exhibited a high resistance. If the “Off” touch contacts are now bridged by a finger the opto-isolator i.e.d. turns on and the transistor exhibits a low resistance between its collector and emitter. In this state it prevents the voltage across C2 from reaching the level needed to trigger the diac and thereby turns on the thyristor. The thyristor simply remains non-conductive during the a.c. half-cycles and the load is turned off.

Thus, touching the “On” contacts turns off the opto-isolator i.e.d. and transistor, but causes the load to be turned on. Bridging the “Off” contacts turns on the i.e.d. and transistor, thereby switching off the load.

The 12 volt zener diode in series with the collector of the opto-isolator transistor plays no significant part in circuit operation, and the circuit will in fact function if the zener diode is short-circuited and the transistor collector connected direct to the diac. However, the transistor has an absolute maximum VCEO rating of 30 volts, whereas the diac triggering voltage is 32 plus or minus 4 volts. A direct connection between collector and diac could therefore cause the transistor voltage rating to be exceeded. The zener diode merely ensures that this cannot happen.

The components required in the circuit require a few comments. A suitable equivalent for the TIL 111 is the 6-pin d.i.l. opto-isolator listed by Maplin Electronic Supplies. The mains transformer can be the sub-miniature component offering 9-0-9 volts at 67mA which is also available from Maplin. The thyristor should be a 400 volt 1 amp type in a TO39 case, such as the THY1A/400 retailed by Bi-Pak Semiconductors.

In the diagrams, the letter “K” is employed to indicate “cathode” instead of the more usual “C”. This prevents confusion with the letter “C”, for “collector”, at the appropriate terminal of the opto-isolator.

**CONSTRUCTION**

The mechanical construction of the touch switch depends upon the application for which it is to be used. In some instances it could be assembled in a case on its own and connected in the mains lead to the controlled item of electrical equipment. In other applications it could be built into the controlled equipment itself.

In either case the electrical construction can be as shown in Fig. 2. Apart from the mains transformer and a terminal block all the components are wired up on a 0.1in. Veroboard having 17 copper strips by 35 holes.

First cut out a board of the required size and then drill out the mounting holes with a 3.2mm twist drill to take M3 or 6BA bolts. Next, make the 24 breaks in the copper strips. Note that the 13
breaks which isolate the touch button section of the circuit from the mains wiring are two holes wide. Any copper between the two holes in each strip may be removed by means of a sharp knife. The components and link wires are soldered to the board, including the flying leads to T1 secondary, the 4-way terminal block and the touch contacts, with IC1 being fitted after all other soldering has been completed. IC1 is a CMOS device and it should be left in its protective packing until it is required, and it must be soldered to the board by means of an iron having a reliably earthed bit.

The diac can be connected either way round. Finally, the primary of T1 and the 4-way terminal block are connected into circuit. The terminal block is cut from a 12-way screw terminal strip of the type which is intended for 5 amp mains circuits.

With a little ingenuity it should not be difficult to fabricate the touch contacts. They should be made of a metal which does not oxidise readily and could, for instance, consist of the heads of panel-headed chrome-plated screws mounted on a piece of insulating material.
It is most important to ensure that all precautions against accidental shock are observed. The switch components and wiring should not be accessible without the removal of a cover secured with screws; a lid which merely clips into position is not adequate. All accessible metalwork, apart from the two outside touch contacts, must be reliably connected to the mains earth. This earth connection must be taken over to the bistable and its power supply, as shown in Figs. 1 and 2. It is not recommended that the touch switch be employed in any significantly damp location.

Before initially connecting to the mains check that there is full isolation between the control and mains sections of the circuit by means of an ohmmeter set to a high ohms range. It is also advisable to check for accidental short-circuits between copper strips and to ensure that there are no wiring mistakes. Remember that the wiring around the thyristor and the diac, etc., is connected direct to the mains and must not be touched when the mains is applied.

The prototype works reliably with very inefficient touch contacts. When the mains is first applied the bistable may take up either the “On” state or the “Off” state, but subsequent control is entirely by means of the touch contacts. Simple thyristor circuits of the type used here can generate noticeable levels of r.f. interference, but the amount of interference produced by the prototype was quite insignificant. This is because the thyristor is triggered on very early in the a.c. half-cycle, when the mains voltage is at a comparatively low level.

It is likely that the switch will be left connected continuously to the mains, but the extra current it consumes is virtually negligible. It is desirable to employ a good quality component for T1, as an inferior transformer may tend to overheat even though it is used well within its specified voltages and currents. An inexpensive transformer can be kept cooler, incidentally, if it is mounted on a metal case or metal chassis, which will act as a heatsink.
LOGIC LEVEL AUDIBLE ALARM

Wonderboard T.T.L. Project

It is frequently necessary to provide an audible alarm in digital systems, and this usually requires interfacing the digital logic circuit with an analog amplifier-oscillator. The circuit presented here uses a t.t.l. i.c. to directly drive a speaker.

Fig. 1. The circuit of the logic level alarm

The circuit employs a Schmitt trigger connected as an oscillator. This produces low frequency logic pulses which drive a miniature speaker. A logic 1 at the input turns on the alarm. The frequency of the sound produced in the speaker can be varied by fitting different values of resistance in the R1 position, these ranging from zero (a piece of wire) to 500 Ω.

TABLE

<table>
<thead>
<tr>
<th>Wire Links</th>
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<tbody>
<tr>
<td>1A-1C</td>
</tr>
<tr>
<td>1D-1F</td>
</tr>
<tr>
<td>2B-2C</td>
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<tr>
<td>2B-3B</td>
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<tr>
<td>3A-4A</td>
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<tr>
<td>4B-6C</td>
</tr>
<tr>
<td>6B-6C</td>
</tr>
<tr>
<td>6A-5E</td>
</tr>
<tr>
<td>1F-3E</td>
</tr>
<tr>
<td>2A-7C</td>
</tr>
</tbody>
</table>

ASSEMBLY

Insert the 7413 i.c. in the Wonderboard with pin 1 at hole 1C. Fit C1 between 2A and 2B, R1 between 3A and 3B, R2 between 4A and 4B, and R3 between 6A and 6B. Add the wire links under the board which are shown in the Table.

Connect the speaker between 3E and 5E, apply 5 volts positive to 1F and connect 2A to ground. The input is connected to hole 1A and the alarm is then all set to operate.
SLEEPER-BLEEPER

Three astables produce a series of bleeps with frequencies and timing adjustable by choice of components

Circuits which give various sound outputs are common enough and are the delight of school electronics clubs, but this is rather an unusual one which gives several short bleeps, then stops before repeating. It makes a useful paging signal or even a useful sound effect (where are you, R2D2?) and several circuits can be built of which no two will give the same pattern of tone or bleeps.

Basically, the circuit consists of three astable multivibrators and an output stage, and it is easier to describe the action of the circuit if we look at the astables in reverse order, output first.

**OUTPUT ASTABLE**

TR5 and TR6 are connected as an astable with a considerably shorter time constant than the other two. The component values chosen give a frequency of around 2kHz, with the unusual feature that a single resistor charges the two cross-coupling capacitors, with the diode D2 providing isolation. The diode also limits the amplitude of the wave at the base of TR6, and has an effect on the frequency, which is higher than that of an astable using separate base resistors. By using different values for C5 and C6 we can change the note produced by this astable, but R9 should not be changed to any large extent.

TR5 and TR6 will therefore produce a bleep tone, but only when point 21 on DeC 2 is returned to a positive voltage via R9. Bleeps are produced by coupling R9 to the collector of TR4. TR3 and TR4 form another astable which runs at a much lower frequency because the cross-coupling capacitors are 10µF. When the collector current of TR4 is cut off, current flows through R8 into R9, so activating the tone oscillator. When TR4 is turned on, the voltage at its collector is too low to allow current to flow to the tone oscillator, so that the note stops. Diode D2 ensures that the tone oscillator does shut off under these conditions because of the need to have at least 0.6 volt across the base-emitter junction of a conducting silicon transistor. If a conventional two-resistor circuit is employed for TR5 and TR6, shut-off is not reliable because the oscillations tend to be self sustaining.

The bleep-producing astable incorporating TR3 and TR4 is itself not allowed to run continuously. The bases of these transistors are returned, through separate resistors this time, to the collector of TR2 which is half of yet another astable. Diode D1 is a catching diode and prevents the base of TR4 being driven more than about 0.6 volt negative of its emitter. This again is necessary to ensure reliable switching on and off.

<table>
<thead>
<tr>
<th>COMPONENTS</th>
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<tbody>
<tr>
<td><strong>Resistors</strong></td>
</tr>
<tr>
<td>(All 1/4 watt 5%)</td>
</tr>
<tr>
<td>R1 1.8kΩ</td>
</tr>
<tr>
<td>R2 56kΩ</td>
</tr>
<tr>
<td>R3 56kΩ</td>
</tr>
<tr>
<td>R4 1.8kΩ</td>
</tr>
<tr>
<td>R5 56kΩ</td>
</tr>
<tr>
<td>R6 56kΩ</td>
</tr>
<tr>
<td>R7 1.8kΩ</td>
</tr>
<tr>
<td>R8 1.8kΩ</td>
</tr>
<tr>
<td>R9 56kΩ</td>
</tr>
<tr>
<td>R10 4.7kΩ</td>
</tr>
<tr>
<td>R11 4.7kΩ</td>
</tr>
<tr>
<td>R12 12kΩ</td>
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</tbody>
</table>

**Capacitors**
- C1 100µF electrolytic, 16V. Wkg.
- C2 100µF electrolytic, 16V. Wkg.
- C3 10µF electrolytic, 16V. Wkg.
- C4 10µF electrolytic, 16V. Wkg.
- C5 0.01µF polyester or mylar
- C6 0.01µF polyester or mylar

**Semiconductors**
- TR1-TR7 2N697 or 2N2219 or BFY50
- D1, D2 1N914 or 1N4148

**Loudspeaker**
- LS1 60Ω to 80Ω (see text)

**Miscellaneous**
- 2-off S-Dec
- 6V battery
TR1 and TR2 are in the third astable, which oscillates very slowly because of the 100μF cross-coupling capacitors. This oscillator operates continuously because the transistor bases are returned to the positive supply through the 56kΩ resistors, R2 and R3. When TR2 is cut off, current flows through R4 into R5 and R6 to operate the bleep astable. When TR2 is bottomed the voltage at point 7 of DeC 1 is too low to feed current into the bases of TR3 and TR4, so that the bleeps stop.

Looking now at the other end of the circuit, TR7 is a loudspeaker driver. R12 limits the amount of signal drive fed to the base of TR7, this transistor being turned on when TR6 cuts off, and turned off when TR6 is turned on. The loudspeaker should preferably be a high resistance type of 60Ω to 80Ω.

Variations in the tone of the bleep have already been discussed. The number of bleeps in each cycle can be altered by changing the frequency of the bleep astable around TR3 and TR4. This is best done by changing the values of capacitors C3 and C4 rather than by changing the values of R5 and R6.

Finally, the time between bursts of bleeping can be altered by changing the time constants at TR1 and TR2. Here, the values of resistors R2 and R3 can be changed provided that values less than 22kΩ or greater than 100kΩ are not used. Very long times may be impossible to obtain because of leakage current through the electrolytic capacitors, but values of 1,000μF for C1 and C2 were used along with 56kΩ resistors in the prototype and gave excellent results.

CONSTRUCTION

Clip the two S-DeCs together to form one long DeC, and plug in the wire links which join the circuit sections together. Now connect the loudspeaker, using single core wire. If stranded wire is used (because of an existing flex) then the wire ends should be twisted tightly and soldered to prevent strands from breaking off inside the DeC. Plug in R9, which links the two DeCs by taking signals from DeC 1 to DeC 2.

Insert the capacitors, noting that C1, C2, C3 and C4 are electrolytic types for which correct polarity must be observed. The diodes are then plugged into place, also noting polarity. If the completed circuit gives a continuous tone or none at all, the polarity of the diodes should be suspected.

The transistors are all n.p.n. types with the same lead-out layout and they can now be inserted into their places in the DeCs, making sure that the emitter and collector leads are not reversed in this symmetrical layout. Some care is needed in building astable circuits of this type where the transistors are “back-to-back,” being placed with their emitter leads on a central line with one collector on a lower numbered line and the other on a higher numbered line, because one transistor is “upside-down” compared with its neighbour. No problems should arise if the diagram is faithfully followed, however.

The remaining resistors can now be plugged into place. Next add a pair of single core wires to the 6 volt battery and your Sleeper-Bleeper is ready to sing for you.
When a continuity tester is required it is common practice to use a multimeter switched to a low ohms range. However, this is far from ideal as the indication of continuity is visual, making it necessary to continually look back and forth between the test prods and the meter. The procedure is inconvenient, to say the least, particularly when the test points are awkwardly placed or when there are a large number of tests to be made.

A continuity tester which provides an audible indication of continuity is much more convenient, and in its simplest form could consist of an audio oscillator coupled to a speaker or earphone, with the test leads inserted in one of the oscillator supply lines. Unfortunately, an arrangement of this nature is not capable of discerning between a fairly low resistance and a direct connection, and in many instances the oscillator will give an indication of continuity where, in fact, there is a resistance of several hundred ohms between the test prods. A performance of this nature can lead to misleading and confusing results.

A better approach is to have the audio oscillator controlled by a discriminator circuit which will only switch on the oscillator when the resistance between the test prods is a few ohms or less. It is a simple instrument of this type which is described here.

**CURRENT COMPARATOR**

The unit employs two Norton amplifiers in a single i.e., one functioning as a current discriminator and the other as an audio oscillator. A Norton amplifier is in many ways similar to an ordinary operational amplifier, with the major difference that it amplifies the difference between two input currents rather than two input voltages.

The discriminator part of the circuit is shown in Fig. 1., it being assumed that the amplifier output is monitored by a voltmeter. A steady reference current passes from the positive supply through RB to the inverting input of the amplifier. A second current flows through VR and RA to the non-inverting input. RA is lower in value than RB, whilst the total value of RA and VR is greater than RB.

**Fig. 1. A Norton amplifier employed as a current comparator**

**Fig. 2. The circuit of the audio continuity tester.**
If VR is adjusted to insert zero resistance into circuit, a greater current will flow into the non-inverting input than into the inverting input and the amplifier output will go positive, as indicated by the voltmeter. VR may then be gradually adjusted to present a continually increasing resistance. The current flowing into the non-inverting input will fall until it becomes slightly less than that flowing into the inverting input, whereupon the amplifier output will swing negative. It will remain negative as the current flowing into the non-inverting input reduces further.

There will be a range of resistance in VR corresponding to about exactly equal currents at the inputs, at which the amplifier output will be between the positive and negative states. However, due to the high gain in the amplifier this range of resistance will be very small and difficult to resolve. The general effect given as VR is adjusted will be a quick output swing from positive to negative as the potentiometer reaches and passes the equal current setting. The amplifier output will swing positive again if the potentiometer is adjusted to insert reducing resistance and once more passes the equal current position.

In the full continuity tester circuit, the test prods are inserted in series with VR and RA. VR is adjusted to the maximum resistance which allows the amplifier output to be positive with the test prods short-circuited together. If a significant resistance of even just a few ohms is presented to the test prods the current at the non-inverting input will be below that at the inverting input and the amplifier output will be negative. The amplifier output is connected, not to a voltmeter as in Fig. 1., but to the audio oscillator, and it turns the oscillator on when it goes positive. Thus, the presence of continuity between the test prods is indicated by an audible output from the oscillator.

COMPLETE CIRCUIT

The full circuit of the continuity tester is given in Fig. 2. The two amplifiers here are both contained within the same i.c., an LM3900. The LM3900 has four amplifiers, but the remaining two are not employed. A small bias current is fed to their inverting inputs via R3 in order to slightly reduce their current consumption, and no other connections are made to them.

IC1(a) is the current comparator, and its operation has already been discussed. The values specified for R1, R2 and VR1 result in a current of about 4mA flowing into each comparator input. If VR1 is carefully set up, the circuit will not respond to resistances of more than about 2 or 3 ohms across the test prods. These are connected into the circuit at jack socket SK1.

IC1(b) is the oscillator amplifier. A negative feedback loop from the output to the inverting input is given by R6 and R5, and these set the voltage gain at about three times. C2 provides a bypass at a.f. without preventing d.c. flowing into...
The Veroboard assembly is secured to the rear panel of the case, connecting to the front panel components by means of flexible wiring.

**COMPONENTS**

**Resistors**
(All fixed values 1 watt 5%)
- R1 2.2kΩ
- R2 1.5kΩ
- R3 820kΩ
- R4 68kΩ
- R5 18kΩ
- R6 33kΩ
- R7 8.2kΩ
- VR1 5kΩ potentiometer, log

**Capacitors**
- C1 100μF electrolytic, 10V. Wkg.
- C2 0.22μF type C280
- C3 0.1μF type C280

**Semiconductors**
- IC1 LM3900
- TR1 BC108

**Switch**
- S1 s.p.s.t., miniature toggle

**Speaker**
- LS1 miniature speaker, 50Ω or more

**Socket**
- SK1 3.5mm. jack socket

**Miscellaneous**
- Case (see text)
- 9-volt battery (see text)
- Battery connector
- 3.5mm. jack plug
- 2 test prods and leads
- Control knob
- Veroboard, 0.1in. matrix
- Nuts, bolts, wire, etc.

Wiring is considerably simplified by the use of a Veroboard panel. This is shown here in close-up.
the inverting input. Positive feedback to the non-inverting input is provided by C3 and, with the component values specified, the amplifier oscillates at a frequency slightly in excess of 1kHz.

The non-inverting input is biased by R4, which is returned to the output of IC1(a). When IC1(a) output is high IC1(b) oscillates, and when IC1(a) output is low oscillation ceases. The output of IC1(b) also goes low. The oscillator output is coupled via R7 to the base of transistor TR1, and this transistor drives the speaker in its collector circuit.

S1 is the on-off switch and is needed because, unlike many continuity testers, this design consumes a current from the battery when a continuity indication is not being given. C1 is the supply decoupling capacitor. The current drawn from the 9 volt battery is approximately 10mA with the test prods open-circuit, and approximately 30mA when they are short-circuit together.

CONSTRUCTION

The continuity tester may be housed in any small case capable of taking the components and the 9-volt battery to be used. The prototype, which uses a PP3 battery, is housed in a plastic case with aluminium front panel having approximate outside dimensions of 120 by 100 by 43mm. If the continuity tester is to be used extensively, it will be desirable to employ a larger battery, such as the PP6, whereupon a larger case will be required. The speaker is a miniature type with an impedance of 50Ω or more. A speaker with an impedance of less than 50Ω should not be used.

The front panel layout for the prototype can be seen in the photographs. The speaker is mounted behind a grid of twenty-one 4mm diameter holes drilled in a symmetrical pattern. It is glued in place using a high quality adhesive, care being taken to ensure that none of the adhesive becomes applied to the speaker diaphragm. Jack socket SK1 is below the speaker. To the right of the speaker is mounted VR1, with S1 below it.

The remaining components are assembled, as shown in Fig. 3, on a piece of 0.1in. Veroboard having 21 holes by 15 copper strips. This board is secured to the rear panel of the case by two 6BA bolts and nuts, with spacing washers on the bolts to keep the underside of the board clear of the inside surface of the case. Connection to the front panel components is made by flexible wires which are just long enough to allow the case to be disassembled with the panel laid alongside the case body.

ADJUSTMENT

After the continuity tester has been completed, the battery and test prods may be connected and VR1 set to a fully anti-clockwise position. The unit is then switched on, and it should produce an audible tone when the test prods are connected together. If there is no tone, switch off at once and check for wiring errors.

When all is well, VR1 can be set up. It is simply adjusted, with the test prods short-circuited together, to the most clockwise position which does not cause oscillation to cease. It may very occasionally be necessary to readjust VR1 in order to maintain the tester at maximum sensitivity.
EGYPT
Cairo on 17670 at 1423, OM with station identification followed by a programme of Arabic-type music. This is the Domestic Service which operates here from 1300 through to 1830.

CZECHOSLOVAKIA
Prague on 17775 at 0917, OM with a talk about local affairs in the English programme directed to Africa, the Far East, South Asia and the Pacific area, scheduled on this channel from 0830 to 0900 (to 0930 on Saturday and Sunday).

FINLAND
Helsinki on 21495 at 0935, OM with a newscast mostly about local affairs in the English programme for Europe, North Africa, the Far East and Australia, scheduled from 0930 to 1030.

ROMANIA
Bucharest on 17805 at 0705, OM and YL announcers with the Dx programme “Listeners Club” in the English programme for the Pacific area, scheduled here from 0645 to 0715.

VENEZUELA
“Radio Bolivar”, Ciudad Bolivar, on 4770 at 0353, local-style dance music, YL with songs in Spanish. The schedule is from 1000 to 0300 (Saturday and Sundays until 0400) and the power is 1kW.
“Radio Universidad”, Merida, on 3395 at 0409, OM with a newscast in Spanish. The schedule is from 1000 to 0400 (weekends until 0500) and the power is 1kW.

AUSTRALIA
Melbourne on 11870 at 1520, OM with U.K. pop records in the English programme to the Asia and Pacific areas (announced).

NORWAY
Oslo on 17840 at 1404, OM with news of local affairs in the English programme ‘Norway this Week’, scheduled for Sundays only from 1400 to 1430.

VATICAN
Vatican City on 17825 at 1517, YL with news of Vatican affairs in the English programme intended for South Asia, scheduled from 1515 to 1530.

EAST GERMANY
Radio Berlin International on 17880 at 1408, YL with a newscast in the English transmission intended for South East Asia, scheduled from 1400 to 1455.
Radio Berlin International on 17755 at 1350, YL with the programme in English beamed to Central Africa, scheduled from 1315 to 1400.

U.S.S.R.
Radio Moscow on 17765 at 1358, YL with station identification in the English language World Service.
Radio Moscow on 17825 at 1400, YL with identification and a newscast in the World Service. Note — the World Service is entirely in English and is on the air from 0400 through to 2300 continuous on many channels and bands.
Radio Moscow on 17855 at 1524, OM with news of Korea in the World Service.

FRANCE
Paris on 17865 at 1445, U.K. pop records with announcements in French in the programme for Africa, scheduled from 0600 through to 1600.

ALBANIA
Tirana on 7080 at 1800, YL with a newscast in the Italian programme to Europe, scheduled here from 1800 to 1830.
Tirana on 9375 at 1450, YL with the programme in Polish for Europe, scheduled from 1430 to 1500.
Tirana on 11985 at 1412, YL with a talk about foreign policy in the English programme to South Asia, scheduled from 1400 to 1430.

PAKISTAN
“Radio Pakistan”, Karachi, on 17640 at 1420, YL and OM announcers with the World Service in Urdu to the Middle East and Persian Gulf, scheduled from 1330 to 1430 on this channel.
“Radio Pakistan” Islamabad, on 17665 at 0718, OM and YL announcers with the Urdu programme for the U.K., scheduled from 0715 to 0830.

SWITZERLAND
Berne on 9535 at 1330, OM with a programme
in English for the Far East, Australia, South and South East Asia, Europe, North and Central America, scheduled here from 1315 to 1345.

- WEST GERMANY
  Cologne on 9650 at 0950, OM with a talk about ice skating in the Federal Republic in the English programme for Asia and Australia, scheduled from 0930 to 1030.

- GREECE
  Athens on 17830 at 1515, YL with identification and newscast in English directed to North America, scheduled from 1515 to 1530.

- ISRAEL
  Jerusalem on 17630 at 1413, light music in a relay of the Domestic Service B programme for listeners abroad. The service is entirely in Hebrew and is scheduled here from 0400 through to 2315.

- NORTH KOREA
  Pyongyang on a measured 6251 at 1600, OM with identification in Korean after a programme of classical music. Not scheduled at this time — programmes should commence at 2000 in Korean to South Korea.

- SOUTH KOREA
  Seoul on 6240 at 1607, light music, U.K. made pop records, YL announcer in Korean. This was a test transmission on an unlisted channel.

- CHINA
  “Radio Peking” on 11675 at 1450, Tamil music and songs in the Tamil programme, scheduled from 1430 to 1500. This channel is jammed.
  Peking on 9965 at 1530, YL and OM announcers at the end of the Bengali programme scheduled from 1530 to 1600.
  Peking on 9880 at 1534, YL with the programme intended for Nepal, scheduled here from 1530 to 1600.
  Peking on 11040 at 1220, YL with a talk in the Tibetan programme, scheduled from 1200 to 1300.
  Peking on 10440 at 1450, YL with the Standard Chinese programme for South Asia and South East Africa, scheduled from 1500 to 1600.
  Peking on 17680 at 1332, Chinese music, YL announcer with the Standard Chinese programme for South East Asia, scheduled here from 1300 to 1400.
  Peking on 11650 at 1400, OM with news of Chinese foreign affairs in the English programme for South Asia, scheduled here from 1400 to 1500.
  Peking on 11675 at 1405, YL with the Tamil programme to South Asia, scheduled here from 1400 to 1430.
  Peking on 11685 at 1409, YL with the programme for Indonesia, scheduled from 1400 to 1430.

- CHINA — REGIONAL
  CPBS Qinghai on 6500 at 2305, OM with songs in Chinese. Schedule unknown.

- TIBET
  Lhasa on 9490 at 1134, OM and YL announcers in a relay of the Radio Peking Tibetan programme, scheduled from 1000 to 1155.

- CUBA
  Havana on 17855 at 2133, OM with identification at the end of the English transmission to Europe, scheduled from 2010 to 2140.

- INDIA
  AIR (All India Radio) Delhi on 9950 at 1435, YL with identification at the end of a newscast in English in the Domestic Service News Broadcasts Service. This particular bulletin is scheduled from 1430 to 1435.
  AIR Delhi on a measured 7412 at 1530, OM with identification and a newscast in English, scheduled from 1530 to 1545. Listed on 7415.

- ECUADOR
  HCJB Quito on 17865 at 2100, OM with announcements and identification in English.

- NORWAY — 2
  Oslo on 9605 at 1415, OM with a programme about winter and wildlife in North Norway. This English programme is scheduled from 1400 to 1430 and is intended for Europe, Africa, the Middle East, North and Central America.

- TANZANIA
  Dar-es-Salaam on 5050 at 1807, OM with the world news in Swahili, many place names mentioned — i.e. Islamabad etc. This is the Commercial Service in Swahili and is scheduled here from 1300 to 2015, the National Service on this channel being scheduled from 0300 to 0500.

- U.S.S.R.
  “Radio Peace and Progress”, Moscow, on 17860 at 0714, OM and YL with the Standard Chinese programme to China, scheduled here from 0500 to 0900. Also logged in parallel on 17890.

- SOUTH AFRICA
  Johannesburg on 17780 at 2140, OM with the English programme for Europe and West Africa, scheduled from 2100 to 2150 on this channel.

NOW HERE THIS
“Voice of Democratic Kampuchea” on 11600 at 1206, YL in Cambodian to Kampuchea (formerly Cambodia). The schedule of this transmission is from 1200 to 1255 and was also logged in parallel on 11990. The transmitter is thought to be located in China and the programme content is pro-Pol Pot regime. This transmitter is classed as Clandestine.

BREADBOARD ’79

The overwhelming success of Breadboard ’78 has necessitated a change of venue for BREADBOARD ’79.

It will be held at The Royal Horticultural Halls, Westminster, London SW1 from December 4th-8th, 1979.

Over 10,000 people attended Breadboard ’78, the first ever show of its kind for the home electronics enthusiast.
EXCLUSIVE SERIES
TUNE-IN TO PROGRAMS

Part 6 By Ian Sinclair

GETTING INTO ROUTINE

So far, our programs have used either a straight run — going from one program step to the next from beginning to end of the program — or a loop, going round and round the same piece of program several times under the control of the \[x=t\] or \[Dsz\] keys. The ability of the calculator to carry out these program instructions is useful and important, but there is another facility available on the TI-57 (but not on the PR-100) which is even more useful. It’s called the subroutine facility, and it’s fetched up by the key marked \[SBR\].

SUBROUTINES

A subroutine is a little bit of program which can be used more than once in the course of a long calculation. The subroutine is identified by the \[Lbl\] key at the start, and by \[INV\] \[SBR\] or a \[GTO\] at the end. The most valuable point about a subroutine is that it avoids the need to write a piece of program twice over. For example, suppose we were writing a program to find the total resistance of a series-parallel circuit of five resistors connected as shown in Fig. 1. The procedure is to find the sum of each parallel pair (R1 and R2, R4 and R5) first, then to add the value of the series resistor. Now to find the resultant of parallel resistors we need to find the inverse of the quantity \(1/R1 + 1/R2\), so that we need a piece of program which might read as in Fig. 2. This uses memory 1 for R1 and memory 2 for R2, and it sums the final answer, after the last \([1/x]\) step, into memory 3 to add to the value of R3.

Now it would be rather a chore and a waste of valuable program steps to write out all this again to carry out on R4 and R5. What we do, therefore, is to write out this piece of program at the end of the main program (after the \[R/S\] instruction) starting with a label, such as \[Lbl\] [0] and ending with the instruction \[INV\] \[SBR\]. This converts the piece of program into a subroutine which we use (the phrase is “call up”) at any part of the main program by the instruction \[SBR\] [0] (or [1] or [2] or whatever the label number is). The subroutine will

\[
\begin{align*}
R1 & \quad R2 \\
\hline
R3 & \quad R4 \\
\hline
R5 & \quad R_{\text{TOTAL}}
\end{align*}
\]

Fig. 1. A series-parallel network of resistors and their total effective resistance
run whenever called up in this way, and at the instruction [INV] [SBR] the program takes up where it left off. We can use such instructions as [+ ] [SBR] [1], meaning "add the number in the display to the result of the subroutine calculation", or [X] [SBR] [1] ("multiply by the result of the subroutine calculation") treating [SBR] [1] as if it were [RCL] [1]. If, at the end of the subroutine, we want to move to some other part of the program we can end the subroutine with [GTO] [9] or wherever we want the to pick up. If we do not have any instruction at the end of a subroutine, the next part of the program carried out will be the step which follows the last step of the subroutine.

The program in Fig. 3 shows the use of a simple subroutine in the calculation for the circuit of Fig. 1. In the subroutine the value of two resistors in parallel is found, and added to the value of series resistance. The parallel resistance values have been stored in memories 1 and 2, and the series resistance value in memory 3. In the course of the subroutine the total value of the resistors in parallel is worked out, and the [SUM] [3] step adds this to the value of the series resistance stored in memory 3. Now if we shift the values of R4 and R5 into memories 1 and 2, using the steps [RCL] [4] [STO] [1] and [RCL] [5] [STO] [2], we can simply repeat the subroutine, finding this time the parallel sum of R4 and R5 and adding this also to the number stored in memory 3. The program ends by bringing this total out of memory 3 and stopping the program to display the final result. There are eight steps to the subroutine, but the instruction is only [SBR] [0], so that seven steps are saved on each repetition of this subroutine.

Now there are several important points about subroutines which have to be observed with some care. One point which is not at all obvious is that it's best to avoid using the [ = ] key to complete a calculation inside a subroutine. The reason is that if there is a calculation waiting to be completed in the main program the [ = ] instruction will complete that calculation, even if the numbers are not correctly worked out. For example, if we had a program which had got to a stage where the displayed number was 7 and the next instructions were [+ ] [SBR] [0] [ = ], then the 7 is held waiting for the subroutine to be completed so that the number which has to be added to the 7 is calculated. This is called a pending operation ("pending" literally means "hanging about") and the use of the [ = ] sign completes such an operation, so that in our example 7 will be added to whatever number is in display just before the [ = ] sign appears. For instance, if [SBR] [0] had at some stage the instructions [RCL] [2] [+ ] [RCL] [5] [ = ], with 3 in memory 2 and 4 in memory 5, what would be carried out would be 3+4+7=14, because the pending 7 would be added in, inside subroutines it's better to get into the habit of using the close parenthesis sign, [ ), to complete a calculation instead of [ = ].

**SHORT PROGRAMS**

Subroutines are also a useful way of storing several short programs in one chunk. Since each subroutine has its own label number, the calculator can be instructed to go through the subroutine by the instruction [SBR] (label number) [R/S], and the [INV] [SBR] instruction will then have the same effect as the [R/S] instruction in a complete program, stopping the action. This way, several separate bits of program can be kept together so that each can be called up as required for as long as the calculator is switched on. This is particularly important when the larger machines like the TI-58 and TI-59 are used, because vast program lengths can be stored; the TI-59 can also record programs on magnetic cards, so that programming, once the card is recorded, is instant.

Any program with a reasonable number of steps can be made into a subroutine and thereafter used, called up, inside another program provided that there is room for all the steps of the program plus the subroutine.

To illustrate how useful this can be, recall the point that was made in Part 3 regarding memory storage. You remember (1) that we could store two numbers in one memory using the [Int] and [INV] [Int] steps and employing a decimal point to separate the numbers. We can write a subroutine to carry out the separation, and then whatever steps are needed (such as multiplication of the numbers) to process the numbers. Fig. 4 shows a subroutine which will carry out the steps of extracting two four-figure numbers in this form out of a memory, and multiplying them together ready for returning to a memory. We can pack all the memories with numbers written in this form, and the program for

---

**Fig. 3**

<table>
<thead>
<tr>
<th>Program</th>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>LRN SBR 0 RCL 4 STO 1</td>
<td>Place resistor values (using the same units for all the resistors) into stores. Then CLR RST R/S. Display shows R total.</td>
</tr>
<tr>
<td>RCL 5 STO 2 SBR 0</td>
<td></td>
</tr>
<tr>
<td>RCL 3 R/S Lbl 0 RCL 1</td>
<td></td>
</tr>
<tr>
<td>1/x + RCL 2 1/x</td>
<td></td>
</tr>
<tr>
<td>1/x SUM 3 INV SBR LRN</td>
<td></td>
</tr>
</tbody>
</table>

**Fig. 4**
The complete program for multiplying six sets of figures and placing the products in the original memories now reads:

Program
LRR C0S 0 SBR 0 STO 0
RCL 1 SBR 0 STO 1 RCL 2
SBR 0 STO 2 RCL 3 SBR 0
STO 3 RCL 4 SBR 0 STO 4
RCL 5 SBR 0 STO 5 Lbl 0
STO 6 INT X RCL 8 INV
INT X 1 EE 3 ) INV SBR LRR

Fig. 5

multiplying them would now read as in Fig. 5. At the end of the program we can read out the products by using [RCL] [O], [RCL] [1] [RCL] [2], etc.

Going a step further with this, we can now look at a program for finding resonant frequencies, using L in mH, C in pF, and finding f in MHz. Each LC combination is written as a decimal, with the value of L before the decimal point and the value of C after the point, so that the pair of values 150 mH and 850 pF comes out as 150.85. At the end of the program, each memory contains the value of resonant frequency for the pair of L and C values which was originally stored in that memory. The program itself consists of the subroutine and the shifting instructions which recall each pair of values, and then load the result back into the same memory at the end of the subroutine. This is an example of a program which is much shorter because of the use of a subroutine. If we were to have to write out the instructions for extracting the L and C values from each memory, we would run out of program space long before we had completed the program.

**RESONANT FREQUENCY**

Fig. 7 shows another program which makes use of a subroutine. The program this time is to find the impedance of a resistance R, inductance L and capacitance C in series, with the values of R, L and C stored in separate memories. To show resonance the value of impedance, Z, should be plotted against capacitance C in series, with the values taken out of store each time and the values of Z at the frequency of resonance and at every 1 kHz above the frequency of resonance in turn. At each pause the value of impedance, Z, is displayed so that the graph can be plotted. Since the resonance curve is symmetrical the values of Z for each kHz below the frequency of resonance can be plotted without the use of the calculator. The subroutine in this case is that for finding the value of Z, with the values taken out of store each time and the frequency altered on each loop. The first part of the program, to find the resonant frequency, is not used again unless new values of C, L and R are placed into store and the [RST] key used to reset the program.

Using [Dsz] more than once. Note that the steps [Dsz] [GTO] [1] must be inside the subroutine. If these steps are used outside the subroutine, the loop will be carried out correctly first time, but will be entered from the [GTO] [1] instruction on the next time round. This in turn will mean that the subroutine will return the program to the step following [GTO] [1] instead of going round the loop again as was intended.

**Procedure**

<table>
<thead>
<tr>
<th>Program</th>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>LRR C0S 0 SBR 1</td>
<td>Key in values of L and C into memories 0 to 5.</td>
</tr>
<tr>
<td>STO 0 SBR 1 STO 1</td>
<td>CLR Fix 3 RST R/S</td>
</tr>
<tr>
<td>RCL 2 SBR 0 STO 2 RCL 3</td>
<td>At the end of the calculation, the display flashes (due to the impossible [GTO] [5] instruction). The values of resonant frequency (in MHz) can now be taken from each memory by pressing [RCL] [O], [RCL] [1], etc.</td>
</tr>
<tr>
<td>SBR 0 STO 3 RCL 4 SBR 0</td>
<td></td>
</tr>
<tr>
<td>STO 4 RCL 5 SBR 0 STO 5</td>
<td></td>
</tr>
<tr>
<td>GTO 5 Lbl 0 STO 6 5=</td>
<td></td>
</tr>
<tr>
<td>GTO 5 RCL 6 INT X 1 EE</td>
<td></td>
</tr>
<tr>
<td>3 X RCL 6 INV INT ) 1/X X 159 ) INV SBR LRR</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 6

This program finds the impedance, resonant frequency and phase angle for a series LCR circuit. The first press of [R/S] gives the impedance at the resonant frequency, which is simply equal to the resistance in the circuit. Memory 4 now stores the resonant frequency (in Hz). On the next press of [R/S], the frequency is incremented by 1 kHz, and the display shows impedance in ohms. Pressing [x5t] will give the phase angle in degrees. The frequency can be checked after a number of runs by the sequence [RCL] [5] [+] [2] [+] [77] [=].

**Procedure**

<table>
<thead>
<tr>
<th>Program</th>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>LRR SBR 1 Lbl 3 RCL 1</td>
<td>The value of R (ohms) is stored in 1, L (in H) in 2, C (in F) in 3, followed by [CLR] [RST].</td>
</tr>
<tr>
<td>STO 7 SBR 2 INV P-&gt;R</td>
<td>Test data:</td>
</tr>
<tr>
<td>RCL R/S 2 EE 3 X PI = SUM 5 GTO 3 Lbl 1</td>
<td>10 STO 1 150 EE 6 +/-</td>
</tr>
<tr>
<td>RCL X RCL 3 ) 1/X ) INV</td>
<td>10 STO 2 850 EE 12 +/-</td>
</tr>
<tr>
<td>STO 4 INV SBR Lbl 2 RCL</td>
<td>STO 3 CLR RST</td>
</tr>
<tr>
<td>5 X RCL 2 — ( RCL 5</td>
<td>[R/S] gives 10, [RCL] [4] gives 445722.99,</td>
</tr>
<tr>
<td>X RCL 3 ) 1/X ) INV</td>
<td>10.17, etc. Note the use of [INV] [P-&gt;R] which calculates impedance and phase angles automatically when the resistive part is in memory 7 and the reactive part in the display.</td>
</tr>
<tr>
<td>SBR LRR</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 7

Oh yes, remember (in Part 5) we mentioned using a [Dsz] routine more than once in a program. Fig. 8 shows the program which was used in Fig. 4 of part 5 re-written as a subroutine.

**Procedure**

<table>
<thead>
<tr>
<th>Program</th>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>LRR 4 STO 0 SBR 1</td>
<td>Set value of resistor R into store. Program shows values of resistor with tolerances of +20%, going down in 5% steps to 5%; then -20%, going up in 5% steps to -5%.</td>
</tr>
<tr>
<td>4 +/- STO 0 SBR 1 R/S</td>
<td></td>
</tr>
<tr>
<td>Lbl 1 RCL 1 + ( RCL</td>
<td></td>
</tr>
<tr>
<td>0 X .05 X RCL 1 )</td>
<td></td>
</tr>
<tr>
<td>Pause Pause Dsz GTO 1</td>
<td></td>
</tr>
<tr>
<td>INV SBR LRR</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 8
IN OUR AUGUST ISSUE

SQUARE WAVE TRANSISTOR TESTER

A very simple and handy device that has the particular advantage that polarity switching for n.p.n. and p.n.p. transistors is carried out automatically.

The unit can also be used to check rectifiers and diodes and to indicate polarity.

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ON SALE 4th JULY 1979  Avoid disappointment. ORDER NOW
Most audio amplifiers these days, whether of low, medium or high output power, are of the solid-state Class B variety. There are obvious advantages with Class B output stages, what is probably the most important of these being their high efficiency and the consequent generation of minimal heat. The high efficiency enables compact amplifiers of quite considerable output power to be produced using standard readily available transistors.

Of course, where only a fairly modest output power is needed and the equipment is mains supplied, Class B operation is less advantageous. So indeed, is the use of solid-state devices rather than valves. Under such circumstances there are points in favour of employing valves and/or Class A operation.

**VALVE AMPLIFIERS**

The major point in favour of valve amplifiers is that, when overdriven, they do not produce such sharp clipping as do standard solid-state designs but offer, instead, a rounded output waveform which is relatively free from high frequency harmonics. Such harmonics tend to give the most noticeable distortion, and so their absence results in a comparatively "clean" output.

Class A amplifiers are completely free from crossover distortion, which can become more and more evident with a Class B amplifier as the output level decreases. Since distortion is most objectionable when it occurs at low volume levels, and since crossover distortion is itself particularly unpleasant, a circuit which is entirely free from it has an obvious attraction.

This fact prompted the author to experiment with some simple Class A designs, and the amplifier finally evolved forms the subject of this article. It is a transistor amplifier having an output power of about 2 watts r.m.s. without clipping occurring. Components for valve amplifiers have become rather difficult to obtain and, primarily for this reason, no valve circuits were tried. It is, in any case, possible to give transistor amplifiers the so-called "valve sound", by employing a soft clipper circuit, and was described in "Soft Audio Limiter" by A. Foord in the June 1975 issue of Radio & Electronics Constructor.

Total harmonic distortion with the present amplifier is well below 1% at all power output levels below the onset of clipping. Above clipping level the t.h.d. naturally rises very quickly. When used with a well smoothed power supply the amplifier has a wideband signal-to-noise ratio of about -76dB with the input left open-circuit. The input impedance is of the order of 10 kΩ and the output is intended to drive an 8Ω speaker. The use of other speaker impedances is not recommended. With the components specified, the amplifier has a sensitivity of about 240mV r.m.s. for maximum output power, but this can be easily altered, if necessary, by adjusting the value of one resistor. The frequency response of the amplifier is approximately 30Hz to 250kHz at the -3dB points.

**SIMPLIFIED CIRCUIT**

A simplified version of the amplifier circuit, showing the basic configuration employed, appears in Fig. 1.

There are just three stages of amplification, these consisting of a common emitter input stage using TR1, a common emitter driver stage using TR2 and an emitter follower output stage incorporating TR3. Direct coupling is employed between stages.

The configuration is basically similar to one commonly used for Class B designs, with the exception that a single emitter follower output transistor is employed instead of a complementary pair. The
### COMPONENTS

#### AMPLIFIER

**Resistors**

(All fixed values +1 watt 5% unless otherwise stated)

- R1 2.2kΩ
- R2 8.2kΩ
- R3 22kΩ
- R4 18kΩ
- R5 1.2kΩ
- R6 1.2kΩ
- R7 56Ω
- R8 12kΩ
- R9 10Ω
- R10 680Ω
- R11 1.8Ω ½ watt
- R12 1.8Ω ½ watt
- VR1 22kΩ potentiometer, log

**Capacitors**

- C1 4.7µF electrolytic, 16V Wkg.
- C2 0.1µF type C280
- C3 100µF electrolytic, 25V Wkg.
- C4 100µF electrolytic 16V Wkg.
- C5 270pF ceramic plate
- C6 100µF electrolytic, 16V Wkg.
- C7 10µF electrolytic, 10V Wkg.
- C8 1,000µF electrolytic, 16V Wkg.

**Semiconductors**

- TR1 2N3702
- TR2 BF390
- TR3 BF391
- TR4 BC109C
- TR5 TIP41A
- TR6 TIP41A
- D1 1N4148
- D2 1N4148

**Miscellaneous**

- Control knob
- Materials for printed circuit board
- Heatsink (see text)

#### POWER SUPPLY

**Resistor**

- R1 4.7kΩ pre-set potentiometer, 0.1 watt, horizontal

**Capacitors**

- C1 2,200µF electrolytic, 25V Wkg.
- C2 0.1µF type C280
- C3 0.1µF type C280

**Transformer**

- T1 mains transformer, secondary 15V at 1A

**Semiconductors**

- IC1 µA7805
- D1-D4 1N4001

**Indicator**

- PL1 panel-mounting neon with integral series resistor, 240V A.C.

**Switch**

- S1(a)(b) d.p.s.t. toggle

**Miscellaneous**

- Materials for printed circuit board
- Heatsink (see text)

---

The output stage gives the low output impedance needed to drive a loudspeaker, whilst the input and driver stages provide the necessary voltage gain. R5 provides 100% d.c. negative feedback between the output at TR3 emitter and the emitter of TR1. This gives the circuit a d.c. voltage gain of unity and simplifies amplifier biasing since it is only necessary to give TR1 base a suitable bias voltage, by means of R1 and R2, to cause the output emitter to be at half supply voltage above the negative rail. The output emitter can then swing by equal voltages positive and negative before clipping occurs, thereby giving optimum output power for a given supply voltage.

A voltage gain of more than unity is, of course, needed at a.c., and this is accomplished by using R3 to decouple some of the feedback introduced by R5. C2 is the decoupling capacitor and R3 limits the amount of feedback that is removed. In company with R5, R3 controls the voltage gain of the amplifier, and this is approximately equal to R5 divided by R3.

C1 and C3 provide d.c. blocking at the input and output respectively. In the simplified circuit of Fig. 1, R4 is the collector load for TR2 and R6 is the load resistor for TR3 emitter.
FULL CIRCUIT

The full working circuit of the 2 watt Class A amplifier is given in Fig. 2. At a quick glance this may seem to be the circuit of a Class B amplifier, but a closer examination of the circuit will soon reveal that it is not. It looks superficially like a Class B design due to the use of constant current loads for the driver and output stages.

For a high gain voltage amplifier such as the driver, TR3, a constant current load has the advantage that the transistor is operating at a fixed collector current so that, in theory at any rate, its gain remains virtually constant and it introduces little distortion. In practice, a certain amount of distortion will be introduced, if only because the constant current generator does not have a perfect performance. Nevertheless, a constant current load gives a considerable improvement in performance as compared with a straightforward resistive load.

The emitter follower output stage has unity voltage gain only, and the use of a constant current load may therefore seem unnecessary since variations in the gain of the transistor will not affect the voltage gain. However, it has to be remembered that the output stage is driving a very low impedance load, and that variations in the gain of the output transistor will cause corresponding changes in the output impedance of the amplifier. The loading effect of the speaker would result in the variations in output impedance causing a certain amount of distortion.

A constant current load also provides a more efficient coupling to the speaker than does a simple resistor load since the constant current source offers an apparently infinite impedance to a.c. output signals, and therefore wastes none of the a.c. output current. All the a.c. output current is thus available to drive the speaker, provided the quiescent output current is greater than the peak speaker current. There is obviously a rather poor efficiency in the output stage in terms of output power and the supply power required, but such inefficiency is an inherent feature of all Class A designs. If a load resistor were to be used instead of the constant current source it would need to have a low value, comparable with the impedance of the speaker, in order to bring the output transistor into suitable operating conditions. The consequence would be that as much of the a.c. output signal flows in the load resistor as flows into the speaker, resulting in an even lower efficiency.

Maximum efficiency would be given by directly connecting the speaker as the output stage load, but this would result in a high quiescent current flowing through the speaker and, at the currents involved in the present amplifier, is not to be recommended. An output transformer could also be used, but a suitable component might be hard to obtain, could easily restrict the quality of the amplifier and would probably offer an efficiency between the output stage and the speaker of only about 60% anyway.

A further advantage of a constant current output stage is that it requires a constant drive current, and does not therefore have an adverse effect on the constant current driver stage.

The use of constant current output stages was, incidentally, covered in more detail in "Constant Current' Class A Amplifier" by G. A. French in the December 1974 issue of Radio & Electronics Constructor.

**Fig. 2. The full working circuit of the Class A amplifier**
**DETAILED OPERATION**

In Fig. 2, the input signal is coupled to volume control VR1, from which it passes to the base of TR1 via C1 and R1. The latter assists in maintaining stability by attenuating the very high frequency response of the amplifier, as also does C5. R2 and R3 in series form the upper half of the bias potential divider for TR1 base, the lower half being given by R4. Bypass capacitor C4 connects to the junction of R2 and R3, and prevents hum and noise on the supply line reaching the input of the amplifier.

The driver stage constant current source incorporates TR2 in a standard constant current circuit. TR2 base is held at about 1.3 volts negative of the positive supply rail by the forward biased silicon diodes, D1 and D2. About 0.65 volt is dropped across the base-emitter junction of TR2, leaving 0.65 volt across the 10Ω resistor, R9. Provided TR2 has a suitably low impedance load in its collector circuit, the emitter and collector currents will then remain virtually constant at about 65mA.

A different configuration, incorporating TR4 and TR6, is used for the output stage constant current source. TR6 is held conductive by the base current it receives via R10, causing a current to flow through the emitter resistance formed by R11 and R12 in parallel. The voltage across the emitter resistance stabilizes at about 0.65 volt, since a higher voltage would cause TR4 to conduct heavily and starve TR6 of base current. The emitter current (and hence also the collector current when the load impedance is suitably low) then becomes about 720mA.

This gives a peak output current of 720mA, or 510mA r.m.s. The r.m.s. output power then calculates at slightly more than 2 watts, and tests on the prototype bear this figure out in practice.

The BFR81 and BFR41 transistors specified for TR2 and TR3 are available from several suppliers, including Electrovalue.

**CONSTRUCTION**

The amplifier is constructed on a printed circuit board which measures 98 by 64mm. The copper backing pattern and component layout of this board are illustrated actual size in Fig. 3. The board is etched and assembled in conventional manner. In the prototype the lead-outs of TR5 and TR6 are bent so that the transistor bodies are horizontal, as shown in the photographs.

It is important that TR5 and TR6 be provided with adequate heatsinking as they will otherwise overheat and be destroyed after a few minutes' operation. The author used “Plastic Power Vaned Heatsinks” (as supplied by Maplin Electronic Supplies) for testing the prototype circuit, but these are not really large enough for continuous normal usage. Either a larger commercially made heatsink should be employed, or the amplifier can be housed in a metal case with the latter acting as a heatsink. In either instance it will be necessary to insulate the transistors from the heatsink using the usual mica washer and insulating bush, and it is advisable to check that this insulation is fully effective with the aid of an ohmmeter before connecting the amplifier to a power supply. When a metal case is used as the heatsink it may be found more convenient to bend the lead-outs of TR5 and TR6 so that their bodies are vertical, allowing the heatsink pads to be bolted to one side of the case.

If necessary, the gain of the circuit can be altered by adjusting the value of R7. Decreasing its value will give a proportional increase in sensitivity and increasing its value will similarly decrease the sensitivity. It would be preferable not to make R7 less than about 12Ω, however, as the reduced negative feedback could seriously degrade the amplifier performance. Nevertheless, the prototype produces reasonably good results even when used “open loop”.

The output power of the amplifier is not very high by modern standards, but two amplifiers in a
Fig. 3. Details of the printed circuit board on which the amplifier is constructed. The two leads to VR1 connect to its slider and to the earthy end of its track.

Fig. 4. A suitable power supply for the amplifier. IC1 is a 5 volt regulator whose output voltage is raised to 14 volts by R1.
The power supply printed board assembly.
Details of the heatsink required for the regulator i.c. are given in the text.

stereo system driving different loudspeakers will supply enough power for most domestic purposes.

POWER SUPPLY

The circuit of a simple mains power supply is given in Fig. 4, and this provides the 14 volts at about 800mA which is required by a mono version of the amplifier. For stereo operation, a mains transformer having two 15 volt 1 amp secondaries may be used, each secondary feeding its own rectifier, smoothing and regulating circuit, and thereby providing a separate supply for each channel. If difficulty is experienced in obtaining transformers with single or dual 15 volt 1 amp secondaries, transformers with tapped 1 amp secondaries which include a 15 volt tap are available from Maplin Electronic Supplies.

The power supply circuit is quite straightforward, with the bridge rectifier given by D1 to D4 being followed by the high value smoothing capacitor C1. There is a loaded supply potential of 17 volts across C1, and this is regulated to 14 volts and given additional smoothing by the voltage regulator, IC1. The regulator i.c. is actually a 5 volt device, but the inclusion of pre-set potentiometer R1 in its common terminal circuit enables the output to be adjusted to the required voltage. C2 and C3 aid the stability of the i.e.

The rectifier, smoothing and regulating circuitry is assembled on a small printed circuit board and details of this are illustrated, again actual size, in Fig 5. IC1 should be fitted with at least a small finned heatsink, more substantial heatsinking being employed if available. If an amplifier metal case is used as a heatsink the i.c. must be insulated from this, as its heatsink pad connects to its common terminal. The power supply is not easily damaged since IC1 incorporates both thermal shutdown and output short-circuit protection, but the supply cannot withstand an indefinite short-circuit on the output.

"Designing Reflex Circuits"

By Sir Douglas Hall, Bt., K.C.M.G.

In Fig. 6(a) of this article, which appeared on page 609 of the June issue, the positive supply is applied to the junction of the interstage transformer primary and the r.f. choke. This is incorrect, and the positive supply should be fed to the junction of the primary and the 33kΩ resistor.
Dick snapped into place the plastic back of the neat little medium and long wave radio and then switched it on. He selected medium waves and tuned it over the band. Radios 1, 2 and 3 turned up at their allotted points on the tuning scale, although Radio 1 and Radio 3 were marred by an irritating background whistle which changed in pitch as he tuned through the signals. He then checked the long wave band, to find that Radio 4 came in at reasonable strength. Cheerfully, he switched off the set and proceeded to take it over to the "Repaired" rack.

"Hey!"

Puzzled, Dick stopped in mid-stride.

"I said, hey!"

Dick located the sound as coming from Smithy's bench on the other side of the Workshop. Smithy had his back towards his assistant and appeared to be completely engrossed in a colour television chassis which lay before him on his bench.

Dick frowned.

"Did you say anything, Smithy?"

"Of course I said something," replied Smithy without looking round. "Am I to understand that you look upon the radio I've just been hearing as being fully serviceable?"

"Blimey, it must be," replied a confused Dick. "All that was wrong with it was that one of the leads from the medium wave coil on the ferrite rod aerial had come adrift from the printed board. The aerial is positioned close to the board and the leads from the coil consist of the thin coil wire itself. I should imagine that the set had been given a bump which had caused the wire to break. At any rate I simply soldered the wire back to the board, checked out the set and found it was working all right again."

**QUICK REPAIR**

"It sounded pretty horrible to me," commented Smithy. "Even over here I could hear what seemed to be quite strong image frequency whistles on two of the stations you tuned in. Bring it over here and let's take a butcher's at it."

Smithy pushed the television chassis to one side of his bench and accepted the radio which Dick handed him. He set it to medium waves again and checked its performance. The whistles were still very noticeable.

"Just a few whistles," commented Dick. "So what?"

"It's daytime now," stated Smithy, "and the medium wave band is pretty quiet. If you get image frequency whistles during daytime conditions the aerial tuned circuit of this radio must be quite some way off trim. At evening and night-time, when the medium wave band is absolutely chock-full with signals, you'd probably get whistles on nearly every signal you tune in."

"Why are you so sure that these whistles are image frequency ones, anyway?"

"Well," confessed Smithy, "I'm not a hundred per cent certain. But everything points to it. One of the major problems of medium wave reception with a simple superhet of the type we've got here is to avoid image frequency whistles, and this can only be done successfully by ensuring that the aerial tuned circuit gives maximum selectivity at the wanted signal frequency. You have yourself said that this radio has probably had a bump which caused a wire from the ferrite aerial medium wave coil to come adrift from the printed board. Following from this, and taking in the presence of those whistles, it seems quite probable also that said bump caused the medium wave aerial coil to be dislodged from its proper position on the ferrite aerial rod."

"Blow me," exclaimed Dick. "I never thought of that."

Smithy opened the back of the receiver and placed an experimental finger on the medium wave ferrite aerial coil.

"Hmm," he commented, "it's not all that tightly secured on the rod."

He tuned to the low frequency end of the medium wave band and found a station, with the tuning capacitor vanes nearly fully enmeshed, which was only just audible. He slowly pushed the medium wave coil along the rod, whereupon signal strength increased considerably. He soon found a point for the coil on the rod which corresponded to maximum signal strength. (Fig. 1).
"That's more like it," he said, "let's see how the set performs now."

He tuned across the medium wave band. The set was noticeably more lively and the whistles on the BBC1 and BBC3 signals had magically disappeared.

Dick was supremely impressed by this display of electronic legendermail, on the part of Smithy. "Gosh Smithy, you're a genius!"

"Nonsense," retorted Smithy, "just a bit of elementary servicing, that's all."

"But why did moving that ferrite rod aerial coil clear those whistles?"

"Because," said Smithy patiently, "it made the aerial input tuned circuit peak more accurately at the required signal frequencies. Now look, as I've already said, this little set is a simple superhet, and it has an intermediate frequency which will be in the range of 455 to 475kHz or so. Let's say, for the sake of argument, that the i.f. is 460kHz. Right?"

"Right!"

"On medium waves," continued Smithy, "the signal coverage will be of the order of 550kHz at the low frequency end to 1,500kHz at the high frequency end. 550kHz is a rough check, the same as about 540 metres, and 1,500kHz is exactly the same as 200 metres. So we set up an aerial tuned circuit and an oscillator tuned circuit which are both tuned by a 2-gang capacitor. These are normally coupled, in a transistor radio, to a single transistor mixer-oscillator, and the tuned circuits are aligned so that the oscillator always runs at the intermediate frequency of 460kHz higher than the frequency to which the aerial circuit is tuned. (Fig. 2)."

"I know all about that," protested Dick impatiently, "it's elementary superhet theory. The oscillator frequency beats with the incoming signal in the oscillator-mixer to produce sum and difference frequencies. It's the difference frequency we're interested in here and that goes into the 460kHz intermediate frequency amplifier."

"Which," said Smithy, "provides most of the gain and most of the selectivity in the receiver. Right?"

"Right!"

"Good. Now having got that settled, the next thing we have to realise is that it is the oscillator frequency which chooses the aerial signal which is going to go into the 460kHz i.f. amplifier. If we set the oscillator to run at, say, 1,460kHz then the signal which the oscillator selects to enter the i.f. amplifier will be one at 1,000kHz. Changing the oscillator frequency has the same effect as operating the tuning control of the receiver, because you're then selecting the signals which are going to be allowed to go into the highly selective i.f. amplifier. And we now come to a snag."

"D'you mean the image frequency business?"

"I do. If the oscillator is running at 1,460kHz, it will let in a 1,000kHz signal all right because there's a 460kHz difference between them. But if there happens to be another signal at 1,920kHz, the oscillator will let that one in too because, once again, there is a 460kHz frequency difference between the two. The 1,920kHz signal is called the 'image' signal. It's also called a 'second channel' signal and it always appears at the frequency which is on the opposite side of the oscillator frequency to the desired signal, and which is spaced away from the oscillator frequency by the intermediate frequency. In a.m. medium and long wave radios the oscillator frequency is higher than the required signal frequency, so the image signal appears above it."

"I suppose," said Dick, "that it's the job of the signal frequency tuned circuit to stop the image signal getting through to the mixer."

"That's right," confirmed Smithy. "In high performance receivers you will have several tuned circuits resonant at signal frequency to stop the image signal, but in simple medium and long wave radios you have to rely on just a single tuned circuit to do the job. Fortunately, the coil in the tuned circuit is the one in the ferrite rod aerial and, because of the ferrite rod, it has a high Q. In practice it doesn't actually prevent an image signal from getting through to the mixer, because with only a single tuned circuit a strong image signal can still manage to force its way past. Instead, the ferrite rod aerial tuned circuit boosts the desired signal so that its amplitude is much greater than that of the image signal."

"Hey, hold on a bit — you're getting away from me now!"

"Think about it," said Smithy. "Let's go back to our example in which the oscillation is running at 1,460kHz. Now, if the receiver has been aligned correctly the aerial tuned circuit will then be resonant at 1,000kHz. Suppose that, due to the receiver having had a bump, the medium wave ferrite aerial coil has become displaced on its rod, so that the signal tuned circuit resonant frequency has changed to 900kHz."

Dick frowned. "Come off it Smithy, there's no need to rub it in."

"The response curve of the signal frequency tuned circuit," went on Smithy sternly, ignoring his assistant, "will now have a very high peak at 900kHz, but the skirts of the response will extend well up to the second channel frequency of 1,920kHz."

"Which," said Smithy, "is now going to be allowed into the mixer, instead of the original 1,000kHz signal, which it was intended to pass."

"You're mad," said Dick.

"Wrong!"

"Now," said Smithy patiently, "the second channel frequency is 460kHz, remember?"

"Oh yes."
1,920kHz. And so an image signal at that frequency will get through. As also, of course, will the desired signal which is present at that frequency will get through.

The response curve shown here is for an aerial circuit incorrectly tuned to 900kHz when the desired signal frequency is 1,000kHz. The response at 1,000kHz is not very much greater than the response at the image frequency of 1,920kHz

(b). When the aerial tuned circuit is correctly aligned to 1,000kHz, the response at this frequency is very much greater than that at the image frequency.

**TRIMMING CIRCUITS**

"Stap me," said Dick slowly. "I've never looked upon the signal frequency tuned circuit of a medium and long wave superhet like that before. To get rid of image frequency whistles, then, you have to ensure that it's giving maximum boost to the desired signal so that any unwanted image signal fades into insignificance when compared with it."

"That's the idea," agreed Smithy. "You probably won't be able to get rid of all the second channel whistles on the medium wave band of a simple a.m. superhet receiver by careful alignment of the signal frequency tuned circuit. But you will certainly get rid of most of them."

"What about long waves?"

"The same situation applies," stated Smithy, "but due to the frequencies involved the problem is not quite so acute. Say you want to pick up Radio 4 on 1,500 metres, or 200kHz. With an i.f. of 460kHz the image pops up at 200 plus 920, or 1,120kHz. This is relatively far removed in terms of frequency ratio from the desired signal frequency than occurs with medium wave images and so the difficulties are not so great. With the less expensive sets you often find that more attention is paid on medium waves to ensuring that the signal resonant frequency is accurately peaked at all settings of the tuning control than is paid on long waves. With poor designs you may even find that, if the long wave signal resonant frequency is correct at the Radio 4 frequency of 200kHz, this is considered good enough."

"Why," asked Dick, "do the image signals give these whistles? Why don't you actually hear the audio modulation which is present on the image signal?"

"You would do," replied Smithy, "if its amplitude were extremely strong. But the most audible effect is given by the image carrier, after conversion in frequency at the mixer, beating with the i.f. carrier of the required signal. The whistle changes in frequency as you vary the receiver tuning, by the way, because of the different frequencies at the output of the mixer. If oscillation frequency rises, for instance, the image carrier intermediate frequency decreases whilst the required signal intermediate frequency increases."

Dick pondered on this for a moment.

"What did you mean just now," he queried, "when you said that medium and long wave sets usually have greater attention paid to correcting signal frequency peaking on medium waves than occurs on long waves?"

**MIXER CIRCUIT**

Smithy leaned forward and plucked up a sheaf of papers at the rear of his bench. He thumbed through these and gave a grunt of satisfaction as he located a service sheet on which was printed a receiver circuit diagram. He showed this to Dick, pointing to the mixer-oscillator section. (Fig. 4.)

"This," he commented, "is representative of what you get in a medium and long wave receiver when the circuitry is really cut to the bone."

"The wave-change switching certainly seems to be very basic," said Dick. "All it needs is a 2-pole 2-way switch."

"Exactly," confirmed Smithy. "Now let's see what happens when that switch is set to medium waves. The left-hand section of the switch takes the lower end of the medium wave ferrite rod coupling coil down to chassis via the 0.47μF capacitor, C1. That capacitor is virtually a dead short at r.f., and it also allows the mixer-oscillator transistor to receive d.c. base bias by way of R1 and R2. Right?"
"Right!" said Dick smartly. "And the right-hand section of the switch shorts out the long wave tuned winding on the ferrite aerial rod. So, everything is set up in the aerial department for medium wave reception."

"Quite so," said Smithy. "The prime requirement which has next to be met is to ensure that the ferrite aerial signal tuned circuit is always resonant at a frequency which is lower by the i.f. than the oscillator frequency at all settings of the 2-gang tuning capacitor, VC1(a) and (b). The aerial winding is directly by VC1(a) and the trimmer TC2. The oscillator tuned winding has the padding capacitor, C4, between it and VC1(b). Another trimmer, TC4, is connected across VC1(b). The oscillator circuit is pretty straightforward, with positive feedback being given from the transistor collector back to its emitter."

"Does the padding capacitor cater for the fact that the oscillator tuning range is lower than the signal frequency tuning range?"

"It does. If we had a medium wave coverage of 550 to 1,500kHz, the oscillator range, with a 460kHz i.f., would be 1,010kHz to 1,960kHz. There is a lower ratio between maximum and minimum frequency, and so the oscillator tuned winding requires less tuning capacitance. The tuning capacitance is reduced by putting C4 in series with VC1(b). Now, the medium wave aerial and oscillator circuits can be aligned very accurately to give almost perfect tracking over the whole range by adjusting TC2 and TC4 at the high frequency end of the band, and the inductance of the medium wave aerial coil and the inductance of the oscillator tuned winding at the low frequency end. You vary the aerial coil inductance by sliding the aerial coil along the ferrite rod and you vary the oscillator inductance by adjusting the core in the oscillator coil. Let's next move the switch to the long wave position."

"Righty-ho! Well, the switch section on the left connects C1 to the top end of the medium wave ferrite aerial coil via trimmer TC1. And the right-hand switch section takes the short off the long wave tuned winding."

"With the result," broke in Smithy, "that both tuned windings on the ferrite rod are in series for long wave reception as are both the coupling windings. The lower end of the coupling windings now effectively couples to chassis via R1 and R2. These resistors will offer some attenuation at long waves, which can be taken up by having a few more turns on the long wave coupling coil. The most important thing to notice takes place in the oscillator circuit. What happens here on long waves is that there is no change in tuning inductance at all. Instead, the right hand switch section simply puts C3 and the trimmer TC3 across VC1(b). These capacitors bring the oscillator frequency down to the range required for long wave tuned circuits, by means of TC1 and TC3, and you can adjust the inductance of the long wave aerial coil by sliding it along the ferrite rod. But you cannot adjust the inductance of the long wave oscillator tuned winding."

"Why not?"

"Because if you do you'll mess up the alignment on medium waves. You can only align the receiver by first lining up the medium wave range and then going to the long wave band. If the receiver is a good design, the result of the medium wave alignment will be such that you can get good tracking on long waves with the limited long wave adjustments which are available to you. Ideally, you should align the medium and long wave bands exactly as detailed in the receiver service manual. With the better class of receiver there will be precise frequency indications at the high and low frequency ends of the tuning scale to enable you to get the medium wave alignment spot-on. The situation for long waves will then be that which the receiver designer has decided will give optimum tracking on that band."

---

**Fig. 4.** Representative medium and long wave mixer-oscillator circuit as encountered in less expensive receivers. The most important point to note is that, on long waves, additional capacitance is connected across the medium wave oscillator tuned circuit.
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**CROSS MODULATION**

"Is that mixer-oscillator circuit you've shown me given in all medium and long wave receivers?"

"You'll find the same basic approach in most," replied Smithy.

"The main variations will be in the way the ferrite rod windings are switched into circuit on the two bands. But you'll nearly always find that, on long waves, extra capacitance is added across the oscillator tuned circuit. Whereupon, once again, the medium wave band has to be aligned first."

Dick grinned.

"Do you realise," he said, "that all this discussion has arisen just because that little radio I serviced had image frequency whistles on it?"

Despite himself, Smithy grinned also.

"I can see that I've fallen into the usual trap," he chuckled. "Still, if I've given you some idea on how to avoid image interference on a.m. receivers the time has been well spent. I'd suggest you take that set fixed back to your bench and give it a full line-up on medium and long waves before you consider it properly serviced."

"Okay-doke, Smithy,"

A thought suddenly occurred to Smithy.

"Before you go," he remarked, "let me tell you about another sort of radio interference. This one disappears when the required signal ceases transmission!"

"Come on, Smithy. You're pulling my leg."

"No, I'm not. It's a form of interference which is mainly troublesome in communications receivers and which can cause some real design headaches. It's known as cross modulation interference."

"Cross modulation?"

"That's right. A strong a.m. signal can cross modulate another a.m. signal if they're applied to an amplifier stage which doesn't have a linear characteristic. If it has a non-linear characteristic the stage amplifies and, if this amplifier has a non-linear response, the strong signal will then cross modulate the weak one. There is no way in which you can remove that cross modulation after it has occurred at the first r.f. amplifier, even if the subsequent effective selectivity is nearly down to zero frequency on either side of the required signal. Cross modulation interference can be recognised because it disappears when the required signal goes off the air." (Fig. 5(b)).

"Blimey," said Dick, impressed, "that's something to think about. How d'you get over the trouble?"

"The only solution is to design the receiver so that all the amplifier stages in the early part of the receiver have very linear characteristics. Funnily enough, nobody worried too much about cross modulation in communications receivers in the old valve days, because valves can easily be made to have quite linear characteristics. Cross modulation only started to cause real unhappiness when the communications receiver design changed over to transistors."

**END OF SESSION**

"Well," said Dick happily, "at least communications receiver design isn't something which need trouble us too much here in the Workshop."

"True, true."

"In fact, we need not get at all uptight or angry about cross modulation."

Smithy sighed.

"And we can cheerfully whistle our way through second channel interference."

Smithy rummaged around on his bench.

"On reflection," persisted Dick mercilessly, "all we have to do is to present an acceptable image!"

Whereupon Dick ducked expertly...
as the 2,200μF 25V, Wkg. electrolytic sailed harmlessly past his right ear, after which he carried the medium and long wave receiver back to his bench for a full and final re-alignment.

Fig. 5(a). The selectivity offered by a communications receiver with two r.f. amplifier stages increases after each tuned circuit

(b). The selectivity curves of the receiver superimposed on each other and centred on a desired reception frequency of 10MHz. If, due to non-linearity in the first r.f. stage, an interfering signal at 10.3MHz cross modulates the 10MHz signal, the interference cannot be removed by the subsequent tuned circuits even though they reject the 10.3MHz signal itself.
An elderly aunt of mine recently decided to buy a new radio, as her existing receiver did not have long waves for reception of Radio 4. Being a bit long in years but short in the purse she bought a very cheap medium and long wave job priced at only £8.95 retail. And to my mind she got quite a bargain, too.

The radio was one of those "made in Hong Kong" models in which costs had obviously been cut to the very bone. But, for its price, it performed well. There was excellent tracking on medium and long waves, and very few second channel whistles on either of these bands. The quality was a little lower than mid-fi, but you could still listen to serious music on it without winning too much.

CIRCUIT DIAGRAM

With the instruction leaflet the makers had obligingly included a circuit diagram. After the mixed-oscillator transistor there were two i.f. stages, allowing the use of three single-tuned i.f. transformers. These had an acceptable and symmetrical passband. You can always get a good idea of the i.f. response of a radio of this nature by tuning slowly through a reasonably powerful signal in the middle to lower frequency end of the medium wave band. The background hiss should rise by equal amounts for equal movements of the tuning capacitor on either side of the central correctly tuned setting.

After the last i.f. transformer came the detector, with the volume control as load. Which means that that volume control will probably start to get scratchy in use at some time in the future. Then an a.f. amplifier transistor feeding an interstage push-pull transformer, followed by the two output transistors driving the speaker by way of another push-pull transformer. And nary the faintest whiff of negative feedback.

I confess to being a little baffled at the fact that these very low cost radios still employ transformers in the a.f. stages instead of the more modern transformerless circuits. Surely, the cost of two transformers having many turns of very fine wire is considerably greater than the price of the few resistors and capacitors that the more recent circuits would require. Still, somebody must have costed the production of this receiver and concluded that the transformers were cheaper. There must be a very cut-rate transformer factory out there in Hong Kong!

VOLUME CONTROL

Why, incidentally, did I say that the volume control could get scratchy in use because it was also the detector diode load? The answer is that, in addition to a.f., there will also be a direct voltage across the volume control track, partly due to the detected signal and partly due to the receiver a.g.c. circuitry.

Now a volume control, particularly one which has seen a good deal of use, does not give a perfectly smooth change of volume as it is adjusted. Instead, there are tiny little discrete hops in the changing resistance which is tapped off by the volume control slider. With a good control these changes are far too small to give an audible effect as the control is adjusted. Indeed, when there is only a.f. and no direct voltage across the track quite large hops in resistance can pass unnoticed by a listener. But when there is a direct voltage across the track, the result is a series of quick changes in voltage on the slider. These then pass through the following a.f. amplifier and become audible as a rushing noise as the control is adjusted. Fortunately, the effect has irritation value only, as the sound ceases when the control slider is stationary. On the other hand, the presence of the noise sometimes indicates that it won't be very long before contact between the slider and the track becomes actually intermittent at places, whereupon there is complete loss of audio at some settings of the volume control.

VARIABLE SPEED DRILL

Of interest to the do-it-yourself fraternity will be the new Skil electric ratcheting drill shown in the accompanying illustration. This is the Model 1471H, with a ¼in. chuck and an input rating of 420 watts. A particularly attractive feature is the Skil patented electronic variable trigger speed control. Increasing pressure on the trigger accelerates the speed whilst less pressure reduces the number of revolutions per minute. Speed control also adds to the applications of the tool because the operator can start from zero and gradually increase the speed. Thus the drill bit will not skid off and damage the work piece, a point of considerable importance when drilling smooth surfaces or critical materials, such as ceramic or tile.

A speed control is also extremely useful for driving screws. With little effort many screws can be installed swiftly and accurately, exactly
where they are wanted. For drilling holes into ceramic tiles into concrete, a variable speed ratchet drill is virtually indispensable. On the tile the drilling action only is used, starting from zero and increasing the speed carefully; as soon as the concrete is reached the ratching system is switched on.

The no-load speed of the Model 1471H can be adjusted from zero to 2,600 r.p.m. and from zero to 36,000 blows per minute. Its weight is just about 2kg, and the drill is supplied with a side handle which mounts on either side of the body for right and left hand users. Further details may be obtained from Skil (Great Britain) Ltd., Fairacres Industrial Estate, Dedworth, Windsor SL4 4LE.

The new Skil Model 1471H ratcheting drill. This has the very useful feature of variable speed control, the drill revolutions being varied by the pressure exerted on the trigger.

**RE-USE OF PARTS**

Electronic components are normally intended to be fitted once to the equipment for which they are destined and left there, only to be removed if at any time they should become faulty. And so the more experimentally minded amongst us must not grumble too much when we find, say, that the type numbers rub off transistors due to continual handling. As originally envisaged by their makers, transistor type number marking is quite acceptable if it withstands the handling of the operator on the production line who inserts them into their printed card.

I've got some BC107's which I've been in so many experimental lash-ups that it's a wonder their locating lugs haven't worn away in addition to the type number printing! These transistors stand up to a fantastic amount of maltreatment including, in particular, continual bouts of heating as they are soldered first into one temporary circuit and then removed from that to be soldered into another. I'm a pretty swift operator with a soldering iron, but, even so, the transistors were manufactured to be soldered into circuit once only.

I wish that d.i.l. integrated circuits were as physically robust. I always use i.c. holders for checking out experimental circuits incorporating these devices but they can stand up to only a limited number of insertions and removals from the holders before one of the pins starts to take on the appearance of a dog's hind leg. The pin can be straightened out, of course, but after that there's always a lingering doubt that it will buckle up completely at the next insertion in a holder.

Still, these risks are all part of the game of experimental electronics. Some types of i.c. holder are surprisingly more difficult to use than others; if you have an awkward one it's a good plan to get used to it by plugging in some i.c.'s for which you have no further use. I keep a few old t.t.l. 7400 types on hand just for this purpose.

**VETERAN TRANSMITTERS**

Did you realise that, before last November, you may have been listening to a.m. radio signals from B.B.C. transmitters which were installed before 1930? Incredible as it may seem, this little item is part of a Marconi release concerning the medium and long wave frequency changes of last year. The B.B.C. took advantage of the changeover to put into honourable retirement some very early Marconi transmitters which were installed nearly 50 years ago, and to open up a number of brand-new transmitters supplied by Marconi Communication Systems Limited.

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**THAT SILICON CHIP**

We are certainly entering the silicon chip revolution with a vengeance these days. You don't need a microprocessor to discover the fantastic computing power provided by current-day chip technology, you can find out by simply playing around with a relatively inexpensive programmable calculator. When our series "Tune-In To Programs" commenced I went out and bought myself a Texas Instruments Ti-57, and I find myself marveling more and more at the capabilities of this machine.

The programmed silicon chip has already taken over many jobs which previously relied on man's expertise, and there is no shadow of doubt that it will continue to do so. However, the chip has to be interfaced with the world around it. For mechanical production processes, the chip has to be coupled into the work being produced by transducers which assess dimensions, shapes and even quality. Somebody has to design and make the interfacing equipment.

Sadly, many traditional human skills, and the satisfactions which go with exercising them, will be lost in the day of the silicon chip. But the need for new skills and expertise will surely increase, to at least partly compensate for the loss. What, I think dismays many people about the advancing ascendancy of the chip is that it's all happening so darned quickly.

The day of the robot worker approaches rapidly. Controlled, perhaps, by a silicon chip on its shoulder?
The author is currently building a visual display unit, a project which involves assembling some 50 integrated circuits onto four double sided printed circuit boards. The wiring jigs described here have made the task much simpler, and they also ensure that there is less risk of dry soldered connections at any of the 800 i.c. pins. Soldering is certainly easier than is given with the more usual method of balancing the board on its components while working on the bench or kitchen table.

**EDGE CONNECTORS**

The main parts of the jigs are two edge connectors intended for making contact to double sided boards. They should have 32 or more pairs of contacts. The author's edge connectors were obtained ex-equipment and some of the tags were broken. Also needed is about 27in. of softwood measuring about \( \frac{3}{4} \) by 1\( \frac{1}{4} \)in. The wood is cut into four equal lengths and, at this stage, these may be sprayed matt black, if desired. The edge connectors are screwed to the top edges of two of the pieces. The two remaining pieces are then screwed to the first two pieces in the manner shown in the photographs, using 1\( \frac{1}{4} \) by No. 6 countersunk woodscrews positioned about 1\( \frac{1}{4} \)in. in from each end. There are two woodscrews for each pair of wood pieces.

The two printed circuit board wiring jigs. The edge connectors are screwed to the inner edges of two of the pieces of wood, the remaining two lengths then being screwed to the first two pieces. Finally, eight white plastic stick-on feet are added, as shown.

A printed circuit board secured to the two jigs. The four stick-on feet on the underside rest on the workbench surface. The whole assembly is simply turned over for work on the other side of the printed board.

Each end of the printed circuit board is held securely by the edge connector contacts.

The finishing touch is provided by eight plastic stick-on feet, available from Maplin Electronic Supplies. These have an adhesive surface which is revealed by peeling off a backing sheet, and four of them are fitted to cover the heads of the woodscrews. The remaining four are mounted in corresponding positions on the opposite side of each jig.

The printed circuit board being worked on is held at each end by the edge connectors and can be turned over when necessary. With these jigs, work on a circuit board becomes a real pleasure.
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