ELECTRONICS TODAY

# electronics today international

JANUARY 1976

30p

## Projects inside:

LOGIC TESTER
CROSSOVER AMP
ELECTRONIC DICE
COMPARATOR

## SURVEY OF SCIENTIFIC CALCULATORS

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TECH-TIPS

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SPECIAL OFFER
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NEWS . . . CONSTRUCTION . . . DEVELOPMENTS

# CHROMASONIC electronics

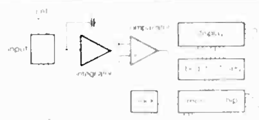
Dept. 7 56, Fortis Green Road, Muswell Hill, London, N10 3HN.
telephone: 01-883 3705

## C-MOS

mix prices

| | 1-24 | 25-99 | 100up |
|---|---|---|---|
| CD4000AE | 19p | 17p | 14p |
| CD4001AE | 19p | 17p | 14p |
| CD4002AE | 19p | 17p | 14p |
| CD4006AE | £1.59 | £1.33 | £1.06 |
| CD4007AE | 23p | 19p | 15p |
| CD4008AE | £1.75 | £1.46 | £1.17 |
| CD4009AE | Use | CD4049* | |
| CD4010AE | Use | CD4050* | |
| CD4011AE | 19p | 17p | 14p |
| CD4012AE | 19p | 17p | 14p |
| CD4013AE | 59p | 50p | 46p |
| CD4014AE | £1.75 | £1.46 | £1.17 |
| CD4015AE | £1.75 | £1.46 | £1.17 |
| CD4016AE | 55p | 48p | 44p |
| CD4017AE | £1.29 | £1.07 | 93p |
| CD4018AE | £1.89 | £1.56 | £1.25 |
| CD4019AE | 80p | 66p | 53p |
| CD4020AE | £1.97 | £1.64 | £1.31 |
| CD4021AE | £1.75 | £1.46 | £1.17p |
| CD4023AE | 19p | 17p | 14p |
| CD4022AE | £1.83 | £1.53 | £1.22 |
| CD4024AE | £1.26 | £1.05 | 84p |
| CD4025AE | 19p | 17p | 14p |
| CD4026AE | £2.79 | £2.32 | £1.86 |
| CD4027AE | 98p | 82p | 65p |
| CD4028AE | £1.53 | £1.28 | £1.02 |
| CD4029AE | £1.89 | £1.56 | £1.15 |
| CD4030AE | 71p | 59p | 47p |
| CD4035AE | £1.75 | £1.46 | £1.17 |
| CD4040AE | £2.01 | £1.69 | £1.34 |
| CD4042AE | £1.49 | £1.24 | 99p |
| CD4046AE | £2.15 | £1.79 | £1.44 |
| CD4049AE | 69p | 58p | 46p |
| CD4050AE | 69p | 58p | 46p |
| CD4051AE | £2.78 | £2.32 | £1.85 |
| CD4052AE | £2.78 | £2.32 | £1.85 |
| CD4056AE | £2.12 | £1.76 | £1.41 |
| CD4060AE | £2.39 | £1.99 | £1.55 |
| CD4066AE | £1.13 | 94p | 75p |
| CD4068AE | 28p | 24p | 19p |
| CD4069AE | 28p | 24p | 19p |
| CD4070AE | 28p | 24p | 19p |
| CD4071AE | 28p | 24p | 19p |
| CD4077AE | 71p | 59p | 47p |
| CD4081AE | 28p | 24p | 19p |
| CD4082AE | 28p | 24p | 19p |
| CD4085AE | £1.28 | £1.06 | 85p |
| CD4086AE | £1.28 | £1.06 | 85p |
| CD4093AE | £1.56 | £1.20 | £1.04 |
| CD4099AE | £2.95 | £2.46 | £1.96 |
| CD4511AE | £2.36 | £1.79 | £1.44 |
| CD4528AE | £1.30 | £1.08 | 87p |

## 3½ DECADE DVM I.C.



This state-of-the-art MOS LSI chip contains all the logic necessary for a 3½ decade, dual slope integrating, automatic polarity detecting DVM. Supplied with free data and circuit booklet. AY-5-3507

OUR PRICE ONLY £6.59 *

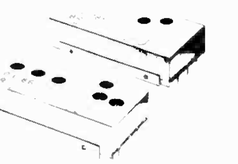
(Data and Circuit Booklets alone 20p.)

## The AY·5·1224 tick·tock

Another marvel from G.I. A 16 pin 12-24 hr. Clock I.C. with 25 pin capability and low external parts count. Supplied with manufacturers detailed leaflet £3.95p* (inc. VAT) (Leaflet alone 20p.) Full Kit (excluding case) available towards end of 1975. Phone Clive for details.

## MULLARD MODULES

Still make the simplest, highly reliable F.M. tuner



| | | |
|---|---|---|
| LP1186 | Varactor front end | £8.60 |
| LP1185 | I.F. Strip | £6.95 |
| LP1400 | Multiplex decoder | £9.02 |

## I.C. SOCKETS

Pin Sockets, pins in strips of 100. Just snip off what you need. 65p per strip *

Dual in line

| | | |
|---|---|---|
| 8 pin 13p. | 24 pin 26p. | TO5 |
| 14 pin 15p | 28 pin 30p. | 8 pin 31p. |
| 16 pin 15p | 36 pin 39 p. | 10 pin 35p. |

## FREE CIRCUITS

Our 8 Page A4 Audio I.C. Booklet is supplied FREE with purchases of Linear I.C.'s worth £1. or more (35p. if sold alone) Contains circuits and pin connections

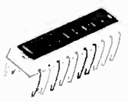
- 15 Amplifiers 250 mW to 20 watts
- 5 Audio Pre-Amplifiers
- 1 Tape Pre-Amplifier
- 1 Power Driver
- 1 Instrument Amplifier (Bifet)
- 1 General Purpose Mini Amplifier
- 1 D.C. Controlled Gain Control
- 1 Micro-mini radio (2 I.C's)

## PHOTO-DARLINGTON

Vceo 25v 2N5777
Vcbo 25v
Vebo 8v
I! 250 mA
Pd 200 mW
Hfe 2500


**35p.**

## LINE-O-LIGHT



NEW LED Linear Cursors each device contains 10 light emitting diodes in a 20 pin dual-in-line package. Ideal for solid state analogue meters or dials Type 101 RED £2.26.* Complete with leaflet.

## 74 TTL

mix prices

| | 1-24 | 25-99 | 100 |
|---|---|---|---|
| 7400 | 14p | 12p | 10p |
| 7401 | 14p | 12p | 10p |
| 7402 | 14p | 12p | 10p |
| 7403 | 15p | 12p | 10p |
| 7404 | 16p | 13p | 11p |
| 7408 | 16p | 13p | 11p |
| 7409 | 16p | 13p | 11p |
| 7410 | 16p | 13p | 11p |
| 7413 | 29p | 24p | 20p |
| 7417 | 27p | 22p | 20p |
| 7420 | 16p | 13p | 11p |
| 7427 | 27p | 22p | 18p |
| 7430 | 16p | 13p | 11p |
| 7432 | 27p | 22p | 18p |
| 7437 | 27p | 22p | 18p |
| 7441 | 75p | 63p | 50p |
| 7442 | 65p | 55p | 43p |
| 7445 | 85p | 71p | 57p |
| 7447 | 81p | 75p | 65p |
| 7448 | 75p | 62p | 50p |
| 7447A | 95p | 83p | 67p |
| 7470 | 30p | 25p | 20p |
| 7472 | 25p | 21p | 17p |
| 7473 | 30p | 25p | 20p |
| 7474 | 32p | 26p | 21p |
| 7475 | 47p | 39p | 31p |
| 7476 | 32p | 26p | 21p |
| 7482 | 75p | 63p | 50p |
| 7485 | £1.30 | £1.09 | 87p |
| 7486 | 32p | 26p | 21p |
| 7489 | £2.92 | £2.80 | £2.10 |
| 7490 | 49p | 40p | 32p |
| 7491 | 65p | 55p | 45p |
| 7492 | 57p | 46p | 36p |
| 7493 | 45p | 40p | 32p |
| 7495 | 67p | 55p | 45p |
| 74100 | £1.08 | 89p | 72p |
| 74107 | 35p | 28p | 22p |
| 74121 | 34p | 28p | 23p |
| 74122 | 47p | 39p | 31p |
| 74141 | 78p | 63p | 53p |
| 74145 | 68p | 58p | 48p |
| 74154 | £1.62 | £1.48 | 86p |
| 74174 | £1.00 | 83p | 67p |
| 74180 | £1.06 | 88p | 71p |
| 74181 | £3.20 | £2.50 | £1.90 |
| 74192 | £1.35 | £1.14 | 90p |
| 74193 | £1.35 | £1.14 | 90p |
| 74196 | £1.64 | £1.34 | 99p |

## LINEAR I.C.'s

| | |
|---|---|
| 555 (8 pin dip)V | 55p |
| 555 (TO-99)T | 81p |
| 556 (14 pin dip) | £1.29 |
| 703 (RF/IF Amp) | 68p |
| 709 (8 pin dip) | 38p |
| 709 (TO-99) | 45p |
| 709 (14 pin dip) | 39p |
| 710 (8 pin dip) | 39p |
| 710 (TO-99) | 45p |
| 710 (14 pin dip) | 44p |
| 711 (TO-99) | 51p |
| 711 (14 pin dip) | 44p |
| 720 (A.M. Radio) | £1.76 |
| 723 (TO-99) | £1.09 |
| 723 (14 pin dip | 55p |
| 741 (8 pin dip | 30p |
| 741 (TO-99) | 43p |
| 741 (14 pin dip) | 36p |
| 747 (14 pin dip) | £1.04 |
| 748 (8 pin dip) | 42p |
| 748 (TO-99) | 46p |
| 748 (14 pin dip) | 49p |
| 753 (F.M. 1st. I.F.) | £1.08 |
| 75491 | 88p |
| 75492 | £1.10 |

Regulators 100 mA

| | |
|---|---|
| 78105WC (TO-92) | 60p |
| 78L12WC (TO-92) | 60p |
| 78L15WC (TO-92) | 60p |

Regulators 100mA

| | |
|---|---|
| 78L05AWC (TBA625A) | 90p |
| 78L12AWC (TBA625B) | 90p |
| 78L15AWC (TBA625C) | 90p |

Regulators 500mA

| | |
|---|---|
| 78M05HC | £1.35 |
| 78M12HC | £1.35 |
| 78M15HC | £1.35 |
| 78M18HC | £1.35 |
| 78M24HC | £1.35 |

Regulators 1A

| | |
|---|---|
| 7805KC (TO-3) | £2.09 |
| 7812KC (TO-3) | £2.09 |
| 7815KC (TO-3) | £2.09 |
| 7818KC (TO-3) | £2.09 |
| 7824KC (TO-3) | £2.09 |

Regulators 1A

| | |
|---|---|
| 7805UC (TO-220) | £1.72 |
| 7812UC (TO-220) | £1.72 |
| 7815UC (TO-220) | £1.72 |
| 7818UC (TO-220) | £1.72 |
| 7824UC (TO-220) | £1.72 |
| ICL8030 | £3.52 |

| | |
|---|---|
| AY-1-0212 | £6.93 |
| AY-1-5051 | £1.44 |
| AY-5-1224 | £3.95 |
| AY-5-3500 | £6.59 |
| AY-5-3507 | £6.59 |
| AY-5-4007 | £7.94 |
| BHA0002 | £3.01 |
| CA2111 | £1.19 |
| CA3045 | £1.69 |
| CA3046 | 88p |
| CA3053 | 59p |
| CA3065 | £1.60 |
| CA3075 | £1.64 |
| CA3078 | £1.26 |
| CA3080 | 59p |
| CA3081 | £1.86 |
| CA3082 | £1.86 |
| CA3089E (TDA1200) | £2.43 |
| CA3097E | £1.67 |
| CA3123E | £1.76 |
| CA3130 | 84p |
| CA3401E (LM3900) | 68p |
| CA3600E | £1.44 |
| L005T1 (TO.3) | £1.46 |
| L036T1 (TO.3) | £1.46 |
| L037T1 (TO-3) | £1.46 |
| L129 (SOT-32) | 85p |
| L130 (SOT-3. | 85p |
| L131 (SOT-32 | 85p |
| LM301T (TO-99) | |
| LM301S (8 pin dip) | |
| LM301A T (TO-99) | |
| LM301A S (8 pin dip) | 59p |
| LM307 T (TO-99) | 59p |
| LM307 S (8 pin dip) | 57p |
| LM308 T (TO-99) | £1.96 |
| LM308 S (8 pin dip) | 98p |
| LM308A T (TO-99) | £7.92 |
| LM308A S (8 pin dip) | £6.90 |
| LM309K | £2.34 |
| LM339 | £2.25 |
| LM370N | £2.85 |
| LM371 | £2.08 |
| LM372N | £1.99 |
| LM373N | £2.99 |
| LM377N | £2.71 |
| LM380 | £1.25 |
| LM381 | £1.85 |
| LM382 | £1.66 |
| LM703 | 68p |
| LM1820 | £1.03 |

| | |
|---|---|
| LM2111 | £1.12 |
| LM3900 | 69p |
| LM3909 | 66p |
| MC1303L | £1.94 |
| MC1306P | 85p |
| MC1310P | £2.10 |
| MC1312 | £2.52 |
| MC1314 | £4.34 |
| MC1315 | £4.85 |
| MC1327 | £1.48 |
| MC1330P | 89p |
| MC1339P | £1.60 |
| MC1350 | 68p |
| MC1351 | 92p |
| MC1352 | 92p |
| MC1357 | £1.60 |
| MC1358(CA3065) | £1.23 |
| MC1375 | £1.56 |
| MC1455 (555T) | 65p |
| MC1456CG | £1.77 |
| MC1458CP1 | 89p |
| MC1468G | £2.30 |
| MC1495L | £4.48 |
| MC1496G | £1.01 |
| MC3302P | £1.65 |
| MC3401P | 81p |
| MFC4000B | 87p |
| MFC4060A | 85p |
| MFC6030A | 85p |
| MFC6040 | £1.01 |
| MM5314 | £4.80 |
| MM5316 | £9.99 |
| MVR5V (TO-3) | £1.45 |
| MVR12V (TO-3) | £1.45 |
| MVR15V (TO-3) | £1.45 |
| NE540I | £1.25 |
| NE546A | £1.16 |
| NE555V | 69p |
| NE556 | £1.29 |
| NE560B | £5.06 |
| NE561B | £5.06 |
| NE562B | £5.06 |
| NE563 | £2.96 |
| NE565N | £2.63 |
| NE566V | £1.87 |
| NE567V | £2.63 |
| SD6000 | £1.22 |
| SL414A | £2.09 |
| SL415A | £2.75 |
| SL437D | £7.50 |
| SL440 | £2.84 |
| SN75491N | 88p |
| SN75492N | £1.10 |

| | |
|---|---|
| SN76001N (TAA611) | £1.82 |
| SN76003N | £3.30 |
| SN76013N | £1.98 |
| SN76023N | £1.98 |
| SN76227N(MC1327) | £1.89 |
| SN76533N | £1.86 |
| SN76544N | £1.81 |
| SN76550-2(TAA550) | 89p |
| SN76552-2 | 81p |
| SN76660N(TBA120) | 75p |
| SN76666N (CA3065) | £1.12 |
| TAA263 | £1.50 |
| TAA300 | £2.16 |
| TAA310A | £1.87 |
| TAA320 | £1.44 |
| TAA350 | £2.43 |
| TAA370 | £3.45 |
| TAA550 | 75 |
| TAA570 | £2.75 |
| TAA700 | £5.03 |
| TBA120S | £1.25 |
| TBA231 | £1.02 |
| TBA281 (723) | £2.59 |
| TBA500Q | £3.16 |
| TBA520Q | £3.85 |
| TBA530Q | £3.27 |
| TBA540Q | £3.72 |
| TBA550Q | £5.29 |
| TBA560CQ | £5.29 |
| TBA625A | £1.03 |
| TBA625B | £1.03 |
| TBA625C | £1.03 |
| TBA651 | £1.87 |
| TBA720Q | £2.79 |
| TBA750Q | £2.79 |
| TBA800 | £1.11 |
| TBA810S | £1.24 |
| TBA810AS | £1.24 |
| TBA820 | 86p |
| TBA920Q | £4.71 |
| TBA990Q | £4.71 |
| TCA270Q | £5.24 |
| TCA760 | £2.16 |
| TCA800Q | £7.24 |
| TCA830S | £1.04 |
| TCA940 | £2.25 |
| TDA1054 | £1.50 |
| TDA1200 | £2.43 |
| TDA1405 | 80p |
| TDA1412 | 80p |
| TDA1415 | 80p |
| TDA2010 | T.B.A. |
| TDA2020 | T.B.A. |
| ULN2111A | £1.52 |
| ZN414 | £1.26 |

ZN414 Leaflet free with devices (10p alone)

MC1310, 2, 4 & 5 Leaflet free with devices (10p alone)

## LED DISPLAYS

Litronix Double Digit Displays 0.5" Common Anode, 2 R/H Decimal Points
DL721 ± 1.9
DL727 0.0 to 9.9
Suitable for Clocks, Meters, Instruments, Channel Indicators
Our price £4.75 * each

**NEW**

C.Anode R/H Dec. pt.
C.Anode L/H Dec. pt.
C.Anode ± 1
C.Cathode R/H Dec. pt.

| | | | |
|---|---|---|---|
| 0.33" | Litronix DL 707 Series | ✓✓✓✓ | all £1.82* each (Red only) |
| 0.33" | Monsanto MAN 50/70/80/3600 | ✓✓✓✓ | all £1.82* Each (Red, green, yellow, Orange) |
| 0.33" | Xciton XAN 70 Series | ✓ ✓✓ | all £1.49* Each (Red Green, yellow) |
| 0.43" | Monsanto MAN 4000 Series | ✓✓✓✓ | all £2.32* Each (Red, Green, Yellow, Orange) |
| 0.63" | Litronix DL747 'Jumbo' Series | ✓✓ | all £2.42* Each (Red only) |

Common Cathode as Common Anode (Red only)

Low cost Red GaAsP Motorola MLED 500 in a TO92 package

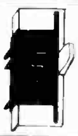
15p.*

NOTE: MAN 4000 Series pin outs are 14 pin dil the same as MAN 50, 70 and 80 series.

## DIGITAL SWITCH

BCD encoded digital switch Reading 0 to 9. Suitable for digital clock alarm setting DVM input Scaling etc.

1 to 9. £1.49 each *



## LIGHT EMITTING DIODES

Free snap-on plastic retainer

| | 0.125" dia. lens (TIL209) 1 | 10 | 100 | 0.16" dia. lens 1 | 10 | 100 | 0.2" dia. lens (MLED 650) 1 | 10 | 100 |
|---|---|---|---|---|---|---|---|---|---|
| Red | 16p | 15p | 13p* | 27p | 24p | 22p* | 18p | 16p | 14p* |
| Green | 27p | 24p | 22p* | 33p | 30p | 27p* | 30p | 27p | 25p* |
| Orange | 27p | 24p | 22p* | 33p | 30p | 27p* | 30p | 27p | 25p* |
| Yellow | 34p | 31p | 29p* | 35p | 32p | 29p* | 35p | 33p | 30p* |

## ......Cont'd

Our Bulk Buying Power enables a repeat of our Special Offer:
0.43" (LIT 707) 90p.* (inc. VAT)
0.63" (LIT 747) £1.99.* (inc. VAT)

## OPTO·ISOLATORS

TIL 4N25 or TIL116
6 pin industry standard package
2.5KV isolation £1.00.*

## MAINS TRANSFORMERS

Secondaries

| | | |
|---|---|---|
| 6-0-6V | 100 mA | 97p |
| 9-0-9V | 100 mA | 97p |
| 12-0-12V | 100 mA | 97p |
| 20-0-20V | 1 A | £4.55 |
| 24-0-24V | 500 mA | £2.48 |
| 28-0-28V | 1 A | £6.18 |

| | ½A | 1A | 2A | 4A |
|---|---|---|---|---|
| 0-9-17 V | - | £1.95 | £2.27 | £2.64 |
| 0-12-15-20-24-30 V | - | £2.48 | £4.15 | - |
| 0-24-30-40-48-60 V | - | £5.18 | £7.02 | - |
| 0-19-25-33-40-50 V | £2.70 | £3.40 | £4.53 | - |

p.p. on transformers 10% of price min. 20p

# electronics today international

JANUARY 1976 VOL 5. No. 1.

## Features



## Projects



## Data Sheets



## Supplement



## News & Information



## Special Offer



COVER: The painting of the Viking Lander on Mars by Charles O. Bennett, reproduced by courtesy of the British Interplanetary Society.

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YOU'RE BOUND TO LIKE THIS see page 36

# Now...the most exciting Sinclair kit ever

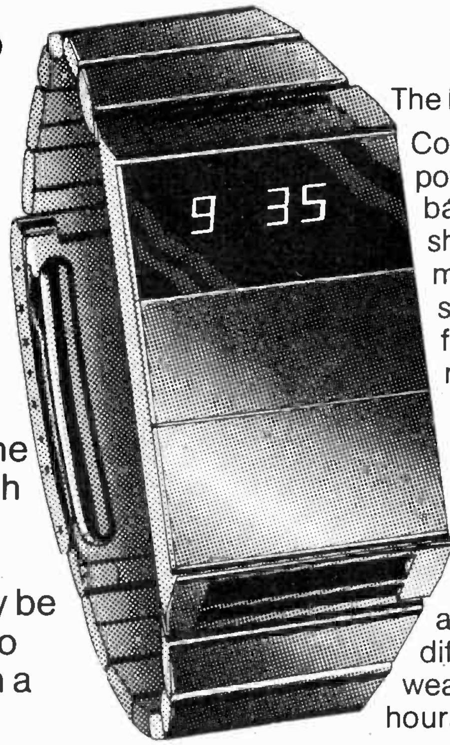
# The Black Watch kit

## At £17.95, it's

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

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

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



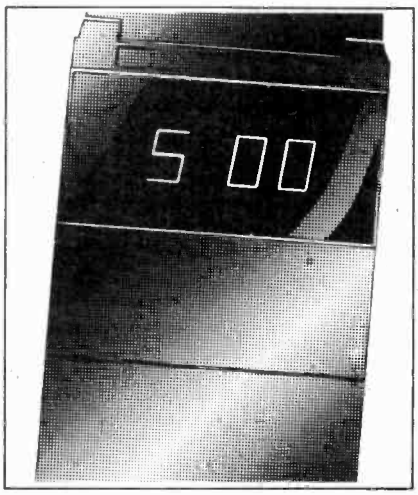

The Black Watch by Sinclair is unique. Controlled by a quartz crystal... powered by two hearing aid batteries...using bright red LEDs to show hours and minutes and minutes and seconds...it's also styled in the cool prestige Sinclair fashion: no knobs, no buttons, no flash.

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

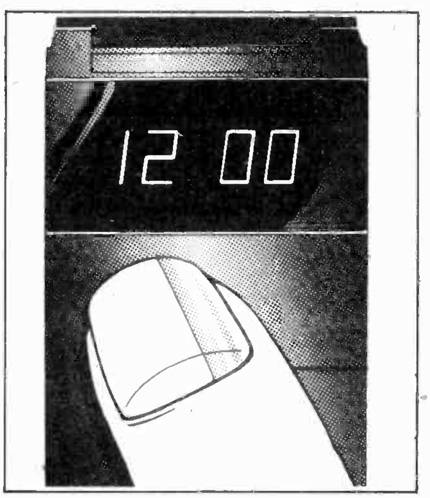
It's simple–anybody who can use a soldering iron can assemble a Black Watch without difficulty. From opening the kit to wearing the watch is a couple of hours' work.

## The special features of The Black Watch

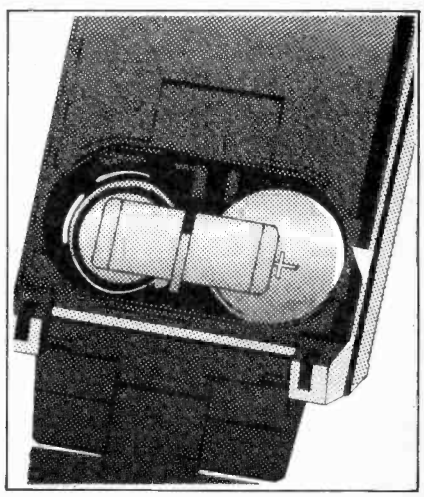
Smooth, chunky, matt-black case, with black strap. (Black stainless-steel bracelet available as extra–see order form.)



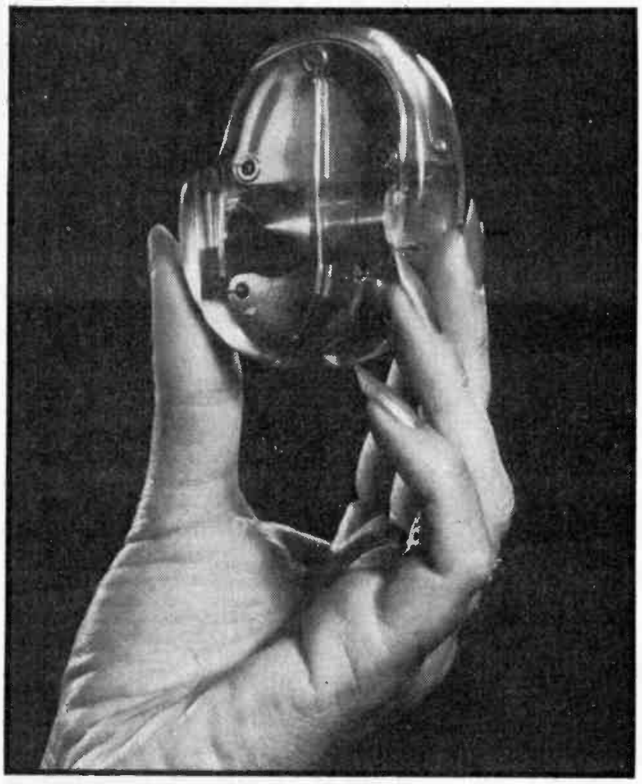

Large, bright, red display–easily read at night.
Touch-and-see case–no unprofessional buttons.

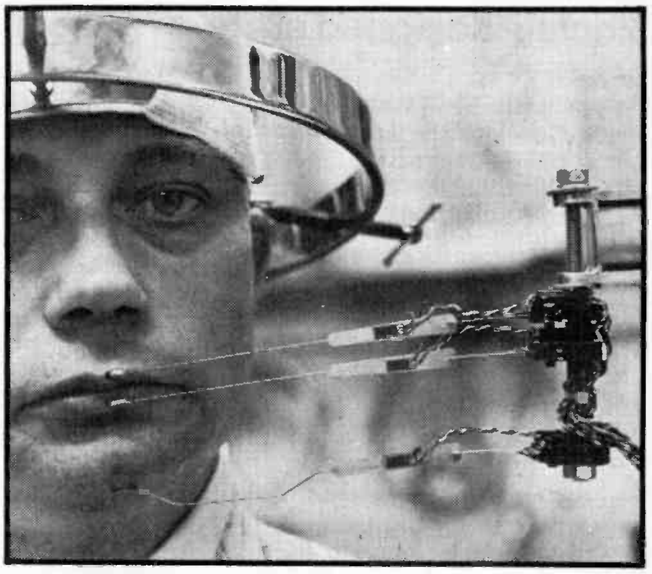



Runs on two hearing-aid batteries (supplied). Change your batteries yourself–no expensive jeweller's service.



# news digest





*Wired for sound . . . Strain gauges mounted on flexible metal sensors are used to obtain information on lip and jaw movements that we make while speaking. Honeywell tape and oscillograph instrumentation records the facial movements for analysis at the University of Washington's Speech Physiology Laboratory.*

## NUCLEAR POWERED PACEMAKER

A nuclear-powered pacemaker, that could bring a new lease of life to thousands of people suffering from certain types of heart trouble, is to be made at the Harwell Atomic Energy Research Establishment. Conventional pacemakers with chemical batteries have to be replaced sugically about every three years. Prolonged trials indicate that the implanted lifetime of the Harwell units could reach 10 or even 20 years.

The Department of Health and Social Security has placed the first production order for 100 of the new nuclear batteries and an order for another 200 batteries is following. Under the present contract Harwell will prepare the heat-producing nuclear sources, each containg less than a fifth of a gram of plutonium oxide, and assemble them, with their miniature thermocouples, in strong metal housings to form the nuclear batteries that power the pacemakers. At the request of DHSS, Harwell has also undertaken for an interim period to assemble 100 pacemakers in which solid-state DC/DC converters and electronics pulse generators (the former also made at Harwell) will be connected to the batteries. The assembly is encapsulated in an epoxy resin known to have lasting compatibility with living tissue.

About 100 pre-production models of the nuclear battery have already been made at Harwell and fitted into pacemakers of similar design. The pacemakers have been subjected to long-term controlled trials at recognised cardiological centres under DHSS supervision. First, they were tested in animals and then, during the last five years, in human patients — the earliest of whom is still using hers.

Internationally agreed safety standards require stringent tests on the batteries. The isotope Plutonium 238 has been chosen for the heat source because its power output falls by only one per cent per year, and its radiation, mainly alpha particles, requires the minimum of shielding for implatation. This isotope is specially prepared for the pacemaker batteries and is markedly different from the very long-lived Plutonium isotopes associated with nuclear weapons and nuclear fuel. Electronics and Applied Physics Division, Building 347.7, Harwell, Oxfordshire, OX11 ORA.

## HENRY'S 'PART EXCHANGE SCHEME'

Henry's-Lindair have announced the formation of a new Part Exchange Department. Customers who bring their old equipment into any Henry's-Lindair store will be given a 'trade-in' allowance which they may then use against the purchase of new equipment from that particular store. The trade-in equipment will then be passed to the Service Department if necessary, and then sold through one of the Bargain Centres in Edgware Road and Tottenham Court Road with a three month guarantee.

## DATAPAD

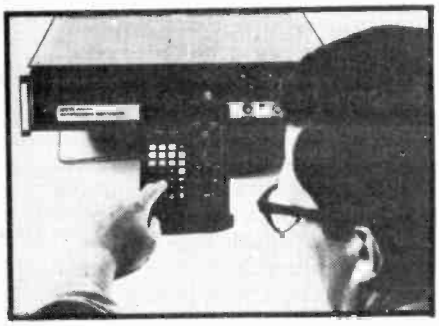
Datapad is a unique computer system where freehand printing is directly input and converted into a computer medium. The system enables data capture as a by-product of normal activity such as clerical staff filling out input forms.

The Datapads are attached to mini-processors which validate the data at source and indicate any errors to the user clerks via a screen. A 'clean' magnetic or paper tape is produced which is read directly into a main frame computer.

The system will completely eliminate the existing punching and verifying load, source validation will improve accuracy since the data will have been 'edited' before leaving the user environment and this elimination of the manual conversion stage will speed up the whole process. Quest Automation Ltd., 26 Cobham Road, Stapehill, Wimborne, Dorset BH21 7NP.

## MICROPROCESSING COUNTER/ TIMERS

Dana Electronics, new 9000 series of microprocessing counter/timers are claimed to be the world's most advanced. The front panel of each instrument bears no controls — the microprocessor is slid out of the front panel, and control programmed through the keyboard.



Both of the first models in the range to be announced (9015 and 9035) work to 100MHz in measuring frequency, period, period average, time interval, time interval average, frequency ratio and total count. Thanks to the microprocesor direct readout of preset operations, reciprocal calculations, and even answers in engineering units are easily achieved. 9-digit constants can operate on measurements through the keyboard.

Trigger levels can be key-set or automatically set: levels are punched into the keyboard, and the processor does the rest, digitally displaying the figures selected for each channel on the integral DVMs. An option is also available to automatically calculate rise/fall times and pulse widths to 10ns resolution, and a range of interface options are available.

The 9015 microprocessor timer costs £1885.00 with a delivery of 8—10 weeks. Dana Electronics Ltd, Collingdon Street, Luton, Beds.

## CUNNING LITTLE B*****S

A recent report by the Assistant Master's Association reveals that schoolboys with a knack for electronics are making devices to bug teachers' studies. Instances reported include that of a boy who concealed a bug inside a radio, which was then confiscated. The radio was then left in a headmaters's study and the boy was able to hear every word that was said there. While we cannot help but admire the ingenuity that must go into some of these espionage-style projects, we do feel that the talents of such enterprising youths could be much better employed in the construction of International 25 Amplifiers or in writing up some of their more conventional projects for ETI.

## ELECTRONICS HELPS CHILDREN LEARN MATHEMATICS

The Novus "Quiz Kid", is to help children aged from about 5 to 9 years to learn mathematics. It is similar to an electronic calculator and is based on a chip we reported in our July issue. The child uses the keyboard to enter a problem followed by what is thought to be the answer (eg 2 x 2 = 4). Then he asks the machine if the answer is correct by touching a question mark key. If it is a 'wise old owl' with red and green eyes will light up its green eye. If the answer is wrong, the red eye comes on.

The Quiz Kid comes with an illustrated Quiz Book containing dozens of mathematical games, riddles and puzzles to help youngsters explore and have fun with numbers. Price is £11.95.

## MICROPROCESSOR PRICE CUTS

To encourage more systems engineers to explore the benefits of using M6800 microprocessors in their design, Motorola are cutting the selling price of the basic MEK6800D1 designers' kit from £177 to £85.

The kit contains all the components needed in a basic MPU system plus technical information in the form of programming and application manuals. The M6800 microprocessor unit is provided with 1 K-Byte random access memories, peripheral interface adaptors (2 off each), an 8 K-bit read only memory containing MIKBUG and the synchronous communications interface adaptor. All the devices are TTL compatible, single level (5 Volt) power driven and use a single bus for memory and input/output transactions. No multiplexing or decoding circuits are required for its operation nor is external buffering for interconnections. The kit is available from approved Motorola distributors.

# news digest

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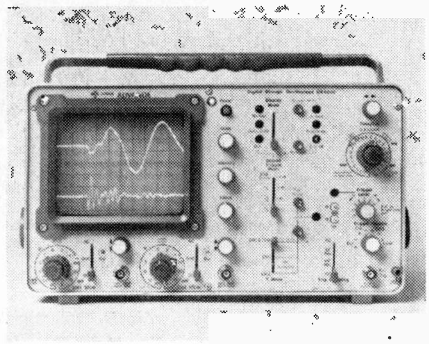


## DIGITAL STORAGE OSCILLOSCOPE

The new OS4000 from Gould Advance combines the facilities and performance of a conventional 10MHz oscilloscope with a digital storage system capable of storing signals up to 450Hz (–30dB). Digital storage has several advantages over tube storage, including the ability to examine what happens immediately before a trigger signal is received, the simultaneous viewing of stored and real-time displays, absence of deterioration of the stored display over a period of time, flicker-free low-frequency performance, and the alimination of the expensive storage tube.

The OS4000 is ideally suited for viewing transient waveforms — for example, in medical, dynamic testing, vibration or pulse-testing applications. It is also suited to low-frequency measurements, where the incorporation of a 'refresh' mode allows flicker to be eliminated. (The longest sweep time is 200s.) In addition, normal 10MHz real-time viewing is possible, and comparisons between stored and real-time waveforms are easily made.

The OS4000 measures 178 x 312 x 417mm, and weighs 11kg. The price of the instrument is £1053 (inc. VAT).

Gould Advance Ltd, Roebuck Road, Hainault, Essex.

## WATCH/CALCULATOR

Now available in the USA is the Uranus LED Solar Calculator timepiece. This is a five-function watch (hours, minutes, seconds, month, date date), with calculator built in. The keyboard consists of 12 pressbuttons arranged around the face and gives all four arithmetic functions, in chain and constant calculations. The readout is a four digit LED display and as far as we can discover, the watch is solar powered. The Uranus is available in gold or silver plated metal, and can be yours for only $800.

## TWO-LAYER TAPE

A new formulation of magnetic recording cassette tape that combines the advantages of both ferric oxide and chromium dioxide tapes has been announced by BASF. Called Ferrochrom, the tape has a two-layer coating which, when used with suitable equipment, gives an improved frequency response for cassette recording. The new tape comprises a polyester base coated with a relatively thick high density ferric oxide dispersion. On top of this is added a carefully controlled layer of chromium dioxide. This composition exploits the simple theory that low frequencies are produced from the whole of the tape coating and high frequencies are reproduced from the top of the coating.


Because of its dual oxide, the optimum bias current for ferrochrom is a value approximately halfway between the current for ferric oxide and that for chromium dioxide. Ferrochrom can still be used on a conventional ferric recorder, but on playback the higher frequencies are unnaturally pronounced, giving an effect similar to those on a Dolbyised cassette played back on a non-Dolby machine. This is easily remedied by a slight adjustment of the amplifier's treble control. The frequency response and dynamic range achieved using Ferrochrom in this way is equal to that of a chromium dioiide cassette played on a machine boased for chromium dioxide. The best results from Ferrochrom are achieved on cassette recorders biased for Fe-Cr. On these the dynamic range from a VU setting of 0dB is 1.5dB greater than that possible from chromium dioxide.

BASF Ferrochrom is available in C60 and C90 length in a new-style cassette housing. The housing has a large window which enables the user to see the tape hubs and BASF's patented tape transport system — Special Mechanics (SM). The amount of tape on each hub is accurately shown and any disturbance of or damage to the tape can be seen before problems occur.

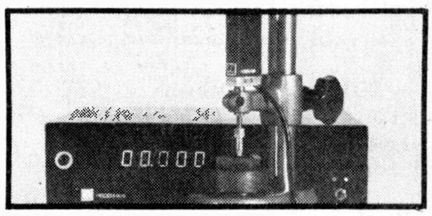
## FISH QUALITY METER

An electronic fish quality meter which indicates the freshness quality of wet fish rapidly and accurately is now being produced in Scotland. The GR Torrymeter is manufactured by GR International Electronics Ltd of Perth. It was designed and developed in Perth in collaboration with Aberdeen University and the Torry Research Station, a Government establishment recognised as a world authority on fish handling and processing.

The GR Torrymeter is a simple, hand-held device 200mm in length and 75mm in width. The instrument measures an electrical property of the fish tissue; this property changes as fish spoils. Individual readings are displayed in illuminated figures one second after the sensing head has been placed on the fish. The meter, equipped with long-life rechargeable cells, is housed in a sealed plastic moulding which can be wiped clean or rinsed under running water. Each unit is supplied in an individual wooden storage case incorporating a mains-operated charger unit. GR International Electronics Ltd, Doman Camberley, Surrey GU15 3DG.

## DIGITAL LENGTH GAUGE

A new miniature measuring instrument in the form of a digital gauge head is announced by Dr. Johannes Heidenhain GmbH. The Metro 1010, surpasses dial test indicators, vernier calipers or analogue measuring heads both technically and economically.



The digital gauge head is suitable for length measurement on smaller machines, micrometer stages, coordinate tables, etc.

The measuring range of the MT10 is 10mm. The resolution is 1$\mu$m. The measuring accuracy of a complete system (digital gauge head with counter) is $\pm 1\mu$m. A genuine incremental design principle and a minimum of mechanical components enables the high degree of accuracy to be maintained.

The measured value is indicated by a five-digit LED display with arithmetical sign and decimal point. As an option, the counter can be supplied with a BCD-output (printer output) for electronic processing of measured values. Heidenhain (GB) Ltd., 202 London Road, Burgess Hill, Sussex RH15 9RD.

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|---|---|
| SN456 | 0.80 |
| 2N456A | 0.85 |
| 2N457A | 1.20 |
| 2N490 | 3.16 |
| 2N491 | 4.38 |
| 2N492 | 3.00 |
| 2N493 | 5.20 |
| 2N696 | 0.22 |
| 2N697 | 0.16 |
| 2N698 | 0.82 |
| 2N699 | 0.59 |
| 2N706 | 0.14 |
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| 2N708 | 0.17 |
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| 2N916 | 0.28 |
| 2N918 | 0.32 |
| 2N929 | 0.37 |
| 2N930 | 0.22 |
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| 2N1907 | 5.50 |
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| 2N2147 | 0.78 |
| 2N2148 | 0.94 |
| 2N2160 | 0.90 |
| 2N2218A | 0.22 |
| 2N2219 | 0.24 |
| 2N2219A | 0.26 |
| 2N2220 | 0.25 |
| 2N2221 | 0.18 |
| 2N2221A | 0.21 |
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| 2N2222A | 0.25 |
| 2N2368 | 0.25 |
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| 2N2646 | 0.55 |
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| 2N3715 | 1.50 |
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| 2N5294 | 0.48 |

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| 2N5492 | 0.58 |
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| 2N5496 | 0.61 |
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| AC176 | 0.30 |
| AC176K | 0.40 |
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| BC183 | 0.12 |
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| BC186 | 0.25 |
| BC187 | 0.27 |

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| BFY51 | 0.23 |
| BFY52 | 0.21 |
| BFY53 | 0.18 |
| BFY90 | 0.75 |
| BRY39 | 0.48 |
| BSX20 | 0.21 |
| BSX20 | 0.21 |
| BSX21 | 0.29 |
| BU104 | 2.00 |
| BU105 | 2.25 |
| C106D | 0.65 |
| CA3180A | 0.85 |
| CA3020A | 1.80 |
| CA3028A | 0.79 |
| CA3035 | 1.37 |
| CA3052 | 1.62 |
| CA3046 | 0.70 |
| CA3048 | 2.11 |
| CA3089E | 1.96 |
| CA3090Q | 4.23 |
| LM301A | 0.48 |
| LM308 | 2.50 |

| | |
|---|---|
| LM309K | 1.88 |
| LM311 | 1.50 |
| LM380 | 1.10 |
| LM381 | 2.20 |
| LM702C | 0.75 |
| LM709T099 | 0.48 |
| 8DIL | 0.38 |
| 14DIL | 0.40 |
| LM710 | 0.47 |
| LM3900 | 0.70 |
| LM723C | 0.90 |
| LM741T099 | 0.40 |
| 8DIL | 0.40 |
| 14DIL | 0.38 |
| LM747 | 1.00 |
| LM7488DIL | 0.60 |
| LM7805 | 2.00 |
| 14DIL | 0.73 |
| LM7805 | 2.50 |
| LM7812 | 2.50 |
| LM7815 | 2.50 |
| LM7824 | 2.50 |
| MC1303 | 1.50 |
| MC1310 | 2.92 |
| MC1330OP | 0.90 |
| MC1351P | 0.80 |
| MC1352P | 0.80 |
| MC1466 | 3.50 |
| MC1469 | 2.75 |
| ME0402 | 0.20 |
| ME0404 | 0.13 |
| ME0412 | 0.18 |
| ME4102 | 0.11 |
| ME4104 | 0.11 |
| MJ480 | 0.95 |
| MJ481 | 1.20 |
| MJ490 | 1.05 |
| MJ491 | 1.45 |
| MJ2955 | 1.00 |
| MJE340 | 0.48 |
| MJE370 | 0.65 |
| MJE371 | 0.75 |
| MJE520 | 0.60 |
| MJE521 | 0.70 |
| MJE2955 | 1.20 |
| MJE3055 | 0.75 |
| MPB111 | 0.32 |
| MPB112 | 0.40 |
| MPB113 | 0.47 |
| MPF102 | 0.30 |
| MPSA05 | 0.25 |
| MPSA06 | 0.31 |
| MPSA12 | 0.35 |
| MPSA55 | 0.26 |
| MPSA56 | 0.31 |
| MPSU05 | 0.65 |
| MPSU06 | 0.58 |
| MPSU55 | 0.63 |
| MPSU56 | 0.80 |
| NE555V | 0.70 |
| NE556 | 1.30 |
| NE560 | 4.48 |
| NE561 | 4.48 |
| NE565A | 4.48 |
| OC23 | 1.35 |
| OC28 | 0.76 |
| OC35 | 0.60 |

| | |
|---|---|
| OC42 | 0.50 |
| OC45 | 0.32 |
| OC71 | 0.17 |
| OC72 | 0.25 |
| OC81 | 0.25 |
| OC83 | 0.24 |
| ORP12 | 0.55 |
| R53 | 1.80 |
| SL414A | 1.80 |
| SL610C | 1.70 |
| SL611C | 1.70 |
| SL612C | 1.70 |
| SL620C | 2.60 |
| SL621C | 2.60 |
| SL623 | 4.59 |
| SL640C | 3.10 |
| SL641C | 3.10 |
| SN76003N | 2.92 |
| SN76013N | 1.95 |
| SN76023N | 1.60 |
| SN76033N | 2.92 |
| ST2 | 0.20 |
| TAA300 | 1.80 |
| TAA263 | 1.10 |
| TAA350 | 2.10 |
| TAA550 | 0.60 |
| TAA611C | 2.18 |
| TAA621 | 2.03 |
| TAA661B | 1.32 |
| TBA641B | 2.25 |
| TBA651 | 1.69 |
| TBA810 | 1.50 |
| TBA820 | 1.15 |
| TBA920 | 4.00 |
| TIL209 | 0.30 |
| TIP29A | 0.49 |
| TIP30A | 0.58 |
| TIP31A | 0.62 |
| TIP32A | 0.74 |
| TIP33A | 1.01 |
| TIP34A | 1.51 |
| TIP35A | 2.90 |
| TIP36A | 3.70 |
| TIP41A | 0.79 |
| TIP42A | 0.90 |
| TIP29c | 0.80 |
| TIP30c | 0.85 |
| TIP31c | 1.00 |
| TIP32c | 1.25 |
| TIP33c | 1.45 |
| TIP34c | 2.60 |
| TIP41c | 1.40 |
| TIP42c | 1.60 |
| TIP49 | 0.70 |
| TIP53 | 0.53 |
| TIP2955 | 0.98 |
| TIP3055 | 0.50 |
| TIS43 | 0.28 |
| ZTX300 | 0.13 |
| ZTX301 | 0.13 |
| ZTX302 | 0.20 |
| ZTX500 | 0.15 |
| ZTX501 | 0.13 |
| ZTX502 | 0.18 |
| ZTX530 | 0.23 |

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| 4002 | 0.36 | 4018 | 2.55 | 4037 | 1.93 |
| 4006 | 1.58 | 4019 | 0.86 | 4041 | 1.86 |
| 4007 | 0.36 | 4020 | 1.91 | 4042 | 1.38 |
| 4008 | 1.63 | 4021 | 1.72 | 4043 | 1.80 |
| 4009 | 1.18 | 4022 | 1.66 | 4044 | 1.80 |
| 4010 | 1.18 | 4023 | 0.36 | 4045 | 2.65 |
| 4011 | 0.36 | 4024 | 1.24 | 4046 | 2.84 |
| 4012 | 0.36 | 4025 | 0.32 | 4047 | 1.65 |
| 4013 | 0.66 | 4027 | 0.43 | 4049 | 0.81 |
| 4014 | 1.72 | 4028 | 1.50 | 4050 | 0.66 |
| 4015 | 1.72 | 4029 | 3.50 | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SN7400 | 0.16 | SN7410 | 0.16 | SN7432 | 0.28 | SN7451 | 0.16 | SN7481 | 1.25 | SN7495 | 0.72 | SN74151 | 0.85 | SN74174 | 1.25 |
| SN7401 | 0.16 | SN7411 | 0.25 | SN7437 | 0.37 | SN7453 | 0.16 | SN7482 | 0.75 | SN7496 | 0.75 | SN74153 | 0.85 | SN74175 | 0.90 |
| SN7401AN | 0.38 | SN7412 | 0.28 | SN7438 | 0.35 | SN7454 | 0.16 | SN7483 | 0.95 | SN74100 | 1.25 | SN74154 | 1.50 | SN74176 | 1.44 |
| SN7402 | 0.16 | SN7413 | 0.35 | SN7440 | 0.16 | SN7460 | 0.16 | SN7484 | 0.95 | SN74107 | 0.36 | SN74155 | 1.50 | SN74180 | 1.40 |
| SN7403 | 0.16 | SN7416 | 0.35 | SN7441AN | 0.85 | SN7470 | 0.33 | SN7485 | 1.25 | SN74118 | 1.00 | SN74157 | 0.95 | SN74181 | 1.95 |
| SN7404 | 0.19 | SN7417 | 0.35 | SN7442 | 0.65 | SN7472 | 0.26 | SN7486 | 0.32 | SN74119 | 1.92 | SN74160 | 1.10 | SN74190 | 2.30 |
| SN7405 | 0.19 | SN7420 | 0.16 | SN7445 | 0.90 | SN7473 | 0.36 | SN7490 | 0.45 | SN74121 | 0.37 | SN74161 | 1.10 | SN74191 | 2.30 |
| SN7406 | 0.45 | SN7423 | 0.29 | SN7446 | 0.95 | SN7474 | 0.36 | SN7491 | 0.85 | SN74122 | 0.50 | SN74162 | 1.10 | SN74192 | 1.15 |
| SN7407 | 0.45 | SN7425 | 0.29 | SN7447 | 0.95 | SN7475 | 0.50 | SN7492 | 0.45 | SN74123 | 0.60 | SN74163 | 1.10 | SN74193 | 1.15 |
| SN7408 | 0.19 | SN7427 | 0.29 | SN7448 | 0.90 | SN7476 | 0.35 | SN7493 | 0.45 | SN74141 | 0.85 | SN74164 | 2.01 | SN74196 | 1.60 |
| SN7409 | 0.22 | SN7430 | 0.16 | SN7450 | 0.16 | SN7480 | 0.50 | SN7494 | 0.82 | SN74145 | 0.90 | SN74165 | 2.01 | SN74197 | 1.58 |
| | | | | | | | | | | SN74150 | 1.50 | SN74167 | 4.10 | SN74198 | 2.25 |
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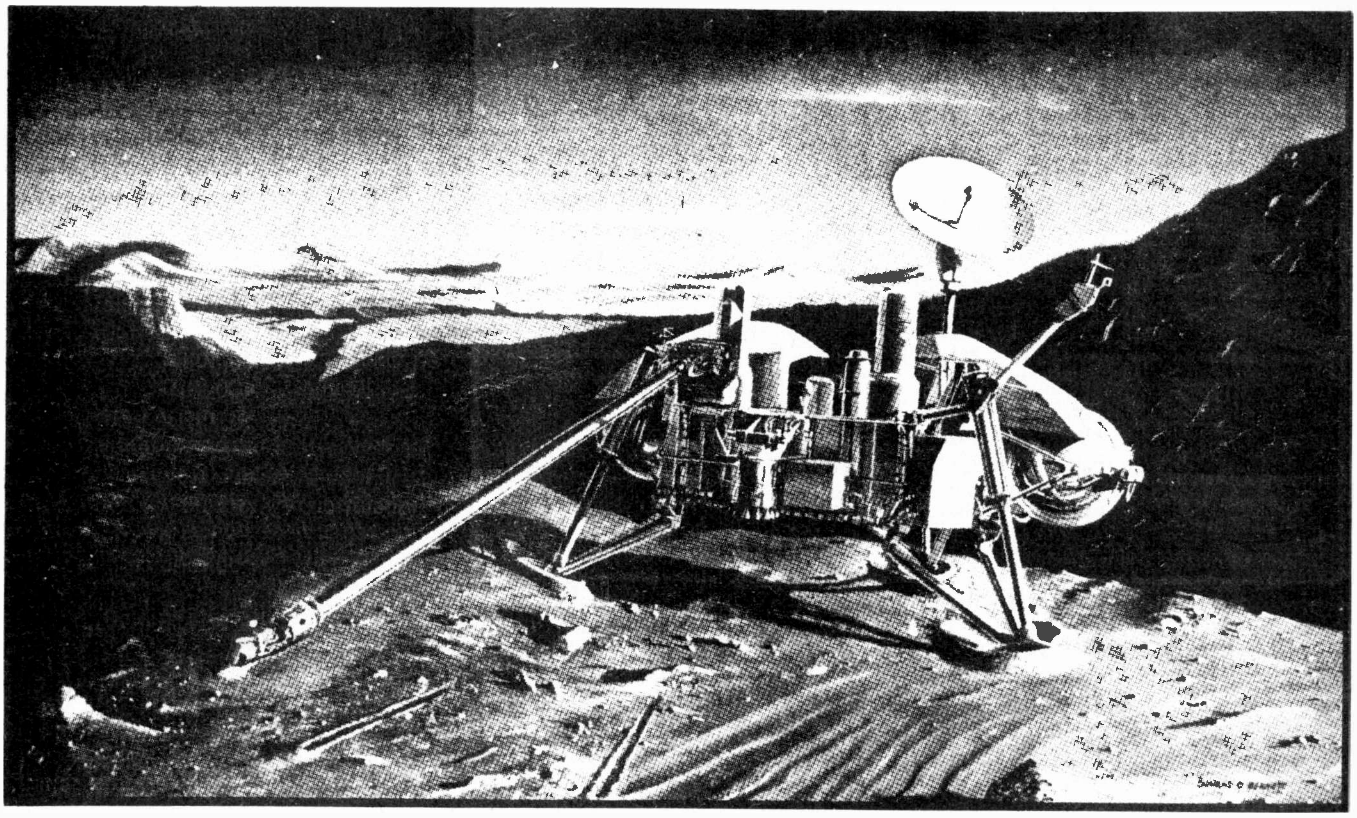
# life on mars?

## Latest Viking space mission specifically seeks for life on Mars



*VIKING LANDER. This magnificent painting by Charles O. Bennett shows the mechanical scoop on the end of the spring-steel arm collecting a sample. Having grasped the material the scoop arm retracts to the spacecraft, swivels and stops over a cylinder covered by a wire grill. The lid of the scoop begins to vibrate and dust and soil particles drop through into a rotating conveyor in the spacecraft's interior which distributes measured quantities to a number of test cells for chemical analysis.*

OUR GALAXY contains upwards of 100 000 million stars and their families of planets, and growing evidence suggests that Earth may not be the only life-bearing planet in this galaxy.

Telescope studies have, for example, shown that Earth's basic chemicals are distributed throughout the Universe – and organic compounds – life's building blocks – have been detected in inter-stellar space.

But *believing* that life may exist elsewhere is one thing – attempting to *prove* it is another.

At our present state of technology the most practical planet on which to search for life is Mars. For if we find that life exists or has existed in the harsh climate of Mars, we will have strong reasons to believe that planets with comfortable climates do support life and that other solar systems are inhabited.

Two unmanned, automated Viking spacecraft have recently been launched from Cape Canaveral to begin a 700 million kilometre journey to Mars.

Once there the two spacecraft will seek evidence of whether life existed on other planets, and obtain information to improved our understanding of how Earth developed as a life-supporting planet and how we can better protect its environment.

Viking is the most complex mission to be flown by NASA, requiring four highly complicated science stations – two orbiters and two landers – to carry out separate co-ordinated operations simultaneously and over an extended period of time.

The 2300 kg orbiter will stay in orbit while the 1090 kg lander descends to the surface, as did the command module and the lunar module during the Apollo missions to the Moon. The Viking lander will use a parachute and retro-rockets to achieve soft landing. It will begin its programme of life-seeking biology experiments on about the 10th day after landing.

Photos from orbiters and landers and information from the science experiments will be transmitted back to Earth by radio. Radio signals will require more than 20 minutes to travel the 320 million kilometres from Mars to Earth. Spacecraft-tracking and communications will involve the Deep Space Network's stations at Goldstone, California, Madrid, Spain and Canberra, Australia.

## VIKING SCIENTIFIC INVESTIGATIONS

The Viking spacecraft will make basically three investigations during their three-month observation of Mars from orbit and from two sites on the surface:

1. A photographic survey of Mars:
2. A search for forms of life; and
3. An analysis of the physical features and makeup of the planet and its atmosphere.

## PHOTOGRAPHIC SURVEY

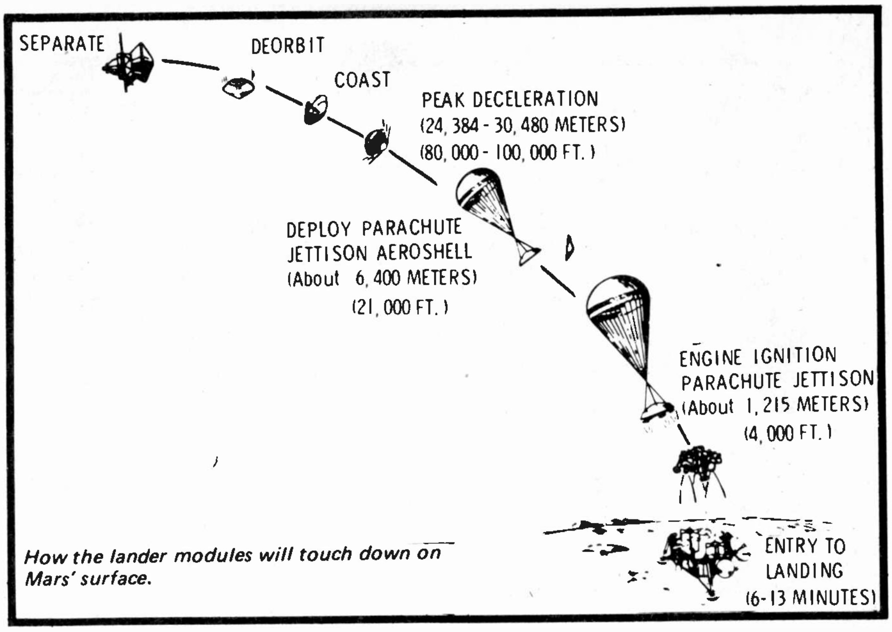
Each Viking spacecraft has an orbiter and a lander. Each orbiter carries two high-resolution television cameras, and each lander a pair of facsimile cameras.

During the last 180 hours of approach to Mars, each spacecraft will obtain a series of photographs of the planet from progressively closer range. After entering orbit, the spacecraft will remain above the designated lander sites to photomap these regions for a number of days before and after the landers are released for descent to the surface. Then the orbiters will leave their fixed positions above the lander sites to photomap almost the entire surface of the planet.

Orbiter photomaps and thermal and water vapour maps will be used to direct the landers to sites where conditions are most favourable to life and where landing hazards are less extreme. Lander cameras will take high-resolution photos of the ground immediately next to the landers, 360-degree panoramic views of the terrain and distance features, and long-range photos of Mars' satellites and celestial objects.

The Orbiter cameras will be rapid-sequence vidicon cameras using 475 mm telescopes. Taken from low-point in orbit a photo shows 40 square kilometre area with resolution of 50 metres. Consecutive photos from one orbital pass show a 80 km by 500 km swath. Photos are stored on magnetic tape for playback to Earth.

Identical facsimile cameras are mounted one metre apart on top of the lander for stereoscopic black and white, colour, and infrared photos. Cameras can view from the ground beside the lander up to 40 degrees above horizon. Each uses a nodding mirror to scan a scene in tiny increments, requiring 20 minutes for a full scene. Light from the scene increments is converted into digital information bits which are radioed to Earth and reconstructed into a photograph.



*How the lander modules will touch down on Mars' surface.*

## SEARCH FOR LIFE

Life may exist on Mars in higher forms, like moss or lichens, or in microscopic forms like viruses or bacteria. Or a rich variety of life may have existed at one time but disappeared later in the planet's history.

The two regions chosen for landings are areas where conditions could be conducive to Earth-like life forms. They are relatively low, temperate-zone sites in the northern hemisphere where there are indications of atmospheric moisture now, and of surface moisture at least at some time in the past.

Higher forms of life and fossils, surface burrows or trails, and artifacts could be identified in the lander camera photos of the surface adjacent to the landers. The search for microscopic plant or animal life will be made in Martian soil samples. The samples will be scooped up by the 3 metre lander boom and fed into automated biology test chambers where they will be observed for signs of photosynthesis and metabolism. Chemistry of the organic compounds in the soil will be analysed for indication of whether they were produced by animal or plant life, or could evolve life.

Discovery of life on another planet would have a more profound effect on man's thinking than any other discovery in history.

## TEST FOR PHOTOSYNTHESIS

Photosynthesis is the basic-life sustaining process by which Earth plant life uses light energy to combine basic compounds like carbon dioxide, water, and salts — forming carbohydrates. Steps in the Viking photosynthesis test are:

(a) Inoculate three soil samples with carbon monoxide and carbon dioxide that bear radioactive tracers.
(b) Inoculate soil and gases under a lamp that simulates Martian sunlight.
(c) Evacuate any remaining free gas.
(d) Heat samples to 590°C to vapourize organic materials.
(e) Measure and analyse the vapourised materials.

Liberation of a substantial amount of tracer gas from the samples will be taken as strong evidence that plant-like organisms in the soil consumed the carbon monoxide and carbon dioxide in photosynthesis.

## TEST FOR METABOLIC ACTIVITY

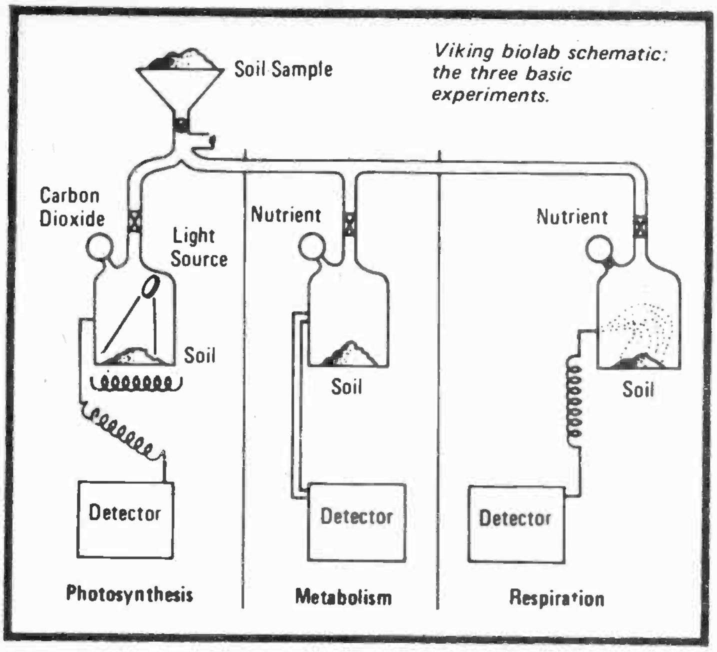
From a science standpoint, the Viking lander is the most complex spacecraft ever built. The biology unit will feed to three soil samples a nutrient or organic compounds like sugar which bear trace chemicals. Instruments will monitor gases given off by the samples over a period of about two weeks.

Steady production of gases by soil samples will be taken as evidence that organisms in the soil consumed the nutrient; steadily increasing production of gases will be taken as evidence of growth by the organisms.

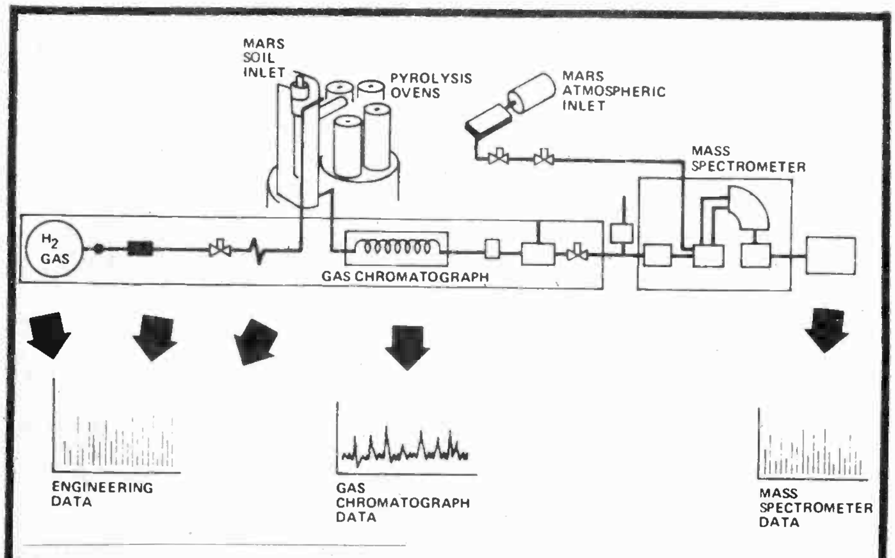
## TEST FOR RESPIRATION

Soil samples will be moistened with nutrients and surrounded in the test chamber with air from the outside, principally carbon dioxide. Constituents of the atmospheric sample will be monitored over a period of about two weeks. Changes in composition of the atmospheric sample will be taken as evidence of

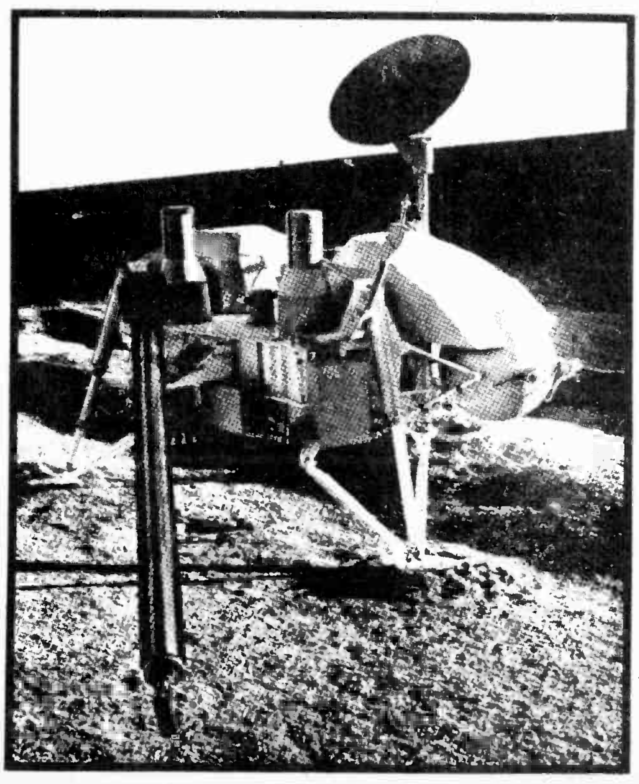
# life on mars?




*Viking biolab schematic: the three basic experiments.*




*Gas Chromatograph Mass Spectrometer.*



*The three-legged lander carries life detection experiments to determine if the Martian environment can, or in fact does, support life.*

respiration from metabolism of organisms in the soil.

## TEST OF STERILISED SAMPLES

In parallel, a soil sample will be sterilised and subjected to the same tests as further validation of any positive results in the tests.

## BIOLOGY INSTRUMENT

The complete range of experiments planned for Viking, if conducted on Earth with today's standard science instruments, would require thousands of pounds of equipment which would fill several ordinary size laboratory rooms.

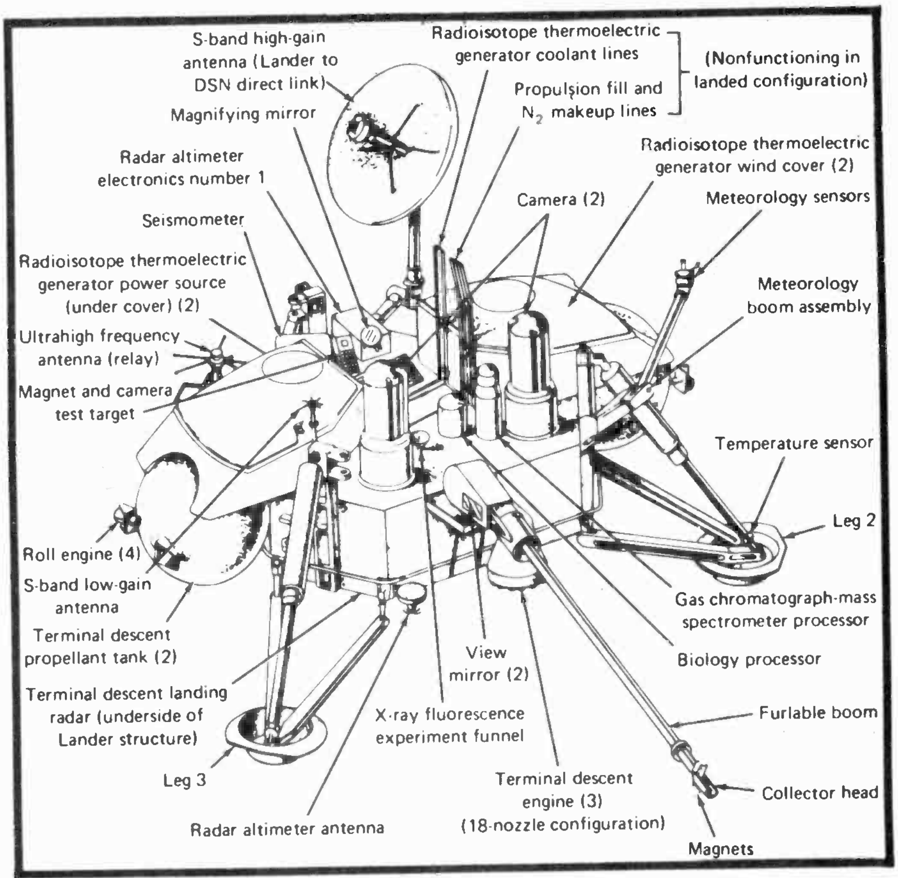
The lander biology unit, in 0.25 cubic metre of space, contains: three automated chemical labs, a computer, tiny ovens, counters for radioactive tracers, filters, sun lamp, gas chromatograph to identify chemicals, 40 thermostats, 22 000 transistors, 18 000 other electronic parts, and 43 miniature valves.

## THE PLANET AND ITS ATMOSPHERE

Instruments of the orbiters and landers will examine the physical features and makeup of the planet and its atmosphere in minute detail. Comparison of the geology and climate of Mars with those of the much more complex Earth and the primitive Moon is expected to resolve many questions about the evolution of Earth and our Solar System.

One landing site is in a valley at the mouth of the giant surface rift, or grand canyon, of Mars. Here, deposits from exposure and erosion of geological features around the chasm are expected to be rich in information about the history and development of the planet.

We still lack a complete understanding of Earth's complex environmental systems; for example, what accounts for the patterns of movement of water vapour and pollutants in our atmosphere. Clues should be found in study of the dynamics of Mars' more rudimentary atmospheric system in the absence of industrialised man.




*The Viking Lander. After landing, the Lander's cameras will take pictures of the terrain — some in colour and some employing both cameras to produce three-dimensional stereo pairs. Other instruments will collect atmospheric and meteorological data, and a seismometer will record Martian quakes and learn about the planet's interior. Surface geology will be examined with the cameras, the soil sampler, the inorganic analysis of soil samples to determine what elements are present.*

## GEOLOGY

The orbiters and landers will conduct experiments to study surface geology and planet internal structure, and to determine whether the planet is geologically alive. Orbiter and lander photographs will identify types of land forms, stratification, folds, joints, faults, rocks, erosion, sediments, and soil, and will give indications of mineral and chemical composition. If there are Marsquakes in adequate number, lander seismic readings can determine whether the planet has a molten core, a mantle, and a crust as does Earth, and can allow comparison of the mantles of Mars and Earth.

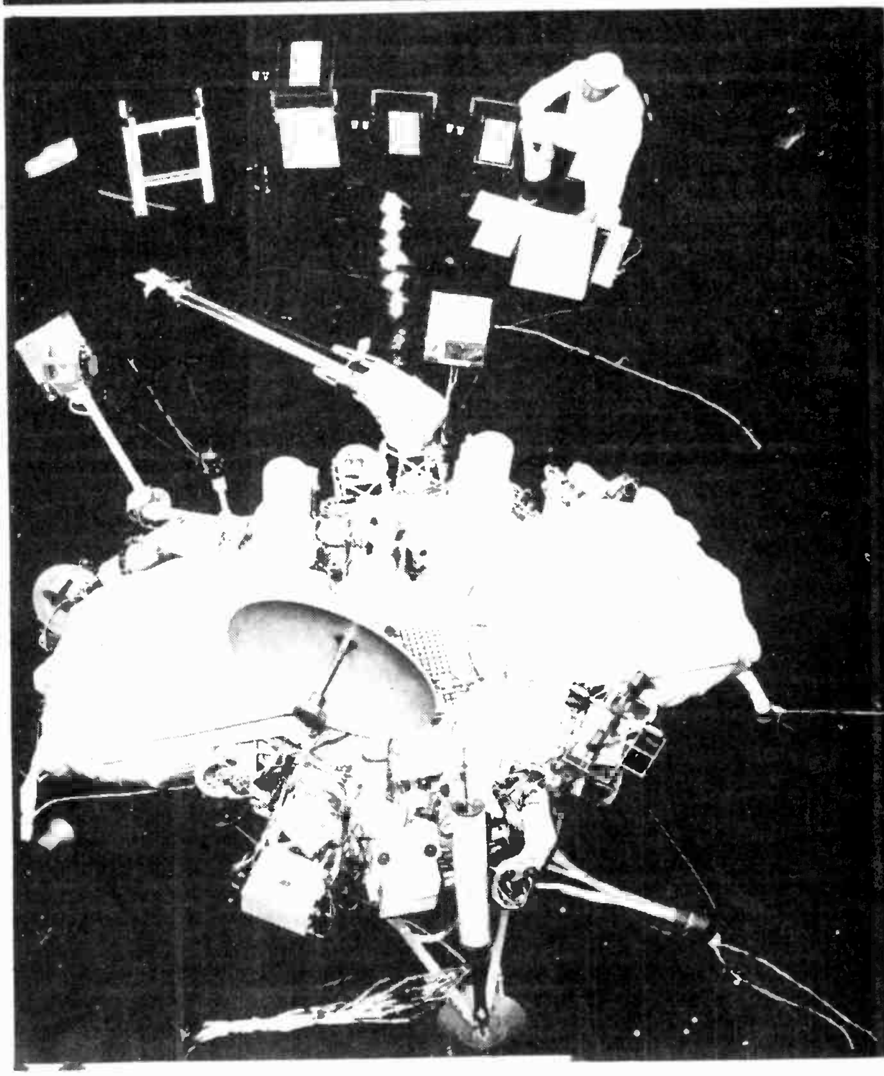
Lander instruments will identify elements and minerals in the soil. Thermal mapping by the orbiters will allow search for ground frost and evidence of planet internal heat, and will aid in identifying surface structural character from difference in heat conductivity.

Viking radio and radar systems will provide information to improve our knowledge of the planet's size, mass, gravitational field, surface density, and electromagnetic properties, and atmospheric density and turbulence, and will allow study of the solar wind.

## SCIENCE INSTRUMENTS

An infrared radiometer from the orbiter measures heat radiating from the planet's surface. It can record temperatures in both the day and night hemispheres and is accurate within 2$^{o}$C.

An X-ray fluorescence spectrometer identifies basic elements in soil by measuring their fluorescence after being exposed to radioactive Cadmium 109 and Iron 55. It can detect elements present in amounts as small as 200 parts per million.



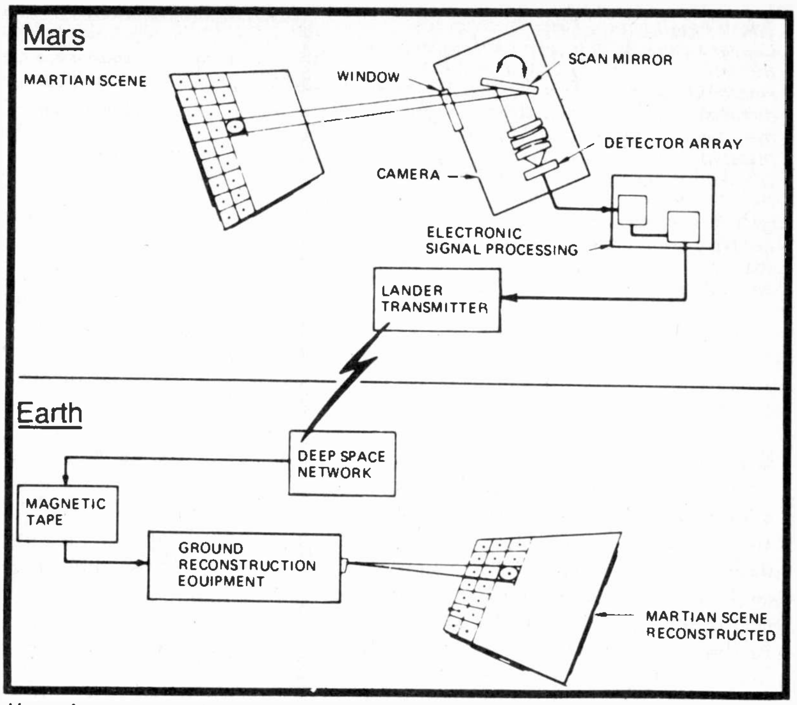
*Viking completes a month-long series of rigorous tests designed to qualify it for operating on the surface of Mars in 1976. The tests were conducted in a huge vacuum chamber at the space facilities centre of Martin Marietta Aerospace at Denver, Colorado.*

# life on mars?

A gas chromatograph-mass spectrometer identifies gases in the atmosphere and organic compounds in the soil.

A seismometer will detect volcanic activity, planet internal structure shifts, and impacts of meteorites on planet's surface. It will be used to determine whether landers are functioning properly by measuring their vibrations.

A soil boom scoop will be used to study characteristics of the soil: cohesiveness, porosity, hardness, particle size. Magnets mounted on the sampler will determine whether soil contains magnetic materials.




*How pictures taken by the television system aboard the Viking Lander will be processed, transmitted and reconstructed on Earth.*

## METEOROLOGY

Requirements for the Viking lander are space flight's most demanding: two days of sterilisation baking before launch; ascent gravity and vibration forces atop a 1.4 million pound rocket; 11 months' exposure to harsh space conditions; buffeting from Mars atmospheric entry, parachute opening and retrorocket firing; impact on surface of Mars at a speed of 1.20 metres/sec. Then it must function as a finely tuned, self-sufficient laboratory and data transmission complex for 90 days.

Landers, as they enter Mars' atmosphere, will analyse the ionosphere to determine the effect of the solar wind on the planet's atmosphere. As they descend they will record the temperature, pressure, and chemical content of the atmosphere at different altitudes.

The Orbiters will observe the formation and movement of clouds and record their temperatures for analysis of their composition. The lander mass spectrometer will analyse the amounts of carbon dioxide, oxygen, nitrogen, and other gases in the atmosphere at the surface during the first three days, before starting analysis of the soil.

Lander instruments will measure pressure, temperature, windspeed and direction periodically to log daily and season all variations in weather and will record the movement of weather fronts, thermals, and dust devils past the landing sites. Seismometers will record background noise from winds and temperature and pressure changes.

In the meteorology unit transducers will measure temperature and pressure; an anemometer measures windspeed by its cooling effect on a heated wire. Accelerometers and radar altimeter are used to determine atmospheric density and pressure from their drag on the descending lander.

An infrared spectrometer will detect and measure moisture in the atmosphere from the changes in solar radiation, as it reflects from Martian surface through the atmosphere to the orbiter. It can detect water in amounts down to one micron.

A retarding potential analyser will measure the concentration and charge of ions and electrons in the ionosphere as they flow across the analyser's charged grid in lander capsule.

An upper atmosphere mass spectrometer will identify chemical content and concentrations in the upper fringe of atmosphere.

Radio and radar systems consist of S-band Earth-Mars microwave link for commands and data relay; UHF lander-orbiter links; X-band orbiter-Earth link for science use.

## COMMUNICATING WITH VIKING

The Viking Lander Communications subsystem consists of a relay link between the orbiter and lander and a direct link connecting the lander and Earth. UHF radio is employed to relay scientific data to the orbiter, and an S-band transmitter on the lander sends data directly to Earth.

The relay link is the primary means of communicating during descent and landing until a direct link between the lander and Earth can be established on the surface of Mars. The UHF circuits use compartmentalised, shielded discrete-element wired circuits.

When the lander separates from the orbiter and descends into the Martian atmosphere, UHF radio will begin transmitting real-time data at 4 000 bps and at a frequency of 381 MHz to the orbiter. This information will consist of entry science data, such as the pressure and temperature of the Martian ionosphere and atmosphere, and engineering information related to the lander's operating performance.

The subsystem utilises split-phase pulse code modulation and frequency shift keying. A fixed, crossed-dipole antenna radiates signals to the orbiter. Any one of three power modes may be selected.

Prior to separation from the orbiter, the lander will under-go a series of system checks in the lower power mode (1 watt). During descent, the 10 watt mode will be used. After touch-down, the transmitter will be switched to 30 watts power to handle a data stream rate of 16 000 bits per second. With successful completion of the soft-landing on Mars, the lander will continue to broadcast for about three days via the UHF system before switching over to the direct S-band link. Imagery showing the area surrounding the landing site as well as data received from the meteorological and biological sensors contained on the lander can then be transmitted to the orbiter for relay to Earth.

The orbiter will be able to receive this data from the lander an average of 20 minutes each pass. It will be orbiting Mars once every 24.6 hours.

## S-BAND DIRECT LINK

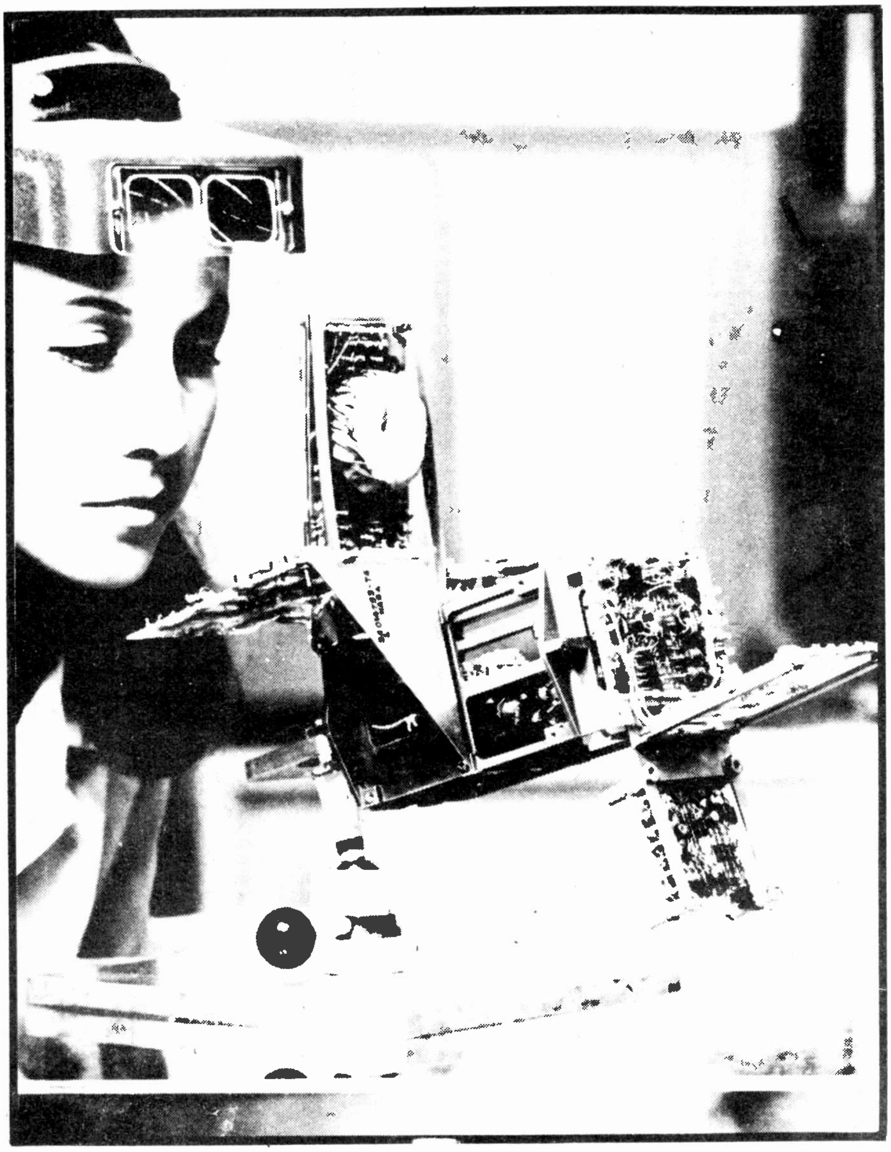
The lander S-band link directly transmits high-volume scientific and imaging data, Doppler tracking planetary ranging and command reception. The subsystem operates at 2.2 GHz and is coherently locked to Earth frequency references.

Engineering data is transmitted at a rate of 8 1/3 bits per second and scientific information may be sent at selectable rates of 250 500 and 1,000 bits per second. Coded (32/S), phase shift keying-pulse code modulating information is received at 4 bits per second.

A 760 mm parabolic reflector high-gain antenna will be used to transmit information from Mars directly to Earth. The high-gain antenna is steerable and utilises a two-axis gimbal. The mast for this antenna is deployed and locked into position immediately upon landing on Mars. Powered by a d-c driven motor, the antenna is stepped to follow the Earth by an open-loop command and control system. A fixed, crossed dipole S-band low-gain antenna will receive the commands from Earth.

Redundant modulator-exciters and a 20 watt travelling wave tube amplifier transmits the telemetry and imaging data at a frequency of 2295 MHz for approximately two hours each day.

Two S-band receivers operate on the same frequency and use the same receiver selector. The receiver selector furnishes signals to the modulator-exciters and the command detectors. One of the receivers is connected to the low-gain antenna and is the primary command receiver. The other receiver is linked to the high-gain antenna to detect the ranging signal. This receiver also serves as a backup command receiver when the high-gain antenna is pointed toward Earth.



*Kathy Daniels of Honeywell's aerospace Division examines part of a special-purpose computer which will control experiments in the Viking Lander.*

## VIKING ANTENNA

The RCA Viking antennas are specially designed and built to operate in the hostile Martian environment. They must withstand harsh surface winds, sand and dust storms, low pressure, and a temperature range from +111°C to −126°C.

The UHF low gain antenna is 450 mm high and is located on the Viking Lander Capsule (VLC). It provides for the rapid, high volume transmission of data from the VLC to the Viking Orbiter for relay to Earth. The antenna will operate during both the descent of the VLC to the Martian surface and at programmed times during the mission after touch-down.

An insulating foam designed to minimise power disruptions during transmission in the low pressure Martian atmosphere is enclosed in cylindrical containers on the ends of the antenna elements.

### UHF LOW GAIN ANTENNA

**Specifications:**

| | |
|---|---|
| Use: | Communications to Earth *via* orbiter relay. |
| Operation: | During Martian entry and from surface |
| Type: | Crossed dipoles, circularly polarized. |
| Frequency: | 400 MHz. |
| Power: | 60 Watts. |
| Weight: | 1.3 kg. |

*The S-Band Low Gain Antenna is 150* mm. high and is also located on the VLC. It will receive signals from Earth and will operate according to the mission programme after the VLC lands on the planet's surface.

### S-Band LOW GAIN ANTENNA

**Specifications:**

| | |
|---|---|
| Use: | Receive commands from Earth. |
| Operation: | Martian Surface. |
| Type: | Broad pattern, circularly polarized. |
| Frequency: | 2100 mHz. |
| Weight: | 0.11 kg. |

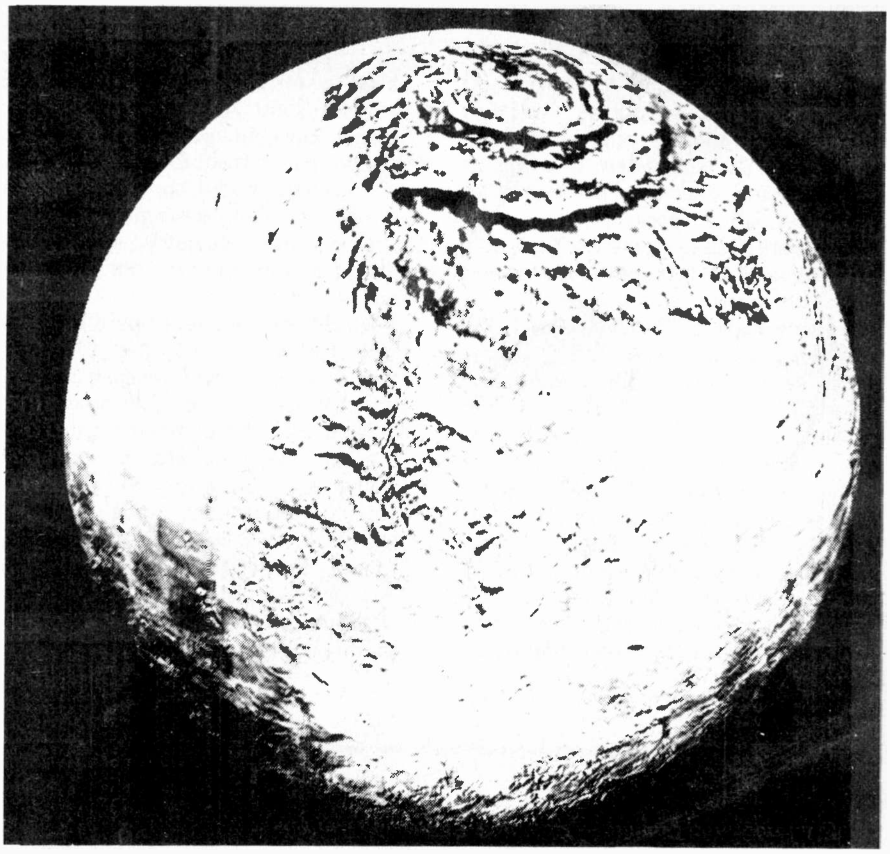
The S-Band High Gain Antenna has a 750 mm. parabolic dish of traditional appearance. It will be used to transmit and receive radio signals between the VLC and Earth and will operate after touchdown according to the mission programme. Since Mars, like Earth, rotates on its axis, it is necessary for the S-Band High Gain Antenna to be facing toward Earth for maximum effective transmission. Once the VLC has landed safely on Mars, an on-board computer will calculate the necessary alignment (both azimuth and elevation) for the antenna. The Viking Command and Control, or controller, will transform this information into commands to motors which will then reposition the antenna relative to Earth. Continuous adjustments will be computed during each transmission. It will take approximately 20 minutes for signals to travel the more than 362 million kilometres between the Viking spacecraft and its home planet. ●

**S-Band High Gain Antenna Specifications:**

| | |
|---|---|
| Use: | Transmit data Mars-to-Earth. |
| Operation: | Martian surface. |
| Dish: | 760 mm diameter. |
| Frequency: | 2100-2300 mHz; |
| Power: | 40 Watts. |
| Pedestal: | Elevation over azimuth |

**Controller Specifications:**

| | |
|---|---|
| Use: | Pedestal drive and encoder processor. |
| Operation: | Martian surface. |
| Input: | Commands from on-board computer. |
| Output: | Drives pulses to two stepper motors sine/ cosine from two resolvers. |
| Weight: | 0.22 kg. |
| Size, Max: | 100mm x 140mm x 178mm |
| Configuration: | Two 2-sided four-layer printed circuit boards |



*Another view of the spectacular 'photo globe' of Mars — the first ever made of any body in the Solar System. It was prepared by the Jet Propulsion Laboratory of California Institute of Technology which managed the Mariner project for NASA.*

*Electronics Today would like to thank the British Interplanetary Society and the Martin Marienatta Corporation for their assistance with the preparation of this article.*

# BLACK WATCH

Another digital watch? Hardly. The Sinclair 'Black Watch' has as much in common with other digital watches as the calculators of three years ago have with today's products.

There are three distinct differences between this new product and the more common digital watches. Most obvious is the styling – we like it because it is designed for this new technology, it owes nothing to conventional designs. I can however understand those who do not find it appealing but appearance is a very subjective field.

Secondly the case is plastic. Ugh, I hear some of you say but you haven't seen it or felt it. Basically it is a two part case which straps together but the plastic used is unlike any we have seen – Sinclair won't say what it is. It doesn't feel, look or behave like better known plastics. The technology and industrial design behind this case is as exciting as the chip used. The top of the case has two flexible diaphagms incorporated in the moulding only 10 thou thick – this in itself is something that has broken new ground. The case design includes no protruding switches or buttons – the switches for display and for setting are controlled by pressure through the case. Batteries can be replaced in a very short period by removing a malleable plastic plug. Sinclair don't claim the watch is waterproof – but it's certainly water resistant.

The biggest breakthrough is the chip – and only one chip is used. This uses integrated injection logic: $I^2L$. This brand new technology is only just becoming known to the public. Sinclair believe that their chip – and they themselves designed it – is the first watch chip using $I^2L$. Other companies have been talking about this – but to date it's only talk.

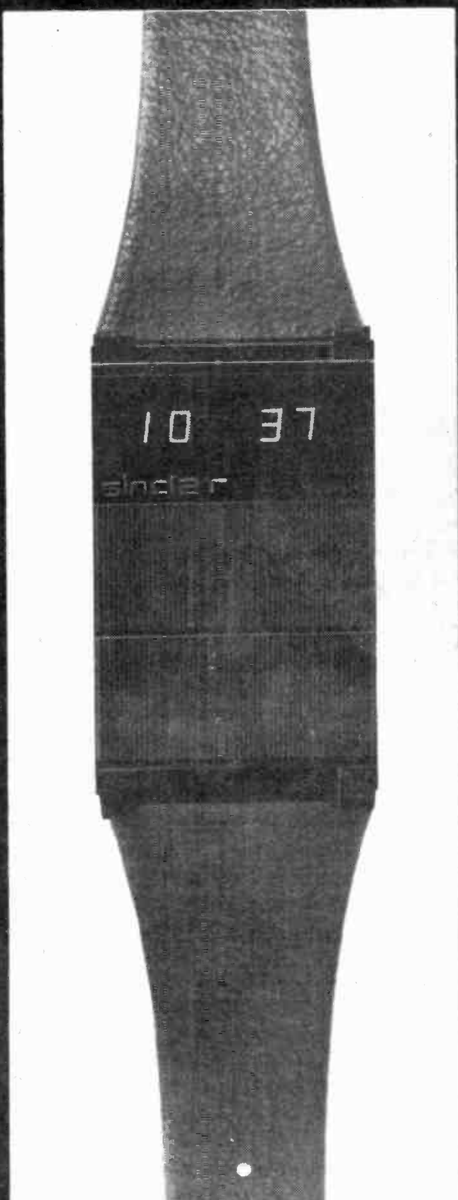
$I^2L$ is suited perfectly to digital watch design. Tiny currents are used but this is combined with the ability to supply high peak current when the display is actually used. It also offers high component packing density among other advantages. The chip contains 2,100 active devices in an area 117x123 thou.

In addition to the chip there is only the crystal – the now near standard 32.768kHz flexural bar crystal. Fine adjustment of this is obtained by means of a small trimmer. A tiny capacitor connected directly across the battery, is used to prevent very short interruptions in the supply throwing the timing out: this could occur during a violent blow to the watch.

An LED display is used. The poor contrast ratio and doubts about reliability of liquid crystal displays now available led to this choice.

Introducing a digital watch has been the aim of Sinclair ; in fact it was first investigated in 1967. Prototypes were developed but a high frequency crystal (4MHz) had to be used – this led to high power consumption. LED's weren't around then so neon type displays were used.

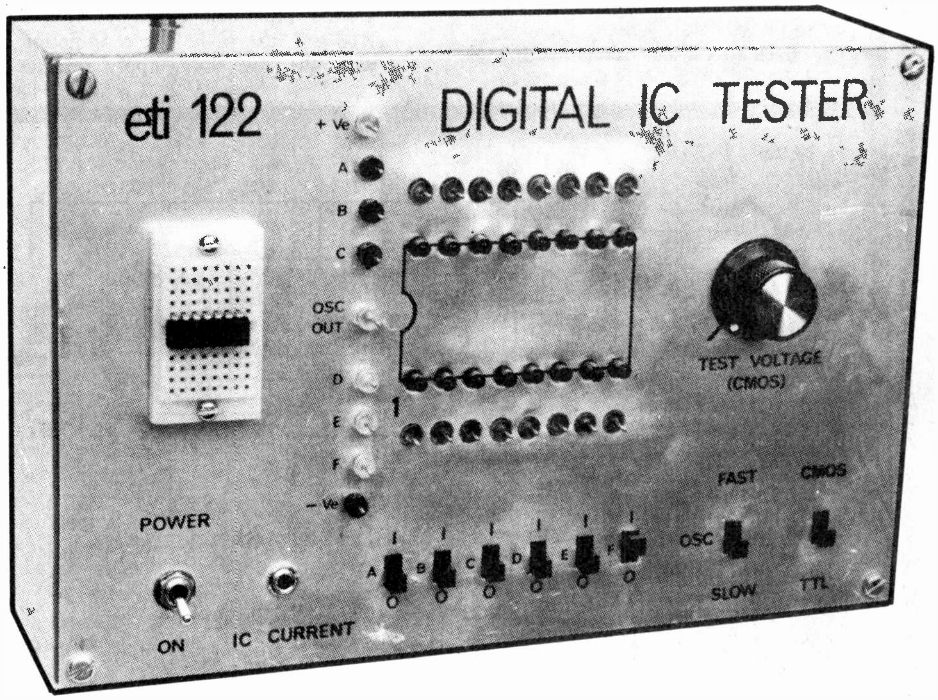
In 1972 with the first news of $I^2L$, the whole programme was turned in this direction. The first semiconductor company decided to pull out leading to a considerable delay. ITT are now making this chip for Sinclair.




When we first saw this watch at a press launch, we were extremely impressed – so much so that your Editor has placed what may be the first order!

## Test CMOS and TTL with this versatile instrument.

# LOGIC TESTER




> **WARNING:**
>
> **When using the tester, remember that manufacturers recommend that CMOS ICs should not be inserted or removed from a circuit without first switching off the power supply.**

**eti project 122**

EXPERIMENTERS often damage ICs in the process of developing a new circuit and often try a new IC in a circuit that is not working to eliminate that as a possible cause. The result of this is that one usually finishes up with a box full of ICs which are of dubious value. To sort out these ICs one must use a tester that is capable of testing the wide range of differing ICs that are available in the most commonly used families.

Until recently the most commonly used family has been TTL. But CMOS is rapidly gaining widespread usage and any tester, to be of value these days, must be able to test both these families. The ETI Logic Tester is capable of testing both families, and is also capable of being used to breadboard and test simple circuits based on single ICs.

An LED indicator is associated with each pin of the IC under test and these are arranged around the perimeter of a box representing the IC under test. This allows a small card, which has the schematic of the particular IC drawn on it, to be fitted to the front of the tester as an aid to the interpretation of the LED test indications.

### CONSTRUCTION

The most expensive single component in the tester, after the transformer, is the case. For this reason we decided to make a wooden case and a plain aluminium front panel. Some people may however wish to mount the unit in a diecast box and for this reason the printed circuit board has been sized to fit in a standard 222 x 146 x 51 mm die-cast box. The following description is for a wooden box specifically, but applies equally well to the metal box.

The printed-circuit board is mounted to the rear of the front panel, copper side to the panel, such that the LEDs and patch pins, mounted on the printed-circuit board, project through the front panel. This greatly simplifies construction as it saves some 48 leads and solder joints. The switches are secured to the front panel by first glueing two pieces of printed-circuit board to the rear and then soldering the switches to the copper side of the board. This procedure avoids the necessity of a multitude of screws passing through the front panel.

The printed-circuit board should be assembled with the aid of the component overlay by fitting all components with the exception of IC1, 5, 6 and 7, and LEDs 1 through 16, and the patch pins. Check that the ICs are orientated correctly as are also C2, 5, 7, 9 and D1, 2 and 3. Now solder these parts into position using the least amount of heat necessary on ICs 2, 3 and 4.

Position the LEDs and patch pins onto the copper side of the board but do not solder them in place as yet. Now fit the board to the front panel so that the pins and LEDs protrude through the panel evenly. Secure the pins and LEDs in position by using a very small drop of five minute epoxy for each, on the component side of the

## HOW IT WORKS.

The tester consists of four basic sections. The socket for the IC under test, the output level-detect logic, oscillators and switches for the inputs, and the power supply.

The socket for the IC under test has the pins in each row electrically connected to each other. These rows are the groups of five holes which are perpendicular to the central groove on the socket. Each row (ie, each pin on the IC under test) is connected via a 10 megohm resistor to ground to prevent the build up of static charges. The resistors also hold all unconnected inputs at ground potential thus preventing any damage to the IC.

Each row is also connected to a pin on the front panel. Test connections are made to these pins by patchable links from the oscillator and test switches so that the correct test conditions may be set up.

Resistors R19-26 and R43-R50 connect each row (ie pin) to a logic level detector, ICs 5, 6, and 7. These CMOS hex-inverters buffer each pin and drive an LED to indicate the logic state of the pin. When the logic voltage on a pin is high the LED will be alight. Resistors R19 to R26 and R43 to 50 protect the internal diodes of ICs 5, 6 and 7 against the possibility of a pin being taken above the positive supply voltage or below ground potential. Resistors R11 to R18 and R51 to R58 in conjunction with the five volt supply set the operating currents for the LEDs.

A 555, IC4, is used as an astable oscillator which initially charges C8 via R9 and R10 until the 2/3 supply threshold is reached. C8 is then discharged via R9 and pin 7 of the 555 to the lower threshold of 1/3 supply volts. Switch SW6, when operated, puts a larger value of capacitance into the circuit which gives a frequency of about one hertz. This is slow enough so that the eye can follow each logic state transition. The high speed operation is used for checking very long counters and shift registers and can also be used in conjunction with an oscilloscope. The square wave output of the oscillator is made available at a

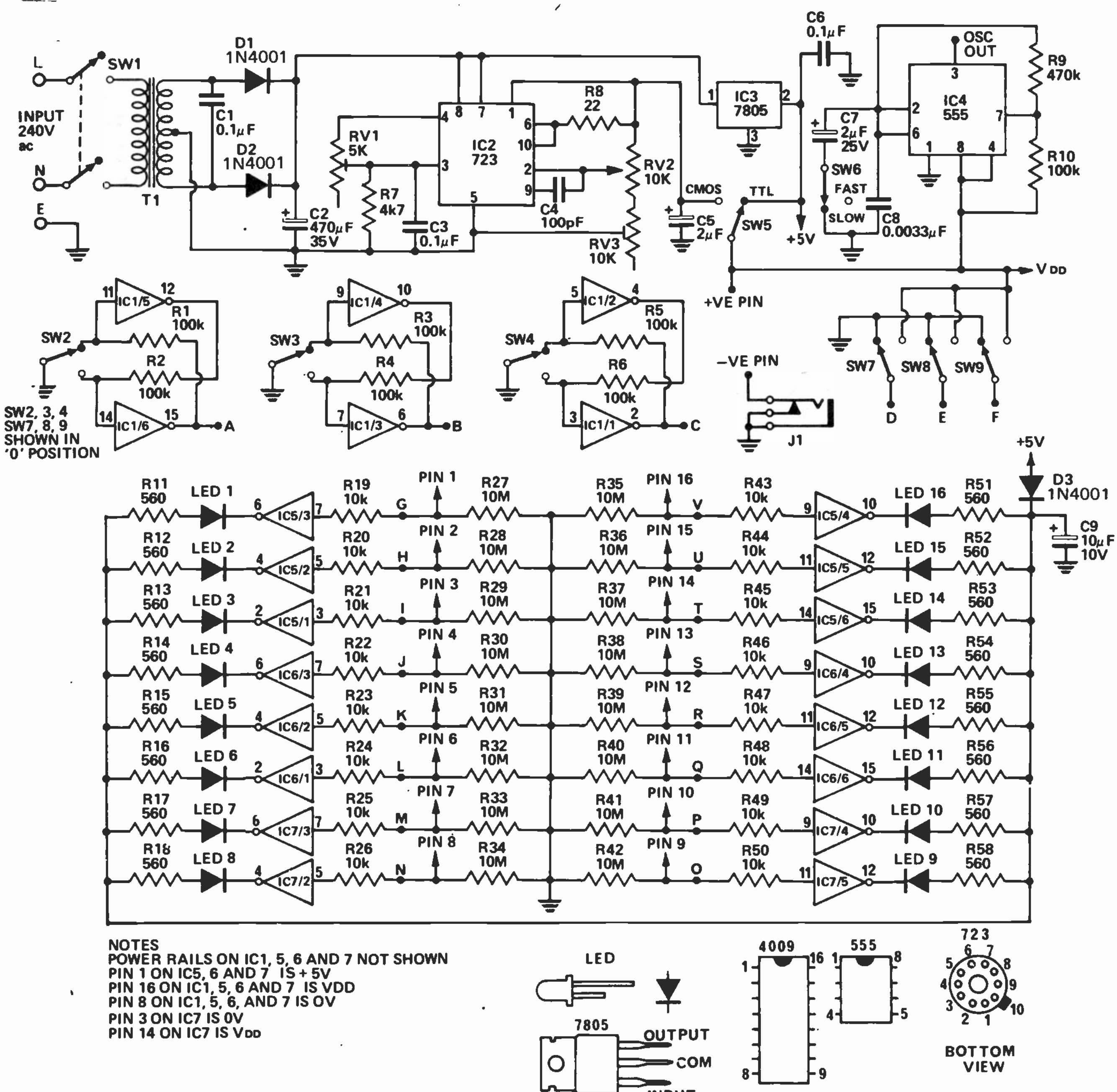



*Fig. 1. Circuit diagram of the logic tester.*

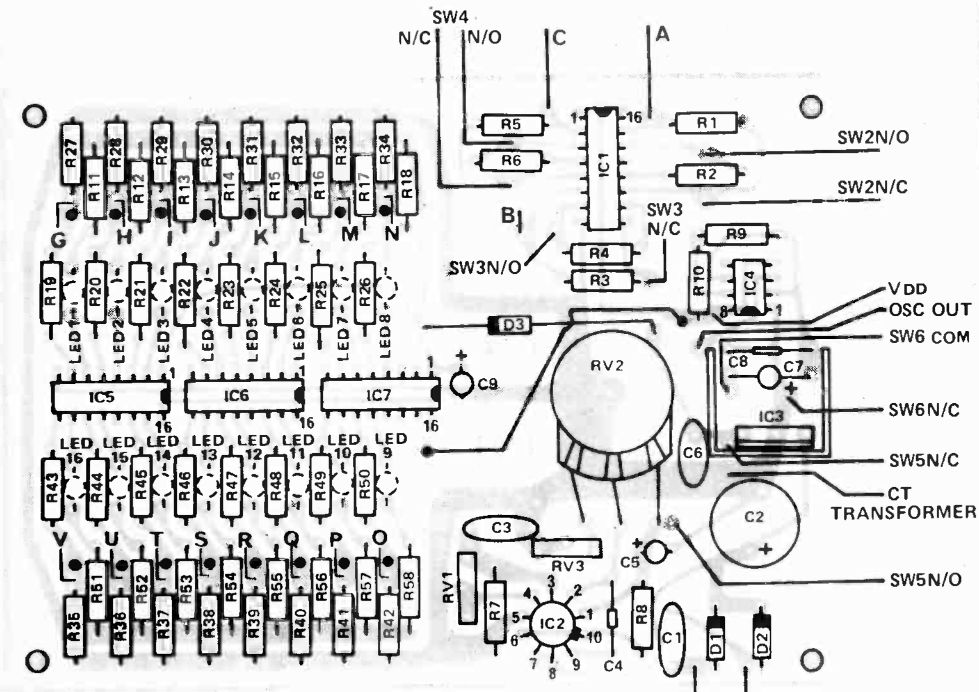
patch-pin on the front panel.

There are six further output pins on the front panel three of which, D, E and F, are set to negative or positive supply by means of toggle switches. As there is no debounce logic associated with these pins they can ònly be used to set up static conditions and not for clocking counters and shift registers. The remaining three pins are also programmed by switches but these switches are connected to IC1 which contains three RS flip-flops to effectively remove any contact bounce of the switches. This operates as follows. If initially the input of IC 1/5 is earthed by SW2 its output will be high and hence the output of IC 1/6 will be low. When IC 1/6 SW2 is operated again it earths the input of IC 1/6 sending the output of IC 1/6 and input of IC 1/5 high and the output of IC 1/5 low. Since the input of IC 1/6 is connected to the output of IC 1/5 it is held low even if the contacts of SW2 bounce several times when the switch is operated. Thus the output at A is one single transition from high to low (low to high when next the switch is operated). The output of the three debounced switches are labelled on the front panel as A, B, and C.

In the power supply diodes D1 and D2 full-wave rectify the output from the power transformer. The output from the rectifier is smoothed by C2 and regulated to five volts by IC3. The resulting five volt supply is used to drive the LED indicators and to power the TTL device under test. Integrated circuit IC2, a type 723, is a regulator the minimum output of which is set to five volts by RV1 and the maximum of 15 volts by RV3. Front panel control RV2 allows the output voltage to be adjusted between five and 15 volts. The current limit on the output is set to 30 mA by means of R8. SW5 selects the high current five volt supply for testing TTL or the low current variable supply for CMOS. Terminal J1 in the negative supply lead is provided for checking the current drawn by the IC under test. ●

# LOGIC TESTER

*Fig. 2. How the components are mounted on the pc board.*




TERMINAL POSTS NEXT TO WIRES MARKED G–V AND THE LED'S ARE MOUNTED ON COPPER SIDE OF THE PC BOARD

## PARTS LIST — ETI 122

| | | | | |
|---|---|---|---|---|
| R8 | Resistor | 22Ω | ¼W | 5% |
| R11,18 | " | 560 | " | " |
| R51,58 | " | 560 | " | " |
| R7 | " | 4 k7 | " | " |
| R19,26 | " | 10 k | " | " |
| R43,50 | " | 10 k | " | " |
| R1,6 | " | 100 k | " | " |
| R10 | " | 100 k | " | " |
| R9 | " | 470 k | " | " |
| R27,42 | " | 10 M | " | " |
| RV1 | Potentiometer | 5 k | Trim type | |
| RV3 | " | 10 k | " | " |
| RV2 | " | 10 k | Linear | |
| C4 | Capacitor | 100 pF | Ceramic | |
| C8 | " | 0.0033μF | polyester | |
| C1,3,6 | " | 0.1μF | " | |
| C5,7 | " | 2μF 25V | electro | |
| C9 | " | 10μF 10V | " | |
| C2 | " | 470μF 35V | " | |

D1,2,3 Diode 1N4001 or similar
LED 1 — LED 16 Light Emitting Diodes

| | | |
|---|---|---|
| IC1,5,6,7 | Integrated Circuit | 4009 (CMOS) |
| IC2 | " | 723 (metal can case) |
| IC3 | " | 7805 (TO-220 case) |
| IC4 | " | 555 |

J1 Jack small earpiece type

SW1 DPST toggle 240V rated
SW2-SW9 miniature slider switch 2 pole 2 position

PC BOARD ETI 122

IC Socket
Wooden case see text
Transformer 240 V primary 30 V CT secondary or 2 x 15 V windings

25 patching Pin feed throughs

front panel
3 core flex and plug
heatsink for IC3 (see Fig.6)

*(Text continued from page 71)*

boards. Do not glue the LEDs to the front panel. Once the glue has set, carefully remove the board from the front panel and then solder the LEDs and pins into position. Fit 250 mm long leads to the board for later connection to the switches and power transformer and then, using a minimum amount of heat, solder ICs 1, 5, 6 and 7 into position.

Solder the leads to the pins on the IC socket — the front panel must be cut out so that these leads may be passed through. Now affix the socket to the front panel and install the printed circuit board. Mount the transformer into the base of the box and interconnect the board and switches etc.

The wooden box was constructed from 12 mm thick pineboard such that the outside dimensions were 225 x 148 x 70 mm. We finished our box with coloured high-gloss enamel which

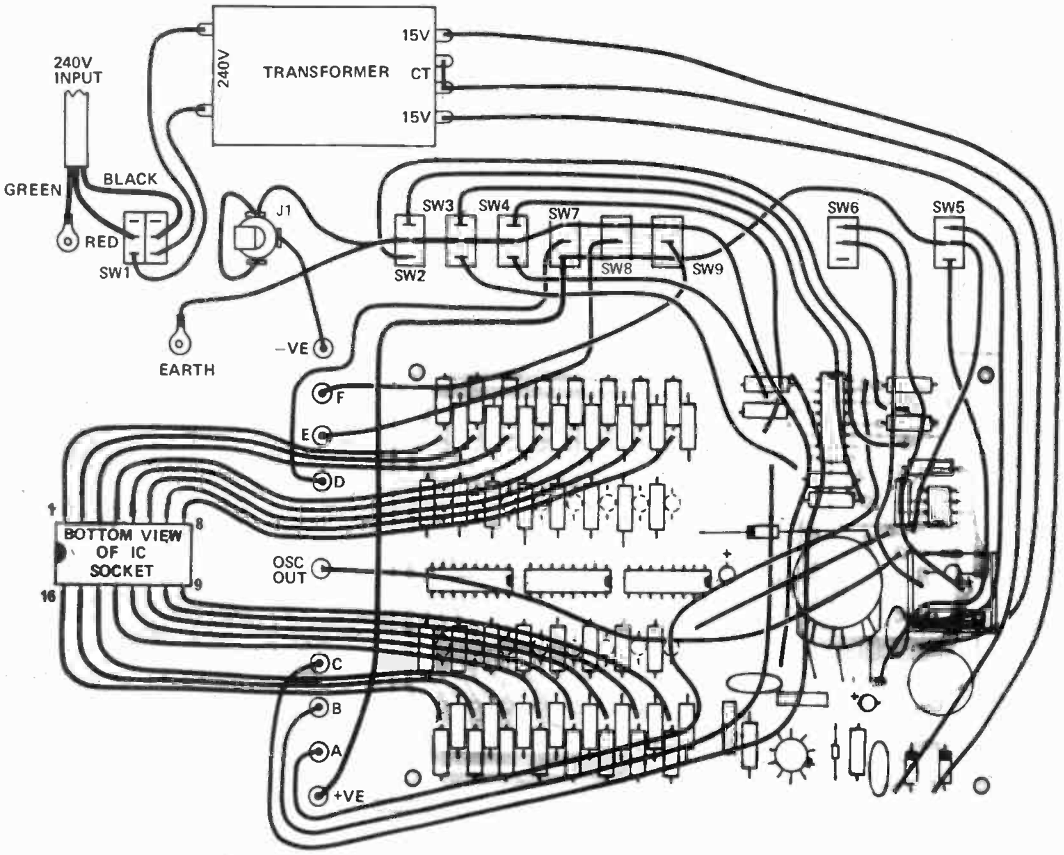
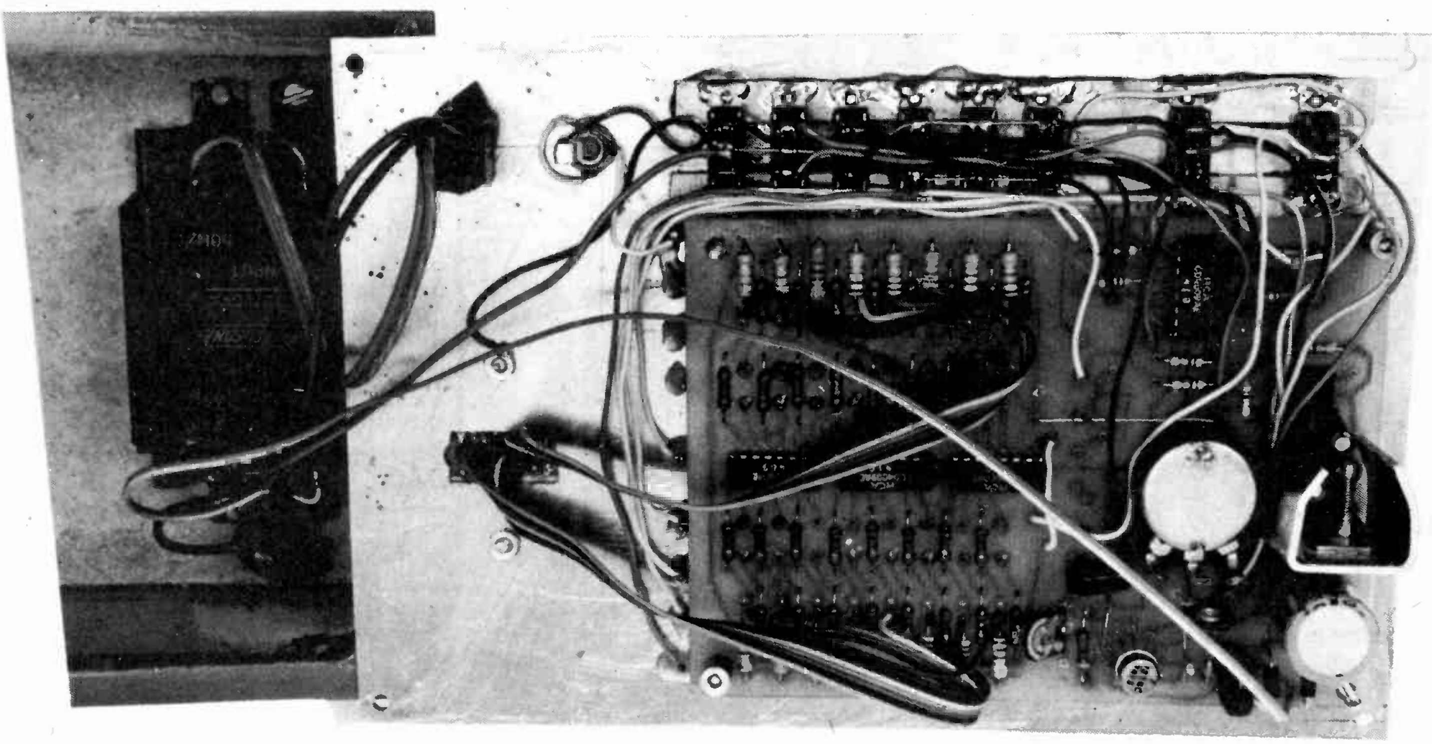



*Fig. 3. Wiring diagram of complete unit.*

# LOGIC TESTER



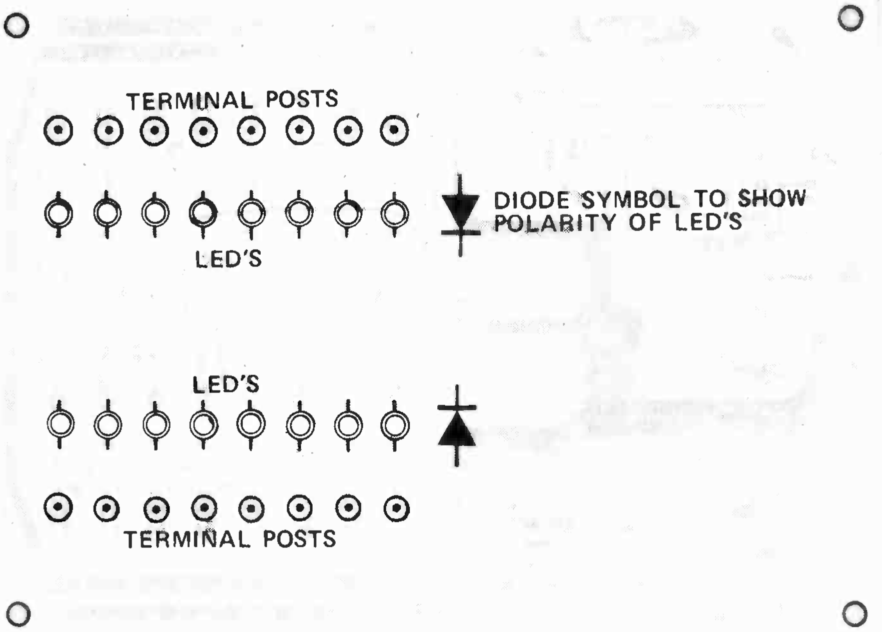



*Fig. 4. Positioning of LEDs and terminal posts on the copper side of the printed-circuit board.*

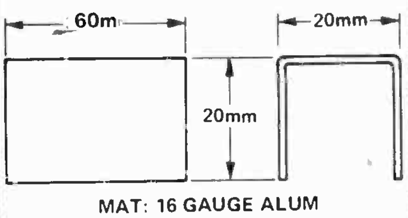



*Fig.6. Heatsink for IC3. The IC is mounted (by a screw) through a 3.2 mm hole in the base of the heatsink (see photograph of inside of unit).*

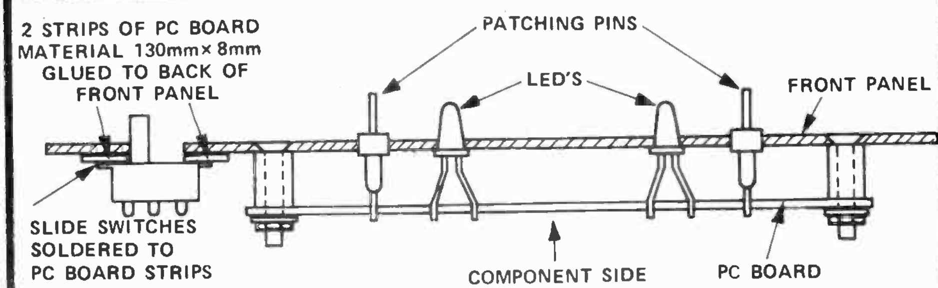



*Fig. 5. How the front panel and printed-circuit board are assembled.*

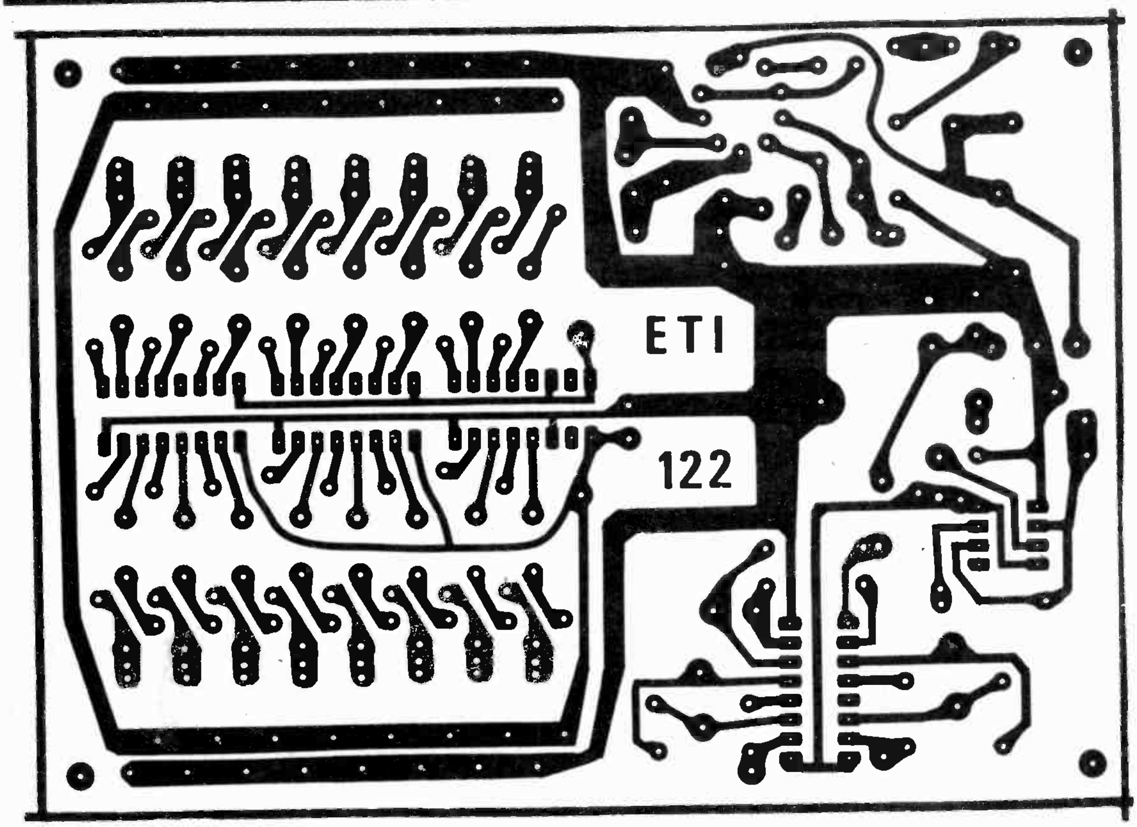



*Fig. 7. Printed circuit-board artwork. Full size 142 x 104 mm.*

# LOGIC TESTER

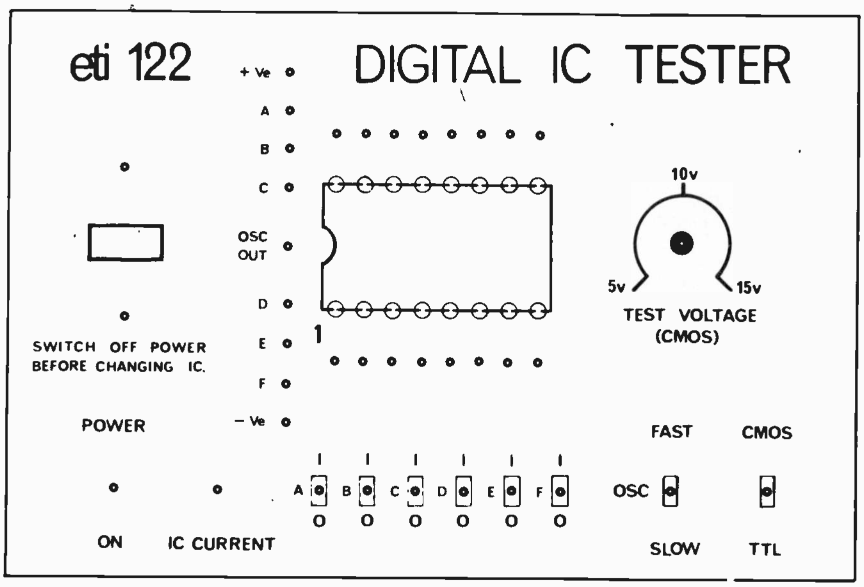



*Fig.8. Front panel artwork (shown half-size — full size should be 223 mm x 148 mm).*

resulted in a very pleasing final appearance.

**DESIGN FEATURES.**

There are several design requirements which must be met in a unit which is designed to test both CMOS and TTL devices. These may be summarized as follows.

1) The unit must be capable of correctly testing both types of logic.

2) Simple gate functions should be tested by go/no-go checks and complex functions such as counters and shift registers should also be reliably checked.

3) There should be the least possible chance of damaging the device during testing.

4) CMOS ICs must be testable with a variety of supply voltages.

5) A clock oscillator and a means of setting up the input conditions must be provided.

One of the major design difficulties with a unit such as this is coping with the many different pin configurations of the differing functional requirements (eg a shift register versus a two-input NAND gate) of devices within the one family, as well as those between different families. A multi-way switch could be used for each input pin but would greatly increase the expense of the unit. A good alternative is to use patchable links, and this is the approach that we have chosen to use in our unit. In addition we have used a small breadboard socket as the test socket, rather than a standard 16 pin dual-in-line socket, as this allows us to improvise special test circuits for the more complex logic ICs, and the means to breadboard simple circuits.

The need for a variable power supply for CMOS testing presented two additional problems. The first of these was the danger of plugging a TTL IC into the unit when it is set up for CMOS and for some higher supply voltage than the five volts required for TTL. Secondly the LEDs used for monitoring each pin would draw more current as the supply voltage increased. The current ratio could be as high as four to one and a corresponding variation of LED intensity would occur. To overcome this problem it was decided to provide a second supply of five volts to operate the LEDs which will also provide the higher current required by TTL for its operation. The other supply is a variable one for testing CMOS and is not capable of supplying more than 30 mA. Thus a TTL gate inadvertently connected to this supply would not be damaged.

The regulator used for the five-volt supply is a three terminal IC which has built in current limiting and thermal shutdown. It will not therefore be damaged by a short circuit due to testing a faulty IC. It is not possible to construct a discrete design, as cheaply, that has the same performance.

Next we need a device that will detect the state of each pin on the device under test and drive an LED to indicate that state. The device has to be driven by TTL and CMOS outputs, that is, by voltages anywhere between 5 and 15 volts. A suitable IC is the CMOS 4009 IC which has six inverters in one package. Each inverter will monitor a pin without drawing appreciable current. The 4009 is also designed to translate logic levels. Thus we may use it to monitor a 5 to 15 volt input level at its input but provide a five volt signal only at its output.

Switches are provided which have debounce logic associated with them. This is necessary so that single bounce free rise and fall transitions can be generated for the testing of more complex logic. The debounce logic must be capable of operating on 5 to 15 volts and of sinking at least two milliamps for TTL tests. The 4009 IC with its high output current capability was again considered to be most suitable for this task.

We would also like to have used the 4009 as the oscillator, but RCA do not recommend using CMOS that has a high output capability in a linear mode as the power dissipation of the device may be exceeded. The oscillator must provide pulses that swing between the positive and negative supply rails (in order to drive CMOS) and must be capable of sinking the two milliamps required by TTL. It must also be capable of operating on supply voltages of 5 to 15 volts. Since the standard CMOS devices cannot provide the current requirement it was decided to use a 555 IC as the oscillator.

CMOS devices should not be operated with inputs left floating as some devices may drift into the linear mode and be destroyed by excessive power dissipation. For this reason a 10 megohm resistor is connected between each pin, on the test socket, and ground. These resistors also conduct away any static charge that may build up. ●

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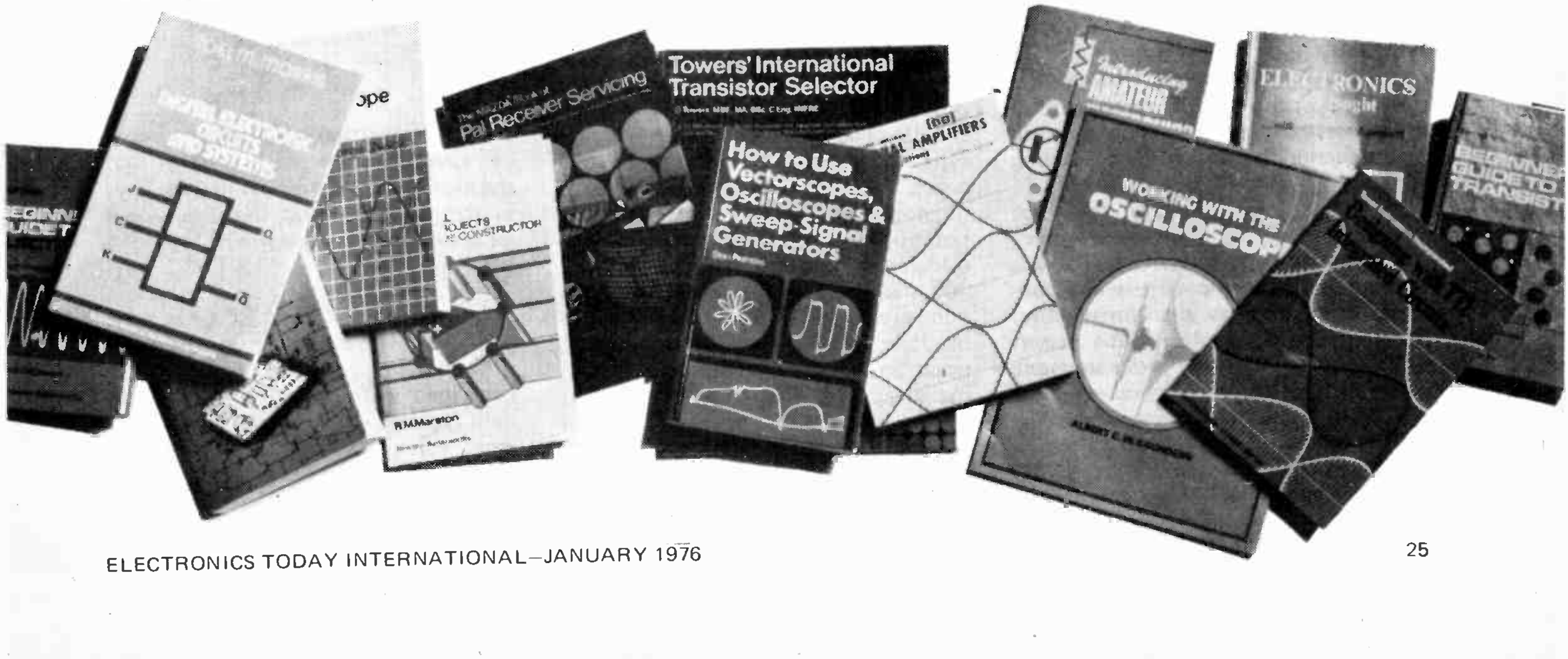


# SURVEY OF SCIENTIFIC CALCULATORS

IF YOU HAVE CONSIDERED buying a scientific calculator recently then you will have been faced with a bewildering choice. One of the larger retail outlets lists 28 different models in the scientific category with prices ranging from about £20 to over £440. This survey sets out to cover the more common models with prices up to about £120 though the models chosen can only be representative of those available – however this survey will enable comparisons to be made with any new or not so common models that may be found.

Early in 1972 Hewlett-Packard introduced the HP-35, one of the first pocket sized scientific calculators, which then cost £199. The HP-35's calculating power was contained in 5 MOS I.C.'s.

Earlier this year, the same company introduced the HP-21, a calculator with a slightly *greater* calculating power than the HP-35 but selling at only £69. This dramatic price reduction has been, and still is, common to all calculator manufacturers and thus the calculators covered in this survey range in price from £19.95 (recommended retail price).

These price reductions have been due to several factors, one of which is obviously competition, as most serious calculator manufacturers now have a scientific in their model range. Another factor has been the steady advance in semiconductor technology during the very recent past. The HP-21 uses more logic circuitry than the original HP-35 yet contains only two I.C.'s against the five of the HP-35.

One new development which appears as exciting as the introduction of the first scientific is the recent introduction of the programmable scientific calculator. There are now at least three major manufacturers offering programmables covering a price range from £29.95 to £442. (The cheapest, the Sinclair Scientific Programmable, was the subject of a review in the November issue of ETI). Programmables are extremely valuable for the solution of repetitive calculators involving a large number of calculating steps having to be performed on many items of separate data. This may well occur when handling experimental data or tabulating a graph for instance. Most manufacturers offer a library of standard programs with their machines. The individual program steps are stored in either a solid state memory or on a magnetic card which is fed into the calculator by a small motor.

There are three tables covering the calculators in this survey, Table 1 deals with those machines which calculate and display in standard floating print (arithmetic) format only, Table 2 covers those calculators which calculate and display in floating point and/or scientific notation (separate mantissa and exponent) and one model which uses scientific notation only. Table 3 covers the programmables.

## CHOOSING A SCIENTIFIC CALCULATOR

With such a vast range of scientifics available in more or less every price range, it is important that the right factors are considered before money is invested in the calculator of your choice. The first decision is which type of calculator will meet your needs - usually the cheaper mpdels do not offer the option of scientific notation and so are limited in their calculating range to numbers between $10^8$ and $10^{-8}$. If you want to handle numbers outside this range then a machine which handles full scientific notation will save the bother of keeping a separate note of the powers of 10 involved, this may well happen when handling calculations in electronics with microfarads, nano seconds, giga hertz etc. being involved.

The programmable calculator is at present being hailed as the answer to everybody's dream of infinite, instant calculating power but in general they are considerably more expensive than their non-programmable equivalents.

Having chosen the type pf calculator required then the available range of that type must ne carefully examined for there are several important differences between models of the same basic type.

The most important decision to be made when choosing a scientific is that of which number entry system the calculator should use. The two systems found are Algebraic and Reverse Polish Notation (RPN), sometimes called Post Fixed Operators. The difference can be seen clearly by following the sequence of keystrokes needed to add two numbers together:

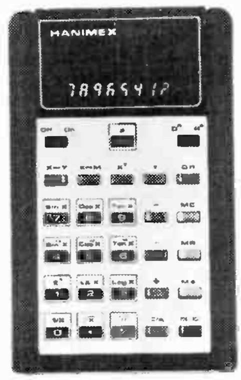
ALGEBRIAC

| Key | Display |
|---|---|
| 2 | 2 |
| + | 2 |
| 3 | 3 |
| = | 5 |

RPN

| Key | Display |
|---|---|
| 2 | 2 |
| enter | 2 |
| 3 | 3 |
| + | 5 |

This sum requires the same number of keystrokes in each system but the algebraic systems operates the keys in the same order as the sum would be read aloud whereas the RPN system has this mysterious "ENTER" key. Algebraic is certainly a simpler system to operate initially but RPN has a lot going for it, especially in the field of complex scientific calculators. If combined with a working stack of data registers, RPN system gives a very great calculator power with instant access to parentheses without keying in and out of them. A four level stack




*Hanimex ESR-100*


*Rockwell 61R*

**TABLE 1 STANDING FLOATING POINT ONLY MACHINES**

| MODEL / Feature | ADLER 88T | DECIMO 2001 | HANIMEX ESR100 | NOVUS 4510 | ROCKWELL 61R |
|---|---|---|---|---|---|
| Recommended Price | £49.95 | £49.95 | £45.00 | £49.95 | £49.95 |
| Rechargable | Extra | Mains adaptor extra | Mains adaptor extra | ✓ | ✓ |
| Digits | 8 | 8 | 8 | 8 | 8 |
| Display | LED | LED | Fluorescent | LED | Fluorescent |
| No. Keys | 25 | 25 | 26 | 32 | 20 |
| RPN/ALG | ALG. | ALG. | ALG. | RPN | ALG. |
| Stack | | | | 3 Level | |
| Brackets | 1 set | | | | |
| Ind. Mem. | ✓ | ✓ | ✓ | ✓ | ✓ |
| Trig | ✓ | ✓ | ✓ | ✓ | ✓ |
| Radians | ✓ | ✓ | ✓ | ✓ | ✓ |
| Degree | ✓ | ✓ | ✓ | ✓ | ✓ |
| 1/x | ✓ | ✓ | ✓ | ✓ | ✓ |
| √x | ✓ | ✓ | ✓ | ✓ | ✓ |
| $x^2$ | | | | ✓ | |
| $M+^{x2}$ | | | | ✓ | ✓ |
| π | ✓ | ✓ | ✓ | ✓ | ✓ |
| $e^x$ | ✓ | ✓ | ✓ | ✓ | ✓ |
| ln x | ✓ | ✓ | ✓ | ✓ | ✓ |
| log x | ✓ | ✓ | ✓ | ✓ | ✓ |
| $10^x$ | | | | | ✓ |
| $x^y$ | ✓ | ✓ | ✓ | ✓ | ✓ |
| M↔x | ✓ | ✓ | ✓ | | ✓ |
| X↔y | ✓ | ✓ | ✓ | ✓ | |
| Change Sign | | ✓ | ✓ | ✓ | ✓ |

is equivalent to three levels of parenthesis (brackets). However the operator of a RPN machine needs to be able to transform a complex equation such as:-
$x=\tan^{-1}((3.5^3 + 8 \sin 37^o)+6(\cos 53^o + 2(1+ \ln 3.55))^{\frac{1}{3}})$
into a number of 'enter' keystrokes whilst the algebraic machine operator can, if he has sufficient 'brackets' available, enter the problem as written.

A good argument can be made out for each system and the choice must be made on your ability to *understand* what you are doing. But do not dismiss RPN as too difficult to understand, have it demonstrated and then try some problems yourself – you might be surprised at the ease with which you can pick up a new system.

One of the arguments advanced in favour of the RPN system is that it is consistent when dealing with the more complex keyboard functions such as the trig functions, logs etc. If you wish to find the 'sin' of 30° then the key sequence for each type of machine is the same- '30' 'sin' which indeed is the sequence expected for a RPN machine, but the reverse of that expected for the algebraic machine – you might find this an inconsistency.

Manufacturers of both types of machines usually offer a separate memory as well as an multi-level stack in the RPN machine or one or more sets of 'brackets' in the algebraic models. Often the choice may be one level parenthesis plus two separate memories or two levels of parenthesis plus one memory.

Having made this decision, which is the most important one, then the next factor to be considered is the type of display and number of digits to be displayed. The most popular type of display is the LED type which is usually red in colour. The cheaper models of calculators use small LED displays with magnifying lenses fixed in front. These lenses tend to narrow the viewing angle (the angle over which the display may easily be read). This is fine in a small pocket calculator but not as satisfactory in an expensive scientific model. The other, not so common type of display is the flourescent type – this is a green display which generally is larger than the LED type and the whole display is built into an evacuated glass envelope. The basic display is more expensive than a LED type and does require more complex additional circuitry (high voltage generators etc) but has the advantage of extremely low power consumption.

Having mentioned power consumption it is a useful next point for consideration; if your choice of calculator is available with or without rechargeable batteries then the extra outlay on the rechargeable version may well be worth considering, the PP3 type battery may be fairly cheap but with the current required by some of the more complex calculators (especially those with LED displays) it will not take all that long to run down a PP3 and so the extra cost of the rechargeable batteries is soon made up.

The next factor for consideration is the keyboard and its layout. The calculators surveyed here range in number of keys from 48 down to a full scientific with only 18 keys. The lesser number of keys, the smaller the calculator and thus the more easily pocketable but with the disadvantage that there are often two keystrokes required for access to a scientific function. Thus if you are going to use the full range of the calculator fairly often then you might well find double function keys awkward to use. The only double function keys which are obvious are those of

*main text continued on page 31*

# SURVEY OF SCIENTIFIC CALCULATORS

*Casio FX 15*

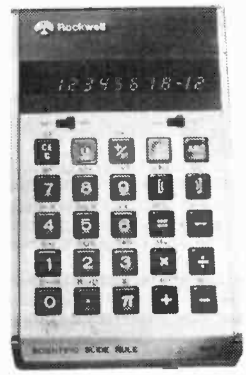
**NOTES FOR TABLE 2**

1. All quoted prices are the manufacturers recommended prices, discounts of up to about 40% are not uncommon on some models.
2. Operates in scientific notation only for the input of data and the displaying of results.
3. Special type of algebraic calculator with extra register which allows the direct evaluation of the sums of products without using the memory although the 'brackets' are not separately accessible.
4. Operates in grads as well as degrees and radians for trig. functions.
5. Additional function: Sexagesimal to decimal conversion, i.e. hours, minutes, seconds to decimal hours etc.
6. EE$\uparrow$ and EE$\downarrow$ keys provided.
7. Twelve additional features: $\binom{n}{k}$, (n)k, Pr(x), $\Gamma$(x), $\Sigma\pm$ $\|x\|$, K$\uparrow$, K$\downarrow$, $\Sigma\uparrow$, $\Sigma\downarrow$, C1grp, Item count.
8. Additional features; full arithmetic on all three separately addressable memories, selectable decimal point, live % key with add on and discounting, % diffrence between $x_1$ and $x_2$, linear regression, random number generation, permutations, twenty separate conversions and their inverse.

**TABLE 2 FLOATING POINT AND SCIENTIFIC NOTATION.**

| Model / Feature | Casio FX 15 | C.B.M. SR890 | C.B.M. SR990 | C.B.M. SR6120R | C.B.M. SR4148R | Decimo 2001E | Dixons Mini | Dixons SC4001M | Hanimex ESR 1010SN |
|---|---|---|---|---|---|---|---|---|---|
| Rec. Price (1) | £49.50 | £22.95 | £29.95 | £39.95 | £49.95 | £59.95 | £19.95 | £24.95 | £49.50 |
| Rechargeable | A.C. adaptor extra | | | ✓ | ✓ | | | A.C. adaptor extra | A.C. adaptor extra |
| Digits | 8\|6+2 | 8\|5+2 | 8\|5+2 | 8\|8+2 | 10\|10+2 | 8\|8+2 | 8\|5+2 | 8\|5+2 | 8\|5+2 |
| Display | Fluorescent | L.E.D. | L.E.D. | L.E.D. | L.E.D. | L.E.D. | L.E.D. | Fluorescent | Fluorescent |
| No. Keys | 37 | 29 | 39 | 39 | 48 | 35 | 19 | 35 | 35 |
| RPN/Alg. | Alg. | Alg. | Alg. | Alg. | Alg. | Alg. | Alg. | Alg. | Alg. |
| Stack | | | | | | | | | |
| Brackets | | | 1 set | 1 set | 1 set | | | | |
| Ind. Mem. | ✓ | 2 | 2 | 2 | 2 | ✓ | ✓ | ✓ | ✓ |
| Trig. | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Radians | | ✓ | ✓ | ✓ | ✓ | ✓ (4) | ✓ | ✓ | ✓ |
| Degree | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ (4) | ✓ | ✓ | ✓ |
| Deg./Rad. Conversion | | | | | | | | | |
| $\sqrt{x}$ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| $x\sqrt{Y}$ | | | ✓ | ✓ | ✓ | | | | |
| $x^2$ | ✓ | | ✓ | ✓ | ✓ | | | | |
| $x^y$ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | |
| Rect↔Polar Co-ord Conv. | | | ✓ | ✓ | ✓ | | | | |
| Hyperbolic functions | | | | | | ✓ | | | |
| ln x | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| $e^x$ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| log x | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | |
| $10^x$ | | | ✓ | ✓ | ✓ | | | | |
| 1/x | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| X! | | | | | | | | | |
| Mean & stand deviation | | | ✓ | ✓ | ✓ | | | | |
| Sum to mem. | ✓ | | ✓ | ✓ | ✓ | | | | |
| M $\rightleftarrows$ x | | | | | | ✓ | ✓ | ✓ | ✓ |
| +/— key | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | |
| x $\rightleftarrows$ y | | | ✓ | ✓ | ✓ | ✓ | | | |
| $\pi$ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Other Functions | (5) | | (6) | (6) | (6) | | | | |

*Qualitron 1448*



*Rockwell 63R*

*Texas SR 50A*

| Hanimex ESR Master | Novus 4520 | Hewlett Packard HP 21 | Qualitron 1448 | Qualitron 1419 | Qualitron 1420 | Rockwell 63R | Sinclair Scientific | Sinclair Oxford 300 | Texas SR 50 | Texas SR 51 |
|---|---|---|---|---|---|---|---|---|---|---|
| £49.95 | £72.45 | £69.10 | £27.33 | £31.25 | £61.55 | £59.95 | £21.55 | £32.35 | £59.95 | £89.95 |
| A.C. adaptor extra | ✓ | ✓ | Extra | Extra | Extra | ✓ | | A.C. adaptor extra | ✓ | ✓ |
| 8\|8+2 | 8\|8+2 | 10\|8+2 | 8\|5+2 | 10\|10+2 | 10\|10+2 | 8\|8+2 | 5+2 only (2) | 8\|5+2 | 10\|10+2 | 10\|10+2 |
| Fluorescent | L.E.D. | L.E.D. | Fluorescent | L.E.D. | L.E.D. | Fluorescent | L.E.D. | L.E.D. | L.E.D. | L.E.D. |
| 25 | 35 | 27 | 35 | 35 | 40 | 25 | 18 | 19 | 45 | 45 |
| Alg. | R.P.N. | R.P.N. | Alg. | Alg. | Alg. | Alg. | R.P.N. | Alg. | Alg. | Alg. |
| | 4 level | 4 level | | | | | | | | |
| 2 sets | | | | | 2 sets | 2 sets | | | 1 (3) | 1 (3) |
| ✓ | ✓ | ✓ | ✓ | ✓ | 3 | ✓ | | ✓ | ✓ | 3 |
| ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ |
| ✓ | | | | | | ✓ | | | ✓ | |
| ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ |
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| ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ |
| ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ |
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| ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ |
| | | | | | ✓ | ✓ | | | ✓ | ✓ |
| | | | | | ✓ | | | | | ✓ |
| ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | |
| ✓ | | | ✓ | ✓ | ✓ | ✓ | | ✓ | | |
| ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ | ✓ |
| ✓ | ✓ | ✓ | | ✓ | | ✓ | | | ✓ | ✓ |
| ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ |
| | | | | | (7) | | | | | (8) |

# SURVEY OF SCIENTIFIC CALCULATORS

*Hewlett-Packard HP25*

**NOTES FOR TABLE 3**

1. Also special engineering notation capability - expressing exponent of number in multiples of three.
2. Also calculates in 'grads' for trig. functions.
3. Additional features: $\Sigma+$, $\Sigma-$, rectangular to polar coordinate conversion and vice-versa, mean, standard deviation, $\Sigma x^2$, $\Sigma y$, $\Sigma xy$, integer value x, fractional portion x, absolute value x, $\pi$, 1/x, %, change sign, $x \leftrightarrow y$, decimal angle/time $\leftrightarrow$ angle in degress/hours, minutes, seconds.
4. Not $10^x$.
5. Additional features: M + x, M — x, M + $X^2$, $\pi$, change sign, $x \leftrightarrow y$.
6. Not $x^2$
7. Additional features: $x \leftrightarrow y$, $\pi$, change sign.
8. Sin x, cos x, arc tan x only: key sequences are given for arc sin x, arc cos x and tan x. (sequences of between 9 and 12 keystrokes).

**TABLE 3 PROGRAMMABLE SCIENTIFIC CALCULATORS**

| MODEL / FEATURE | DIXONS PROGRAM | HEWLETT PACKARD HP.25 | NOVUS 4515 | NOVUS 4525 | QUALITRON 1421 | SINCLAIR PROGRAMM-ABLE |
|---|---|---|---|---|---|---|
| Price | £49.95 | £119 | £99.95 | £119.95 | £45.97 | £29.95 |
| Rechargable | | ✓ | ✓ | ✓ | | Mains adaptor supplied. Not re-chargable batteries |
| Digits | 8 | 10/8+2[1] | 8 | 8/8+2 | 8 | /5×2 |
| Display | L.E.D. | L.E.D. | L.E.D. | L.E.D. | L.E.D. | Fluorescent |
| No. Keys | 36 | 34 | 36 | 39 | 36 | 19 |
| R.P.N./ALG | R.P.N. | R.P.N. | R.P.N. | R.P.N. | R.P.N. | R.P.N. |
| Stack/Bracket | 3 level stack | 4 level stack | 3 level stack | 4 level stack | 3 level stack | 2 level stack |
| Ind. Mem. | ✓ | 8 | ✓ | ✓ | ✓ | ✓ |
| Prog. Mem. (Steps) | 102 | 49 | > 100 | 100 | 102 | 25 |
| Trig | ✓ | ✓ | ✓ | ✓ | ✓ | ✓[8] |
| Rads/Degree | ✓ | ✓[2] | ✓ | ✓ | ✓ | Radians only |
| Rads/Degree Conversion | ✓ | | | | ✓ | |
| Direct Branching | | ✓ | | | | |
| Conditional Branching | | ✓ | | | | |
| Tests | | $x \geqslant 0$, $x<0$<br>$x \neq 0$, $x=0$<br>$x \geqslant y$, $x<y$<br>$x \neq y$, $x=y$ | | | | |
| Single Step | ✓ | ✓ | ✓ | ✓ | ✓ | |
| Back Step | | ✓ | | | | |
| Pause | ✓ | ✓ | ✓ | ✓ | ✓ | |
| $E^x$, 1n x | ✓ | ✓ | ✓ | ✓ | ✓ | |
| $10^x$, log x | ✓[4] | ✓ | ✓[4] | ✓[4] | ✓[4] | ✓ |
| $x^2$, $\sqrt{x}$ | ✓ | ✓ | ✓ | ✓[6] | ✓ | ✓ |
| $y^x$ | ✓ | ✓ | ✓ | ✓ | ✓ | |
| Others. | ✓[5] | ✓[3] | ✓[5] | ✓[7] | ✓[5] | |

*text conintued from page 27*
trig and inverse trig function keys. Pressing 'arc' 'sin' seems a good use of the double function key and saves two keys on the keyboard.

Whilst discussing keyboards, it is worth considering the *feel* of each key and whether there is any 'break-away' action to a keystroke or whether the key has a 'spongy' feel to it. There is particular advantage to either system and it is really a matter of personal choice, though it does seem as though the more expensive the machine, the more positive the action of the keys. Again the recommendation is to try several different models and see which you like.

In the tables it has been impossible to list every function for each model so the tables have only the main functions and the models which have, extra, less common functions have a separate note at the end of the table.

A recent feature introduced on the latest range of CBM scientifics is worthy of note, especially to electronic enthusiasts, is the provision of two keys marked 'EE↑' and 'EE↓'. These keys are used when the machine is being operated in the scientific notation to increase or decrease the value of the exponent whilst shifting the position of the decimal point in the mantissa. This feature appears to be very useful in electronic calculations when we tend to come across component values whose unit values are separated by a factor of $10^3$. Thus if a time constant calculation is being carried out and the answer comes out as a required capacitor of '$3.3 \times 10^{-10}$' Farads then by pressing the 'EE↓' key twice the display will show '$330 \times 10^{-12}$' or more simply 330pF.

As may be seen from the tables, several manufacturers are now offering statistical functions on their more expensive models. These are usually the mean and standard deviation of a set of numbers and these are very useful when handling a set of experimental results and trying to analyse some trend or conclusion from them. The one problem with statistical functions in a scientific calculator is that some of them use the calculator memories during the computation of the statistic so those memories are not available for other use during the finding of statistical functions.

Well, good luck in your research for a calculator that will meet your needs. Probably the final piece of advice that we can give is to have a good look at all the models available in your local dealers — try them all out on the same sequence of problems and see which seems to be most convenient to you — and also have a good look at the handbook supplied with the machine; it might make all the diffrence one day when you are stuck if your machine has a comprehensive handbook.

We would like to thank all those manufacturers who have assisted in the preparation of this article by supplying data and handbooks etc. A list of addresses of the major manufacturers appears at the end of this article.

## MANUFACTURERS AND AGENTS

*CASIO*
**Automatic Business Machines Ltd,
A.B.M. House,
11 Wyfold Road,
London SW6.**

*C.B.M.*
**C.B.M. Business Machines Ltd,
446 Bath Road,
Slough, Bucks, SL1 6BB.**

*DECIMO*
**Decimo Limited,
Park House,
96-98 Park Street,
Luton, Beds. LU1 3EX.**

*DIXONS*
**Dixons Photographic Limited,
Devonshire House,
Pinner Road,
Harrow.**

*HANIMEX*
**Hanimex Calculator Division,
Hanimex House,
Dorcan,
Swindon, Wilts. SN3 5HW.**

*HEWLETT-PACKARD*
**Hewlett-Packard Limited,
King Street Lane,
Winneresh, Wokingham,
Berkshire, RG11 5AR.**

*QUALITRON*
**Imtech Products Limited,
Imp House,
Ashford Road,
Ashford, Middlesex.**

*NOVUS*
**National Semiconductor (UK) Ltd,
The Precinct,
Broxbourne,
Hertfordshire EN10 7HY.**

*ROCKWELL*
**Rockwell International,
Anita House,
Rockingham Road,
Uxbridge, Middlesex, UB8 2XL.**

*SINCLAIR*
**Sinclair Radionics Limited,
London Road,
St. Ives, Huntingdon,
Cambs. PE17 4HJ.**

*TEXAS*
**Texas Instruments Limited,
European Calculator Division,
165 Bath Road,
Slough, SL1 4AD,
Buckinghamshire.**

## GLOSSARY OF SCIENTIFIC CALCULATORS TERMS

**Some of the terms associated with scientific calculators originated in the computer world and are therefore may be new to many engineers. Some of the terms commonly found in calculator handbooks and advertisements are given in this glossary together with brief explanations.**

**REGISTERS:** The names of the memories in which data is stored whilst it is being operated on or used as a longer term store known as a memory. The X register is the register that is used to hold the data that is shown in the display. Thus the X register holds the last keyboard entry during a calculation or the answer when the calculation is terminated.

The Y register is used to store the second number during those operations requiring two variables (+,—,÷,$y^x$).

**STACK:** A series of extra data registers, found especially in calculators using Reverse Polish Notation. The stack is used as a 'first-in, last-out' type of memory. Data is shifted into the stack by pressing the enter key, or by entering a new number after pressing an operational key, and is shifted down by pressing an operational key. The lowest registers of the stack are the X and Y registers described above and any subsequent registers become temporary storage registers on a non-randomly accessible basis to allow storage of intermediate results prior to their re-use with a later completing operation. Thus, access to parenthesis (brackets) is automatic upon pressing of the 'enter' key. A four level stack (X,Y,Z,t) has the capability of three levels of parenthesis (three sets of brackets).

**MEMORY:** One or more sets of data registers all of which are randomly accessible. It is often possible to act upon the data contained in the memory with the data in the X register by using keys such as M+, M—,Mx,M÷, and sometimes data in the memory and data in the X register can be interchanged by using the M↔X key. X↔Y is the key which directly interchanges the contents of registers X and Y. This key is mainly used when using the function XY, although it can also be used when interchanging the terms in a division or a subtraction.

**STANDARD DEVIATION:** A statistical measure used most often when analysing experimental data. The standard deviation of a set of data is the measure of the dispersion of data values about the mean.

**LINEAR REGRESSION:** This is a statistical function used again when handling experimental data. It is especially used when using an experiment to find a mathematical relationship between two variables. Linear regression is the name of the procedure which is used to find the line which best fits the set of data points which have been found experimentally. The procedure usually finds the equation of the straight line and also a parameter called the correlation coefficient which indicates how well the data fits the line.

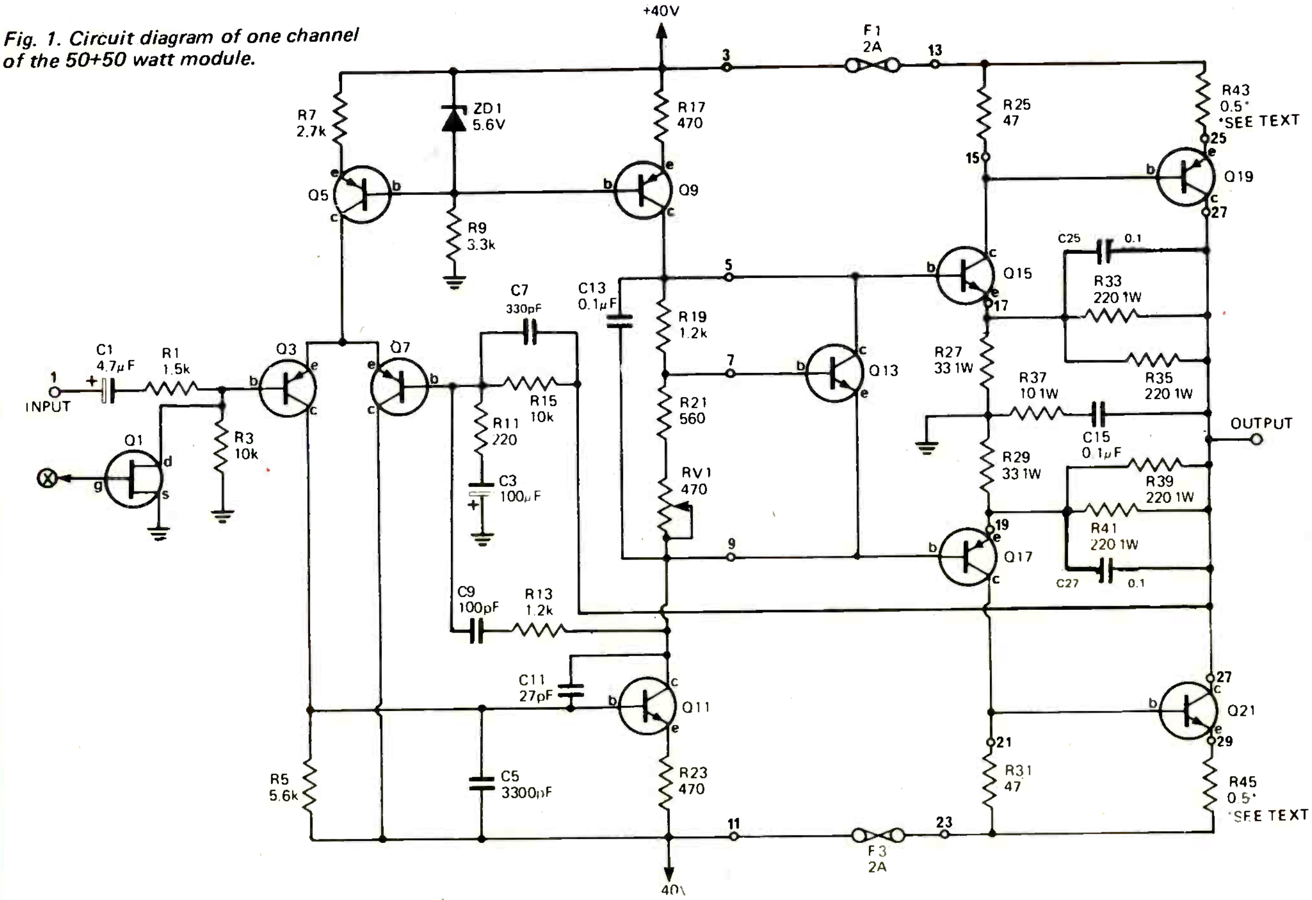
**RADIANS:** A measure of angle like the degree;1 radian = 57.3° approx, and 2πradians = 360°. Many problems use, or give results directly in radians. Thus a calculator capable of handling degrees and radians is extremely useful as is an easy conversion between the two.

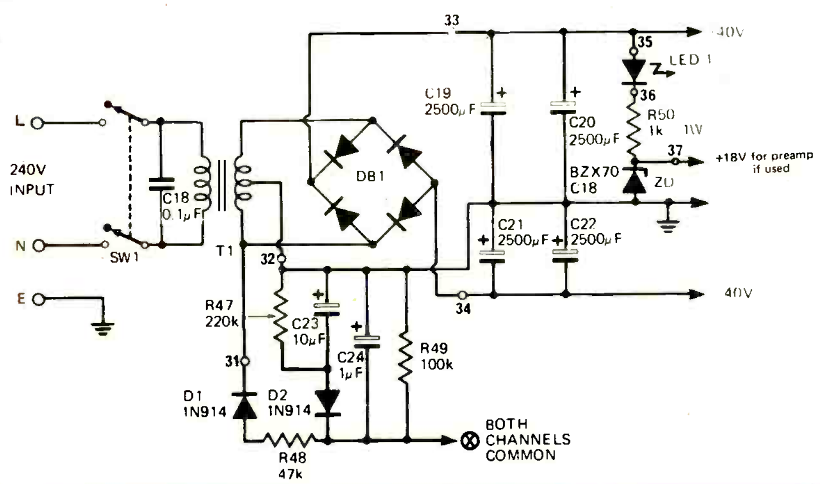
# 50+50 WATT POWER MODULE

project 422

**Details of the basic amplifier used in the Crossover amplifier. The module can be used to boost the output of a low power stereo to 50W per channel!**

*Fig. 1. Circuit diagram of one channel of the 50+50 watt module.*




**NOTES**
**Q1 2N5485**
**Q3,5,7 BC557,BC177**
**Q9,17 BD140**
**Q11,15 BD139**
**Q13 PN3643**
**Q19 MJ2955**
**Q21 2N3055**

**RIGHT CHANNEL ONLY SHOWN LEFT CHANNEL IS IDENTICAL EXCEPT COMPONENT NUMBERS ARE THE EVEN NUMBERS ie, R16 IS THE SAME AS R15**

**COMPONENTS D1,2 Q1,2 R47,48,49, C23,24 ARE FOR THE DETHUMP CIRCUITRY AND MAY NOT BE REQUIRED**

**LED 1, R50 AND ZD3 ARE USED ONLY IF THE 422 PREAMPLIFIER IS USED**

THE CROSSOVER AMPLIFIER described in this issue uses the power amplifier module out of the International 422 amplifier – described in the August 1974 issue of Electronics Today. For new readers who do not have this issue we are publishing details here.

Most of the electronics is mounted on either the printed circuit-board or on the heatsinks. The board may be assembled in accordance with the component overlay diagram given. Note that capacitors C25, 26, 27 and 28 do not have holes provided for them and they are therefore mounted directly across resistors R33, 34, 41 and 42 respectively.

The heatsink should be assembled as shown in the photograph and the drawing. The transistors Q13 and 14 should each be epoxied into a hole in one of the heatsinks to ensure good thermal contact. Also secure all leads to the heatsink with epoxy. The interconnections between the printed circuit board and the heatsink should be carried out in accordance with the wire numbering on the diagrams. Final wiring details are given in the respective separate projects.

*text continues on page 36.*

## HOW IT WORKS –

The input signal is fed via C1 and R1 to the base of Q3 which, with Q7, forms a differential pair. Transistor Q5 is a constant current source where the current is [5.6 V (ZD1) – 0.6 (Q5)]/2700 (R7) – that is about 2 mA. This current is shared by Q3 and Q7. Transistor Q9 is also a constant current source supplying about 10 mA which, if no input signal exists, flows through Q13 and Q11. The differential pair controls Q11 and thus the voltage at its collector.

The resistors R19 and R21, together with potentiometer RV1, control the voltage across Q13 and maintain it at about 1.9 volts. But as Q13 is mounted on the heatsink, this voltage will vary with heatsink temperature. Assuming that the voltage at points 5 and 9 is equally spaced about zero volts (ie ± 0.95 volts), the current will be set at about 12 mA through Q15 and Q17. The voltage drop across the 47 ohm resistors (R25 and R31) will be enough to bias the output transistors, Q19 and Q20, on slightly to give about 10 mA quiescent current. This quiescent current is adjustable by means of potentiometer RV1.

Local feedback is applied to the output stage by the network R33, R35, R39 and R41, giving the output stage a voltage gain of about four. The overall feedback resistor, R15, gives the required gain control.

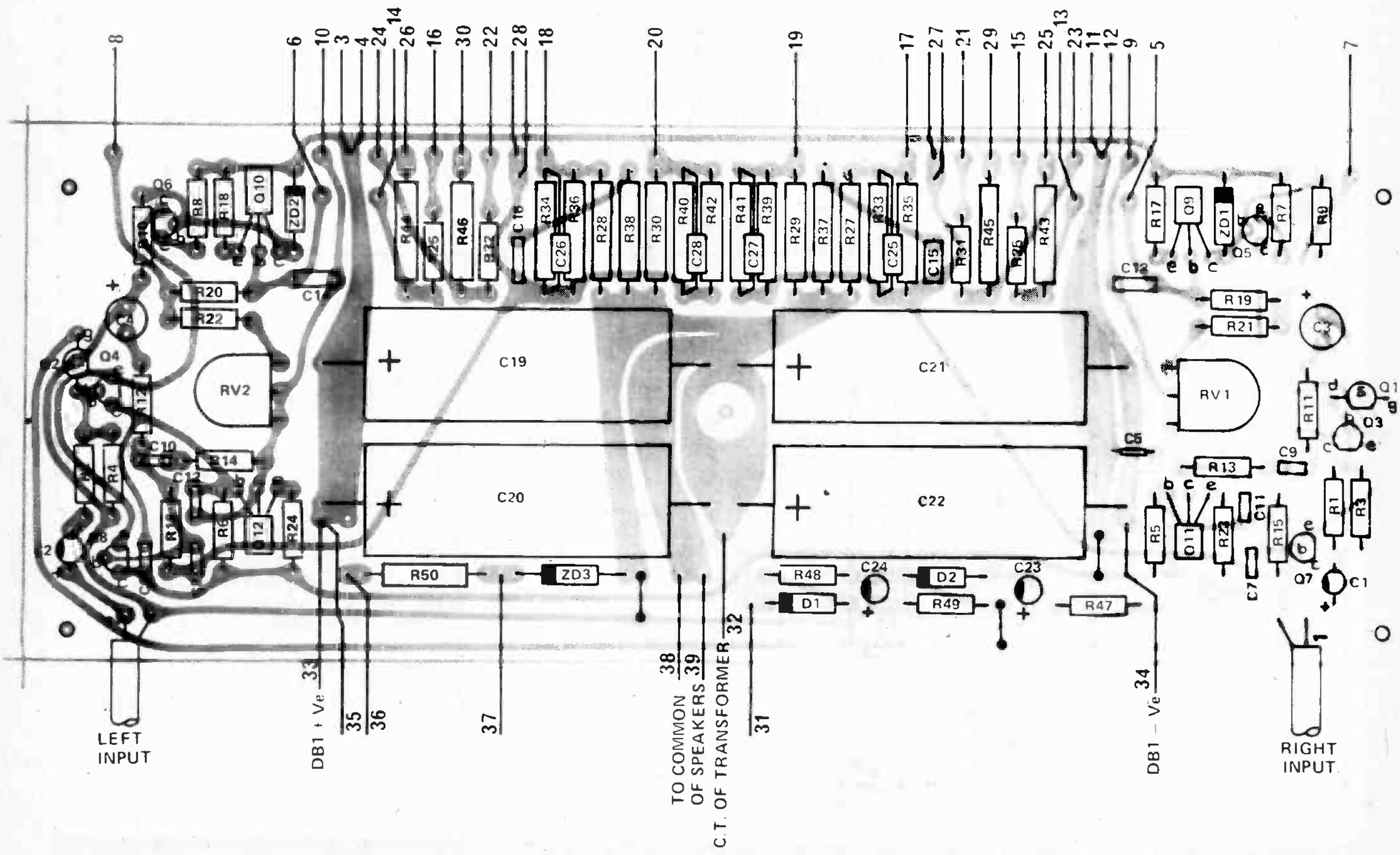
Protection to the amplifier, against shorted output leads, is provided by fuses in the positive and negative supply rails to both amplifiers.

Temperature stability is obtained by mounting Q13 on the heatsink. Q13 will thus automatically adjust the bias voltage. Frequency stability is ensured by C9/R13, C5, C7, C11, C25 and C27.

Although the power amplifier itself does not produce a thump in the loudspeakers on switch on, the preamplifier used may. To reduce any thump to an acceptable level, Q1 is used to short the input for about two seconds on switch-on and immediately after switch-off.

The power supply is a conventional full-wave bridge with centre tap, providing + 40 volts and –40 volts. Diode D1 is used to rectify a second negative supply which is used to control the FETs. Due to the resistance in series with the diode, the charge of C24 is slow. In addition, during the charge period, C23 is also being charged increasing the delay. On switch off, however, C23 cannot assist the voltage on C24 and the off-timing is much shorter than the on-timing.

*Fig.3. Component overlay.*



# 50+50 WATT POWER MODULE

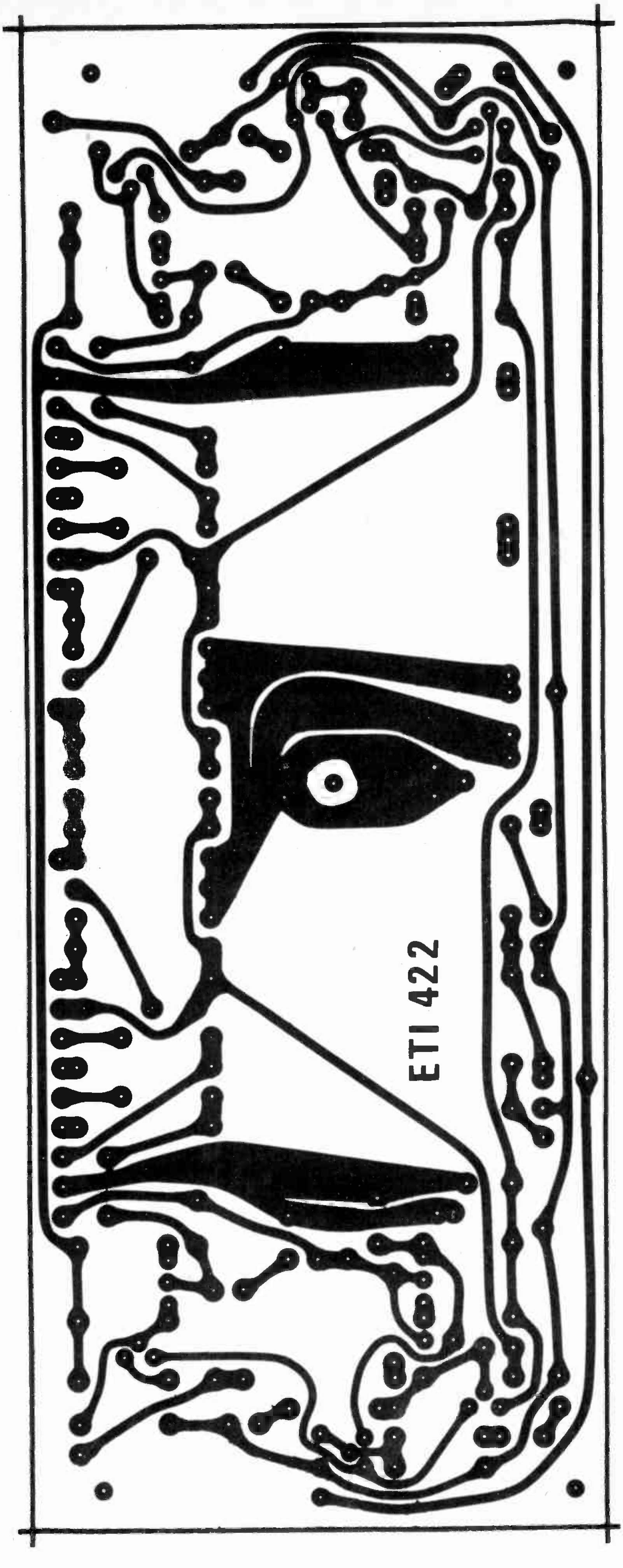



*Fig. 4. Printed circuit layout for the amplifier. Full size 255 x 97 mm.*

## PARTS LIST
### ETI 422

| | | | | | |
|---|---|---|---|---|---|
| R43,44,45,46 | Resistor | 0.5 ohm | 2W* | | |
| R37,38 | " | 10 | " | 1W | 5% |
| R27,28,29,30 | " | 33 | " | " | " |
| R25,26,31,32 | " | 47 | " | ½W | " |
| R11,12 | " | 220 | " | " | " |
| R33,34,35,36 | " | 220 | " | 1W | " |
| R39,40,41,42 | " | 220 | " | " | " |
| R17,18,23,24 | " | 470 | " | ½W | " |
| R21,22 | " | 560 | " | " | " |
| R13,14,19,20 | " | 1 k2 | | " | " |
| R1,2 | " | 1 k5 | | " | " |
| R7,8 | " | 2 k7 | | " | " |
| R9,10 | " | 3 k3 | | " | " |
| R5.6 | " | 5 k6 | | " | " |
| R3,4,15,16 | " | 10 k | | " | " |

*If difficult to obtain, these resistors may be fabricated from a short length of electric fire element—about 90mm is sufficient for each. Wind securely around a 1 watt resistor (100 ohms or higher) and solder into place.

RV1,2 Potentiometer 470 ohm Trim

| | | | |
|---|---|---|---|
| C11.12 | Capacitor | 27 pF | ceramic |
| C9,10 | " | 100 pF | ceramic |
| C7,8 | " | 330 pF | ceramic |
| C5,6 | " | 0.0033 μF | polyester |
| C13,14,15,16 | " | 0.1 μF | " |
| C25,26,27,28 | " | 0.1 μF | " |
| C18 | " | 0.1 μF | 250 Vac |
| C1,2 | " | 4.7 μF 10V | Electro- |
| C3,4 | " | 100 μF 10V | lytic |
| C19,20,21,22 | " | 2500 μF 50V | " |

| | | |
|---|---|---|
| Q1,2 | Transistor | 2N5485 |
| Q3,4,5,6,7,8 | " | BC177,2N3645 |
| Q9,10,17,18 | " | BD140 |
| Q11,12,15,16 | " | BD139 |
| Q13,14 | " | BC177 |
| Q19,20 | " | MJ2955* |
| Q21,22 | " | 2N3055* |

*with mounting hardware

ZD1,2 Zener diode 5.6V 400mW

DB1 Diode bridge min 100V PIV, 1.5A

PC Board ETI-422
F1-F4 Chassis mounting Fuse holders and 2 Amp. Fuses.
T1 Transformer 56V CT 1.5A
Heatsinks 2off 75mm of 35D or 40D (Mullard)

If the dethump circuitry is required add the following components.

R47 Resistor220 K

| | | | | |
|---|---|---|---|---|
| R47 | Resistor | 220 k | ½W | 5% |
| R48 | " | 47 k | " | " |
| R49 | " | 100 k | " | " |

| | | | |
|---|---|---|---|
| D1,2 | Diode | 1N914 | |
| Q1,2 | Transistor | 2N5485 | |
| C23 | Capacitor | 10μF 25V | electrolytic |
| C24 | " | 1μF 25V | " |

NB Heatsinks' The Mullard 40D Heatsinks are available from Syace of Blyth Road, Maltby, Yorks S66 8HZ. Quote Ref. 40D N00750A100 and send £3.24 (includes P&P and VAT) for four 75mm pieces (2 pieces, £1.64; 1 piece 85p).

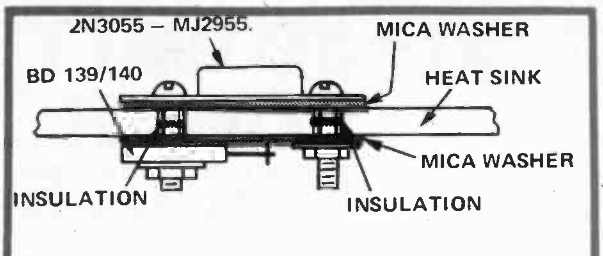
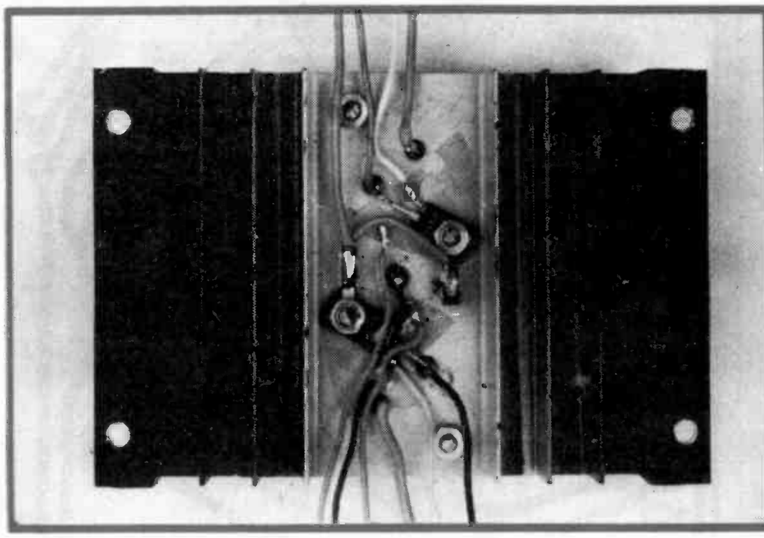
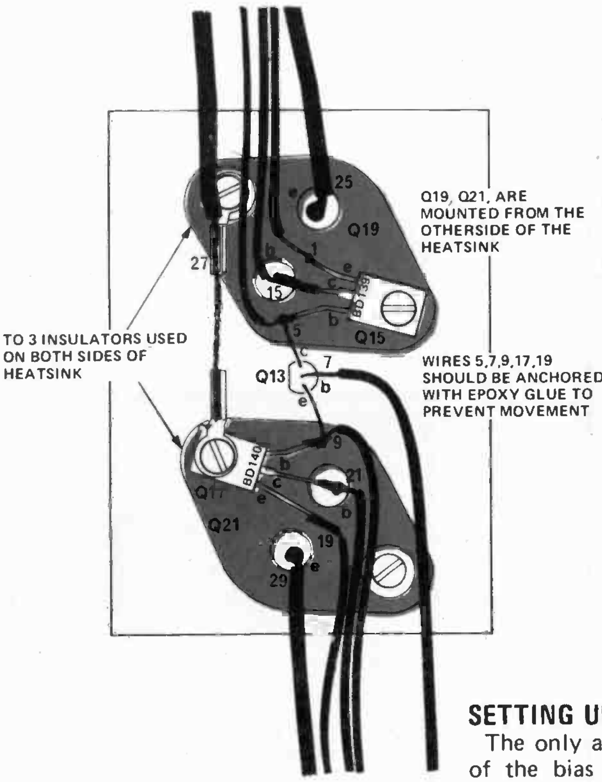



*Fig. 5. How the heatsinks are assembled.*



*How the completed heatsink assembly appears.*




## SETTING UP

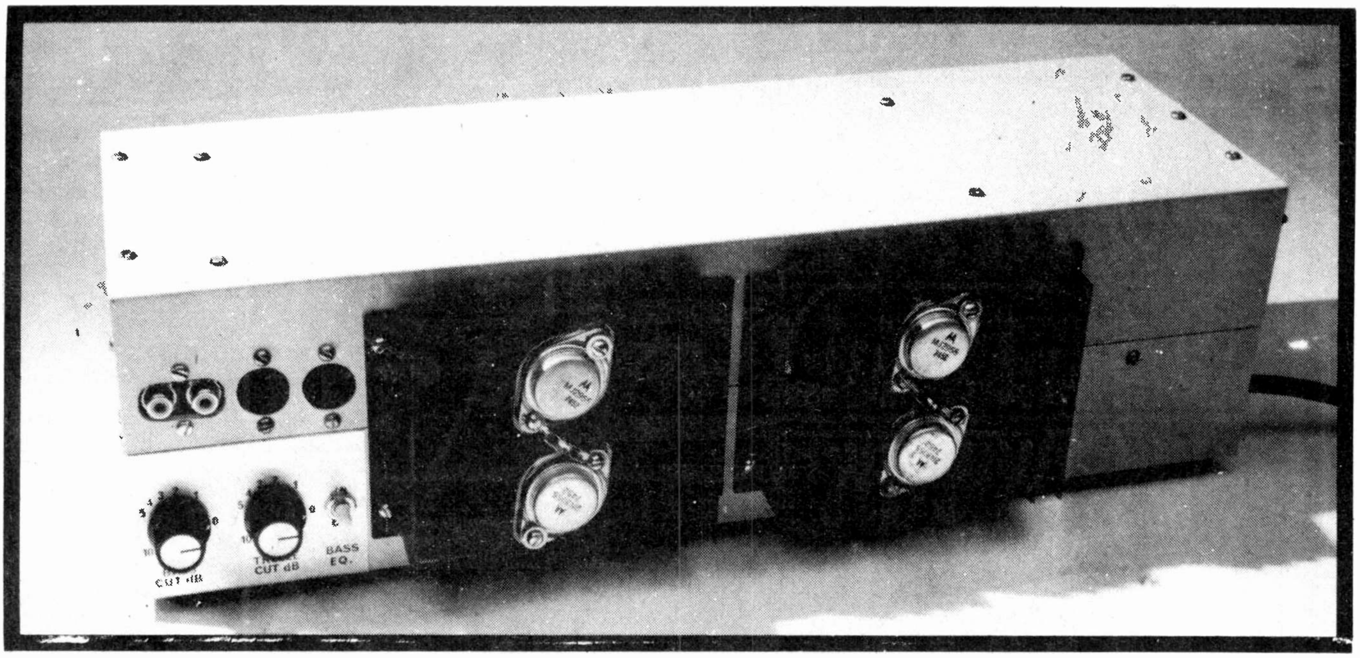
The only adjustment required is that of the bias current. This is normally done with an ammeter in the power-supply lead to the output stage and, with the speaker disconnected and no signal, RV1 is adjusted to obtain a current of about 20 milliamps. However if a major fault exists, or occurs, with the above method the meter as well as the output transistors may be damaged.

To obviate this we recommend a different approach as follows. Take out the fuses and temporarily connect a 220 ohm half-watt resistor across the fuse holder. Adjust RV1 to obtain about four volts across these resistors. If a major fault exists these resistors will get hot and possibly burn out. However no other damage will occur to the amplifier as the resistors limit the maximum current that can flow. After bias adjustment these resistors are removed and the fuses replaced.

It may be found that the voltage across the resistor in the positive lead is slightly different from that across the resistor in the negative lead. This is due to a slight offset in the output voltage but as long as the average is about four volts it will be satistactory.●

etiproject

# CROSSOVER AMPLIFIER




## One approach to an electronic crossover system.

LAST month we published the details of active-crossover boards for use with high-fidelity speaker systems. This month we give details of a typical complete system. The system described is not intended to be considered as the only possible way, merely as an example of the way in which a system may be built.

The system described uses two 422 power-amplifier modules, but any other amplifier could equally well be used eg, the 440 amplifier. A two-way system is described, that is, one amplifier is used for the high frequencies and one amplifier is used for the low frequencies for each speaker system. Thus only two two-way crossover boards are used together with the two amplifier boards and the power supply to make the complete system.

### CONSTRUCTION

We build our prototype into two pieces of channel aluminium as may be seen in the photographs. The aluminium channel used had dimensions of five inches by two inches and we used a piece 380 mm long for each side. Readers may have difficulty in getting hold of this but an equivalent can readily be made from 1.6mm aluminium bent up as required. We suggest that you make your chassis about 430 mm long as we found ours to be a little cramped.

The heatsinks used were the Mullard 35D x 75 mm and these were assembled as detailed in the 422 amplifier section. The printed circuit boards were also assembled as detailed in that section. Printed-circuit pins should be used for all connections to the board as this makes interconnection of the unit much easier.

The location of the individual modules and components can be seen from the internal photograph of the unit. If construction similar to ours is used, with the transformer close to one end of the printed circuit boards, some trouble with hum may be encountered in the main amplifiers closest to the transformer. We overcame this problem by using these amplifiers for the high channels and by reducing their bass response by changing C4 from 100 microfarad to 2.2 microfarad. With this modification the response of the amplifier will drop off below 300 Hertz, thus reducing hum, but will still be adequate for high channel use. If the high channel response is required to be lower than 300 Hertz then the transformer must be mounted further away from the amplifier modules.

Some care must be taken to prevent earth loops causing problems. The wiring of the power cables is as shown in Fig. 1, the most important being the zero volt line. The zero volt lines of both boards are linked by a heavy cable and the common side of the transformer is joined to the centre of this link. The common for the speakers is also joined to this same point. Make sure that this junction is insulated so that a short does not occur when the unit is closed up. The plus and minus 40 volts are taken to the crossover board which has the regulator on it, and the plus and minus 7.5 volts is linked between the two boards. The zero volt line for the crossover boards is taken via the signal output leads to the appropriate amplifier board.

Due to the power dissipation in the regulator for the crossover, a heatsink must be used. We simply bolted the crossover boards onto the end panel by means of a piece of angle aluminium, and bolted the transistors onto the end panel using insulating washers. We used a piece of cardboard

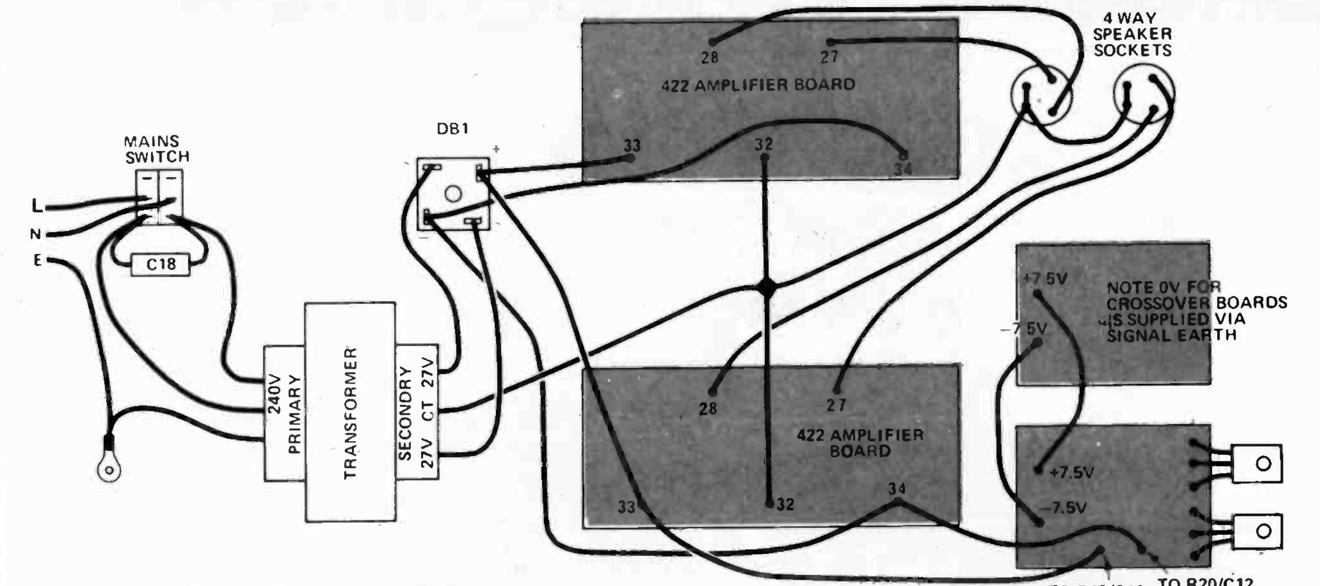



*Fig. 1. Power wiring of the crossover amplifier.*

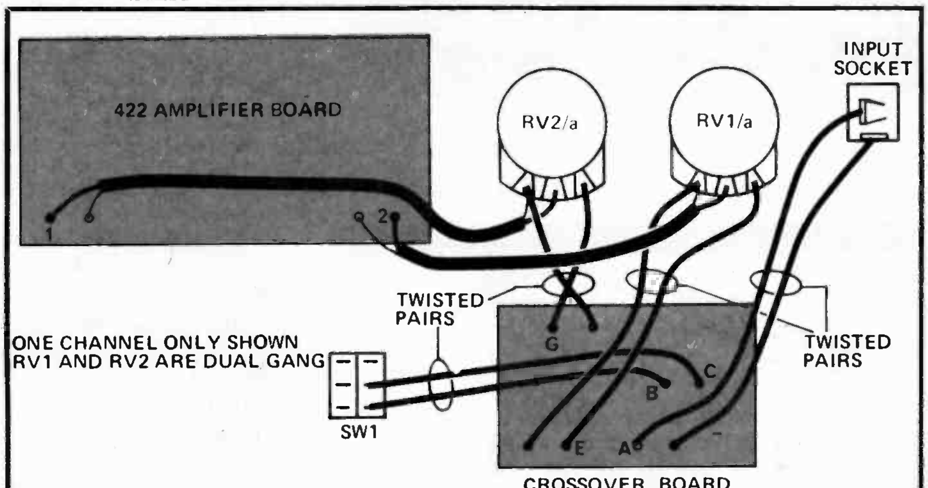



*Fig. 2. Signal wiring of the crossover amplifier.*

between the two boards to prevent any shorts occuring between the two boards. We also installed cardboard under each of the power amplifier boards similarly to protect them.

Coaxial cable was used to connect the inputs from the potentiometers to the main amplifiers but only twisted pairs from the crossover boards to the potentiometers. Coaxial cable could have been used here but was found to be not necessary as these leads are a long way from the power transformer.

Finally, a word about the power transformer. We have only used a single power transformer, as used in the 422 amplifier, to power the two complete 422 amplifier boards. But remember that the frequency spectrum is split up between the high and low channels and hence each amplifier, although called upon to provide the same peak power, only has to handle half the average power. The transformer is thus quite capable of handling the total load as the system is still nominally 50 watts per channel.

## PARTS LIST – CROSSOVER AMPLIFIER

Two complete sets of components as detailed for the 422 power amplifier module except that only one transformer and rectifier bridge is required for domestic use – especially if the crossover is above 2 kHz.

Two ETI 433A boards with the following exceptions. The transformers, D1 to D4, C11 and C12 are not required for either, and C13, C14, R19, R20, Q1, Q2, ZD1 and ZD2 are not required on the second board. The value of R19 and R20 on the first board should be 8.2 k.

Switch SW1, if required, should be a double pole switch and RV1 and RV2 should be dual gang linear potentiometers.

Chassis.

Input and output sockets as required.

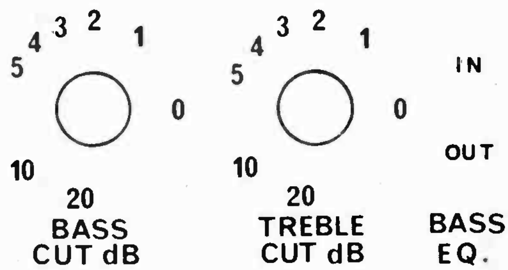



*Fig. 3. Artwork for the level control panel. Full size 73 x 50 mm.*

## ETI TIMING MODULES:

# COMPARATOR MODULE

of any Q time, to exclude 'difference' outputs which are due to switching times, etc.

The Q output of a J-K Flip-Flop (4027 (A)) is set to '1' half-way through Q0 time by Q0 and C1'. During one word (Q0 time to Q9 time) it will be reset if there are any differences between the numbers set by the BCD switches and the contents of the clock module (SR). If, however, a whole word passes with no differences between the two sets of data, Q will still be set halfway through the following Q0 time, and Q of Flip-Flop (B), the comparator alarm output, will be clocked high. This alarm output is cleared when power is first applied, and may be cleared or disabled by closing the 'clear' switch.

If the jumper connection J1 is made (indicated by a dotted line), when the alarm output goes high it will stay high until the middle of the next Q0 time, i.e. it will be high for one word time. If this output is connected to the clock module reset connection it will reset the clock module to zero, and leave it counting. This can be used to provide a programmed pulse generator with a range of milliseconds to hundreds of hours. Any number of digits between 1 and 9 can be used to 'set' the comparison time. Unspecified digits will be treated by the comparator as being zero's. As mentioned earlier, any number of comparator modules may be connected to one clock module.

Any enquiries about the three timing modules can be answered by Sintel, of 53a Aston Street, Oxford. Sintel can supply pcbs and components for these projects.

A final note about the clock module described last month. The 4020 first-stage divider should be selected for operation at 5.12MHz. All the Fairchild devices are suitable. ●

**PARTS LISTS**

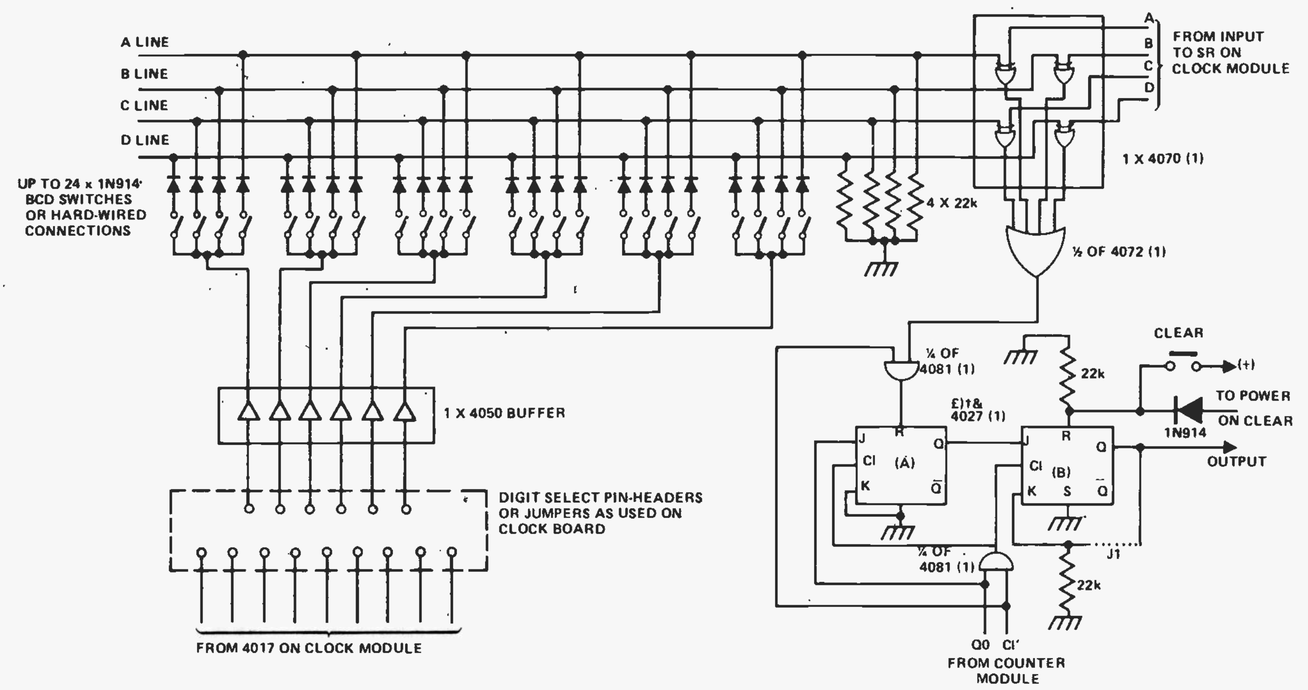
**CMOS–**
4001
4027
4050
4070
4072

**RESISTORS–**
Six 22k ¼W

**CAPACITORS–**
Five 10nF ceramic
one 4.7μF, tantalum

**DIODES–**
up to 25 x 1N914

**ALSO:** pcb ETI553, three 14 pin DIL sockets, two 16 pin DIL sockets, DIL 16 pin header, optional 22 pin LSI socket and plug, 20-way cable (6" or so), optional I/O plug, socket and cable for BCD switches.




*Circuit diagram of the Comparator Module.*

# tech-tips

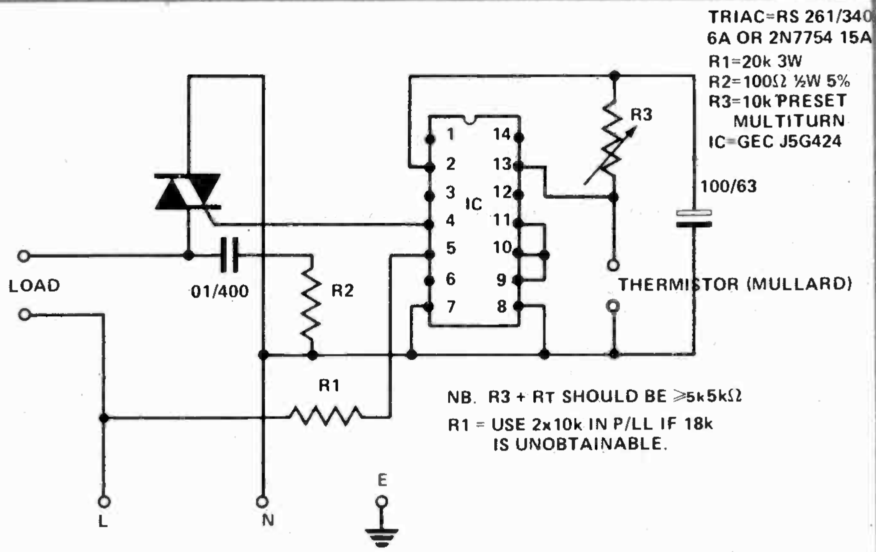
## LOW DIFFERENTIAL THERMOSTAT

This circuit evolved as a result of the need for a more satisfactory method of controlling the temperature in our paint heaters which operate at 170°F. The differential of conventional mechanical thermostats was too wide, both in actual rating and in % accuracy, so that severe overheating occurred when the demand for paint momentarily lapsed. The result was poor finish and in a number of cases the destruction of the thermometer (at approx £10 a time).

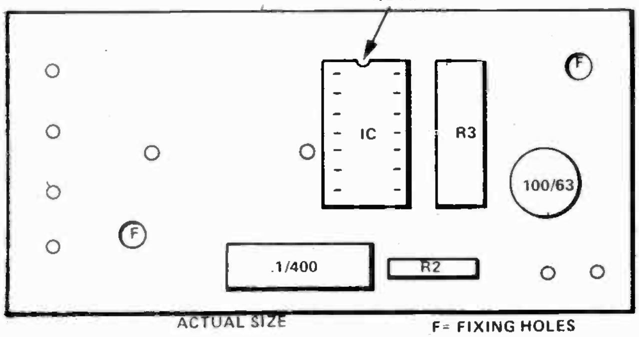
The introduction of the new thermostat completely eliminated the problem. The circuit consists of a GEC J5G424 Zero Voltage Switch in IC form together with a Mullard 2322 640 90004 which is plastic encapsulated giving it both mechanical and electrical protection. It is available in four sizes with a temperature coverage from −30 to +200°C.

The RC network, 0.1mF + 100ohms, prevents self latching of the Triac.

The J5G424 is, by nature of its design free of RFI. The type of Triac employed will depend on the loading. We were using 6 and 15 amp loads.

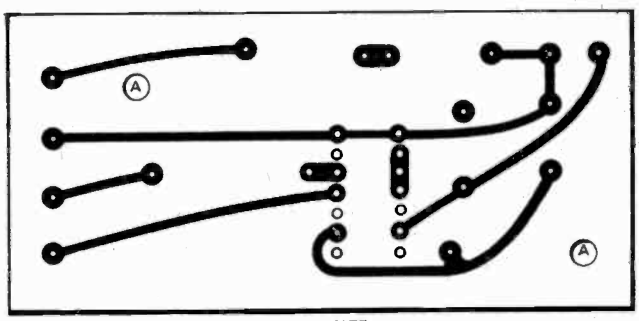



NOTE NOTCH IN I/C




ACTUAL SIZE

F= FIXING HOLES



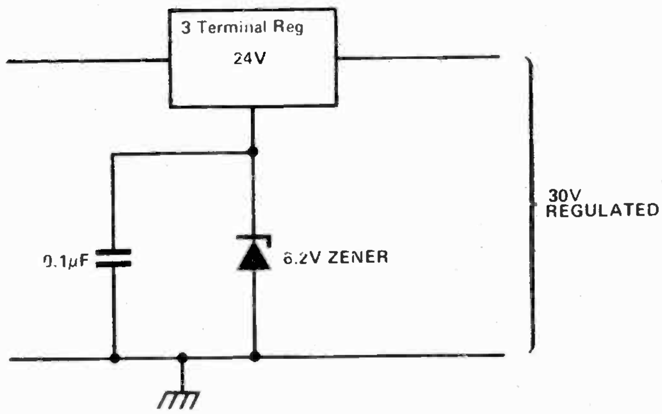

ACTUAL SIZE

This pcb is available from Ramar or Crofton (see Ad. index) for 76p including VAT & P and P.

## 30V REGULATORS

Three-terminal voltage regulators are available in 5,9,12,15,18 and 24V types. If you require a 30V supply use a 24V regulator with a 6.2V zener diode in the earth lead as shown.This increases the volatge to 30V. A 0.1μF capacitor should be connected across the zener diode as shown.

The zener should be of suitable wattage rating. In a similar manner for 27V use a 3.3V zener or for 33V a 9.1V zener.

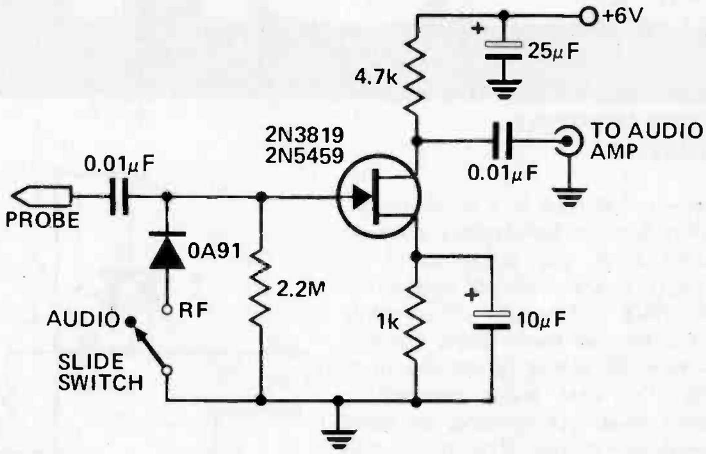


# tech-tips

## AUDIO-RF SIGNAL TRACER PRE-AMP

This economical signal tracer is very useful for servicing and alignment work in receivers and low power transmitters. It is easily constructed on a small piece of matrix board which can be mounted inside a commercially-available probe case or homemade probe. The slide switch can be mounted on the probe housing. A miniature toggle switch could be used as a substitute.

When switched to RF, the modulation on any signal is detected by the diode and amplified by the FET. A twin-core shielded lead can be used to connect it to an amplifier and to feed 6 volts to it.

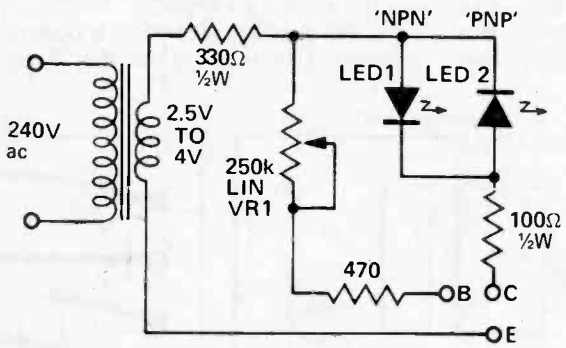


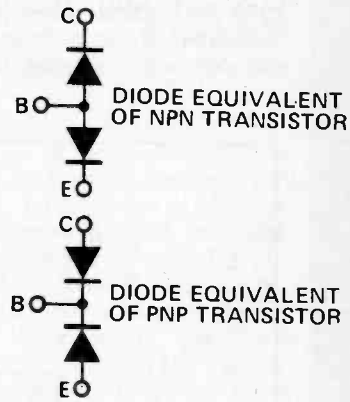

## GO/NO-GO DIODE/TRANSISTOR CHECKER

A diode can be checked by connecting it between C and E. If LED 1 lights the diode is OK and its anode is connected to C. If LED 2 lights its cathode is connected to C. If both light it is a short circuit suitable only as a link!

To check transistors with known pin connections, set VR1 at maximum resistance and connect the transistor. Advance VR1 until one LED lights. If LED 1 lights it is NPN, PNP if LED 2 lights. If both light you have a three-legged link. If neither light you have a three-legged fuse!

To check transistor connections, if unknown, short two of its leads together and check as for a diode making note of which lead/leads respond as anodes. Short two other leads together and do it again. Refer to diagrams above.



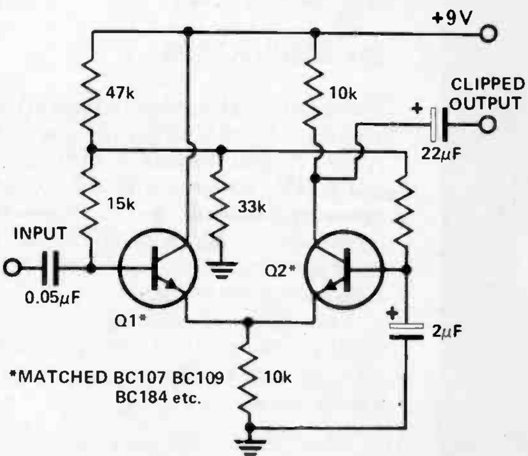

## TINNING WITH SOLDER WICK

Do not discard the lengths of solder saturated solder wick. Further use can be made of them to plate printed-circuit boards by pre-tinning the joints, prior to inserting components and soldering.

The simple operation is as follows — place the saturated solder wick on the printed board and apply a heated soldering iron to melt the solder in the wick. At the same time, move the wick and iron along sections or joints requiring tinner. A neat plated copper print will result.

## PRECISE AUDIO CLIPPER

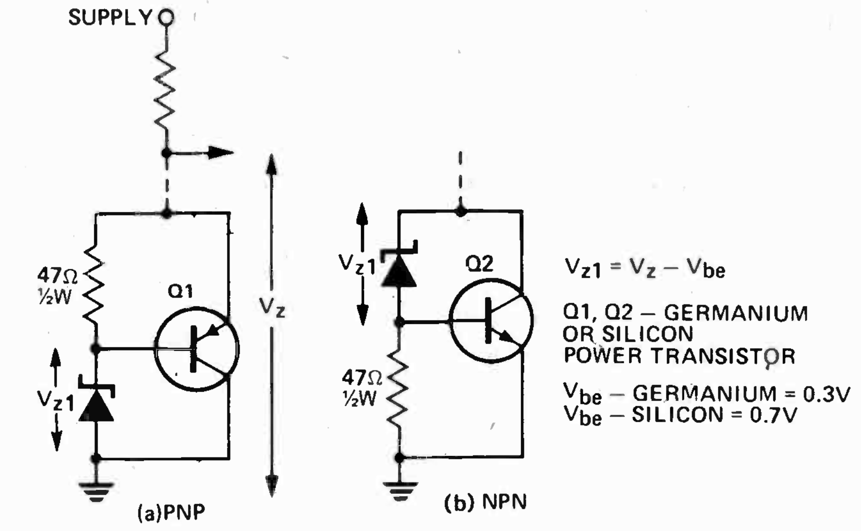
A differential amplifier makes an excellent audio clipper and can provide precise, symmetrical clipping. The circuit shown commences clipping at an input of 100 mV. The output commences clipping at ±3 V. Matching Q7 and Q2 is necessary for good symmetrical clipping, however, if some asymmetry can be tolerated this need not be done.



## HIGH-POWER ZENERED VOLTAGE FROM LOW POWER SOURCES

A power transistor can be used to provide a high power zenered voltage from a low wattage zener. A 400 mW zener can be used where a 10 watt zener is required or a 1 W zener can be used where a 50 to 80 watt zener is required, by using appropriate transistors for Q1 and Q2 in the circuits shown.

Where low rating is required Q1 would be a ASZ 15 (germanium) or an AY9140 (silicon). Q2 could be a 2N3054 (silicon). For higher powers Q1 could be an ASZ18 (germanium) or a 2N2955 (silicon) and Q2 a 2N3055 (silicon) or an AY8149 (silicon).

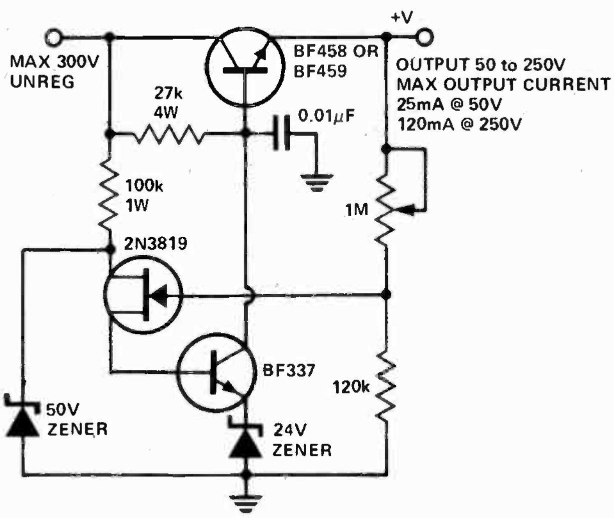



A heatsink on the transistor is required. The circuit in (a) has the advantage that power transistors can be bolted directly on to a chassis which may serve as a heatsink.

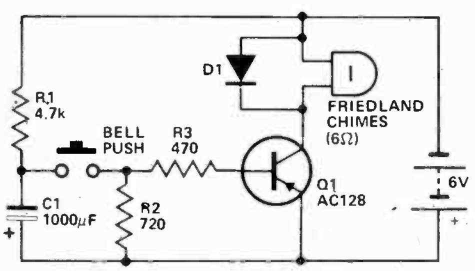
## VARIABLE, HIGH VOLTAGE REGULATOR

This regulator is ideal for SSB linear amplifier tube screens. It would also have application in the repeller supply for a reflex-klystron microwave oscillator. CRO deflection amplifier supply is another possible application.

Regulation is about 0.5%. The output transistor will need to be mounted on a small, insulated heatsink. A BF459 is preferred (30V Vceo) as the BF458 is sailing a bit close to the wind when the output is down to 50 V.




## DOORCHIMES DELAY




Ever get tired of people who repeatedly press your doorbell?

With values shown, this simple circuit will permit one operation every 10 seconds or so. Capacitor C1 charges through R1 when the button is released. Making R1 larger will increase the delay.

## FLICKER-FREE FLUORESCENT STARTING

Here is an extremely simple, yet effective modification which will eliminate the annoying flickering when a fluorescent lamp is first switched on.

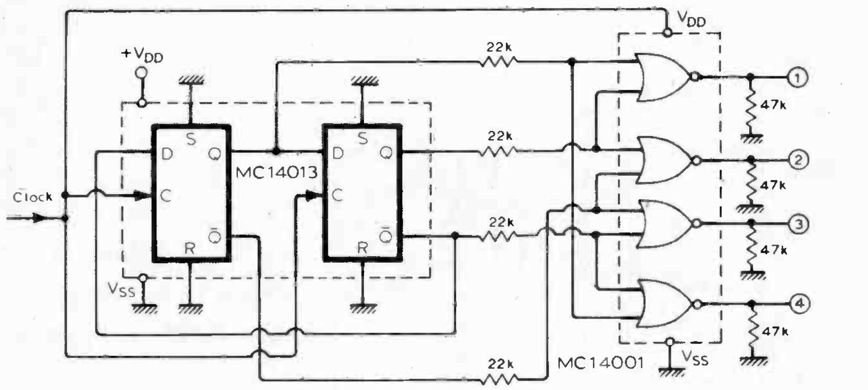
The modification consists of inserting a diode (P.I.V. about 600 V) in series with the starter. This results in a fairly heavy current on initial switch-on, which heats the filaments quickly. When the starter contacts open again, the lamp fires immediately.

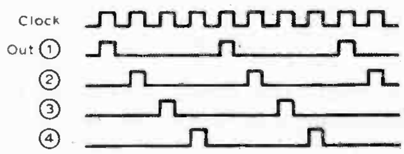
NOTE: The effectiveness of the modification, depends largely upon the characteristics of the starter; try and find one that is quick-acting.

My original unit has been working successfully in my desk lamp for the past three years, and I've had no problems with dc magnetisation of the ballast, or excessive power consumption on switch-on.

# tech-tips

## MULTIPHASE CLOCK GENERATOR

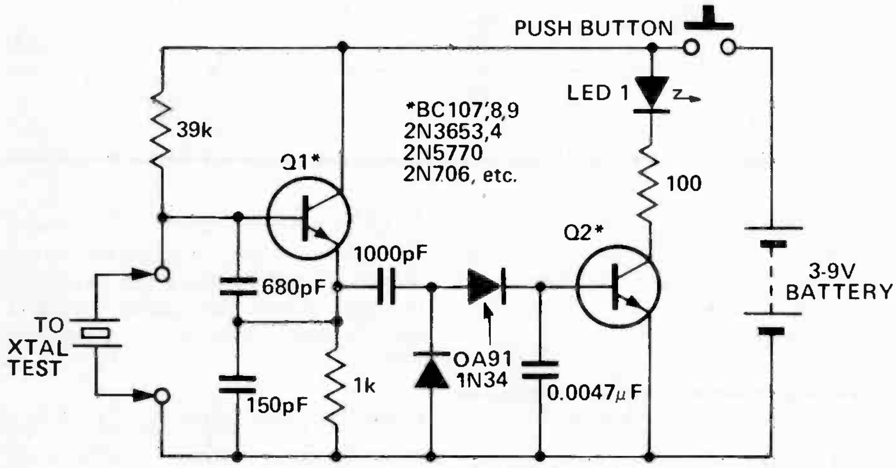



Whenever sequential logic operations are to be performed, a multiphase clock generator is often required. The circuit shown, which uses only two CMOS ICs, was designed by Michel Burri of Motorola's Geneva applications laboratories. It will produce a pulse on each of the four output lines in turn. These pulses do not overlap one another.

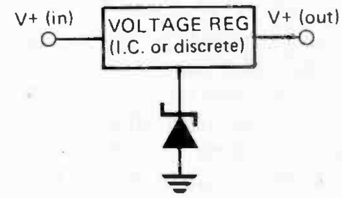
Operation of the circuit is self-evident from an examination of the schematic; however, it is interesting to note that the power supply of the MC14001 is derived from the clock input. The maximum operating speed of this circuit is about 1 MHz.

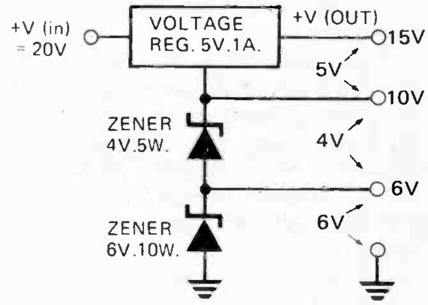
## CRYSTAL CHECKER




For checking fundamental HF crystals on a 'Go-No-Go' basis, the above circuit works quite well, An untuned Colpitts oscillator drives a voltage multiplier rectifier and a current amplifier. If the crystal oscillates, Q2 conducts and the LED lights. A3 or 6V, 40mA bulb could be substituted for the LED.

## ZENER BOOSTS OUTPUT VOLTAGE OF REGULATOR




In this circuit the zener diode raises all voltages — with respect to earth — by the zener voltage, i.e.

Vin (max) ≙ voltage regulator Vin (max) + zener voltage

Vin (working min) ≙ voltage regulator Vin (min) + zener voltage

Vout = voltage regulator Vout + zener voltage

As the voltage regulator dissipates all excess power while the zener merely clamps the output voltage above its own voltage, a low wattage zener (250 mW) should be adequate — unless lower voltage taps are used, as in the second example in which the total output is one amp.

For other value zeners, wattages can be worked out by the formula W = zener voltage X current.

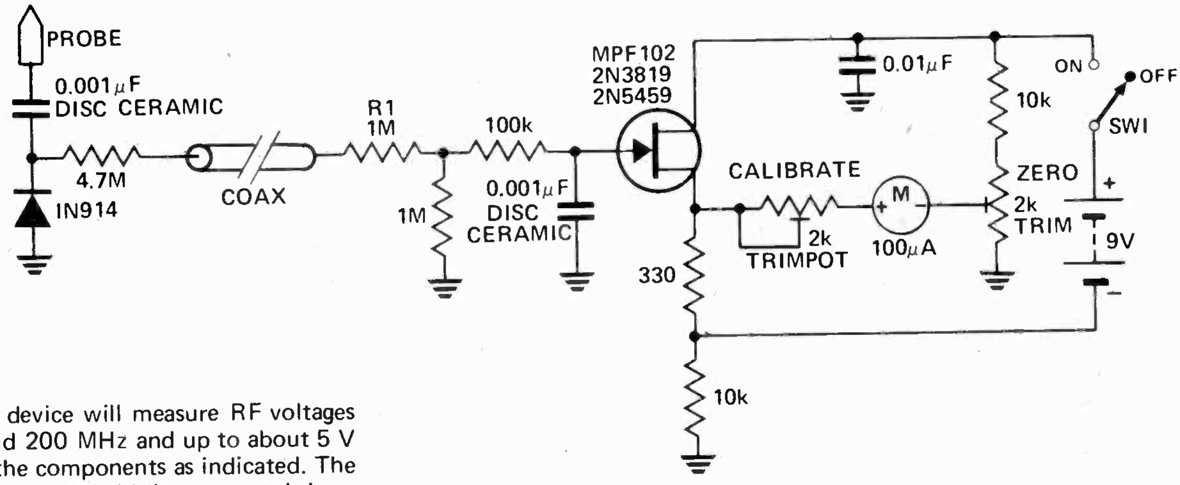
## COLOUR CODING COMPONENTS

The resistor colour code can be extended for use in codifying all manner of other components.

Zener diodes for example can be thus coded once their parameters have been established. Similarly it assists when building a unit to mark the leads of transformers, coils transistors etc with short lengths of coloured insulating spaghetti. If for example one has a centre-tapped transformer then — from the top of the winding inwards — the code could be top = brown, centre = red, bottom = orange.

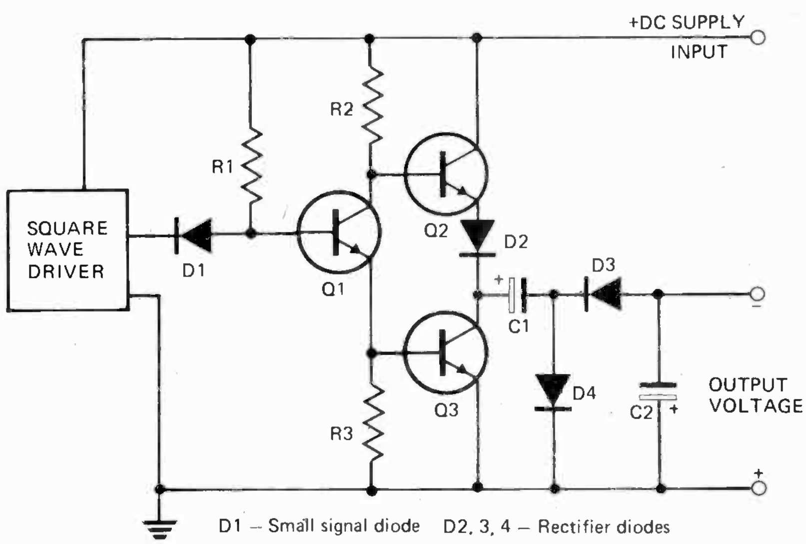
With a transistor base (B) = 2 = red; collector (C) = 3 = orange; emitter (E) = 5 = green. Just follow a numerical sequence equating numbers with letters of the alphabet.

## SENSITIVE RF VOLTMETER




This device will measure RF voltages beyond 200 MHz and up to about 5 V with the components as indicated. The diode etc should be mounted in a remote probe, close to the probe tip. Sensitivity is excellent and voltages less than 1 V peak can be easily measured. The unit can be calibrated by connecting input to a known level of RF voltage, such as a calibrated signal generator and setting the calibrate control. The output indicates in RMS. As it is it reads about 2 V RMS full scale. This can be increased to 20 V or more by increasing R1 to 20 M (two 10 M in series). The 100 µA meter could be a multimeter if desired.

## TRANSFORMERLESS INVERTER




D1 – Small signal diode  D2, 3, 4 – Rectifier diodes
Q1 – Small signal N.P.N.  Q2, Q3 – Output transistors

This transformerless inverter chops the dc supply voltage then rectifies the resulting square wave using a conventional voltage doubling circuit.

The square wave source can be a simple IC multivibrator which is used to drive phase splitter Q1 through coupling diode D1. Base bias is established through R1 and the collector and emitter load resistors are R2 and R3 respectively.

The output power transistors Q2 and Q3 in conjunction, with diode D2, serve as a simple high/level switch developing a square wave whose peak to peak amplitude is near that of the dc supply voltage.

The output square-wave is coupled via C1 (which must be a suitably chosen high-value electrolytic) and fed into a voltage doubler circuit thus producing a dc output of reverse polarity.

Capacitor C2 is the output ripple filter.

Resistor values are dependent on the original supply voltage – the drive frequency is not critical but signals in the kilohertz region are preferred (2-6 kHz).

## HOME-MADE LDR

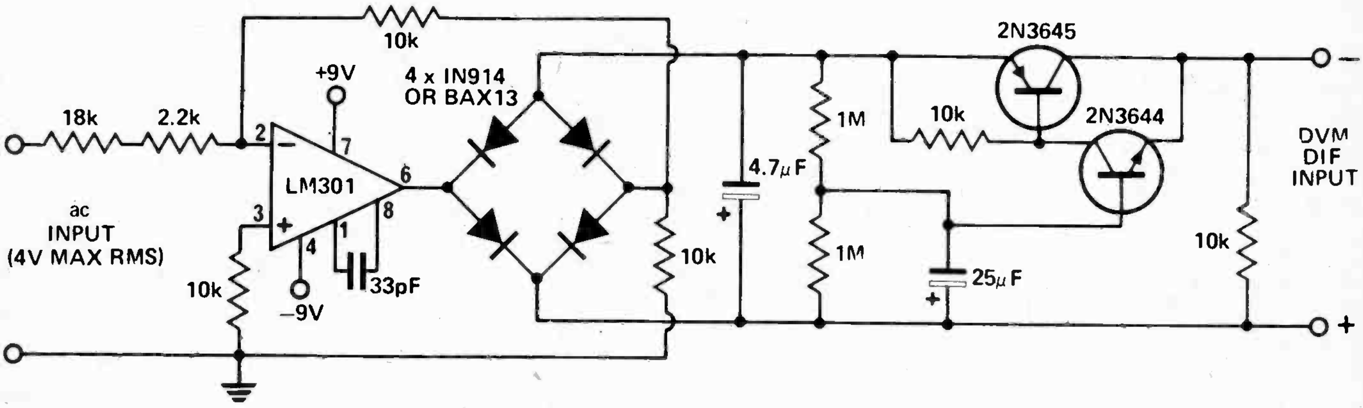
I had to find a cheap and easy way to improvise for an LDR or photo-transistor. I took several medium power silicon transistors from my surplus box and carefully cut off with a saw and filed the top part of the can, exposing only the silicon chips. They worked quite well as substitutes for LDRs or photo-transistors.

For use as an LDR use only the collector and emitter legs. As a photo-transistor use all three legs – emitter base, collector.

In some circuits the component values need not be changed, while in others a change is necessary for the circuit to work.

High powered silicon transistors also give a similar effect but they are costly unless found in the surplus box. Germanium transistors cannot be used because of the 'grease' present in them.

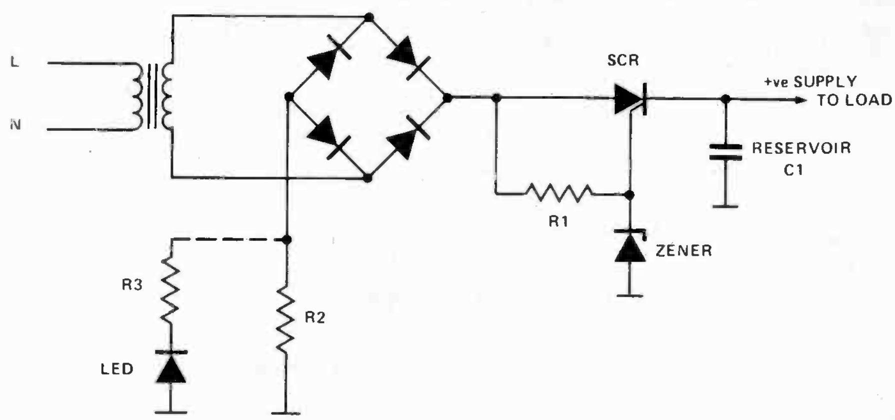
## MEASURING RMS VALUE OF AC WITH A DC DVM




The above circuit may be used for measuring the RMS value of ac (sinewave) with a dc digital voltmeter. It has a frequency response to beyond 10 kHz and will measure signals as low as 400 mV. The error rises at low frequencies, somewhat below 50 Hz, to about 4% mean. The LM301 supply may be as low as ± 4V. or up to ±15V, if desired, with reduced sensitivity at the lower voltage.

The DVM input must be floating and a differential input is required. To increase the input range a step attenuator may be used.

## 'BUCKET' REGULATOR




There are a number of applications where a simple cheap form of regulated power supply, giving a supply regulation of the order of 5–10%, is useful. One such application is the class B audio amplifier. The cost of the additional components required to achieve regulation is more than offset by the saving in cost and size of the electrolitic capacitors alone.

Fig. 1. shows the circuit of the regulated supply. The only additional components required to affect regulation are the SCR, R1, and the zener.

At switch on the the reservoir C1 is discharged and the cathode of the SCR is at zero volts. The positive going output from the bridge rectifier will cause gate current to flow via R1 triggering the SCR. The reservoir C1 starts to charge. At the end of the half-cycle the SCR will turn off.

The following half-cycles will repeat the process charging C1 until the supply voltage approaches the zener voltage. However the maximum positive potential at the SCR gate is determined by the zener, so there comes a time when the reservoir will have charged to the point where the SCR gate cannot be driven positive with respect to its cathode. At this stage the SCR will stop firing and no further charging current will be delivered to the reservoir. The reservoir will discharge via the load, whatever power is being supplied, until the gate is once more positive, when the SCR will fire again. One or more half cycles are sufficient to raise the reservoir voltage sufficiently to prevent further firing.

Thus the SCR fires as necessary to keep the reservoir "topped up" and it is this topping up action which gave the regulator its name. The number of times it fires in any particular interval being dependant on the load current taken from the supply.

There are two particularly attractive features of this type of supply. First its efficiency is high, there are none of the power losses associated with either series or shunt regulators.

The second is that it is possible to obtain very simply an indication of the current being delivered, This may be obtained by connecting a LED (in series with a current limiting resistor R3) across the main current limiting resistor R2. The LED will flash each time the SCR conducts and hence the rate at which the flashes occur will depend on load current, the flash rate varying from once every few seconds when only leakage is being made good - to continuously under full load conditions.

As an indication of circuit values the following where used for a 25V, 1.5A supply: R1=1.2k, R2=2Ω, R3=330Ω, C1=5000μF, 25V, Transformer 30V.

The SCR and bridge rectifier should be rated at full load current, but for many music and speech applications the transformer can be derated as much as 50%.

## SOUND EFFECT GENERATOR

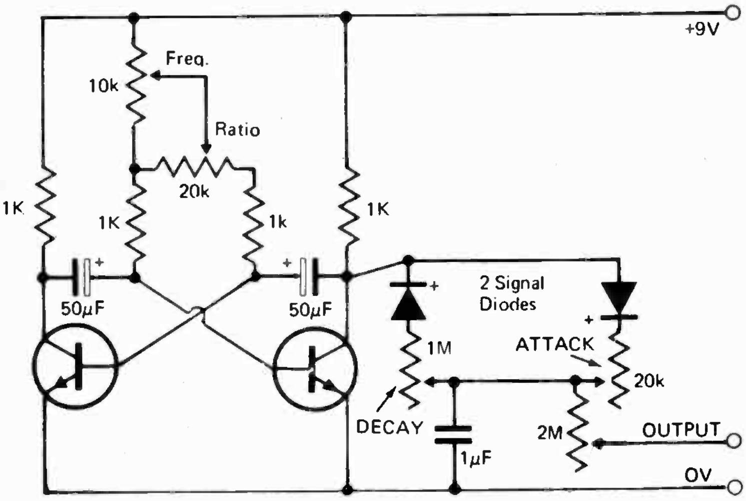



FIG 1

FIG. 2

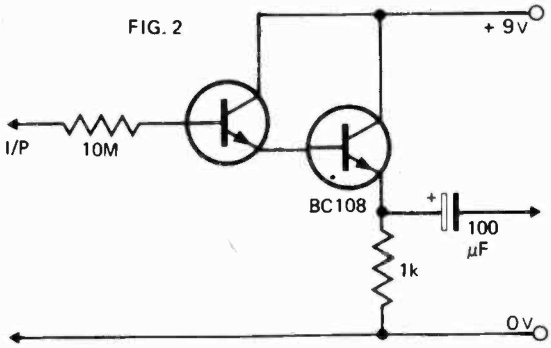
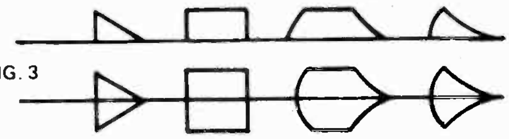



FIG. 3



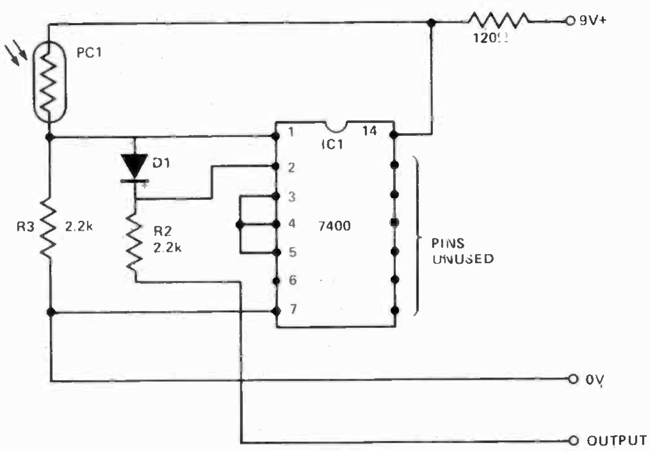
AFTER MODULATION

The waveshape generator shown in this circuit will interest those readers experimenting with sound effects.

Basically the circuit is a slow running oscillator with variable attack and decay. A variable amplitude (high impedance) output is available via the 2 meg potentiometer. Figure 2 shows an add-on circuit which should be used if a low impedance output is required.

Some of the output waveforms that can be produced are shown in Fig 3.

## INTRUDER ALARM

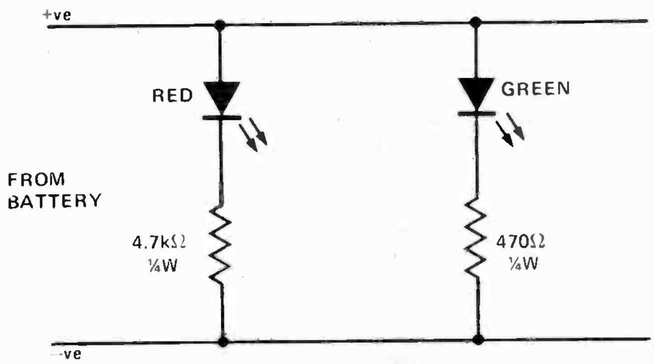



Here two gates of a 7400 are used to provide photoelectric control in conjunction with an ORP 12 photocell. When light falls on PC1 the potential is applied to the trigger circuit consisting of ½ the 7400. The feedback provided ensures a positive output change at pin 6. The output, whilst PC1 is under illumination, is equal to the supply voltage. R1 enables a small 9V battery to be used. If PC1 is shaded the output at pin 6 is 0V. This may now be used to trigger a relay for an intruder alarm. If this is the case it is wise to use a small mains supply and to incorporate a diode across the relay coil, to prevent high back EMF from destroying the IC.

## GOOD/NO GOOD BATTERY TESTER

This is a simple tester for use with a PP3 or similar battery.

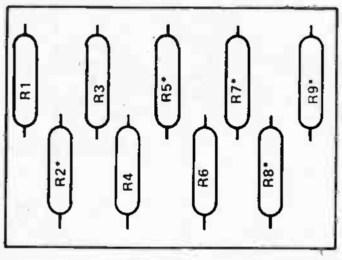
It is wired to a PP3 battery clip remembering that red is connected to −ve of battery and black to the +ve. It uses 3 small LEDs of the same size: one red, one green. Due to the fact that the green LED needs a far greater current, the green will glow only if the battery is in reasonable condition. The red will glow even if battery is down. If the red glow is very faint the battery is no good.



# tech-tips

## ELECTRONIC LOCK

* REPRESENTS REED SWITCHES THAT HAVE TO BE TURNED ON I.E. MAGNETISED




REED SWITCHES ARE SHOWN IN ONE ROW IN CIRCUIT DIAGRAM BUT SHOULD BE WIRED AS SHOWN ABOVE TO AVOID CROSS TRIGGERING BY CLOSE REED MAGNETS

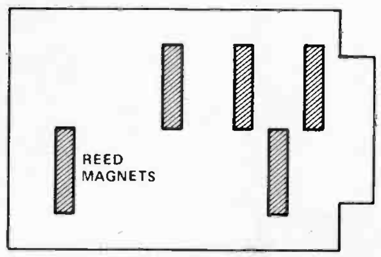
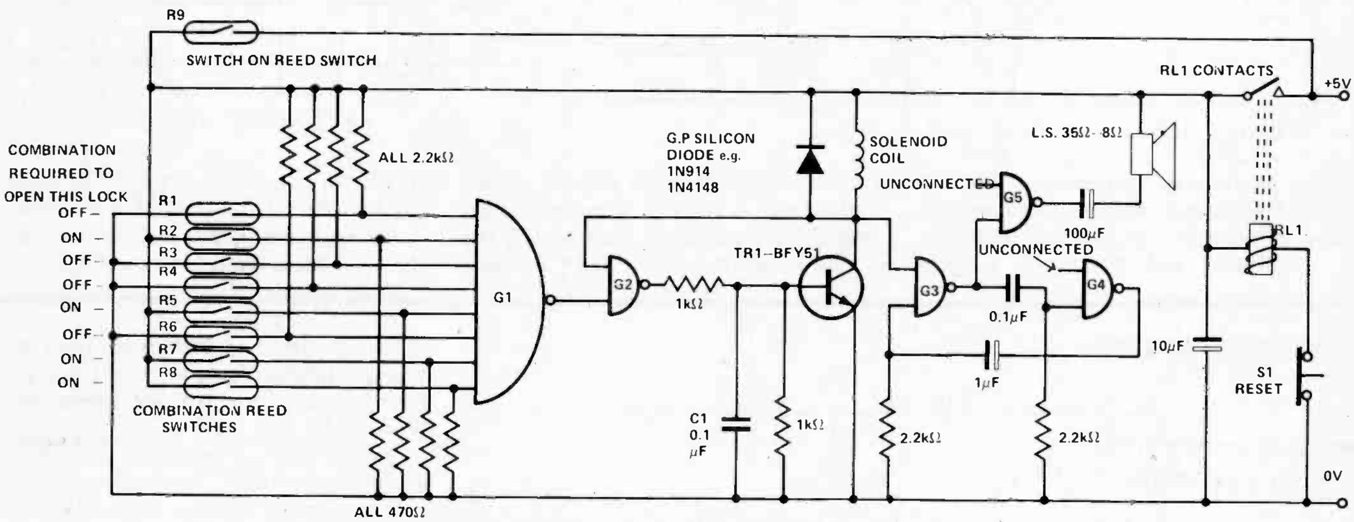



DIAGRAM OF KEY NEEDED TO OPEN THIS LOCK




NOTE G1 = SN7430 8 INPUT NAND GATE I.C. G2,G3,G4,G5 = SN7400 QUAD 2 INPUT NAND GATE I.C.

This device enables a solenoid to be switched on by means of an electronic key. If the correct key is used the circuit will latch, but if an incorrect key is inserted a warning tone rings until the correct key is used. The circuit has automatic switching to turn it on, but this can be replaced by a conventional ON-OFF switch if desired.

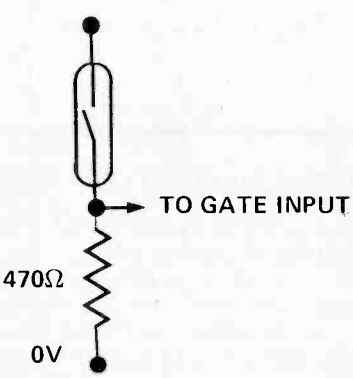
The main element of the circuit is G1 the eight-input NAND gate. If all inputs of the NAND gate are high (achieved by closing the right combination of reed switches) the output will be low. The low output is fed to G2 forcing its output high which turns on TR1 energising the solenoid coil. At the same time a low is fed, back from TR1's collector to G2's other input latching it. Thus once the solenoid is energised the key may be removed. C1 (0.1μF) ensures that TR1 is always 'off' on switch-on of the circuit.

TR1's collector is also connected to G3's input which along with G4 forms a multivibrator. When TR1's output is low the multivibrator is dis-enabled. However if an incorrect key is used TR1's output will be high and the multivibrator will oscillate. G5 acts as a buffer to drive a loudspeaker.

R9 with RL1 forms the automatic switch on circuit. When R9 is closed RL1 is energised pulling in it contacts to permanently connect the supply. If R9 is opened after this the circuit continues to operate. This means if an incorrect key is used and R9 is closed the alarm tone will continue to ring even if the key is removed.

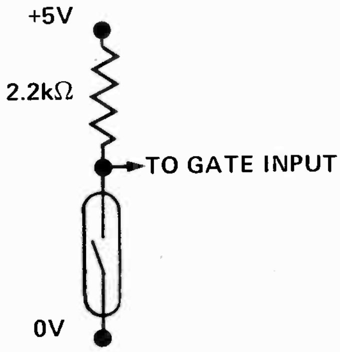
Nine reed switches are used in the circuit. One to switch on the circuit and the other eight to provide the correct input combination. The lock opens only if all eight inputs to the NAND gate are high. To do this the circuit is wired so that some reed switches must be on and some **must be off**. The eight reed switches give $2^8 = 256$ possible combinations.

Reed switches that have to be turned on are wired like this




If the reed switch is not closed the 470Ω will pull gate input to low and the lock will not open.

Reed switches that have to be left open are wired like this

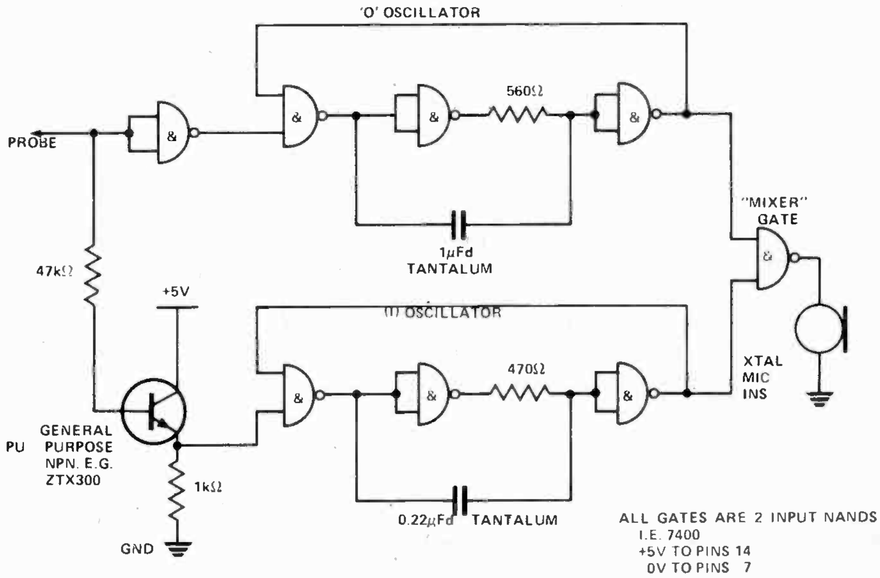



If the reed switch is closed it will put gate input to low and the lock will not open.

If preferred the reed switches could be replaced by simple ON/OFF switches then the circuit would act as a combination lock, like a tumbler lock.

The construction of the circuit is in no way critical. Veroboard provides a relatively cheap mounting. The connections of Vcc and gnd to the two ICs should not be forgotton!

## AUDIBLE TTL PROBE

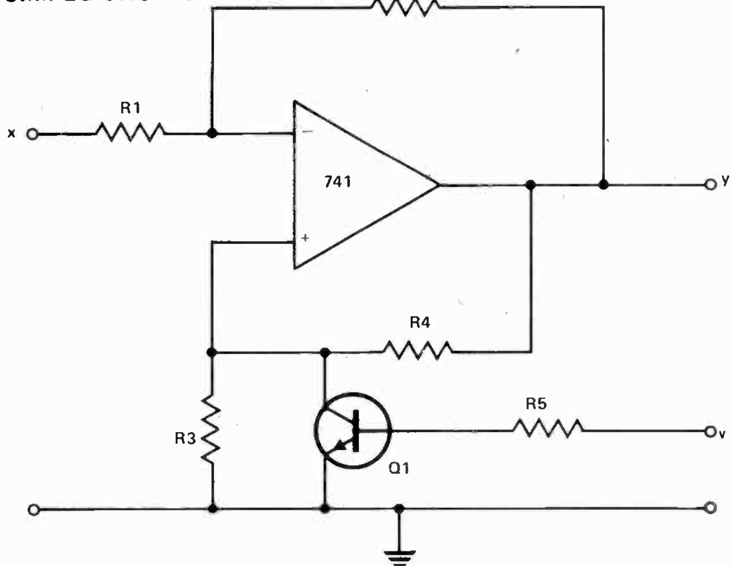


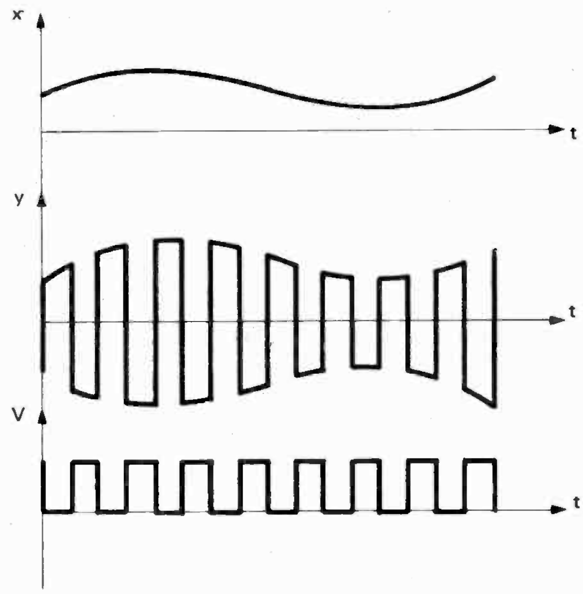

With many LED TTL logic probes it is difficult to watch the LEDs and the circuit one is testing. The following circuit is an attempt to produce a new sort of probe.

When the probe is in contact with a TTL low (0) the probe emits a low note. With a TTL high (I) a high note is emitted.

The whole circuit uses only two TTL ICs and several auxiliary components. This low component count makes it easy to miniaturise the unit. The power is supplied by the circuit under testing so no battery is required.

## SIMPLE CHOPPER




The circuit shown is a simple amplifier, the gain of which can be switched between two precisely controlled values by the application of a signal voltage: V. If V is such that Q1 is saturated, then the voltage gain of the circuit is simply $-\frac{R2}{R1}$. If the transistor is cut off, then the voltage gain becomes $(1+\frac{R3}{R4})/(\frac{R3}{R4} - \frac{R1}{R2})$.

One obvious application of the circuit is if the resistors are adjusted such that the two gains are equal in magnitude, but opposite in sign, (e.g. R1 = 20k, R2 = 10k, R3 = 50k, R4 = 10k gives voltage gains of +2 and −2) Then the circuit could be used as a chopper for the input of a DC amplifier.

The value of R5 is largely arbitrary, depending on the magnitude of the chopper signal, V. Its sole purpose is to prevent excess current being drawn by the base of Q1. Suitable components for the op amp and transistor are the 741 and BC182L.

# tech-tips

Tech-Tips is an ideas forum and is not aimed at the beginner. We regret we cannot answer queries on these items.

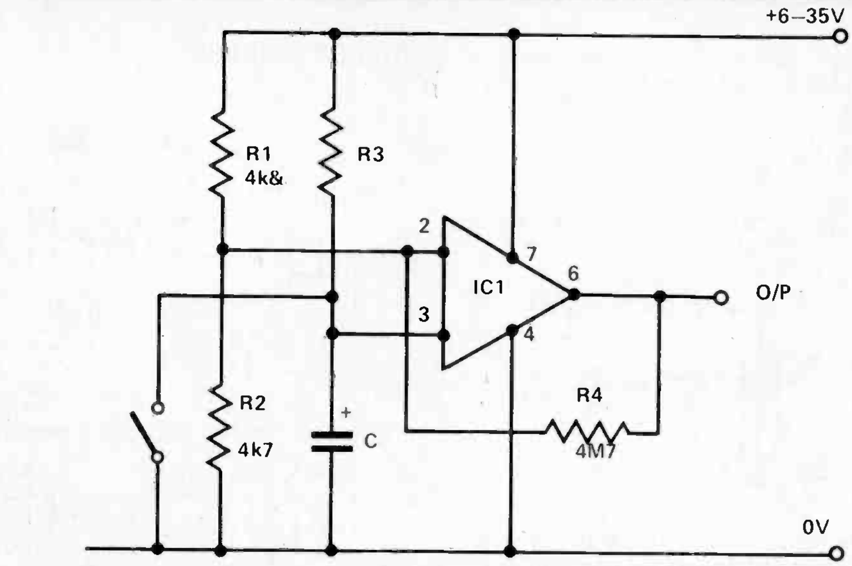
ETI is prepared to consider circuits or ideas submitted by readers for this page. All items used will be paid for. Drawings should be as clear as possible and the text should preferably be typed. Circuits must not be subject to copyright. Items for consideration should be sent to ETI TECH-TIPS Electronics Today International, 36 Ebury Street, London SW1W 0LW.

## 741 TIMER

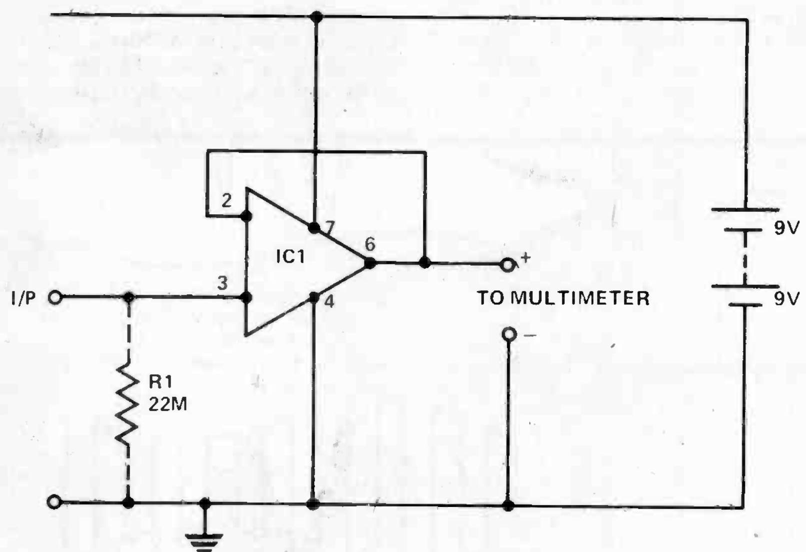
The circuit shows a very simple timer based on a 741 op amp.

R1 and R2 hold the inverting input at half supply voltage. R4 applies some feedback to increase the input impedance at pin 3, but its value is such that negligable damping of pin 2's voltage occurs. Pin 3, the non inverting input, is connected to the junction of R3 and C. After S1 is opened and C charges via R3. When the capacitor has charged up sufficiently for the potential at pin 3 to exceed that at pin 2 the output abruptly changes from 0V to positive line potential. If reverse polarity operation is required simply transpose R3 and C.

R3 and C can be any values and time delays from a fraction of a second to several hours can be obtained by judicious selection. The time delay is 0.7CR seconds where C is in Farads and R in ohms and hence is completly independent of supply voltage.




## 100,000MΩ DC PROBE?




Most multimeters used for transistor work have an input impedance of 20,000Ω/V.

Occasionally, especially when measuring potentials on high impedance equipment, this sensitivity is sufficient. The circuit shown, however, presents neglible loading on the circuit under test.

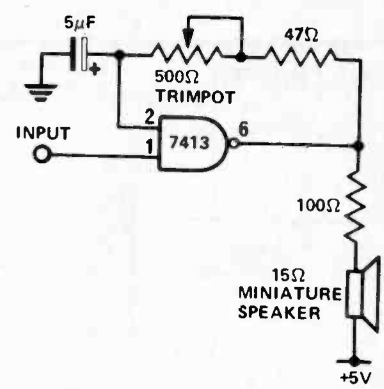
A 741 op amp is used with 100% AC and DC feedback to provide a typical input impedance of $10^{11}\Omega$ and unity gain *(or so the contributor, Ed.)*

Due to the possibility of hum and RF pickup the input leads should be kept as short as possible and the circuit should be mounted in a small *earthed* case.

The output leads may be as long as required since the output impedance of the circuit is a fraction of an ohm.

With no input the output level is indeterminate. This state of affairs can be changed by including R1 in the circuit through this lowers the input impedance to 22MΩ.

## MAKING SLOW LOGIC PULSES AUDIBLE

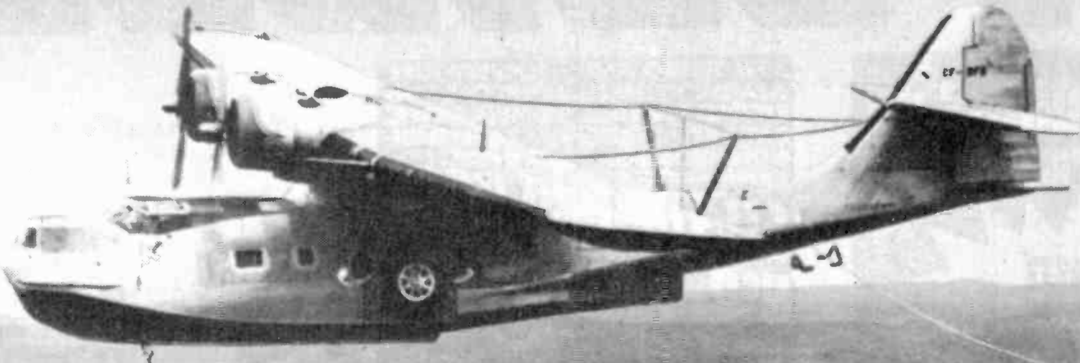



For monitoring slow logic pulses a Schmitt trigger is connected as an oscillator. The trimpot controls the pitch of the output. Very useful as a keying monitor or digital clock alarm. When the input goes high, the 7413 will oscillate.

## DIL DRILLING

Drilling holes in a pcb for 14 and 16 DIL ICs is quite difficult and if the holes are slightly off centre it is tricky to fit the IC. An easy way to get it right use a small piece of 0.1 matrix veroboard as a template.

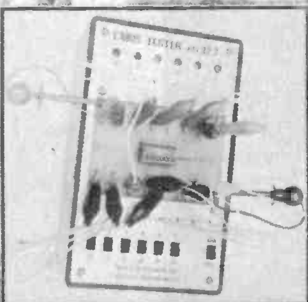
# NEXT MONTH'S ETI



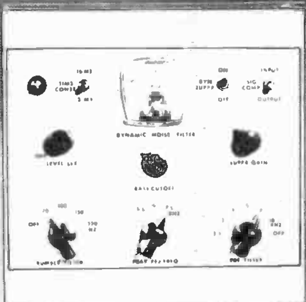
## WHAT IS THIS?

Geophysics uses some really sophisticated electronics to find oil and minerals — in one tenth the time of conventional surveys. ETI looks at some of the electronics installed in the aircraft that help to give you more miles per pound.

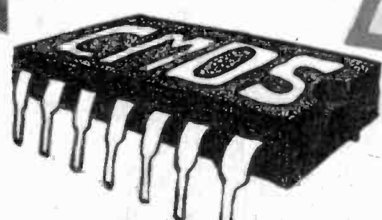

**TONE BURST GENERATOR** — This one won't access GB3LO but it's mighty fine for testing loudspeakers! The versatile unit will also test telephone channels and reverberation chambers, and can be modified for use as a 'silent switch' for A/B speaker testing.



**CMOS TESTER** — A simple and inexpensive battery-operated tester for those CMOS chips that you can't use because they're 'suspect'.



**DYNAMIC NOISE FILTER** — Improve your 'fidelity-to-noise' ratio with this exceptional flexibility unit which enables you to enjoy once again your aged 78's. You can also use this unit to give at least 8dB improvement in s/n ratio with magnetic tape equipment.

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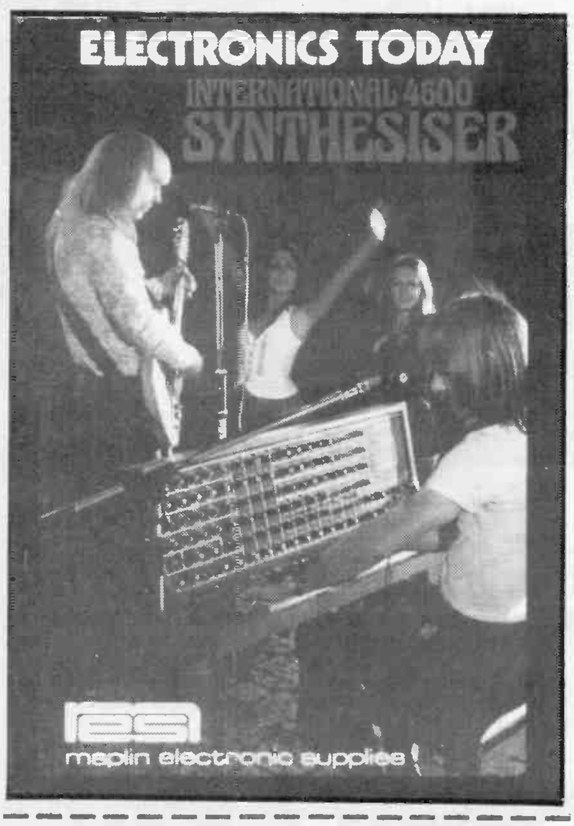


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# BI-PAK SEMICONDUCTORS

## COMPONENTS

**CARBON RESISTOR PAKS**

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

| | | | |
|---|---|---|---|
| R1 | 50 | Mixed 100 ohms — 820 ohms 1/8th W. | 0.60 |
| R2. | 50 | Mixed 1K ohms — 8.2Kohms 1/8th W. | 0.60 |
| R3. | 50 | Mixed 10K ohms — 82Kohms 1/8th W. | 0.60 |
| R4. | 50 | Mixed 100K ohms — 820Kohms 1/8th W. | 0.60 |
| R5. | 30 | Mixed 100 ohms — 820 ohms ½ W. | 0.60 |
| R6. | 30 | Mixed 1K ohms — 8.2Kohms ½ W. | 0.60 |
| R7. | 30 | Mixed 10K ohms — 82Kohms ½ W. | 0.60 |
| R8. | 30 | Mixed 100K ohms — 820Kohms ½ W. | 0.60 |

These are unbeatable prices.

**LOW COST CAPACITORS**

500 μF 50V Elect 0.09 each
.01 μF 400 V 0.03 each

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RF Chokes CH1 2.5mH 0.27
CH3 7.5mH 0.29
CH5 1.5mH 0.26
CH2 5.0mH 0.28
CH4 10mH 0.31

COILS DRX1 Crystal set 0.29
DRR2 Dual range 0.42

**CARBON POTENTIOMETERS**

Log and Lin 4.7K, 10K, 22K, 47K, 100K, 220K, 470K, 1M, 2M.

| | | |
|---|---|---|
| VC 1 | Single Less Switch | 0.14 |
| VC 2 | Single D.P. Switch | 0.26 |
| VC3 | Tandem Less Switch | 0.43 |
| VC 4 | 1K Lin Less Switch | 0.14 |
| VC 5 | 100K Log anti-Log | 0.43 |

**HORIZONTAL CARBON PRESETS**

0.1 Watt 0.06 each

100, 220, 470, 1K, 2.2K, 4.7K, 10K, 22K, 47K, 100K, 220K, 470K, 1M, 2M, 4.7M.

**REPANCO TRANSFORMERS**

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

| Type | Amps | Price | P&P |
|---|---|---|---|
| MT50/½ | ½ | £1.79 | 0.45p |
| MT50/1 | 1 | £2.24 | 0.48p |
| MT50/2 | 2 | £3.06 | 0.60p |

**COIL FORMERS & CORES**

NORMAN ¼" Cores & Formers 0.07p
⅜" Cores & Formers 0.09p

**SWITCHES**

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SP/ST Toggle 0.22p

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1¼" and 20mm, 100mA, 200mA, 250mA, 500mA, 1A, 1.5A, 2A QUICK BLOW *0.5p each
Anti-surge 20mm only *0.8p each

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VB 1 containing approx. 50 sq. ins. various sizes all 0.1 matrix *0.60p

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Etch resistant printed circuit marker pen. Full instructions supplied with each pen *0.92p

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Takes 6 H.P. 7s complete with terminal clip and lead *0.31p each

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| | | | Per Metre |
|---|---|---|---|
| CP | 1 | Single lapped screen | *0.08 |
| CP | 2 | Twin Common Screen | *0.11 |
| CP | 3 | Stereo Screened | *0.12 |
| CP | 4 | Four Core Common Screen | *0.21 |
| CP | 5 | Four Core individually screened | *0.28 |
| CP | 6 | Microphone Fully Braided Cable | *0.11 |
| CP | 7 | Three Core Mains Cable | *0.11 |
| CP | 8 | Twin Oval Mains Cable | *0.08 |
| CP | 9 | Speaker Cable | *0.06 |
| CP | 10 | Low Loss Co-Axial | *0.14 |

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## INSTRUMENT CASES

(In 2 sections, Black Vinyl covered top and sides and bezel)

| No. | Length | Width | Height | Price |
|---|---|---|---|---|
| BV1 | 8" x | 5¼" x | 2" | *£1.25 |
| BV2 | 11" x | 6" x | 3" | *£1.62 |
| BV3 | 6" x | 4¾" x | 1½" | *0.92 |
| BV4 | 9" x | 5¼" x | 2½" | *£1.39 |

## ALUMINIUM BOXES

| No. | Length | Width | Height | Price |
|---|---|---|---|---|
| BA1 | 5¼" x | 2¼" x | 1½" | *0.45 |
| BA2 | 4" x | 4" x | 1½" | *0.45 |
| BA3 | 4" x | 2¼66 x | 1½" | *0.45 |
| BA4 | 5¼" x | 4" x | 1½" | *0.54 |
| BA5 | 4" x | 2½" x | 2" | *0.45 |
| BA6 | 3" x | 2" x | 1" | *0.39 |
| BA7 | 7" x | 5" x | 2½" | *0.79 |
| BA8 | 8" x | 6" x | 3" | *£1.02 |
| BA9 | 6" x | 4" x | 2" | *0.65 |

(Each complete with ½" deep lids & screws)

PLEASE ADD 20p POSTAGE AND PACKING FOR EACH BOX

## COMPONENT PAKS

| Pak No. | Qty. | Description | Price |
|---|---|---|---|
| C1 | 200 | Resistors mixed values approx. count by weight | .60 |
| C2 | 150 | Capacitors mixed values approx. count by weight | .60 |
| C3 | 50 | Precision Resistors mixed values | .60 |
| C4 | 75 | 1/8th width Resistors mixed preferred values | .60 |
| C5 | 5 | Pieces assorted Ferrite Rods | .60 |
| C6 | 2 | Tuning Gangs. MW/LW VHF | .60 |
| C7 | 1 | Pak Wire 50 metres assorted colours | .60 |
| C8 | 10 | Reed Switches | .60 |
| C9 | 3 | Micro Switches | .60 |
| C10 | 15 | Assorted Pots & Pre-Sets | .60 |
| C11 | 5 | Jack Sockets 3 x 3.5m, 2 x standard Switch Type | .60 |
| C12 | 30 | Paper Condensers preferred types mixed values | .60 |
| C13 | 20 | Electrolytics Trans. types | .60 |
| C14 | 1 | Pack assorted Hardware-Nuts/Bolts, Grommets, etc. | .60 |
| C15 | 5 | Mains Slide Switches, 2 Amp | .60 |
| C16 | 20 | Assorted Tag Strips & Panels | .60 |
| C17 | 10 | Assorted Control Knobs | .60 |
| C18 | 4 | Rotary Wave Change Switches | .60 |
| | 2 | Relays 6-24V Operating | .60 |
| | | Sheets Copper Laminate, approx. 200 sq. ins. | *.60 |

Please add 20p post and packing on all component packs, plus a further 10p on pack nos. C1, C2, C19 & C20.

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SOLVE THOSE STICKY PROBLEMS! with


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The wonder bond which works in seconds — bond plastic rubber transistors components permanently immediately!

**OUR PRICE ONLY 60p** *for 2gm phial*

## BIB HI-FI ACCESSORIES *

| REF | | PRICE |
|---|---|---|
| B | Stylus and turntable cleaning kit | *31p |
| J | Tape head cleaning kit | *68p |
| P | Hi-Fi cleaner | *30p |
| 9 | Wire stripper/Cutter | *94p |
| 31 | Cassette head cleaner | *58p |
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| 36A | Record stylus cleaning kit | *32p |
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| 43 | Record care kit | *£2.68 |
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| 46 | Spirit level | *68p |
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**NEW EDITION JUST OUT!**

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| | |
|---|---|
| x25, 25 watt | *£2.45 |
| Model G. 18 watt | *£2.70 |
| CCN 240, 15 watt | *£2.90 |
| SK2. Soldering Kit | *£3.90 |

**BITS AND ELEMENTS** *

| Bit No. | | |
|---|---|---|
| 102 for model CN240 | 3/32" | *42p |
| 104 for model CN240 | 3/16" | *42p |
| 1100 for model CCN240 | 3/32" | *42p |
| 1101 for model CCN240 | 3/8" | *42p |
| 1102 for model CCN240 | ¼" | *42p |
| 1020 for model G240 | 3/32" | *42p |
| 1021 for model G240 | 1/8" | *42p |
| 1022 for model X25 | 3/16" | *42p |
| 50 for model X25 | 3/32" | *44p |
| 51 for model X25 | 1/8" | *44p |
| 52 for model X25 | 3/16" | *44p |

**ELEMENTS** *

| | |
|---|---|
| Model ECN 240 | £1.10* |
| Model EG 240 | £1.35* |
| Model ECCN 240 | £1.55* |
| Model EX 25 | £1.20* |

**SOLDERING IRON STAND**

ST3 Suitable for all models *£1.10
Antex heat shunt *10p

**PLUGS**

| | | PRICE |
|---|---|---|
| PS1 | D.I.N. 2 Pin (Speaker) | 0.10 |
| PS 2 | D.I.N. 3 Pin | 0.11 |
| PS 3 | D.I.N. 4 Pin | 0.14 |
| PS 4 | D.I.N. 5 Pin 180° | 0.15 |
| PS 5 | D.I.N. 5 Pin 240° | 0.15 |
| PS 6 | D.I.N. 6 Pin | 0.16 |
| PS 7 | D.I.N. 7 Pin | 0.17 |
| PS 8 | Jack 2.5mm Screened | 0.17 |
| PS 9 | Jack 3.5mm Plastic | 0.11 |
| PS 10 | Jack 3.5mm Screened | 0.17 |
| PS 11 | Jack ¼" Plastic | 0.14 |
| PS 12 | Jack ¼" Screened | 0.20 |
| PS 13 | Jack Stereo Screened | 0.33 |
| PS 14 | Phono | 0.09 |
| PS 15 | Car Aerial | 0.14 |
| PS 16 | Co-Axial | 0.14 |

**INLINE SOCKETS**

| | | |
|---|---|---|
| PS 21 | D.I.N. 2 Pin (Speaker) | 0.13 |
| PS 22 | D.I.N. 3 Pin | 0.19 |
| PS 23 | D.I.N. 5 Pin 180° | 0.19 |
| PS 24 | D.I.N. 5 Pin 240° | 0.19 |
| PS 25 | Jack 2.5mm Plastic | 0.15 |
| PS 26 | Jack 3.5mm Plastic | 0.15 |
| PS 27 | Jack ¼" Plastic | 0.28 |
| PS 28 | Jack ¼" Screened | 0.32 |
| PS 29 | Jack Stereo Plastic | 0.28 |
| PS 30 | Jack Stereo Screened | 0.35 |
| PS 31 | Phono Screened | 0.17 |
| PS 32 | Car Aerial | 0.20 |
| PS 33 | Co-Axial | 0.20 |

**SOCKETS**

| | | |
|---|---|---|
| PS 35 | D.I.N. 2 Pin (Speaker) | 0.07 |
| PS 36 | D.I.N. 3 Pin | 0.09 |
| PS 37 | D.I.N. 5 Pin 180° | 0.09 |
| PS 38 | D.I.N. 5 Pin 240° | 0.10 |
| PS 39 | Jack 2.5mm Switched | 0.11 |
| PS 40 | Jack 3.5mm Switched | 0.11 |
| PS 41 | Jack ¼" Switched | 0.19 |
| PS 42 | Jack Stereo Switched | 0.28 |
| PS 43 | Phono Single | 0.07 |
| PS 44 | Phono Double | 0.09 |
| PS 46 | Co-Axial Surface | 0.09 |
| PS 47 | Co-Axial Flush | 0.19 |

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**PROFESSIONAL D.I.Y. PRINTED CIRCUIT KIT**

Containing 6 sheets of 6" x 4" single sided laminate, a generous supply of etchant powder, etching dish, etchant measure, tweezers, etch resistant marking pen, high quality pump drill with spares, cutting knife with spare blades, 6" metal ruler, plus full easy to follow instructions.

*£7.80 per kit

Spare container of etchant for above, complete with instructions *60p

**P.C.B. MARKING PENS**

2 x quality market pens, specifically designed for drawing fine etchant resistant circuits on copper laminate. Complete with full instructions *£1.53 per pair

## LOW-NOISE CASSETTES

| | |
|---|---|
| C60 | *33p |
| C90 | *44p |
| C120 | *56p |

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Containing a range of slider pots.

| | |
|---|---|
| SP1 6 mixed values sliders | 0.60 |
| SP2 6 47OR Lin. sliders | 0.60 |
| SP3 6 10K Lin. sliders | 0.60 |
| SP4 6 22K lin. sliders | 0.60 |
| SP5 6 47K lin. sliders | 0.60 |
| SP6 6 47K log. sliders | 0.60 |

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S238 2 pin DIN plug to 2 pin DIN socket length 5m .68p

S268 5 pin DIN plug to 3 pin DIN plug 1 & 4 and 3 & 5 length 1.5m £1.00

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S271 5 pin DIN plug to 2 phone plugs connected to pins 3 & 5 length 1.5m .70p

S275 5 pin DIN plug to 2 phono sockets connected to pins 3 & 5 length 23cm .68p

S318 5 pin DIN socket to 2 phono plugs connected to pin 3 & 5 length 23cm .68p

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S217 3 pin DIN plug to 3 pin DIN plug length 1.5m .80p

S219 5 pin DIN plug to 5 pin DIN plug length 1.5m .80p

S474 3.5mm Jack to 3.5mm Jack length 1.5m .68p

S600 5 pin DIN plug to 3.5mm Jack connected to pins 3 & 5 length 1.5m .80p

S700 5 pin DIN plug to 3.5 jack connected to pins 1 & 4 length 1.5m .80p

## CROSSOVER NETWORK

K4007 1/P Impedance 8 ohms. (2-way) Insertion Loss 3dB. Crossover Frequency 3 KHz. PRICE £1.12

## 3-WAY-STEREO H/PHONE JUNCT BOX

H 1012 Enables change-over from loudspeaker to headphone listening. Also has a centre position for both outputs. PRICE £1.73

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FULL RANGE I STOCK
VOLTAGE RANGE 2-33v

| 400 mw | 1.5 w | 10 w* |
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| 8p | 17p | 30p |

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Containing 75 of the C280 range of capacitors assorted in values ranging from .01μF to 2.2μF. Complete with identification chart.

FANTASTIC VALUE ONLY £1.20

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Containing a range of miniature ceramic capacitors in mixed values, unrepeatable value.

MC1 24 ceramic capacitors: 22pF, 27pF, 33pF, 39pF, 47pF, 56pF, 68pF, and 82pF 0.60

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MC4 21 ceramic capacitors: 4700pF, 6800pF, 01μF, .015μF, .022μF, .033μF and .047μF 0.60

## MAMMOTH I.C. PAK *

**APPROX. 200 PIECES**

Assorted fall-out integrated circuits, including: Logic, 74 series, Linear, Audio and D.T.L. Many coded devices but some unmarked — you to identify.

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Offering the amateur a fantastic bargain PAK and an enormous saving — identification and data sheet in every pak.

**ONLY £1.85 each**

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Manufacturers "Fall Outs" which include Functional and part Functional Units. These are classed as 'out-of-spec' from the maker's very rigid specifications, but are ideal for learning about I.C.'s and experimental work.

| PAK | NO. | | CONTENTS | PRICE |
|---|---|---|---|---|
| ULIC709 | = | 10 x | 709 | 0.60 |
| ULIC710 | = | 7 x | 710 | 0.60 |
| ULIC741 | = | 7 x | 741 | 0.60 |
| ULIC747 | = | 5 x | 747 | 0.60 |
| ULIC748 | = | 7 x | 748 | 0.60 |

**ALL PRICES EXCLUDE V.A.T.**

*Postage & packing add 25p Overseas add extra for airmail. Minimum order 75p*

## SIL G.P. DIODES

300 mW 40 PIV(min) SUB-MIN FULLY TESTED
Ideal for Organ builders
**30 for 50p, 100 for £1.50, 500 for £5 1,000 for £9**

## G.P. SWITCHING TRANS

TO18 SIM. TO 2N706/8 BSY27/28/95A. All usable devices. No open and shorts. ALSO AVAILABLE IN PNP similar to 2N2906, BCY 70.
**20 for 50p, 50 for £1, 100 for £1.80, 500 for £8, 1,000 for £14.**

*When ordering please state NPN or PNP.*

## GP 100

30W GERMANIUM TO3 METAL CASE. Vcbo 80V, Vceo 50V, IC 10A, Hfe 30-170 replaces the majority of Germanium power Transistors in the OC, AD NKT range.

| 1-24 | 25-99 | 100 + |
|---|---|---|
| 44p | 41p | 37p |

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115 WATT SILICON TO3 METAL CASE

Vcbo 100V, Vceo 60V, IC 15A, Hfe 20-100 suitable replacement for 2N3055, BDY11 or BDY20.

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|---|---|---|
| 50p | 48p | 46p |

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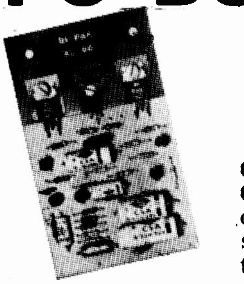
**Open Mon.-Sat. 9-5.30 p.m. Tel. 61593**

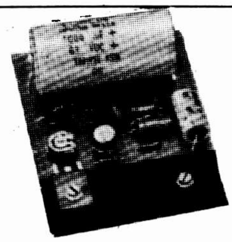
# PO BOX 6 WARE HERTS



## AL 60 — ONLY £3.95

### 50w. PEAK (25w. R.M.S.)

● Max Heat Sink temp 90°C ● Frequency Response 20Hz to 100K Hz ● Distortion better than 0.1 at 1KHz ● Supply voltage 15-50 volts ● Thermal Feedback ● Latest Design Improvements ● Load — 3, 4, 5 or 16 ohms ● Signal to noise ratio 80dH ● Overall size 63mm x 105mm x 13mm. Especially designed to a strict specification. Only the finest components have been used and the latest solid state circuitry incorporated in this powerful little amplifier which should satisfy the most critical A.F. enthusiast.

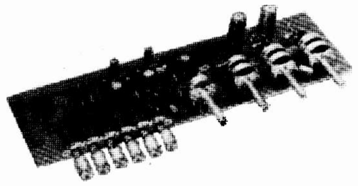


## STABILISED POWER MODULE SPM80

SPM80 is especially designed to power 2 of the AL60 Amplifiers, up to 15 watt (r.m.s.) per channel simultaneously. This module embodies the latest components and circuit techniques incorporating complete short circuit protection. With the addition of the Mains Transformer BMT80, the unit will provide outputs of up to 1.5 amps at 35 volts. Size: 63mm x 105mm x 30mm.

These units enable you to build Audio Systems of the highest quality at a hitherto unobtainable price. Also ideal for many other applications including:—Disco Systems. Public Address Intercom Units. etc. Handbook available 10p.

**TRANSFORMER BMT80 £2.60** **PRICE £3.00**



## STEREO PRE-AMPLIFIER TYPE PA100

Built to a specification and NOT a price, and yet still the greatest value on the market, the PA100 stereo pre-amplifier has been conceived from the latest circuit techniques. Designed for use with the AL50 power amplifier system, this quality made unit incorporates no less than eight silicon planar transistors, two of these are specially selected low noise NPN devices for use in the input stages.

Three switched stereo inputs, and rumble and scratch filters are features of the PA100 which also has a STEREO/MONO switch, volume, balance and continuously variable bass and treble controls.

**£13.20**

## GUARANTEE

**SATISFACTION OR YOUR MONEY REFUNDED**

### MK 60 AUDIO KIT

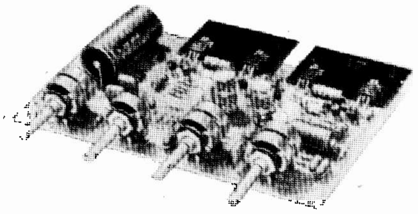
Comprising: 2 x AL60, 1 x SPM80, 1 x BTM80, 1 x PA100, 1 front panel, 1 kit of parts to include on-off switch, neon indicator, stereo headphone sockets plus instruction booklets.

COMPLETE PRICE: £27.55 plus 45p postage.

### TEAK 60 AUDIO KIT

Comprising: Teak veneered cabinet size 16¾" x 11½" x 3¾", other parts include aluminium chassis, heatsink and front panel bracket, plus back panel and appropriate sockets, etc.

KIT PRICE: £9.20 plus 45p postage.



## STEREO 30 COMPLETE AUDIO CHASSIS

### 7 + 7 WATTS R.M.S.

The Stereo 30 comprises a complete stereo pre-amplifier, power amplifiers and power supply. This with only the addition of a transformer or overwind, will produce a high quality audio unit suitable for use with a wide range of inputs, i.e. high quality ceramic pickup, stereo tuner, stereo tape deck, etc.

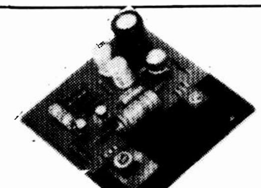
Simple to install, capable of producing really first-class results, this unit is supplied with full instructions, black front panel, knobs, mains switch, fuse & fuse holder and universal mounting bracket, enabling it to be installed in a record plinth, cabinets of your own construction or the cabinet available.

Ideal for the beginner or advanced constructor who requires Hi-Fi performance with a minimum of installation difficulty. Can be installed in 30 mins.

**PRICE £15.75** Plus 45p postage & packing

**TRANSFORMER £2.45** plus 45p postage & packing  **TEAK CASE £3.65** plus 45p postage & packing

**PLEASE ADD V.A.T. AT 25% TO ALL ITEMS EXCEPT**
**✲ ADD 8%**
**# NO V.A.T.**
**GIRO NUMBER 388-7006**



## AL 10/AL 20/AL 30

The AL10, AL20 and AL30 units are similar in their appearance and in their general specification. However, careful selection of the plastic power devices has resulted in a range of output powers from 3 to 10 watts R.M.S.

The versatility of their design makes them ideal for use in record players, tape recorders, stereo amplifiers and cassette and cartridge tape players in the car and at home.

**AL10 £2.30, AL20 £2.65, AL30 £2.95**

### SPEAKERS

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OUR SPECIAL PRICE ONLY £27.75 per pair P&P £3
WHILE STOCKS LAST!

### HEADPHONES

4-16 ohms impedance frequency response 20 to 20,000 Hz stereo/mono switch and Volume Control £4.56

### FRONT PANEL

FOR PA100. Attractive matt silver. Finish with black trim and lettering. Adds that professional touch. £1.10 only.

### M.P.A.30

Enjoy the quality of a magnetic cartridge with your existing ceramic equipment using the new Bi-Pak M.P.A.30 which is a high-quality pre-amplifier enabling magnetic cartridges to be used where facilities exist for the use of ceramic cartridges only.

Used in the construction are 4 low noise, high gain, silicon transistors. It is provided with a standard DIN input socket for ease of connection.

Supplied with full, easy-to-follow instructions.

**PRICE £2.65**

### STORAGE-CARRY CASES

RECORD CASES
7 in E.P. 18 3/8th in. x 7 in x 8 in (50 records) *£2.48
12 in L.P. 13¾in x 7 3/8th in x 12¾ in (50 records) *£3.30

CASSETTE CASES
Holds 15. 10in x 3¾in x 5in. Lock and handle *£1.50

8-TRACK CARTRIDGE CASES
Holds 14. 13in x 5in x 6in. Lock and handle *£2.20
Holds 24. 13 3/8th in x 8 in x 5 3/8th in Lock and handle *£3.20

### CARTRIDGES

| | | |
|---|---|---|
| ACOS GP91-1SC | 200mV at 1.2cms/sec | £1.11 |
| GP93-1 | 280mV at 1cm/sec | £1.43 |
| GP96-1 | 100mV at 1cm/sec | £2.31 |
| TTC J—2005 | Crystal/Hi Output | £0.97 |
| J—2010C | Crystal/Hi Output Compatible | £1.11 |
| J—2006S | Stereo/Hi Output | £1.52 |
| J—2105 | Ceramic/Med Output | £1.81 |
| J—2203 | Magnetic 5mV/5cm/sec including stylus | £4.78 |
| J—22038 | Replacement stylus for above | £2.88 |
| AT—55 | Audio-technica magnetic cartridge 4mV/5cm/sec | £3.06 |

### DYNAMIC MICROPHONE

TYPE B1223 200 ohms impedance. Complete with stand, on/off switch and 2.5mm and 3.5mm plugs. Suitable for cassette tape recorders. PRICE £1.67.

## JUST OUT!

**STEREO FM TUNER**

**WRITE *NOW* FOR FULL DETAILS**

**Anne E. Crump looks at the development of dice and suggests a technological innovation—**

# ELECTRONIC DICE

THE CUBICAL DIE is the oldest game known to man. The dice our ancestors rolled more than two thousand years ago had pretty well the same configuration of dots as the ones we use today. Even before he gambled with them, primitive man considered them to be magical devices, and by their fall he divined the future.

It wasn't very long, of course, before he cottoned on to the possibility of making special dice with which he could cheat! We have found crooked dice along with the treasures of the tombs of the ancient Egyptians, which leads to at least two intriguing possibilities. Did they intend going on into the next world armed with slightly more than a fair sporting chance, or did they take their dice along for old times sake, having used them to acquire all that treasure in the first place? On either count, that's really no way to get to heaven!

But times have changed. Modern man produces hand-made "perfect" dice for his casinos. Sawn from extruded plastic rods and produced to a tolerance of 1/5,000in, these perfect dice have spots drilled approximately 17/1,000in into each face and filled with a paint of the exact same weight as the plastic which has been removed. Buffed and polished so that no recesses remain, they are then ready for the gambling tables of the world.

Now, after 2,000 years, electronic technology has caught up with the oldest game in the world, and electronic dice have been proven to be even more random than their predecessors. The dice described in this article has been designed with minimisation of cost in mind.

The complete circuit uses 74 series integrated circuits only, plus a few discrete components, and is divided into three main areas, i.e. the pulse generator, the pulse counter, and the final decoding electronics.

## THE PULSE COUNTER

The Pulse Counter is a simple arrangement utilising two 2-input NAND gates with the output of the second gate connected to the inputs of the first — a straight forward and convenient way of producing a low-cost oscillator. The frequency of oscillation is determined by the capacitor and resistance values selected, the actual frequency being relatively unimportant so long as it is as high as possible in order to avoid any possibility of the user being able to predetermine his "throw." A figure of 120kHz is suitable. The oscillator output is connected directly to a 7492 counter, which is used in the "divide by six" mode, and in this way a full scan of counts one to six occurs 20,000 times each second.

## THE DECODER

The BCD output of the 7492 is connected to an arrangement of gates which decode the BCD information into suitable drive signals for the LEDs. The decoding arrangements and the diode drive combination have been derived in such a way that the final illuminated display appears in the same dot configuration as a conventional die. The Boolean equations for the gating system are shown on the circuit diagram.

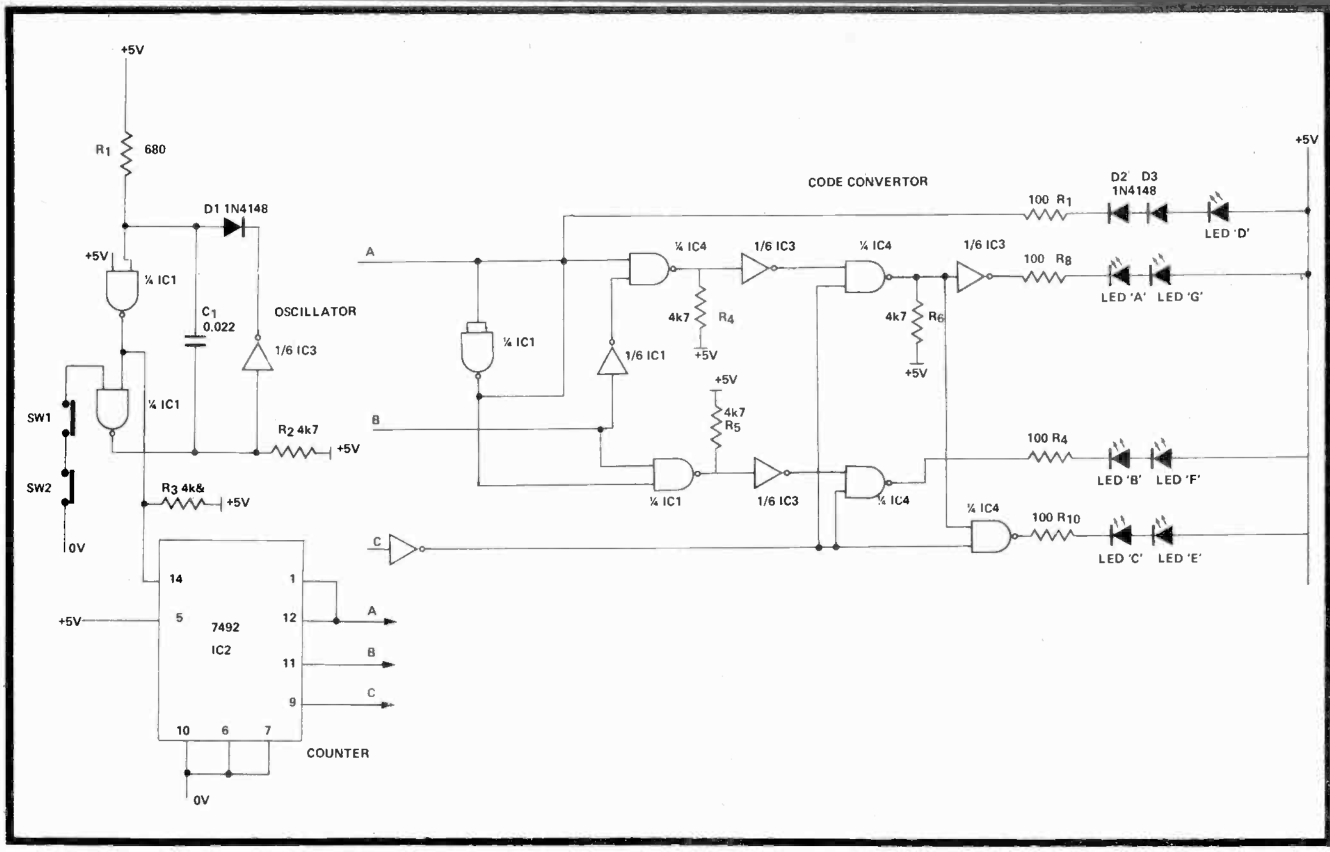
## THE PULSE GENERATOR

In order to obtain the maximum degree of randomness, it is essential that the dwell time should be equal on each of the six counts. The main factors affecting these requirements are the stability of the oscillator and also the spread of output reactances around the counter. If, for example, the frequency of the oscillator shifts during the one to six count cycle, the length of time spent on some of the counts will be greater, and the "throw" will therefore be biased in favour of those numbers. In practice, however, the simple oscillator shown gives adequate stability over the significant period of six pulses, long-term drift being of little importance. A further important point to be borne in mind is the parasitic reactances around the counter area, which could also be instrumental in biasing the "throw," and a good layout of the final unit is therefore essential. A ready-made printed circuit board, complete with assembly and testing instructions, is currently available, and its use is recommended.

The actual degree of randomness of the die is easily obtained by pressing the operating button a number of times, and recording the amount of times each number appears. In order to get a reasonable accurate picture, it is necessary to record at least 3,000 "throws," from which an average should be worked out. The results obtained are excellent, and in tests have shown the random distribution figures of the electronic dice to be in most instances superior to that of the conventional dice. In any group of 10 or 20 "throws" there will always tend to be a predominance of one or two numbers which does tend to be discouraging when first encountered. It is therefore essential to remember that this also happens when using ordinary dice!

## CONSTRUCTION

There are a number of ways in which an electronic die can be activated. The method chosen for the particular unit described here is for the unit to display the last throw until play resumes and the operating switch is pressed again. The last "throw" remains clearly visible for all to see, this avoiding any danger of arguments which might arise if the "throw" was only displayed while the operator's finger remained on the button. Two microswitches




## LED MATRIX

| | | |
|---|---|---|
| E | | A |
| B | D | F |
| G | | C |

Physical placement to simulate dot format on ordinary dice.

Fig. 2.

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| A: | H | L | H | L | H | L |
| B: | L | L | L | L | H | H |
| C: | L | H | H | L | L | L |

Fig. 3. Logic states at A,B & C for each number.

are shown on this circuit. One is sufficient, but it is useful to have a number of switches in series so that people at different parts of the table can operate the unit by pushing a local button.

Power for the circuit is provided by four 1½ volt transistor radio cells, and the randomness of the counter is unimpaired so long as the brightness of the LEDs is reasonable. As soon as the LEDs begin to dim, the batteries should be changed immediately, as deterioration in the random quality of the circuitry may occur. It is important that the battery supply should not be allowed to fall below 4.5V or to exceed 7V. The voltage adversly affects the random operation and the higher voltage is the maximum safe ceiling at which TTL can be run. With LEDs and solid-state electronics used throughout, the reliability of the dice is excellent, and the switches should be first to wear out.

The finished product is very much to the design of the individual himself. Double or even treble dice, operating from a single switch or two or three individual buttons, can be made. A buzzer could be added, to be triggered each time a single, double or treble six is "thrown." This is easily done by adding the necessary gating to the outputs of the A, B and C outputs of the 7492 so that the buzzer is activated each time the appropriate combination appears. Some form of sound, even if only the click of the microswitch, is essential in order to prove to other players that the button has actually been pressed, and a further improvement could be a brief audible tone emanating from the dice when activated.

It is important to note that in addition to their obvious leisure uses, electronic dice have other varied applications, particularly where statistical calculations are involved, an excellent example being their use for quality assurance in factories. Here, by their use, a truly random selection of the production run of a factory can be obtained for testing purposes. Perhaps if the Romans had had electronic dice, human nature being as it is, the selection of Christians going to the lions would have been a trifle more random? And Nero would still have fiddled while Rome burned — but chances are he'd have been fiddling with an electronic die!

### PARTS LIST

| | | |
|---|---|---|
| R1 | Resistor | 680Ω |
| R2–R6 | " | 4k7* |
| R7–R10 | " | 100Ω |
| C1 | Capacitor | 0.022μF |
| D1,D2,D3 | Diodes | 1N4148 |
| LED 'A'–LED 'G' | | TIL409 |
| IC1, IC4 | 7400 or 7403* | |
| IC2 | 7492 | |
| IC3 | 7404 | |
| SW1, SW2 | microswitches | |

* NB: R2–R6 are not used with the 7400 gates — only with open — collector gates, such as 7403.

# ETI DATA SHEET

## TCA280A TRIGGER INTEGRATED CIRCUIT — MULLARD

The TCA280A is a monolithic IC designed for thyristor and triac control circuits. It will operate in phase control, synchronous on/off switching and time proportional modes.

Fig. 3 gives a circuit for a typical application as a synchronous on/off switching controller. The synchronous switch gives triggering around the zero crossings of the mains voltage with a typical pulse duration of 160µS. The values of $R_d$, $R_g$ and C1 are chosen for triacs requiring a gate current, $I_G$, typ. of 50mA at $V_G$ typ. 30V. For other triacs see the manufacturer's full data sheet.

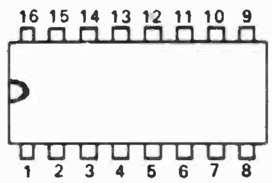
A single phase control circuit using trigger pulse bursts is shown in Fig. 4. If used in conjunction with a triac this will provide full-wave a.c. control and if used in conjunction with a thyristor, gives a controlled half-wave rectifier. Once again, component values are given for the SC45D or similar triac but can be estimated from graphs in the manufacturer's data.

**SPECIFICATION** — typical values

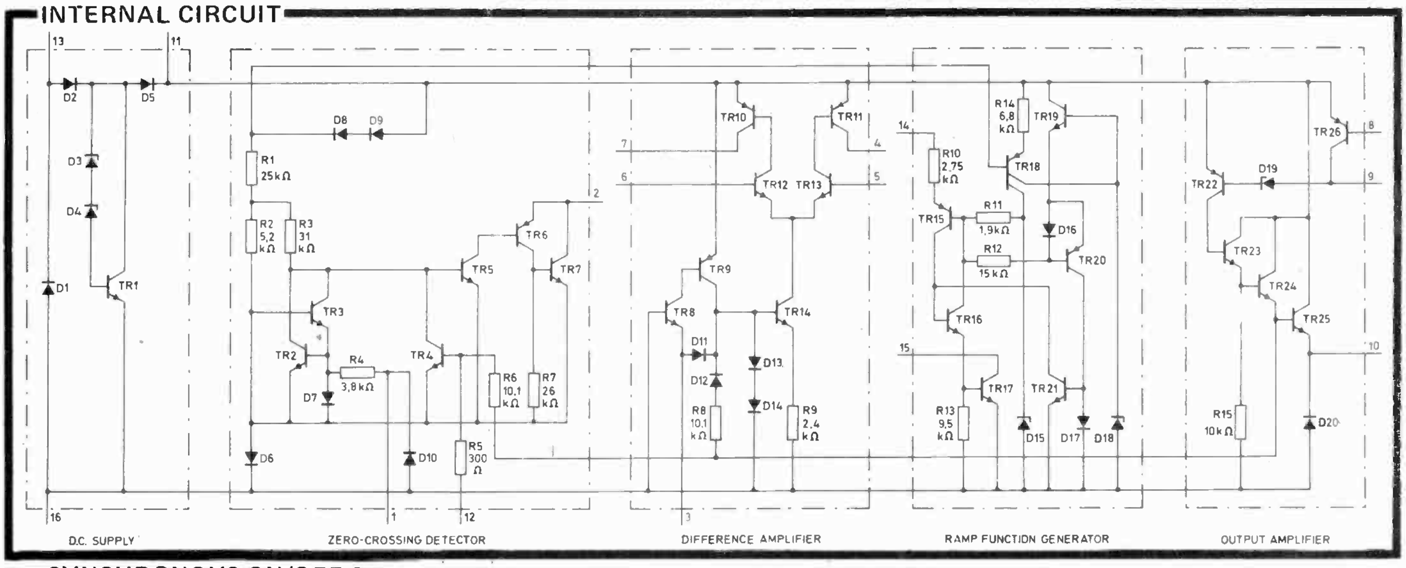
| | |
|---|---|
| Supply voltage | 14V |
| Output trigger pulse | 250mA |
| Output voltage drop $V_{11-10}$ | <2.8V |

**PACKAGE 16 pin DIL**

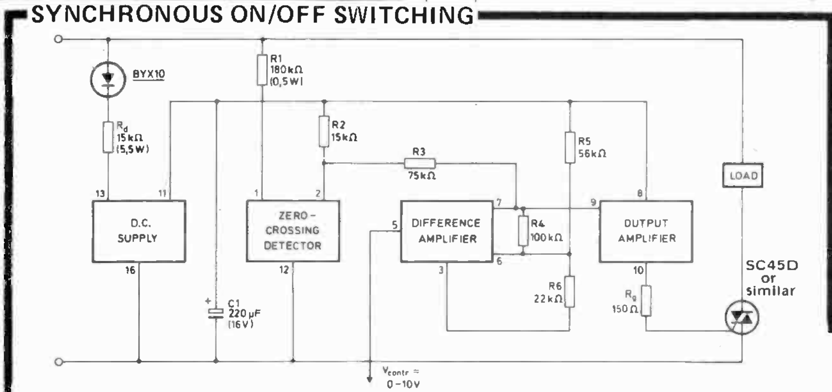
**For pin functions see Figs. 3 & 4.**

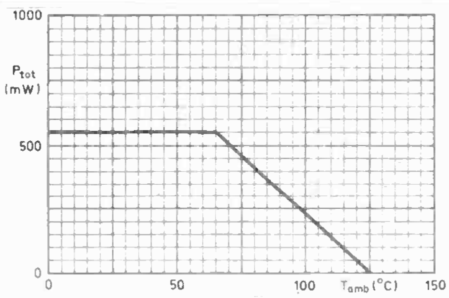



## INTERNAL CIRCUIT




## SYNCHRONOUS ON/OFF SWITCHING



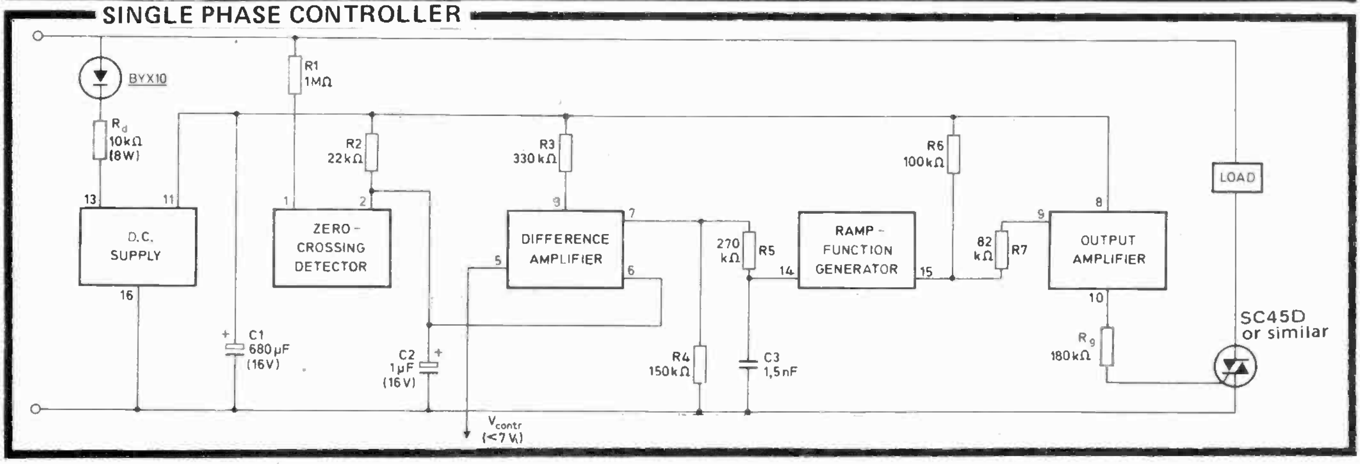




*Total power dissipation*

The synchronous switch gives triggering a round the zero crossings of the mains voltage with a typical pulse duration of 160µS.

NOTES: Values of $R_d$, $R_g$, and C1 are chosen for triacs requiring a gate current $I_G$ of 50mA at $V_G$ of 3V. For other conditions see manufacturer's full data. The recommended applications circuits make use of a mains rectifying diode in series with the mains supply device. Suitable diodes from the Mullard range are the BYX10, BYX94 and the BY127.

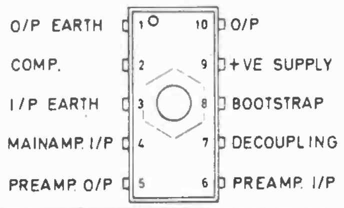
## SINGLE PHASE CONTROLLER



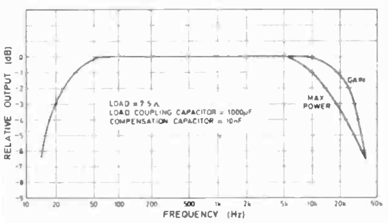
# SL415A & SL414A 3W & 5W AUDIO AMPLIFIERS

The SL415A and SL414A are robust high gain audio power amplifiers each with a separate pre-amplifier. The circuits, which have been optimized to give maximum reliability, have guaranteed power outputs of 5W and 3W respectively under the conditions specified.

## PIN CONNECTIONS




## FREQUENCY RESPONSE




## OPERATING NOTES

Each circuit has built in resistance to damage caused by voltage overload or short circuits across the output.

For high inductive loads a high frequency load of 47nF and 22Ω connected in series may be required between pins 10 and 1 to enhance stability. When connecting the circuit shown in Figs. 5,9 and 10 is recommended that:

(a) The capacitor between Pins 9 and 1 should be kept close to the integrated circuit.

(b) The earth path between Pins 3 and 1 should be kept short.

(c) The earth connection from the supply should be connected to Pin 1 not Pin 3.

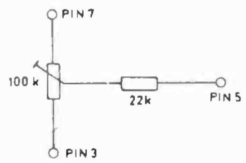
The circuits are designed to centre the o/p DC bias point half way between supply and earth. Any variations in this level can be adjusted with the use of the circuit shown in Fig. 4.

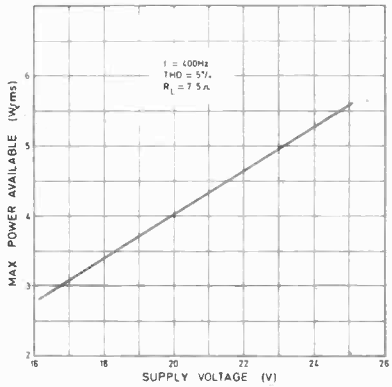
The devices should be used with a suitable heat sink of approximately 20cm$^2$ (3 in$^2$). Typical advertised prices are SL-414A £2.00, SL415A £2.75.

## SPECIFICATION

| CHARACTERISTIC | | CONDITIONS |
|---|---|---|
| Supply voltage | | |
| SL414A | 18V | 30W r.m.s. o/p Load = 7.5Ω |
| SL415A | 24V | 5W r.m.s. o/p THD = 5% |
| Power into 15Ω load | | |
| SL414A | 2.2W | $V_{supply}$ = 18V 5% THD |
| SL415A | 3.8W | $V_{supply}$ = 24V |
| Pre. amp. voltage gain | 24dB | |
| Main amp. voltage gain | 26dB | |
| D.C. input current | | |
| Pre amp. | 100nA | |
| Main amp. | 100nA | |
| Main amp. o/p impedance | 0.2Ω | |
| Distortion | | |
| Pre amp. | 0.1% | Pre amp. o/p = 0.9V r.m.s. |
| Main amp. | 0.3% | f = 400Hz, $P_{out}$ = 1W |
| Noise level | −75dB | Source impedance = 1MΩ, gain = 26dB |
| Ripple rejection | 30dB | with pin 7 decoupled |
| Input impedance | | |
| Pre amp | 20MΩ | |
| Main amp | 100MΩ | |
| **ABSOLUTE MAXIMUM RATINGS** | | |
| Supply voltage | | |
| SL414A | | +20V |
| SL415A | | +25V |
| Max. peak loud current | | 1.4A |
| Storage temp. | | −20°C to +80°C |
| Operating temp (with suitable heat sink) | | −10°C to +70°C |

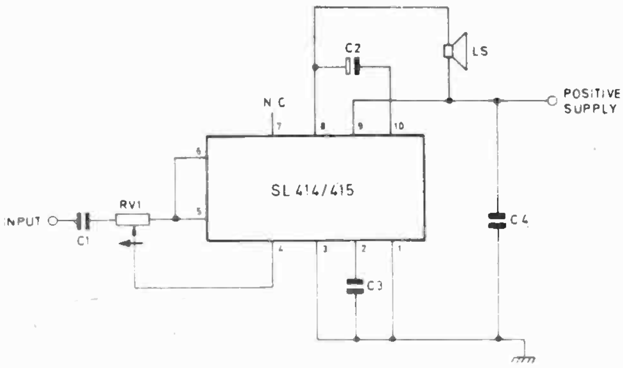
## OUTPUT BIAS BALANCE CIRCUIT



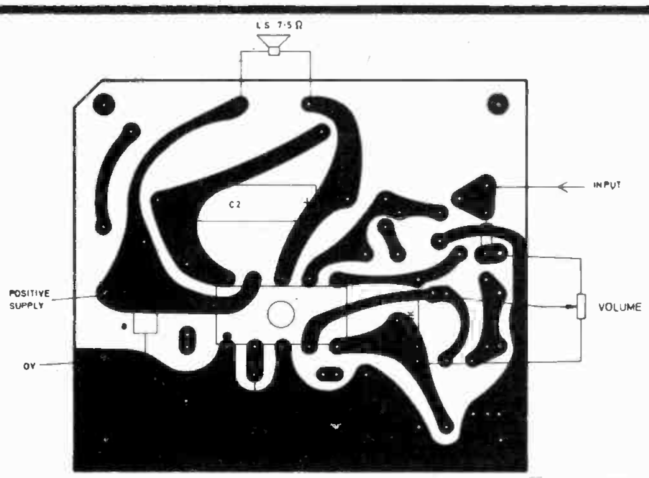




*Power V supply Volts*

## MINIMUM COMPONENTS CIRCUIT



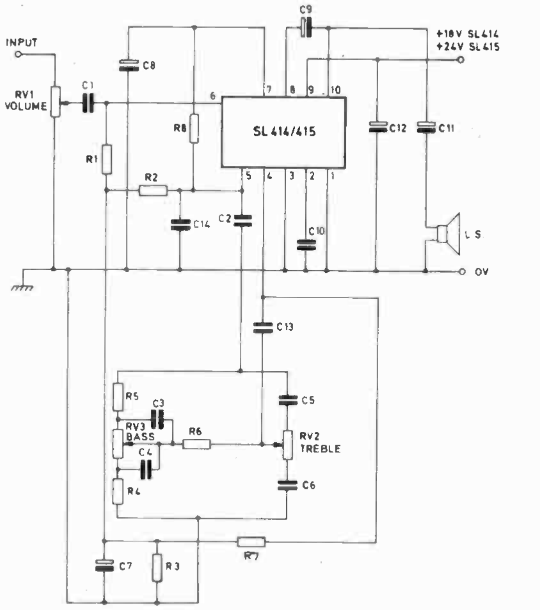

RV1 100 kΩ (log)
C1 100 nF
C2 400 μF
C3 10 nF
C4 0.1 μF

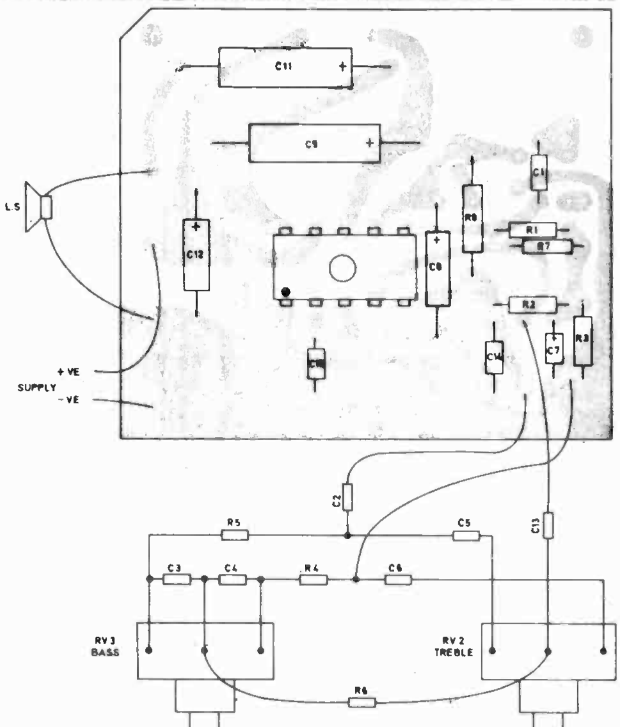



**(NOT ACTUAL SIZE)**

**In the 'minimum components' application (which is the simplest possible configuration for the SL414/415) the preamplifier provides a temperature-compensated input bias to the power amplifier (pin 4). The circuit has an input impedance of 100kΩ. With an input of 250mV r.m.s. and a 7.5Ω load, typical power outputs of 2.5W (SL414, 18V supply) and 4.0W (SL415, 24V supply) are obtained. The supply rejection is 6dB.**

## MONO AMPLIFIER WITH TONE CONTROLS




(NOT ACTUAL SIZE)

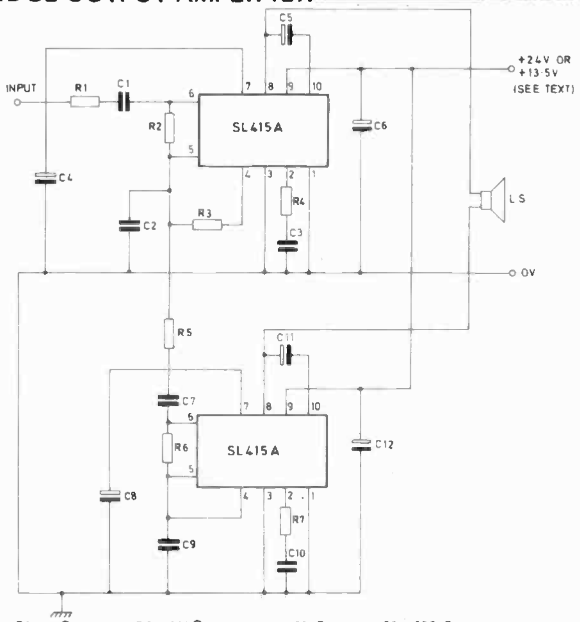
| | | | |
|---|---|---|---|
| R1: 1MΩ | R8: 22kΩ | C7: 2µF | C14: 680pF |
| R2: 150kΩ | C1: 10nF | C8: 22µF | RV1: 2MΩ |
| R3: 75kΩ | C2: 220µF | C9: 125µF | RV2: 250kΩ LOG |
| R4: 3·3kΩ | C3: 10nF | C10: 10nF | RV3: 250kΩ LOG |
| R5: 33kΩ | C4: 47nF | C11: 1000µF | L.S: 7·5Ω |
| R6: 10kΩ | C5: 1nF | C12: 22µF | |
| R7: 1MΩ | C6: 10nF | C13: 10nF | |

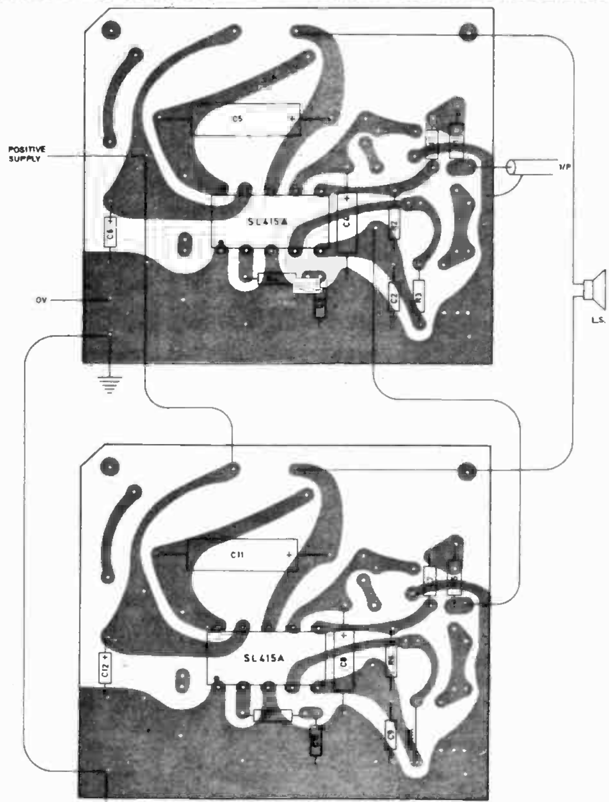
Note: If it is required to make the output quiescent voltage adjustable, replace R8 with a 47kohm preset.

This circuit has a typical output power of 3W (SL414) or 5W (SL415) into a 7.5 load with an input to the preamplifier of 250mV r.m.s. The preamplifier is used at full gain to offset the 20dB midband loss in the tone control network. The tone control is an insertion 'loss' network between the preamplifier and the main amplifier.

To drive the main amplifier a maximum swing from the preamplifier of 2.5V r.m.s. is required. As the maximum output swing is normally IV r.m.s. (limited by bottoming) the quiescent output voltage has been raised by inserting the potential divider R2/R3 in the mid-point of the divider via R1 and the feedback by passed at audio frequencies by C7. A component layout using a printed circuit board is shown

## BRIDGE OUTPUT AMPLIFIER




| | | | |
|---|---|---|---|
| R1 1MΩ | R6 100kΩ | C4 22µF | C9 680pF |
| R2 1MΩ | R7 22Ω | C5 1000µF | C10 2·2nF |
| R3 1MΩ | C1 10nF | C6 22µF | C11 1000µF |
| R4 22Ω | C2 680pF | C7 100nF | C12 22µF |
| R5 100kΩ | C3 2·2nF | C8 22µF | |

In this application, the load is driven from two antiphase outputs so that twice the single-ended output swing is available. With a 15Ω load, this provides twice the single-ended power and since the second harmonic distortion is out of phase in the load an improved distortion figure is obtained. The interconnections between boards should be kept as short as possible.

The input sensitivity (which can be adjusted by changing the value of R1) is typically 100mV for 5W r.m.s. output, using SL415As.

(NOT ACTUAL SIZE)

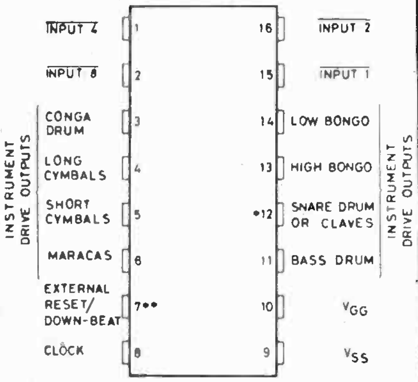
## SPECIFICATION

| | |
|---|---|
| $V_{GG}$ | −12V typ. |
| $V_{SS}$ | 5V typ. |
| $I_O$ (at any pin) | 3mA max |
| CLOCK & DATA INPUTS HIGH | 5V |
| CLOCK & DATA INPUTS LOW | 0V |

**PACKAGE 16 lead DIL**

**M252 B1 - AA**

Standard content configuration

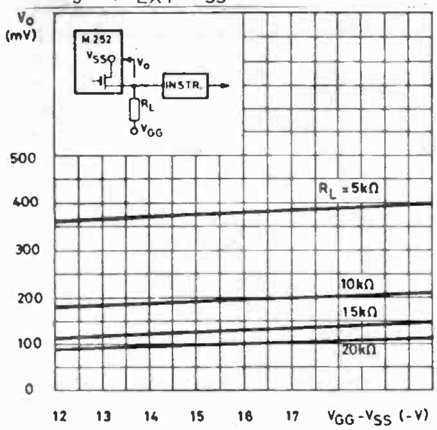



* This output must be connected so as to drive the "snare drum" when the rhythms from 1 to 9 (see rhythms selection) are selected, and the "claves" when the rhythms from 10 to 15 (see rhythms selection) are selected.

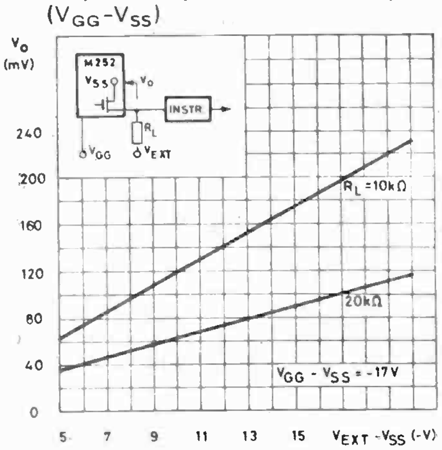
** This pin generates a down - beat trigger which can be used to drive an external lamp to indicate the start of each measure.

Typical Advertised Price: £7.50.

Output voltage vs. external supply voltage ($V_{EXT}$-$V_{SS}$)




Output voltage vs. supply voltage ($V_{GG}$-$V_{SS}$)




The M252 is a PMOS IC which will supply any of fifteen rhythms to drive eight sound generators. A down-beat output is provided and a version (M252 B1AA) is available with standard music content.

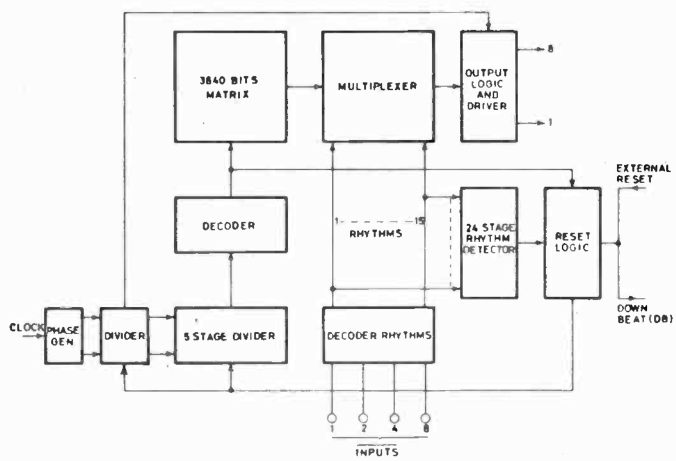
Rhythm is selected by binary coded input, (see table 1) 8 or 9 instrument generators are required as well as a variable clock generator operating at TTL levels.

## RHYTHM SELECTION

The following binary code must be generated to select each rhythm (logic positive)

| CODE INPUT 8 | CODE INPUT 4 | CODE INPUT 2 | CODE INPUT 1 | STANDARD CONTENT | |
|---|---|---|---|---|---|
| 1 | 1 | 1 | 0 | Waltz | 3/4 |
| 1 | 1 | 0 | 1 | Jazz Waltz | 3/4 |
| 1 | 1 | 0 | 0 | Tango | 2/4 |
| 1 | 0 | 1 | 1 | March | 2/4 |
| 1 | 0 | 1 | 0 | Swing | 4/4 |
| 1 | 0 | 0 | 1 | Foxtrot | 4/4 |
| 1 | 0 | 0 | 0 | Slow Rock | 6/8 |
| 0 | 1 | 1 | 1 | Rock Pop | 4/4 |
| 0 | 1 | 1 | 0 | Shuffle | 2/4 |
| 0 | 1 | 0 | 1 | Mambo | 4/4 |
| 0 | 1 | 0 | 0 | Beguine | 4/4 |
| 0 | 0 | 1 | 1 | Cha Cha | 4/4 |
| 0 | 0 | 1 | 0 | Bajon | 4/4 |
| 0 | 0 | 0 | 1 | Samba | 4/4 |
| 0 | 0 | 0 | 0 | Bossa Nova | 4/4 |

## BLOCK DIAGRAM

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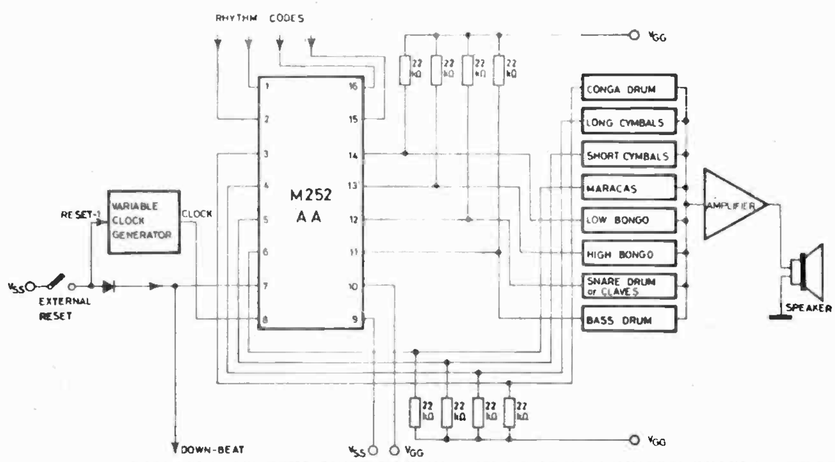

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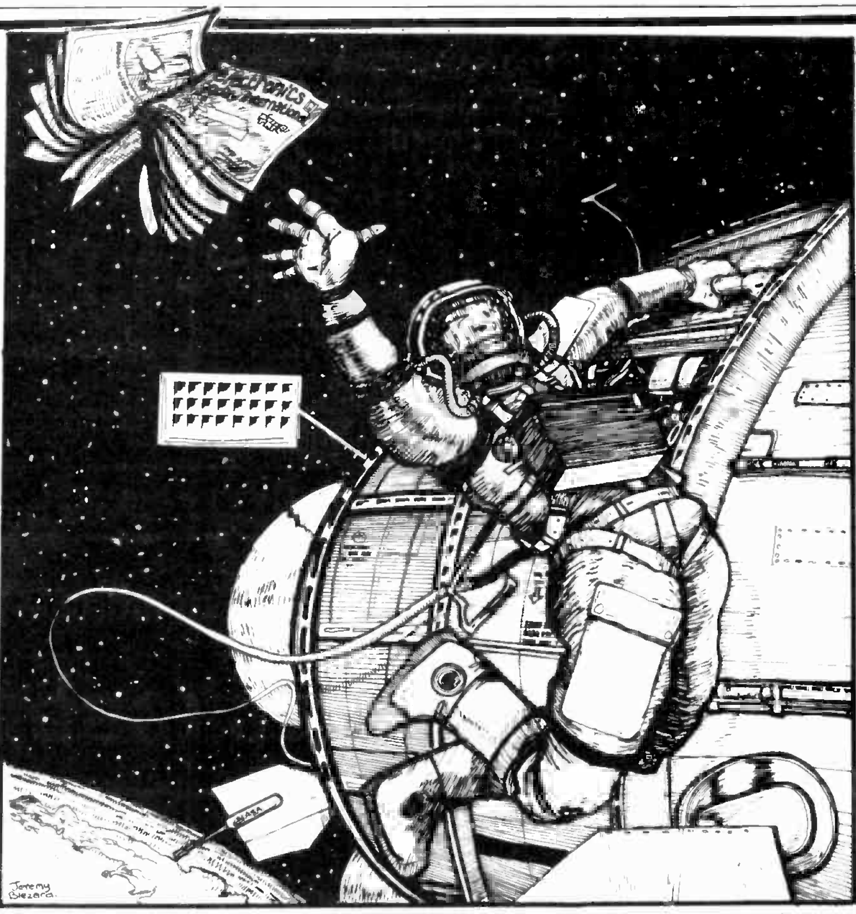

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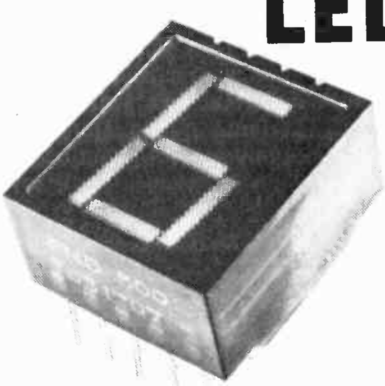

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PART 2

# Op Amps

Two practical projects aid understanding

by J.T. NEILL

LAST MONTH the basic theory of operational amplifiers was given. This month we give constructional details of, firstly, a dual power supply suitable for running all the units to be described in this series, followed by the description of a sine wave audio oscillator. The oscillator is the first of a series of small projects designed to give practical experience with op-amps.

## THE POWER SUPPLY

The limitation when attempting to reduce the size of any small piece of equipment is, with the present state of the art, the dimensions of the mains operated power supply required to drive it. Thus although an oscillator can be constructed with one IC and a few passive components, the companion ac power supply, by comparison, is extremely bulky. Thus it is fairly pointless to attempt to construct the power supply in such a way as to minimize its total volume. This is not really a disadvantage, however, as the power supply can be used to power other circuits and the diminutive oscillator can, of course, be powered by separate, small, batteries when that is desirable.

Small size may not be a feature of the power supply, but it does have several important characteristics, namely, *automatic* short circuit protection and good voltage stabilisation. A brief specification is given in Table 1, while the full circuit diagram appears in Fig. 1.

Consider first that part of the circuit above the dotted line.

Diodes D1 and D2 full-wave rectify the transformer output and charge C1 positively. Capacitor C1 has a sufficiently large value to filter out nearly all the 100 Hz ripple component and provide a smooth dc to the regulator.

The constant potential across the Zener diode D3 maintains the base of Q1 similarly constant. Should the mains voltage vary, or the load current alter, then the output voltage will tend to change too; however, that voltage is fed, via the diode D4, to Q1 emitter, where it is compared with the Zener voltage at Q1 base. Thus, the collector current of Q1, and hence the base current of Q2, will alter, so effectively changing the emitter-collector impedance of Q2 in such a way as to correct for the original variation. The voltage drop across D4, D8 compensates for the drop across Q1 and Q3 thus ensuring the output voltage is the same as the zener voltage.

Such a configuration will give good load regulation but very large variations in mains voltage will not be counteracted as well as is done in some other circuit designs. This is because the Zener diode is fed from an unstabilised supply. Improvement in output voltage stability – by the order of a factor of five or so – can be achieved by modifying the circuit to drive the Zener from the output, rather than the input, of the regulator, but this would not permit the incorporation of short-circuit protection components, in an arrangement now to be described. Short circuit protection of the supply is vital in experimental work, especially on integrated circuits, where the small size and close spacing of the connecting leads printed circuit tracks can so easily result in unwanted shorts which may overload and possibly damage the power supply.

Consider what happens when the output of the voltage regulator is connected directly to the earth line. The germanium diode D4 is no longer forward biased, for its anode,

**PARTS LIST — POWER SUPPLY**

| | | |
|---|---|---|
| D1,2,5,6 | Diode | IN4001 |
| D3,7 | " | BZ x 79 C12 or other 12 V Zener |
| D4,8 | " | IN914 |
| Q1 | Transistor | BC547, BC107 |
| Q2 | " | BD140, BD136 |
| Q3 | " | BC177, BC557 |
| Q4 | " | BD139 |
| R1,3 | Resistor | 1.5 k ¼W |
| R2,4 | " | 6.8 k ¼W |
| C1,4 | Capacitor | 1000μF 25 V electrolytic |
| C2,5 | " | 22μF 16 V electrolytic |
| C3,6 | " | 100μF 16 V electrolytic |

Transformer 12 V – 0 12 V 100 mA

SW1 double-pole double throw

Die-cast box 165 x 114 x 51 mm

| | | |
|---|---|---|
| F1 | Fuse | 1 amp |
| Fuse holder | | 20 mm |
| Terminals (screw) | | 1 red, 1 black, 1 greer (earth 1 other) |
| Neon indicator | | |

Veroboard, 0.15" pitch 100 x 60 mm

**TABLE 1**

| | |
|---|---|
| Input | 220 – 240 V 50 Hz |
| Output voltage | 1. –12 V and +12 V |
| or | 2. –24 V |
| or | 3. +24 V |
| Output current | 100 mA maximum |
| Protection | Automatic constant current limiting (210 mA) on short circuit |
| Regulation | Better than 80 mV variation, no load to full load |
| Hum and noise | Less than 3 mV |

**TABLE 2**

| | |
|---|---|
| Frequency range | 120 Hz – 1.2 kHz<br>1.2 kHz – 12 kHz |
| Output level | 1 V rms maximum, continuously variable |
| Output impedance | 70 ohms |
| Min. load at 1 Vrms | 1.5 k |
| Power supply needed | 3 mA at +12 V<br>2 mA at –12 V |

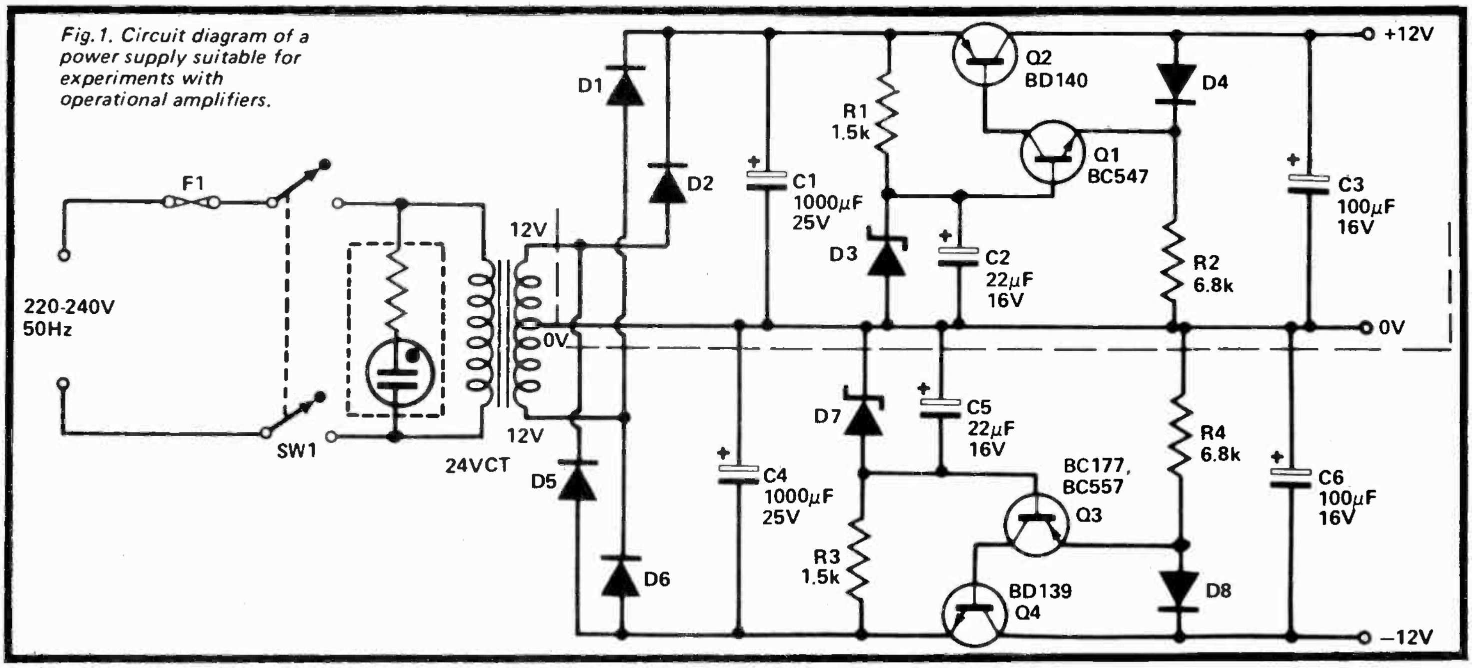



*Fig. 1. Circuit diagram of a power supply suitable for experiments with operational amplifiers.*

connected now to earth, is not more positive than its cathode; accordingly, D4 can be considered to be absent and the effective circuit arrangement is as in Fig. 2. The base voltage of Q1 is still fixed (by the voltage across the Zener) at 12 V with its emitter taking up a voltage about 0.7 V less. This fixed voltage appears across R2, which means that a fixed current flows through R2 and Q2 into the base of Q1 and hence, the emitter current of Q1 is fixed also. The emitter current of Q2 will be larger than its base current by a factor equal to the current gain of transistor Q2. The emitter current of Q2 is the load current however, so that it can be seen that, under short circuit conditions, a constant current of a magnitude determined by R2 flows into that short circuit.

A suitable value of R2 must be selected to obtain the desired short circuit current. Here, it is chosen so that 210 mA flows in short circuit conditions. It is under these conditions that the greatest power dissipation occurs in Q2 and accordingly it has been ensured that a continuous short circuit will not give rise to overheating of that transistor.

In point of fact, about 3.4 watts are then dissipated in Q2, a value well within the capability of the transistor type employed. It is bolted to, but insulated from, the die-cast box in which the power supply is housed, so that it is thereby provided with a very large heatsink. Accordingly, in normal use all components run with hardly any temperature rise, and even when running into a short circuit, the combination of current limiting and large heatsink ensures that the power supply is not damaged.

What has been discussed so far is a single power supply, giving an output of 12 V. The actual unit contains two such supplies, as Fig. 1 shows, of similar circuit configuration, but, in the second case, a PNP transistor is used instead of an NPN and vice versa, and with a negative supply voltage, derived from D5 and D6, fed to it. The Zener diode and its electrolytic capacitor, as well as the germanium diode, are all connected with the opposite polarity from before. Therefore, a stabilised and protected −12 volts appears at the output, relative to the centre supply terminal.

As quoted in the specification, this permits the output from the power supply unit to be connected in any one of three configurations:—

1. + 12 V and −12 V relative to earth
2. + 24 V relative to earth
3. −24 V relative to earth

This is achieved by connecting the two supplies in series, with the common point brought out as an external connection. Further, this common point is not earthed, but a separate earth terminal provided. The three different modes of operation are then obtained by means of the appropriate external connections — see Fig. 3.

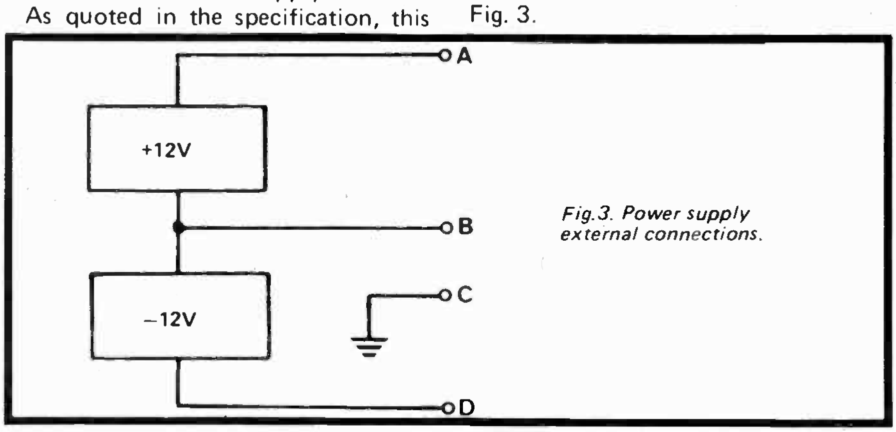



*Fig.3. Power supply external connections.*

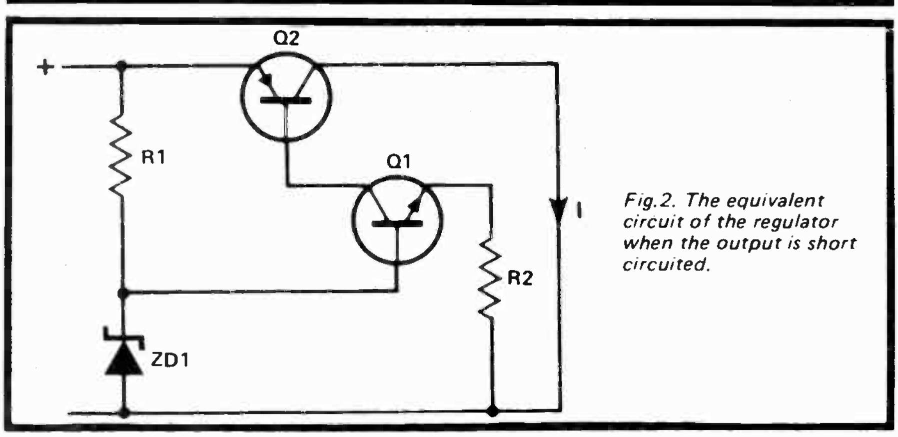



*Fig.2. The equivalent circuit of the regulator when the output is short circuited.*

# Op Amps

For use with the type of operational amplifier dealt with here, the first mode i.e. ± 12 V will usually be employed.

The rated output, of 100 mA from either side, will be found to be more than adequate for the intended use, since type 709 and 741 op. amps. draw less than 5 mA each, unloaded.

A suggested layout and constructional technique for the dual power supply is given in Fig. 4, but the layout is by no means critical and the constructor may employ any alternative method. Nevertheless, a robust housing is required and the best is probably a die-cast box — any small extra expense incurred, to obtain such a convenient and easily worked case, is well worthwhile.

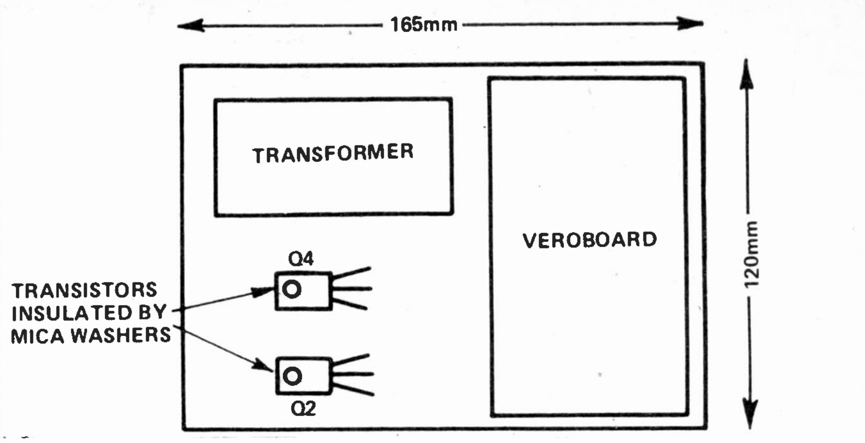



*Fig. 4(a). Suggested layout of major components in the box. Note that the Veroboard should be insulated from the box by inserting cardboard between it and the box.*

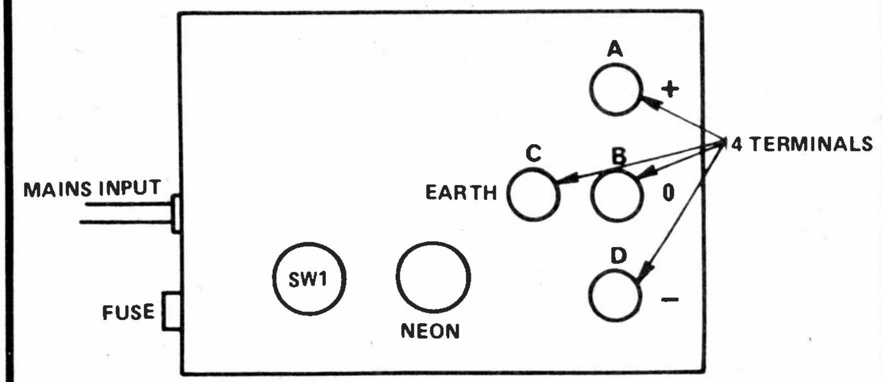



*Fig. 4 (b) Suggested front panel layout.*

## THE OSCILLATOR

Now for the first constructional project using an operational amplifier. As mentioned earlier, this is a sine wave audio oscillator. The circuit is given in Fig. 5 and its specification in Table 2.

The oscillator makes use of the well known Wien-bridge network to set the frequency of operation. A resistor (in this case RV1a and R1) and a *parallel* capacitor (either C1 or C2) are connected to further resistors (RV1b, RV3 and R4) in *series* with a further capacitor (either C3 or C4). It is a property of the Wien network that the junction of the two RC arms, has, at a single frequency only, a voltage in phase with, but smaller than, that applied to the whole network. Since, in the oscillator, this in-phase voltage is fed to the non-inverting terminal of the op. amp. it constitutes positive feedback, and thus oscillations will occur and be maintained at one specific frequency — a frequency determined by the values of the resistors and capacitors employed in the Wien network.

So much for the frequency of oscillation. What of its amplitude?

Consider for a moment what would happen if, with the oscillator already giving a sine wave output, the output amplitude should increase for some reason. If it continues to do so, eventually the voltage will become so large that it will be limited by the supply rails and a clipped sine wave will result. Conversely, if the amplitude of oscillation should decrease, then oscillations will eventually die away to nothing.

Such variations in amplitude can easily arise due to temperature changes etc., and will in any case occur as the frequency is altered, due to tolerances in the capacitor values and tracking errors in the twin-gang potentiometer.

Thus, some means of automatic gain control is essential in order to maintain a constant output amplitude.

It will be recalled that the signal voltage applied to the op. amp. non-inverting input was smaller than the output voltage due to the attenuation in the Wien network. To maintain oscillation the op. amp. must have a gain equal or exceeding this attentuation — which is in fact x3. The desired gain is obtained by selecting the ratio of feedback resistance to input resistance of the inverting input (RV2 + R3)/R2.

If the overall gain, including feedback, exceeds unity the circuit will produce sine wave oscillation at a frequency set by the Wien network.

Stabilisation of the gain is brought about by the action of diodes D1 and D2.

When the instantaneous output voltage is close to zero, neither diode conducts, since even a germanium diode requires 0.4 volts or so forward voltage to bias it on. Consequently, the negative feedback loop is open (giving maximum gain) and, under the action of the positive feedback via the Wien network, oscillations build up rapidly. As soon as their amplitude is sufficient to bias on either D1 or D2 (depending on the polarity of the output voltage swing), then R2, R3 and RV2 provide negative feedback, so limiting oscillations to a convenient level.

Re-inforcement of such oscillations takes place close to each zero crossing when D1 and D2 are open i.e. non-conducting; the setting of RV2 determines the final amplitude.

This method of stabilisation does give rise to a very small amount of crossover distortion, but the effect of this can be minimised by setting VR2 for the largest possible sine wave without clipping. In any event, some distortion is a small price to pay for such a simple, easy-to-get-working sine wave oscillator and, further, it is a *low* level of distortion — some class B audio amplifiers are worse!

Range switching is confined to a choice of two ranges, in the interest of simplicity and cheapness, but more ranges could easily be provided if the constructor is so inclined.

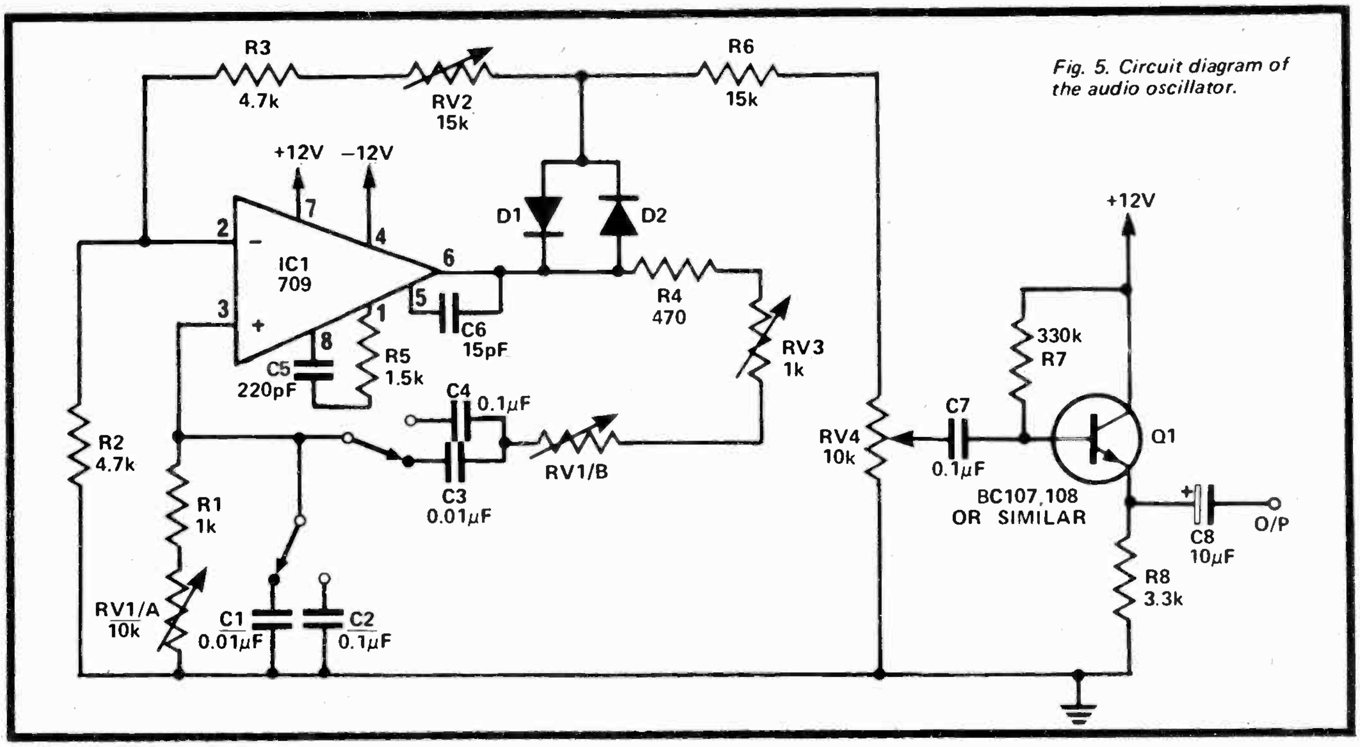



Fig. 5. Circuit diagram of the audio oscillator.

The frequency ranges mentioned in the specification are a little unusual, in that most audio generators provide ranges starting and ending at 1 kHz, 10 kHz and so on. However, in the present case, the selection of easily available components having standard values produced the ranges shown and these were, in fact, found to be convenient in practice.

A simple emitter-follower output stage completes the unit, with a logarithmic potentiometer as a level control, enabling the output to be set from 1 V rms down to 10 mV rms or so.

Suitable compensation components R5, C5 and C6 are required for the type 709 op. amp. A layout found suitable for the oscillator is given in Fig. 6. Notice that this calls for a box of only 100 x 75 x 30 mm, which, whilst making the oscillator quite small and neat, does not result in cramping of the layout, which is straightforward and easily followed.

With wiring up completed and thoroughly checked, switch on and, if possible, monitor the output on an oscilloscope. No 'scope? Then a pair of headphones, of reasonably high impedance, can be used instead. Set RV4 about half way, S1 to "low" and RV1 about half way. If there is no output, adjust RV2; clockwise rotation should give increased output.

With an ac meter, measure the signal level at the junction of D1, D2 and RV2. Adjust RV2 for 3 volts rms. This will ensure the highest output level (thus reducing the effect of crossover distortion) consistent with sine wave operation (no clipping). This should provide about one volt rms at the output.

It was found on the prototype that changing to higher frequency range gave a slightly reduced output – doubtless due to the use of 10% tolerance capacitors in the Wien network. Closer tolerance capacitors are, of course, more expensive but the amplitude difference may be overcome by adding small capacitors to either C1 and C3 or C2 and C4 whichever reduces the amplitude difference.

Variation of output level as RV1 is

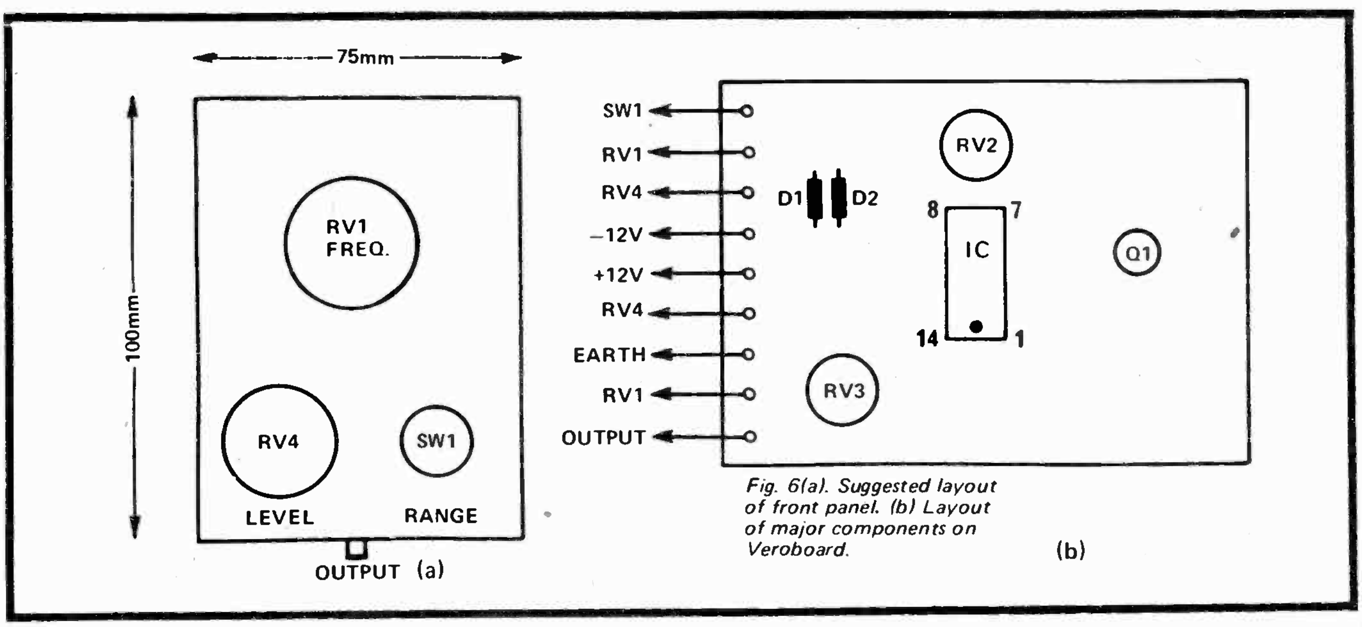



Fig. 6(a). Suggested layout of front panel. (b) Layout of major components on Veroboard.

# Op Amps

**PARTS LIST — AUDIO OSCILLATOR**

| | | |
|---|---|---|
| IC1 | Integrated Circuit | 709 |
| Q1 | Transistor | BC107,108 or similar |
| D1,D2 | Diode | OA95 |
| R1 | Resistor | 1k 1/8W or 1/4W |
| R2,R3 | " | 4.7k |
| R4 | " | 470 1/8W |
| R5 | " | 1.5k " |
| R6 | " | 15k " |
| R7 | " | 330k " |
| R8 | " | 3.3k " |
| C1,C3 | Capacitor | 0.01µF polyester |
| C2,C4,C7 | " | 0.1µF polyester |
| C5 | " | 220pF " |
| C6 | " | 15pF " |
| C8 | " | 10µF electrolytic 16V |
| RV1 | Potentiometer | 10k + 10k ganged |
| VR2,RV2 | " | 5k pre-set (horizontal) |
| VR3,RV3 | " | 1k pre-set (horizontal) |
| VR4,RV4 | " | 10k logarithmic |
| S1 | Switch | DPDT |
| Aluminium box | | 100 x 75 x 40 mm |
| Veroboard, 0.1" pitch 80 x 62 mm | | |
| 8 pin IC holder | | |
| 3.5 mm jack | | |

rotated, due to tracking errors between RV1 sections, can be minimised by adjustment of RV3. To do this, set RV1 close to its high frequency end. Adjust RV3 to give about the same level of output as with RV1 at mid-travel. If the twin gang potentiometer RV1 is particularly poor in its tracking an alteration to the value of R4 may be called for.

Calibration of the frequency scale is always a problem with any home constructed audio equipment such as this oscillator. Comparison with other audio signals is one method, either by ear, oscilloscope or frequency counter. Ideally comparison with another oscillator will allow the frequency scale to be marked up accurately.

Regarding alternative components: a 741 in place of a 709 will function well, except for some slew rate limiting at the higher frequencies, leading to distortion. If a 741 is used delete C5, C6 and R5. A type 301 may also be used; in this case C5, C6 and R5 are deleted as before and a 10 pF capacitor is fitted between pins one and 8. Almost any silicon NPN transistor will be satisfactory for Q1, but some alteration in R7 value may be necessary. Silicon diodes for D1 and D2 give rise to much greater levels of crossover distortion, due to their greater forward voltage drop.

This little oscillator will be found to give a sufficiently pure sine wave to assist in the testing of almost any audio equipment, its restricted frequency range being no great drawback for that work.

A truly portable oscillator can be made by replacing the dual 12 volts batteries by two small nine volt batteries. If this is done, however, some re-adjustment of RV2 and a reduction in the value of R6 to give a sine wave free from clipping, will be required.

*to be continued . . .*

# ELECTRONICS -it's easy! PART 23

## Last word on filters

WE CONTINUE our discussion of active filter design following our analysis of single and multiple feedback systems. The most common active filter is the multiple feedback path design shown last month. Other options open to us are to use an op-amp set up as either a controlled source with added elements — see Fig. 1, or as the negative-impedance convertor shown schematically last month. These can offer certain advantages over the voltage-amplifier design but suffer some disadvantages. NIC devices, for instance, do not give the ideal zero output impedance. Stages must be buffered to retain designed performance for example, when they are cascaded to obtain higher orders. One the good side is the small number of passive elements needed. Fig. 2 compares the four alternatives showing that no one type is exclusively the best choice.

At this stage we can only suggest that details of designs can be found in the many text books and application notes now available. Very few people would attempt (or even could) design an active filter from basic theory today. There are now available many well-prepared circuit design guides — we heartily recommend the Burr-Brown "Handbook of Operational Amplifier Active RC Networks". This contains twelve basic circuits, along with quite manageable design procedures for each, in which desired values are put in formulae to arrive at circuit values for low-pass, band-pass and high-pass requirements.

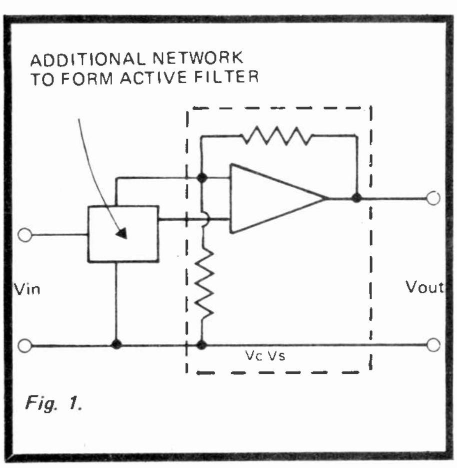



Fig. 1.

| Property | Realization Technique: Infinite-Gain Single-Feedback | Infinite-Gain Multiple-Feedback | Controlled Source | Negative-impedance Converter |
|---|---|---|---|---|
| Minimal number of network elements | - | + | + | + |
| Ease of adjustment of characteristics | - | 0 | 0 | + |
| Stability of characteristics | + | + | - | - |
| Low output impedance | + | + | + | - |
| Presence of summing input | + | - | - | - |
| Relatively high gain available | + | - | + | + |
| Low spread of element values | + | - | + | + |
| High-Q realizations possible | + | - | + | + |

+ indicates the realization is superior for the indicated property

0 indicates the realization is average for the indicated property

- indicates the realization is inferior for the indicated property

*Fig. 2. Comparison table for various kinds of active filter realisations (from Burr-Brown handbook).*

### FILTER CHARACTERISTIC TERMINOLOGY

The ideal edge on a filter characteristic is usually a sharp "square" response with attenuation occuring instantly as the frequency passes through the corner point. It should also have a constant response level at all points in the pass-band regions. As well as the rudimentary RC filter characteristic which falls off at 20 dB/decade from a breakpoint, two other kinds of response are commonly encountered. These are Butterworth and Chebyshev responses. Both derive their names from persons who developed the mathematics involved — (Butterworth designed filters around 1930, Chebyshev developed certain mathematical theory in his study of steam-engine linkages around 1850).

The Butterworth response is said to be maximally flat (that is as flat as possible) in the pass-band region. It has the optimum constancy possible with a given number of available peaking resonances (the complex passive or active filter circuits can be regarded as a group of staggered-tuned resonating sections, each arranged to peak just aside of the others, thereby, providing a broadened response band and a reject region). Fig. 3 shows the kind of Butterworth responses obtainable. Note that each passes through the 3 dB, down half power, point. The order (a mathematical term denoting the number of resonances available) of the filter is denoted 'n' in the chart. A typical roll-off rate is 20 n dB/decade so a fourth order Butterworth response filter (which can

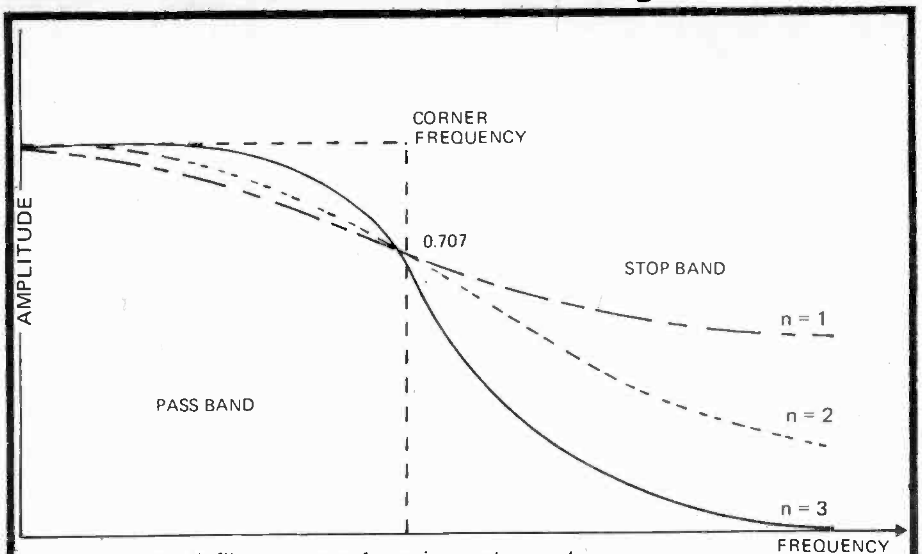



*Fig. 3 Butterworth filter responses for various orders used.*

be realised by either passive or active methods) will attenuate at around 80 dB/decade.

Whereas the pass-band response is reasonably constant, the rate of roll-off is not as good as can be obtained if the resonating sections are staggered differently. Other criteria of staggering the resonances can provide higher roll-off rates but only by introducing "ripples" in the pass-band response. When these individual ripples have equal amplitude across the pass-band response Chebyshev polynomials describe the shape, thus giving the name to an alternative response situation. As with Butterworth designs the higher the order the better the roll-off rate as can be seen diagrammatically in Fig. 4. The depth of ripple that can be tolerated also influences the roll-off rate — the smaller the variation that can be allowed the less the roll-off rate. (This can be readily seen by sketching in the required number of ripples of given depth at the appropriate scale).

Normally Butterworth or Chebyshev response filters will be of order 1 to 4 but higher orders are possible. These two forms are not the only sophisticated filter responses available: other mathematical criteria could be used to set up workable mathematical equations for designing other networks. These two will, however, meet most demands required and all filter design, as we have seen, is dominated by need to compromise between what is needed and what can be handled mathematically.

## PHASE SHIFT AND DELAY FILTERS

These act to provide a phase shift to a signal without selectively attenuating the frequency content. They are sometimes called all-pass filters. The amount of phase shift of practical circuits, however, usually varies with the frequency of the signal even though the amplitude response is invariant. Constant time-delay or linear-phase filters have a reasonably straight (linear) phase response as shown in Fig. 5. The so-called Bessel filter approximates this response using a workable mathematical formulation. Fig. 6 gives the general configuration of such a method realised as an active filter design.

## COMPONENTS TO USE

Resistors — In non critical applications the normal 20% tolerance carbon composition resistor may be acceptable. If tighter filter characteristics are needed then one must resort to more expensive resistors such as 5% or closer tolerance carbon composition. Even better, use

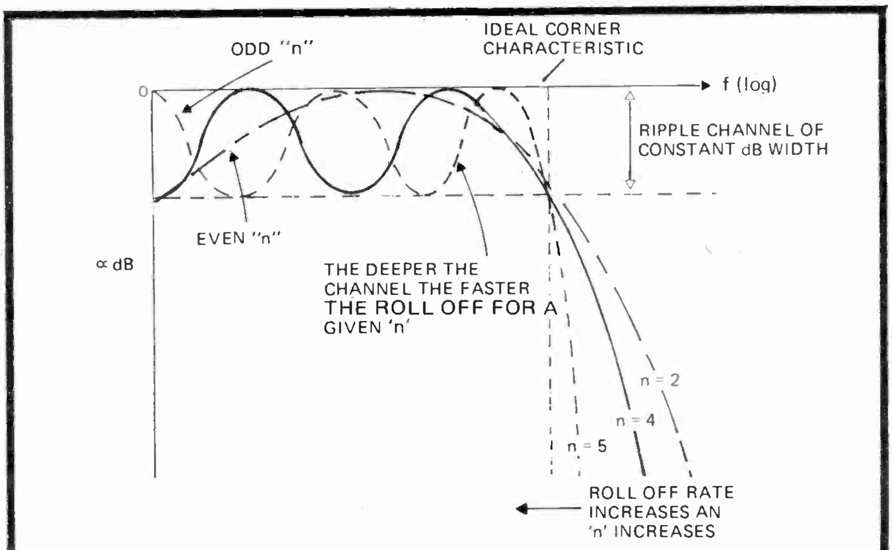



*Fig. 4 Chebyshev filter responses for various orders.*

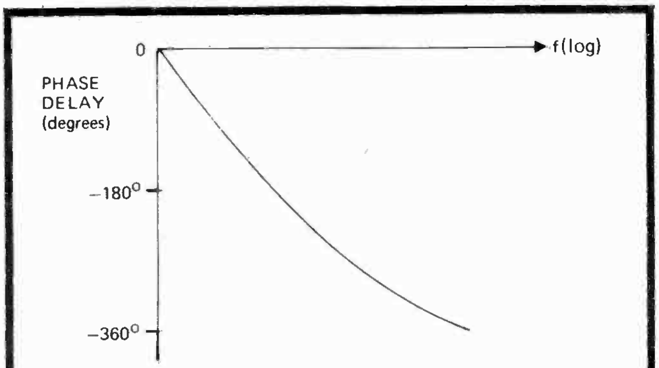



*Fig. 5 Phase response of phase-linear all-pass filter.*

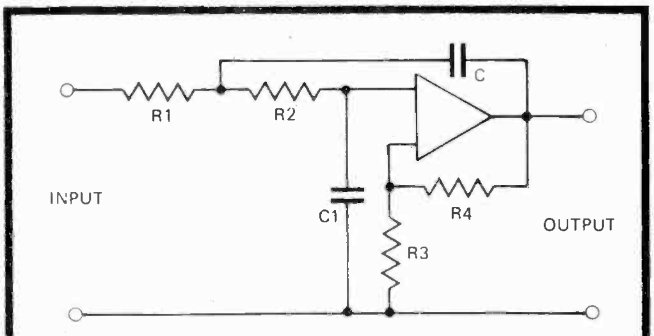



*Fig. 6 General configuration of constant time-delay Bessel all-pass filter.*

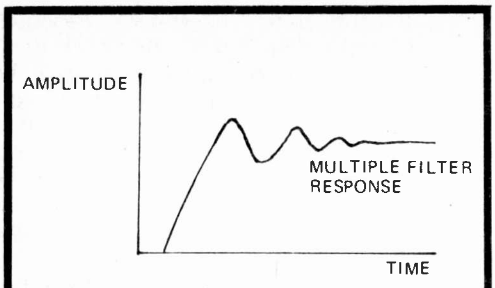



*Fig. 7 Multi pole filters resonate with transient excitation.*

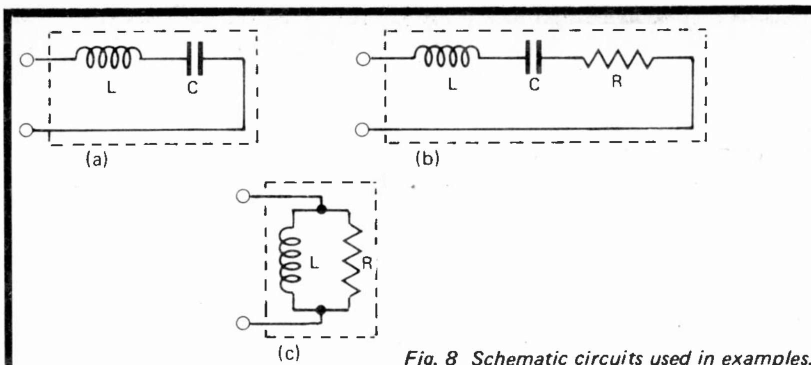



*Fig. 8 Schematic circuits used in examples.*

metal-film or wirewound types. It is sometimes permissible to hand choose values from wide tolerance groups in order to produce specific values, but it must not be forgotten that wide tolerance resistors often lack the same degree of time and temperature stability as the more expensive types.

Capacitors — Ceramic disc capacitors can be employed but they are best avoided. Nylon film, polystyrene and Teflon capacitors are much the better to use. When especially long-period filters are needed the capacitance value will be large. In such cases the leakage current due to losses in the dielectric is extremely critical and this rules out, in the majority of cases, using electrolytics.

Op-amp — It is easy to assume all op-amps will provide good active filters but this is not so. The main factor is a low offset current, this being especially important in long-period filters. As a general rule the more critical the need the better the op-amp should be. When op-amp filters also add gain they should have an open-loop gain at least 50 times the filter gain. Many active-filter design procedures enumerate the requirements of the op-amp.

## RESPONSE TO TRANSIENTS

Filters of second order and higher invoke the characteristics of resonating circuits for their operation. In passive filters we can readily identify the inductance and capacitance; in active circuits these may not be so obvious, the mathematical expression showing that resonances do occur.

When a step change in signal is applied to a resonant circuit, the circuit 'rings', that is, the output rises rapidly but then oscillates with decreasing amplitude to the final value as indicated in Fig. 7. The extent to which a resonant circuit rings is decided by the damping provided — the higher the Q of the resonant configuration the greater the ringing effect.

It is not hard to see that higher order filters, therefore, will tend to ring more than the lower order designs when transient signals appear at their input terminals. Transients occur in practice as noise spikes, switching spikes, sudden signal appearance and departure.

## THE S-PLANE, POLES AND ZEROS
### (For the advanced reader)
### S-Notation

The above study of filters can only act as a guide to filter selection. From there one must turn to the many articles and books available for details. To make good use of such material it is necessary to have a basic understanding of the mathematical methods used. This section is given to assist the more advanced reader. It is possible to get by without this information, provided a suitable configuration and design procedure can be located. Therefore do not be concerned if you are unable to understand this section.

Scanning through even basic, well-organised books on filter (and feedback amplifier) design the terms transfer function, s-plane, poles, zeros and root-locus will be encountered. Sadly, most books omit to provide the background explaining what this is all about. The concepts are not difficult to grasp, any confusion arising almost certainly from the number of synonomous terms used and the fact that the concepts are, perhaps, quite alien to begin with.

We have seen how reactive elements (capacitance and inductance) have apparent resistances of $2\pi fL$ for inductance and $1/2\pi Fc$ for capacitance. These terms, however, do not provide information about the phase changes produced with these reactance elements.

Electronic circuit designers use the operator symbol j (mathematicians use i) to denote a phase change of 90° hence, $j2\pi fL$ represents both the reactance value *and* the phase change. Furthermore $j = \sqrt{-1}$. For capacitive reactance the complete notation is $-j2\pi$ Fc, as the capacitor introduces a 90° phase shift of opposite sign to inductance. Resistance, having no phase shift, nor being frequency dependent is merely R. We can be a little more basic still and use $\omega$ instead of $2\pi f$. $\omega$ is the angular frequency being expressed in radians $\sec^{-1}$. (There are $2\pi$ radians in one cycle).

When reactance and resistance are mixed we represent the value as a complex number as, for example, $R + j\omega L$. The left-hand part is known as the Real part, the other (that after j) the Imaginary part, the whole forming what is called a complex number.

Where the circuit element is only reactive the complex number representing the impedance reduces to $j\omega L$ or $-j\omega C$ for which the symbol 's' is used instead of $j\omega$. (In some books 'p' is used instead of 's'). A trap can occur here for the $-j$ of $-j\omega C$ indicates a 180° phase shift over j, not a negative quantity in the normal way. To avoid confusion we rewrite $-j\omega C$ as $1/j\omega C$ (which is valid — it comes from multiplying both numerator and denominator $-j\omega C$ by j. Hence we obtain sL and 1/sC as the shorthand way of writing inductive and capacitive reactance in which frequency dependency and phase information are both retained.

Once these terms and concepts are mastered it becomes much more straightforward to write down the transfer function for a frequency dependent network. For example, consider finding the impedance presented by a series, lossless, resonant circuit shown in Fig. 8a.

$$Z = sL + 1/sC = \frac{L\,(s^2 + 1/LC)}{s}$$

(The individual components of the expression are put on a common denominator, dividing out to get the $s^2$ terms with unity coefficients).

For the series resonant lossy circuit of Fig. 8b.

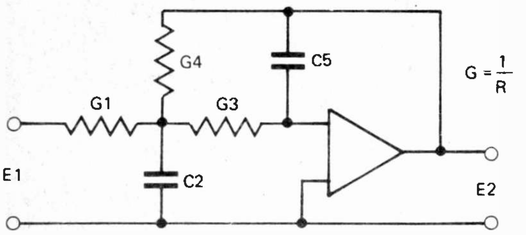
$$Z = sL + 1/sC + R = \frac{s^2 + R/L\cdot s + 1/LC}{s\cdot 1/L}$$

Again, for the parallel L and R circuit of Fig. 8c.

$1/Z = 1/sL + 1/R$ from which

$$Z = \frac{R\cdot s}{(s + R/L)}$$

# ELECTRONICS -it's easy!




$$\frac{E2}{I1} = \frac{-G_1 G_3}{S^2 C_2 C_5 + SC_5 (G_1 + G_3 + G_5) + G_3 G_4}$$

*Fig. 9 Typical low-pass active filter with its transfer function in s-notation form.*

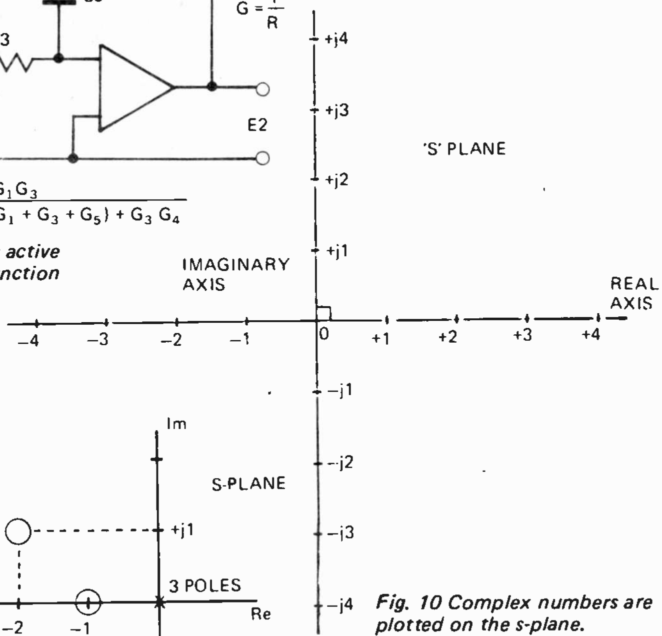



*Fig. 10 Complex numbers are plotted on the s-plane.*

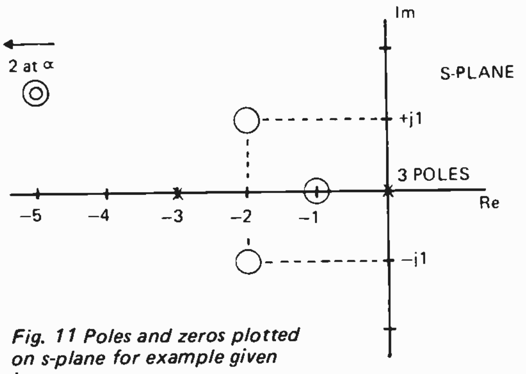



*Fig. 11 Poles and zeros plotted on s-plane for example given in text.*

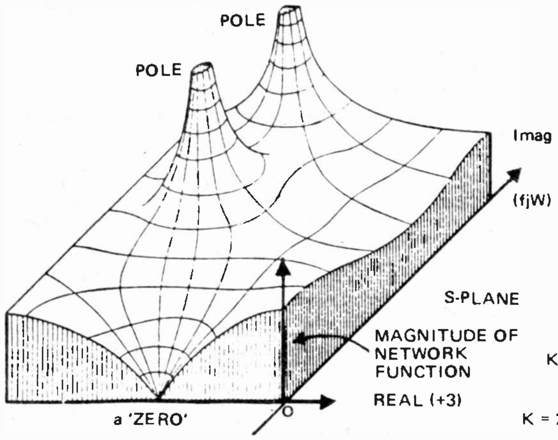
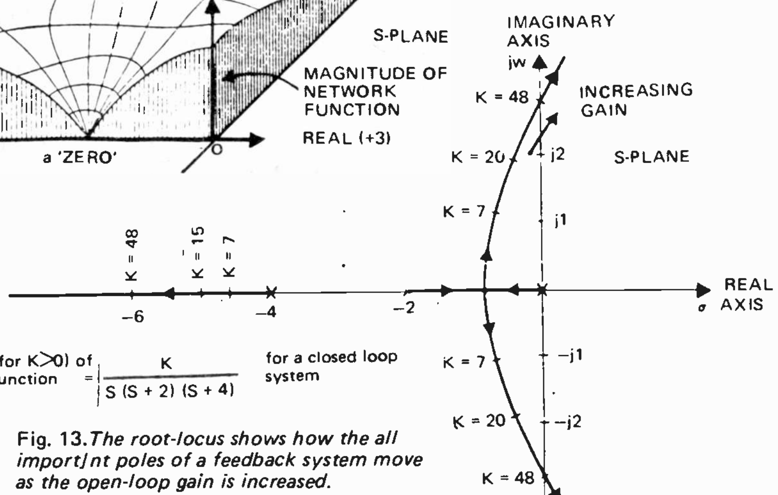



Fig. 12. *Topographical representation of poles and zeros in s-plane.*




root-locus (for K>0) of open loop function $= \dfrac{K}{S\,(S+2)\,(S+4)}$ for a closed loop system

Fig. 13. *The root-locus shows how the all importJnt poles of a feedback system move as the open-loop gain is increased.*

It is these forms of expression that are quoted in circuit design books. The form of expression is not restricted to two terminal networks — it applies for all frequency dependent reactive networks. Fig. 9 gives the circuit of a low-pass multiple feedback active filter along with its derived transfer function expressed in 's' notation form.

As these complex numbers possess two parts we must use a two-axis graph to represent them in which the two axes are mutually perpendicular. Thus complex-number quantities need a plane rather than a line to depict a unique number. This plane is known as the s-plane (see Fig. 10). The two axes are usually labelled Re, R or $\sigma$ for the Real axis and Im, I or $j\omega$ for the Imaginary axis, each pair being used respectively.

## POLES AND ZEROS

We have seen above how a network of passive elements (active designs also apply) produces a mathematical expression in terms of s notation. As s merely represents $j\omega$ and j denotes only phase information we can, whenever s appears, substitute $\omega$ (or $2\pi$ f) to see how the expression varies in magnitude with varying frequency.

Consider the case where a function is given by the numerical example:

$$\frac{(s+1)\,(s+2+j1)\,(s+2-j1)}{s^3\,(s+3)\,(s+5)}$$

When s = −1, −2 -j1 or −2 + j1, the numerator becomes zero for one of the bracketed terms becomes zero. Hence at each of these frequency values the expression becomes zero. We say it has 'zeros' at these points. Zeros also exist when the singular s term goes to infinity in the denominator. When s = 0 (three times, as it is from $s^3$ = s.s.s.), −3 or −5, we get the reverse situation for at all of these values of $\omega$ the denominator goes to zero making the function rise to infinity. These frequency points are called 'poles'.

Thus the poles and zeros express the peaks and hollows of the function. The position of these can be plotted on the s-plane diagram as shown in Fig. 11. 0 is used for zeros, a cross X for poles. In realisable networks there must be as many poles as zeros — including those at zero and infinity.

Another way to imagine the network characteristic is to draw a topographical representation giving relative height to poles and zeros on the s-plane placed horizontally as shown by the example of Fig. 12. This makes the terms poles and zeros more meaningful in a physical sense.

In the numerical example we avoided, in that case, using a quadratic or higher order term such as $s^2$ + 4s + 5. When these are encountered they must be factorized by finding the roots of the expression — giving the two terms s + (2 + j1) and s + (2 − j1) in this case. These are the individual roots, i.e., poles and zeros, of the expression. Note that quadratic elements involving an Imaginary part form mirror image pole or zero pairs — called a conjugate pair. If these are lossless (no Real part) they lie on the imaginary axis, if lossy (with Real part) they will be displaced out into the s-plane depending upon the resistive value. Positive values of resistance result in displacement into the left-hand plane, negative resistance gives poles or zeros in the right-hand plane, these halves being denoted LHP and RHP respectively.

Mathematics of complex numbers show that resonant systems with roots lying in the LHP are stable systems, their oscillations die down because to be in the LHP they must contain resistive damping. If the roots lie on the Imaginary axis itself the system is marginally stable — transients will undoubtedly create unstable situations at times even though the system is not absolutely unstable. Note that this situation only arises if the resistive component occurs as negative resistance — oscillators create this condition by the use of an active element.

## ROOT LOCUS

When considering the behaviour of feedback systems, such as amplifiers, controllers and active filters, it is highly valuable to plot the changes in position on the s-plane of the closed-loop poles of the system transfer function as the open-loop gain changes. The path traced, by the movement of the poles in this way is called the root-locus. These are often referred to in amplifier and other feedback-mechanism designs and it is, therefore, helpful to at least appreciate what they are. It is, however, not a simple matter to produce them from an original expression; lots of experience is vital.

By way of example the root-locus for a relatively simple transfer function is given in Fig. 13. This tells us that an open-loop gain in excess of 48 places some of its poles in the RHP establishing an unstable situation. The value of the root-locus is that we can "see" the behaviour of the system as the gain is increased and, more importantly, what we should do to the position of the poles most influencing an unstable situation. By altering the transfer function we can place the locus in more favourable situations. This is done by altering original component values where possible or by adding other networks that reduce the effect of the dominant poles — those lying close to the RHP. ●

*Next month we look at digital electronics.*

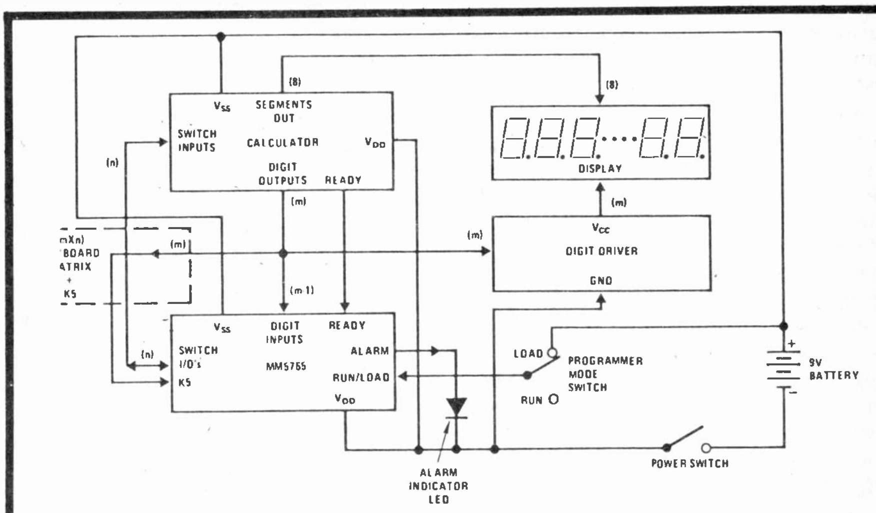
# Electronics Tomorrow

by John Miller-Kirkpatrick

## MORE MONEY-SAVING IDEAS

Yet again we bring you news of how to get more from a clock chip for less money! National Semiconductor have now released the MM5318 clock chip as a separate chip. You may remember that we mentioned it a couple of months ago as being connected to the TV time display chip. The IC has all of the features of the MM5311 — six digits, seven segment and BCD outputs, 12/24 hour and 50/60 Hz operation. The outputs are multiplexed but controlled. Whereas the MM5311 outputs were under the control of an internal oscillator and multiplexer, the MM5318 outputs are demanded by the data input on three pins. To operate the MM5318 you need a simple oscillator and a BCD divide-by-6 counter, about £1, or less, in cost. (In addition to the displays and drivers you would need with the MM5311). *'How is this a saving?',* I hear you ask — the answer is quite simply that the recommended price of the MM5311 is £5.69, but the MM5318 is only £3.36, a staggering difference of £2.33! Thus for about £4.50 you can build a £5.69 clock chip. I can only assume that National have sold such vast quantities of these chips to TV manufacturers that the production costs are very low and that these low costs are being passed on to the low volume market. Large industrial sales can mean that there are no low volume chips available but it could be worth trying to get one if you want to save some money.

To those of you who build computers, data recorders and similar bit processing systems, it is interesting to note that the MM5318 can be strobed by any BCD data highway and deliver its digit data in BCD and seven segment data to any TTL or MOS system. Much to my own personal annoyance I have recently completed the building of a system to feed a pen plotter with a time signal in BCD format for printing, the unit was built in TTL and took many hours and many chips. It could have been built using a MM5318 and a couple of other chips — less time, fewer chips and less money.




MM5765 Programmer Connected in Low-Cost Battery Operated Calculator System

## DON'T MISS A THING!

Whilst on the subject of TV clocks and tuners we bring you news of the latest in the 'let's get more ICs in TVs' onslaught. The most elaborate channel-selection device is due on the market from Toshiba early in 1976. No more clock watching so that you don't miss Magic Roundabout, no more boring changing channels when News at Ten starts. With this new chip you settle down with the evening paper spralled open at the TV page and program the TV to change channels at predetermined times, then you can ease back in your armchair to an evening's uninterrupted viewing. The chip displays your selection and lists the time and channel as you choose them, up to 16 programs with the on and off time for each channel. The clock operates from 4.5MHz (presumably a crystal) and has full power-failure back-up facilities. It would seem that the chip could also be used outside of a television set for programming central-heating, anti-burglar lights and any number of other useful things in the home, do not even bother to start thinking of its applications in the industrial area, and yet this chip has come to life as a chip to make a boring life even more boring.

Programming chips are next year's IN product: microprocessors at under £200, TV programmers, oven programmers, central-heating, etc. The latest is another National chip for programming calculators, or how to put new life into last year's calculator. The MM5765 calculator programmer provides a convenient and inexpensive way of adding a 'Learn mode' to virtually any calculator chip. It memorizes any combination of key entries during the Learn mode, then automatically plays back the programmed sequence as often as required when in the Run mode. Up to 102 characters or operations can be stored in multiprogram sequence blocks. Each program can be executed individually or the operator can make the decision to branch to specific programs.

The MM5765 is coupled to the calculator by paralleling the digit drives and key inputs between the calculator chip and the programmer chip. The calculator encodes a key depression by sensing which digit drive was active when an input was received by one of its 'K' inputs. Most calculators have 6, 8, 10 or 12 digit drives and up to 4 'K' inputs; thus a six-digit calculator with 3 'K' inputs can recognise 18 different key inputs and a 12-digit machine with 4 'K' inputs can have up to 48 keys. The MM5765 can handle 47 different key positions by having 12 digit inputs and 4 'K' drives. In operation a calculator key is pressed and this will connect one of the digit drives to one of the 'K' inputs, at the same time the digit drive is connected to the digit input of the programmer and to the 'K' input of the programmer. The programmer stores this information as a binary number in six bits (up to decimal 64) as a number 0-46, other non-keyboard entries such as SKIP and HALT give codes in the series 47-63. When the program is put into the RUN mode the programmer will decode this number into a high level output on one of the 'K' lines when the same digit drive is strobed again, in this way the calculator chip is fooled into thinking that a keyboard depression has caused that digit drive to be directed to that 'K' input and will thus execute that function. As we are fooling the calculator chip we can enter any valid key depression or series of depressions and on a scientific machine (such as the NOVUS) the radius of a circle of known area could be —

HALT Enter known area
START start programmer
÷ Divide
3 by Pi
.
1
4
= Give Result 1
LOG Log of RES 1
÷ Divide
2 log by 2
=
ALOG Compute Antilog
HALT with approx result.

If you are satisfied with this result you can SKIP to program 2 and use it in a calculation there, otherwise you can continue with program 1 which might now reverse the computation in order to check its accuracy —

START Cont PGM 1 with previous result
X Multiply result by
= itself
X and then by
3 Pi
.
1
4
= to give comparison with orig area.

If the calculator has memories then it would have been possible to save the original area in a memory and calculate the percentage error in program 1 before continuing with program 2.

The applications of this chip do not end at calculators, many clock chips use the Digit/'K' method of inputting data and a MM5765 plus a CT7001 could probably make a Lunar Module Command Computer look sick. If the Mostek cooker timer MK50206 is ever fully released it could be combined with the MM5765 to cook a meal or range of meals, all programmed as switch on and off times. You could even use the same combination to set up a selection of TV programmes and on and off times! The price of the MM5765 calculator programmer chip is £9.97, data from National.

## CT7001 et al

The CT7001 series of clock chips and the CT6002 series of watch chips from Caltex were so widespread at the time of the financial crisis of the company that supplies did not start to dry up for some time. Eventually no CT7004s could be found, then 7002s, 6003s, 6002s, and now even the CT7003 and Big Daddy the CT7001 are becoming scarce. This chip caused a great stir some time after its announcement and when its capabilities became known; but just at its peak two things happened. First a lot of faulty chips came onto the market, and secondly Caltex had financial problems. The company finally stopped trading last spring and the future of the 7001 looked grim indeed. The last batch of full-spec devices had just been delivered to the UK and there were no more to come — that batch number 7448 indicated that the 7001s had been made in 1974, it is probable that none were made in 1975 at all.

If you are a TIME/DATE/ALARM fanatic fear not, because the CT7001 has now become the HCM7001 from Fairchild, who bought the Caltex plants, a few CT7001s are still around at £7.30 (Bywood, Walter Scott and some other retailers) but nobody yet knows the availability or the price of it now that it is the HCM7001. Fairchild also seem to intend to produce the HCM7002, 3 and 4 as well as introducing the HCM 7010 which seems to incorporate most of the family features, further details on the 7010 as soon as Fairchild let me have them.

## PERSONAL

Two personal things from me, firstly I would like to buy a cheap teletype terminal to interface to a microprocessor — if you know of one please let me know. Secondly, I would like to wish you all the compliments of the season and an electrifying 1976 ●

Continued from page 8

## PROM SELECTOR WALLCHART

Intel have published an attractive wallchart which has been designed to aid the engineer in the selection of programmable read only memories. It lists the significant characteristics of 39 different PROM types manufactured by Intel. These are divided into three groups on the chart: Schottky bipolar, silicon gate EPROMs (ultra-violet erasable) and silicon gate MOS.

For each Intel PROM there is a pin-for-pin compatible mask programmable ROM shown on the chart; therefore, one a design has passed from the development cycle into production, the PROMs can be replaced with ROMs without the need for any circuit or printed board changes.

Also featured on the chart is a comprehensive PROM equivalents guide which lists the important characteristics of PROMs from many manufacturers and gives the Intel equivalent, if one exists. Intel Corporation, Broadfield House, 4 Between Towns Road, Cowley, Oxford OX4 3NB.

## RCA TO BUILD METEROLOGICAL SPACECRAFT

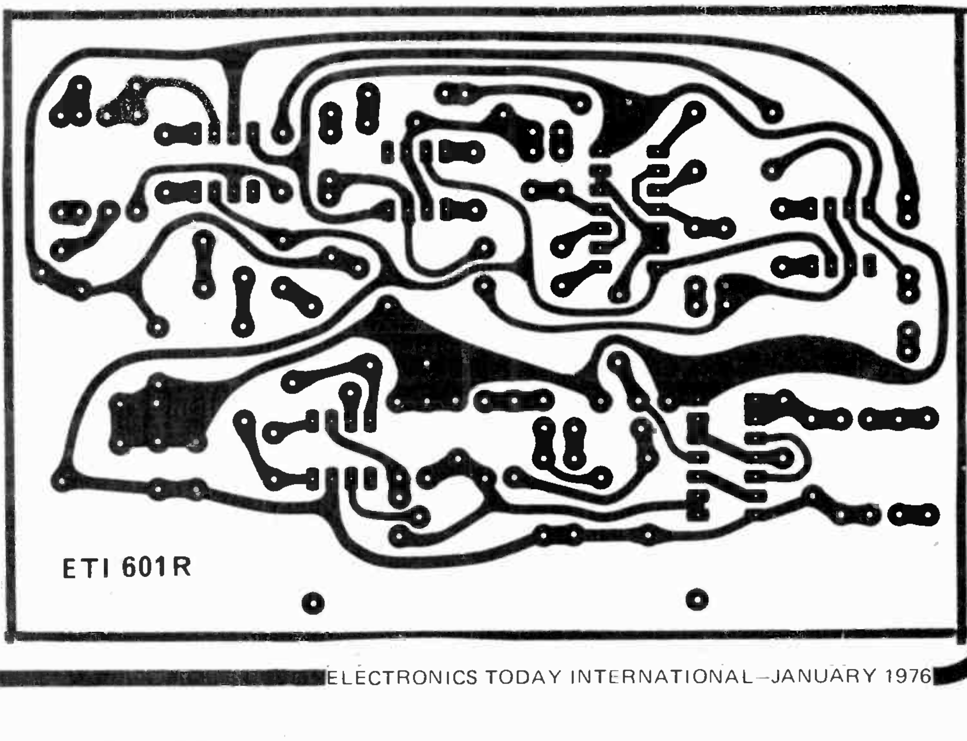
RCA has announced receipt of a $45.6 million NASA contract to design and build eight third generation meteorological spacecraft known as TIROS-N. These are expected to make possible weather forecasts two days in advance with accuracy equal to present day predictions. The first launch is scheduled for 1978.

TIROS-N will weigh about 1,400 pounds in orbit and will stand 17 feet tall. They will be advanced polar orbiting satellites that will carry out not only weather forcasting but also worldwide oceanographic and hydrological services.

The TIROS-N spacecraft will provide day and night cloud cover imagery andwill take atmospheric and sea surfacetemperature and water vapour readings.The device will also measure proton, electron and alpha particle activity around the planet.

## ADDENDA

3600 Synthesiser, ETI July '76 The pcb design shown alongside is for the Voltage Controlled Filter.




## MOTOROLA SEMICONDUCTOR DATA

Motorola have published a seven-volume Semiconductor Data Library with a combined thickness of about nine inches giving specifications for all their semiconductor devices. The library also lists the function and the significant characteristics of all EIA registered semiconductor devices.

The product range is divided into six volumes (1N-2N, 3N-4N, in-house type numbers, MECL, CMOS and linear ICs). The seventh volume functions as an index and an equivalents guide, and it contains outline drawings and an index of application notes.

The Semiconductor Data Library is available from Motorola Distributors for £15. Individual prices include the MECL Data Book for £2, the CMOS book for £1.50 and the Linear Data Book for £2.50.

## COS-B SATELLITE

The first satellite to be launched by the new European Space Agency was recently successfully put into orbit by a Delta 2913 rocket, from the Western Test Range in California.

This scientific satellite, called COS-B, is a remotely-controlled astronomical observatory which will detect, locate and enable scientists to study extraterrestrial gamma radiation, the most energetic and penetrating form of radiation known.

Gamma-rays come from certain radio-active atoms, from nuclear explosions and from the depths of outer space. They provide a knowledge of the structure of matter, and possibly of the origins of the Universe. Highly energetic gamma radiations from space is detectable even in coal mines after penetrating the earth's rocky crust, but it is found most freely outside the earth's atmosphere in space itself. The gamma radiation which COS-B will detect may be the remnants of exploding stars or quasars, pulsars and other radio and X-ray sources.

The cylindrically shaped COS-B weighs 278 Kg. including the payload, which is a single experiment assembled from five primary and two subsidiary experiment units supplied by six institutes in four European countries (France, Germany, Italy and Netherlands). COS-B will have an operational life of two years during which time it will study 24 targets for approximately one month each.

After the successful launching and initial performance checks, the Satellite very rapidly commenced its scientific observation programme by looking at the Crab Nebula. Approximately 14 days after launching a genuine Gamma event was observed and with all systems functioning perfectly COS-B is giving every indication of fulfilling its two year mission lifetime successfully.

Designer-approved

# TEXAN AMPLIFIER AND TUNER KITS

...from Henry's Radio. The Sole UK Distributors.

Here's your opportunity to build the superb Texan amplifier and tuner! Designed especially for Henry's by Richard Mann of Texas Instruments, the Texan amplifier was featured in Practical Wireless. Through bulk buying, Henry's are able to offer both these kits of quality components at low cost. Naturally, as sole appointed UK distributos, Henry's offer a full after sales service – so if your kits don't result in properly functioning units, we'll help you sort them out!

## TEXAN AMPLIFIER

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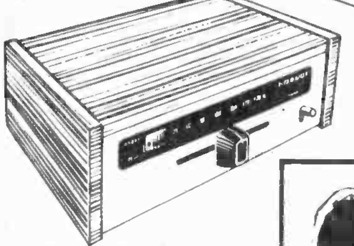

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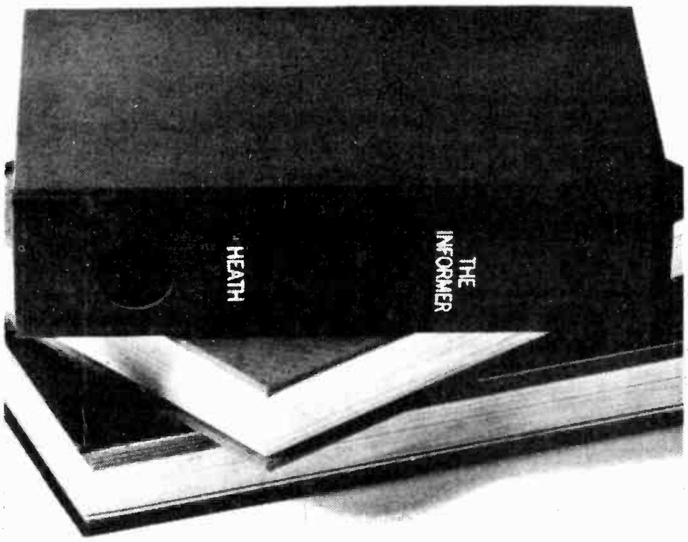


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Written queries can only be answered when accompanied by an SAE, and the reply can take up to three weeks. These must relate to recent articles and not involve ETI staff in any research. Mark your letter ETI QUERY . . . Telephone queries can only be answered when technical staff are free, and never before 4 pm.

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We cannot solve the problems faced by individual readers building our projects unless they are concerning interpretation of our articles. When we know of any error we print a correction as soon as possible at the end of News Digest. Any useful addenda to a project will be similarly dealt with. We cannot advise readers on modifications to our projects.

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Before submitting any material for publication contact the editor who will advise on suitability (except for letters, news & Tech-Tips).

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