wireless world

Australia A$2.40
Canada C$4.25
Denmark DKr. 20.25
Germany Dm. 6.00
Greece Drs. 125.00
Holland Dfl. [illegible]
Italy L [illegible]
Norway NKr. 21.00
Singapore M$5.[illegible]
Spain Pts. [illegible]
U.S.A. $[illegible]

FEBRUARY 1981 60p

Wind meter

'Just detectable' distortion

Morse decoding program

WIRELESS WORLD FEBRUARY 1981 VOL 87 NO 1541

wireless world

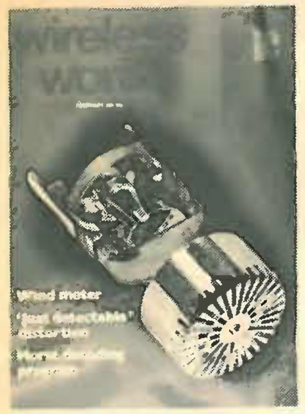
Australia A$ 2.40
Canada C$ 4.25
Denmark DKr. 20.25
Germany DM 6.00
Greece Drs. 125.00
Holland Dfl. 5.75
Italy L 2300
Norway NKr. 21.00
Singapore M$ 5.50
Spain Pts. 150.00
U.S.A. $3.75

FEBRUARY 1981 60p

Wind meter

'Just detectable' distortion

Morse decoding program



Cutaway model of a capacitor measuring microphone from Brüel & Kjaer (UK) Ltd symbolically introduces the article on 'just detectable' distortion in this issue.

IN OUR NEXT ISSUE

A range of counters **for construction based on the versatile Intersil ICM7216 i.c. From a set of modules a variety of instruments can be assembled.**

Magnetic recording progress. **Tape recording has developed rapidly, urged on by the popularity of hi-fi reproduction. James Moir reviews advances in equipment and tape coatings.**

Guide to s.a.w. devices **for the professional applications engineer, covers electrical characteristics and applications of three s.a.w. types: bandpass filters, delay lines and oscillators.**

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wireless world

ELECTRONICS/TELEVISION/RADIO/AUDIO

FEBRUARY 1981 Vol 87 No 1541

Electronic Brokers~Europe's Premier Test Equipment Company offer

SUPERLATIVE USED EQUIPMENT CALIBRATED TO ORIGINAL SPECS

The Electronic Brokers GUARANTEE

Unless otherwise stated, all test equipment sold by us carries a 12 month warranty; For VDUs and Teletypes we offer a 90 days warranty, and computers are offered with on site acceptance and diagnostic tests (which may qualify them for independent on-going maintenance). When you buy from Electronic Brokers you know the equipment is in 'top notch' condition. It is refurbished in our own service laboratories and checked to meet the original manufacturer's sales specifications. And it's serviced by our own highly qualified technicians.

A copy of our Trading Conditions is available on request.

February 1981...... Latest Test Equipment.....

ANALOGUE VOLTMETERS AND MULTIMETERS

Boonton.
93A True RMS Voltmeter. Bandwidth 10Hz-20MHz. 1mV-300 FSD £375.00

Fluke.
883AB AC/DC Differential Voltmeter. 20Hz-100KHz. 1mV-1100V. Very high accuracy £975.00
895A DC Differential Voltmeter. 0-1100V. Null sensitivity. 100µV-100V. Very high accuracy £950.00

Hewlett Packard.
400E AC Millivoltmeter. 10Hz-10MHz. 1mV-300V DC o/p proportional to i/p £235.00
7563A DC Log Voltmeter / Amplifier. Single i/p range 360µV-100V O/P 0-1.1V @ 10mV/dB £400.00

Marconi.
TF2600 AC Millivoltmeter. 10Hz-5MHz. 1mV-300V £175.00
TF2603 RF Millivoltmeter. 50KHz-1.5GHz. 1mV-3V £525.00
TF2604 Electronic Voltmeter. AC 20Hz-1.5GHz. 300mV-1KV. DC 10mV-1KV. 0.2Ω-500MΩ £350.00
TF2606 DC Differential Voltmeter. 1mV-1100V on 5 decade dials £200.00

Philips.
PM2454B AC Millivoltmeter. 10Hz-12MHz. 1mV-300V £225.00

ANALYSERS

Biomation.
1650D 16 Channel Logic Analyser. Displays Timing, Map, hex, octal. Clock rate upto 50MHz. Supplied with display formatter and a Hameg HM312-8 oscilloscope £3600.00

General Radio.
1911A Sound and Vibration Analyser. C/W Graphic leve recorder. 4.5Hz-25KHz. 1/3 or 1/10 octave £1750.00


141T-8552A Spectrum Analyser. 0.5 to 1200MHz. —117dBm sensitivity. Log and linear display. Variable persistence CRT £4350.00
8407A/8412A Network Analyser. C/W 8600A/8601A sweeper. 0.1-110MHz £3500.00

Marconi.
TF2330 Wave Analyser. 20Hz-20KHz. 30µV-300V £395.00

Tektronix.
1L5 Spectrum Analyser. 10Hz-1MHz £750.00

BRIDGES & COMPONENT TESTERS

AVO/BPL.
CB154/4 Electrolytic Bapacitance Tester. 0.1µF-1F. Accuracy 1% to 2% £515.00

Boonton.
63H Inductance Bridge. 0-110mH. Bridge frequency 5-500KHz £1950.00
280AP VHF Q Meter. Q 20 to 25,000. 210-610MHz £650.00

General Radio.
1607A Transfer Function and Immitance Bridge. 25-1500MHz. Direct reading £750.00

Marconi.
TF1245-TF1246-TF1247 'Q' Meter and Oscillators. Q 5 to 500. 40KHz-300MHz £950.00
TF1313/2M 0.25% LCR Bridge. 0.1µH-110H, 0.1pF-100µF. 3mΩ-110MΩ. 1 and 10KHz £325.00
TF2700 1% LCR Bridge. 0.2µH-110H, 0.5pF-110µF. 0.01Ω-11MΩ. Battery operated £210.00

Rohde & Schwarz.
KRT (BN5100) Capacitance Meter. 1pF-100µF. 2.2-285KHz £395.00
LRT (BN6100) Inductance Meter. 1pH-100µH. 2.2-285KHz £395.00

Wayne Kerr.
B221 0.1% LCR Bridge. 0.0002pF-11.1µF. 9Ω-500GΩ. 0.9mH = 5MH, 2pu-111mu £225.00
B641 0.1% LCR Bridge. 0.002pF. 50,000µF. 200nH-5MH, 2mΩ-50,000MΩ, 20pu-500u £445.00
A60 Testmatic Dynamic Circuit Tester. Automatically checks upto 60 functions in 10 seconds on PCB's £895.00

CALIBRATION EQUIPMENT

Advance.
OFS2B Off Air Frequency Standard. O/P 1 and 10MHz £95.00

Bradley.
125B AC Calibrator. 0-511V in 0.1V steps @ 50-60-400Hz £425.00

Fluke.
332A DC Voltage Calibrator. 0 to 1111.1110V. 0.1ppm resolution. 0.003% calibration accuracy £1750.00
760 Meter Calibrator. DC/AC Volts and current £2150.00

Hewlett Packard.
741B DC Voltage Source and AC/DC Differential Voltmeter £695.00

Tektronix.
191 Constant Amplitude Generator. 350KHz-100MHz £350.00

FREQUENCY COUNTERS

Advance.
TC15 & P1 Frequency Counter. DC — 500MHz, 9 digits £400.00

Fluke.
1900A-01 Frequency Counter. 5Hz-80MHz. 6 digits. Mains / battery operation £195.00
1911A-01 Frequency Counter. 5Hz-250MHz. 7 digits. Mains / battery operation £325.00
1912A Frequency Counter. 5Hz-520MHz. 7 digits £340.00
1925A Frequency Counter. 5Hz-125MHz, 9 digits. EMI proof case £375.00

Philips.
PM6604 Timer Counter. DC — 50MHz, 6 digits £150.00
PM6614 Frequency Counter. 10Hz-520MHz, 9 digits £450.00


PM6615 9 digit 1GHz Frequency Counter. 10mV sensitivity. Period, ratio and totalizing £695.00
PM6664 Fully Auto Frequency Counter. 10Hz-520MHz. 8 digits £250.00

DVM's AND DMM's

Advance.
DRM6 4½ Digit True RMS DVM. DC — 1MHz. 10µV resolution £150.00

Datron.
1051 5½ Digit DMM. AC/DC Volts. Resistance. True RMS. 0.1µV resolution £900.00

Fluke.
8800A 5½ Digit DMM. AC/DC volts. resistance. 1µV resolution £495.00

Hewlett Packard.
34702A & 34740A 4½ digit DMM. AC/DC volts, resistance £225.00
3490A 5½ Digit DMM. AC/DC volts, resistance. 1µV resolution £495.00

Philips.
PM2513A 3½ Digit DMM. AC/DC volts and current, resistance £80.00
PM2514 3½ Digit Autoranging DMM. AC/DC volts and current, resistance £95.00
PM2517E 4 Digit Auto ranging DMM. AC/DC volts and current, resistance £115.00
PM2527 4½ Digit DMM. AC/DC volts, current and resistance. 10µV resolution. True RMS £400.00

Solartron.
A243 5½ Digit DMM. AC/DC volts, resistance. 1µV resolution £425.00
7055 Microprocessor DMM. Scale length 200,000. AC/DC volts, resistance £850.00
7055 plus processor control and RS232 interface £1150.00
7065 Microprocessor DMM. Scale length 1,400,000. AC/DC volts, resistance £950.00
7065 plus processor control and RS232 interface £1250.00

Weston.
4440 3½ Digit DMM AC/DC volts, DC current resistance £90.00

MISCELLANEOUS

Avantek.
UA101 RF Modular Amplifier. 5-500MHz, 10.5dB gain £39.00
UA103 RF Modular Amplifier. 10-500MHz, 10dB gain £39.00
UA301 RF Modular Amplifier. 1-400MHz, 7dB gain £39.00
UA305 RF Modular Amplifier. 2-500MHz, 13dB gain £39.00

Avo.
VCM163 Valve Tester £425.00

Dymar.
1581 RF Power Meter. DC — 500MHz. 30mW-100W £350.00

Ferrograph.
RTS2 Recorder Test Set Measures Wow & Flutter, Distortion, Gain £345.00

Hewlett Packard.
335E Programmable Attenuator. 0-12dB. DC — 10GHz, 50Ω £75.00
432A Power Meter with 478A Thermistor Head. 10MHz-10GHz. 100µW-10mW £450.00
4329A Insulation Resistance Meter. Range 500KΩ to 2 × 10^{16}Ω £500.00


4815A Vector Impedence Meter. 0.5 to 108MHz. 2 range 1Ω-100KΩ. Phase 0-360°. Recorder O/P 0-1V £1650.00
8745A S Parameter Test Set. Fitted with 11604A Universal Arms 0.1-2GHz £2750.00

Marconi.
TF791D Deviation Meter. 4-1024MHz £195.00
TF893A AF Power Meter. 1mW-10W £185.00
TF2300 AM/FM Modulation Meter. 0.5-1200MHz £375.00

Rohde and Schwarz.
MSC Stereo Coder. 30Hz-15KHz £500.00

Radiometer.
BKF10 Automatic Distortion Analyser. 20Hz-20KHz 0.02%-10% £1100.00

Rifa.
EVV 300 Microprocessor Development Kit. Based on Motorola 6800 TTY interface £495.00

Tektronix.
TM515 Main Frame C/W FG504. 0.001Hz-40MHz Function Generator and 2 off PS503A Power Supplies £1250.00
TM515 Main Frame C/W SC502. 15MHz oscilloscope, FG503 1.MHz-3MHz Function Generator, DM502 3½ digit DMM, DC503 100MHz counter £1495.00

Electronic Brokers

February 1981...... Latest Test Equipment......

MULTIMETERS

Avo.
8 MK 5 Multimeter 20KΩ/volt £70.00
Full lead kit £5.25
Test Set Number 1. 20KΩ/volt, very robust £75.00
Full lead kit £5.25
EA113 Electronic Multimeter. High input impedance £115.00

S.E.I.
Super 50 Selectest. 20KΩ/volt £77.00

OSCILLOSCOPES

Hewlett Packard.
130C XY Oscilloscope. DC — 500KHz. 200µV-20V/div £250.00
1707A Dual Trace Portable Oscilloscope. DC — 75MHz Full delayed sweep. 30 day warranty £550.00


1707B Dual Trace Portable Oscilloscope. DC — 75MHz. 10mV-5V/div. Full delayed and intensified sweep. Trigger hold off £725.00

Philips.
PM3212 Dual Trade Portable Oscilloscope. DC — 25MHz. 2mV-10V/div £625.00
PM3262 Dual Trade Portable Oscilloscope. DC — 100MHz. Full delayed sweep £1250.00

SE Labs.
SM121 6 Channel Monitor. 12" crt. Internal sweep £395.00

Tektronix.
432 Dual Trace Portable Oscilloscope. DC — 25MHz. 1mV-10V/div £510.00
465 Dual Trace Portable Oscilloscope. DC — 100MHz. 5mV-5V/div. Full delayed sweep £1195.00
T932 Dual Trace Portable Oscilloscope. DC — 35MHz. 2mV-10V/div £550.00
521A PAL Vectorscope. Measures Luminance Amplitude, Chrominance Phase, Chrominance Amplitude, Differential Phase and Gain. As new condition £2650.00
7704A Main Frame C/W 7A26, 7B80, 7B85. Dual Trace DC — 200MHz £3550.00

Telequipment.
DM64 Dual Trace B1-Stable Storage Oscilloscope. DC — 10MHz. Max writing speed 250div/mS £715.00
D67A Dual Trace Portable Oscilloscope. DC — 25MHz. Full delayed sweep £575.00
D75 Dual Trace Portable Oscilloscope. DC — 50MHz. Full delayed sweep £715.00

OSCILLOSCOPE PROBES

EB90 X1 Probe. 1.2 mtr length DC — 20MHz £9.00
EB91 X10 Probe. 1-2 mtr length DC — 100MHz £11.00
EB95 X1, X10 Probe. 1.2 mtr length DC — 10MHz or DC — 100MHz £15.00

POWER SUPPLIES

Advance.
PMA47 0-15V preset @ 3A £37.00
PMA50 0-15V preset @ 5A £45.00
MG5-60 5V @ 60A switching £160.00
MG5-20 5V @ 20A switching £120.00
MG5-10 5V @ 10A switching £95.00
MG24-12 24V @ 12A switching £130.00

RECORDERS

Bryans Southern.
40000 12 Channel UV Recorder Plus 2 off 40501 Galvo Amps. 6" paper £950.00

Hewlett Packard.
2FA XYY A3 Plotter. 2 Pens on Y axis. Internal X sweep. Electric paper grip £725.00
7035B XY A4 Plotter. 4mV-4V/cm X and Y. Electric paper grip £650.00

Philips.
PM8110 Single Channel Chart Recorder. 10mV-10V £195.00

Racal.
Store 4 Tape Recorder. 4 Channels FM. DC — 20KHz £1650.00

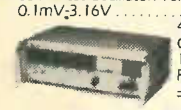
S. E. Labs.
3006/12 12 Channel UV Recorder. Grid and timing lines. 6" paper £550.00
6012 50 Channel UV Recorder. Servo paper drive upto 5 métrs/sec. 12" paper £1100.00

Watenabe.
MC641 6 Channel Chart Recorder. 1mV-100V. 250mm scan width £1950.00
MC611-S4L. 4 Channel Chart Recorder; 100µV-2V. 400-800-1600mm/Hour/Minute £700.00
WTR 281 6 Channel Chart Recorder. 2mV-1000V FS. 0.5 to 250mm/sec/min £1250.00

Yokagawa.
3047 2 Channel Chart Recorder. 0.5mV-100V. 2cm/hr-60cm/min £450.00

SIGNAL SOURCES

Hewlett Packard.
203A Variable Phase Oscillator. 0.005Hz-60KHz. 0-360° £450.00
606B AM Signal Generator. 50KHz-65MHz. AM 0-95% £850.00
612A AM/PM UHF Generator. 450-1230MHz. 0.1µV-0.5V £775.00
616B UHF Signal Generator. 1.8 to 4.2GHz. Int pulse Mod £1000.00
651B Test Oscillator. 10Hz-10MHz. 0.1mV-3.16V £415.00


4204A Digital Oscillator. 10Hz-1MHz. 1mV-10V into 600Ω. Frequency accuracy ±.2% or ±0.1Hz £695.00
8640B opt 002 Phase Locked Digital Readout AM/FM Generator. 500KHz-1024MHz £3650.00
8600A + 8601A RV Sweeper + Markers. 100KHz-110MHz £1500.00
8690B RF Sweeper Main Frame C/W the following RF Modules: 8698B 400KHz-110MHz 8699B 0.1-4GHz. 8694A 8-12.4GHz £2500.00

Marconi.
TF144H/4 AM Signal Generator. 10KHz-72MHz. 2µV-2V £750.00
TF144H/4S AM Signal Generator. 10KHz-72MHz. 2µV-2V £550.00
TF995B/2 AM/FM Signal Generator. 200KHz-220MHz. 1µ-200mV £675.00
TF995B/5 AM/FM Signal Generator. 200KHz-220MHz. 1µV-200mV. Narrow deriation for mobiles £695.00
TF1370A Wide Range RC Oscillator. 10Hz-10MHz. Sine wave, square wave upto 100KHz £275.00
TF2002B AM/FM Signal Generator. 10KHz-88MHz. 0.1µV-1V. 20Hz-20KHz Mod frequency £1200.00
TF2005R 2 Tone Signal Source. 20Hz-20KHz. 0-111dB in 0.1dB steps £295.00
TF2100 AF Oscillator. 20Hz-20KHz. 0.05% distortion £150.00

Philips.
PM5108 Function Generator. 1 Hz-1MHz. Sine, square and triangle. Triangle O/P £250.00
PM5127 Function Generator. 0.1HZ-1MHz. Sine, square and triangle £395.00
PM5167 Function Generator. 1MHz-10MHz. Sine, square, ± pulse, ramp and triangle £500.00

Tektronix.
2101 Pulse Generator. 2.5Hz-25MHz. + and — O/P £375.00

Telonik.
2003 RF Sweeper System. 1-300MHz. 5 and 10MHz markers £950.00

SOUND LEVEL METERS

Bruel and Kjaer.
2203 Sound Level Meter. C/W 4145 1" Microphone. A, B, C, weighting £395.00

General Radio.
1933 Sound Level Meter C/W 1935 Cassette Data Recorder. 10-130dB. ABC weighting Octave band filters at 10 centre frequencies from 31.5Hz to 16KHz £995.00
1981 Sound Level Meter. 70-120dB. Digital and analogue reading. Peak hold. A weighting £300.00
1983 Sound Level Meter. 70-12db. A weighting £195.00

TRANSMISSION MEASURING EQUIPMENT

Marconi.
OA2805A PCM Regenerator Test Set. Comprised of TF2801/2, TF2802/2 and TF2823. For use on systems at 1.536 and 2.048Mbits £2700.00
TF2807A PCM Multiplex Tester. Comprises Noise / Sinewave source and level meter £1500.00
TF2332 AF Transmission Test Set. 20Hz-20KHz £425.00
TF2333 MF Transmission Test Set. 30Hz-560KHz £600.00

Siemens.


D2040 Selective Level Analyser and Voltmeter. 10Hz-60KHz. —110dB to +50dB. 3µV-300V Lin and log indication. 5 digit frequency readout £1200.00
D2072 + W2072 Level Meter and Oscillator. 50KHz-100MHz. —110dB-0dB. Receive bandwidth 3.1 and 10KHz £2200.00
D2074 + W2074 Level Oscillator and Level receiver. 50KHz-100MHz. —100 to +20dBm. Receive bandwidth 80Hz, 3.1KHz and 10KHz. C/W G2006 to perform as a programmable system £2600.00
W2006 + D2006 Carrier Level Test Set. 10KHz-17MHz. —100 to +10dB £1650.00
W2007 + D2007 Carrier Level Test Set. 6KHz-18.6MHz. —120 to +20dB .. £1800.00
D2021 + W2021 + G2021 Carrier Level Test Set. 10KHz-25MHz. —100 to 10dBm £1700.0000

Wandel and Golterman.
PF-1 Digital Error Rate Measuring Set. Consisting of PFM-1 Digital Error Rate Meter and PFG-1 Pettern Generator £2490.00
PSO-5 and PMO-5 Level Measuring Set. 10KHz-36MHz. —110 to +20dB. C/W AZD-1 Scale expander £2050.00
SPM-6 and PS-6 Level Measuring Set. 6KHz-18.6MHz. —110dB to +20dB. Mains / battery operation £2150.00
Andimat (PSM-4 2MHz Automatic PCM Testing System) composed of the following PCM-1 PCM Test Set, PDA-64 PCM Signalling Analyser, PMD-1 Digital Level and Noise Measuring System, PDG-1 Digital Signal Generator, PDA-1 PCM Digital Signal Analyser, PSM-4 Level Measuring Set, MU-4 Scanner, R1-1 computer interface £6500.00

WW-040 for further details

Electronic Brokers is Europe's largest specialist in quality, second user test equipment, computers and associated peripherals. Established 14 years ago, we have pioneered the second user concept in Britain, and many overseas territories.

To support our growth we have a skilled team. This includes trained sales staff, whose role is not only to sell, but provide a helpful information service to our many customers. Backing this team is our own service laboratory where technicians monitor each item of equipment we sell. Our maxim is service, and those who have dealt with us will know that we endeavour to always live up to our reputation.

Wherever your business is — UK, Europe, in fact anywhere in the world, the Electronic Brokers Organisation is just a telephone or telex call away!

Hours of Business: 9 a.m.-5 p.m. Mon-Fri.
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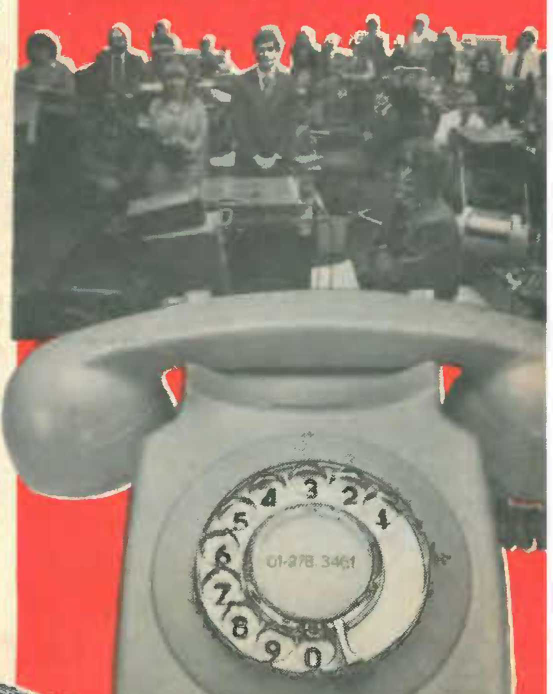
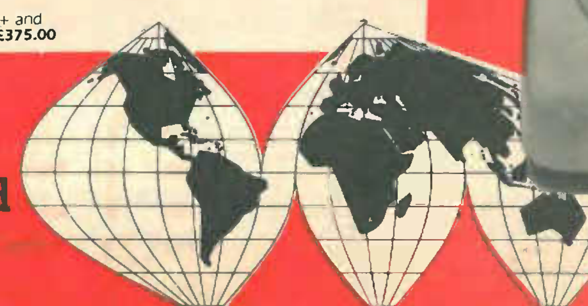
Carriage and Packing charge extra on all items unless otherwise stated.





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61/65 Kings Cross Road
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Electronic Brokers~Europe's Premier Used Computer Company offer

SUPERLATIVE USED COMPUTER EQUIPMENT~AS NEW CONDITION

........February 1981.................. Latest Computer Equipment ....

PDP11 C.P.U.s

This bestselling mid-range mini is now coming available on the second-user market at worthwhile price savings and, often just as important, we can offer fast delivery.

Available with parity MOS core or cache memory, expandable to 124KW, the processor includes as standard many features which are often expensive add-ons on other systems.

- ★ Integral memory management.
- ★ Integral extended instruction set (EIS)
- ★ Self-test diagnostic routines.
- ★ Automatic bootstrap loader.
- ★ Direct memory access.
- ★ Automatic Power Fail/Restart.

DEC.
PDP11/03-SD Processor in 3½" chassis complete with 16KW MOS memory and E1S option.
BRAND NEW — ONLY **£1495.00**
PDP11/04 Processor in 10½" chassis complete with 16KW MOS memory and DL11W Interface.
BRAND NEW (can be enhanced to 28KW) **£4500.00**
PDP11/34 in 10½" chassis complete with 69KB MOS memory **£5500.00**
PDP11/34 Processor (non-A) in 10½" chassis complete with 128KB MOS memory, DL11W Interface and programmers front panel **£5900.00**

PDP11 MEMORY

DEC.
MF11L 8KW core memory c/w 9-slot system unit **£975.00**
MM11L 8KW core memory **£795.00**
MM11LP 8KW parity core memory **£750.00**
MM11DP 16KW core (ex DEC-maintained 11/34 systems).
BARGAIN OFFER — ONLY **£395.00**
MM11UP 16KW Parity core memory complete with 9-slot system unit **£1500.00**
MM11UP 16KW parity core memory (pre-requisite MF11UP) **£1250.00**
MS11JP 16KW MOS memory **£675.00**
MSV11C 16KW MOS memory (LSI11) **£495.00**
MJ11-BE 64KW 11/70 memory **£4500.00**
MK11-BE 64KW MOS memory for 11/70 .... **£3950.00**
MS11-MB 256KB ECC MOS memory for 11/44 (NEW) ... **£3942.00**

DISKS

DEC.
RK05J add-on disk drive 2½ meg. Exchangeable cartridge type.
From **£1850.00**
RK06 Add-on disk drive 14 meg. Free standing. From **£3250.00**
RK07-ED Add-on Disk drive 28 meg. .... **P.O.A.**
RL01-AK Add-on Disk drive 5 meg. **£1975.00**
RP02 20 meg add-on disk drive **£1250.00**
RP04 add-on 88 meg disk drive **£8000.00**
RP06 add-on 176 meg disk drive **£15,950.00**
RX11-BD Dual floppy disk drive and control **£1800.00**
Controllers usually available for above drives.

MAGNETIC TAPE

DEC.
Available from time to time — TU10, TU45, TE16 TS03 etc.

PDP11 OPTIONS

DEC.
AA11D VT01 Controller with 4-slot System Unit **£125.00**
DD11A 4-slot System Unit **£125.00**
DD11B 4-slot System Unit **£150.00**
DD11-DK 9-slot backplane **£465.00**
DL11 Serial Interface **£250.00**
DL11WA/B Serial Interface/Line Clock **£395.00**
DR11C General Purpose Interface **£250.00**
DRV11V 16-bit Parallel Interface **£225.00**
DZ11A 8-line E1A MUX **£1395.00**
FP11A Floating Point **£1750.00**
KL11 TTY Interface **£150.00**
KW11L Real Time Clock **£150.00**
KW11P Programmable Clock **£345.00**
M105 Device Selector **£30.00**
M792 ROM Diode Matrix **£195.00**
M920 Unibus Connector **£12.00**
M9310-YB Bootstrap **£325.00**

POWER SUPPLIES

DEC.
H720 Power supply for BA11 Expander Box, BRAND NEW SURPLUS **£175.00**

PDP8A C.P.U.

DEC.
PDP8A Processors, systems and add-on memory usually available.

PDP8A MEMORY

DEC.
MM8AA 8KW Core **£750.00**
MM8AB 16KW Core **£995.00**

PDP8E CPU, MEMORY, OPTIONS

DEC.
DP8EB Communications Adaptor **£395.00**
KA8E Positive 1/0 Bus **£95.00**
KD8E Databreak **£145.00**
KL8E Synchronous Interface **£250.00**
KP8E Power fail/auto restart **£95.00**
MM8E 4KW Core memory stack **£350.00**
TA8E Dual Cassette Drive and Controller **£525.00**
VT8E Set graphics Control Modules **£250.00**

TERMINALS

DEC.
LA34 DECwriter 1V 30cps desk-top terminal, 132 columns, upper/lower case ASCII **£495.00**

LA36 DECwriter 11 Keyboard Printer Terminal. The Terminal that has become an industry standard, with 132 column upper/lower case printing and switch-selectable speeds of 10, 15 & 30cps. Available with either 20mA or RS232 interface **£750.00**
VT52 24 lines by 80 columns, 7 x 7 dot matrix, upper and lower case ASCII, includes numeric keypad, 20mA or RS232 interface . **£450.00**
VT100 — Also available from time to time. DEC's latest 132 column display terminal. Please enquire for latest price and delivery **£750.00**

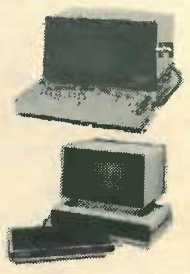
VDUs

Hazeltine.

H1000 The low, low priced teletypewriter-compatible video display terminal, offering your choice of transmission speeds up to 9600 baud as well as parity generation and checking. 12 x 80 display upper case ASCII, RS232 interface, choice of baud rates
SUPER VALUE **£199.00**

VDUs

Hazeltine.



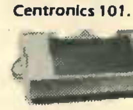
H2000 Superb spec. including full XY cursor addressing and edit facility, 27 x 74 display, upper case ASCII, RS232 interface, switch-selectable baud rates **£299.00**

H2000C NOW ALSO AVAILABLE with 25 x 80 line format and C-MOS logic **£375.00**

Modular One. Now with upper/lower case, XY cursor addressing. 24 x 80 line display. dual intensity detachable keyboard, choice of 8 transmission rates up to 9600 baud ... **£399.00**

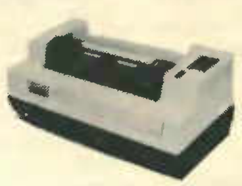
PRINTERS

Centronics 101.



Heavy Duty Matrix printer with 64 ASCII upper case character set. 165 cps operation. 132 print positions with adjustable tractor feed. Parallel input. ONLY **£495.00**

GP80 GRAPHICS.



BRAND NEW — LOST COST MATRIX PRINTER IDEAL FOR MICROPROCESSOR USERS SUCH AS HOBBYISTS & EDUCATIONALISTS OR ANY LOW-BUDGET APPLICATION

- ★ Full upper/lower case ASCII PLUS GRAPHICS Mode
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- ★ 30 cps print speed with 1-line buffer
- ★ Standard parallel (Centronics-type) interface
- ★ Optional interfaces available for RS232, IEEE488, Tandy, PET, Apple II
- ★ ONLY **£199.00**
  (Mail order total ..... £240.35)

GE Terminet 1200.
RO printer, 80 columns, tractor feed, upper/lower case, ASCII, 20mA Interface **£325.00**

Hazeltine.
Thermal printer, 80 columns, 30 cps silent RO with parallel TTL input **£395.00**

Tally 1602.
Matrix printer, parallel input, upper/lower case, tractor feed, as new **£995.00**

Teletype.
ASR 33 input/output terminal incorporating paper tape punch and reader. 64 ASCII upper case character set. 110 baud operation, even parity keyboard choice of RS232 or 20mA interface.
NOW ONLY **£595.00**

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Teletype 33 printer mechanism including case but no keyboard or electronics. 64 upper case ASCII, 10 cps, pinfeed platen, ideal for the electronic hobbyist ONLY . **£85.00**

Termiprinter 7075.
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725 portable terminal with acoustic coupler **£625.00**
733 ASR terminal utilising high performance twin cassette drive for fast time-saving transmission and off-line storage.
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- ★ Switch-selectable transmission speeds 10, 15, & 30 cps
- ★ Full tape editing capability
- ★ High-speed duplication and rewind
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745 LIGHTWEIGHT (13lbs) terminal with integral acoustic coupler. 10/30 cps, carrying case **£750.00**

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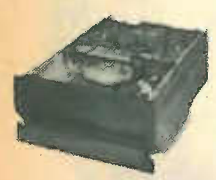
15in. diagonal tube, integral power supplies, accepts composite or separate video input. BRAND NEW SURPLUS **£100.00**

Ball Miratel TTL15.
15in. diagonal green phosphor tube, integral power supply. Requires separate horizontal and vertical video input. BRAND NEW SURPLUS **£75.00**

FLOPPY DISK DRIVES

Shugart SA400.
5¼" MINI-FLOPPY (NEW)
- ★ Capacity (unformatted):
  110Kb (single density)
  220Kb (double density)
- ★ Transfer rate: 125/250 kilobits/sec.
- ★ Average access time: 463ms.
- ★ Read/Write and Write Protect electronics
- ★ Power requirements +5VDC + 12VDC
  Dimensions 5¾" x 3¼" x 8", weight 3lbs

Supplied complete with technical manual.
Application notes are available on interfacing the SA400 to Intel 8080A, Motorola etc **£195.00**



Shugart SA450.
Double-sided, double density minifloppy providing 440KB unformatted storage capacity, yet the same compact size and weight as the SA400 .... **£299.00**

Shugart SA801.
8" FLOPPY (NEW)
- ★ Capacity (unformatted):
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  800Kb (double density)
- ★ Transfer rate. 250/500 kilobits/sec.
- ★ Average access time: 211ms
- ★ Read/Write and Write Protect electronics
- ★ Power requirements
  +24VDC +5VDC −5VDC
  Dimensions 4⅝" x 9½" x 14¼"

Supplied complete with technical manual **£395.00**

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Digitronics.
P120 paper tape punch. Solenoid-actuated unit capable of punching 5 to 8 channel tapes at speeds up to 35 cps.
Pulse amplitude 27 VDC. Compact table-top unit **£95.00**

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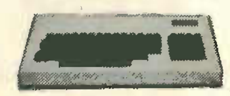
New ASCII Keyboards
New Low Prices



KB771 Superb 71-station ASCII keyboard incorporating separate numeric/Cursor control pad and installed in custom-built steel enclosure with textured blue enamel finish. Ideal for the VDU builder. Case dimensions: 17¼" x 7½" x 3⅜".
Total weight 4kg. PRICE .. **£85.00**
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KB756MF as above, fitted with metal mounting frame for extra rigidity **£45.00**
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KB710 10-key numeric pad, supplied with connecting cable .. **£8.00**
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KB702 Steel enclosure for KB756 or KB756MF **£18.00**
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KB2376 Spare ROM encoder **£12.50**
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KB15P Edge connector for KB756 or KB756MF **£3.25**
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DC-512 DC convertor to allow operation at 5V only (plugs in to P.C.B.) **£7.50**
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DB25S Mating connector for KB771 .... **£4.25**
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PERK 56-station ASCII keyboard for PET complete with PET interface, built-in power supply and steel enclosure **£95.00**
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New. Latest hot-off-the-press design by John Linsley-Hood described in this months issue of Hi Fi News. External appearance is identical to the 30 watt design but minor circuit changes and MOSFET output devices give lower distortion, audibly better sound and higher power output. The delicacy and transparency of tone quality enable this amplifier to outperform on a side-by-side comparison the bulk of amplifiers available today, even surpassing the Authors own 75watt design.
Complete Kit for fully integrated 35watt MOSFET amplifier **£87.40.** Plus VAT
Same but 45watt output **£94.80.** Plus VAT.
Conversion Kit with full instructions for use with existing 30-watt amplifiers **£16.90.** Plus VAT.
Reprints of MOSFET article. 25p. No VAT. Post Free.

LINSLEY-HOOD 30 WATT AMPLIFIER

The very latest amplifier design to be published and in our opinion the best yet. The concept was to produce an amplifier that sounded as good as the authors 75 watt design but which was cheaper and simple to build for applications where the higher power is not needed. This new kit is designed to match the Linsley-Hood Cassette Recorder 2 and a tuner will be available later to make a complete stackable system. A very advanced assembly system has been devised by us to make construction ultra simple and anyone who can solder components in a printed circuit board will find it great fun. Conventional wiring is at an irreducible minimum, only being needed to connect the mains transformer and pilot light. For an amplifier of this quality this kit represents incredible value for money.
All parts can be bought separately at a total cost of £79.12 but complete kits are available at a special introductory discount price of only **£72** + VAT.
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For those who missed our recent bargain CT4s we now are delighted to be able to offer Brand New Lenco FFR Decks complete with motor speed and auto-stop control board fitted and tested. These will operate with any supply between 9 and 16 volts. This deck can be used for both record and playback applications and is fitted with an erase head. A mono record/play head is fitted and we can supply an extra stereo head, if ordered with the deck at the very special price of £2 plus VAT. We also supply, with each deck and completely FREE, one of our specially moulded escutcheons. This deck would normally cost about £25 but we are able to offer them, while they last, at only £9.99 plus VAT.

TOP LOADING HI FI CASSETTE DECK. Very limited quantity of British made Thorn 4499 top loading decks fitted with stereo R/P head, 3 digit re-settable counter, 12 volt electronic speed controlled motor and auto stop read.
Very special price £12.99 Complete with top cover and cassette door. Post etc. £1.50. VAT £2.34.
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A very useful device, connected to loudspeakers giving a 4 light readouts of peak power delivered for the protection of both the loudspeaker and the perceived quality of sound. Gives instant indication even for peaks of only 5 microseconds duration. Unit uses CMOS technology, is self-contained and battery powered. Complete Kit except batteries, **only £17.40** plus VAT.
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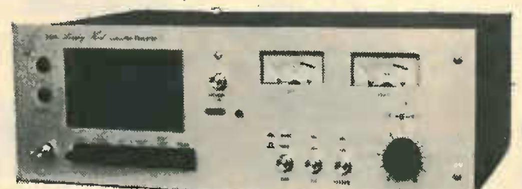
LINSLEY HOOD CASSETTE RECORDER 2



Our new improved performance model of the Linsley Hood Cassette Recorder incorporates our VFL 910 vertical front mechanism and circuit modifications to increase dynamic range. Board layouts have been altered and improved but retain the outstandingly successful mother and daughter arrangement used on our Linsley Hood Cassette Recorder 1.
This latest version has the following extra features. Ultra low wow-and-flutter of .09% — easily meets DIN Hi-fi spec. Deck controls latch in rewind modes and do not have to be held. Full Auto stop on all modes. Tape counter with memory rewind. Oil damped cassette door. Latching record button for level setting. Dual concentric input level controls. Phone output. Microphone input facility if required. Record interlock prevents re-recording on valued cassettes. Frequency generating feedback servo drive motor with built-in speed control for thermal stability. All these desirable and useful features added to the excellent design of the Linsley-Hood circuits and the quality of the components used makes this new kit comparable with built-up units of much higher cost than the modest **£94.90** + VAT we ask for the complete kit.

LINSLEY HOOD CASSETTE RECORDER 1

We are the Designer Approved suppliers of kits for this excellent design. The Author's reputation tells all you need to know about the circuitry and Hart expertise and experience guarantees the engineering design of the kit. Advanced features include: High-quality separate VU meters with excellent ballistics. Controls, switches and sockets mounted on PCB to eliminate difficult wiring. Proper moulded escutcheon for cassette aperture improves appearance and removes the need for the cassette transport to be set back behind a narrow finger trapping slot. Easy to use, robust Lenco mechanism. Switched bias and equalisation for different tape formulations. All wiring is terminated with plugs and sockets for easy assembly and test. Sophisticated modular PCB system gives a spacious, easily built and tested layout. All these features added to the high-quality metalwork make this a most satisfying kit to build. Also included at no extra cost is our new HS15 Sendust Alloy record/play head, available separately at **£7.60** plus VAT, but included FREE as part of the complete kit at **£75** plus VAT.
REPRINTS of the 3 articles describing this design **45p.** No VAT.
REPRINT of Postscript article **30p.** No VAT.

CASSETTE HEADS

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HS16 Very latest Sendust Alloy Super Head with even better HF Response	8.20
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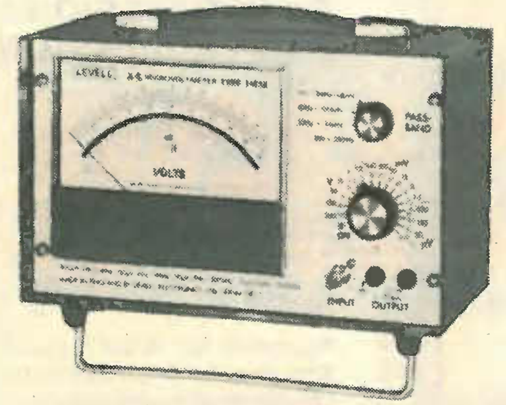
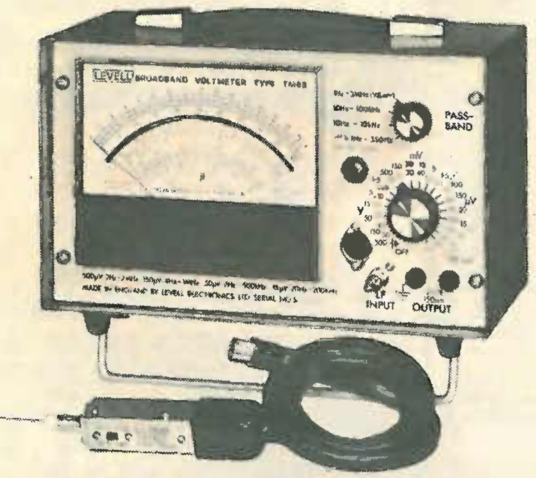


A.C. MICROVOLTMETERS

VOLTAGE & dB RANGES	15µV, 50µV, 150µV . . . 500V fsd. Acc. ± 1% ± 1% fsd ± 1µV at 1kHz. — 100, —90 . . . + 50dB. Scale —20dB/+6dB ref. 1mW/600Ω.
RESPONSE	± 3dB from 1 Hz to 3MHz, ± 0.3dB from 4 Hz to 1MHz above 500µV. TM3B filter switch: LF cut 10Hz, HF cut 100KHz, 10KHz or 350Hz.
INPUT IMPEDANCE	Above 50mV: 10MΩ <20pF. On 50µV to 50mV: >5MΩ <50pf.
AMPLIFIER OUTPUT	150mV at fsd.

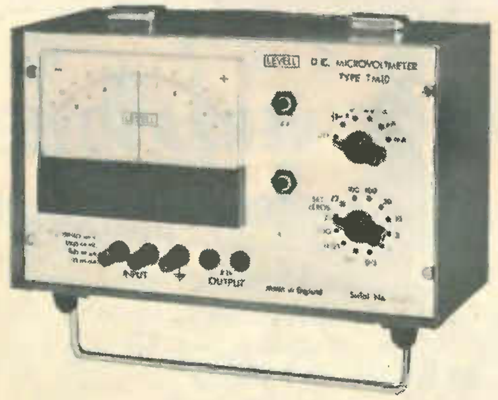
type TM3A **£130** type TM3B **£145**



BROADBAND VOLTMETERS

H.F. VOLTAGE & dB RANGES	1mV, 3mV, 10mV . . . 3V fsd. Acc. ± 4% ± 1% fsd at 30MHz. —50, —40 . . . +20dB. Scale —10dB/+3dB ref. 1mW/50Ω.
H.F. RESPONSE	± 3dB from 300kHz to 400MHz. ± 0.7dB from 1MHz to 50MHz.
L.F. RANGES	As TM3.
AMPLIFIER OUTPUT	Square wave at 20Hz on H.F. with amplitude proportional to square of input. As TM3 on L.F.

type TM6A **£199** type TM6B **£215**



D.C. MICROVOLTMETERS

VOLTAGE RANGES	30µV, 100µV, 300µV . . . 300V. Acc. ± 1% ± 2% fsd ± 1µV. CZ scale.
CURRENT RANGES	30pA, 100pA, 300pA . . . 300mA. Acc. ± 2% ± 2% fsd ± 2pA. CZ scale.
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These instruments incorporate many useful features, including long battery life. All A type models have 83mm scale meters and case sizes of 185 x 110 x 130mm. B types have 127mm mirror scale meters and case sizes of 260 x 125 x 180mm. Fully detailed specification sheets are available on request for our complete range of portable instruments. Prices are ex-works, carriage, packing and VAT extra. Optional extras are leather cases and power units.

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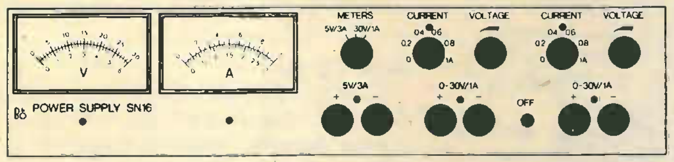

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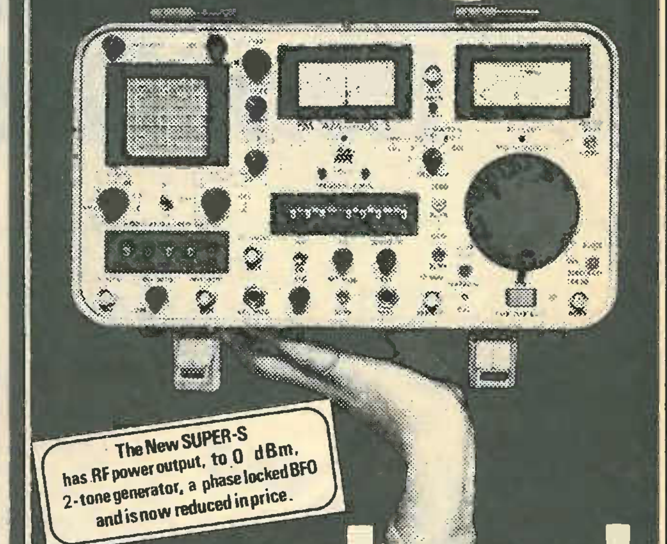
Bang&Olufsen

DK – 7600 Struer

Testing... Testing... Testing...



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A portable communications service monitor from IFR, light enough to carry anywhere and good enough for most two-way radio system tests. The FM/AM 1000s can do the work of a spectrum analyser, oscilloscope, tone generator, deviation meter, modulation meter, signal generator, wattmeter, voltmeter, frequency error meter-and up to five service engineers who could be doing something else!

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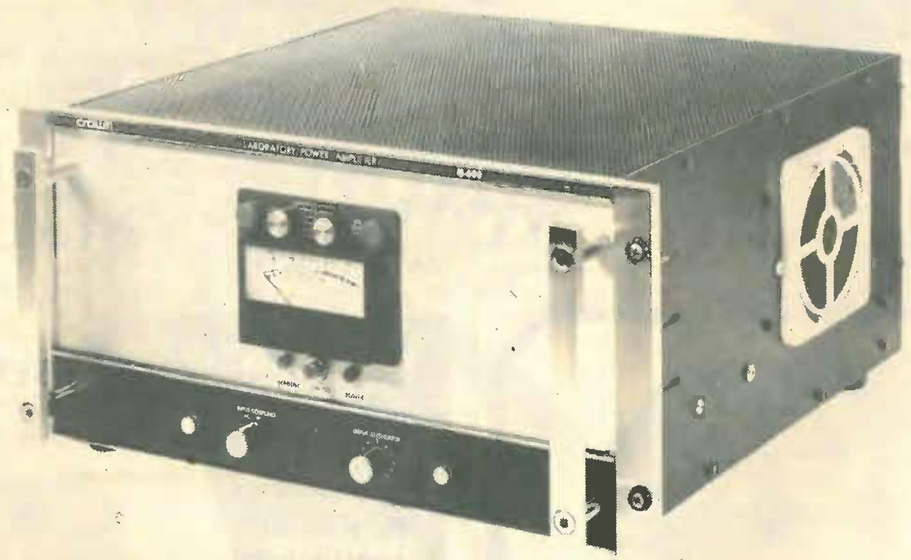

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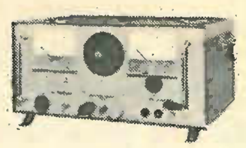
Now available with 3 OUTPUTS



Type 250VRU/30/25

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Series III arms are true low mass designs with headroom to increase effective mass as desired whereas with high mass arms reduction is generally impracticable.

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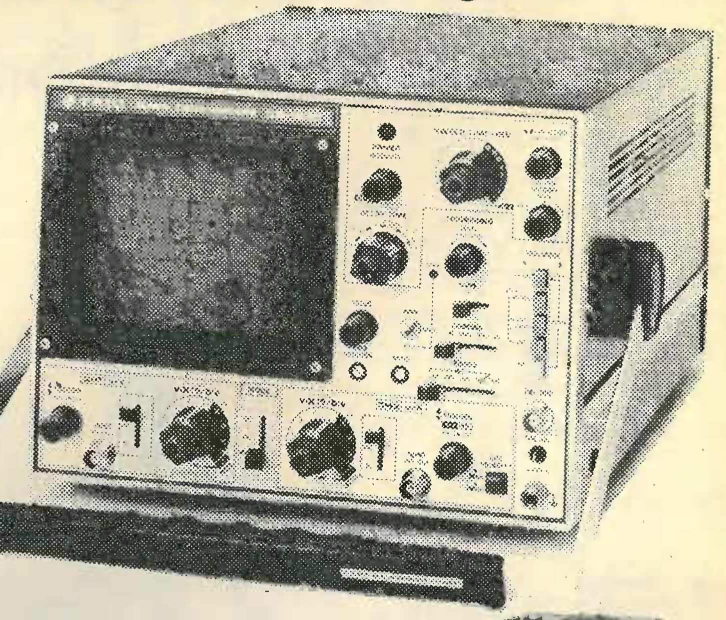
WW — 008 FOR FURTHER DETAILS

CS1830 FROM TRIO



Since it's introduction, the CS1830 has been our top seller, and no wonder, when you glance at the comprehensive specification **and** the extremely attractive price which includes two matching X1/X10 probes.
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C.R.T.:
120 x 96 mm rectangular PDA with internal graticule
Y Bandwidth:
DC - 30MHz
Sensitivity:
5mV/div (30MHz)
2mV/div (20MHz)
Input RC:
1M/23pF
Risetime: 11.7nS
Beam Switch:
Chop/alternate
Modes:
CH1, CH2, Dual, Add, Subtract
Time Base:
Triggered, auto, or single shot
Sweep Time:
0.5S/div-200nS/div (40nS using X5 mag) 20 ranges in 1-2-5 sequence
Sweep Delay:
100mS-1uS adjustable with trace bright up for delay location
Z Modulation:
TTL compatible 10K impedance 5MHz bandwidth
Trace Rotation:
Electrical
And the Price?
£455 + VAT (includes 2 probes)

Also
CS1577A
Dual 30Mhz/2mV Signal
Delay etc
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NRD 515 SYNTHESISED HF MONITORING RECEIVER	**£948.75 inc. VAT**
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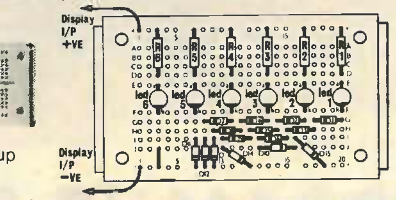
Want to get started on building exciting projects, but don't know how? Now using EXPERIMENTOR BREADBOARDS and following the instructions in our FREE 'Electronics By Numbers' leaflets, ANYBODY can build electronic projects. For example, take one of our earlier projects, a L.E.D. Bar Graph;



You will need; One EXP 300 or EXP 350 breadboard, 15 silicon diodes, 6 resistors, 6 Light Emitting Diodes.
Just look at the diagram, Select R1, plug it into the lettered and numbered holes on the EXPERIMENTOR BREADBOARD, do the same with all the other components, connect to the battery, and your project's finished. All you have to do is follow the large, clear layouts on the 'Electronics by Numbers' leaflets, and ANYBODY can build a perfect working project.

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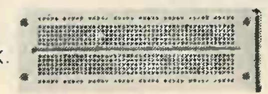
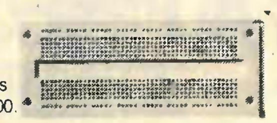
All EXP Breadboards have two bus-bars as an integral part of the board, if you need more than 2 buses simply snap on 4 more bus-bars with the aid of an EXP 4B.

EXP 325 £1.60 The ideal breadboard for 1 chip circuits. Accepts 8, 14, 16 and up to 22 pin ICs. Has 130 contact points including two 10 point bus-bars.

EXP 350 £3.15 Specially designed for working with up to 40 pin ICs perfect for 3 & 14 pin ICs. Has 270 contact points including two 20 point bus-bars.

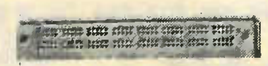


EXP 300 £5.75 The most widely bought bread-board in the UK. With 550 contact points, two 40 point bus-bars, the EXP 300 will accept any size IC and up to 6 x 14 pin DIPS. Use this breadboard with Adventures in Microelectronics.



EXP 600 £6.30 Most MICROPROCESSOR projects in magazines and educational books are built on the EXP 600.

EXP 650 £3.60 Has ·6" centre spacing so is perfect for MICROPROCESSOR applications.



EXP 4B £2.30 Four more bus-bars in "snap-on" unit.

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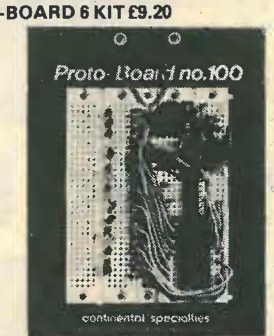
PB6 Kit, 630 contacts, four 5-way binding posts accepts up to six 14-pin Dips.
PROTO-BOARD 6 KIT £9.20



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EXP 350	270	3	**£ 4.48**	
EXP 300	550	6	**£ 7.76**	
EXP 600			**£ 8.39**	
EXP 650	270	use with 0.6 pitch Dip's Strip Bus-Bar	**£ 5.00**	
EXP 4B	Four 40 Point Bus-Bars		**£ 3.50**	
PROTO-BOARDS				
PB6	630	6	**£11.73**	
PB100	760	10	**£14.72**	

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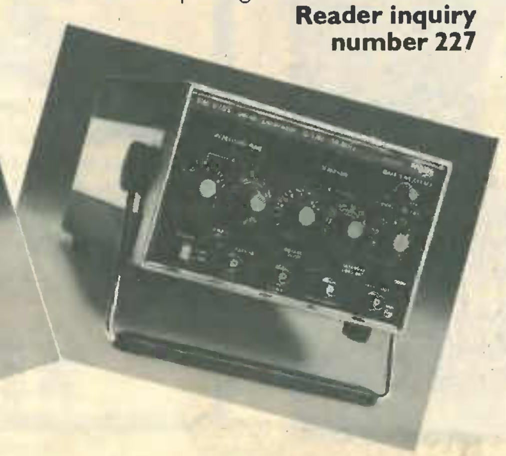

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PM 2505 analogue multimeter	**221**
PM 3207 15 MHz oscilloscope	**222**
PM 6667/6668 counters	**223**
PM 5190 LF synthesizer	**224**
PM 5132 function generator	**225**
PM 5716 pulse generator	**226**
PM 5705 pulse generator	**227**
1981 Test & Measuring catalogue	**228**

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5X015	22+22	3.63
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5X017	30+30	2.66
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6X018	35+35	3.21
6X026	40+40	2.81
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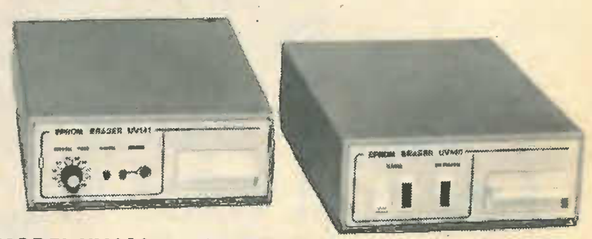

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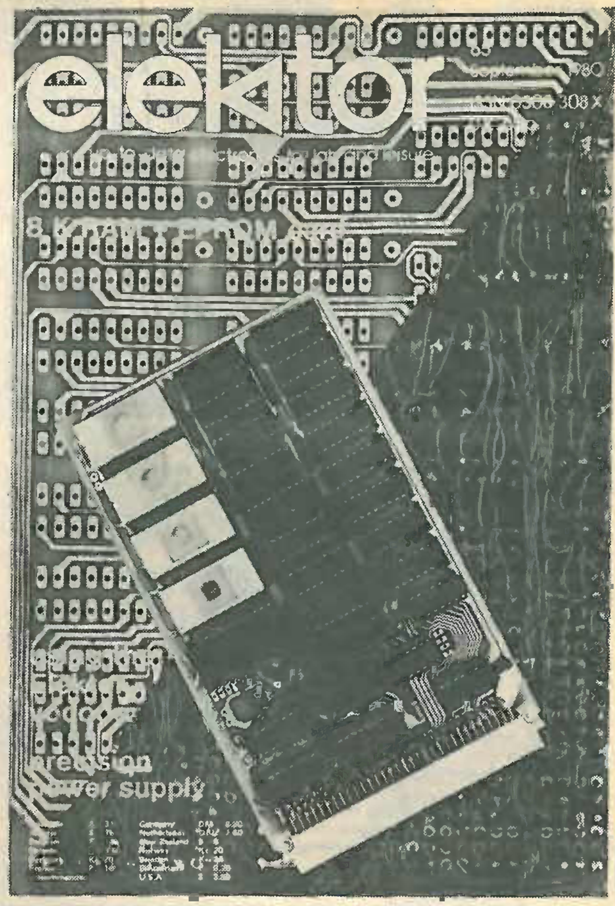

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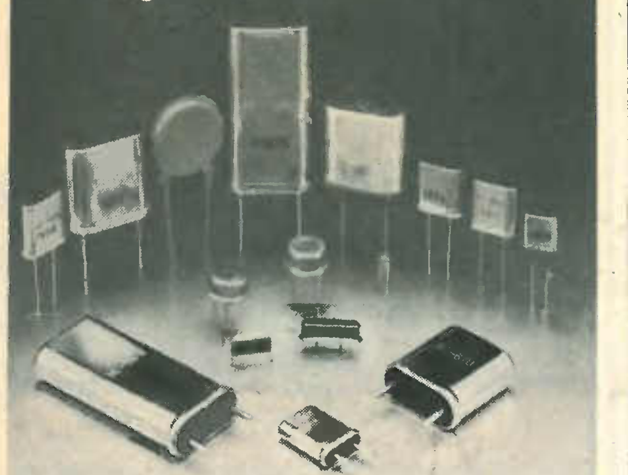

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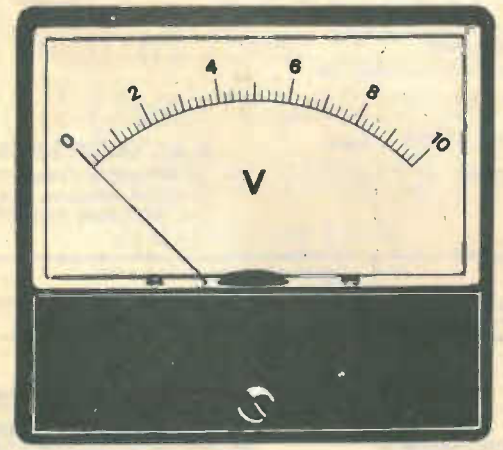

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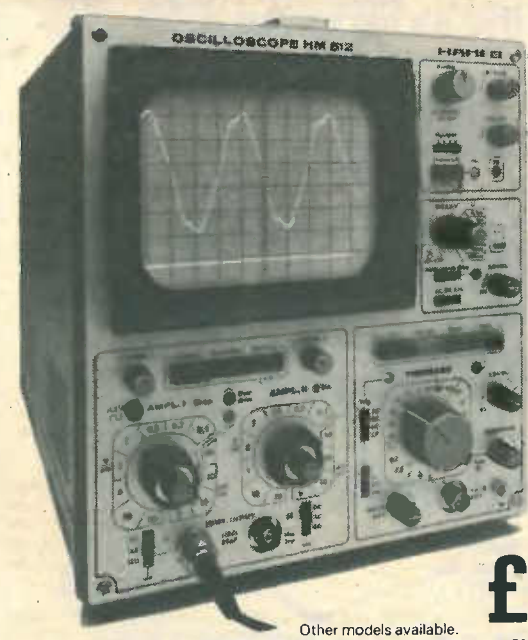

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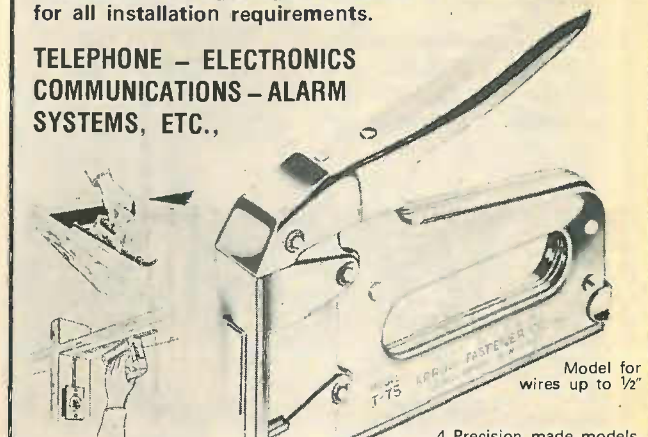

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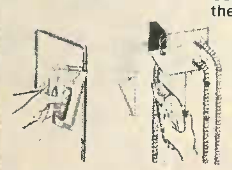

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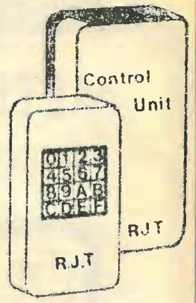

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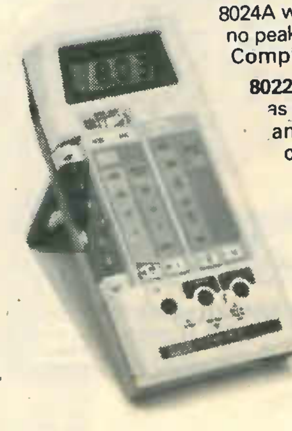

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wireless world

The new bureaucracy

In the 1940s the construction of computer memory was difficult and expensive. So was the construction of a processor (then called a mill, or arithmetic unit). It was out of the question to cope with the technical problems of building a combined unit. The Von Neumann architecture was a creature of these historical engineering constraints. The result was a list processor, and all problems to be solved by digital electronics had to be converted into a list of sequential steps. The people who did the conversion were called 'programmers'.

It is historically unfortunate that this Von Neumann architecture proved to be so versatile that it remained fixed long enough (1944-1980) for a glamorous mythology, and also a client society, the programmers, to develop around it, innocent of technology and also rather lacking in knowledge of the nature of the problems to be solved. This architecture has now been carefully copied, without improvement, into today's microprocessor. The resulting situation, which we are encumbered with, is similar to the man at the information desk in a railway station. He knows nothing about the technology of trains or railway line networks, or that train times can be altered, neither does he know the reasons why you want to make your journey. All he can do is advise you on how to use the existing schedule, which is very awkward indeed.

The programmer class became powerful enough to insist that the computer remain unchanged, and there has been no change in computer architecture for 36 years. Similarly, the railway information man would prefer the time-table and network of lines to remain unchanged, but, unlike the programmer, he does not always have his way.

Programmers developed a glamorous view of themselves, and made heavy inroads into the media. From the beginning they were very well paid, to say the least. Borrowing from Marshal McLuhan's philosophy, they caused society to think that the essence of modern society was 'information processing', and even that the human brain was an 'information processor' following their own baroque, bureaucratic procedures. This left them free to remain ignorant on the one hand of the technological nature of their machines, and on the other hand to take little interest in the customer's real problem, for which he wanted a mechanised solution. In classic style, the programmer introduced an informational bureaucracy between machinery and problem to be solved, and insisted that any link between the two must be via the mandarin language which was devised in the 1950s to try to make the best use of the slow, awkward Von Neumann machine architecture of that time.

This incursion of an informational bureaucracy between social needs and technological solutions is now likely to be institutionalised by the setting up of a 'Minister of Information Technology' (December 1980 issue, News, p.46). In fact, there is nothing technical about the information explosion that technically uninformed programmers are busily creating around themselves and us.

Digital electronics is a very powerful branch of engineering with massive potential for social benefit, but it will be hampered in contributing to society's needs until the technically uneducated, parasitic bureaucracy variously called 'information technology', 'computer science', 'information science' gets off its back and lets it get on with the job.

'Just detectable' distortion levels

Attempts to arrive at a practical criterion for assessing audio equipment

by **James Moir, F.I.E.E.** James Moir & Associates

Are distortion levels of 0.1% really detectable when programme material is being reproduced? asks the author. Manufacturers' t.h.d. figures would be of much greater value if information were available on the levels of distortion that were just detectable or just acceptable, he says. This article first examines the various signal characteristics which control the detectability of distortion to the ear, then reviews attempts that have been made to determine 'just-detectable' distortion, including a new technique devised by the author. Finally the author gives some actual examples of what he considers to be 'just-detectable' distortion levels in various kinds of audio equipment.

Equipment suppliers generally provide a reasonable amount of information on the extent of the harmonic distortion introduced by their amplifiers and tuners, though less frequently on loudspeakers and most other items of equipment. This distortion data is usually in the form of a quotation of the total harmonic distortion (t.h.d), the r.m.s. sum of the individual harmonics. Typical values are generally in the range of 0.01 to 0.1% for amplifiers, 0.1 to 0.3% for tuners and around 0.5% for loudspeakers. Analogue record/reproducer systems have much higher distortions, 3% to 8% being average values, even for professional equipment. On the reasonable assumption that low values of harmonic distortion are desirable if 'clean' sound is to be obtained, information about the t.h.d. is desirable.

The adoption of t.h.d. as an objective measure of subjectively judged distortion follows the international standardisation, though it is appreciated that it is almost certainly the accompanying intermodulation components that are responsible for the 'objectionableness' of the distortion signal. In the majority of situations the total intermodulation distortion is directly proportional to the total harmonic distortion, the relative values depending only upon the ratio of the amplitudes of the two test signals.

However the value of the manufacturers' t.h.d. data would be greatly increased if information on the levels of distortion that are just detectable or just acceptable were available. Are distortion levels of 0.1% really detectable when programme material ns being reproduced? Is an amplifier having 0.01% or 0.001% distortion audibly 'cleaner' than one having a t.h.d. of 1%? This is the problem to which the present discussion is directed. It would be idealistic to suggest that zero distortion should be the target. A more realistic approach would be to try and define the level of distortion that is 'just detectable' using modern equipment and critical listeners.

The 'just detectable' level is a function of so many variables that a precise specification, a single figure such as 0.1% or 1%, is unlikely to emerge from the discussion. Even in the simple situation where the test signals are single-frequency tones it is impossible to specify a single figure without setting wide limits. An experienced observer will detect the addition of a second or third harmonic when this is less than 0.1% but, given the opportunity to make repeated comparisons of the distorted and un-distorted tone, he will lower the detection level by a factor of at least ten, so 0.01% distortion becomes detectable. But the 'just detectable' level of distortion in sinusoidal tones is rarely of more than academic importance and will not be given further consideration. However, the same problem exists when attempting to detect the presence of distortion in a musical programme, if the test facilities allow a smooth variation of the distortion content the 'just detectable' distortion (JDD) level continues to decrease with increasing experience and it is doubtful if any figure is meaningful without providing full information on the test routine.

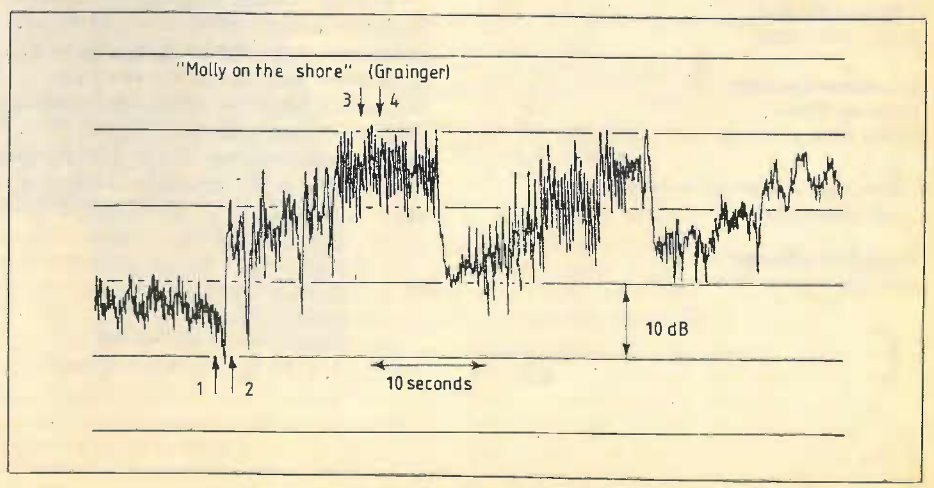
The specification of the 'just detectable distortion' in programme material is inherently more difficult, for the signal is continuously varying in amplitude and in consequence the instantaneous value of the distortion is also varying continuously.

Fig. 1 is a chart recording of the instantaneous levels during a one minute period of 'Molly on the Shore' (Grainger) taken from an Enigma recording No. K. 53574. Between points 1 and 2 the level will be seen to vary by at least 30dB but this is not an extreme example, for records are capable of handling a volume range of at least 50 to 60dB and this range is commonly employed.

If we now look at some data on the variation of the distortion with signal output of a typical amplifier and a domestic type of loudspeaker, we get the results illustrated by Fig 2. If it is assumed that a maximum level of 95dB at 1 metre is the highest level that will be reproduced it is seen that the distortion content is in the region of 3%. At a level about 30dB lower the distortion has fallen to less than 0.1%.

The amplifier introduces much less distortion into the signal. If the sound level of 95dB is achieved by a power output of 10 watts (a rather inefficient speaker) the distortion introduced is about 0.1% or less and it falls even lower at lower power outputs. Thus the distortion that is audible in the acoustic signal is practically all due to the loudspeaker and it varies over a range of about 30 to 1 when the acoustic signal output various over a range of about 30dB. (The numerical agreement is a coincidence.) Thus one has the problem of trying to decide what is the effective value of the distribution when it varies over a range of 30dB during a short section of the programme. The degree of distortion that is detectable is obviously a function of the distribution in time of the instantaneous amplitudes of the music. If the loud signals persist for a small fraction of the total time then the high levels of distortion that appear on loud signals will be less objectionable than if these loud signals occupied a large fraction of the few seconds over which the brain is able to analyse the signal while still exposed to the music.

Fig 1. Illustrating large variations of audio signal level that can occur in musical performances – for example between points 1 and 2. (Chart recording of instantaneous levels during one minute of "Molly on the Shore" by Percy Grainger).



Now the detectability of distortion depends not only upon the instantaneous value of the distortion, but also upon the length of time during which each burst of distortion persists. It appears from experiments on the fusing of tone pulses that the hearing system requires a time interval of 10-20 milliseconds to form an opinion about the spectral content of a mid-frequency tone. At the low frequency end of the spectrum the processing time rises to 40-60 milliseconds. This may be the mechanism that makes the hearing system oblivious to bursts of distortion of short duration, the just detectable value increasing very rapidly as the duration of the distortion decreases.

We investigated this aspect using a simple double zener clipper to clip sine wave pulses of variable length while listening on headphones for the just detectable distortion point. Fig 3 illustrates the results. It will be seen that the distortion due to clipping of a 4 millisecond burst reached about 10% before it was detectable, but increasing the pulse length to 20 milliseconds reduced the 'just detectable' distortion point to around 0.3%. As a consequence it will be appreciated that programme amplitude indicating meters in which the deflection is a function of the peak signal amplitude indicating meters in which the deflection is a function of the peak signal amplitude (p.p.ms) rather than the average or r.m.s amplitude (VU meter) may have the disadvantage of indicating the amplitude of signal peaks that do not result in audible distortion. In many applications the use of a p.p.m. type meter may only result in a reduction in the signal noise-to-noise ratio.

For this reason, a passage that contains perhaps one peak having a duration of several seconds will sound 'dirtier' than a similar passage in which there are many peaks of the same amplitude, but each of short duration, even though the total duration of the peaks is the same for both passages.

However, there are other factors that are of significance. It is well established that distortions of the simple amplitude dependent type (harmonic and intermodulation distortion) are less obvious when the distortion occurs at the low frequency end of the spectrum. The data quoted later suggests that the just detectable value of distortion at a frequency of 100Hz is at least ten times the just detectable value at frequencies in the 1000Hz region. Thus the just detectable distortion is likely to depend not only on the distribution in time of the peak amplitudes in the music, but also on the frequency band in which they occur. Characteristically the sustained peaks occur in the low frequencies where the distortion introduced is less easily detected. Indeed it has even been claimed that distortion introduced in the low frequency region makes the music sound 'rich' 'round' or 'fat', a view that is unlikely to appeal to the hi-fi purist.

There is also good evidence that the intermodulation distortions that result from second-order curvature of the transfer characteristics are less disturbing subjectively than the distortions introduced by odd order curvature. All these considerations suggest that any simple single figure value that is quoted as an objective indication of the effective total distortion in a system is unlikely to agree with a subjective estimate of the consequent quality deterioration, for the annoyance aroused by the presence of the distortion will depend on the order of the harmonic responsible for the major proportion of the objectively measured distortion.

In summary the just detectable distortion depends on:

1. The ratio of the peak-to-mean amplitudes of the signal during the effective listening interval.
2. The duration of each amplitude peak; ten peaks each lasting two milliseconds are less objectionable than one peak lasting twenty milliseconds in the same listening period.
3. The frequency band in which the maximum distortion occurs. Peaks of distortion at the low frequency end of the audio band are more difficult to detect than peaks of the same amplitude in the middle frequency band.
4. The order of the harmonics introduced by the overload. Even harmonics and the resultant quadratic intermodulation distortion components are less objectionable than the odd harmonics and the resultant cubic intermodulation components.

In spite of all these complications there have been many attempts to determine a figure for the JDD and these will be briefly considered, but the wide spread of the dates at which the tests were carried out, the intrinsic quality of the sound systems employed and the variation in the methods of expressing the distortion necessitate great care in making any closely detailed comparison of the quoted distortion values.

Using a system claimed to be flat between limits of 40Hz and 14kHz, Olson suggested that the introduction of 0.7% distortion was just detectable, the JDD being the same for both even order and odd order distortion, a conclusion that is at variance with almost all the data obtained by subequent investigators. Olson also noted that the JDD was doubled if the frequency range was restricted to 4kHz, the possible basis for P. P. Eckersley's comment that "the wider the window, the more dirt gets in".

In his book 'Elements of Acoustic Engineering' published in 1940, Olson notes that: "Tests of music reproduction on a system with a uniform response from 45 to 8500Hz at a peak level of 80dB have indicated that 5% second harmonic and 3% third harmonic are noticeable on a direct comparison with a system having less than 1% total distortion."

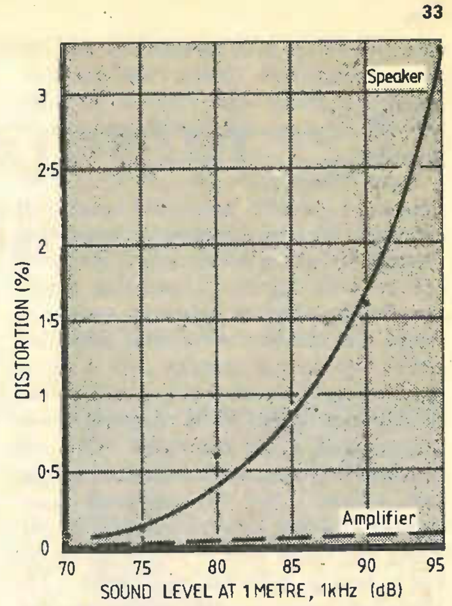


Fig 2. Percentage distortion against sound level for a typical 8-in loudspeaker and amplifier.

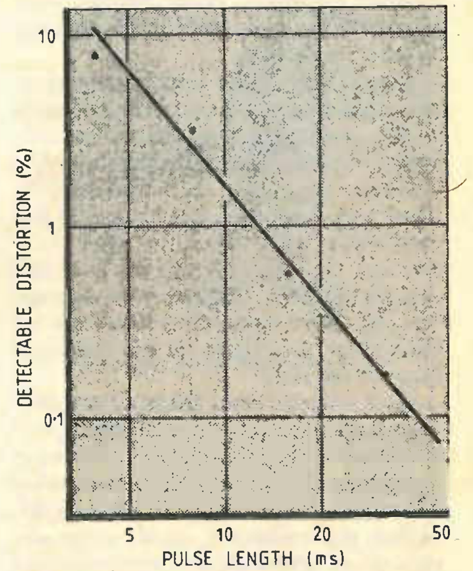


Fig 3. Detectable distortion vs. pulse length for burst of 1kHz sine wave of variable length. Detectability depends on length of time for which each burst of distortion persists.

In the late thirties the problem of determining the JDD was exercising the world's telephone administrations, while they were trying to fix some performance limits for the telephone lines used for the international distribution of speech and music. Braunmuhl and Weber in Germany and the BBC and Post Office Research Department in this country made very extensive investigations of the subject, the tests being extended to produce data on the sensitivity of the hearing system to distortion when this distortion was confined to selected frequency bands. There is reasonable agreement between the results obtained from both the investigations in finding that around 1%-2% distortion is detectable when it occurs in the range above about 500Hz, but that the distortion may be allowed to rise to something in the range of

15% to 25% if it is confined to the frequency band below 100Hz. Odd order harmonic distortions were found to be more subjectively annoying than the even order distortions.

Some fifteen years later (1950) D.E.L. Shorter of the BBC Research Department compared the sound quality of a number of systems for which the measured harmonic spectra were known. Comparing amplifiers having different harmonic spectra he found that the just perceptible distortion was 0.4% in one instance and 2.6% in another, an illustration of the wide spread of distortion values to be expected in any quotation of a just detectable value. He obtained better agreement between subjective opinion and the objective measurements when he multiplied each harmonic amplitude by $n^2/4$ before taking the r.m.s. sum. (n is the harmonic order.) The spread of just perceptible values was then reduced to 0.8% to 1.3% but it should be remembered that weighting in this way prevents his values being directly compared with the unweighted values obtained by other researchers.

Wigan (1961) made a very comprehensive investigation of the problem and came to the conclusion that the subjectively judged unpleasantness is a function of the time-rate-of-change of the departure of the signal from normality, but his results and conclusions are difficult to apply to a practical case where only the harmonic data are available. They do, however, confirm the earlier suggestions that there are likely to be wide limits on any suggested value for the JDD.

More recently Fryer made a very thorough investigation of the problem using a distortion producing technique that introduced only the first order intermodulation distortion components into a clean signal. Skilled male listeners could detect the presence of total distortion components of about 2% to 4% in piano music and 4% to 5% in other types of programme. However his circuitry did not introduce the harmonic distortion that would inevitably accompany the intermodulation products if they were produced by curvature of the transfer characteristics of an amplifier or other circuit component. If the harmonic components had been included the r.m.s. sum would probably have been near the top end of the quoted JDD range of 4%, but, as with Shorter's weighted data, his JDD percentage cannot be directly compared with the data obtained by others.

Recently we took the opportunity of making a re-assessment using modern equipment. A 15in/s master tape recording of a concert orchestral programme was used as a signal source, the amplifier output being fed to a pair of headphones chosen for their good frequency response and particularly low distortion. We were specially interested in the audibility of cross-over distortion, a particularly annoying form of distortion. A simple addition to the bias circuitry in a good amplifier allowed the bias on the output stages to be smoothly varied by a single knob control from the under-biased to the over-biased condition, thus varying the amount of cross-over distortion over a wide range.

The amplifier output signal was monitored by an oscilloscope to show up any amplitude limiting and to reproduce the calibration waveforms. Bias on the output stages was adjusted until distortion on the programme material when subjectively judged was just detectable, each listener spending as much time as he wished in finding the point at which the distortion was 'just detectable'. The bias control knob carried calibration markings and these were recorded for each observation and averaged over about twenty determinations to obtain the quoted JDD value. Additional readings were taken at a distortion level well below the 'just detectable' to confirm that the residual distortion 0.13%

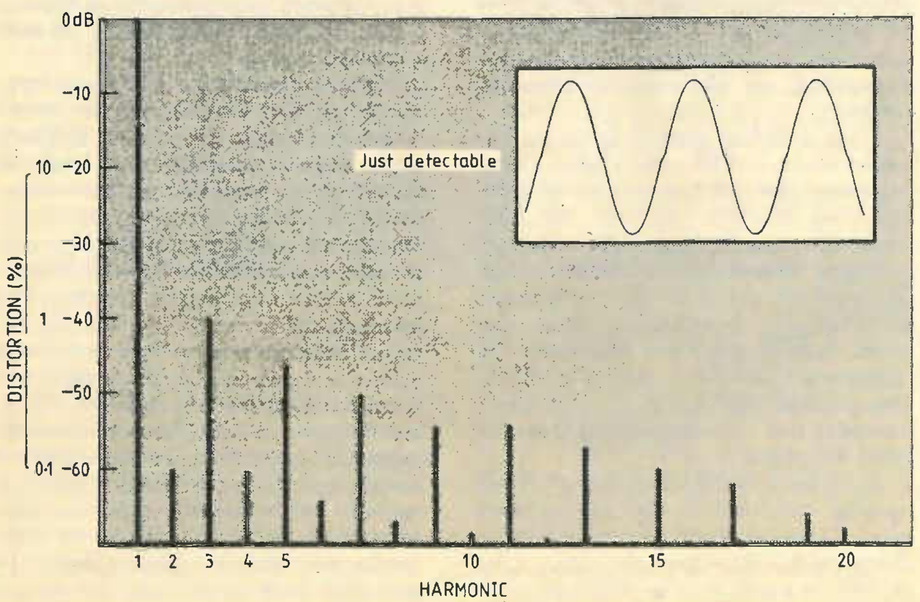


Fig 4. Cross-over distortion analysis, showing amplitude of harmonics measured on a narrow-band analyser. Inset is waveform, as seen on an oscilloscope, of a sinewave signal having the same peak-to-peak amplitude as the programme signal and showing the slight cross-over distortion.

in the equipment was unlikely to affect the results obtained.

This is a very sensitive technique for determining the 'just detectable distortion' for after a few comparisons the subject begins to recognise the particular form of distortion introduced into the music by the bias change. During subsequent comparisons the subject becomes increasingly sensitive to that particular distortion. After 10-15 minutes' experience his sensitivity to the distortion has probably increased by a factor of at least ten times.

As pointed out earlier in the discussion the actual distortion content in the reproduced music cannot be directly measured but it can be approximately indirectly. The peak-to-peak amplitude of the programme material at the level at which the distortion was just detectable was marked on the oscilloscope face and a sine wave signal of the same peak-to-peak value substituted. This sine wave signal across the headphones was then analysed in the conventional manner using a Marconi Type TF2330 narrow band analyser, all components up to about the 20th being separately measured. Fig. 4 indicates the amplitude of all the harmonics that were present and also reproduces the waveform of the sine wave signal having the same peak-to-peak amplitude as the programme signal. If the r.m.s. sum of the harmonics is taken in the conventional manner it is 1.2%, or if weighted using the Shorter technique, multiplying each harmonic by $n^2/4$ then it is 15%. It is an interesting observation that when distortion on the sine wave signal was 'just detectable' visually it was also 'just detectable' audibly.

On examining the data from all the investigations and rather naturally giving rather greater weight to our own results in view of the relatively recent date of the investigation, it would appear that the 'just detectable' level can be no lower than 1%. Indeed in view of the critical nature of our test technique, smoothly adjustable distortion and repeated comparisons using the same test passage, it would seem unlikely that even experienced observers listening to a normal programme presentation could detect the effect of adding 1% distortion to the signal. It would seem reasonable to suggest that Fryer's value of around 3% distortion represents the 'just detectable' level in practice with limits in the range between 1% and 5%. If it is intended to be ultra-critical our 'well below the detectable distortion' value of 0.13% could be accepted as the desirable target.

With these values in mind it is interesting to see how all the individual items of equipment in a system measure up to this standard. Amplifiers appear to be the only system component that have a performance that comfortably exceeds the 'just detectable' standard. Reasonably priced units can introduce distortions that are below 1% (40dB down) at half their rated output power. Amplifiers in the very top class, but still in domestic usage, have distortions in the 0.01% to 0.001% class (60-80dB down).

continued on page 38

Wind speed and direction meter – 1

Digital and analogue indication for racing yachts or met. stations

by N. Pollock

A windspeed and direction measuring instrument suitable for amateur construction is described. Although specifically designed for yacht masthead use it is also suitable for land-based meteorological applications. The novel masthead transducer unit avoids the use of expensive commercial components and can be constructed relatively easily by anyone with access to a small lathe.

A cockpit display of masthead windspeed and direction has become an essential for offshore racing yachts and is very useful for the cruising yachtsman. A number of commercial instruments are available, but they tend to be very expensive. The main requirements for such an instrument are as follows.

- the masthead unit must be small, light and weatherproof.
- the number of wires coming down the mast must be reasonably small.
- both speed and direction systems should work over a speed range of about 1 knot to 60 knot. At lower speeds, boat motion makes the indications unreliable, while at higher speeds it is only too evident what the wind is doing.
- the direction display should have a resolution of 1°, at least over the range of 45° port and starboard of head-to-wind. This is needed for fine tuning when beating to windward.
- There should be a continuous 360° analogue-type display of direction which can be read at a glance in moments of stress, such as when gybing in a strong breeze.
- the system should operate from a 12V accumulator with a low current consumption.

To the best of the author's knowledge, no instrument suitable for amateur construction which meets all the above requirements has been described previously. A number of wind direction indicators using simple 3 or 4-bit optical encoders has appeared over the years, but they have inadequate resolution. A high-resolution direction indicator with a limited angular operating range, suitable for close hauled use, is described in Reference 1.

Operating principle

The most difficult problem in designing this type of instrument is the selection of the method of encoding the wind direction information. Commercial 360° rotation, low-friction potentiometers, selsyns, resolvers and non-contacting digitizers can all be eliminated due to cost and availability problems.

The encoding technique adopted is one originally described by Tyson[2]. The principle of operation will be described with reference to Fig. 2. A cup anemometer and a wind vane, shown in Fig. 1, are mounted on a pair of coaxial shafts, which carry a pair of opaque discs with a small clearance between them. A fixed annular disc surrounds the small-diameter direction disc. These three discs are shown separated in Fig. 2, for clarity. A light source is located below the anemometer disc. The clock photodetector, fitted above a hole in the fixed annulus, produces a pulse train as the circle of holes in the anemometer disc

Fig. 1. Complete masthead assembly.

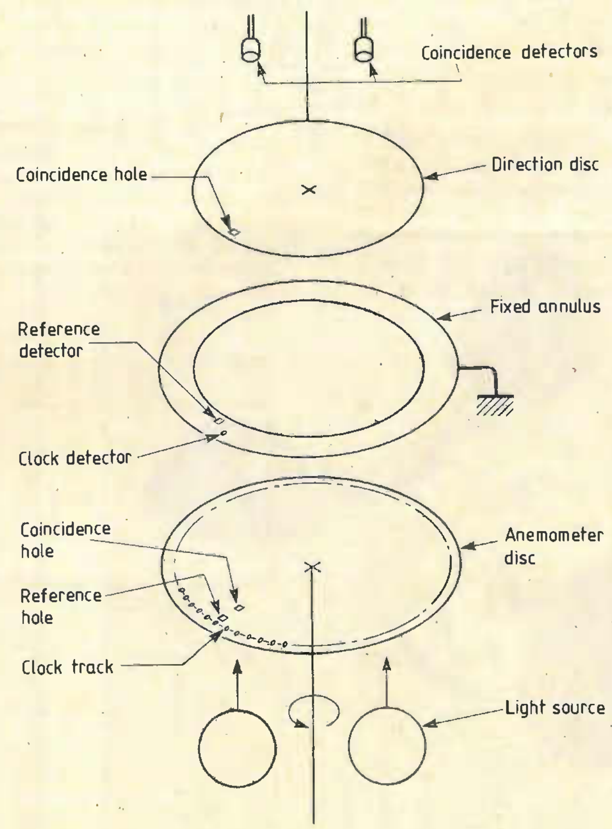


Fig. 2. Operation of transducers. Annulus and upper disc are normally in same plane.

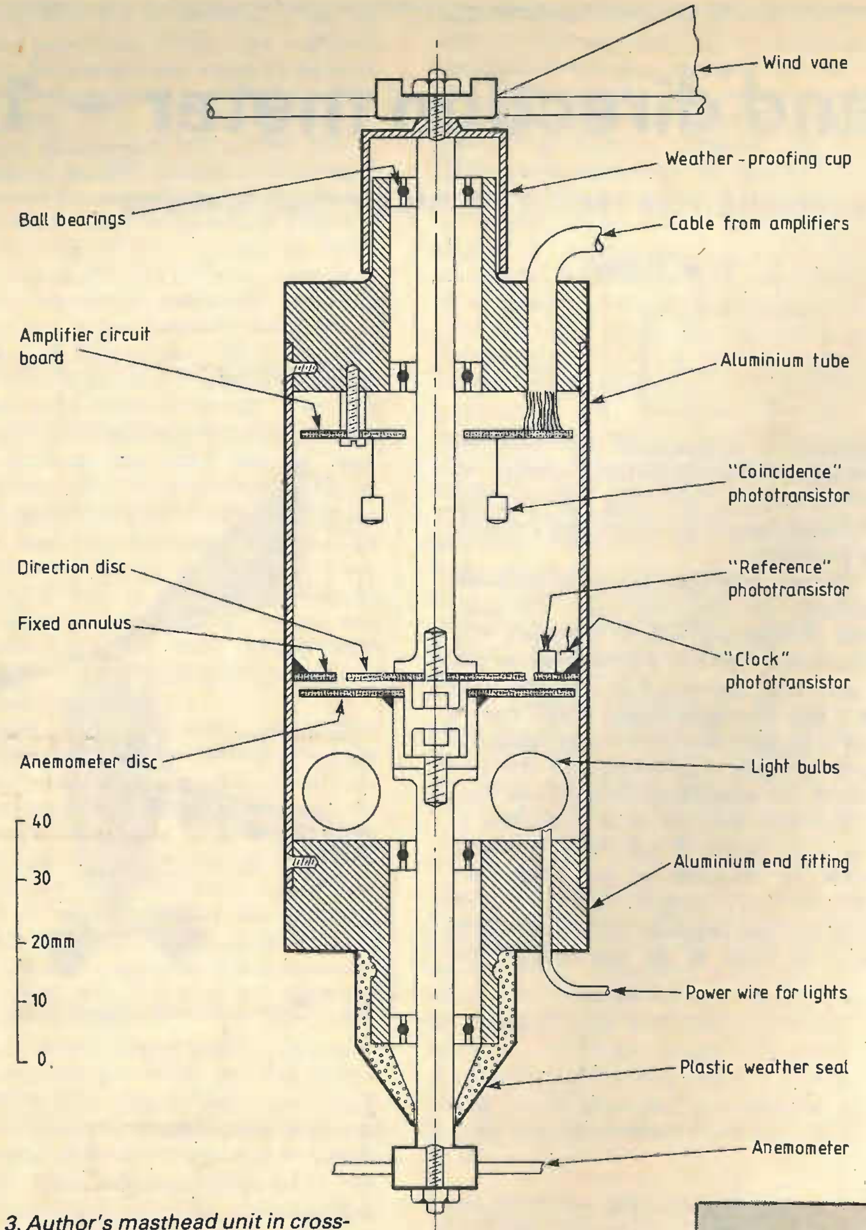


Fig. 3. Author's masthead unit in cross-section. Dimensions may be arranged to suit materials and components to hand.

(which are referred to as the clock track) sweep past, the frequency of this clock-pulse train giving the windspeed. Once per revolution of the anemometer disc, the reference hole passes the reference photo-detector and an output pulse results. Also once per revolution, at a point dependent on the angular position of the direction disc, the two coincidence holes pass each other and the coincidence photodetectors produce an output pulse. The number of clock pulses occurring between the reference and coincidence pulses gives the wind vane angle. In this simple form, the angular resolution is equal to the angle between successive clock-track holes. This resolution limit can be overcome by using a phase-lock-loop frequency multiplier to increase the clock frequency.

Mechanical design of masthead unit

This article is primarily concerned with the electronics of the system, but to assist potential constructors, some hints of the mechanical design will be included. A cross-section view of the prototype masthead unit is shown in Fig. 3 and photographs of the various components are re-

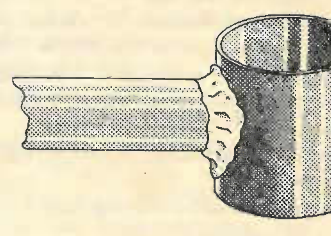


Fig. 6. Method of mounting assembly on masthead. Unit is clamped in sleeve.

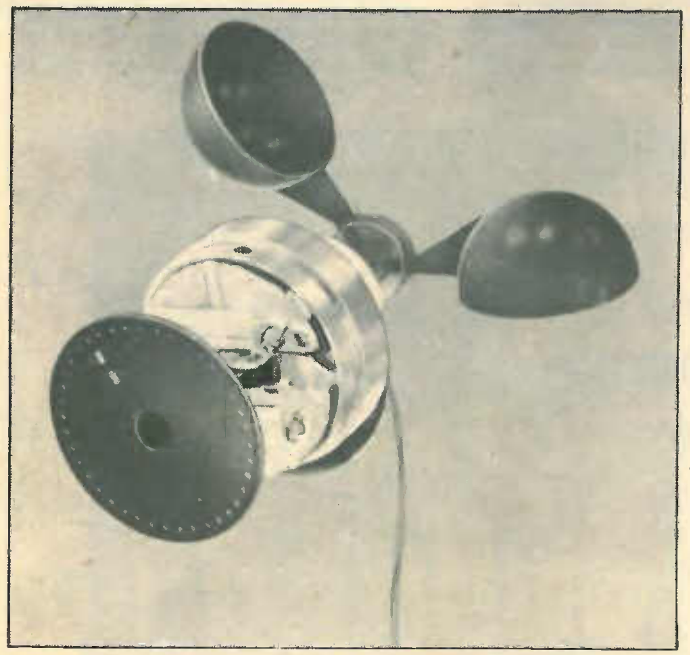


Fig. 4. Anemometer mounting and perforated disc. 'Festoon' bulbs without end caps are used.

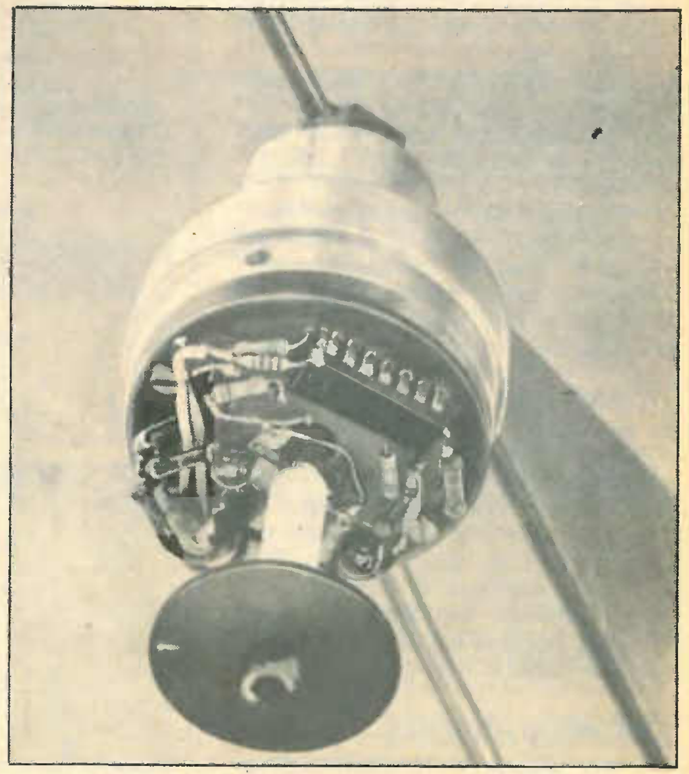


Fig. 5. Amplifier board and direction disc driven by vane. LM339 contains all four amplifiers.

produced in Figs. 4 and 5. The unit was constructed inside a piece of 50 × 1.6mm aluminium tube, the various discs being cut from glass-fibre printed-circuit board. The clock track has 36 holes 1.7mm diameter, equally spaced on a 40mm diameter circle, the clock photodetector window in the fixed annulus is 1.0mm diameter and all the other holes in the discs were about 1.7mm square. The light source consists of two tubular, linear-filament, automotive tail-light bulbs with the end contacts removed to fit them in the available space. Ball bearings are secured in the end fittings and the shafts fixed in the bearings with an adhesive such as "Loctite Bearing Mount". The spacing between the discs (about 0.4mm) was set using temporary spacers between them while the adhesive on the shafts cured. This procedure avoids the need to accurately machine bearing-locating shoulders. Adjacent faces of the discs were painted matt black, while the rear faces of the discs and the rest of the interior was painted white.

The wind vane can be constructed from a variety of materials, the main requirements being that it should be of light weight and accurately balanced about its axis of rotation. A strong, well-balanced cup anemometer is difficult to make, so a commercial unit, manufactured by VDO and obtainable from chandlers was adapted. This anemometer, which had a mean cup radius of about 44mm, was found to give a clock calibration factor of 22.5 hertz/knot. Since the system speed calibration is adjustable, any convenient commercial or home-made anemometer could be substituted.

Power supply

A 9V supply was selected for the instrument, since it can conveniently be derived from a 12 volt battery system. The circuit of a suitable regulator is shown in Figure 7.

Masthead circuit

To provide high-level, low-impedance signals to drive the long wires down the mast, the three photodetector outputs are amplified in the masthead transducer unit. The necessary circuitry conveniently fits on a circular printed-circuit board which mounts on the direction end fitting, as shown in Fig. 5. The circuit of the masthead system is shown in Fig. 8. The two 12V bulbs in series are operated so far below their rating that they should have a very long life. It is desirable that the clock and coincidence amplifiers just swing to full output when the anemometer disc is rotated slowly and the direction disc is in

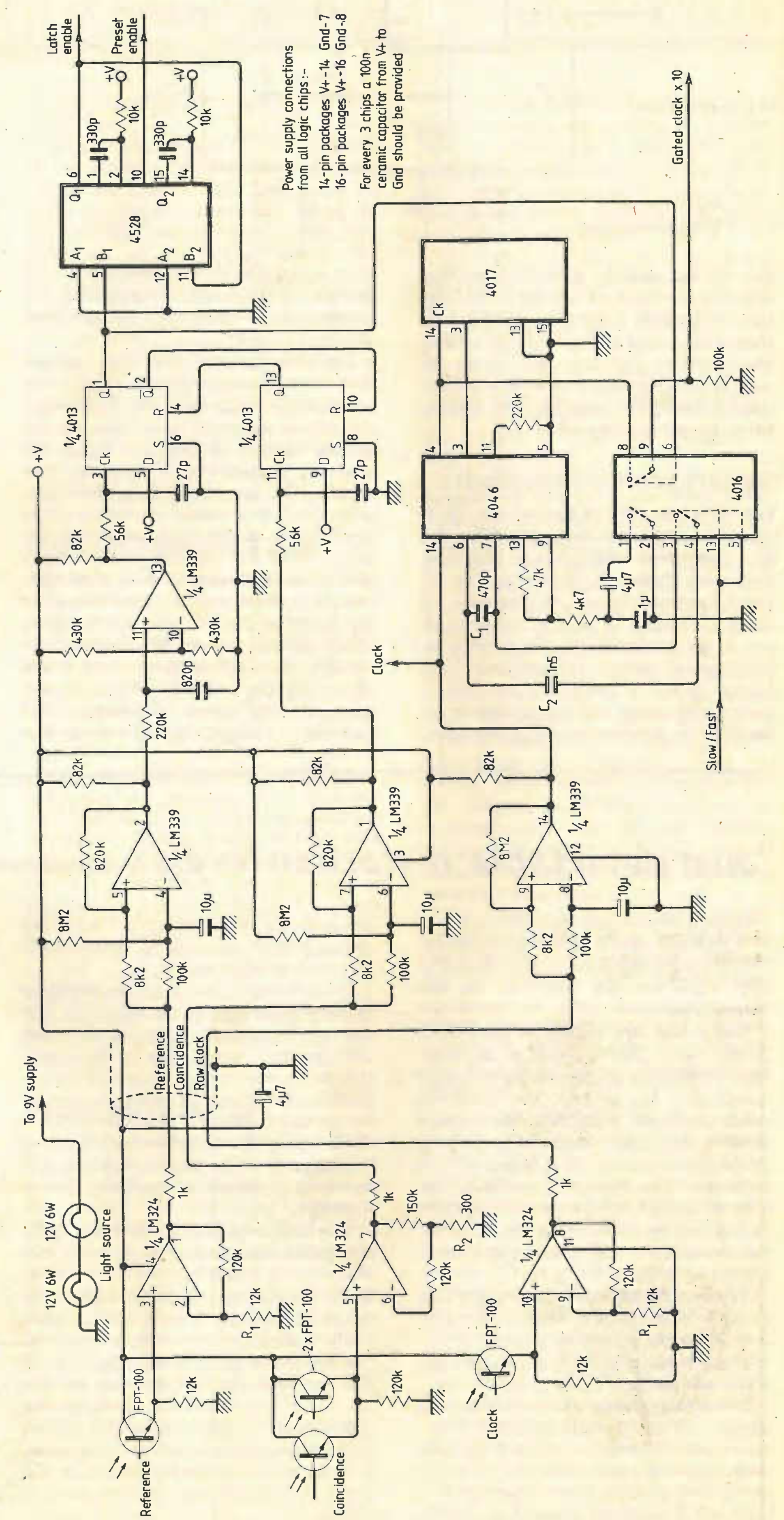


Fig. 8. Circuit diagram of masthead amplifiers and signal conditioner. On 14 pin packages, 9V goes to pin 14, 0V to pin 7; on 16 pin types, 9V is on pin 16 and 0V on pin 8. A 100n ceramic capacitor should be connected between 9V and 0V for every three i.cs. ▶

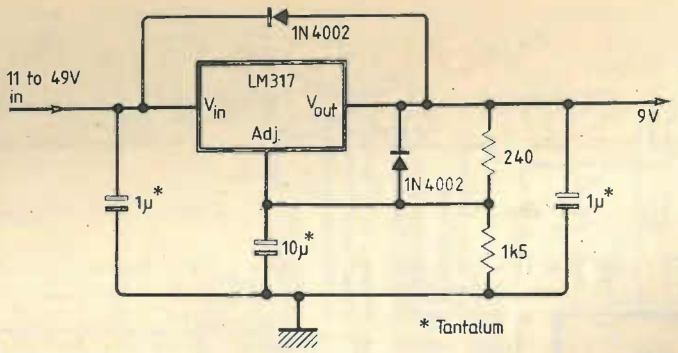


Fig. 7. Voltage regulator.

the position which gives the smallest coincidence output. If the mechanical design is changed it may be necessary to change the values of R_1 and R_2 to achieve this situation. The 1kΩ resistors on the amplifier outputs are to ensure amplifier stability under the capacitive load presented by the connecting cable.

Signal conditioning circuit

The reference, coincidence and raw clock signals from the masthead unit drive the three comparators with adaptive triggering levels and hysteresis shown in Fig. 8. These comparators are very tolerant of changes, induced by ageing, temperature etc., in the amplitude and offset voltage of the incoming signals. The reference comparator drives a low-pass filter and a further comparator which compensates for the different response speeds of the reference and coincidence photodetector systems. Without this compensation the measured angle would vary with the wind speed.

The reference and coincidence signals then drive an edge-triggered RS flip-flop constructed from a 4013 dual D flip-flop, the output of which goes high on the leading edge of the reference signal and low on the leading edge of the coincidence signal. (The use of a simpler level-triggered flip-flop produced erroneous results when the two signals nearly coincided). An output from the flip-flop drives a 4528 dual monostable multivibrator, which generates the two 4µs logic pulses needed by the direction circuit. The clock signal, which has one pulse per 10° of anemometer rotation, is multiplied by 10, using a 4046 phase-lock loop and 4017 counter, to give one pulse per degree of rotation. This CLOCK × 10 signal is gated with the flip-flop output, using a 4016 analogue switch.

In practice, the maximum lock-in frequency ratio obtainable from a 4046 is about 50:1, which barely covers the design wind-speed range. To ensure reliable operation, the 4046 timing and loop-filter capacitors are switched for high-speed and low-speed operation, the switching being controlled by the SLOW/FAST logic signal derived from the speed-measuring circuit described later. The SLOW/FAST signal goes high when the speed drops through 10 knots and low when the speed rises through 20 knots: this hysteresis ensures that the capacitor switching, which causes the 4046 to momentarily lose lock, occurs only infrequently. Capacitors of C_1 and C_2 are appropriate for a clock calibration factor of 22.5 hertz/knot. If the anemometer used has a different calibration factor, C_1 and C_2 must be altered in inverse proportion to the ratio of calibration factors.

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To be continued

'Just detectable' distortion levels continued from page 34

Gramophone records reproduced by the best pick-ups can have distortions in the 3%-6% range, but distortions in the 8% to 10% region are very typical of the best current records.

Reel-to-reel tape recordings have t.h.ds in the 2%-3% class but most of the distortion components are due to the odd order harmonics. In general the distortion content of tape recordings has a much simpler harmonic structure than the distortion spectra of a gramophone recording. The distortion content of cassette recordings is about twice as high as in reel-to-reel machines but the variation between nominally similar cassettes is much greater.

Typical current tuners have distortions in the 0.2% to 1% class. Indeed a live f.m. transmission generally provides programme material of the best quality available to the public.

Good loudspeakers of the monitor class can provide sound levels around 80dB at 1 metre with distortions of about 0.3% in the mid-frequency range, rising to 1% or 2% at the low frequency end of the range.

It will be seen that amplifiers are the only units in a system that have distortions that are well below the JDD value. Gramophone recordings appear at the bottom of the distortion league table but this ranking should be greatly improved when digitally recorded pressings appear.

The distortions introduced by amplifiers of good design are so far below the 'just detectable' and so far below the distortion introduced by other units in the system that they appear to be of no consequence in practice. However it is relatively easy for the amplifier designers to obtain such low distortion levels and as this eases the job of the designers of the other system units it is worth while designing amplifiers for low distortion.

The levels suggested as 'just detectable' are much higher than those generally considered to be acceptable, but there is little, if any, engineering evidence to suggest that values of distortion in the 0.1% region are really necessary. It should be remembered that it is the system distortion that is heard and that when the overall system includes any of the current record/reproduce links, the system distortion is in the 2%-3% range, even using professional equipment. It is the record/reproduce equipment that is the weak link in our sound reproducer system.

Returning to the opening question, it seems unlikely that items of equipment that have distortion levels around 0.01% will sound any 'cleaner' than those having distortions about 0.1% but they sound better in the advertising department.

Finally it will be observed that the discussion is based on the assumption that the non-linear distortions, the harmonic and intermodulation components, are the primary distortions. T.i.m., d.i.d., s.i.d. and most, perhaps all, of the currently popular esoteric distortions are not thought to be significant in equipment of professional or semi-professional standard used as the designer intended.

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WORLD OF AMATEUR RADIO

Atlantic barrier

For British amateurs (as for Marconi) the Atlantic has always been considered the single most important hurdle for radio signals. The ability to bridge the Atlantic on each of the various frequency bands available to amateurs often seems to be what "DX" (long distance) is all about. Two recent events have highlighted this special cachet: one the happy event of the first successful spanning of the Atlantic by ionospheric reflection on 70MHz (in a crossband 70 to 50MHz contact since American amateurs are not permitted to use 70MHz and British amateurs cannot use 50MHz) by Gordon Pheasant, G4BPY, of Walsall; the other, a sad event, the death of J. W. ("Jimmy") Mathews, G6LL, an active amateur for more than 50 years and the first European amateur to make contact with America on 28MHz ("Ten Metres") in October 1928.

Firsts on 50 and 70MHz. The 70/50MHz contact was made between G4BPY and Canadian VE1ASG (St John, New Brunswick) on November 17 at 1627GMT. Morse signals from the British stations on 70MHz were heard weakly in Canada at a time when the Canadian 50MHz signals were coming into the UK at great strength. Two-way contact was made and has since been confirmed.

Ten days later, Gordon Pheasant chalked up another "first" for a British amateur station. On November 27, he made contact with VK6OX in Caernavon, West Australia, hearing the Australian signals on 50MHz and replying on 28MHz. This completed for G4BPY his 50/28MHz "worked all continents". His contacts with Asia (Cyprus), South America (Equador) and (Europe) were made in late 1979 at the time of the sunspot maximum, while Africa (South Africa) followed in March 1980. But in completing "WAC" he was only a whisker ahead of Ken Ellis, G5KW whose contact ten minutes later with VK6OX also completed a 28/50MHz crossband WAC.

On 28 in '28. In 1928, Jimmy Mathews, G6LL was one of the very few British amateurs with a home-constructed crystal-controlled transmitter capable of running with an input of about 50 watts to a DET1 valve. He was also one of the few amateurs who believed that 28MHz (double the frequency of the then popular 20-metre band) was capable of providing long-distance contacts. What was not appreciated at that time was the significance of the fact that 1928 was in the declining phase of a sunspot cycle. In the event, following his initial contact on October 21 with American station NU2JN (this was before the adoption of the international prefixes) a few other stations "got across" but then the band virtually went dead for five or six years.

Jimmy Mathews was the first recipient of the RSGB's Wortley-Talbot Trophy, one of the Empire Link Stations of the 1930s and played a prominent role in the early technical publications of the Society, including a period when he was Honorary Editor of the old "T & R Bulletin". Although not a professional engineer (his career was in banking) his technical expertise and constructional ability were outstanding. In 1941 he was one of the first of the many British amateurs at "The Farmyard" (the special Intelligence interception station at Hanslope Park) where he spent a number of years as an engineering officer. He remained an active amateur virtually until his death.

GB2RS news service

The weekly GB2RS amateur radio news bulletins that go out from amateur stations in many parts of the UK are being listened to by about 2000 of the RSGB's 25,000 members, according to Basil O'Brien, G2AMV, 1981 president of the society. These self-help broadcasts, specially authorized by the Home Office, have been transmitted since September 1955 and the service was expanded during 1979. Some 1569 members responded to a questionnaire from which it is evident that of these 701 receive the bulletins on 3.5MHz, 652 on 144MHz f.m., 207 on 144MHz s.s.b. and 27 on 7MHz a.m. (the 7MHz transmissions are intended primarily for listeners not having communications receivers). The survey showed that 1275 members enjoyed satisfactory reception compared with 157 who found reception inadequate. The survey shows that this form of broadcasting to a specialist section of the community can be remarkably successful.

From all quarters

Some of the candidates who sat the Radio Amateur's Examination on December 1 claim that the "multi-choice" questions and answers still included a number in which more than one answer could be correct and that there were other ambiguities in what was clearly intended to be a testing set of questions. As a result of specific complaints, the City & Guilds Institute have agreed that question 37 in Part 2 of the paper *could not* be answered correctly, and the paper is being marked out of 59 questions only.

The VHF Committee of the RSGB is recommending that the frequency band 144.15 to 144.40MHz should be reserved for s.s.b. stations seeking "long-distance" contacts while 144.40 to 144.50MHz should be used for local and mobile operation with a local calling frequency at 144.40MHz.

The British Amateur Television Club in *CQ-TV* reports that a group of "narrow-band tv" enthusiasts in Melbourne, Australia recently successfully transmitted 32-line pictures in the 1.8MHz band to receiving stations in Adelaide (430 miles) and Sydney (470 miles).

In the UK, a 32-line Nipkow-disc system was demonstrated by Douglas Pitt at BATC's Leicester convention last September. Currently there are over 50 amateur tv stations in the UK transmitting fast-scan television on u.h.f. A group of French and Swiss amateurs in the Geneva area are experimenting with 10GHz amateur tv and have achieved distances of 25km.

John Tye, G4BYV of Swanton Morley, Norfolk can be well pleased with the remarkable results he achieved during 1980 using home-constructed equipment on the 2.3GHz (13cm) band. His contacts on s.s.b. included SM6ESG, Sweden (869km) and OK1KIR/P, Czechoslovakia (866km). Many of the transistors he uses are "out-of-spec" disposals. He produces an s.s.b. signal at 144MHz and this is then mixed in a 2C39A cavity with the 2160MHz output from an oscillator chain starting at 90MHz, then amplified in a further 2C39A cavity stage with 42 watts d.c. input. His receiver has an NE64535 low-noise amplifier, followed by HP35823 stage and interdigital mixer with HP2565 Schottky diode and i.f. output at 144MHz. His 4-ft diameter dish aerial is made from wire-mesh with aluminium T ribs.

The RSGB has commented upon the Government consultation document in which the proposal is made to levy a fee of £30 on planning applications seeking permission to erect aerial masts. The Society urges that either no fee or a purely nominal fee should be payable where the mast is intended for non-professional applications.

Radio-ZS, journal of the South Africa Radio League, reports that local amateurs are co-operating with the South African Broadcasting Corporation in investigating the reception of tv pictures from the Russian Statsionar and Ekran series of geostationary satellites. These are located at around 55°East and 99° East and are using down frequencies between 702 to 726MHz except for Ekran 3 on about 4GHz. The 700MHz transponders use powers of up to about 200 watts. Despite the use of frequency-modulated vision signals, black-and-white pictures are being resolved in South Africa on normal u.h.f. tv receivers intended for amplitude-modulated vision provided that aerials of more than about 16dB gain are used. Colour, however, is on the SECAM system and cannot be realized on PAL-type receivers as used in South Africa.

Pat Hawker, G3VA.

NEWS OF THE MONTH

Satellite for business communications

Now in orbit is the first of a group of three communications satellites designed to provide voice, video, high-speed data and facsimile services for American business firms and industries. Launched in November 1980, the satellite is called SBS, which stands for the name of its owner, Satellite Business Systems, a private company jointly owned by IBM Corporation, Comsat General Corporation and Aetna Life and Casualty. It is expected to begin commercial operations early this year.

The spin-stabilized satellite was built by Hughes Aircraft Company's space and communications group at El Segundo, California, and was launched by NASA on a Delta rocket into a geosynchronous orbit at 106° West longitude, roughly south of El Paso, Texas. It is 7ft in diameter and over 9ft high in its "stowed" position, but when, in space, its solar panels are fully extended and its communications aerial is raised it has an overall height of 21ft 8in. The solar panels take the form of two concentric cylinders, the outer of which extends nearly six feet downward in space. This capability of expanding in space doubles the spacecraft's solar-power generating capacity over many previous satellites. Improved solar cells also enhance this capacity.

The electronics payload includes a high-speed, digital 10-transponder system capable of relaying data at rates up to 480 Mb/s. Reception and transmission make use of the 12/14 GHz satellite band and in fact the SBS is the first US domestic commercial satellite to operate at these frequencies. The aerial beams, which are despun, cover the continental United States, delivering higher power to metropolitan regions in the East, Mid-West and West Coast where the communications traffic for SBS's customers is greatest.

The second satellite in the series is scheduled for launch on a Delta vehicle in April this year, and the third one will be launched from the Space Shuttle in late 1982. By 1983 Satellite Business Systems also plans to establish an inter-city satellite telephone service connecting up to 150 metropolitan calling areas.

For use with the satellite 100 earth terminals are being built, also by Hughes. They will be installed on the roofs of customers' buildings or on adjacent ground. Delivery has already started and is expected to be completed in 1982.

Levy on blank video cassettes?

At the first meeting of the British Videogram Association's Council of Management, Donald MacLean of Thorn-EMI was elected Chairman and Maurice Oberstein of CBS, Vice-chairman. Peter Scaping will act as Secretary while the Association is becoming established.

Videogram producers are evidently experiencing roughly the same problems as those in the audio recording industry; the Association's priorities include consideration of the 'commercial piracy problem' and 'an approach to Government for a levy on the sales of blank video cassettes . . .' with a view to controlling the recording of tv programmes on domestic video recorders. When asked whether such a tax was, perhaps, a little unfair on people who intended to use the tapes for other purposes, Michael Kuhn of Polygram, who chairs the working party on industrial relations and copyright, expressed the view that "there's a case for saying 'too bad'." Alternatively, he suggested, such purchases could be exempted from tax if they signed a form at the time of purchase to the effect that they had no intention of using the tape for nefarious purposes. Such a provision, he pointed out, was common in libraries where one-off photocopying was permitted for the purposes of study.

Mr Kuhn went on to explain that the Association was determined that in a "short time", the UK would be the centre of video production and experimentation, the "hub of the video industry", in fact. To attract video manufacturers here, there would need to be rights agreements and unfair competition must be prevented. He saw home taping as unfair competition on the same level as piracy and 'parallel importing', which is the production of tapes in less strictly controlled countries and importation here.

With the increasing expansion of Ceefax comes the added demand for a stable, bright image for those who prepare the pages for transmission. These EV 6000 Series colour picture monitors, at a price of about £1200 each, have been chosen by the BBC for use by the Ceefax journalists and are supplied by Electronic Visuals Ltd, of Woking.

Data convention in Europe

In the past few months a European convention on data exchange and protection has been drawn up and has been approved by the committee of ministers of the Council of Europe. At the time of writing it is due to be formally signed by the Member States at the end of January. The convention aims to move obstacles to the free passage of data between participating countries by encouraging them to trust each other's data protection. It specifically requires that each country must have data protection legislation in force before it can ratify the convention. What form this legislation must take is not stated, but a set of principles to be followed has been provided. These include a right of subject access to files, rectification of mistakes and publishing the existence of files.

Compared with the rest of Europe, Britain has been slow in producing legislation on data protection. There were the 1975 proposals made in the White Paper "Computers and Privacy" (February 1976 issue, p.29) and later the Lindop report (February 1979 issue, p.38) but so far no definite laws have emerged. However, the UK government's representative at the Council of Europe, Donald Cape, did vote in favour of approving the new European convention and, in view of the requirement on data protection mentioned above, this does imply that the government has finally made up its mind to go ahead with such legislation.

Meanwhile the European Parliament has been studying a radical ECC proposal for a directive that would give employees a right to know what is going on in national and multinational corporations. If adopted, the directive would require central managements of corporations with national subsidiaries, as well as multinational companies operating within the European Community, to provide regular information to their employees on matters that directly affect them, including production plans, management changes, and employment trends.

The ECC proposal argues that while large companies have become more complex, with subsidiaries or establishments in a given country or even in several foreign countries, consultation with employees still tends to be conducted at local shop, plant or office level. Even local governments, let alone workers whose very livelihoods may be affected, are often ignorant of the motives for action taken at higher levels. In general, also, disclosure of information to employees is confined to local business matters so that workers can only obtain a partial or incorrect picture of the affairs of the company as a whole.

The proposal is in line with OECD and International Labour Office voluntary guidelines, and with existing industrial practices in the community, as for example in West Germany, Belgium and the Netherlands. But the idea that disclosure procedures should be mandatory, though welcomed by trade unions, has so far aroused considerable misgivings among employers.

Prestel goes international

Prestel, the public viewdata service of British Telecom, is to add international data retrieval to its facilities in July this year. The decision to implement Prestel International, as it is called, was made following the successful outcome of an international market trial which ran throughout 1980. The trial involved more than 300 business users in seven countries and had the co-operation of the telecommunications authorities and carriers concerned.

The international service is expected to follow the pattern found most successful in the trial – information for specific business sectors. These included shipping movements, investment statistics and commodity prices, plus a considerable use of private "closed user groups" in which organisations have exclusive use of certain parts of the information bank to meet their own needs. It will have a single database, which will be quite separate from the one used for Prestel in the UK. This will be updated by selected international information providers, and British Telecom say it is designed to enhance and complement rather than compete with any national service there may be. The full international service, like the trial, will run on a GEC 4080 computer, sited in London. A second GEC computer will be commissioned towards the end of 1981 and will be located in the United States. Further computers will be brought into service in other countries, according to demand.

Access to public information on the international database will be available to users normally for the cost of a call on their own country's domestic telephone network. Access to the private closed user groups will be available via the public telephone network or data links, at the national or international call rate to the nearest computer.

Although access will be possible from anywhere in the world, direct support and marketing is to be restricted initially to the seven trial countries – Australia, the Netherlands, Sweden, Switzerland, West Germany, the United States and the United Kingdom – plus Hong Kong. Tariff levels for the full service, which will be run on commercial lines, are being decided and will be announced nearer the launch date.

The trial database used more than 20,000 pages of information, provided by more than 50 national and international organisations. These included BP, ICL, ICI, Newsweek (USA), News Limited of Australia, and the Chase Manhattan Bank. Public service and government organisations included the Australian Department of Productivity, the European Economic Community Commission, and the House of Lords library.

At present there are 11 countries operating national trial viewdata services, six of which have Prestel computers and software and all of which use the terminal standards applicable to Prestel.

It is expected that considerable use will be made of the developing packet switched data services, including Euronet (see News, February 1980 issue, p.58) and the International Packet Switched Service.

Voice recognition for mariners

Because senior officers on ships don't readily take to the idea of pressing buttons on keyboards but are used to barking orders at subordinates, a seagoing version of Prestel viewdata has been equipped with a voice recognition system instead of the usual keypad for interactive communication. The seagoing Prestel is called Seaview and its purpose is to give ships' officers immediate access to information available in shore-based data banks. Developed by a partnership between Siemens and Computer Analysts and Programmers (CAP), in collaboration with British Telecom, the Home Office, the Departments of Trade and Industry and Liverpool Polytechnic, the Seaview system underwent trials at sea off Dover last year, using 150 of the pages available in Prestel. In a more recent test using voice recognition, uttering the command word "Dover" caused the display screen of a terminal to show all the information held within Prestel on the Dover coastline.

The voice recognition was developed by Threshold International Electronics Ltd (formerly EMI Threshold Ltd and now a company in which Siemens has a major shareholding). The analogue voice signals are first digitized and then fed into a computer system which uses a voice recognition algorithm developed as software by CAP. The system depends on the user's first recording 240 speech sounds on magnetic tape, each sound being recorded ten times to allow for variations in the production of the speech. In operation the spoken command words are matched against these stored reference patterns. More recently Threshold have field-tested a new voice recognition algorithm called Quicktalk which recognizes semi-connected speech and allows the speech input speed to be doubled. (See also the section on speech recognition and understanding in "Artificial Intelligence" by Malcolm Peltu in the January 1981 issue.)

The Doro 721 QA answering machine, recently launched by Ansamatic can act as a message taker, information giver, dictation/transcription and recording machine. It also has the ability to ask a series of questions of the caller, such as account number, address, goods required, delivery date, etc.

C.b. Green Paper – CBA's response

In response to the invitation extended by the Home Office in the Green Paper-discussion document Open Channel, the Citizens' Band Association has submitted a detailed reply with a letter to all MPs, offering them a copy and the loan of a 27MHz receiver so that they can gauge the level of illegal use.

The C.B.A.'s submission is extremely critical of the Home Office proposals which, the C.B.A. say, are didactic in tone, stating as fact a number of things which are no more than opinions. Out of 27 numbered paragraphs and sections, the C.B.A. finds itself in whole-hearted agreement with only six and in qualified agreement with a further four. In common with what the Home Office say is the "vast majority" of over 12,000 submissions, the C.B.A. is not in favour of a frequency in the 928MHz region on the grounds of its probable high cost and short range. It also mentions the possible danger to health of such frequencies, particularly in hand-portable use.

The Home Office is accused of "grossly overstating" the problems of interference to television and other users of the 27MHz band. The C.B.A. claim that, in the ten countries where 27MHz is used legally, there is some interference with other services, but say that "this is generally quite tolerable". It does not explain to whom it is quite tolerable.

The submission concluded with a call on the Home Office to announce a v.h.f. f.m. system during December 1980 or, if this is not possible, to legalise the 27MHz immediately, using the American 40-channel a.m. system unchanged.

One feels that the C.B.A. have submitted a somewhat intemperate document, which may, for that reason, not carry with it the influence its case deserves.

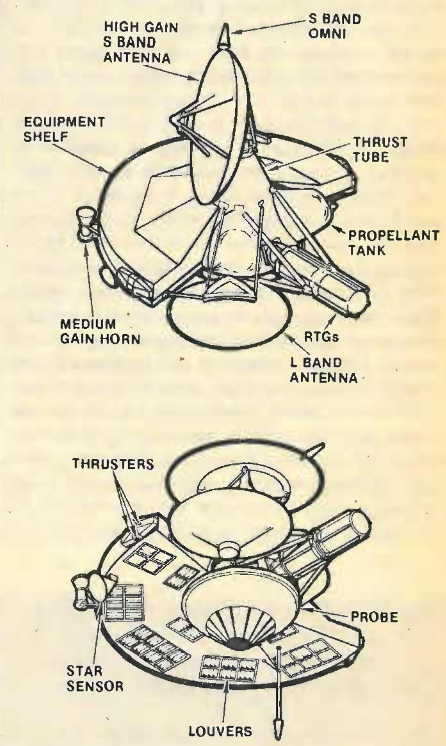
★ ★ ★

In a written answer on December 18, Mr William Whitelaw, the Home Secretary, said that he was "disposed to allocate frequencies to Open Channel Radio in the neighbourhood of 930 MHz." This is in line with recommendations contained in the discussion document 'Open Channel', published in August.

Since, on December 17, the Home Office was still engaged in correlating the 12,000-plus responses to the discussion document, it appears that Mr Whitelaw has not felt compelled to pay excessive attention to the views expressed, which were, according to the Home Office department doing the correlation, greatly in favour of frequencies other than 930 MHz.

Jupiter probe

The Galileo probe will transport an atmospheric entry probe to the planet Jupiter later in the decade as part of NASA's planetary exploration programme. The carrier will receive scientific data transmitted from the probe during its descent through the Jovian atmosphere and then relay the data over a distance of 560 million miles back to Earth. The probe carrier spacecraft will be launched from the Shuttle in March 1984 and will transport the Galileo probe to Jupiter on a journey lasting approximately 3½ years. Both probe and carrier are to be developed for NASA by the Hughes Aircraft Company.



GALILEO PROBE CARRIER

Computer network aids astronomers

A network of computers has been set up at six centres in the UK to provide and co-ordinate image processing and data reduction for British astronomers. Called the Starlink network, it is controlled from the Science Research Council's site at the Rutherford and Appleton Laboratories, Chilton, Didcot, Oxfordshire.

Astronomers in Britain now have access to a wide range of telescopes operating at all wavelengths, on the ground and in space. These are equipped with instruments that produce data in the form of large digital arrays so there is now a pressing need for powerful data processing facilities. Previously astronomers either had to reduce the data manually or devise their own data processing systems. The modest facilities that did exist could be used by only a few astronomers and were heavily over-subscribed, particularly where interactive reduction of the image data was demanded. In the 1980s most astronomy will be done using data in digital form and adequate image processing machinery is essential.

The Starlink system is cased on six Digital Equipment Corporation's VAX 11/780 computers linked in a communications network using Post Office lines. Each computer supports two image displays. The display system used, the Advanced Raster Graphics System (ARGS) made by Sigma Electronics, will show colour images consisting of a matrix of up to 512 × 512 picture elements. It can switch between such pictures, transform the colour mappings to highlight features, zoom in on parts of the picture, generate lines and other graphics and perform other such functions. Each of these displays form part of an 'image processing workstation' consisting of the ARGS, a graphics terminal (for spectra, intensity plots, etc) and a v.d.u. from which the user controls the system. In addition there are other terminals from program development.

Through the network the astronomer will also have access to devices such as larger plotters and camera systems to produce colour prints and slides of astronomical objects.

Intelsat V launched

Intelsat V, the first in a new generation of nine geostationary communications satellites, was launched by NASA on December 6. When it is placed in its permanent orbit, it will take up a position 21.5° west over the equator.

During 1979, around twenty million telephone calls were made between the UK and USA, and the number rises by over 30% per year. Each new set of communication satellites must have increased traffic capacity to cope with this loquacity, and an Intelsat V has double the capacity of an Intelsat IV. It can handle 12,000 telephone calls and two television channels simultaneously.

Five of the nine Intelsat V satellites, which will be launched at intervals up to 1983, are to carry facilities for ship communication, forming part of the global system operated by the International Maritime Satellite Organization (Inmarsat).

The new satellites are not spun for stability, but employ flywheels and earth/sun sensors to maintain the structure in the required attitude. Further novel features include its use of the 14-11 GHz band, which is less congested than the 4-6 GHz band – also used in Intelsat V. Similar frequencies can be used for different purposes by aiming the beams in widely divergent directions at heavy-traffic regions on the earth, and by cross-polarizing the transmissions.

VDUs get clean bill of health – almost

According to a research paper published by the Health and Safety Executive, visual display units used commercial process and business machines are not a risk to the health of most operatives.

The level of radiation of all wavelengths emitted from the screen and elsewhere in the equipment are said to be insignificant compared with national and international limits for continuous exposure, in both short and long term, although no figures are quoted.

One area in which the paper does admit cause for concern is the possibility of epileptic attacks being precipitated in certain circumstances. Since the majority of people who suffer from epilepsy have their first seizure before the age of 20, it is assumed that a first attack is unlikely to be triggered by a v.d.u, but for those who are known to be prone to photosensitive epilepsy, there is a risk, as there is with a large-screen domestic television set. It is increased by prolonged close-range viewing and, in particular, by 25Hz interlacing, which is used in both television and character-enhanced (rounded) v.d.us. Photosensitive epileptics are urged to seek medical advice before working with v.d.us.

News in brief

Viking – the Swedish scientific satellite is to be launched in 1984 to observe the magnetosphere above the north hemisphere. It incorporates a band-S (2GHz) transponder supplied by Thomson-CSF. The coherent transponder will receive remote-control instruction and telemetry data and send back localisation signals.

The BBC was able to open their 22nd local radio station, **Radio Lincolnshire**, three days ahead of the scheduled date in order to broadcast a service from Lincoln Cathedral attended by The Queen and the Duke of Edinburgh. V.h.f. signals are transmitted from Belmont and are of mixed horizontal and vertical polarisation. Medium wave transmissions are radiated from Lincoln, providing a daytime service up to a radius of about 20 miles. A more powerful medium wave transmitter is to be operated in about a year's time.

Radar simulators are needed to help train operators in control procedures. Marconi Radar simulators, as supplied to the RAF recently, are designed to produce a very realistic situation for trainee operators, and in the course of complex tactical situations which are set for executive team training. The computer-generated models of airspace activity can depict any type of aircraft or and armament as well as geographical or meteorological factors. The equipment interfaces readily with all types of display and communications equipment. It can be set up either on its own or can be added to an operational radar system, when it may be used without interfering with the operational readiness of the system.

Electronic Brokers Ltd, who market second-hand test equipment, minicomputers and peripherals, with a refurbishing and calibration service have recently moved to new premises at 61-65 Kings Cross Road, London WC1X 9LN. Their telephone number is 01-278 3461.

Underlining the conclusions of the Photovoltaic Solar Energy Conference, held in Cannes, that **solar electrical systems** is one of the fastest growing 'alternative energies', Lucas Energy Systems Ltd have recently landed a £2 million contract to supply batteries with solar and mains chargers for about 600 sites in Algeria.

Audio 81 hi-fi show is to be held at the Holiday Inn, Swiss Cottage, London, from 3 p.m. on Friday 6th February to 6 p.m., Sunday 8th February. It will remain open until 8 p.m. on Friday and Saturday. The sponsors, Audio T and A T Labs, promise a complete cross section of the hi-fi industry from the large Japanese companies to the smaller enthusiast British manufacturers.

Harmonized electronics standards. As part of the continuing policy of harmonizing the series of standards produced in conjunction with the European Committee for Electrotechnical Standardisation, the BSI have published BS CECC 11000 *Harmonised system of quality assessment for electronic components: generic specification: cathode-ray tubes* and BS CECC 12000 *Harmonised system of quality assessment for electronic components: generic specification: image converter and image intensifier tubes.* Both standards give the terminology, quality assessment procedures, test and measurement conditions for the entire families of the products. They are available from BSI Sales Department, 101 Pentonville Road, London N1 9ND.

More satellite communications for shipping

A new global satellite communications system is being set up to meet the growing international telecommunications needs of the world's shipping and offshore industries during the 1980s. Initiated by the International Maritime Satellite Organisation in November, it involves the leasing of two dedicated ESA satellites, Marecs A and Marecs B, as well as three Intelsat V satellites with Maritime Communication Subsystem packages and one Marisat satellite of the Comsat General Corporation. The system will provide coverage of the Atlantic, Pacific and Indian oceans and will also act as a follow-on to Comsat's existing Marisat system. Transition from Marisat to the new system is expected to be made in early 1982.

The decision by Inmarsat involves contracts to three major suppliers – ESA, Intelsat and Comsat – worth 180 million US dollars over the period 1982-89.

A second major decision made by Inmarsat is on the space segment portion of charges for the telephony and telex services. The final rates to end-users of Inmarsat sevices will now be determined by telecommunications administrations who are signatories to Inmarsat. These rates will reflect additional charges for the use of the coast earth stations of the telecommunication administrations, as well as any landline extension charges.

The coast earth stations of the present Marisat system will continue to provide service in the new system in 1982. They are the Comsat stations in Southbury, Connecticut and in Santa Paula, California, USA, and the Kokusai Denshin Denwa Co. Ltd (KDD) station in Yamaguchi, Japan.

Other stations expected to operate in 1982 include: a second KDD station in Ibaraki; the Norwegian Telecommunication Administration's station in Eik; the Ministry of Communications of Kuwait station in Umm-Al-Aish; the Singapore Telecommunications Administration station; the Italian PTT's station in Fucino and the British Telecommunications station in Goonhilly.

Nine additional coast earth stations are planned, or under study for operation in 1983, while another dozen are similarly under consideration for the post-1984 period.

Inmarsat has also selected KDD of Japan and the Communication Satellite Corporation of USA to be suppliers of network co-ordination services. These services, based on coast earth stations in Ibaraki and Yamaguchi in Japan and in Southbury, USA, will control and co-ordinate the traffic through the satellites in the Pacific, Indian and Atlantic Ocean regions, respectively.

Racal-Decca in Transit

The cost of marine navigation by satellite is drastically reduced by the introduction of Racal-Decca's new DS4 sat-nav receiver. At £3,000, the technique can now be used by small ships and pleasure craft, while its performance is such that it is well suited to use by vessels such as supertankers.

The satellite system used in the US Navy Navigation Satellite System (NNSS), now known as Transit – a system of five satellites in polar orbits which transmit on 400 MHz. Position is obtained by Doppler measurements on the satellites carried out in the receiver each time a satellite is over the horizon and in a usable position relative to the ship. Intervals between passes are around 2.4 hours average (4 hours maximum) so that the position between passes must be obtained by dead reckoning. This is also performed by the receiver using inputs from the ship's gyrocompass and log.

Displayed information includes latitude, longitude, time, date, heading and speed, and the user can obtain the course and distance to ten waypoints and information on the next 100 satellite passes to enable him to plan the voyage. Under normal ionospheric conditions and with an error of 0.2 knot in speed, the receiver will determine position to within 0.05 nautical miles.

Morse decoding

A machine-code program for decoding Morse transmissions on a home computer

by N. Kyriazis

Decoding Morse by means of a computer is a fairly simple matter and many programs have already been produced for home computers such as the TRS 80. This article describes such a program, which was written in machine code for the Z80-based Wireless World scientific computer. The main advantages offered by this program are that it can be used to decode either machine or manually produced Morse and that it provides a certain amount of immunity to the effects of noise and interference associated with short-wave reception, which would normally cause unacceptable decoding errors.

To minimize the effects of poor sending and to ensure reliable decoding from typical short-wave reception, the following features have been included in the program.

- The ability to recognize and reject the effects of short-lived interference, such as that generated by ignition systems.
- The ability to recognize and reject short gaps in the transmission which may occur as a result of the type of interfernce described above. (These gaps may not occur in more advanced receivers which have effective noise limiters.)
- Generous tolerance for the definition of *dits*, *dahs*, characters, spaces, etc., to cater for the different "fists" of c.w. operators.
- The provision of simple 'filtering' of the input from the receiver to reduce the effects of noise on weak signal during fades.

Program description

The program compares the time lengths of *mark* periods, i.e. periods of tone output from the receiver, and *space* periods, i.e. periods of no tone output, with a predetermined time unit. The tone mentioned here is, of course, the audio frequency generated by the receiver in the c.w. mode, usually around 750-1000Hz. This audio output from the receiver must be converted to a logic-compatible signal, so that it can be fed into the computer via one of the five serial inputs. Bit 1 was used in this application, but any other bit may be used if required by modifying the masking instruction following the IN instruction, details of which will be given later. The various elements of Morse characters are defined as follows.

- A *dit* has a duration of one unit of time.
- A *dah* has a duration of three units.
- Elements of the same character are spaced one unit apart.
- Characters are spaced three units apart.
- Words are spaced at least five units apart.

To make the program tolerant to sending errors (bad "fists") and to minimize the effects of interference, as mentioned earlier, the time unit values for the elements of the Morse characters are modified as follows:

- A *dit* becomes a *mark* period which is between one half and two units long.
- A *dah* becomes a *mark* period which is two or more units long.
- An inter-element *space* is from one half to one and a half units long.
- The *space* between characters is from one and a half to four units long.
- Words have a *space* between them of four units or more.

A maximum limit of eight units length is placed upon the *dah* by the program as will be described later. *Mark* or *space* periods less than one half unit long are regarded as the result of interference and are dealt with accordingly by the program.

It may seem initially that there is too much tolerance in the definition of these basic Morse elements as, for example, a *dit* has a range of 4:1 in time duration. It has been found, however, that this method works well in practice and most hand-sent Morse is decoded accurately. The regarding by the program of *mark* units of less than one half unit as interference reduces to a large extent the tendency to display the letter E as a series of Es under interference conditions. Similarly, the minimum limit of one half unit for a *space* results in fewer errors during periods when the output signal from the receiver is weak and reaches the minimum limit required to operate the interface circuitry.

Before giving the detailed description of the program, here is a list of definitions of the terms used in the accompanying flowchart: MARK – a counter used for measuring the duration of "tone" output from the receiver which corresponds to the key-down time and is represented by the H register of the Z80. SPACE – a counter used for measuring the "no-tone" or key-up time which is represented by the L register of the Z80. UNIT – used to hold the current basic time unit of the Morse code being received, i.e. the duration of an inter-element space, which is represented by the B register of the Z80. CHAR – is the variable that holds the HEX equivalent of a Morse character after it is converted by the program. A *dit* is represented by a logic "1" and a *dah* by logic "0". The initial value of CHAR before any elements are inserted is HEX01 and elements are inserted by shifting CHAR one bit to the left first so that no ambiguity results. For example, the Morse character *dit dah* (A) will be HEX 06, and the character *dah dah dit dit* (Z) will be HEX 13. CHAR is represented by the C register of the Z80.

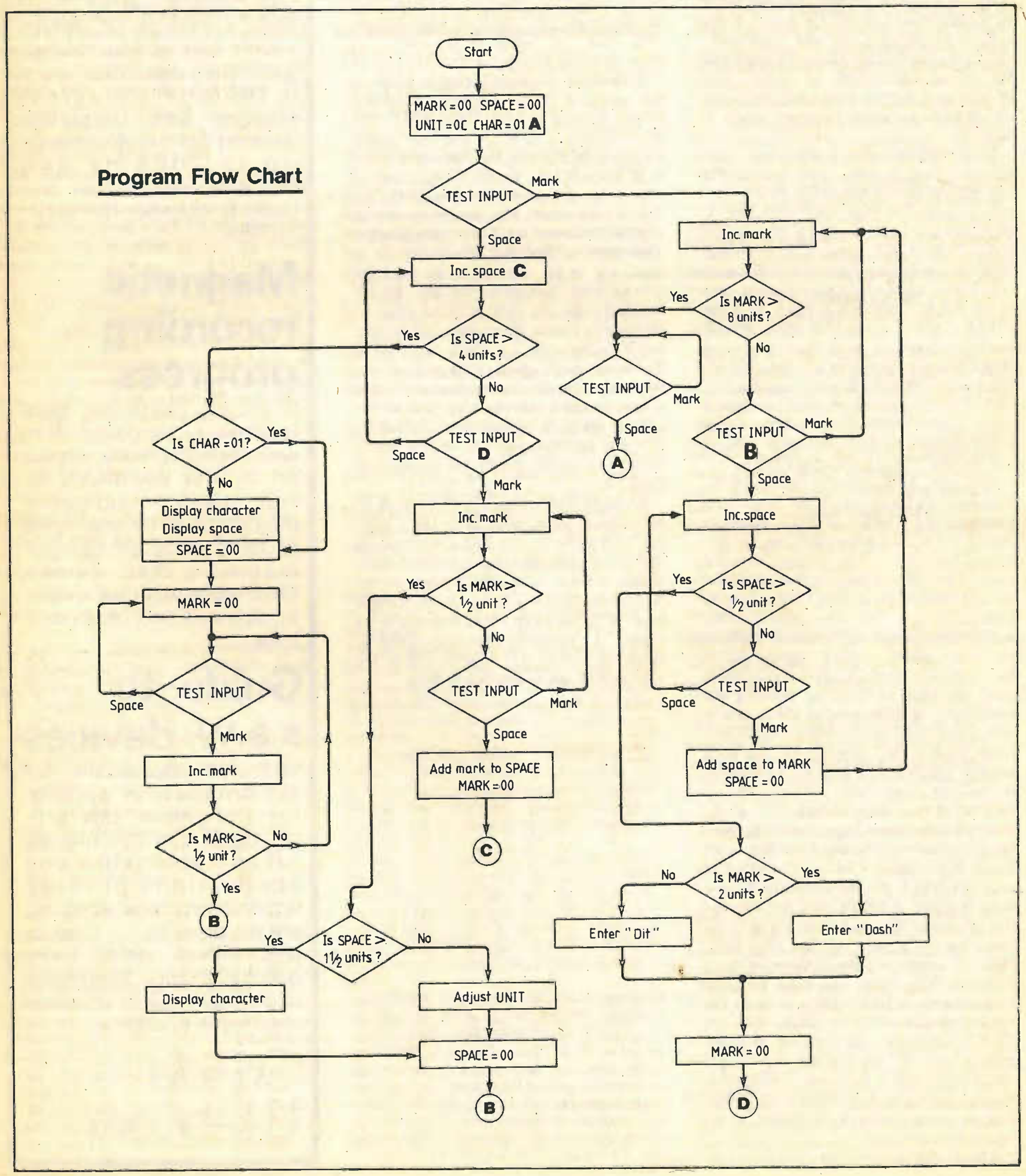
The program in machine code

0C00	11	00	81	01	01	0C	21	00	00	CD	95	0C	30	34	24	7C
0C10	CB	3F	CB	3F	CB	3F	B8	38	07	CD	95	0C	30	E5	18	F9
0C20	CD	95	0C	38	E9	2C	78	CB	3F	BD	38	0C	CD	95	0C	30
0C30	F4	7C	85	67	2E	00	18	D6	7C	CB	3F	B8	CB	11	26	00
0C40	18	09	2C	7D	CB	3F	CB	3F	B8	30	18	CD	95	0C	30	F2
0C50	24	78	CB	3F	BC	38	29	CD	95	0C	38	F4	7D	8C	6F	26
0C60	00	18	DF	79	FE	01	28	06	CD	AB	0C	CD	AB	0C	2E	00
0C70	26	00	CD	95	0C	30	F9	24	78	CB	3F	BC	30	F4	18	A0
0C80	78	CB	3F	80	BD	38	07	78	85	CB	3F	47	18	03	CD	AB
0C90	0C	2E	00	18	8B	C5	06	05	0E	00	DB	00	E6	02	81	4F
0CA0	CD	36	03	0F	10	F4	79	FE	06	C1	C9	79	FE	01	20	20
0CB0	7B	E6	38	FE	38	20	19	13	7B	E6	07	20	FA	7A	FE	87
0CC0	38	02	16	81	C5	D5	06	80	3E	20	12	13	10	FC	D1	C1
0CD0	C5	E5	79	01	32	00	21	E8	0C	ED	B1	01	31	00	09	7E
0CE0	12	13	E1	C1	0E	01	C9	00	01	06	17	15	0B	03	1D	09
0CF0	1F	07	18	0A	1B	04	05	08	19	12	0D	0F	02	0E	1E	0C
0D00	16	14	13	30	38	3C	3E	3F	2F	27	23	21	20	2E	6A	2D
0D10	4C	35	BA	7A	73	47	55	52	37	00	20	01	02	03	04	05
0D20	06	07	08	09	0A	0B	0C	0D	0E	0F	10	11	12	13	14	15
0D30	16	17	18	19	1A	31	32	33	34	35	36	37	38	39	30	3D
0D40	2E	2F	2C	23	2D	3C	3F	3A	3B	29	22	2A				

The main program depicted in the flowchart uses two subroutines, one to test the input to the computer from the receiver interface and to determine whether a *mark* or a *space* is being presented (in this case the interface gives a logic "0" when a tone is seen and a logic "1" where there is no tone) and another to display the decoded Morse character. More details of these subroutines will be given later in this description.

Referring again to the flow-chart, the program starts by clearing the MARK and SPACE to HEX 00, setting the UNIT to HEX 0C (corresponding to about 17 w.p.m.) and the CHAR to 01 (one *space*). Next, the TEST INPUT subroutine is called and if the input is a *mark*, the MARK is incremented. If the *mark* value reaches eight units the program will wait until a *space* is detected and then return to the start and reset. Hence, *mark* periods are limited to eight units and if one tunes to the calibrator of the receiver the program resets automatically as it sees a *mark* greater in length than eight units. If the *mark* does not reach eight units the MARK counter is incremented until a space is encountered. The SPACE counter is then incremented but if the *space* does not reach one half unit in length, it is regarded as a break due to interference and its length is added to the *mark* period. If the *space* count does reach a length of half a unit then it is regarded as a valid *space*, so the program checks whether the *mark* is greater than two units and if so inserts a *dah* (logic "0") in the CHAR register. If the MARK is not greater than two units a *dit* (logic "1") is inserted. The MARK counter is now reset 00 and the program enters the SPACE count sequence at block D.

The SPACE counting sequence that starts at block C is almost identical to the



MARK sequence as far as the handling of short *mark* periods is concerned but when a valid *mark* is encountered, i.e. a mark of more than a half unit long, it checks whether the SPACE count is less than one and a half units. If less than one and a half units long, the *space* is regarded as an inter-element space. The value in SPACE is added to the UNIT, the sum divided by two and the result entered in UNIT again. This results in an exponential adjustment of the UNIT towards the value representing the incoming speed. This allows the program to adapt automatically to the speed of the sender, provided it is not less than two thirds or greater than two times the preset speed (about 17 w.p.m.). If the *space* is greater than one and a half units then it is regarded as a character space and the display subroutine is called. The SPACE is set to 00 and the program enters the MARK counting sequence again at block B.

If the SPACE count reaches four units then it is regarded as a word space and if the content of CHAR is not 01 (no elements inserted) then the character is displayed and is followed by a space on the v.d.u. The SPACE count is set to 00 and then the program waits for a valid *mark* (more than a half unit long) before it exits to the MARK sequence at block B. If the CHAR register contains 01 when SPACE reaches a count of more than four units then nothing is displayed and the program waits for a valid *mark* before continuing. This is to avoid the printing of spaces under some interference conditions that cause the *space* to reach four units without any elements being inserted in CHAR.

And now, here are some details of the two subroutines used by the main program. All TEST INPUT question blocks use a subroutine that has the following function:– The output from the receiver interface is input to the accumulator and masked by an AND instruction to retain only bit 1. Next, the contents of the accumulator (which will be either HEX 02 or 00) are added to the C register which was originally pushed onto the external stack and than set to 00 on entering the subroutine. A time delay of about 1ms is now called and the process repeated five times. Hence, the C register will contain a number which will be 00 if all the samples of the input were logic "0", or 0A (10 decimal) if they were all logic "1". If the input changes state during sampling then the C register will contain a number equal to twice the number of "1s" input. The content of the C register is compared to a fixed number (HEX 06) and the subroutine returns to the main program with the carry flag set if there are less than three logic "1" inputs or reset if there are three or more "1s". Thus, the main program uses a Jump on Carry (JRC) to go to the MARK sequence or a JNRC for the SPACE sequence (the receiver interface gives a logic "1" for no tone and a logic "0" when a tone is detected). Taking five samples of the input provides some immunity to noise during weak signal or interference conditions.

The display of characters is handled by another subroutine which checks to see if the v.d.u. address points to the last eight positions of a line, in which case if the character is a space the next two lines are cleared and a new line called to avoid splitting words and to keep the display tidy. Next a search is made through the Morse table to find the ASCII equivalent of the HEX code for the converted character which is then sent to the v.d.u. for display. If a HEX code outside the table is presented an asterix will be printed. The Morse table contains the characters from A-Z, numbers from 0-9 and the following auxiliary characters; full stop, comma, question mark, semicolon, oblique (/), break (–), double-break (=), end of transmission (#), end of work (<), wait ("), colon and parenthesis.

A machine language listing is given in the standard W.W. scientific computer format starting at 0C00. The TEST INPUT routine is at 0C95 and the display routine at 0CAB with the conversion table at 0CE8 to 0D18, the HEX equivalent of Morse characters, and 0D1A to 0D4B, the ASCII equivalent. The instruction E6 02 at 0C9C is used to mask bit 1 of the input. This may be modified if another bit is used, e.g. if bit three is to be used the instruction becomes E6 08. Note, however, that the byte at 0CA8 must be changed to a value three times the weighting of the bit used, e.g. HEX 18 for bit 3. The initial preset speed of the program can be changed by altering the byte at 0C05 to a value equal to the unit of time of the desired speed in milliseconds divided by five, e.g. for 12 w.p.m. the unit of time is 100ms, so 0C05 should be changed to HEX 14.

A simple receiver interface was made by the author using parts from the "junk-box" but for better results he recommends that a more effective circuit be built using ideally a p.l.l. tone switch such as the NE567 arranged to give a t.t.l. output with logic "0" given when a tone is received and a logic "1" when the tone is removed. A hand-key with a 1kΩ resistor tied to the +5V supply can be used for testing. □

European Electronic Component **Distributor Directory** 1980/81, is one of the Mackintosh compilations, which details distributors, in their several guises, in France, Italy, UK, West Germany. Names and addresses of the distributors are given first and are followed by a keyed list of products handled by each company. The Directory contains 304 pages and is available at £30/75 dollars from Mackintosh Publications Ltd, PO Box 28, Luton, England LU1 5DB.

IN OUR NEXT ISSUE

A range of counters

Constructing a range of counters based on the versatile Intersil ICM7216 i.c.. From a set of modules a variety of instruments can be assembled. Examples described are a 0-100MHz universal counter, two frequency measuring instruments, up to 200MHz and 500MHz, and a low frequency counter for 10Hz-10MHz.

Magnetic recording progress

In recent years the tape recording progress has developed rapidly, urged on by the popularity of high-quality sound reproduction and by the need to store data on tape or magnetic disc. James Moir reviews advances in equipment and tape coatings.

Guide to s.a.w. devices

Intended specifically for the professional applications engineer, this article describes the electrical characteristics and applications of three types of surface acoustic wave devices – band-pass filters, delay lines and oscillators. Emphasis is on their use in modern electronic systems.

On sale 18 February

LETTERS TO THE EDITOR

"OPEN CHANNEL" FREQUENCIES

The recent Green Paper called "Open Channel" (October 1980 issue, p.68) has aroused great interest from all those concerned with radio communications, not least Philips Research Laboratories, Redhill. We have carried out field trials to ascertain the performance of a radio service at 900MHz, and made comparisons of 900MHz with other frequencies.

Three-watt transmitters for 27, 85, 172, 456 and 958 MHz were installed in a van. The 27MHz equipment was a.m., the others were f.m. with a peak deviation of ±5kHz. The antennas were simple monopoles, mounted on the vehicle roof 7 feet above ground.

An estate car was fitted with receivers for each band, from which signal level and speech were recorded. Transmissions to the estate car were also made from a base station, where the antennas were approximately 33 feet above ground level.

At 958MHz, the useful range in an urban environment was about 1.5 miles when operating base to mobile, and ¾-1 mile mobile to mobile. Listening tests showed that the coverage was patchy, but it was found that reception was relatively unaffected by tunnels and bridges. A test in open country, with a near line-of-sight path, revealed that the mobile range was about 3-3½ miles. Under more usual mobile conditions it was found that the range was about 1½ miles due to the presence of trees and hedges.

A summary of the results is shown in the following table.

Useful range in miles for a 3W transmission

Frequency MHz	Base-mobile	Mobile-mobile
958	1.5	0.75-1
456	4-5	3
172	9	7
85	13	8
27	7	5

Fading was noticeable at 456MHz, very noticeable at 172MHz, but virtually absent from the 85 and 27MHz transmissions. The surprisingly low results for 27MHz were due to heavy interference from overseras stations.

By use of the inverse fourth power law, the range predictions cited in the "Open Channel" document can be scaled from 25W down to 3W, and are shown below.

Base to mobile range in miles

Frequency MHz	Our results 3W	"Open Channel" Predictions 3W
900	1.5 (958MHz)	3
450	4-5	6
225	9 (172MHz)	9

These results show that the usable range falls as the frequency is raised. The range at 900MHz could be increased by raising the transmitter power, and by use of a gain antenna. A 30W, 900MHz vehicle mounted transmitter should achieve an urban range of 2-3 miles. The power output of hand-portable equipment is limited to a few watts by safety and battery size, so a range of only a few hundred yards would be achieved at 900MHz.

The results show that the range of a personal radio service at 900MHz would not prove to be equal or better than that at 27MHz. It therefore seems unlikely that present illegal users of 27MHz would invest in equipment that would give them a performance inferior to that to which they are accustomed.

C. S. Barnes and D. W. H. Calder
Philips Research Laboratories
Redhill
Surrey

IS LIGHT VELOCITY A CONSTANT?

This letter is an open invitation to interested physicists to begin working towards an experiment that could test directly the constancy of the velocity of light and hence the validity of the theory of relativity. The experiment would endeavour to measure time intervals four orders of magnitude greater than those in the Michelson-Morley experiment and thus would be entirely free of time dilation and length contraction effects.

Two clocks will be required, able to measure time down to 100 picosecond and, most important, able to be *synchronised* within the same uncertainty. By "synchronised" I mean compared by some appropriate technique while *both* positioned at *one* point in space.

Now keeping one of the clocks at the point A, the other clock will be transported to the point B, a distance d in the direction of Earth's orbital velocity v. (The speed of transport can, of course, be adjusted so that time dilation imparted to the clock will be as small as we please.)

Let a ray of light depart from A at the t_A time, let it at the t_B time be reflected at B and arrive at A again at the $t_{A'}$ time. Then $t_B - t_A = d/(c-v)$ and $t_{A'} - t_B = d/(c+v)$.

Thus Δt, the time difference between the two journeys, is equal to $d/(c-v)$ minus $d/(c+v)$ or $2dv/(c^2-v^2)$. If we take $d = 3$km and assuming $v = 30$ km/s, then Δt will very nearly equal to 2 nanoseconds.

In the Michelson-Morley experiment $\Delta t = dv^2/c^3$; using the same numerical values for d and v as above, $\Delta t \approx 3 \times 10^{-13}$ second. As time dilatation and length contraction are quantities of the same order, they will have no bearing on our results.

Increasing the distance between the two clocks to 30km or 300km would result in the correspondingly greater value for Δt (20 and 200 nanoseconds, respectively), thus broadening the required time uncertainties tenfold or hundredfold respectively.

Our reasoning has, so far, been quite consistent with the theory of relativity. The two clocks should according to the theory be declared to be out of step by that (Δt) amount of time.

Why? Because of the manner in which the theory defines synchronism. To quote Einstein ("On Electrodynamics of Moving Bodies", Dover):

> (we cannot define the common time for the clocks at A and B) . . . "unless we establish by definition that the time required by light to travel from A to B equals the time it requires to travel from B to A"

that is, the two clocks are in step if $t_B - t_A = t_{A'} - t_B$ and are out of step if $t_B - t_A \neq t_{a'} - t_B$.

The fault with this definition of synchronism is that it transposes the *a priori* and *a posteriori* modes of reasoning, thus freezing the postulate of the velocity of light into a fait accompli law of nature.

Indeed, if we set out to throw any light on the nature of the velocity of light, then our clocks must be synchronised *prior to* performing any measurements. It is the clocks that will be used to decide whether the velocity of light is a constant and hence, contrary to Einstein, *light cannot be used to synchronise them.* (Light or an electric pulse can, of course, be used as a trivial means of setting, provided that during this process both clocks are positioned very close to each other.)

Thus if it is found in our experiment that $t_B - t_A \neq t_{A'} - t_B$ we will be free to conclude that the velocity of light is not a constant; and should we find that the two time intervals were equal, well then . . . .

In either case we will need a theory to replace the one that has outlived its usefulness.

Michael M. Albahari
Whangarei, New Zealand

FLOATING BRIDGE AMPLIFIERS

I read with some interest the recent articles by R. M. Brady on the "Floating Bridge Amplifier" (September, October 1980). It is indeed a superior method of producing reliable, low-distortion, very high power amplifiers.

We have been producing such a design since 1972 in the form of the Amcron M600 (600 watts, 0-45kHz in 8Ω) and the corresponding bridge-bridge version, M2000 (2000 watts, 0-40kHz into 8Ω). They were advertised on p.6 of the September issue and p.89 of the October issue by Kirkham Electronics.

Gerald R. Stanley
Crown International
Elkhart
Indiana, USA

COMMERCIAL BROADCASTING

Lord Reith said in 1952 "Somebody introduced dog-racing into England. And somebody introduced Christianity and printing and the uses of electricity. And somebody introduced smallpox, bubonic plague and the Black Death. Somebody is minded now to introduce sponsored broadcasting into this country".

But another former BBC director-general, Sir Frederick Ogilvie wrote: "Freedom is choice. And monopoly of broadcasting is inevitably the negation of freedom, no matter how efficiently it is run, or how wise and kindly the boards or committees in charge of it. It denies freedom of choice to listeners. It denies freedom of employment to speakers, musicians, writers, actors and all who seek a chance on the air".

In 1977 Lord Annan's Committee on the Future of Broadcasting, although not without its criticisms of ITV-ILR, reported that any broadcasting service must be judged on the quality of its programmes and that it is one of the achievements of British broadcasting (in a passage clearly applying to both BBC *and* ITV) that "programmes are regarded as hand-made products produced by individual craftsmen and not as articles of mass production".

Clearly your editorial "Save our public service broadcasting" (December 1980) sided more with the late Lord Reith than either Sir Frederick Ogilvie or Lord Annan. But the picture it painted of commercial companies producing programmes designed to "insulate people from reality, to keep them quiet, uncritical and accepting" seems, to say the least, out of all touch with reality. What price "World in Action", "TV Eye", "The London Programme" . . . etc, etc? The Annan Report commented "There is one department in which the commercial sector has by common consent surpassed the BBC. That is in the presentation of news". Insulating its viewers from reality?

You assume, furthermore, that producers are dominated by the advertisers (do the better editors of our press take their cues from advertising managers?); it ignores the role of the IBA which "has the central resposibility for administering the ITV and ILR systems and is ultimately responsible for the content and quality of everything which is transmitted", it ignores the furious endeavours of the Corporation to hold 50 per cent of the audience rating to justify the payment of licences by *all viewers,* it ignores the fact that there is no clear dividing line between those who for part of their careers produce programmes for the whiter-than-white Corp or the blacker-than-black ITV. In short, sir, your editorial is written from cloud-cuckoo-land where smallpox, bubonic plague and the Black Death are the Reithian synonyms that never did and never will exist in public service broadcasting by either licence-funded or advertisement-funded British organizations.

J. Ring
Member IBA
Imperial College of Science and Technology
London, SW7

Professor Ring is the IBA member with special interest in engineering. – Ed.

Your comments in the December 1980 issue on commercial broadcasting are particularly apt, especially in view of the fact that there was no demand or great enthusiasm, at the time, for its introduction. This is just one more area where succeding Labour governments have failed to make a re-adjustment which is long overdue.

Robin H. Mann
Barnet
Herts

What has *Wireless World* come to? First you urge us to abandon our nuclear defences, and now (December issue) you tell us that the purpose of independent broadcasting is to "insulate people from reality, to keep them quiet, uncritical and accepting. It purveys a synthetic culture . . .", which sounds like another way of saying that viewers are stupid and don't know what they want.

In case there are other people with a similar view, here is a lesson in simple economics. Advertising is an information service, nobody is forced to buy anything. Advertising can increase turnover and competition, keeping prices down in the shops. ITV-ILR is paid for by advertising revenue which comes partly from savings made through mass production, enabled by increased turnover, which in turn means showing programmes most people want to see.

Independent broadcasting is therefore independent of government and dependent on the viewers. I would suggest any lack of choice in ITV-ILR programming is the result of having only one channel.

If people want to save public service broadcasting, as you put it, they should persuade the government to introduce a fairer funding system, where viewers who watch ITV-ILR don't also have to subsidise BBC programmes, but where public broadcasting revenue is linked by some formula to the size of audience and range of programmes.

Perhaps, then, when public service broadcasting (or state broadcasting) operates under commercial pressures, rewards and competition will its programme output, technical support, and administration relate to what the viewer and listener actually want rather than what the staff think thay should want.

Ian S. Thorburn
Edinburgh

While I agree with your editorial in December's issue "Save our public service broadcasting", I would like to make the following points.

Competition between the BBC and ITV-ILR which leads to one out-bidding the other is the main cause of the BBC's financial problems. Entertainers and promoters are getting richer, as are the staff working for the broadcasting authorities.

It would be interesting to know the cost to the public when the IBA costs are added to the licence fee.

Will an increase in the licence fee solve anything? I think not: we will still get the BBC trying to out-bid the commercial broadcasters. Putting up the licence too much, with the large number of people unemployed, might result in a drop in revenue. What is the solution?

J. W. Jordan
Stroud
Glos

As a long term subscriber to *Wireless World* I have viewed with disquiet the recent trend towards political, rather than technical, editorials. Phrases in your most recent leader on the subject of commercial broadcasting bring to mind such descriptions as 'hysterical outburst' and 'political diatribe', yet even these do scant justice to the ill thought-out collection of clichés, non-sequiturs and downright untruths which appear on page 35 of the December issue.

It must be clear even to your jaundiced eye (cf. your own leader "the growing professionalism of commercial broadcasting") that neither quality nor lowest common denominator programming is the sole prerogative of any one organisation. The interdependence of advertisers and the media on which they advertise is all pervading, as I am sure you would find were you to fail to deliver to your advertisers the readership they expect. Far from rejoicing in the financial difficulties of the BBC, most thinking commercial broadcasters accept that a strong, high quality public service broadcasting service is essential to the maintenance of standards while, equally, an enlightened public service organisation will be able to make use of the many innovations and ideas which the economic pressures of commercial broadcasting of necessity produce.

As someone who makes his living from the despised (by your leader writer) commercial broadcasting, I found the last paragraph grossly offensive. My own organisation, with a full-time staff of 30, provides 18 hours a day, 7 days a week of entertaining, informative, and popular local commercial broadcasting. Lest the old saying about 'juke box radio' come to mind I would point out that a typical day includes 8-8½ hours of music, 2-2½ hours of news, 3 hours of talks, reatures and current affairs, 2 hours of commercials, 2 hours of 'short' features (interviews, traffic, what's on, where to go, etc.) and up to 1 hour of promotional material.

It really is 'make believe' to suggest that commercial broadcasting is only designed to "insulate people from reality" to purvey a "synthetic culture" or is a "substitute for the real thing". Such biased and emotive phrases have no place in such an august and respected journal as *Wireless World.*

T. J. Mason
Plymouth Sound Limited
Plymouth

Congratulations on your editorial "Save our public service broadcasting" in the December 1980 issue. I couldn't agree more!

D. A. Barlow
Bingley
W. Yorkshire

FAILURE OF DISTRESS SIGNALS AT SEA

The letter from Mr Boyd (December 1980 issue) adds considerable weight to the mounting evidence on the inadequacies of some ships' aerials at 500 kHz and the consequent risks to which both ships and crews are exposed. The circumstances described by Mr Boyd almost exactly parallel those experienced by Mr Harding, from whose letter I quoted in my article in *Nautical Review,* September 1979. I would like to comment on two points raised by Mr Boyd:

1. Whether insulator leakage, poor siting or low aerial capacitance is the dominant cause of poor performance will depend on the particular layout, and will vary from ship to ship. It is not therefore possible to dismiss the deck insulator as a factor, nor the analysis of the effects of leakage given in the "Admiralty Handbook of Wireless Telegraphy", which is as valid today as when it was written. Mr Boyd himself obtained improved performances on washing down the insulators.

2. The emergency generator may start automatically on some ships, but on others the diesel must be started manually and if the ship is listing or on fire, that may not be easy. The B.O.T. recognised the 500kHz battery equipment as being the ultimate means of salvation, and indeed required that an instruction card be displayed to enable any ship's officer to use it in an emergency.

It would not be necessary for Mr Boyd's marine superintendent to lay out $10,000 for a mast aerial. Observation in many ports shows that the Continental powers (France, Belgium, USSR, Poland) are using multi-wire cage aerials to obtain maximum capacitance in the minimum space, with minimum number of supporting insulators. My article in *Safety at Sea,* May 1978, touches on that point.

My thanks to Mr Sawyer (December letters) for his comments.

John Wiseman
London E3

MICROCHIPS AND MEGADEATHS

I was somewhat surprised by the nature of your leading article "Microchips and megadeaths" in the November 1980 issue. The world has always existed of course with a "balance of power" in one form or another and I feel that I must put the following points to you.

1. You reprint an account of the Hiroshima atomic bomb but do not balance it with an account of the horrors suffered in Japanese prisoner-of-war camps by British and American soldiers. Why?

2. Can you ever see engineers in the communist countries being asked to voice their views on how their government should use their expertise? I think the answer is an emphatic "No."

3. Can you see the communist countries giving up their arms? I cannot.

4. If we gave up our weapons can you see the communist countries leaving us in peace or for that matter our own internal fifth column? I think not.

So it seems to me we keep our weapons or opt for world wide communism complete with its psychiatric hospitals for dissidents – I know what I would prefer.

L. G. Martin
Abbots Leigh
Bristol

We, the Central London Medical Branch of the Association of Scientific, Technical and Managerial Staffs, wholeheartedly support the leading article "Microchips and megadeaths" published in the November 1980 issue. We hope that this article is part of a more general policy of yours covering all articles, exhibition reports and advertisements. Scientists and engineers seem to have a tradition of being non-political, especially at rank and file level. Your article correctly points out that this must stop. Technically trained people must start to consider the results of their work in terms of morality rather than in the immediate attainment of purely technical achievement.

Many people interested in electronics, young and old, professional and amateur, read and respect *Wireless World,* considering it to be one of the more sophisticated in the field. From this position *Wireless World* has a positive contribution to make in the Campaign for Nuclear Disarmament. We wish that other electronics magazines would follow this lead so that future engineers and scientists can devote more of their time and the dwindling world resources to the pursuit of aims beneficial to the whole human race.

E. Cady (Branch Secretary)
ASTMS (Central London Medical)
London WC1

"ANATOMICAL" LOUDSPEAKER

I fully agree with Mr R.I. Harcourt ("An acoustically small loudspeaker" October 1980) who draws attention to the inadequacies of the cuboid loudspeaker for the reproduction of certain sounds. It has, in fact, been my opinion for some years that to reproduce a given sound perfectly the loudspeaker should have the same size and 'anatomy' as the thing which emitted the original sound. If this is a correct view we can fairly easily design a speaker by giving a unit a housing which is near enough the same as that of the original source. But, obviously, one cannot take this principle very far. It would be impossible, for instance, to reproduce the sound from a whole orchestra by assembling an equivalent number of speakers all designed to reproduce perfectly the individual instruments, and to accommodate these in the living room. But we can go some way towards this. I am thinking of the human voice, the sound which is most important of all and to which we are specially attuned. For myself I cannot say that I have ever heard speech satisfactorily reproduced on any cuboid speaker: people just do not speak with boxes round their heads.

I did something about this a few years ago: I made it the theme of an 'entertainment' lecture to our students. My argument went as follows: the sound of a voice comes primarily from the larynx and from there, through a lined bony tube, makes an exit via the mouth cavity. And of course, some important sounds emanate from the chest as well. I first produced a Wellington boot and filled it with rags; this was the chest and lungs. On the top of the boot I placed a little loudspeaker on a board; this was the larynx. I then produced a skull (loaned by a kindly Anatomy Department), cupped it in a shallow foam polystyrene plinth with a hole in it, and sat this on the speaker board. The jaw was propped open with a match-stick and the brain cavity filled with cotton wool. I then reproduced the recorded voices of lecturers with whom the students were familiar. The effect was remarkably good, the clarity was especially impressive and there was none of the booming which makes listening to speech reproduced on a box speaker so tiring. A student later admitted to having quailed on hearing the craggy accents of his class head.

I took the theme one step further. Prior to the lecture I had recorded a soulful Scottish tune played by a musician friend on a violin. During the lecture I replayed this using as a loudspeaker the same violin with a small unit strapped underneath, there being contact made between the unit and the underside of the violin by means of a cork. The reproduction could hardly be distinguished from the original and I demonstrated

Lena the loud-talker

this by inviting my friend out of the audience, whereupon he played the secondo of a duet on the same violin while it was reproducing his original recording. The effect was stunning. I have never seen an audience so affected by a demonstration. Strong men wept, almost.

Recently I returned to the problem of my skull and wellie boot loud-talker – how to 'normalise' it. The skull is, of course the main difficulty – they are not easily procured, even in this Burke and Hare country. The result of my labour is Lena (named after the lady who provided the mop head). But Lena is not as good – let me say at this point – as my original S and WB loud-talker. She is, however, obviously on the right lines.

Firstly, it will be noticed that she has no chest. Actually she has, it is in her cranium. The whole thing is inverted and the chest, in fact, consists of a partly cut-away p.v.c. football stuffed with rags. At the base of the chest, behind the nose, is the larynx, and under that is the throat, leading down to the mouth. The other embellishments are added for aesthetic reasons.

It occurs to me that it would be pleasing to fashion the instrument in the likeness of one's nearest and dearest – what a fine tribute, or memorial, it might make.

John T. Lloyd
Department of Natural Philosophy
University of Glasgow.

ELECTRONIC ORGAN TONE FILTERS

Many thanks to your magazine and to Dr Pykett for a much-needed basic guide to tone filters suitable for the average home-built organ. I would certainly agree with Dr Pykett's reply to Mr Robins of Rugby, and add that the art of a classical organist (electronic or pipe) is to breathe life into a mechanical system and add interest to the music using the means he has available. By this I do not mean gimmicks but phrasing judiciously and accenting notes, making them sound louder by giving a slightly longer pause before the note is played. The cinema organist, of course, keeps one foot glued to the swell pedal to add interest. The more discriminating classical organist can use it to add a swell box full of strings to the great flues at the appropriate time with good effect. However, having heard Bach's *Passacaglia* performed more convincingly on a tiny one-manual pipe organ than on a four-manual monster, I am convinced that, as with a Stradivarius, it is the performer and not the instrument which produces a good or a bad performance.

Bernard Jones says that pipe organs can only get more expensive. I prefer to say that their value can only appreciate whereas electronic organs depreciate, especially at such a time of rapid development as the industry is going through now. However, ranks of "free-phase" oscillators will always sound superior – like valve amplifiers.

May I suggest one oscillator per note, each driving its own amplifier and speaker mounted in a wooden rectangular cabinet tuned to the length of the standing wave for that note?

M. R. Berzins
Hanwell
Middlesex

WW's FIELD OF INTEREST

I have been following with interest the recent deviations from topics of a strictly technological nature in *W.W.* from questioning the grounds of relativity theory to commenting on the role of the electronics and telecoms industry in providing the means of implementation for certain political philosophies.

It is only to be expected that some readers will be disturbed by suggestions that their leaders may be mistaken in various matters; the shock may be greater if they have previously concentrated their attention on books and journals limited by their particular interests in technology. May I refer briefly to a few of the correspondents in December's issue:

Desmond Thackery finds controversies in basic physics to be above his head, but nevertheless entertaining.

Reg Williamson is not amused by cranky views and wants to confine *W.W.* to good (clean?) engineering.

Peter C. Gregory is a technical person and knows a few highly skilled persons, and can thus state that suggestions of gaps in their knowledge are rubbish.

M. G. Scroggie, whilst conceding that it is difficult to know what to do, declares *W.W's* comments on nuclear strategy to be insulting and, indeed, treasonable!

The editor has much to answer for, and there is yet more – "Worried" thinks there are too many advertisements!

Perhaps some of us are worried, even deeply concerned, at the present state of the world and the frame of mind of some of the scientists, technologists and engineers who occupy themselves with the techniques of communication and control.

What proportion of the *W.W.* readership, one wonders, wants only information on bare technicalities, well-remunerated jobs that are open, and perhaps a few words on how wonderful everything is going everywhere?

Yes, we pay 60p a month to be informed, to relate ourselves to the activities of our fellows, and to have our view of life broadened; at least that's what I would have thought. If fair comment is to be stifled, free enquiry suppressed, what may we have to pay one day to obtain information we desperately desire but which is withheld in the interests of state security?

I, for one, welcome the broadening of *W.W's* field of interest, even if I may sometimes be unamused or confused, or find it weighty with "commercials" – after all, I don't *have* to read every word if I don't want to; I can even manage without an "off" switch.

C. B. V. Francksen
Farnborough
Hants

THE DEATH OF ELECTRIC CURRENT

I refer to the interesting article by Mr Ivor Catt in your December 1980 issue. It is indeed refreshing to find Mr Catt having a sideways look at the apparently trivial matter of electric current.

If one rewrites the Maxwell equations using tensor notation in a four dimensional Riemanian Space, the effects predicted by Mr Catt become more obvious. E and H cease to have separate meanings, removing that most embarrassing of dualisms and the electromagnetic field (complicated in three dimensions) becomes a simple tensor field in four dimensions.

N. D. Levin
Telecommunications Accessories Ltd
Thame
Oxon

The author replies:
It's a pity that the obfuscation has to continue like this. I did not realize that my December 1980 article predicted any effects. What were they?
Ivor Catt

LOGIC DIAGRAMS

While I applaud the aims of Tony Cassera's article "Intentional logic diagrams" in the November issue, I disagree with his use of a suffix L as the mnemonic for the 'active low' signal in place of the bar over its name.

In microprocessor, and I presume mainframe computer, jargon and even in 'ordinary' logic the prefix N is used to indicate an 'active low' signal (e.g. the N in NAND which is used to show that the output is 'active low'). The origin of this is I suppose the term Negative Logic used to describe circuitry where the more negative voltage is regarded as the true, i.e. logic 1, state.

So I suggest the use of N rather than L as either prefix or suffix to indicate the 'active low' signal.

We could even coin some new names to go with Mr Cassera's modified symbols as shown here in Fig. 1. Incidentally the EXOR symbol for the 'active low' input version as shown in the article is inconsistent – the symbol does not need the extra bar at the input but should be as in Fig. 2. In fact this really should be the

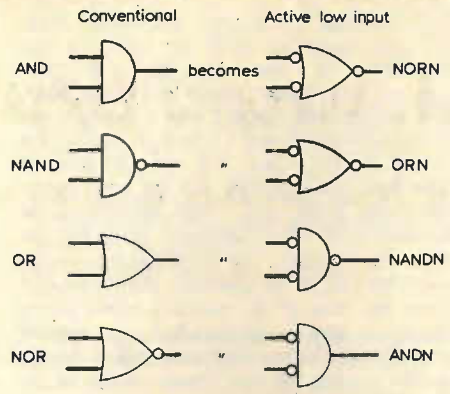


Fig.1

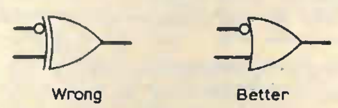


Fig. 2

symbol in conventional logic as well as it is the one type of gate (along with EXNOR) whose function is the same for both normal and 'active low' inputs.

Rex I. G. Palmer
Ascot
Berks.

The term NAND is generally understood to be a contraction of NOT AND, where the NOT corresponds to the denial 'not' used in formal logic. – Ed.

TV SETS FOR THE HARD OF HEARING

I was interested in the plight of your correspondent Mr Holloway (October letters), who had a problem finding a television set with a headphone facility.

Mr Holloway was not specific as to whether he was looking for a monochrome or colour receiver but, in any case, many sets make use of power supplies which connect the chassis either directly, or via a diode bridge, to the mains. Obviously direct connection of the chassis to a headphone socket would be a hazard to a customer and some form of isolation is necessary. Since little power is involved a small transformer would be suitable but this must have adequate isolation to safeguard the customer. BS 415: 1979 requires this isolation to be able to withstand over 2kV.

Such a transformer could prove to be a comparatively expensive component and a set designer must consider whether the extra cost on the receiver would still be acceptable to potential customers.

The above line of reasoning partly led to our decision to use a switch mode power supply to fully isolate most of the chassis on our current range of receivers (see part 4 of my recent series of articles on these chassis). This enabled us to provide a headphone socket as standard throughout the range; however, I do not think we are the only UK or European manufacturer to provide this facility.

It seems rather a sad reflection on the dealers in Mr Holloway's area that they showed little or no interest in promoting British made sets with these features.

Ray Wilkinson
Decca Radio & Television Ltd
Bradford
W. Yorkshire

LEVY ON BLANK TAPES

As one of the relatively few holders of the Amateur Recording licence, I found myself totally unable to support the proposed levy on blank tapes and those who have studied the case for a levy will indeed be amazed. So much money is alleged to be at stake that a levy of several pounds per cassette would be called for.

As technically informed people we should readily see that if it were imposed there would be a great sale for a new generation of tape recorders running at 1⅞in/s or even ¹⁵⁄₁₆in/s speeds and even with four mono tracks. The fact is that most "pop" music, in which the money lies, is listened to on cheap transistor radios or record players and hi-fi is unwanted. Obviously, for this and many more reasons, a levy on tape is doomed to failure.

But is your correspondent Mr Simmons (December letters) not a little naive in accepting without qualification the proposition that musicians and their agents are entitled to a just reward for their labours? The money which is alleged to be lost by the use of tape recorders is that which once had to be spent if one received a permanent record of a performance. Is it necessarily just that any price could be placed upon the permanent record whether it was a gramophone record or tape? The very existence of the Monopolies Commission indicates that the answer must be no. Therefore one needs to examine a little more carefully the matter of copyright, because that is the mechanism used for keeping the prices of records and pre-recorded tapes at a level far higher than the costs, royalties apart, justify.

In simple terms the musical world divides into classical, where the composers are dead and their works are out of copyright, and the world of "pop" where composers now aim for the "jackpot." The performers of both ought in theory to be content with a flat rate fee for their performances on the basis that it is just a job of work, but if that notion suits clsssical musicians it manifestly does not suit "pop" musicians who are going for the "jackpot" as well. In practice of course it may be difficult to distinguish between performers and composers in the "pop" field but even so it strikes me that the proposed levy is a Luddite-type action.

Two media, namely radio and records, were exploited vigorously and with the objective of making money. Radio, whatever the BBC may say, was the advertising medium and the objective was to make the money. Tape has now come and it is easy to record from radio, with the obvious result. Perhaps we should reflect that had the BBC not allowed itself to become the tool of the record producers we would never have been exploited as the source of vast sums of money which went to the record producers. Now we have the means of not being exploited by using a tape recorder, it is that freedom which is being attacked.

Looking back to the old days, e.g. those of the 78 r.p.m. record, it is noteworthy that we paid a modest fee to the BBC which provided music on a considerable scale almost entirely by employing musicians and paying royalties to the composers. What went wrong? It seems to me that by hook or by crook a lot of people in the "pop" world are determined to get far more out of us than the BBC ever did.

It will fail if for no other reason than that "pop" music is ephemeral and the same tape will be used ad nauseam and the new generation of good tapes will be those with literally infinite life.

L. Streatfield
Poole
Dorset

T.t.l. logic probe

Performs static and dynamic tests on logic circuits, including 'glitch' detection

by A. J. Jameson, B.Sc.

The probe described is unusual in that it will detect and indicate the presence of 'glitches', the transients caused by propagation delays in logic circuits. In addition to the usual static testing, it also shows positive or negative coincidence in two pulse trains of different frequencies.

A logic probe is a useful aid to testing and fault-finding digital systems. The many commercial and amateur designs currently available provide information about the static and dynamic behaviour of circuits, but have the limitations of not providing 'coincidence-detection' and cannot indicate the presence of 'glitches' in the waveform under investigation.

For example, in the simple case of Fig. 1, a 'standard' probe would indicate pulses at A and B, but the output C would remain high, leading to the conclusion that either the gate is faulty or the pulses are not coincident. The next step in the exercise would probably require the use of a dual-beam oscilloscope to prove whether or not A and B are coincident. Even so, if the pulses are of different frequencies, the task of 'coincidence proving' may be impossible using an oscilloscope. In addition, the use of an oscilloscope has made the purpose of the highly portable, pocket-sized logic probe somewhat futile.

Another example encountered all too often, despite careful design, is that of 'glitches' produced by static and dynamic race-hazards. In the example of Fig. 2, a negative-going 'glitch' is produced due to the propagation delay (t_d through the JK flip-flop. This example is also shown in Fig. 3, where a 20ns pulse has been produced using the circuit above.

The use of a logic probe on such a circuit would reveal no faults whatsoever. Even an oscilloscope with delayed-sweep facilities would probably show nothing unless the frequency of A was greater than 1MHz. However, the presence of such a circuit within a system, gives rise to erratic operation and is quite often diagnosed as an 'elusive dry-joint'.

The logic analyser probe now described, solves these problems whilst still providing the features of the standard probe. It should be mentioned that the t.t.l. i.cs used in the probe are operating with pulse durations shorter than is recommended by manufacturers. Although two probes have been made without trouble in this respect, it may be necessary to experiment with several i.cs. The total cost of the unit is about £10.

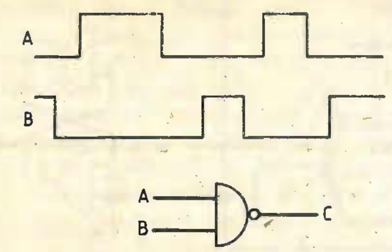


Fig. 1. An ordinary probe would not show whether a lack of output from the gate was due to the pulse trains not being in coincidence, or the gate being faulty.

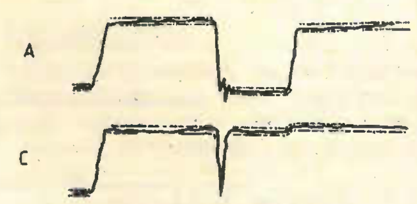


Fig. 3. Evidence of the glitch in Fig. 2, based on a screen photograph.

Circuit operation

Protection circuitry. The protection circuitry shown in Fig. 4 has been incorporated to prevent damage to the probe due to incorrect supply voltages. In addition, D_5 is illuminated when the supply voltage is correct, i.e., when the applied voltage is 4.5-5.8V. This feature is very useful, as all too often the most obvious fault of incorrect supply voltage is overlooked and much time can be wasted investigating 'suspect' digital circuitry.

Under normal operation, T_{r1} is off, T_{r2} is on and hence 5V is applied to the probe circuitry via RLA. However, above 5.8V, D_2 conducts and T_{r1} is biased on. This switches T_{r9} off and opens RLA, thus isolating the logic probe circuitry.

Also, voltages above 4.5V cause D_4 to conduct, switching T_{r3} and T_{r4} on and thus D_5 is lit.

Probe circuit. IC_1 and IC_2 in Fig. 5 form 'window discriminators' with threshold voltages of 2V and 0.8V. These i.cs are 9637 dual differential line receivers and, because of the input characteristics of the device, R_{10} and R_{12} are needed to 'pull-down' the input to 1.5V when the probe is floating.

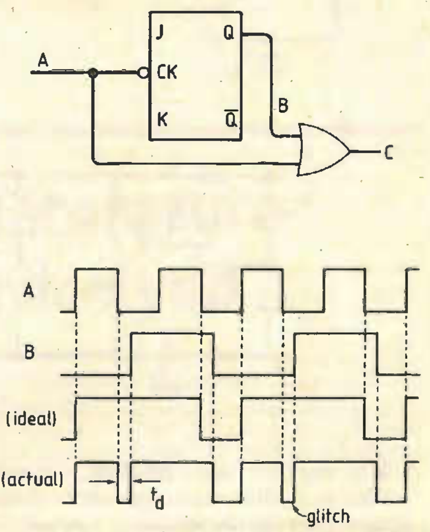
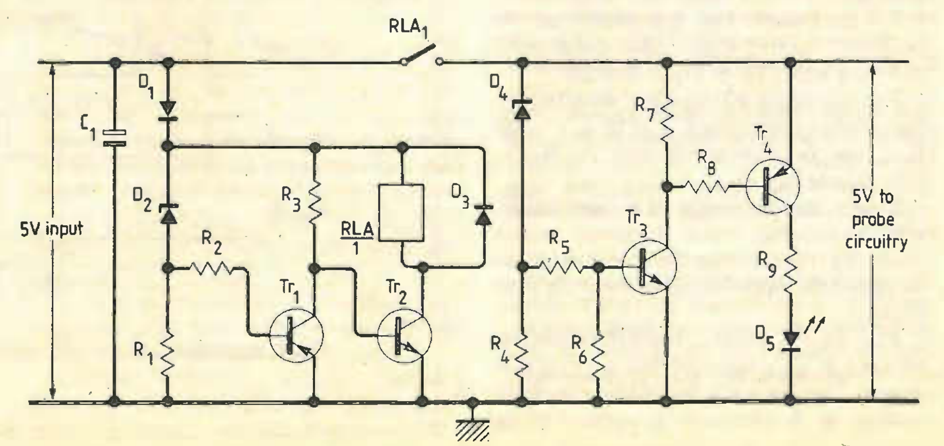


Fig. 2. Propagation delay between the input and output of the flip-flop produces a narrow pulse or glitch at C.

Fig. 4. Protection circuit avoids damage to the probe in the presence of incorrect supplies, and shows that the supply voltage is in the usable range.



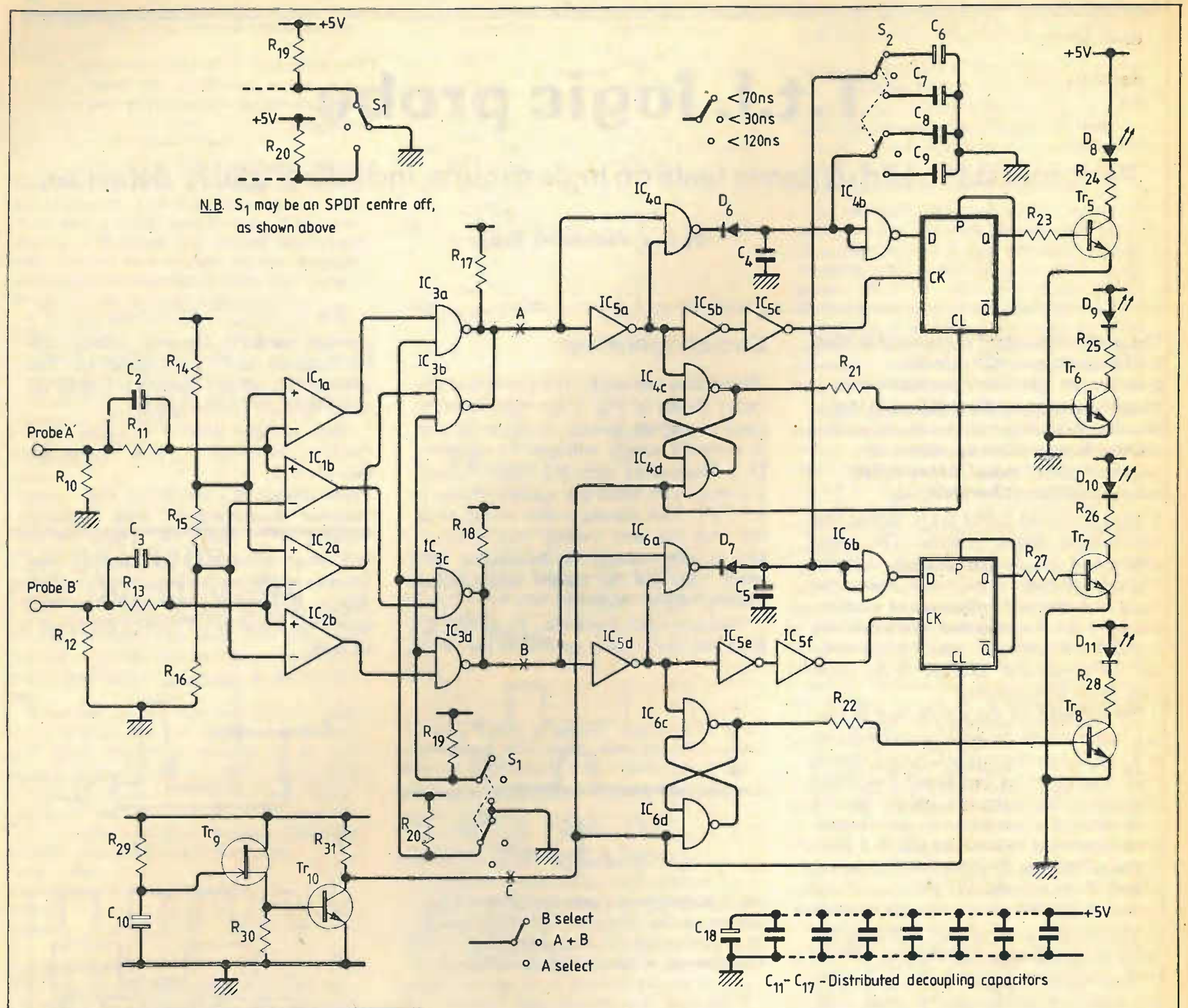


Fig. 5. Circuit diagram of the probe.

IC_3 provides the ANDing circuitry needed to facilitate the coincidence detection mode of operation.

The latches comprising $IC_{4c,d}$ and $IC_{6c,d}$ indicate the logic level at the probe. If a 1 is present at the input to IC_1, point A will also be high. This in turn is inverted by IC_{5a} and a low is therefore present on IC_{4c}. Thus T_{r6} is conducting and the red l.e.d. D_9 is lit. These latches are reset by narrow pulses produced by the unijunction oscillator T_{r9}.

If a permanent 1 or 0 is present at the probe, it overrides this reset pulses and therefore either D_9 or D_{11} remain lit.

Positive going glitches are detected by the circuit comprising $IC_{4a,b}$, $IC_{5a,b,c}$ and IC_{7a}, and negative-going ones by $IC_{6a,b}$, $IC_{5d,e,f}$, and IC_{7b}.

These circuits consist of a monostable, with switchable pulse duration, and a latch. By considering the positive glitch detector, the operation of the circuit is as follows.

IC_{4a}, D_6, C_4 and IC_{4b} form the monostable and $IC_{5a,b,c}$ equalize the propagation delays. The leading edge of the waveform present at A produces a negative-going

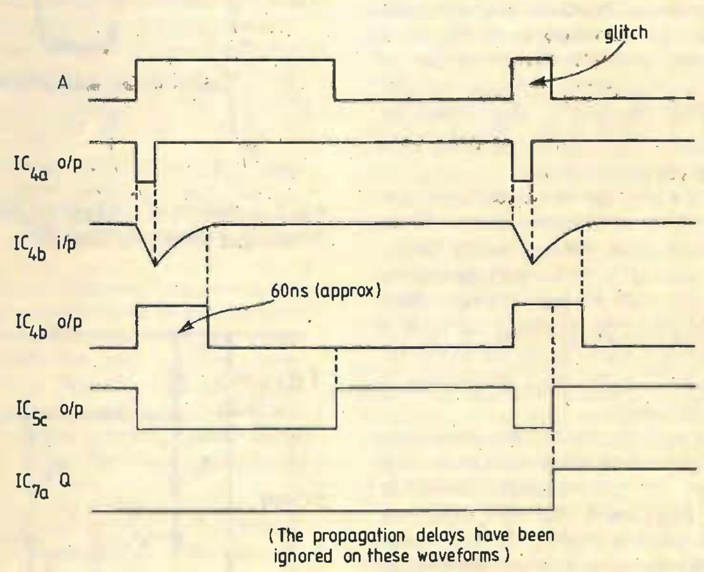


Fig. 6. Waveforms show glitch detection.

Components

Resistors (⅛W)

1, 3, 4	1k0
2, 7, 10, 12	10k0
21, 22, 23, 27	
5	4k7
6	22k0
8	2k7
9	100R
11, 13	560R
14	910R
15, 16	270R
17, 18, 19, 20	2k2
24, 25	220R
26, 28, 30	120R
29	33k0
31	1k5

Capacitors

1	100µF 10V tantalum
2, 3	22pF mica
4, 5	strays
6, 8	3.3pF mica
7, 9	10pF mica
10	2.2µF 35V tantalum
11, 12, 13, 14	
15, 16, 17	10nF ceramic
18	10µF 35V tantalum

Semiconductors

D_1	1N4002
D_2	BZY88 4V7
D_3	contained in relay
D_4	BZY88 4V3
D_5	TIL212 (yellow)
$D_{6,7}$	OA47
$D_{8,9}$	TIL209 (red)
$D_{10,11}$	TIL211 (green)
$T_{1,2,3,6}$	2N3704
$T_{7,8,10}$	
T_9	TIS43
T_4	2N3702

Integrated circuits

1, 2	9637 (Fairchild)
3	SN74LS03
4, 6	SN74LS132
5	SN74LS14
7	SN74LS74

Miscellaneous

RLA	d.i.l. relay s.p.s.t. (N/O)
S_1	d.p.d.t. or s.p.d.t. centre-off
S_2	d.p.d.t. centre off
1mm sockets 3 red; 2 black	
Case to suit (100 x 50 x 25mm)	

Printed circuit boards

A set of 2 double-sided p.c.bs for the logic probe will be available for £6.00 inclusive of v.a.t. and UK postage from M. R. Sagin, 23 Keyes Road, London N.W.2. Alternatively, copies of the author's suggested layout can be supplied from this office on receipt of a stamped, addressed envelope. Please mark your envelope 'Logic'.

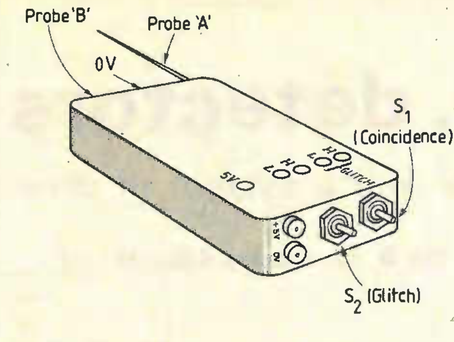


Fig 7. Suggested form of case.

pulse at the output of IC_{4a}, whose duration is equal to the propagation delay through IC_{5a} (approximately 15ns). This pulse duration is extended by D_6, C_4, and IC_{4b}: C_4 is discharged rapidly via D_6 and the output of IC_{4b} becomes high. D_6 is now reverse biased and C_4 is charged by the input circuitry of IC_{4b}, until the high input-threshold level of IC_{4b} is reached, when the output of IC_{4b} returns to a low.

The duration of the monostable period has two additional lengths, determined by C_6 and C_8, which enable the glitch period to be determined approximately.

The propagation delay of $IC_{4a,b}$ is compensated by a similar delay through $IC_{5a,b,c}$. Thus, the trailing edge of the pulse at the CK input to IC_{7a} is time coincident with the positive edge of the pulse at the D input. These pulses are illustrated in Fig. 6, which shows that if the pulse produced by the monostable (IC_{4b} output) is of shorter duration than the input pulse at A, then the Q output of IC_{7a} remains unchanged and therefore is not detected as a glitch. However, if the pulse from IC_{4b} is longer than that at A, then the D-type flip-flop (IC_7) toggles and the Q output goes high, registering a glitch. This latch is periodically reset by the unijunction oscillator.

Construction

As will be appreciated, pulses of less than 100ns duration are easily attenuated by stray capacitance and inductance. Therefore, all leads must be as short as possible.

By careful choice of components, it will be found that the two boards may be 'sandwiched' with component sides together and therefore can be fitted into a case of 100×50×25mm, as illustrated in Fig. 7.

Testing

If a high-frequency oscilloscope (of around 50MHz bandwidth) is available, the test circuit consists of a simple oscillator running at about 1MHz, driving a 74121 monostable with a variable pulse duration from 20-200ns. Using such an arrangement, it is a comparatively simple matter of checking the pulse lengths at which the glitch circuitry operates.

However, without a suitable oscilloscope, the only way of checking the monostable periods is to generate glitches of approximately known length, relying on the propagation delays of cascaded gates. It should be stressed that the timing periods need only be approximate and consequently, no great difficulty will be encountered.

The probes consist of a 1mm plug with a sewing needle soldered in place and also another needle, soldered to a short length of wire. The earth point should be connected by a short lead to the area under investigation to minimize pulse attenuation. □

Specification

Power consumption	100mA (l.e.ds off) 180mA (all l.e.ds on)
P.s.u. indication	4.5V-5.8V ± 0.2V
Input impedance	5k
'Low' threshold	0.8V ± 0.1V
'High' threshold	2.0V ± 0.1V
Max. input freq.	25MHz
Min. det. glitch	15ns
Glitch det. ranges	(1) 30ns (2) 70ns approx. (3) 120ns

Literature received

Celestion have sent us a leaflet on the interferometric testing of loudspeaker cones, using the Doppler effect in a laser system. The leaflet also provides a complete history. It was accompanied by a spectacularly illustrated brochure and an incomprehensible poster. WW401

Greenweld's catalogue of electronic components, hardware, tools, etc, complete with prices, is now available from Greenweld Electronics Ltd, 443 Millbrook Road, Southampton SO1 0HX, price 50p.

A series of leaflets from Ferranti describe the F100-L, which is said to be the only 16 bit microprocessor to be designed, developed and made in Europe for commercial and military applications. The leaflets can be obtained from Ferranti Computer Systems Ltd, Computer Sales Dept., The Courtyard, 20 Denmark St., Wokingham, Berks. RG11 2BB. WW402

A full catalogue of the enormous range of TAB books, which includes publications on radio, antiques, aviation, d.i.y., car mechanics and many more subjects, is available from TAB Books, Inc., Blue Ridge Summit, PA 17214, U.S.A. WW403

Babani's range of low-cost publications on radio and electronic topics are described in their new catalogue, which can be had from Bernard Babani (Publishing) Ltd, The Grampians, Shepherds Bush Road, London W6 7NF. WW404

F.m. detectors – 2

A survey and a system of classification

by S. W. Amos, B.Sc. M.I.E.E.

Phase-comparator detectors

This type of detector also makes use of the varying phase relationship between two input signals, nominally in quadrature, such as the voltages across the primary and tuned secondary windings of a transformer but it does so in a manner quite different from that of the detectors described earlier. In Seeley-Foster and ratio detectors the two input signals are added to produce resultant voltages (the amplitude of which varies with the phase difference) which are applied to amplitude detectors, the combined output giving the required modulation-frequency signal.

In phase-comparator detectors the two input signals are limited so as to form rectangular pulses. Limiting may be carried out in separate stages preceding the phase comparator or in the phase comparator itself. The degree of overlap of these pulses varies with the phase difference between the two inputs and determines the output current of the comparator which is therefore a copy of the modulation waveform. The output of the comparator thus depends on the relative timing of the two sets of pulses and is independent of the amplitude of the input signals provided this is sufficient to give satisfactory limiting. To summarise: in the detectors described in the first article the amplitude of the primary and secondary voltages is the significant quantity whereas in the phase comparator it is the timing of these voltages which matters.

The general form of a phase-comparator detector is illustrated in the block diagram of Fig. 13(a).

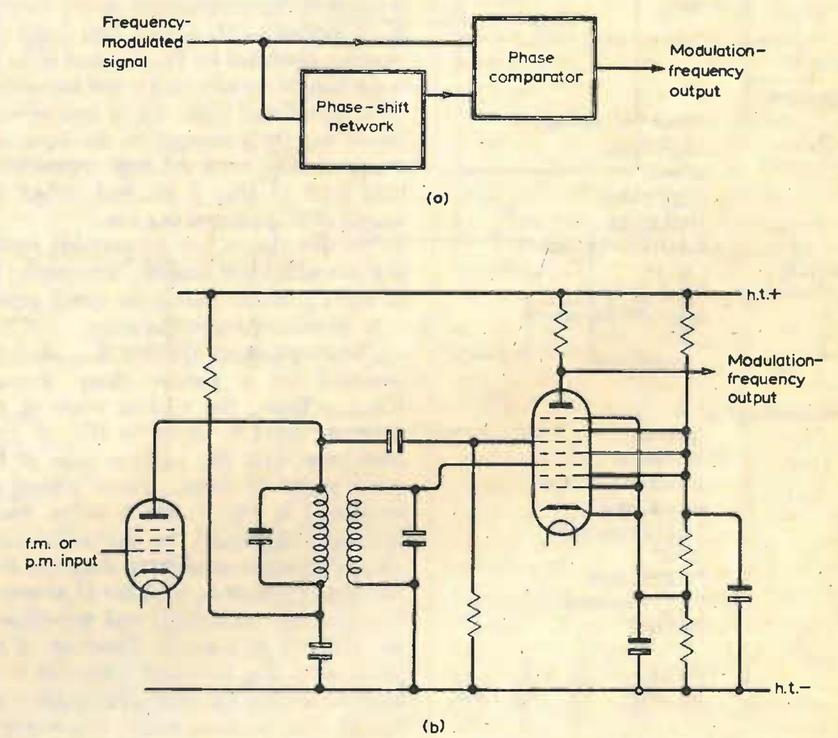


Fig. 13. (a) General form of phase-comparator detector. (b) Self-limiting coincidence detector using a nonode valve.

Self-limiting phase-comparator detectors. In an early form of phase-comparator detector the two input signals are applied to the two input grids of a special valve. The grids are required to give limiting action: in other words positive-going signals are required to increase anode current up to a particular value after which further positive excursions should produce no change in anode current. This is the type of control achieved by the suppressor grid of a pentode. Signals applied to such a grid deflect cathode current from anode to screen grid or vice versa but cannot increase or decrease cathode current which is determined by the screen-grid and control-grid potentials. Thus the ideal valve for this particular application is one with two suppressor grids.

In addition it is important to minimise damping of the input-signal source (normally the primary and tuned secondary windings of a transformer) by the input grids when they are driven positive with respect to cathode and, to this end, input-grid current must be kept to a low value. This is achieved by so constructing the valve that each input grid is situated between two positively-charged screen grids where there is no space charge to support grid current. Finally therefore the valve required consists of three screen grids, two input grids, a control grid and a suppressor grid next to the anode to suppress tetrode kink.

Thus was the nonode derived and Fig. 13(b) shows the circuit diagram of an f.m. detector using a nonode. Its operation is illustrated in the waveform diagrams of Fig. 14 which show that anode current can flow only when g_3 and g_5 are both positive i.e. when the pulses derived from primary and tuned secondary windings overlap. As the degree of overlap varies with frequency modulation the anode current varies

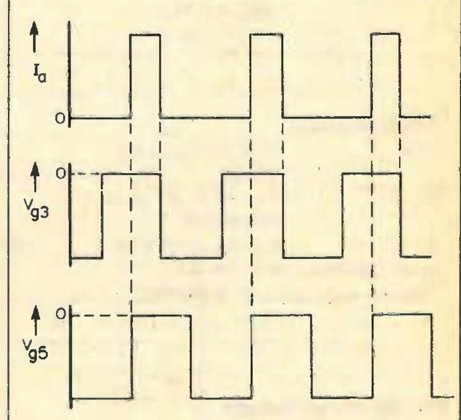


Fig. 14. Action of the nonode valve. Diagram shows V_{g3} and V_{g5} in quadrature, the conditions when the input signal is at the centre frequency. Anode current can flow only when V_{g3} and V_{g5} are simultaneously at zero.

accordingly and so contains a strong modulation-frequency component.

There was a simpler valve which was used in a similar way to the nonode. It was a pentode in which the two input signals were applied to the control grid and the suppressor grid but the geometry of the electrode structure was quite different from that of a conventional pentode in order to achieve the type of limiting action required at the two grids. It was known as a gated-beam valve.

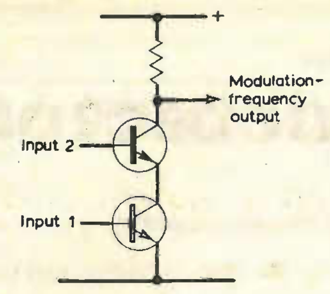


Fig. 15. Basic form of transistor coincidence detector.

Transistor phase-comparator detectors. In its simplest form a transistor equivalent of the nonode or gated-beam tube could take the form shown in Fig. 15. One of the disadvantages of such a simple circuit is that the output would contain a large component at the input frequency in addition to the wanted modulation-frequency component and in practical forms of phase-comparator detector precautions are taken to minimise this unwanted component.

In integrated circuits, for example, extensive use is made of the push-pull principle and a simplified version of a typical circuit is given in Fig 16. The output of the i.f. amplifier (also included in the i.c.) is applied in the form of push-pull pulses to the bases of Tr_5 and Tr_6 so that when one of these transistors is driven into conduction the other is cut off. The quadrature signal is derived from the i.f. output by use of an external LC circuit and associated reactance (one possible arrangement is shown in dashed lines) and is applied also in pulse form to two push-pull pairs Tr_1Tr_2 and Tr_3Tr_4 in a balanced circuit which ensures that none of the quadrature component appears between the output terminals. Suppose Tr_1 base is driven positive by the quadrature signal at an instant when Tr_5 is conductive. The effect is to promote conduction in Tr_1 and thus to cut Tr_2 off, producing a net output between the output terminals. Half a cycle later, when Tr_6 is conductive, Tr_3 and Tr_4 behave similarly and again there is a net output. The duration of these outputs depends, of course, on the extent of the overlap between the i.f. and quadrature inputs and varies with the phase difference between the two inputs. The output can be used as a.f. in f.m. receiver or for a.f.c. purposes.

Tr_7 is included to stabilise the mean current through the detector and is one of the many auxiliary components included in i.cs to ensure that the performance is substantially unaffected by variations in ambient temperature or in supply voltage.

A number of i.cs designed for use in f.m. receivers incorporate detectors with a circuit similar to that of Fig. 16 and they are often described as balanced, symmetrical, quadrature or product detectors.

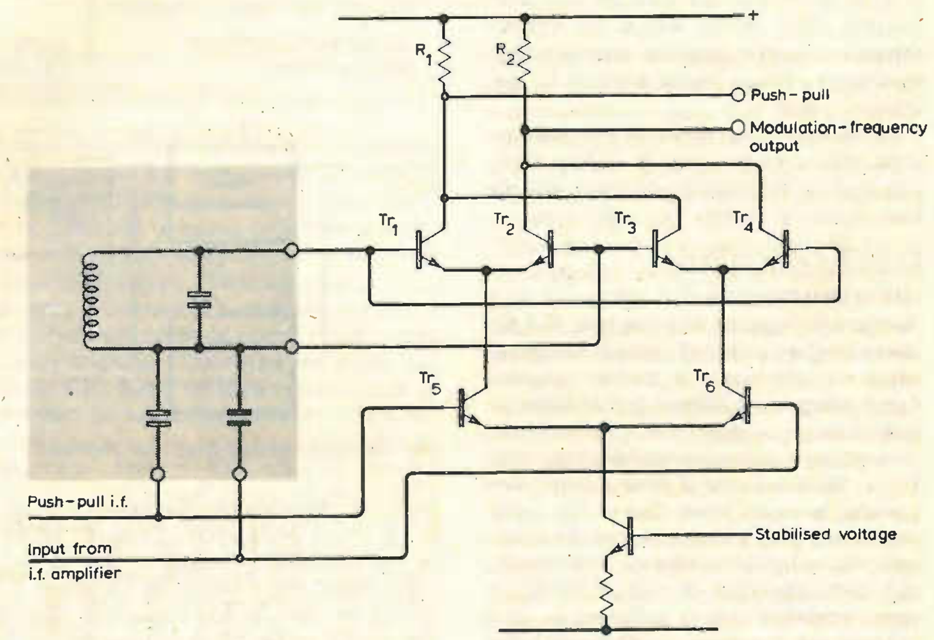


Fig. 16. Simplified version of coincidence detector used in i.cs.

Counter discriminator

This uses a principle quite different from those employed in the detectors so far described. If an f.m. signal is rectified the result is a succession of half-sinewave pulses the frequency of which varies according to the modulation. At periods where the pulses are crowded the mean value per unit time is greater than at instants when they are less crowded. This variation in mean value represents the modulation waveform and if the rectified signal is passed through a low-pass filter to suppress all but a.f. the output consists of the wanted modulation-frequency component superposed on a direct component. The change in frequency in the signal radiated from an f.m. broadcast transmitter is, however, very small compared with the centre frequency, typically ±75kHz maximum at a carrier frequency of, say, 90MHz – a variation of less than ±0.1% representing a very small change in mean value of the rectified signal and thus a very small a.f. output from the low-pass filter. The relative change in frequency is greater in the i.f. circuits, ±75kHz in 10.7MHz being approximately ±0.7%. It is usual, however, in receivers using pulse-counter discriminators to employ an i.f. of 455kHz or even lower. At 455kHz the maximum change in frequency is nearly ±17% which gives a worthwhile modulation-frequency component in the rectified signal.

The signal presented to the low-pass filter must be free of amplitude variations because these would give a spurious output. Moreover all the input pulses must be of identical shape because variations in shape could also give unwanted components in the output. The problem is, therefore, to generate from the i.f. signal a series of pulses all of identical form and amplitude, the number per unit time varying according to the modulation.

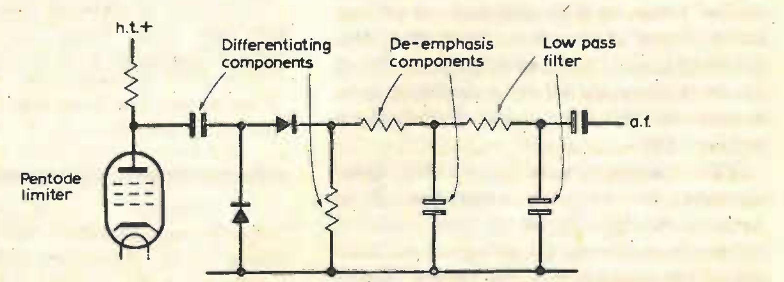


Fig. 17. Early form of pulse-counter discriminator.

Early pulse-counter discriminators were fed with square waves from the final limiting stage in the i.f. amplifier. The square wave was differentiated in an RC circuit which, as shown in Fig. 17, incorporated diodes to eliminate negative-going blips. The resulting train of positive-going blips was passed through a low-pass filter with a cut-off frequency of, say 30kHz. A simple RC filter is shown in Fig. 17 which is taken from an article published by M.G. Scrggie in 1956.*

In more recent pulse-counter discriminators the positive-going blips are used to trigger a multivibrator giving, for example, 1-µs pulses which are passed through a squarer stage (to eliminate any overshoots) before being applied to the low-pass filter.

Pulse-counter discriminators are used in applications where linearity is important e.g. in f.m. rebroadcast receivers and in f.m. deviation meters.

Locked-oscillator discriminators

As the title suggests this last type of f.m. discriminator is based on an oscillator which is synchronised by the f.m. signal so that its frequency follows any changes in that of the input signal. Such a system can be expected to have two useful properties. Firstly the amplitude of the oscillator output can be many times that of the input signal, implying a useful degree of voltage gain. Secondly the oscillator output amplitude is independent of that of the input signal provided this is sufficient to give effective synchronising: in other words the system should give effective amplitude limiting. Thus the oscillator can be used as a source of amplified and amplitude-limited f.m. signals which can be followed by any of the types of discriminator described above. Used in this way, of course, the oscillator is not itself a discriminator but a source of input signal for a discriminator. Circuits of this type were described as early as 1944.

The synchronised oscillator can, however, act as a discriminator. If it operates in class C, taking one burst of current from the supply per cycle of oscillation, the frequency of the bursts follows that of the input signal and so contains a modulation-frequency component which can be used as detector output. For the reasons given under the previous section, however, a low value of intermediate frequency (and hence oscillator frequency) is necessary to give a worthwhile performance from such a circuit.

Phase-locked-loop circuits. In this more recent application of the principle the frequency of the oscillator is controlled not by direct application of the f.m. signal but by a control voltage dependent on the difference between the phase of the oscillator and that of the f.m. signal. The circuit, illustrated in principle in Fig. 18, is so designed that the effect of the oscillator control voltage is to minimise the phase difference between the two signals applied to the phase comparator. Thus the phase of the oscillator is locked to that of the input signal and follows any variations in it. As in the circuits described earlier the output of the phase comparator contains the required modulation-frequency component but the output is usually passed through a low-pass filter to suppress any radio-frequency components.

This type of detector has something in common with those described under "phase comparator detectors". Comparison of Fig. 13(a) and 18 shows that in phase-comparator circuits the quadrature input is derived from the other input by use of a phase-shifting network whereas in the phase-locked-loop the second input is derived from the output of the comparator so introducing negative feedback.

The oscillator must be such that its frequency can be readily controlled by a voltage applied to it. It can be a Hartley or Colpitts type in which part of the capacitance of the frequency-determining network is provided by a varactor, the d.c. input to which therefore controls the operating frequency. Alternatively, and this arrangement avoids any need for an LC circuit, the oscillator can be an astable multivibrator, the control voltage being applied to the resistors of the RC circuits which determine the free-running frequency of the oscillator. The phase comparator may have a circuit similar to that shown in Fig. 16.

To conclude this article the classification of f.m. detectors surveyed is summarised in the table above.

* 'Low-distortion f.m. discriminator', *Wireless World*, April 1956.

Classification of f.m. detectors

Type	Example	Self-limiting?
(a) f.m.-to-a.m. converter plus a.m. detector	slope detector Round-Travis detector Seeley-Foster discriminator	no
	ratio detector	yes
(b) phase-comparator	nonode gated-beam tube	yes
	balanced detector symmetrical detector quadrature detector product detector	no
(c) counter discriminator		no
(d) locked-oscillator discriminator	early types	yes
	phase-locked-loop	no

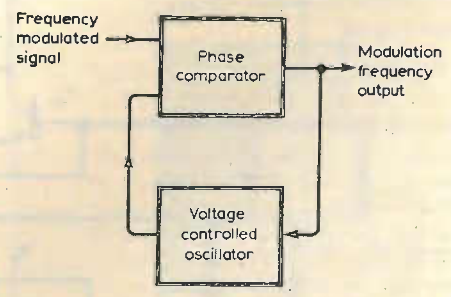


Fig. 18. Phase-locked-loop f.m. detector.

BOOKS

Proceedings have been published in book form of the European Hybrid Microelectronics Conference of 1979, which was held at Ghent in Belgium, to discuss various topical aspects concerning applications and manufacturing techniques. Each of the papers is categorized and slotted into one of eleven sections, the last ten of which are devoted to technical matters related to the production and uses of thin and thick-film components and hybrid circuits.

As one of the intentions of the papers is to advance hybrid microelectronic technology already in existence, the level of background knowledge required to enable full comprehension of the subjects is, of course, high. Illustrations and an occasional photograph supplement the written matter, which seems to consist of direct copies of originals as the type face varies from one paper to another. The print is, however, in all cases clear, the quality of paper used is quite high and random samples indicate that those works written by authors whose native language was not English were not prone to the gross syntax errors which often make works of a scientific or highly technological nature even more difficult to understand.

Not yet mentioned is the first section of the book which is entitled Opening Session and consists of a paper called Economics and Market by E. Effenburger. Included in this paper is an attempt to evaluate the world market for hybrids and resistor networks which, although it constitutes only seven pages of a book of around 560 pages in total, is a rather good assesment of trends in this field. Mr Effenburger concludes his paper by stating "In our opinion the time for film technics is now favourable and the significant growth is yet to come".

With a full title of **Proceedings – European Hybrid Microelectronics Conference 1979**, this book is denominated ISBN 90 6231 068 0 and published in paperback form by the Dutch Efficiency Bureau, P.O. Box 90, Pijnacker, The Netherlands.

Battery-powered instruments

Choosing and using dry batteries, with some suggestions for improving service life

by Ian Hickman

The use of batteries as the power source for small electronic instruments and equipment is often convenient and sometimes essential. The absence of a trailing mains lead (especially when there is no convenient socket into which to plug it) and the freedom from earth loops and other hum problems offset various obvious disadvantages of battery power. When these and other considerations indicate batteries as the appropriate choice, the next choice to be made is between primary and secondary batteries, i.e., between throw-away and rechargeable types.

Rechargeable versus primary batteries

Rechargeable batteries offer considerable economies in running costs, though the initial cost is high. For example, direct comparisons can be made between certain layer-type batteries, e.g. PP3, PP9, and also certain single cells, e.g. AA, C and D size primary cells, where mechanically interchangeable, rechargeable nickel/cadmium batteries and cells are available. These cost about ten to twenty times as much as the corresponding zinc/carbon (Leclanché) dry battery or cell, and as much or more again for a suitable charger. This doubtless accounts for the continued popularity of the common or garden dry battery. Another point to bear in mind is that, contrary to popular belief, the ampère-hour capacity of many nickel/cadmium rechargeable batteries is no greater than (and in the case of multicell types often considerably less than) the corresponding zinc/carbon battery. Nevertheless, where equipment is regularly used for long periods out of reach of the mains, rechargeable batteries are often the only sensible power source – a typical example would be a police walkie-talkie. In other cases the choice is less clear: for instance, an instrument drawing 30 to 35mA at 9V, and which is used on average for four hours per day five days a week, would obtain a life of 100 or more hours from a PP9 type dry battery (to an end point of 6.5V, at 20°C.

Assuming the cost of a PP9-sized, rechargeable nickel/cadmium battery plus charger is 25 times the cost of a PP9 dry battery, it would be two and a quarter years before the continuing cost of dry batteries would exceed the capital costs for the rechargeable battery plus charger. (The effects on the calculation of interest charges on the capital, inflation and the very small cost of mains electricity for recharging have been ignored.)

Using primary batteries

Often, then, the lower initial costs will dictate that a product uses primary batteries, and any measures which can reduce the running costs of equipment so powered must be of interest. When a decision to use primary batteries has been taken, there are still choices to be made, one of which is the choice between layer-type batteries or single cells. Some designers prefer to use a number of individual cells in series to power a piece of equipment, rather than a layer-type battery. The main advantage here is in a wider choice of "battery" voltage by using the appropriate number of cells, although if the usual moulded-plastic battery holders are used, one generally arrives at a voltage obtainable in the layer type.

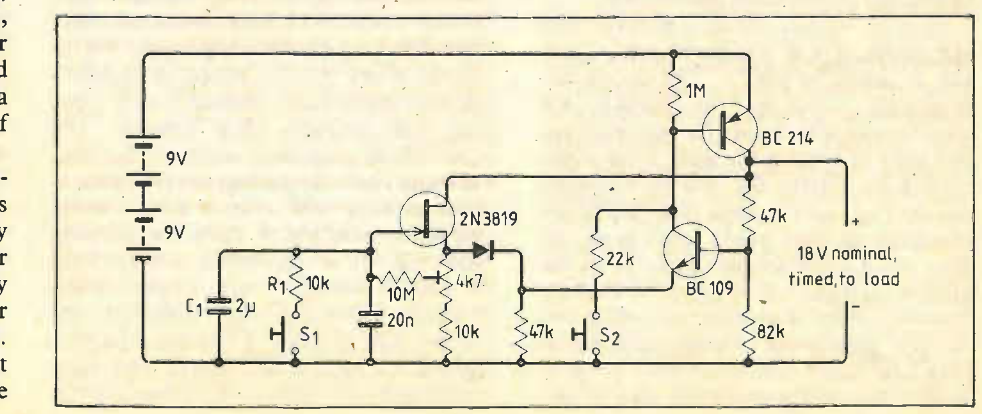
The other advantage of using individual cells is that the user then has the choice of primary cells other than zinc/carbon, such as alkaline batteries. On low to medium drains with an intermittent duty cycle, e.g. radio, torch, calculator, these will give up to twice the life of zinc/carbon batteries. However, they are approximately three times the price and therefore the running cost is greater. With very high current requirements and continuous discharge regimes the ratio of capacity realized (alkaline: zinc/carbon) would be increased.

One of the main disadvantages of batteries is that they frequently prove to be flat just when one needs them. As often as not, this is because the instrument has inadvertently been left switched on. If the batteries are of the zinc/carbon type, they can then deteriorate and the resultant leakage of chemicals can make a very nasty mess. (If the batteries are rechargeable nickel/cadmium types this problem does not arise: modern nickel/cadmium batteries are not damaged by complete exhaustion. However, note that if a nickel/cadmium "battery" is being assembled from individual cells they should all be in the same condition – ideally new – and in the same state of charge. Otherwise, one cell may become exhausted before the rest and thus be subject to damaging "reverse charging".)

A really effective indicator on a battery-powered instrument might prevent this lamentable waste of batteries. However, of the many types of 'on' indicator used, nearly all have proved of very limited effectiveness. One well-known manufacturer uses a rotary on/off switch, the part transparent skirt of the knob exposing fluorescent orange sectors when in the 'on' position, and this is reasonably effective when the front panel is in bright light. Indicator lamps have also been used but usually with intermittent operation to save current. Examples are a blocking oscillator causing a neon lamp to flash, and a flasher circuit driving an l.e.d. Unfortunately, the power that can be saved by flashing a lamp is very limited. The flashing rate cannot be much less than one per second or it may fail to catch one's attention. On the other hand, the eye integrates over about 100ms, so flashes much shorter than this must also be much brighter to give the same visibility. Thus a saving of about ten to one in power (ignoring any "housekeeping" current drawn by the flasher circuit) is about the limit in practice.

The author must have ruined as many batteries as most people by inadvertently leaving equipment switched on when not in use, and decided many years ago that the only effective remedy was to replace

Fig. 1. Ten-minute timer designed by the author in 1969.



the on/off switch by an 'on' push-button. This switches the equipment on and initiates an interval at the end of which the instrument turns itself off again. Clearly, it would be most annoying if just at the wrong moment – say when about to take a reading – the instrument or whatever switched itself off, so the push-button should also, whenever pushed, extend the operation of the instrument to the full period from that instant. One can thus play safe, if in doubt, by pressing the button again, 'just in case'.

The period for which the instrument should stay on is, of course, dependent on its use and the inclination of the designer. However, a very short period – a minute or less – would generally be rather pointless; provided one had one hand free one would be better off with a straightforward "on whilst pressed" button, which is also cheaper and simpler. For many purposes, ten or fifteen minutes is a suitable period, but clearly it is not critical unless the equipment is exceedingly current-hungry. After all, it is being left on overnight (or a week-end) that ruins batteries controlled by an ordinary switch, not the odd half hour or so.

In the late 1960s, when the author first used a ten-minute timer to save batteries, producing such a long delay economically and with little cost in "housekeeping" current was an interesting exercise, especially as monstrously high resistances were ruled out as impractical or at best expensive. So the circuit of Fig. 1 was developed and proved very effective. The preset potentiometer was set to pick off a voltage just slightly positive with respect to the gate of the n-channel depletion f.e.t., so that only a small aiming potential was applied across the 10MΩ resistor to the timing capacitor, C_1. Thus pressing the 'on' button set the complementary latch, turning on the instrument and initiating a bootstrapped ramp at the source of the f.e.t. This eventually turned off the latch and hence the instrument, unless the button were pressed again first, when the capacitor was discharged again via R_1 and the interval updated. This circuit was very effective in saving batteries, although the exact period was rather vague due to variation of the gate bias voltage of the f.e.t. with temperature. Incidentally, the purpose of the 0.02μ capacitor was to enable the preset potentiometer to be set for a 6 second period before the 2μF capacitor was connected in circuit. This made setting up the 600 second period much less tedious.

An even simpler circuit is possible with the advent of v.m.o.s. power f.e.t.s, and this is shown in Fig. 2. The circuit undoubtedly works well in practice, but whilst it might be handy for incorporation in a piece of home-made gear, it has major drawbacks. Firstly, the date sheet maxima for the f.e.t. gate leakage plus that of the tantalum capacitor would result in an 'on' time much less than that predicted by the time-constant of 47μF and 10MΩ. Secondly, there is no clear turn-off point. As the gate/source voltage falls below +2V, the drain resistance rises progressively, gradually starving the load of current rather than switching it off cleanly. This might be handy if you like your transistor radio to fade out gradually while you go to sleep, but it is not generally a useful feature.

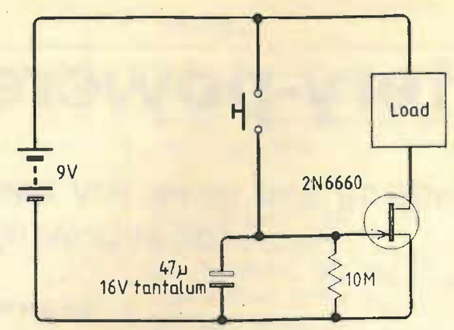


Fig. 2. V.m.o.s. circuit, which is simple but which does not turn off cleanly.

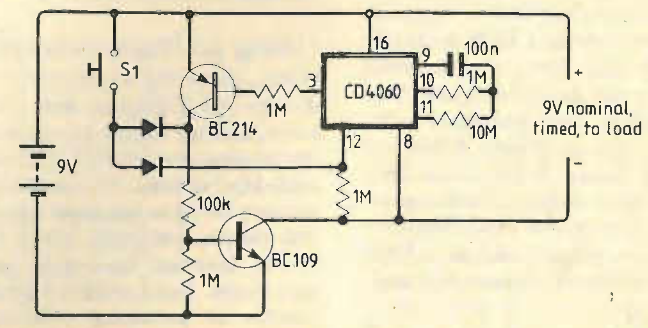


Fig. 3. Delay circuit using an oscillator, followed by a counter. Very long delays can be obtained by this method.

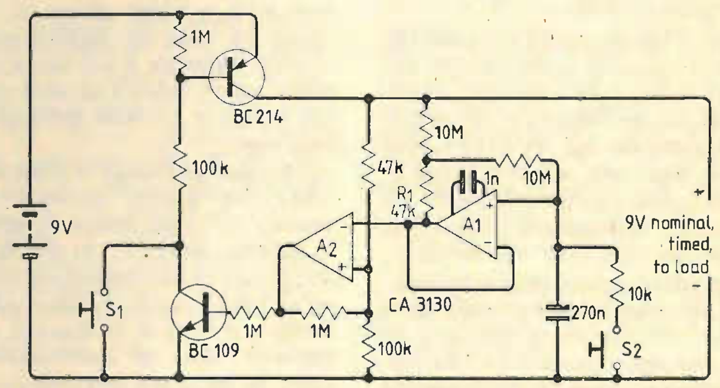


Fig. 4. Analogue delay circuit avoids possibility of interference from oscillator. A_1 and A_2 are CA 3130.

With such a wide choice of integrated circuits it is possible nowadays to obtain long delays much more easily, and one way is simply to count down from an RC oscillator using readily obtainable values of resistance and capacitance. Various timer i.cs are available working on this principle, although for a dry battery powered instrument, where current saving is always a prime consideration, obviously t.t.l. types are less desirable than c.m.o.s. The CD4060, in particular, can form the basis of a timer providing an on interval of up to half an hour with only a 0.1μF timing capacitor, as in Fig. 3. Here, on operating the push button, the complementary latch is set, switching on the output, which starts the CD4060 oscillator with the count at zero. The divide by 2^{14} output at pin 3 is therefore at logic 0, holding the p-n-p transistor and hence also the n-p-n transistor in saturation. On reaching a count of 2^{13}, the output at pin 3 rises to the positive rail, turning off the p-n-p transistor and hence the n-p-n transistor and the output. Clearly, by increasing the timing resistor and capacitor at pins 10 and 9 respectively, delays of many hours could be obtained if required.

Such a timing circuit is reasonably cheap to incorporate in an instrument and requires no setting up. As shown in Fig. 3, it is capable of supplying up to 10mA or more load current; larger load currents simply require the 100kΩ resistor in the base circuit of the BC109C transistor to be reduced in value as appropriate. The circuit will switch off quite reliably, even though an electrolytic capacitor be fitted in parallel with the load to give a low source impedance at a.c. If a d.p.s.t. push button is used, the circuit can be further simplified by the omission of the two diodes.

The small, but nonetheless finite, "housekeeping" current drawn by the circuit of Fig. 3 means of course that whilst 'on', the battery is actually being run down

slightly faster than if an on/off switch were used. However, in practice this is more than offset by the reduced running time of the equipment. Quite apart from inadvertent overnight running, an equipment fitted with an automatic switch-off circuit is usually found to clock up considerably less running hours during the normal working day than one with a manual on/off switch.

With modern i.cs, counting down from an oscillator running at a few Hertz is not the only way of obtaining a long delay with modest values of R and C. Fig. 4 shows an updated version of the bootstrapped timer of Fig. 1, which could be preferable for use in sensitive instruments where interference might be caused by the fast edges of the oscillator in Fig. 3. The analogue delayed switch-off circuit of Fig. 4 achieves the long delay by applying a very much smaller forcing voltage to the 10MΩ timing resistance than the reference voltage at the non-inverting input of A2. With the values and devices shown, no setting up is required as this forcing voltage is still large compared with the maximum offset voltage of the CA3130, A1. For longer delays, the 47kΩ resistor R_1 may be reduced, but it would then be necessary to zero the input offset voltage of A1 for consistent results from unit to unit. This circuit also will switch off reliably with an electrolytic bypass capacitor connected across its output.

Figure 5 shows a useful and inexpensive battery-voltage monitor which may be connected across the output of either of the circuits of Figures 3 and 4. The preset potentiometer can be set so that the front-panel-mounting light-emitting diode illuminates when the supply voltage to the circuit falls below the design minimum, e.g. 6V. The temperature co-efficient of the supply voltage at which the l.e.d. illuminates is approximately −20mV/°C, which is generally acceptable, but this can be considerably reduced, if required, by connecting a germanium diode in series with the lower end of the 22kΩ preset potentiometer. The 47μF capacitor delays the build-up of voltage at the base of Tr_1 on switch-on, causing the l.e.d. to illuminate for a second or so, assuring the user that batteries are fitted to the instrument and are in good condition. If the voltage falls to an unserviceable level whilst the instrument is on, the l.e.d. will illuminate again.

By connecting the monitor circuit across the output of the delayed switch-off circuit, the monitor draws housekeeping current only whilst the instrument is on.

Choosing the battery size

Using one of the above circuits can reduce the average daily running time of an equipment by a useful amount (as well as eliminating overnight run-down), but the question still remains – "which dry battery to use?" Circuit design considerations usually dictate the minimum appropriate supply voltage. If a 6V nominal supply is chosen, a wider choice of capacities is available using four single cells rather than a layer type battery, but for many purposes, an end of life voltage of around 4V is too inconvenient. A 9V battery can provide a more useful end of life voltage, whilst if a higher voltage is required, two layer type batteries in series can be used, 6V or 9V types as required.

To decide what size battery of a given voltage to use, refer to the battery manufacturer's data. Tables 1 to 3 give the total service life in hours to various end voltages (at 20°C) for three different types of layer batteries. The top value PP9 and the ubiquitous PP3 represent the upper and lower capacity ends of the range, whilst the PP6 is one of the three intermediate sizes – PP4, PP6 and PP7 in order of increasing capacity – which, whilst readily available, are not quite so commonly used. It is important to note that the tables give the service life in hours for the stated current at 9V, i.e., for a constant resistance load. Thus the current provided at for example a 6V end point is only two thirds of that in the left-hand column of the table.

The first fact which strikes one is the much greater milliampere-hour capacity of the PP9 than the PP6 and of the PP6 than the PP3, in each case the ratio approaching 6:1. Yet the price differential (by comparison) is tiny. It would therefore appear at first sight that it must always pay to use the PP9, or at least the largest battery capable of being accommodated within the case of equipment. In general this is true, except for an equipment drawing only a very small current and/or receiving only very occasional use. Under these circumstances a large battery would only be partially used before dying of "shelf life", and a smaller cheaper battery would be a more sensible choice. In fact if the current drawn is very small – microamps or up to a milliamp or so – it is worth considering saving the cost of a switch entirely and letting the equipment run continuously. It is in any case good practice to replace a layer type battery every year, regardless of how much or little use it has had, although in a temperate climate they will often remain serviceable much longer than this. In tropical climates routine replacement after 6 to 9 months is recommended.

The circuits of Figs. 3 and 4, when 'on' apply the full battery voltage to the load circuit, except for a 300mV or so drop due to the collector saturation voltage of the series pass transistor. This being so, the load current is likely to be very nearly proportional to the battery terminal voltage, and hence Tables 1 to 3 are directly applicable. (Strangely, this is the exception rather than the rule; more of which later). Thus if a 9V battery is to be used, Tables 1 to 3, plus those for the PP4 and PP7 will indicate the optimum style of battery, bearing in mind the load current, daily running time and acceptable end voltage. Having chosen the battery type, a graph can readily be drawn for the appropriate daily usage to permit interpolation between the current values in the table, giving an accurate estimate of the total serviceable life. Fig. 6 is an example of such a graph, for the PP9 battery at 20°C, with four hours daily usage, to an end point of 6.5V. In the author's experience,

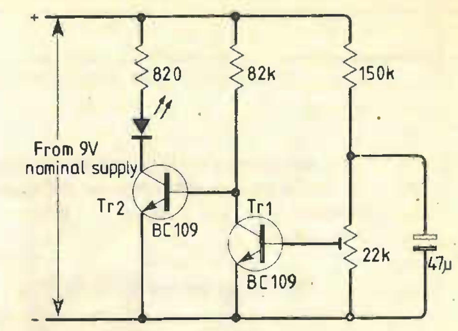


Fig. 5. Low battery-voltage indicator. L.e.d. illuminates when supply falls below designed minimum.

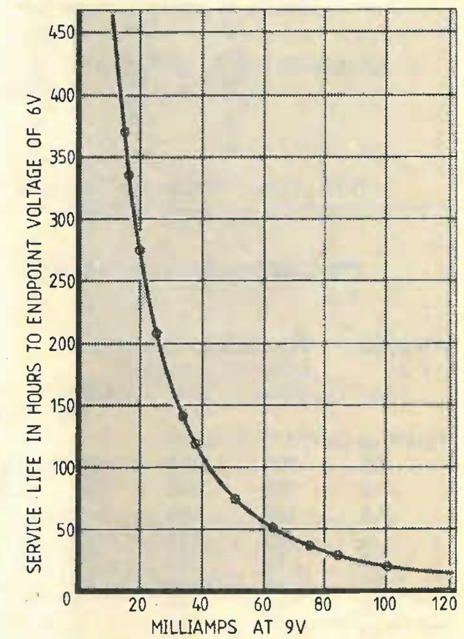


Fig. 6. Service life of PP9 battery, used four hours per day.

the figures quoted in Table 1 are conservative, and although there must be some variation from battery to battery, they can safely be taken as minima rather than typical. This view is confirmed by informal tests which were carried out some years ago by the laboratories of the Finnish PTT in Helsinki.

There is a growing (and welcome) tendency for Japanese and US battery manufacturers to adopt IEC designations for their products rather than using their national or in house codes, and we can expect U.K. manufacturers to follow suit in the next year or two.

A final point about using dry cells is a warning that attempts to recharge them are futile and can be dangerous. Recharging leads to the evolution of gases which the sealed cell cannot vent and the cell constituents cannot recombine. In the case of a layer-type battery, the gas evolved forces the layers apart, resulting in an open circuit battery.

Stabilized supplies

A piece of electronic test or measuring equipment powered by dry batteries is often required to possess a degree of accuracy and stability which can only be obtained by operation from a stabilized

PP3 Estimated Service Life at 20°C

Milliamps at 9.0v	Service life in hours to endpoint voltages of 6.6v	6.0v	5.4v	4.8v
Discharge period 30 mins/day				
10	26	29	32	34
15	17	19	21	23
25	9.2	11	12	13
50	2.3	4.1	5.1	5.8
Discharge period 2 hours/day				
1.5	180	190	200	205
2.5	112	122	132	136
5.0	56	62	68	72
10.0	24	28	31	34
15	14	16	20	22
25	–	7.4	9.5	11

Milliamps at 9.0v	Service life in hours to endpoint voltages of 6.6v	6.0v	5.4v	4.8v
Discharge period 4 hours/day				
1	322	355	395	412
1.5	215	240	260	277
2.5	132	147	162	167
5	63	71	77	82
10	17	23	30	33
15	–	12	17	19
Discharge period 12 hours/day				
0.5	695	750	785	815
1.0	365	390	417	427
1.5	240	262	277	292
2.5	125	152	162	170
5.0	44	54	62	72
7.5	18	22	29	36

Note: Also available are the higher capacity PP3P for miniature dictation machines etc. and the PP3C for calculator service.

PP6 Estimated Service Life at 20°C

Milliamps at 9.0v	Service life in hours to endpoint voltage of 6.6v	6.0v	5.4v	4.8v
Discharge period 4 hours/day				
2.5	492	517	535	545
5.0	240	270	287	302
7.5	142	166	173	194
10	93	111	124	137
15	51	63	73	81
20	33	42	49	55
25	23	30	35	40
50	–	7.8	10	12
Discharge period 12 hours/day				
0.75	2075	2200	2325	2400
1.0	1510	1650	1760	1815
1.5	965	1080	1155	1200
2.5	532	620	635	690
5.0	214	263	202	312
7.5	117	147	109	187
10	75	97	111	127
15	38	50	59	69
25	16	21	25	31
Discharge period 30 mins/day				
50	15	19	22	24
75	0.6	10	12	14
100	25	6.2	7.8	9.1
150	–	2.3	3.5	4.4
Discharge period 2 hours/day				
7.5	169	194	205	215
10	117	140	151	161
15	67	83	93	99
25	31	38	45	48
50	8.9	12	14	16

PP9 Estimated Service Life at 20°C

Milliamps at 9.0v	Service life in hours to endpoint voltages of 6.6v	6.0v	5.4v	4.8v
Discharge period 30 mins/day				
125	24	35	40	44
150	16	28	33	37
166.67	12	23	29	33
187.5	7.8	19	24	28
250	1.9	9.3	16	19
Discharge period 2 hours/day				
25	193	233	269	286
33.3	150	180	209	223
37.5	122	147	168	180
50	81	99	113	124
62.5	57	71	82	92
75	41	53	62	69
83.33	33	45	53	60
100	20	32	39	44
125	9.8	19	25	29
150	6.1	13	17	20
Discharge period 4 hours/day				
15	332	370	409	437
16.67	291	336	367	394
18.75	266	294	324	349
20	235	273	304	328
25	180	208	234	251
33.33	115	141	158	176
37.5	96	118	134	148
50	59	75	90	101
62.5	37	51	63	72
75	25	35	46	54
83.33	19	30	38	44
100	12	20	27	31
Discharge period 12 hours/day				
15	292	340	379	407
16.67	254	294	321	352
25	127	151	178	206
33.33	73	89	105	134
37.5	58	71	86	110
50	30	40	47	65
62.5	17	24	30	42

supply voltage. The current drawn by the instrument at the stabilized voltage is then usually constant, and the data in the tables is thus no longer appropriate. The bulb of a flash lamp likewise tends to be a constant current load, due to its high temperature coefficient of resistance – remember the barretter? On the other hand, the motor of a battery-powered turntable or tape transport with a mechanical or electronic governor tends to draw a constant power, so that the current drawn actually rises as the battery terminal voltage falls. In theory, one could design a switching regulator for the stabilizer of our piece of electronic equipment, so that the current drawn from fresh batteries was actually less than that consumed at the stabilized voltage, rising to the same current as the battery terminal voltage fell to nearer the stabilized voltage.

In practice, for a stabilized voltage of two thirds of the nominal battery voltage, e.g. 12V for two PP9s in series, the efficiency of a conventional stabilizer is almost 66% if the housekeeping current is low, rising to well over 90% at end of life battery voltage. This can be held to less than 12.5V, i.e. an end point of barely over 1.0V per cell. The average efficiency of energy usage over the life of the battery is thus over 80%, a figure it would be difficult to better economically with a switching regulator, which would also need careful suppression if used in a sensitive measuring instrument. Thus a supply stabilizer for a dry battery operated instrument is likely to be of the conventional series type and the battery current drawn is virtually constant. To estimate the service life of the battery therefore, tables such as Tables 1 to 3 cannot be used directly, and the following method should be used.

For an initial battery voltage E_1, an end-of-life voltage E_2 and a constant current I, the initial load resistance $R_1=E_1/I$, and end-of-life load resistance $R_2=E_2/I$. The effective load resistance R_e is defined as $R_e=(R_1+R_2)/2$ and Fig. 6 gives battery life, taking $I_e=E_1/R_e$.

Since $I_e=2E_1I/E_1+E_2$, the end-of-life voltage is 1V and initial battery voltage is 1.5V, $I_e=1.2I$.

An automatic delayed switch-off is just as desirable in a battery-powered instrument incorporating a stabilizer as in one using the 'raw' battery voltage. The circuit of Fig. 3 incorporates a couple of transistors, and it would be elegant and economical to make these function also as the stabilizer circuit. This can be done with just a few extra components, as Fig. 7 shows. Whereas the positive-feedback loop of the complementary latch in Fig. 3 is completed only via the CD4060 pin 3 output, that in Fig. 7 is completed independently of the i.c. When the zener diode is not conducting, loop feedback is positive and one of the two stable states is with both transistors cut off. Once either transistor starts to conduct, the collector voltage of the BC 109 will fall rapidly until the zener diode conducts, at which point the loop feedback changes from positive to negative and a stable 'on' condition is established. This persists until a count of

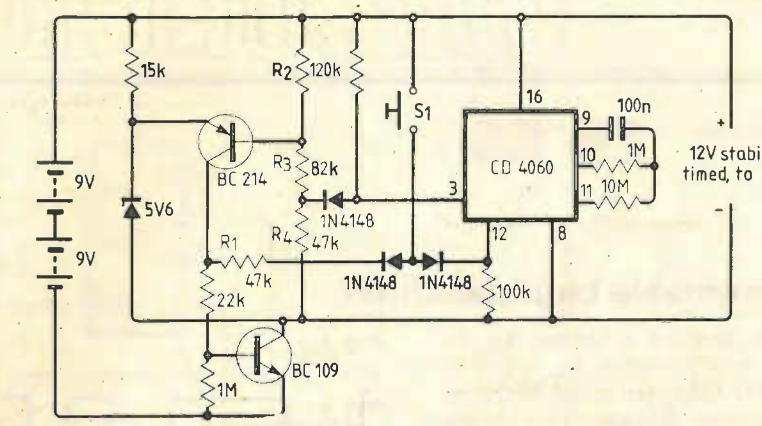


Fig. 7. Circuit of Fig. 3, modified to act as stabilizer.

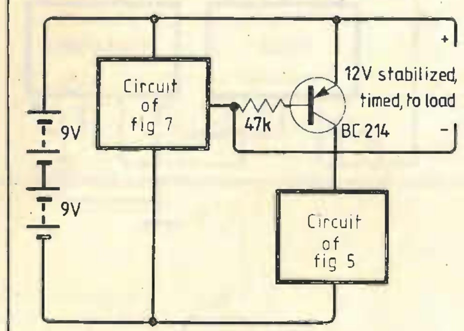


Fig. 8. Use of a low-voltage indicator with a stabilizer.

2^{13} is reached, when the output at pin 3 of the CD4060 rises to the positive rail, switching off the p-n-p transistor via the diode. The n-p-n device therefore also cuts off and the 'on' period terminates. The 10kΩ resistor at pin 3 of the i.c. is necessary to guarantee the switch-off of the BC214, since the p-channel output device in the CD4060 cannot achieve this unaided when the voltage between pins 8 and 16 falls to a low value.

With the circuit as shown in Fig. 7, i.e. no load connected, the output voltage will equal the battery voltage whilst the 'on' push button is closed. This applies equally at switch-on and when updating the 'on' period. However, for any completed instrument design, once the load current is known, it is a simple matter to calculate an appropriate value for R_1 which will reliably initiate the circuit without exceeding the designed stabilized voltage. In practice also one would provide a preset potentiometer as part of the R_2, R_3, R_4 chain to allow adjustment of the voltage at the base of the BC214. This will enable the stabilized output voltage to be set to, say, −12V exactly, despite the selection tolerance of the zener diode.

As the analogue delayed turn-off circuit of Fig. 4 also includes a p-n-p and an n-p-n transistor, it should be a fairly simple matter to turn these into a stabilizer along the lines of Fig. 7, though with inverted polarity of course. Such an analogue timed stabilizer could be useful where the instrument it powers might be troubled by the switching edges of the oscillator in Fig. 7. The battery voltage monitor of Fig. 5 obviously cannot usefully be connected across the output of a stabilizer, nor, although its housekeeping current is only a fraction of a milliamp, would one want to leave it permanently connected across the battery. Fig. 8 shows how it can be adapted for use with the stabilized delayed switch-off circuit of Fig. 7. The 22kΩ potentiometer would, of course, be set to indicate a battery end voltage of 12.5V.

Tables 1-3 are reproduced by kind permission of the Ever Ready Company (Great Britain) Ltd. This company operates internationally under the trade name "BEREC" and has no connection with Union Carbide, which uses the trade mark "Eveready". □

Amateur radio and illegal c.b.

Police investigation of illegal 27MHz "citizens' band" activities continues to include the stopping of vehicles carrying unusual-looking aerials, sometimes resulting in radio amateurs experiencing considerable difficulty in proving that their transmitters are legal. Since amateur licences are not computerised, immediate confirmation cannot be obtained through the police data networks, although it seems likely that this information will in time be stored on a Home Office computer and thus become part of the amateur's "electronic dossier".

CIRCUIT IDEAS

Programmable bandpass filter

This design simulates a resistor, R_{eq}, by switching a small capacitor, C_u, at a clock rate f_r in the frequency range 50kHz to 500kHz. The size of the equivalent resistor is $1/f_rC_u$, and a multivibrator circuit for simulating R_{eq} is shown in Fig. 1. The s.p.s.t. analogue switch can be replaced by a dual switch, type TL 191 CN. Clock frequency is set by the RC networks to, say, 100kHz and this circuit replaces resistors R_{F1} and R_{F2} in Fig. 2. Centre frequency of the filter, f_0, is $1{,}592.10^8/R_F = 1{,}595.10^8 f_rC_u$ assuming $R_{F1} = R_{F2} = 1/f_rC_u$. Under this condition Q depends on R_4, R_G and R_Q. Gain, A_{BP}, for the pass band is $5.10^4/R_G$, so $R_G = 5.10^4/A_{BP}$, and $R_Q = 5.10^4/(2Q - 1 - A_{BP})$.

Fig. 3. shows an example of a four-pole Butterworth or Chebyschev band-pass filter where Q_{BP} is 25, f_c is 1.5 kHz and A_{BP} is unity.

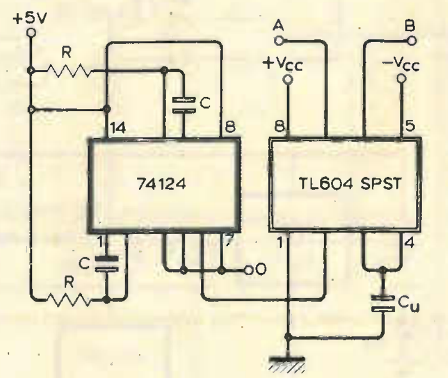
Computed values for Fig. 3.

	Butterworth	Chebyschev
f_{n1}	1.01424	1.02028
f_{n2}	0.98596	0.98012
Q_1	35.36850	35.08733
Q_2	35.36052	35.07999
$C_{u1}=C_{u2}$	95.6pF	96.1pF
$C_{u3}=C_{u4}$	93pF	92.3pF
R_G	50kΩ	50kΩ
R_Q	1040Ω	1040Ω

Operation of the band-pass is corrected by slight variation of the clock frequency f_r.

K. Kraus
Ejpovice
Czechoslovakia

Fig. 1



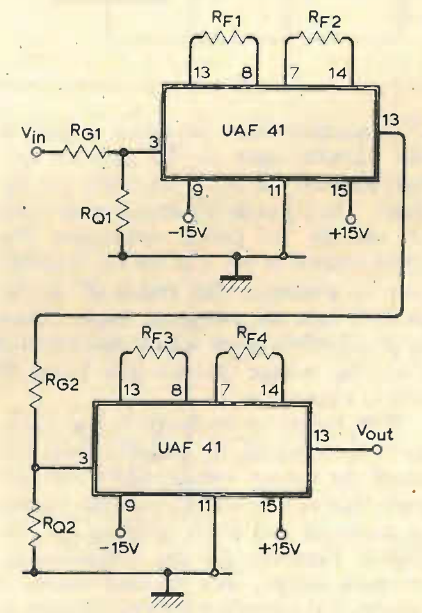
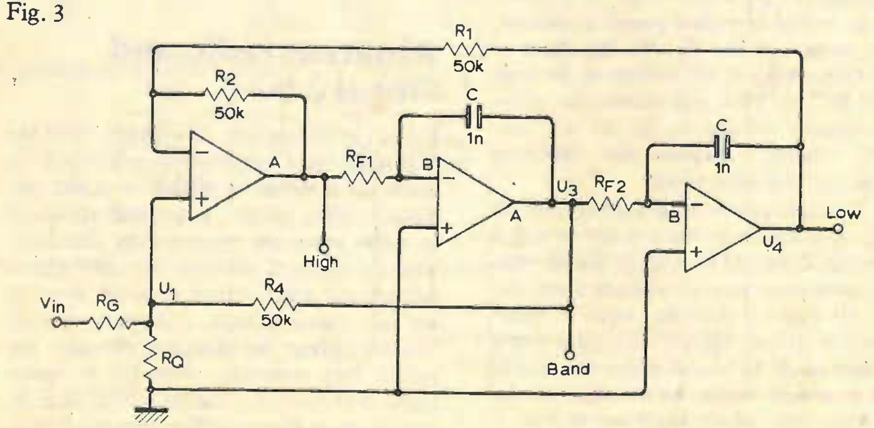


Fig. 2

Fig. 3



Improved audio-visual circuit

Where several locations or sub-systems are monitored, for example in an alarm system, it is common to have an audible alarm, which is activated if a monitor point is triggered, and an array of visual indicators to show the particular location(s) involved. Since the audible alarm has a large number of inputs, this system can be costly in terms of wiring and connectors.

A simpler solution is to use the l.e.ds as an OR gate, with the output as a current to ground which can be detected by a current mirror. Because the current can become reasonably high, Tr_1 must be a medium-power type. Although this unbalances the current mirror, linearity is not important in this switching application. The final design used a p-n-p switch as an active pull-up. With this arrangement only one input connection is required for the audible alarm.

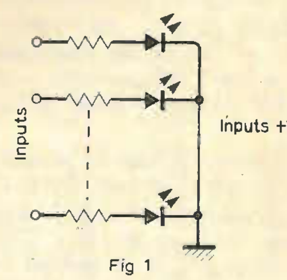
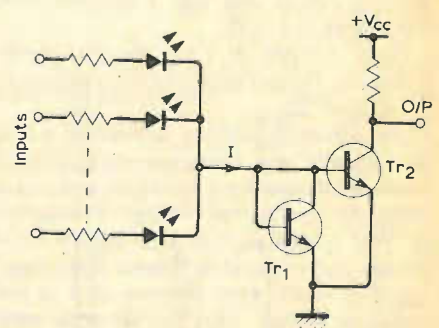


Fig 1



The mirror can also be used in an analogue mode for current to voltage conversion where the output represents the number of l.e.ds turned on. The output can either cover all possible states, or Tr_2 can saturate with, say, four or more l.e.ds and operate an extra alarm when a pre-set number of faults require attention. Note that ac inputs and indicators can be used if a diode is connected across the base-emitter of Tr_1, and Tr_2 output is taken through a retriggerable monostable.

T. M. Forcer
Southampton

Ringing-tone generator

A reasonable approximation to the standard telephone ringing tone can be achieved with two i.cs and two transistors. A c.m.o.s. oscillator/binary divider generates both the tone and the gating signals so, in the quiescent state, only c.m.o.s. current and transistor leakage current is drawn. The output-stage values are appropriate for a V_{DD} of 10V and a low voltage supply of 4V. Resistor R_1 gives a f.m. warble on the tone and can be omitted if this is not required.

T. Williams
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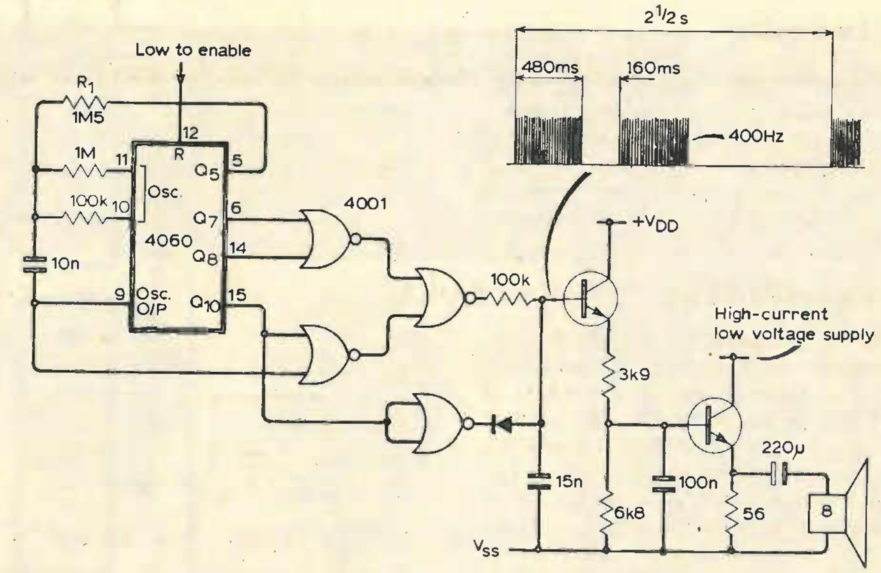
Kent



Wide-range p.p.m.

By using the exponential conduction characteristic of a silicon diode, a l.e.d. bar or moving-dot display of audio level over a range of 40dB can be achieved.

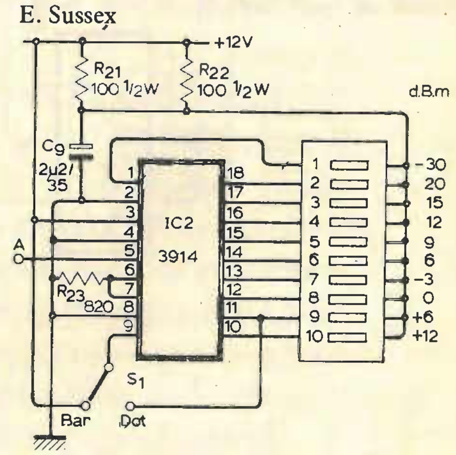
The collector load of Tr_1 is bootstrapped by Tr_2 and C_4 to produce a near constant-current drive to D_1 and D_2. The clipped signal is then amplified to drive a rectifier transformer, and Tr_5 maintains a constant current through the rectifier bias diode D_3. Capacitor C_8 and R_{14} determine the rectifier discharge time-constant, and IC_1 buffers the output. The l.e.d. driver, IC_2, supplies 15mA through the display diodes, and R_{21}, R_{22} limit the dissipation of IC_2 during large input signals.

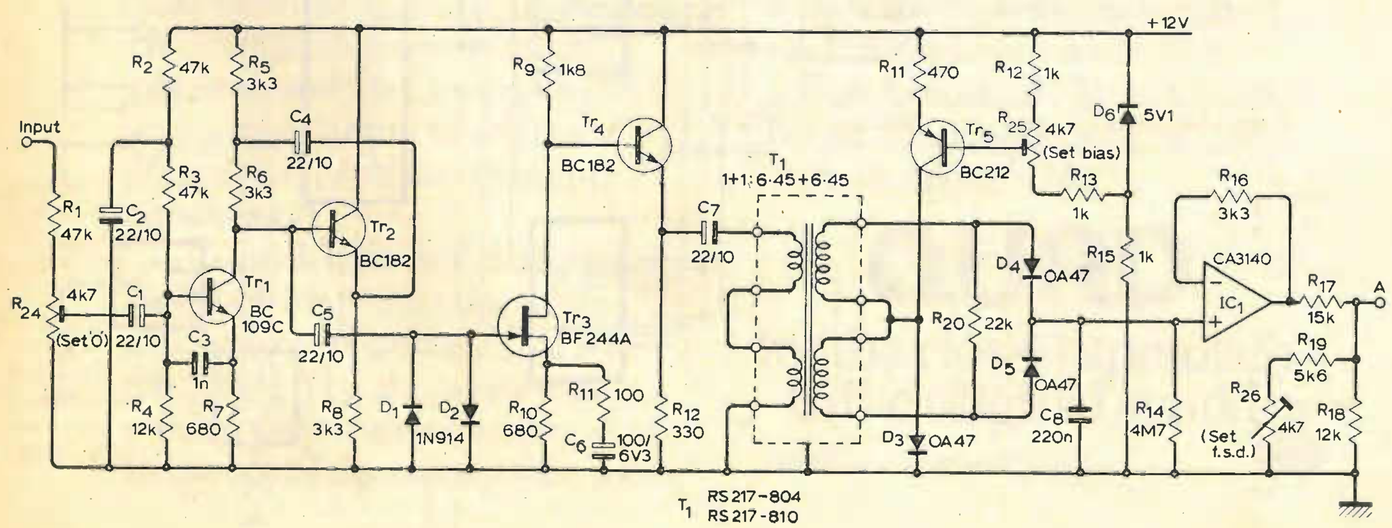
To adjust the circuit, set R_{24} for maximum input, R_{25} to the mid-position and R_{26} to maximum resistance. Apply 12V and feed a 1kHz signal of at least +12dBm to the input. All of the l.e.ds should turn on. Reduce the input to 0dBm and adjust R_{24} until l.e.d. 8 is just extinguished. Increase the input to +12dBm and adjust R_{26} until l.e.d. 10 is just on. Repeat the last two adjustments as necessary. Reduce the input to −30dBm and adjust R_{25} until l.e.d. is just on. Re-adjust R_{24} and R_{26} if necessary.

The calibration should now be within 1dB over the range 80Hz to 15kHz. The lower sensitivity limit can be extended by connecting a 33Ω resistor in series with D_3. R_{25} can then be adjusted so that l.e.d. 1 turns on with an input of −55dBm, but the scale below l.e.d. 8 will need to be recalibrated.

The circuit is fairly sensitive to temperature variations, due to the characteristics of D_1 and D_2, but it is nevertheless useful in studios and other controlled environments.

N. McLeod
Hove
E. Sussex





Gate tester

Fig. 1 tests quad dual-input type gates by comparing the logic operations of a reference i.c. with the device under test. Input signals are provided by a square-wave generator and divider.

Two alternative circuits are shown for testing 3-input and 4-input gates, using the same output arrangement.

K. Wright
Colchester
Essex

Fig. 1

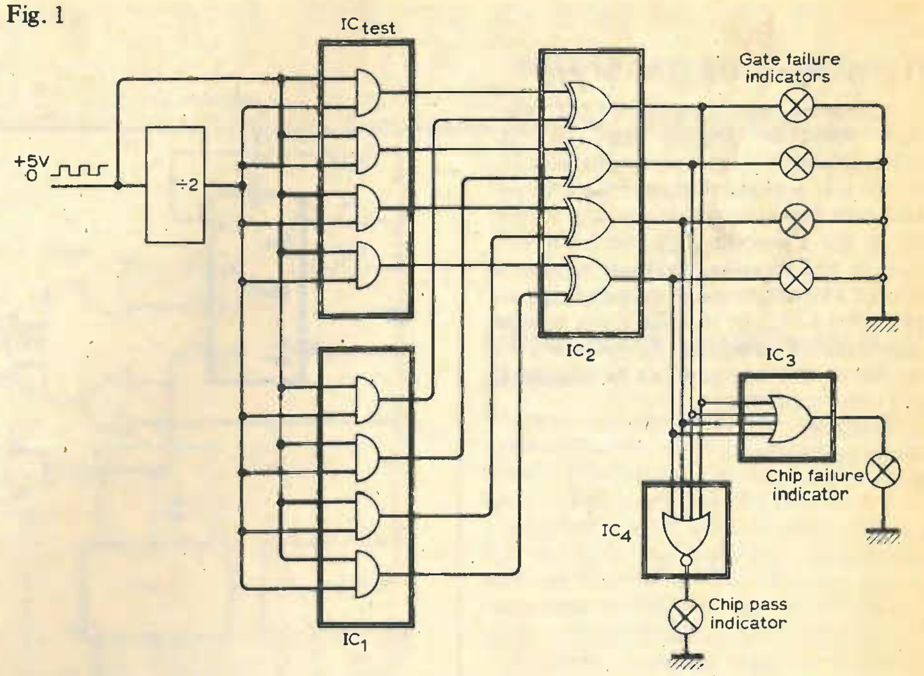


Fig. 2

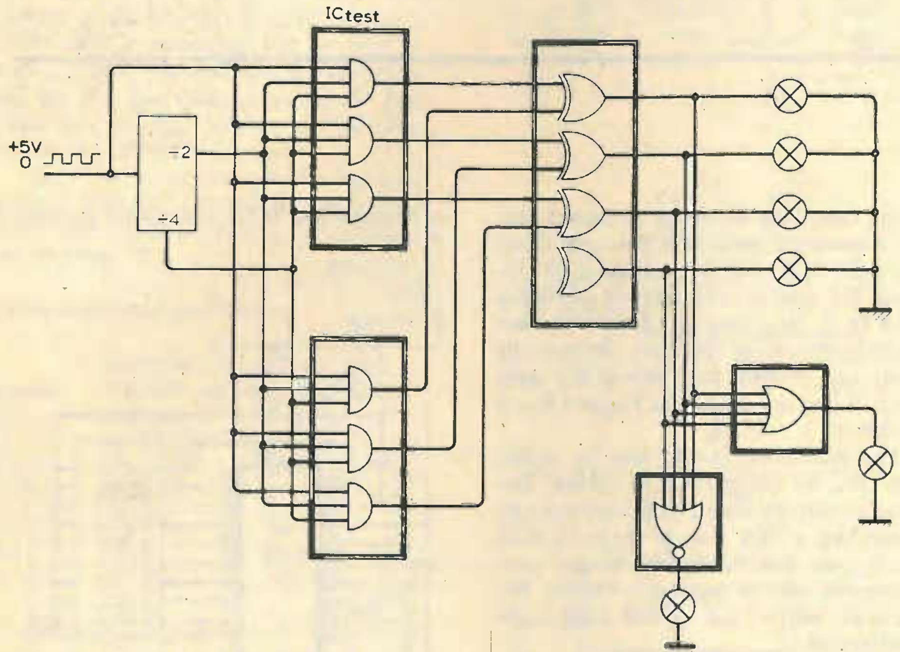
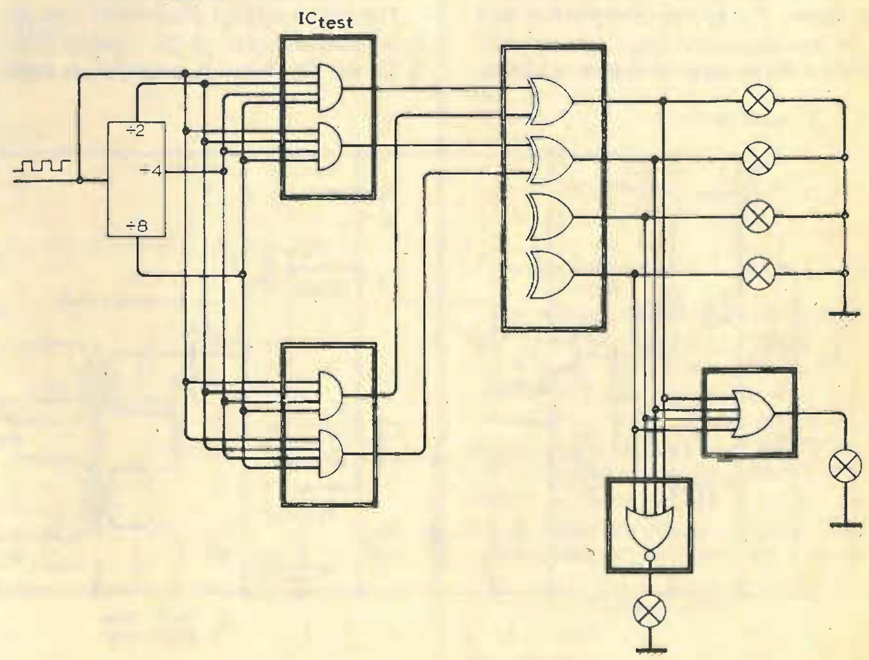


Fig. 3



Interfacing microprocessor systems

The control of industrial plant and simulator circuits

by P. Jackson and S. O. Newstead

Several microprocessor systems are available, either in kit form or assembled, which can be adapted to control plant. These systems are usually modified desk-top computers with connections to additional memory devices.

Although many training establishments purchase such systems to teach programming, interfacing the microprocessor is not always tackled. This article outlines the design principles required for interface circuits and describes a simple boiler simulator suitable for microprocessor control.

Interfacing circuits for plant control should enable a microprocessor to read an 8-bit digital number, operate an a-to-d convertor and read the output, switch external devices on and off independently, and output an 8-bit digital number. The first function is useful when several pieces of equipment are monitored. For example, when raising steam an oil-fired industrial heating boiler must have a flame, an induced draught fan and a forced draught fan in continuous operation. A sensor on each fan and a sensor on the flame, whose outputs are converted to logic levels, can be read as the three l.s.bs of an 8-bit number with the remaining bits connected to ground.

A subroutine which deals with this monitoring process can be written as follows,

```
SUBROUTINE NO. 1010
1000 RETURN
1010 READ 27,A
1020 IF A=7 GOTO 1000
1030 IF A=0 PRINT "ALL SYSTEMS
     FAIL"
1040 IF A=1 PRINT "F.D. & FLAME
     FAIL"
.
.
1100 WRITE 30.1
1110 GOTO 600
```

The digital number is read into the microprocessor and stored in memory location A. The circuit which responds to instruction 1010 is discussed later. If the plant is operating correctly, the program leaves the subroutine. However, if there is a fault it is displayed on the v.d.u., instruction 1100 switches on an audible warning and the plant closes down. Instruction 600 is assumed to be the start of the closing down routine. A program stop can be included in this routine as follows,

```
.
.
650 IF A=7 GOTO 670
660 STOP
670
.
.
```

Therefore, a healthy system can be temporarily closed down, and a faulty system closed down permanently. The second function is useful whenever an analogue transducer is used. For example, pressure, temperature, acidity, rate of flow or position measuring devices. The program must be held until the a-to-d converter has completed its task. If the converter uses a counter and a comparator, the time for the converter to operate is proportional to the magnitude of the analogue signal. The status strobe from the converter is therefore

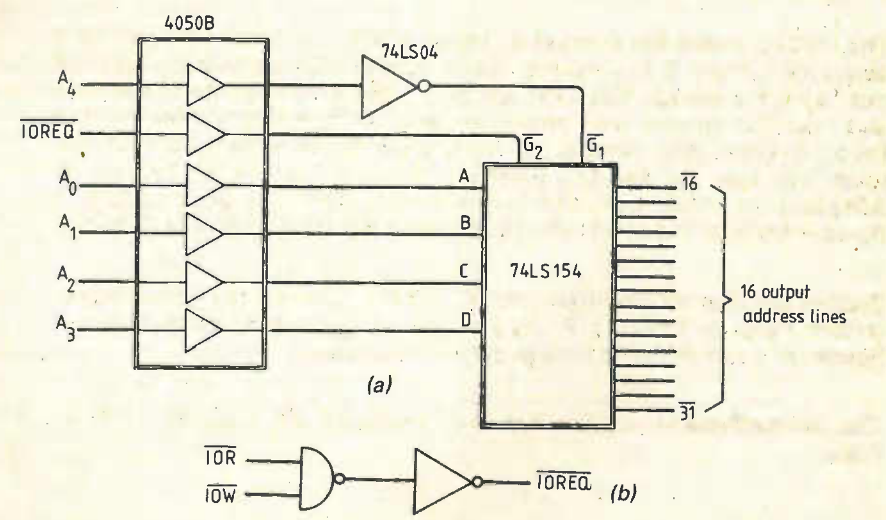


Fig. 1 (a). 16-address demultiplexer. If ports 8 to 15 are required, use 74LS138 in place of 74LS154. Control signals from a microprocessor system may be RD and WD to distinguish between read and write, with IOREQ and MREQ to distinguish between input/output ports and memory. Alternatively, they can be IOR and IOW with MR and MW. In this case IOREQ can be achieved as shown in (b).

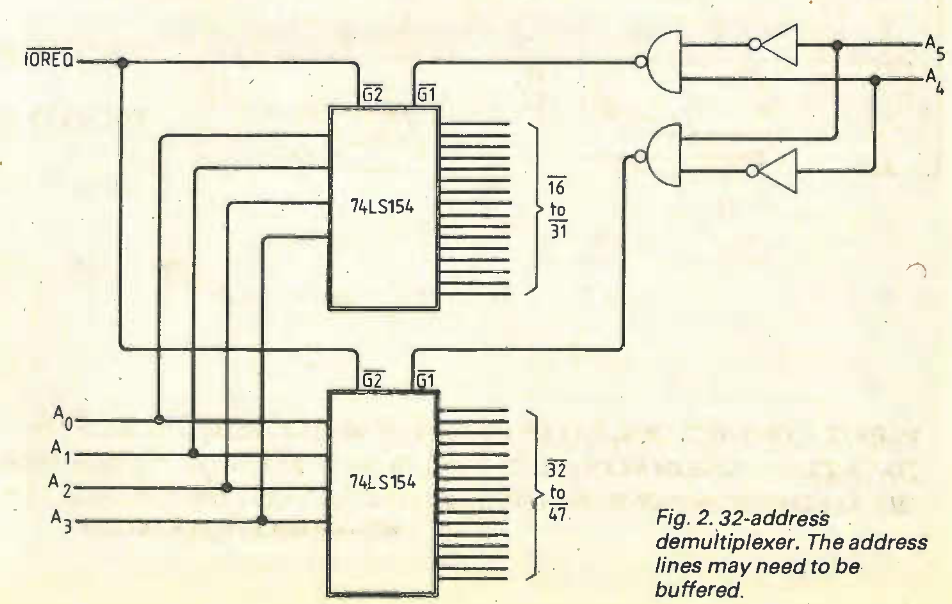


Fig. 2. 32-address demultiplexer. The address lines may need to be buffered.

used to hold the program.

The third function, switching external devices on and off, is the control of the plant by the processor. The final function, which gives an 8-bit digital number as an output on eight lines, can be used when variable control signals are needed. A programmable power supply in automatic test equipment could be controlled in this way.

When designing interface circuits, the signals available from the c.p.u. must be considered together with the system it is connected to and the plant to be controlled. Some of the pins on the c.p.u. are fully buffered and will drive 74LS logic, others are unbuffered and will drive c.m.o.s. As the interface circuits will probably contain a mixture of 74LS and 74 gates, control signals from the microprocessor must be buffered, and a c.m.o.s. 4050B provides six buffers at a reasonable cost. If the microprocessor contains a large memory, c.m.o.s. buffers may be needed between address, data and control busbars and the interface devices which load them, but this is a matter of judgement.

Some microprocessor systems already contain ports, and the process to be described assumes that these exist but additional ports are needed. The ports which are added to the microprocessor, and through which the four functions listed previously are carried out, need to be addressed. Microprocessors have 8, 12 or, more usually, 16 address lines which form the address bus. These are normally fully buffered to cope with the complete memory, 64K for 16 address lines. For port use, the eight least significant lines A0 to A7 are available together with the input/output read ($\overline{\text{IOR}}$) and input/output write ($\overline{\text{IOW}}$) control signals. The control signals are used when read and write instructions are reached in a programme.

Although machine code can be used to fetch data from a port or to output data to another port, because it is generally easier to work in a high-level language, the examples given here are in BASIC.

A system as purchased may contain some ports which use addresses 0 to, say, 7. Additional ports for plant control can therefore be numbered 8 to 255, using A0 to A7. To obtain 16 extra ports use Fig. 1, or Fig. 2 for 32. C.m.o.s. buffers have been included but it may be possible to use 74LS154 devices and omit the buffers. To read an 8-digit number, connect the eight lines which carry the number to the inputs of the tristate buffer in Fig. 3. An instruction such as 30 READ 26, B will cause address lines A1, A3 and A4 to go high, and when the $\overline{\text{IOREQ}}$ pulse reaches the demultiplexer in Fig 1, line 26 will go low. The other demultiplexer outputs remain high.

While the $\overline{\text{IOREQ}}$ pulse is present, the $\overline{\text{RD}}$ pulse is received by the tristate buffer in Fig. 3. This pulse, together with address 26, opens the buffer and connects the input signal to the data bus. During the $\overline{\text{RD}}$ pulse the buffer in the c.p.u. opens and closes to load the number on the data bus into a register. Several tristate buffers can be connected to the data bus and selected in turn by each address. If the input to one of these buffers is obtained from an a-to-d converter, three instructions may be used. The first instruction produces a pulse which sets the converter counter to zero and starts the count. At the same time, the c.p.u. is set to a Hold mode, which prevents it from advancing in the program until the wait signal is removed. The wait signal is held by the status signal from the a-to-d converter. The second instruction reads data into the c.p.u., and the third instruction resets the latch set by the first instruction. Typical instructions to read an analogue signal from address 20 and to store it in the memory at location Q are,

80 WRITE 19,1
90 READ 20,Q
100 WRITE 19,0

where 19 is the address of the latch which starts the converter. In this example, which uses the circuit in Fig. 4, the least significant data line is coupled with address line 19 to operate the latch in two ways. If this is not done, two address lines must be used, which makes the data quoted in the write instruction irrelevant. This method is advantageous when surplus address lines are available.

External devices may be switched by latches with different addresses as shown in Fig. 4, or eight latches with the same address, connected to D0-D7, can output an 8-bit number. These can also be viewed as eight separate switchable lines. If reed relays are driven by the 74 logic which makes up the interface system, it is possible to control many types of plant.

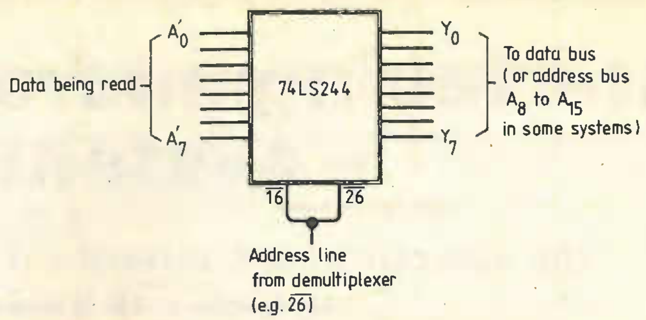


Fig. 3. 8-bit number input using a tristate buffer. In some systems ports are addressed on address lines A0 to A7 and data is transmitted on data lines D0 to D7. Other systems reserve data lines for memory data and use address lines A8 to A15 as data lines when ports are addressed by A0 to A7. This should be checked in the c.p.u. manual.

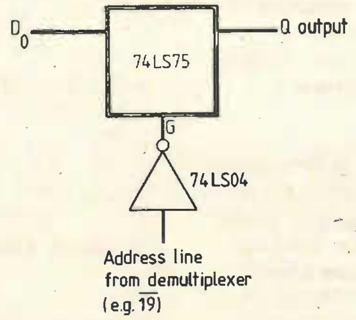


Fig. 4. Output latch. Q is set to D0 when the $\overline{\text{IOREQ}}$ pulse strobes the address demultiplexer. An 8-bit number can be latched into an output port by using eight latches fed from D0 to D7, and connecting the G pins in parallel.

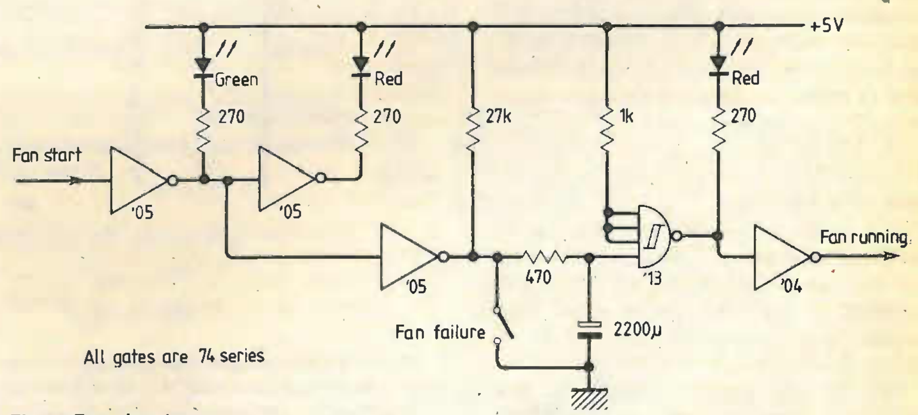


Fig. 5. Fan simulator.

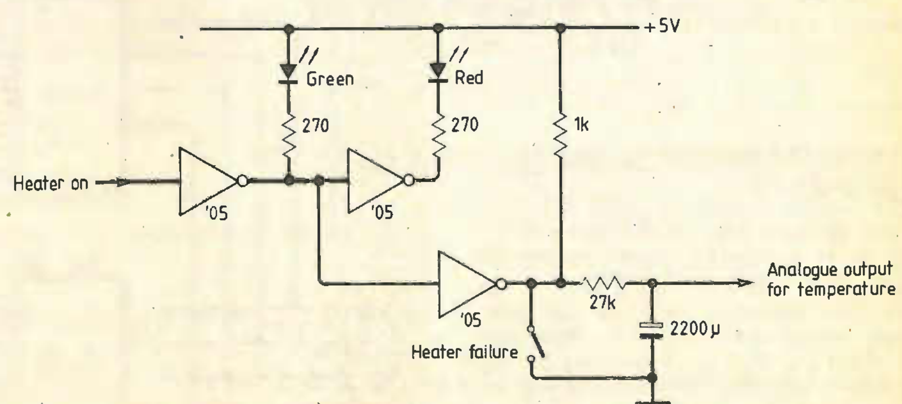


Fig. 6. Fuel heater and temperature sensor.

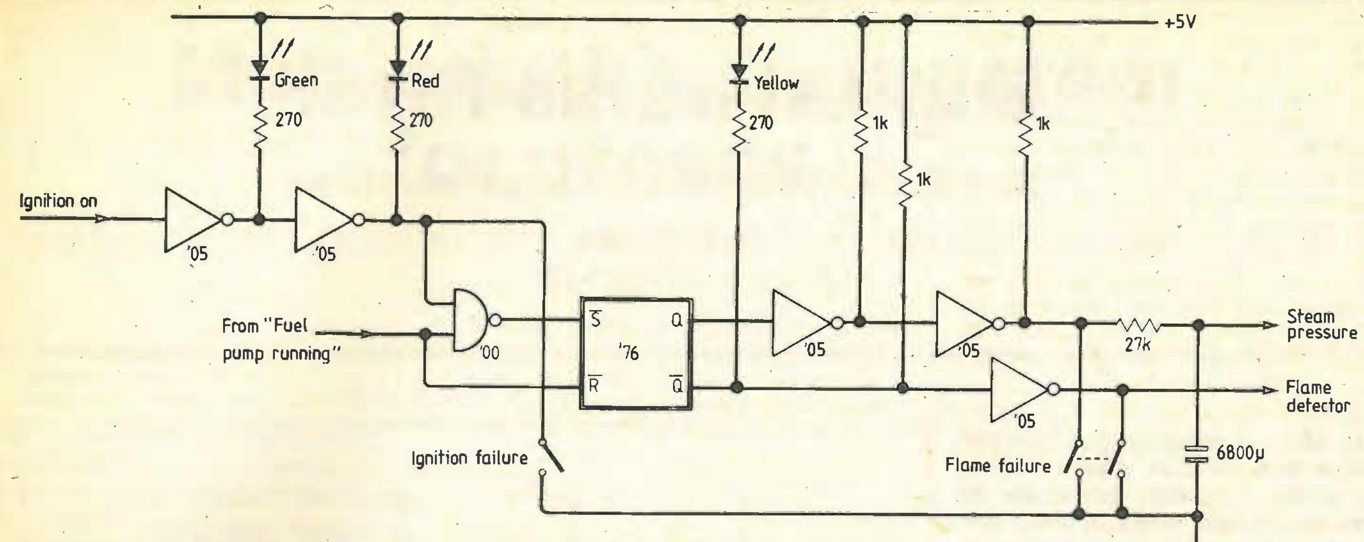


Fig. 7. Ignition and steam pressure.

An oil-fired boiler simulator for microprocessor control

This simple model illustrates sequential switching of equipment, monitoring of the plant by reading a digital number and taking appropriate action, reading of an analogue number via an a-to-d converter and taking action based upon its value, use of a software time delay after switching a device on and then verifying that the device is operating, printing pressure and temperature at predetermined intervals and, in the event of major failure within the plant, closing down and locking out the plant followed by a print out of the failures and an audible alarm.

The boiler simulator comprises an induced draught fan and forced draught fan. When the starters are switched on, these fans gradually run up to speed so the fan-running signal is subject to a delay. When the boiler is started, the fans must run for a while to purge the furnace before fuel is sprayed in.

A fuel pump, which must not be switched on unless the furnace has been purged, the fuel has been heated above the minimum temperature and the ignition has been switched on.

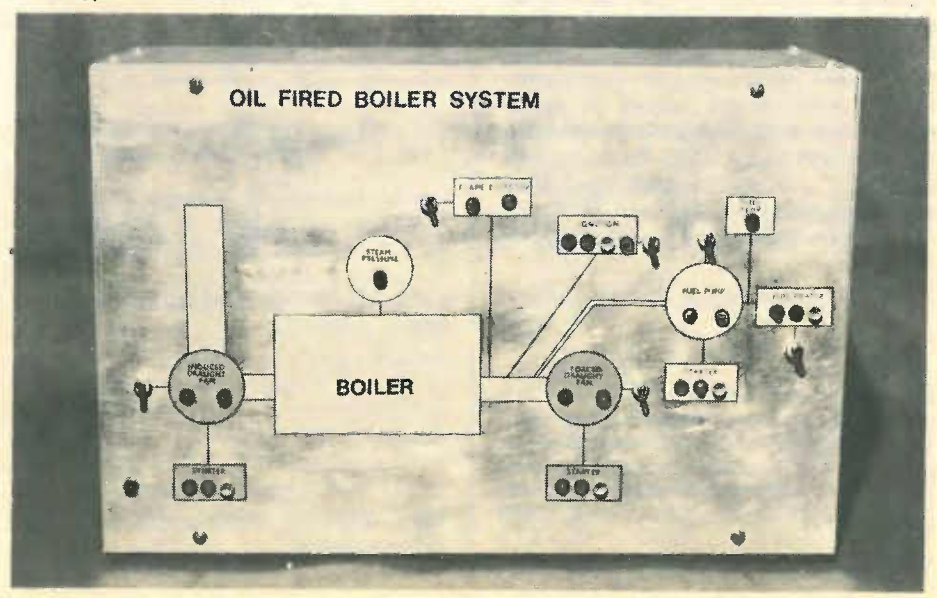
A flame detector. The flame must appear a short time after the fuel pump has been switched on and, if it does not appear, the boiler must be shut down. The microprocessor can be programmed so that a flame failure stops the fuel pump, purges the furnace and attempts to ignite the boiler again.

A fuel heater. This is easily switched on, but a check can be made by measuring the fuel temperature, switching on the heater, introducing a software delay, measuring the fuel temperature again and checking that the temperature has risen.

The logic, is 74 series throughout, does not provide latches in the simulator because they are part of the output ports of the microprocessor system. A logic 1 applied to the fan start input of Fig. 5 switches the starter l.e.ds from red to green. After a short delay the red l.e.d., which indicates that the fan has run up to speed, turns on and a logic 1 appears at the fan-running terminal. The delay must be allowed for by the software. This circuit can be used for both fans and for the fuel pump with a smaller capacitor to simulate the faster response. If the fan-failure switch is closed, the starter will operate but the fan will not run up to speed.

The a-to-d converter in Fig. 6 gives an output proportional to the fuel temperature. This output is between 00 and FF (0 and 255) and can be displayed as °C without scaling. Once the oil is alight, the ignition can be switched off. If the fuel pump stops, however, the flame will go out. Flame failure and ignition failure can be manually introduced at any time as shown in Fig. 7 and the program should cater for these eventualities.

Prototype boiler simulator



Digital noise filter

Simple design suitable for electronic clocks

by P. A. F. Lam

Although l.s.i. techniques and mass production have produced reliable low cost digital clocks, the logic circuits are still susceptible to false triggering pulses from electrical noise and switching transients. A common solution to this problem is the addition of a carefully designed low-pass filter, but, in some applications, this does not always remove the problem. A more effective solution is the addition of a simple digital noise filter which can eliminate over 90% of all false trigger pulses.

A typical digital clock arrangement is shown in Fig. 1(a) and a modified circuit is illustrated in Fig. 1(b). The filter is based on a non-retriggerable monostable, shown in Fig. 2, whose time constant must be smaller than the period of the incoming pulses in Fig. 3. In most clocks i.cs, the time reference is derived from the mains frequency, therefore, $T = 1/50s$ and $t<1/50s$. Because the monostable is non-triggerable, the clock is immune to noise which occurs during the t period in Fig. 4. If a false pulse appears in the T-t region, the monostable is triggered but the next correct trigger pulse occurs within the new t range and is rejected. Therefore, the reference frequency is not changed and the phase error only lasts for one pulse. Clock accuracy can only be affected if a continuous stream of noise pulses occur during the T-t region in a time $T^1 \geq nT$ where n is $(T/T\text{-}t)-1$.

A longer period for t gives a higher noise immunity coefficient n but, usually, t cannot be longer than 95% of T due to the stability of the circuit. If this filter is to be used in a very noisy environment, the addition of an ordinary power-line filter will improve the performance. Application of this circuit is not limited to digital clocks because the design can be extended to any digital signal which has a periodic nature e.g., the synchronizing signal from a communication modem.

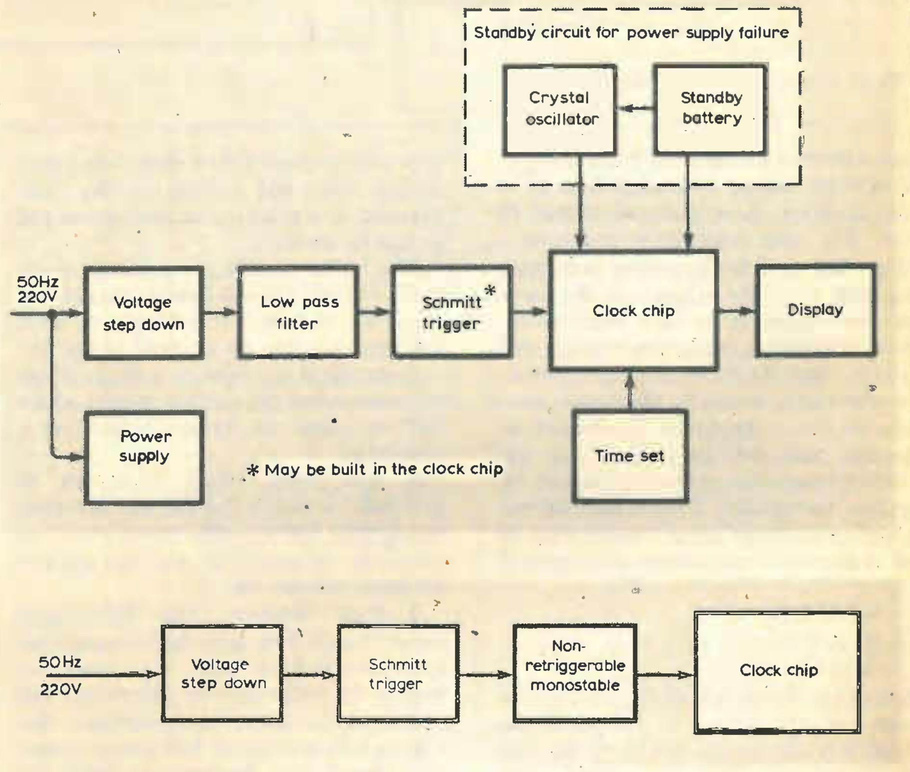


Fig. 1. (a) Typical digital clock arrangement, (b) modified system incorporating a noise filter.

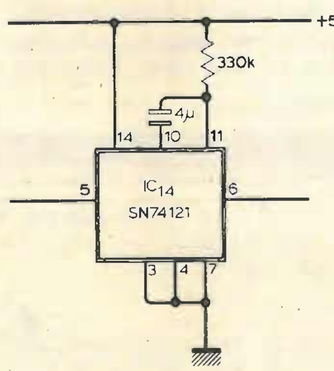


Fig. 2. Non-retriggerable monostable noise filter.

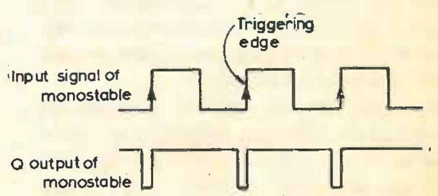


Fig. 3. Normal input and output signals from the filter.

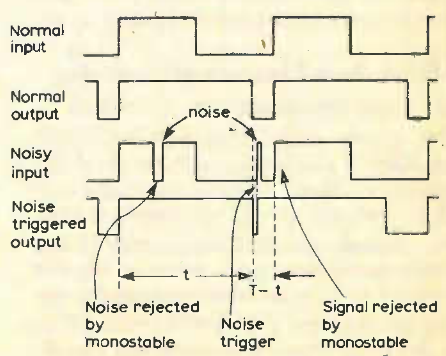


Fig. 4. Input and output signals with noise pulses present.

We have received from Plessey an application note on the use of the TDA 1085A phase-control i.c. in closed-loop systems with tacho frequency or voltage feedback. It is available from Plessey Semiconductors, Crowdy's Hill Estate, Kembrey Street, Swindon, Wilts SN2 6BA. WW405

Multiplex keying system for organs – 2

A practical solution to the wiring problem of multiple key contacts in pipe or electronic organs

by A. W. Critchley, Dipl.El., M.I.E.R.E.

TDM system reduces drudgery and cost of building an organ, whether pipe, electronic or hybrid. It permits a wide range of organ features, many hitherto unobtainable on electronic organs, allowing closer simulation of pipe organs at a fraction of the cost. The principles can easily be adapted for microprocessor control at a much lower hardware cost and complexity.

As demultiplexers comprise not only a significant part of the electronics but also a source of complexity it obviously pays to use the extension principle, see part 1.

The various manual outputs come out of the pitch shift register at different times so they must be delayed to arrive at a common demultiplexer at the same time. So manual scan period delays are necessary when collecting the voice outputs for an extension organ, but not for the traditional one.

Mixture stops

These are normally found only on the large pipe organs and almost never on cinema organs. The principal reason is that they require two or more ranks of pipes for each stop. They have a peculiarity in that the notes sounded are always toward the top of the range, no matter which keys are played, to add brilliance. To achieve this the individual ranks break to lower notes as they come in turn to the top of the keyboard. These breaks occur at different places in the scale of the manual.

To be strictly musical these stops should key generators which are independent from the rest of the organ (and have no tremulant on them either) as the pitches are supposed to be true harmonics of the keyed pitches. This is really a question for argument amongst purists but the reasoning is that the multiple notes sounded generate beat frequencies which should be the same as the fundamental or other low harmonics of the keyed notes. With common generators this does not happen due to the deliberate mis-tuning of the even-tempered scale and the resulting beats are off tune.

For most purposes this does not matter too much as a pipe organ is full of mis-tuned beats at the best of times (the chorus effect) due to the many independent pipes – especially so when mixtures are likely to be used. In an electronic organ of one generator rank it is a different story. Still, any mixture is better than no mixture and it is simplicity to provide one with this system. The method is shown in Fig. 9 which shows how to generate a four-rank mixture stop as found on a large organ. This one is based on the one found on the choir manual of St Albans cathedral organ.

The range of notes played is from 45 to 92. The maximum pitch required from the generators is 1⅓ ft but the maximum pitch relative to a key is ¼ ft (for notes 1 to 12). The pitch shift register thus has to extend for five octaves beyond unison pitch in order to accommodate this mixture stop.

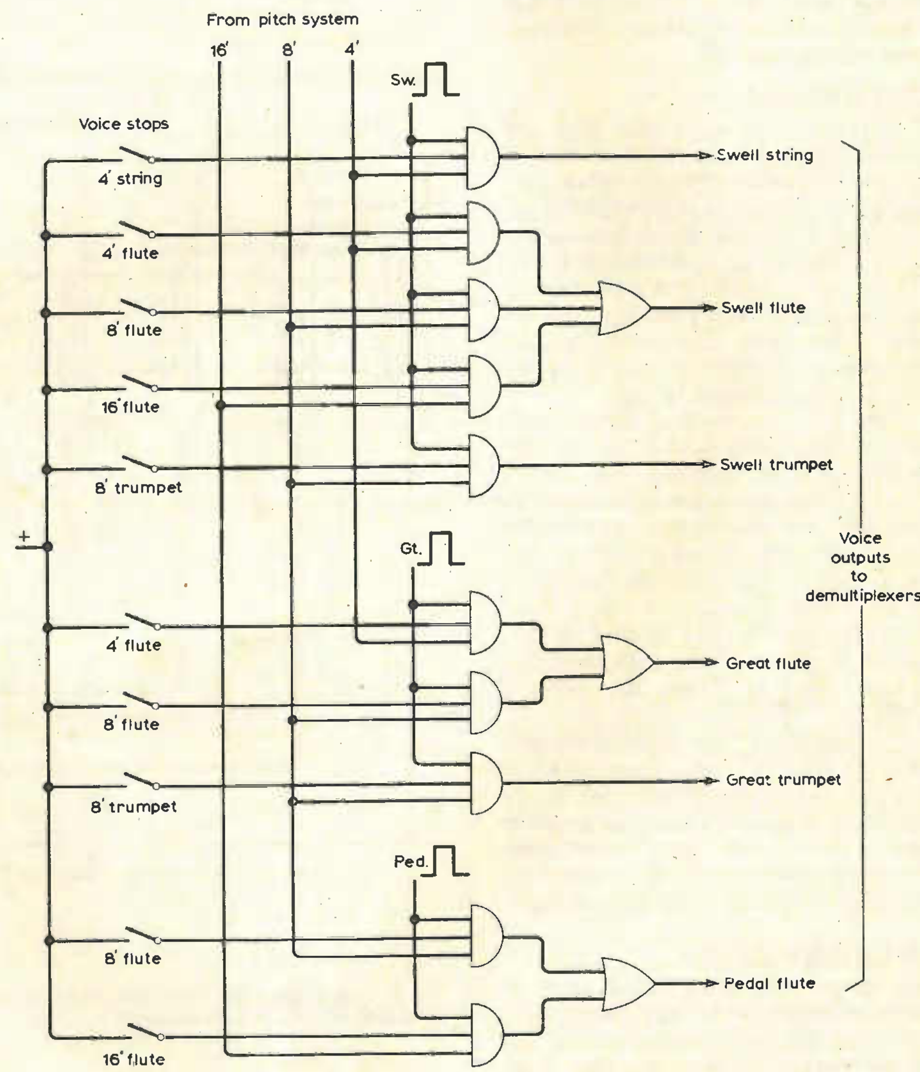


Fig. 7. Simplified pitch selection system for two-manual church organ, resulting in three demultiplexers instead of six.

Composition of a four-rank mixture

Played keys	Ranks I	II	III	IV	Notes played I	II	III	IV
1-12	26	29	33	36	45-36	49-60	57-68	61-72
13-20	22	26	29	33	49-56	57-64	61-68	69-76
21-33	19	22	26	29	52-64	57-69	65-77	69-81
34-44	15	19	22	26	58-68	65-75	70-80	78-80
45-51	12	15	19	22	64-70	69-75	76-82	81-87
52-61	8	12	15	19	64-73	71-80	76-85	83-92

Timing

The unison pitch delay due to sub-octave coupling and 32ft pitch generation amounts to three octaves. With the five octaves required to generate up to ¼ ft pitch for mixtures, eight octaves have to be added to the six for each keyboard scan to give clearance between keyboards. This results in a total of 14 octave pulses. It would be reasonable to settle for the good binary number of sixteen which then allows for a super-octave coupler (2ft pitch) if desired. A further keyboard scan period could be added to cater for other contact data such as stops, pistons, etc.

Sixteen octaves contains 192 pulses (keys). This is convenient as a suitable c.m.o.s. shift register contains 64 bits so that three packages would give the correct delay between manuals.

Demultiplexing

Conversion of the serial data back into parallel information to switch on and off the various pitches is performed in a demultiplexer consisting of a D-bistable per pitch and a decoder which sequentially clocks them, Fig. 10. The data inputs of all bistables are paralleled and each clock input receives one clock pulse per complete scan of the organ. The output data are therefore incremented in scan and faithfully follows the original keying.

There is unfortunately a practical problem with this arrangement in that the integrated circuits are packaged with separate data inputs and a common clock input. To overcome this, another shift register with taps at every stage is used to drive the data inputs sequentially whilst the clock input of the bistables receives a single clock pulse per scan. The clock input of the shift register is driven at the data pulse frequency. Fig. 11 shows the practical system.

The outputs of the bistables operate whatever form of keying circuit is to be used; a c.m.o.s. transmission gate is one possibility. A transistor interface would be used to drive a pipe organ magnet when the demultiplexer could be mounted on the pipe chest and thus save more wiring.

Automatic pedal

Pianists are sometimes called upon to amaze onlookers at an organ but are not able to perform adequately with their feet for the bass part of the music. Here is the answer!

The pedal department can be played from the lowest note *only* of whatever is being played on the manuals, usually the great manual. Due to the scanning process, the first note obtained from the manual is also the one of lowest frequency. The simple circuit of Fig. 12 obtains this note and ignores the rest. The input data sets an R-S latch which can be set only once by the input data if enabled by the great gating pulse. The resulting pulse is then shortened to obtain only the leading edge. This signal, together with a pulse occurring just before the great scanning period, reset a counter clocked at note rate. Its period is sufficient to place the output transition in the right place for the

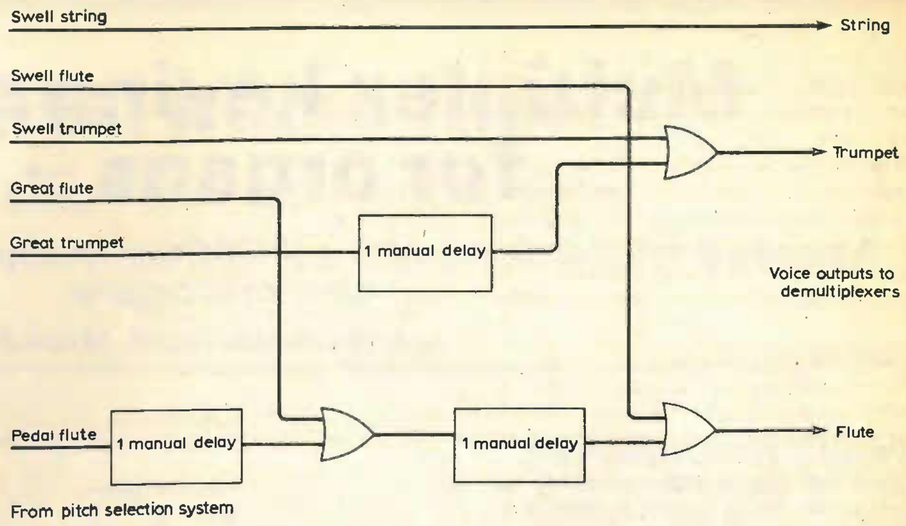


Fig. 8. Voice collection system for extension organs (simplified).

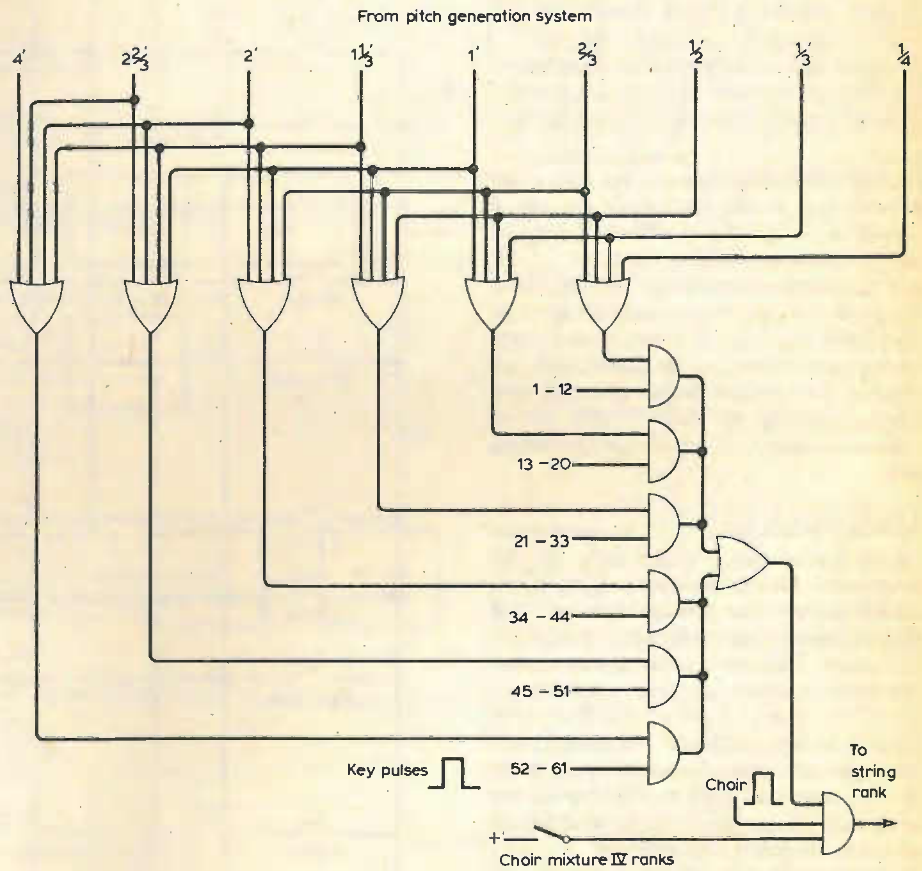


Fig. 9. How to generate a four-rank mixture stop as found on a large organ (based on St Albans Cathedral choir manual).

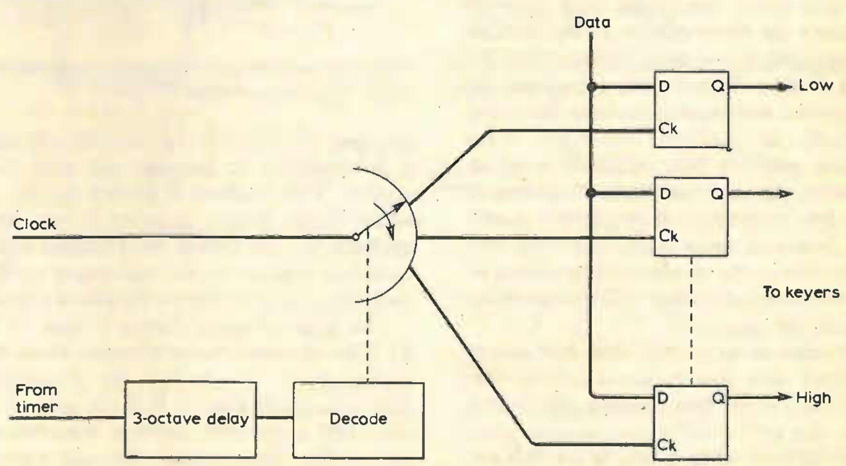


Fig. 10. Serial to parallel data conversion is achieved by a D-type bistable per pitch and a decoder to sequentially clock them.

note to be played in the pedal scan time – it must be less than one total scan. A D-bistable and nor-gate reduce the long pulse from the counter to a one-note wide pulse at this time.

The output signal could be further gated to prevent the pedals from being operated by high notes on the manual. It could also "break back" the pedal notes to the lowest octave whichever keys were being played if a variable shift register were also included.

Automatic melody

With a small organ it would be useful to be able to solo and accompany on the same manual without the bother and expense of second-touch keys or splitting the keyboard. This can be done by extracting the last, or highest, note from the keyboard in use and using it to operate some other keyboard or voice. It is the reverse of the automatic pedal system.

A counter with a period at least equal to the delay between the played note and the note to be played is clocked at the note rate. It is continually being reset by the input data from the manual so that the counter produces an output change at the correct time to activate the note to be played as a solo. To prevent continuous action, the reset-pedal is fed with a pulse which disables the counter after the time required to produce the output. If no notes are played, the counter will not then give a false result. A D-bistable and AND-gate convert the counter output back to a single note-wide pulse. Fig. 13.

For soloing on the same manual with a different voice, a complication arises in that the counter has to be reset just before that manual can operate. So to get the information to the voice demultiplexer requires that the counter have a delay to one total scan less one manual scan and the manual scan is made up with a shift register to render it coincident with the original note.

Percussive action

For bells, chimes and similar percussive effects, each note has only a short duration even though the key may be held on. It also has to operate whether or not other keys are held down on the same manual. This is achieved by digitally shortening each note in the serial data stream for a particular demultiplexer. One such circuit will work for all the notes on that demultiplexer. Each note has its own decay system as required for the voice effect which is part of the demultiplexer.

A suitable period for each note to operate is perhaps two scans of the organ (1/50 second, say) and the delay is provided by a shift register.

An AND gate cancels out any pulses after the two scan periods. The shift register must be clocked at note rate but the total delay has to be in increments of the total scan time to effect cancellation in the gate. This gives a long shift register, Fig. 14.

One of these circuits can handle all the percussive requirements of the entire organ if the output is routed and gated by appropriate manual gating pulses. With

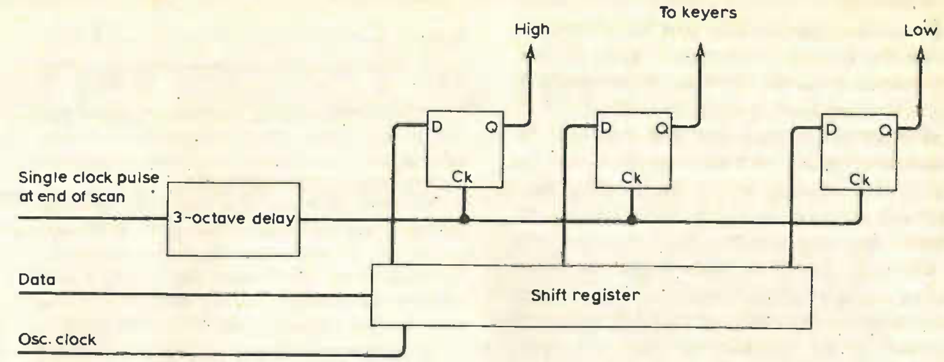


Fig. 11. Practical demultiplexer uses additional shift register to drive data inputs sequentially whilst the clock input of the bistables receives a single clock pulse per scan.

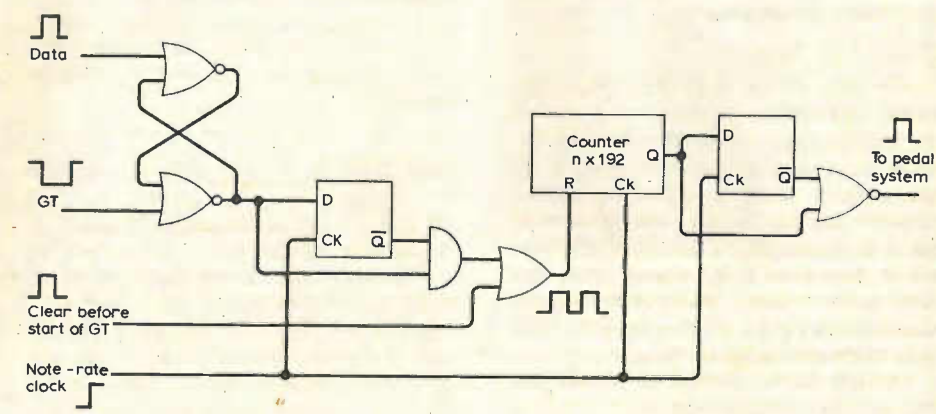


Fig. 12. Pedals can be played from the lowest note only of whatever is being played on the manuals.

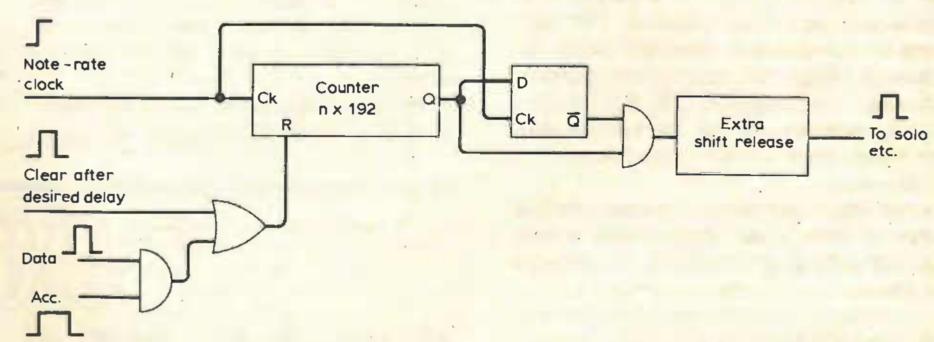


Fig. 13. Solo and accompaniment can be obtained from the same manual by extracting the highest note in use.

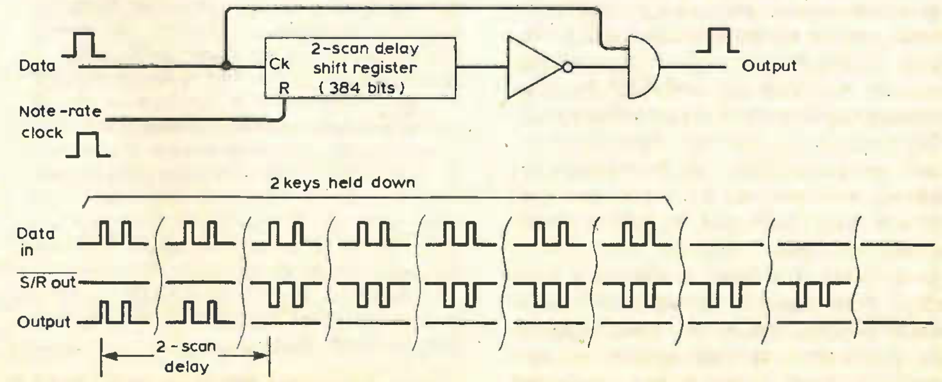


Fig. 14. For percussive effects each note has to be shortened to two scans of the organ. Delay is provided by a shift register.

further delays in increments of manual scan periods it can also provide pizzicato coupling between manuals. These delays already exist in the coupling system so that all that is required is some logic.

Pizzicato coupling can also be used to momentarily key in noise or harmonics in electronic organs in order to simulate starting tones or chiff in flute and diapason pipes.

As the percussion output ceases if the notes are held down, it follows that a pulse will occur every time any note is changed even if the rest are still down. This is very useful; it means that untuned percussion is possible merely by gating out each manual or pedal scan to a simple percussion effect generator without the need for a demultiplexer. This is not possible on theatre organs where the key contacts were simply paralleled to operate the "traps."

Microprocessor control and other possibilities

The multiplexing system is an ideal application for a microprocessor. It could be implemented with a good deal less hardware than indicated, but at a great cost in programming. Basically, the organ can be considered to be a large programmable memory source which is continually being altered by the player. A sequential scan can be generated by the microprocessor in 8-bit format instead of 12 and the data stored in a holding store.

All stops, couplers, keys, switches and other controls can also be read into the store which then contains all the data available. The program then consists of manipulating the contents en route to another output store according to the presence or absence of stops and couplers. For instance, to add an octave needs the microprocessor to look for available notes and then add 12 to their addresses. The output store can be read out in serial form or the data can be transferred in 8-bit bytes directly to the keyers.

The same hardware can cater for all types of organ and the specific details stored in programmable read-only memories.

Combination pistons can be included in the scanning process. The bigger organs have the facility of being able to couple them together in much the same way as the keys, e.g. to couple great and pedal pistons. In any case it would further reduce the wiring.

Including a stitchable delay in the demultiplexer clock path, or in the data stream gives a method of transposing the pitch of the entire organ – something novel for a pipe organ. Extra pitches are desirable on the ends of the ranks though.

Synthetic stops are sometimes fitted to small extension organs and are intended to be used as solo voices. A typical one is the clarinet which is formed by keying three pitches of flute together – 8, $2\frac{2}{3}$, $1\frac{3}{5}$ ft. This is a form of coupling and can easily be done by this system. Another synthetic stop is the oboe formed from 4, $2\frac{2}{3}$ and $1\frac{3}{5}$ ft pitches of flute. Acoustical bass, although not musically satisfactory, can be obtained by keying a pedal flute at 16 and $10\frac{2}{3}$ ft. Chimes are obtained by using $6\frac{2}{5}$, 4, $2\frac{2}{3}$ and 2 ft pitches of flute with a decay. A two-octave range is usual.

The data stream can be displayed on an oscilloscope to represent the organ keyboard layout. The trace is triggered at the manual reptition rate and the manual gating pulses used to add different amounts of s.c. to the data to separate the traces. Each black key can be decoded to lift up the traces more than for a white key. This results in a fair representation of the keyboards.

It is possible to store the data in a memory – perhaps as a way of learning chords. The memory could even drive l.e.ds situated over each key for teaching purposes.

The scanning process could conceivably be used to generate automatic arpeggios. Finally, the organ could be played automatically from the memory – shades of yesteryear with player pianos and organs. Sooner or later somebody reinvents a good idea! □

Arthur W. Critchley is President of Crosspoint Video Limited of Scarborough, Ontario. He is a former committee member of the British Amateur Television Club and has contributed many articles to their magazine CQ-TV as well as to other magazines and *Wireless World* (Aug. 71).

His interest in organs is purely private, learning to play the church organ at the age of 14 in St Annes-on-Sea in Lancashire. Famous broadcasters on the cinema organ kindled his interest in this instrument and later on he became Minor's organist at a cinema in Uxbridge, playing for his own amusement. A life-long interest in the innards of organs led to several unfinished electronic organs – whoever finishes one of these projects! They must surely have the highest mortality rate of any home construction project. Presently he is building a three-manual entertainment type of organ with all the effects and second touch which embodies the principles outlined in this article.

Glossary

Stops are controls which select either the kind of sound or the manner in which keys may be coupled together. May be a form of rocker switch or drawstop types. Either kind might be electrically operated by solenoids for combination selections.

Manuals (keyboards) have various names according to the type or organ; accompaniment, choir, swell, great, solo, orchestral, echo are typical.

Ranks, complete scale of pipes or other generators.

Magnets, solenoids which control the air feed to each pipe.

Couplers, stops which enable keys to be joined so that one key can also do the job of another, but not in reverse.

Unison, normal pitch of the keys, also known as 8ft pitch.

Mutation, pitch which is not octavely related, e.g. $2\frac{2}{3}$ft.

Mixture, stops play several high-pitched notes for every key to add brilliance.

Second touch, keying a second set of contacts by pressing a bit harder on the keys or stops, used in cinema organs to permit the playing of a melody and accompaniment on the same manual, usually by one hand!

Octave, twice the frequency, **Sub-octave** half of it.

Tenor-C, the C below middle C or the second C up from the bottom.

Chiff, splitting sound that some flutes make when they start up.

Voice, kind of sound a rank of pipes makes, e.g. a trumpet.

Pitch, frequency of a note. Refers to the length of an open-ended pipe for the lowest note on the keyboard which is 8ft long. An octave up would be half as long at 4ft, and so on.

Diatonic scale, doh, ray, me, etc., the white notes only if doh is C.

Fifth, five-note spacing in the diatonic scale e.g. G and C.

BOOKS

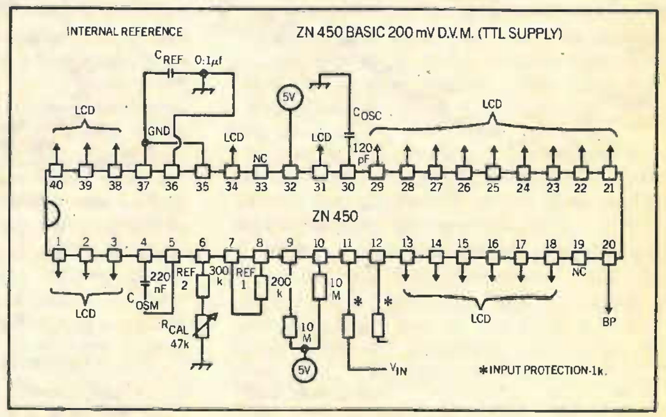
Hi-Fi Choice No. 20 – Cartridges and Headphones, by Martin Colloms, is the latest in this very useful series of guides to the choice of audio equipment. It follows the familiar form of a long introduction for both technical and non-technical readers, preceding a large number of test reports and data charts, buying recommendations and comparison charts on cartridges and accessories, the same procedure being followed for headphones. Clearly, the reviews themselves are an extremely useful guide to potential buyers of this type of device, which is not easily understood by the layman, the information otherwise being tediously culled from a large number of audio magazines, if it exists at all, but perhaps the most helpful parts of these books are the introductions. There have been many attempts to explain the finer points of audio devices to the general public, but these are models of clarity.

Hi-Fi Choice No. 20 costs £2.00 in paperback, is published by Sportscene and is available from booksellers.

Communicating with Microcomputers, by Ian H. Witten, is a layman's introduction to methods of relating humans and microcomputers. It begins with some general talk on the subject of what micros are and what they can do, establishing the level of subsequent treatment and explaining some of the terms to be used later in the book. Communication within the micro itself – buses and bus control – is then examined with a view to providing a sound base for the ensuing descriptions of input and output man/machine interface equipment – keyboards and v.d.us, for example.

Later sections of the book are concerned with the technology of graphics displays and their control, and with the ways in which a microcomputer can be induced to speak. Throughout, the processor is considered as a component in a system, and programming is not dealt with at all.

Dr. Witten was, until recently, at the Man/-Machine Systems Laboratory of the University of Essex, and has contributed several articles to *Wireless World* on the subjects covered in this book. The publishers are Academic Press Inc (London) Ltd, 24-28 Oval Road, London NW1 7DX, and the book costs £8.80 in hardback (£4.95 in paperback).



Tellegen's theorem – some applications

Encounters with a powerful network tool

by Harry E. Stockman

Although Tellegen's theorem is a really basic network theorem, implying as it does a re-statement of the law of energy conservation in networks, it is not very well known to electronics engineers. This article first introduces the original formulation of the theorem in terms of energy and power, then discusses an immittance version of it, written for driven networks with storage elements, and finally gives some examples of its application to practical linear networks.

Tellegen's theorem is one of the most basic network theorems ever formulated, since it implies a re-statement of the law of energy conservation as applied to networks.[1,2] It offers a highly useful method for analysis of electrical systems. In mathematical shorthand, the fundamental message of the theorem may simply be stated as $\Sigma ivt=0$, where i is current, v voltage, and t time. The prerequisites for the use of the theorem are knowledge of the network topology, and Kirchhoff's laws. In some instances and special cases one need not even know the network topology so long as certain mathematical relations pertaining to the network are known. Typically, Kirchhoff's voltage-sum law and Tellegen's theorem together imply Kirchhoff's current-sum law, and the latter plus Tellegen's theorem imply Kirchhoff's voltage-sum law.

The very general nature of Tellegen's theorem is evident from the fact that it holds for non-linear as well as linear networks, whether time-variant or time-invariant. It holds for the periodic steady state as well as for transients, and for reciprocal as well as non-reciprocal networks. With reference to transients, we should not be surprised to find that among the many things that can be arbitrary belong also the initial conditions. The excitation of the system can be almost anything, with one or more driving sources, in any mixture of coherent, incoherent, and random sources. The system can be driven in the steady state, periodic steady state, or transient state, with exponential and sine-wave drive common cases. In spite of all these remarkable features the theorem is not well known, or rather, it has remained quite unknown to the practical engineer up towards the end of the 1970 decade. The reason for this is the stark simplicity of the theorem, its appearance of being self-evident. In numerous applications it is simply taken for granted.

In this short article we shall stay away from any and all proofs of Tellegen's theorem. The reader interested in such proofs may consult ref. 2, which proceeds to show how Tellegen's theorem may be used to derive or prove other theorems. Virtually, there is no end to the number of theorems derivable from Tellegen's theorem. The following quotation from ref. 2 is timely: "There is hardly a basic network theorem that cannot be proved by invoking Tellegen's theorem". A few typical cases are Heaviside's transient theorem, Van der Pol's transient theorem, the reciprocity theorem, and the reactance theorem. The last two are well known. Heaviside's transient theorem deals with energy supplied during transients in non-linear networks, and Van der Pol's transient theorem pertains to excess electric energy over magnetic energy in a *CLR* one-port, excited by direct voltage. Actually, when we are using Tellegen's theorem, we are inclined to automatically involve other theorems, and indeed we shall find this to be true in the following.

Tellegen's theorem implies that the energy entering the system equals that leaving it, some of the departing energy often being changed into other forms of energy. We may write a basic power relation for resistive networks in the simple form

$$P_{in}=P_{dissipation}+P_{out}$$

Here P_{in} includes the power contributed by existing dependent sources, if any, the sign of the term being decided by the relative direction of the current and voltage that applies to each dependent source. These sources, so common in today's transistor devices and i.cs, are here of the simple kind $\mathbf{k}\mathbf{i}(s)$ or $\mathbf{k}\mathbf{v}(s)$, in complex notation $\mathbf{k}\mathbf{I}$ and $k\mathbf{V}$. The proportionality constant k may also be complex. In the following application examples we shall limit ourselves to linear networks.

Reducing to immittance

In his theorem formulation, Tellegen employs current-voltage products, thus dealing with power, readily extended to energy. Accordingly, he achieves an elegant treatment, independent of the precise form of the network, its number of meshes and nodes. In communications and electronics, however, many energized networks are inherently of single-mesh or single node-pair form, or can with a reasonable amount of work be turned into one or the other of these two forms. Some interesting possibilities now evolve. If, in a given power relation such as equation (1), we divide out the common variable (current in a mesh, voltage in a node pair), one of Kirchhoff's laws results. If we carry out the same division a second time, an immittance (admittance or impedance) summation obtains, still governed by Tellegen's theorem. While our reduction from power to immittance scarcely requires a theorem of its own, such a theorem has nevertheless been published.[3] Written for driven networks with storage elements, the immittance theorem takes the general form

$$\Sigma[Y(s)\text{ or }Z(s)]=0 \qquad (2)$$

Note that this formula is restricted to single mesh and single node-pair networks. Like its parent theorem, the immittance theorem holds true whether the network is stable or brought to the point of instability. The summation always yields a zero with (2) providing an identity. This matter will be clarified in a following example. With reference to (2) it goes without saying that all sources must be converted to immittance by an application of the compensation theorem. Currents and voltages are automatically eliminated.

One important field of application for the original theorem as well as its immittance version is that of checking already obtained solutions to network problems. Such checking may involve considerable labour, however, particularly for algebraic solutions. On the other hand, since the Tellegen theorem solution may differ considerably from more common solution methods, the mathematical tool Tellegen has given us is highly useful for checking purposes.

As a first application example, consider the simple operational amplifier in Fig. 1, identified by the following formulas

$$A_s=\frac{V_2}{E}=\frac{aR_L}{r_o+(1+ab)R_L} \qquad (3)$$

$$R_{OUT}=\frac{r_o}{1+ab} \qquad (4)$$

Here A_s is the system amplification, R_{OUT} the system output resistance, r_o the inherent amplifier output resistance, R_L the load resistance, and a and b initially constants. The voltage aV_1 marks a dependent source. Let us dwell for a moment on the derivation of (4). Perhaps the most basic procedure for that purpose, when the network is given with or without dependent sources, is to make use of the applied source method. We apply the voltage V_o to the output port, determine the ensuing current I_o into the network, and then form the quotient V_o/I_o, which is R_{OUT}.

As another alternative, we may for a moment go back to the time when Thévenin's and Norton's theorems were combined into a single theorem.[4] This theorem formulation strongly brought out the idea, already in practical use, to write the output immittance as a consequence of the Thévenin and the Norton equivalents, existing simultaneously. The procedure is specifically described by the Thévenin-Norton dependent-source theorem, this being one of the names under which this theorem appears.[5] If the driving sources in the two network equivalents under discussion are E^* and I^*, the quotient E^*/I^* simply depicts the output impedance, and this is true whether or not the network contains dependent sources.

The starting point for the application of this theorem may be either the given network, or its transfer function, which in our example is (3). Thus (4) is actually included in (3). This entire procedure of deriving the Thévenin generator and the Norton generator from the transfer function is specifically spelled out in a highly time-saving theorem called the equivalent generator theorem.[6,7,8,9] Its time-saving feature stems from the fact that the output immittance is determined in quite a different manner, and if the output immittance is all we want, the parent theorem degenerates into the output immittance theorem.[9] This theorem clearly verifies that indeed (4) is contained in (3), and in such an obvious way that in most network problems the output immittance can be read off directly without the need for any calculations whatsoever.

With reference to our example, with (3) the proper transfer function, the theorem simply states that the output resistance is the denominator, less the term that describes the load resistance. Of the methods discussed above, this is by far the quickest one, and, like the other two methods, it holds whether or not the network contains dependent sources. But to use this theorem, we must have access to the transfer function in (3).

Practical example

Above we have given particular consideration to output immittance because we wish to make this quantity a key issue in our application of Tellegen's theorem. The network in Fig. 1 is a stable system, in fact, a negative-feedback system, for which Tellegen's theorem, as given by (2), simply takes the form $\Sigma r = 0$. In summing up the resistance around the mesh we are using the immittance theorem, and as we find the sum to be zero, we obtain the identity 0=0. However, the interested reader may instead use power, following the formulation of Tellegen's theorem, and certify that the net result is precisely the same identity 0=0.

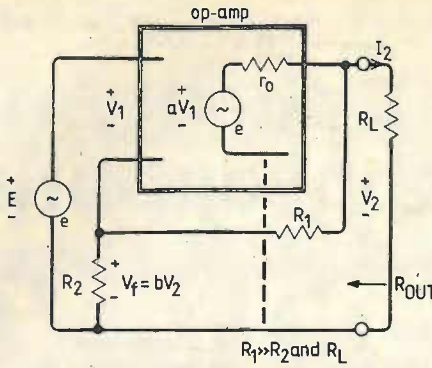


Fig. 1. Simple operational amplifier with negative-feedback voltage $V_f = bV_2$ and dependent source aV_1.

The steps in using the immittance theorem are as follows. First we apply the compensation theorem to the source aV_1 to turn it into resistance, then sum up all resistance, writing

$$-\frac{aV_1}{I_2} + r_o + R_L = 0$$

The first term here represents a negative resistance. Eliminating all variables with the aid of the relations $V_1 = (E - bV_2)$ and $V_2/I_2 = R_L$, and using V_2/E from (3), we quickly find the identity 0 = 0.

Knowing that Tellegen's theorem is extremely general, we have the right to expect that the mathematical reasoning above would remain the same if the network instead had positive feedback. The switch from degeneration to regeneration can be accomplished simply by a change of the sign for b. Specifically, then, we conclude that the identify is independent of the sign of b. The reader can easily verify that this is the case. If we keep increasing the regeneration in a practical amplifier system, a point will be reached where we must accept non-linearity, and thus give up the use of a linear network theory approach. In theoretical work, however, we have the right to assume that the system remains linear up to the "take-off" point, the point of instability. We cannot proceed beyond this point with linear network theory, but Tellegen's theorem is equally valid after surges and oscillations have commenced. This observation is an important one.

Returning to our application example, we shall now claim that the previous result of an obtained identity holds true even when the system becomes unstable. As the network attains self-excitation, it maintains currents and voltages although there is no applied signal voltage, and with $V_1 = b_cV_2$, our summation takes the form

$$-ab_cR_L + r_o + R_L = 0 \qquad (6)$$

where b_c is the critical value of b. Solving for b_c, we obtain

$$b_c = \frac{r_o + R_L}{aR_L}$$

Turning this around and claiming that we have available the information of b_c in (7), we can quickly establish the significant identity 0 = 0 by inserting b_c in (6). In the above examination of the network, we arrived at a summation that gave zero. The same result obtains if we instead work from the transfer function in (3) and insert $-b_c$ from (7) in its denominator.

Stability considerations

If our aim is to establish the stability conditions for a network in general, starting from the network, the above discussion shows that the summation of power, or, in the simplified case, immittance, will provide the answer. In the many cases where the pertinent information is given by formula similar to (3) and (4), with the network either known or unknown, Tellegen's theorem guides us, however, to a much more direct and time-saving procedure. We are already familiar with the determination of the stability conditions by setting the denominator in transfer functions like (3) equal to zero. We shall now find that in cases where the only available information is a port termination formula like (4), Tellegen's theorem again gives us the stability conditions, and in a most direct way.

While Tellegen did not present his theorem as a stability criterion, it nevertheless contributes this information, and indeed, in certain applications, it provides an excellent and time-saving stability criterion. In his original theorem formulation, employing power, Tellegen implies that, unless the power in a port load "sees" itself inside the port with the opposite sign in the power summation, the system is not lossless. In the simplified case of a single mesh or a single node pair, the corresponding statement is that unless the load immittance "sees" itself inside the port with the opposite sign in the immittance summation, the system is not lossless. In terms of the immittance theorem, and with reference to our example, the consequence of this reasoning is the simple stability criterion

$$R_{OUT} = \frac{r_o}{1 - ab_c} = -R_L$$

which directly gives b_c in (7). On the other hand, (8) is the direct result when the transfer function denominator (R_{OUT} + R_L) is set equal to zero. The point is that the transfer function may be unknown, but a formula for the port output immittance is known.

In passing, we shall make use of at least one other method for determination of the stability conditions in the given example, the popular Barkhausen criterion H_cA = 1. In our example, the feedback transfer function is $H_c = b_c$, and A is obtained from (3) with b = 0. We find that $b_c A$ = 1, solved for b_c, yields (7).

If we go the route of (8) to find the stability conditions, we must know the output immitance. Our entire problem may simply be to determine this immittance. We have already learned how to do this when the proper transfer function is known, but now let us instead assume that it is the network that is known. Equation (8) then hints a very direct method of determining output immittance from a given network. We must find the ratio of r_o to (1

$-ab$) whatever value b has up to the value b_c, but certainly R_L must not appear in our calculation although clearly R_L controls the mesh current. However, in the very specific case of $R_L = -R_{OUT}$, we don't mind that R_L appears in our derivation. This is the key to the procedure, Tellegen's lossless condition gives us the mathematical tool we must have. We simply terminate the port in $-R_{OUT}$ instead of R_L, and employ the compensation theorem to turn the source into a resistance. R_{OUT} solved from the ensuing immittance equation is then our answer.

This method is described by a new theorem called the image output immittance theorem, and it gives the answer in shorter time than the application of the applied source method would. The procedure we follow to apply this new theorem to our network in Fig. 1 is first to replace R_L by $-R_{OUT}$, then to use the compensation theorem to turn the source aV_1 into a resistance, and finally to make use of the relation $V_2/I_2 = -R_{OUT}$, so as to secure the all-resistance summation

$$-ab(-R_{OUT}) + r_o - R_{OUT} = 0 \qquad (9)$$

Solving here for R_{OUT} we obtain (4) for the case of regeneration. If we instead enter $V_1 = -bV_2$, the result is (4) for degeneration; the case the formula represents.

Second example

Some of our basic thinking in the above discussion will now be applied to the amplifier network in Fig. 2, which contains storage elements both inside the amplifier and in the load. The source μE is related to the driving voltage E while the dependent source μKV signifies positive feedback. Complex notation is used in the figure, and corresponding symbols in the text should be taken as complex quantities. The transfer function and the output impedance are known and are, with $s=j\omega$ and $(sL+R+R\omega+1/sC')=Z$,

$$A_s = \frac{V}{E} = \frac{\mu Z_L}{(1-\mu K)Z_L + Z}$$

$$Z_{OUT} = \frac{Z}{1 - \mu K}$$

Here R' is contributed by the Cg-combination as a series resistance, and C' is the ensuing series capacitance. From now on we shall consider the network as forming a single mesh. As in the previous example, (11) is instantly read off from (10) with the aid of the output immittance theorem. In accordance with Tellegen's theorem, the sum of all power around the mesh is zero. If the reader works this out as an exercise, he shall find that the identity 0 = 0 indeed obtains. We shall here limit ourselves to the use of the immittance theorem, writing

$$-\frac{\mu E}{I} - \frac{\mu KV}{I} + Z + Z_L = 0$$

With $V/I = Z_L$ and E/V obtained from (10), we quickly find that the identity 0=0 obtains. Thus if (10) had been the result of some solution, the writing of (12) would have been the way we invoke Tellegen's theorem for checking purpose in this parti-

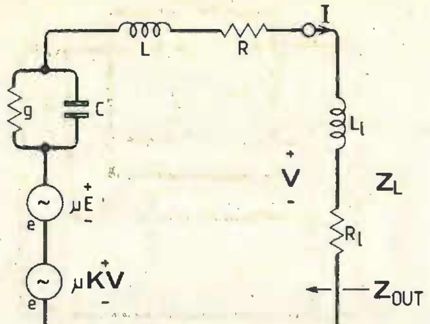


Fig. 2. Linear network to be turned into a single mesh. The calculation results are checked with Tellegen's theorem and the immittance theorem.

cular case. On the other hand, if instead the immittance theorem was used to secure an initial solution, then we simply leave V/E in, and, solving for this quantity in (12), obtain the answer in (10).

Guided by the above applications, we can now formulate the immittance theorem as follows:

> For a linear single-node-pair or single-mesh energized network, Kirchhoff's current-sum law, respectively voltage-sum law, divided by the common variable, yields

$$\Sigma[Y(s) \text{ or } Z(s)]=0$$

For K the feedback variable, we set the denominator of (10) equal to zero to find the stability conditions, or, we set (11) equal to $-Z_L$, obtaining

$$K_c = \frac{Z + Z_L}{\mu Z_L}$$

where K_c is the critical value of K. If instead (10) and (11) had been unknown, but the network given, a summation of all impedance around the mesh, with the sum equal to zero, would have given the same answer for K_c.

Using the image output immittance theorem to obtain Z_{OUT} from the network, we first replace Z_L by $-Z_{OUT}$ and then sum up as follows, using the compensation theorem and reading off V/I as $-R_{OUT}$,

$$\mu KZ_{OUT} + Z - Z_{OUT} = 0 \qquad (14)$$

from which the answer in (11) obtains directly. Precisely the same procedure, with proper attention to signs, would give the correct answer for negative feedback. The image output immittance theorem is therefore general, and is often the quickest way available when we wish to determine the output immittance of a given network, not known by given formulas. The theorem may be formulated as follows:

> For a linear active network with an output port at which the network forms a single node-pair or a single mesh, the output immittance is the locking-in immittance when the driving source is removed and the load immittance replaced by the image of the looking-in immittance with a negative sign.

In conclusion it should be mentioned that readers concerned with the checking of already obtained solutions might also consider the superposition theorem since it gives solutions of a different kind. For this theorem to apply to networks with dependent sources, these sources must be entered with the values they have in the undisturbed network.

The above discussion confronts us with Tellegen's theorem from only a few avenues of approach, with examples chosen from among those which may be of common interest to people working with networks. Nevertheless, we have touched upon only a few possible exploitations. That the power of this theorem goes far beyond networks is perhaps evident if we realize that Kirchhoff's laws are merely approximations under specified conditions of two of Maxwell's equations. These two may be referred to as the curl-H and curl-E equations. Specifically, if we use the curl equations, invoking certain manipulations and writing a power equation that covers the total volume of the radiating system, the mathematical relation is in effect the same as that resulting from an application of Tellegen's theorem. In view of this tie-in with Maxwell's equations, we should not be surprised to find that if we have a charge flying by a conductor, inducing a current in it, the ensuing network analogue can be proven by means of Tellegen's theorem. If instead the charge stands still and the conductor flies by at arbitrary velocity, we become concerned with the message of Einstein's relativity theory. In the macroscopic world, then, Tellegen's theorem still holds, as properly modified by relativity theory. Dr Tellegen has given us an extremely powerful mathematical tool that deserves vastly increased use over what it enjoys presently.

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NEW PRODUCTS

10MHz oscilloscope

The Scopex 14D10 is a 10MHz, dual-trace oscilloscope which supersedes the company's 4D10B. The 10 × 8cm display and associated controls have been moved to the left of the front panel and the two input channels to the middle. All the function switches are push-button and are in line across the lower half of the front panel. The trigger control has been replaced by a potentiometer and a ± push-button switch to give the ability to trigger positive and negative edges of pulse trains without re-adjustment.

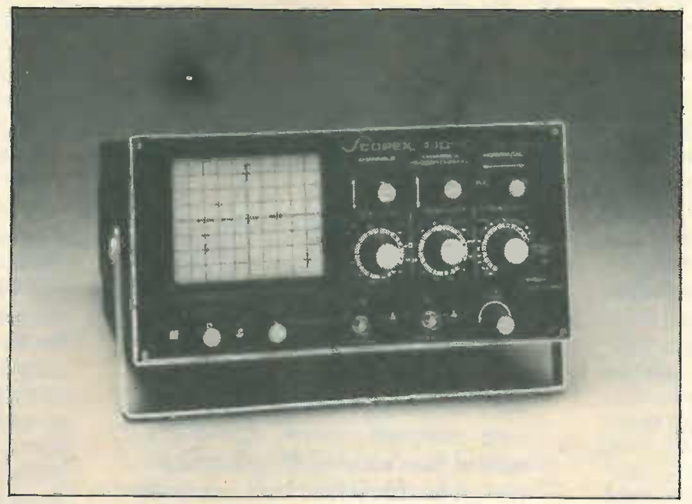
Sensitivity of both channels is 2mV/cm to 10V/cm in the internationally approved 1-2-5 sequence. Timebase speed ranges from 100ms/cm to 1µs/cm, with the option of ×5 expansion to give 200ns/cm. Add and invert facilities enable computer service engineers to align floppy disc drives and other computer peripheral devices.

The conventional power supply has been replaced by a switched-mode version and this has reduced the weight of the instrument to 5kg. The price of £230.00 plus v.a.t. includes two high-impedance probes, carriage (UK mainland) and the manufacturer's one-year guarantee. Scopex Instruments Ltd, Pixmore Avenue, Letchworth Herts SG6 1JJ.

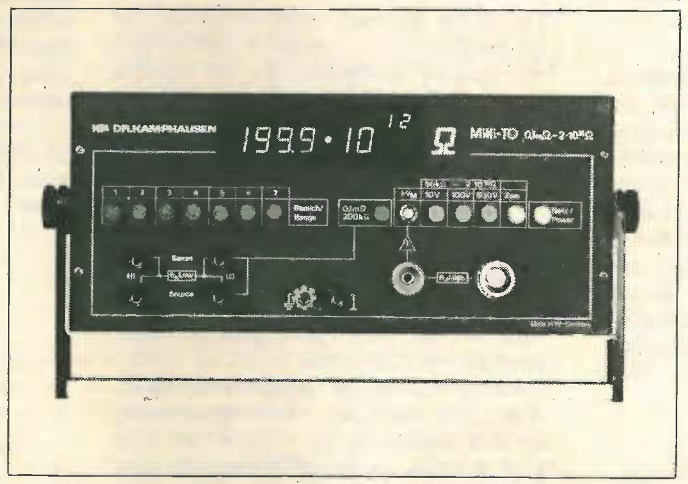
WW301

Resistance meter

Digital readout of resistance in the range 10^{-4} up to 10^{14} ohms is the main feature of the Milli-TO resistance measuring instrument from Cropice Ltd. Low resistance measurements can be made in one of seven ranges from 0.1mΩ to 200kΩ. The d.c. test voltage across the sample reaches a maximum of 500mV at a reading of 2000 digits but is limited to 750mV if the wrong range is selected. For very low resistances, four-terminal measurements can be made (using the Kelvin principle) to avoid difficulties which may arise from test lead resistances. High-resistance measurements from 50kΩ to 2×10^{14}Ω are covered in seven ranges. The 10V, 100V or 500V test-voltage is selected by push buttons. Capacitor and cable dielectric measurements can be made accurately as the ripple of the test voltage is less than 200µV at 1Hz. The test voltage current is limited to 3mA for safety reasons. The Milli-TO is said to be easy to use



WW301



WW302

WW303

and an optional b.c.d. data output with digital adjustable limit control allows the instrument to be used for 'go/no-go' applications in production processes. A 31/2 digit 15mm l.e.d. and separate exponent display are used for the readout. Cropico Ltd, Hampton Rd, Croydon CR9 2RU.

WW302

Printer/plotter

One of the first of a new generation of printers, the 'intelligent' printer/plotter, has recently been announced by Roxburgh Printers Ltd. The features of the X80SP needle printer include three character generators (one of which is fully programmable), bi-directional printing and paper feed, 8×8 matrix, horizontal and vertical tabs, selectable print direction in steps of 45 degrees, programmable line spacing, start/finish of print at any point and 80/96 chars. per line. For plotting, graphics and images, the X80SP has: X and Y, vector, rectangle and ellipse generators, single dot control, digitizer output, eight automatic centring symbols and recognizes pen up/down instructions. Various versions are available with interfaces for the PET, Apple II, Centronics parallel and RS232/20mA, 50 to 9600 baud. The plot accuracy is 0.1mm horizontal, 0.2mm vertical and the speed is 100ch/s. Measurements of the printer are 49.5×31×14.5cm and the cost per unit is £840 for the version with RS232 interface and £795 for other versions. Roxburgh Printers Ltd, 22 Winchelsea Rd, Rye, E. Sussex TN31 7BR.

WW303

High-temperature regulator

Designed mainly with high-temperature environments in mind, the Teledyne Philbrick 2115 15V hybrid regulator will provide up to 50mA of current at temperatures of up to 275°C. Output voltage variation with temperature is 0.5V from +25 to +275°C and a line regulation of ±10mV is also specified for the 16V minimum and 25V maximum supply voltages. For loads of from 15 to 50mA the regulation is also specified as ±10mV and ±20mV for 5mA and upwards. The hermetically sealed package of the 2115 measures 1.15 × 0.75 × 0.23ins. Technical Selling Services, Unit 5, Brunel Gate, West Portway Ind. Est, Andover, Hants.

WW304

Voltage standard

High-resolution d.v.ms, multimeters and a-to-d converters can be calibrated using the transportable Transcell-II d.c. reference calibrator made by Standard Reference Laboratories and marketed by Lyons Instruments. Two outputs are provided: the working voltage of 10.00000V with a source impedance of less than 100Ω and a stability error of 10p.p.m./year if untrimmed, and the prime reference output of 6.3V which is calibrated to 2p.p.m. and has a stability error of 10p.p.m./year. The 10V reference can supply currents of up to 2mA and can be corrected at any time using the 6.3V reference. Both outputs are said to be predictable to within 1p.p.m./1000hrs. Internal rechargeable batteries provide up to 75 operating hours. Lyons Instruments Ltd, Hoddeson, Herts.

WW305

Fibre-optic dual cable

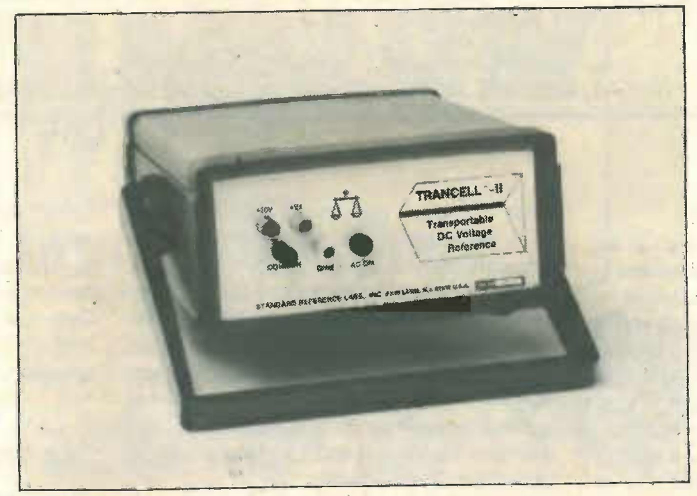
Dual channel fibre-optic cables with optional, factory-fitted connectors are available from Hewlett-Packard Ltd in lengths of from one to 1000 metres. The HFBR-3100 duplex optical cables consist of two single-fibre cables extruded together and surrounded by a common black polyurethane sheath. A tracer is provided along one of the two sections to enable identification and the cable can easily be split into two parts for convenience where the termination sockets are placed some distance from each other. These flame-retardent cables measure 6.35×3mm, weigh 17g/m and cost around £2.67 per metre, with an extra cost of £106.92 for factory fitting and testing of four connectors. HFBR-3100 cables are compatible with the HFBR-1001, HFBR-1002 and HFBR-2001 transmitter and receiver modules. Hewlett-Packard Ltd, King Street Lane, Winnersh, Wokingham, Berks RG11 5AR.

WW306

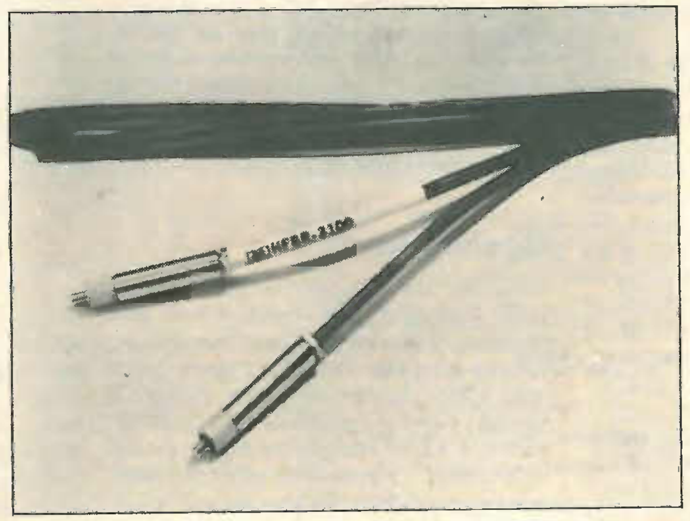
S.a.w. delay line

When used in compressive receiver applications, 250MHz of bandwidth can be analysed in 0.25µs with a frequency resolution of 4MHz using the DS 1313 dispersive s.a.w. delay line from Signal Technology Ltd. A centre frequency of 750MHz, a bandwidth of 500MHz, a dispersion time of 0.5µs and a 1000MHz/µs 'down-chirp' sweep rate are some of the specifications quoted for the device. The DS1313 is manufactured on lithium-niobate substrate and housed in a four lead solid based TO-5 package for use in compressive receivers and spectrum analysers. Signal Technology Ltd, Cheney Manor, Swindon, Wiltshire SN2 2PJ.

WW307



WW305



WW306

WW308

I.f. filters

Small if filters for broadcast and communications receivers have been introduced to the market by Ambit International. Toko manufacture the filters, of which there are three basic types: the CFL ceramic a.m.-i.f. filter, the CFM low-profile mechanical filter with which a selectivity equivalent to three conventional single tuned i.f. transformers can be obtained in the range 450 to 530MHz, and the CFSKM ceramic f.m.-i.f. filter which features a low temperature coefficient. Two bandwidth types are available in the CFSKM series – the CFSKM1 has 280kHz bandwidth and the CFSKM2 has 230kHz. The CFL filters are available for the range 450 to 470kHz with a nominal 8kHz bandwidth (−6dB). Ambit International, 200 North Service Rd, Brentwood, Essex CM14 4SG.

WW308

Prestel adaptor

An adaptor costing under £200 that will turn a standard colour or monochrome tv set into a Prestel terminal is marketed by Zycor Ltd. The Teledek 2000 requires connexion to a tv set via the aerial socket, to a standard telephone network jack-socket and to the mains supply. Approval for the unit has been obtained from the Post Office, and it complies with issue six of the Prestel Terminal specifications. Information selection is via a 16-key infrared remote-control pad, supplied with the terminal, which can operate at distances of 9 metres from the terminal. A wired full alphanumeric keyboard can be supplied for an extra £50. Sockets are provided for connexion to a printer, to a tape-recorder for recording and re-displaying information, and to a tv monitor or a tv set with direct r.g.b. inputs. Dimensions of the 2000 are 408×214×89mm. The mains supply voltage requirement and r.f. modulator are adjustable internally as the unit has been designed with export in mind. Zycor Ltd, 33 Fortress Rd, London NW5 1AD.

WW309

Wideband op-amp

An op-amp with a gain bandwidth product of 1.5GHz and a slew rate of ±800V/µs is made by Analog Systems and distributed by Pascall Electronics Ltd. Some of the applications for which this bipolar monolithic i.c., the MA-207, can be used are video, ultrasonic and pulse amplifiers and high speed cable drivers. Untrimmed, the input offset voltage of the device is 1mV and the input noise voltage $2nV\sqrt{Hz}$. The output current, based on a ±2V output swing, is 200mA maximum and power dissipation is 600mW maximum. The 207 is housed in a standard 14-pin d.i.l. package, costing £20.31 per unit and £13.53 in 100 up quantities. Pascall Electronics Ltd, Hawke House, Green St, Sunbury-on-Thames, Middx TW16 6RA.

WW310

V.m.o.s.f.e.ts

Plastic TO-273 packaged v.m.o.s. power f.e.ts with a low-price have been developed by Siliconix. The VK1010 and VK1011 are capable of handling peak currents of up to 1A and have maximum blocking voltages of 100V and 30V respectively. Power dissipation is 1W in free air at 25°C. The devices feature five nanosecond switching times and will interface directly with t.t.l. or c.m.o.s. logic. For 100 up quantities the VK1010 costs 53p and the 1011 costs 43p. Siliconix Ltd, Morriston, Swansea SA6 6NE.

WW311

16K static r.a.m.

This 16K × 1 bit fully static r.a.m. features 50ns maximum address access and read cycle times and 660mW max. active state power consumption. The IMS1400 v.l.s.i. r.a.m., manufactured by Inmos, runs from a single 5V power supply and its i/os are all t.t.l. compatible. One of the 20 pins on the 0.3in d.i.l. package is a 'chip enable' input which can be used to place the device in standby mode to reduce consumption to 110mW. IMS1400 is at present only available in sample quantities but full availability is expected within the next three months. Inmos, Whitefriars, Lewins Mead, Bristol BS1 2NP.

WW 312

SIDEBANDS

By Mixer

Bourgeois ballistics

There has never been a better time for the d.i.y. enthusiast. Employing tradesmen to come and poke about in your house or on your car gets more ruinous by the day, and the results are very often little better than could be achieved by a troop of monkeys with a talent for social advancement. Run-of-the-mill joinery, bricklaying, plumbing and painting need hold no terrors for the averagely dextrous and even those of us with a full set of ten thumbs usually win through in the end. You can often obtain a lot of quiet pleasure, too, from a well-decorated sitting-room or a nicely finished set of bookshelves.

There has always been a feeling of cosiness, for me, in all these d.i.y. magazines. The same old subjects appear every year: loft insulation in November, swimming pools in May. It's astonishing the things some people will attempt, but I doubt that many folk would consider a project I've just seen on a press handout, here on my desk – a do-it-yourself bullet-proofing kit for vehicles. No experience necessary, it says here. There's one thing, though; it could give rise to some stimulating over-the-garden-fence conversation.

" 'Morning, George. Trouble?"

" 'Morning, Harry. No, I'm just bullet-proofing the car. The wife keeps getting shot up on the way back from Sainsbury's, so I thought I'd beef the old bus up a bit. It's costing me a fortune, filling all these bullet holes in every weekend."

"Yes, see what you mean. Mind you, it's all right for your three-oh-three high-velocity stuff, but you'll be in trouble with those blasted bazooka rockets."

"Well, I haven't got time for more than heavy-calibre machine-gun protection. I said I'd put the new lino tiles down in the hall today, and you know what she's like if I don't do things straight away. She's out this morning, down at the hand-grenade class."

Butter side down

Having just taken our library out of the orange plastic boxes it came from Dorset House in, I've had a unique opportunity to observe Murphy's Law in inexorable action. The library's former home was more a hole in the wall than a room, and everything was stacked up in unusable heaps of erudition. We've got stuff here going back to 1911 and the collection is growing all the time, what with the scores of magazines and books for review that come in. The library also used to be the place where all the office embarrassments were hurled, on the basis that so long as no-one found them until 2001 they wouldn't matter any more.

Packing it all up for the move, we decided to give the old heave-ho to a great stack of papers and books that we didn't want and couldn't find space for. Some of it hadn't been seen, let alone used, since the BBC was a Company, not a Corporation. So, with a heavy heart and with moaning and wailing, we slung it. After all, you have to be sensible about this sort of thing – it's not a bit of good hoarding waste paper. We kept the useful stuff and the more important historical material and thought we'd done well.

I expect most of you are well ahead of me by now. Yes, of course, the very first thing I wanted from our new, streamlined, efficient library was in one of the old magazines I'd insisted, against good advice, on chucking out. And it isn't as easy as it was to nip across the road to the Patent Office library or the IEE.

I just hope they never have to move, or we'll be right in the soup.

Cycling hertz

Since the day some unprincipled lout at RAF Stafford stole my bike, I have not pedalled. (I was going to say I haven't set foot on one, but that didn't seem quite right.) With the move to Sutton, though, I thought I'd have a go with a view to giving myself a bit of exercise by riding to the office, since it's only three miles. So I did my daughter's Moulton up a bit and began to work up to three miles in easy stages, starting with a short hop to the paper shop.

I'd been looking forward to riding the bike, and the feeling this tentative spin gave me of being in the wrong century was a bitter disappointment. The last time I rode a bike, the roads were uncrowded and I was thirty years younger. This time, I discovered what it is to be an unconsidered trifle; and, come to think of it, that is a good way of putting it, because I was quaking like a jelly when I got home again. Apart from the way the bike doubled its weight every hundred yards, the main worry was the sheer malevolence of the car drivers. I tell you, if I never ride a bike again, it will be much too soon. There was certainly no chance of thinking of anything but staying upright and in one piece, which is what makes me wonder about the latest marvel of modern science – a bike computer.

What is there to compute about bikes? Well, if you are of a statistical turn of mind, you can discover your speed, average speed, maximum speed achieved during a journey, distance travelled and journey time. And if that isn't enough to divert you, you can have a radio as well.

I can only suppose that your experienced cyclist is a lot more nonchalant about dicing with death than I am, because I'm pretty sure that knowing my average speed would not be nearly enough inducement to get me to tear my eyes away from the monstrous regiment of car-borne werewolves intent on frightening the living daylights out of me. Personally, I think I'd rather spend the money on a suit of armour.

No sale

Now we are heading so surely towards the cashless, chequeless society you would think commercial transactions would have become simplicity itself. It only seems to be a mere mechanical process of transferring a few digits out of one computer into another in a matter of microseconds. Not so, unfortunately. The old Adam (which includes his rib, I hasten to add) still holds sway in such ignoble instincts as distrust of the other fellow and his computer.

The other day, for example, we had a despairing phone call from an engineer in a large public utility who was unsuccessfully trying to buy a kit of electronic parts from one of our mail-order advertisers. Could we help? Apparently the public utility wanted to place an order through its normal system, by which payment would be made after the delivery of the goods. The mail-order firm, however, was not playing. They insisted on cash with order, or no sale. It seems at least three wily accountants in the public utility had had a go at them at different times, no doubt trying to catch them off guard with a variety of siren voices; but no, they were adamant. Mind you, I can understand their reluctance. A friend who runs a small business tells me you can easily face ruin with a few of these large organizations as customers – they can take up to a year to pay their bills.

Anyway, the only help we could offer the engineer was: why not pay the required sum himself, out of his own pocket, and then recover it later from his employer, who surely must be honest enough to cough up? There was a sharp intake of breath at the other end of the telephone, followed by a long silence: "Oh, er . . . I don't think our organization could cope with anything like that . . . "

It's extraordinary that there can be such a stalemate between two parties who genuinely want to do business together. One is keen to buy, the other is willing to sell, but because each is a slave to his own method of transaction the result is no business at all. If human organizations have become so refractory it's surely time we got in some of those intelligent machines that our contributor Malcolm Peltu wrote about last month. *Machina sapiens* might be able to teach *homo sapiens* a thing or two about how he should be functioning.

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545B/1A1. DC-30 MHz. dual trace. Delayed timebase	325
585A/82. DC-80 MHz. dual trace 10 mV sensitivity	525
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7403N DC-60 MHz 3 Plug-in Mainframe	450
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TELEQUIPMENT	
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D83 DC-50 MHz. Dual trace. Large 6½" CRT. Dual Time Base	650
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1805A Dual Trace DC-100 MHz 5mV. 1MΩ/50Ω	550
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Type R. Transistor R.T. tester. Pulse rate 120 pulses/sec. R.T. Less than 5 mμs	100
Type G. Differential amplifier. 100:1 CMR DC-20 MHz. 50 mV sensitivity Plug-ins for 500 series	50
1A1 dual trace Plug-in DC-50 MHz	225
1A2 dual trace Plug-in DC-50 MHz	180
1A4 four trace Plug-in DC-50 MHz	375
1A5 Differential Plug-in	175
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81 Adaptor Plug-in 1A Series to 580 Series	75
7A12 Dual Trace DC-105 MHz 5mV/div.	410
7A22 High gain diff. amp. 0.1 Hz-1 MHz 10μV	450
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TF 893A 10 Hz-20 kHz. 20μW-10W.	120
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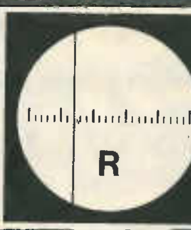

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AF124	0.34	BC159	0.09	BC303	0.26	BD203	0.78	BF200	0.30	BRC4443	0.85	TIP2955	0.84
AF125	0.32	BC160	0.28	BC307	0.09	BD204	0.70	BF241	0.15	BT106	1.00	TIP3055	0.66
AF126	0.32	BC161	0.28	BC327	0.10	BD222	0.46	BF257	0.28	BT108	1.22	TIS91	0.20
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BC107B	0.10	BC182	0.09	BC550	0.07	BF158	0.18	BF363	0.31	BU208A	1.52	2N3708	0.12
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				BC558	0.07	BF167	0.24	BF457	0.23	BU326A	1.42	2N5296	0.48
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E182CC	4.50	ECL86	0.74	EM80	0.70	ME1402	4.50	PFL200	1.13	RG3-250A	11.75	4CX-350A	39.00
E810F	8.25	EF37A	3.00	EM84	0.65	MU14	1.40	PL360	0.96	STV280/40	8.00	5B/254M	11.50
EABC80	0.56	EF39	2.00	EMM803	2.25	N78	8.90	PL81A	0.74	STV280/80	23.00	5B/255M	15.00
EAF801	1.40	EF50	1.50	EN32	9.50	OA2	0.78	PL84	0.65	TY2-125A	30.00	5R4GY	1.25
EB91	0.52	EF80	0.48	EN91	1.60	OB2	0.80	PL500	1.12	TY3-250A	28.00	5R4WGY	1.85
EBC41	0.85	EF85	0.48	EN92	2.55	PC86	0.80	PL504	1.13	TY4-350	90.00	5U4G	0.90
EBC81	0.85	EF86	0.70	EY51	0.80	PC88	0.80	PL508	1.48	TY4-500A	41.50	5Z4G	0.90
EBC89	0.85	EF89	0.65	EY84	9.00	PC92	0.85	PL509	2.30	U19	11.95	6AF4A	1.20
						PC97	0.85	PL519	2.00	U25	0.68	6AW8	3.25
						PCC84	0.48	PL802	2.50	UABC80	0.65	6BW6	4.00

6CL6	1.50	12AU6	0.60	92AG	7.85	5763	3.20
6EA8A	1.00	12AU7	0.60	92AV	7.85	5814	2.75
6J5GT	1.00	12AX7	0.65	150B2	1.50	5876A	8.25
6KD6	0.50	12BA6	0.80	150B3	3.90	5879	3.90
6L7	0.75	12BE6	1.05	155UG	25.00	5965	3.00
6LD20	0.60	12BH7	0.95	807	1.00	6057	2.75
6L6GC	1.75	12EI	16.50	811A	9.00	6060	1.20
6L6GT	1.10	12SN7GT	1.85	813	11.30	6067	3.00
6SL7GT	1.05	30FL2	1.24	833A	47.85	6080	4.20
6SN7GT	0.90	30PL1	2.50	866A	2.50	6146A	4.45
6V6GT	1.05	40KD6	2.80	2050A	3.90	6146B	4.85
6X5GT	0.65	85A1	5.40	5642	6.00	6870	11.50
11E2	15.50	85A2	1.20	5687	5.15	7025	1.50
12AC6	0.80	90C1	1.00	5696	2.55	7360	7.50
12AT7	0.60	90CG	10.85	5749	3.00		

WIREWOUND RESISTORS

4 WATT	4R7 5R6 6R8 10R 22R 33R 47R 68R 100R 150R 220R 330R 470R 1K 1K5 1K8	0.13
	2K2 2K7 3K3 3K9	0.15
	4K7 5K6 6K8	0.17
	10K	0.22
7 WATT	R47 R68	0.12
	1R 1R5 2R2 3R3 4R7 6R8 10R 15R 22R 33R 47R 56R 68R 100R 220R 330R 560R 1K 1K5 1K8 2K2 2K7 3K3 4K7	0.14
	5K6 6K8 8K2 10K 12K	0.15
	15K 22K	0.18
11 WATT	1R 1R5 2R2 3R3 4R7 5R6 6R8 10R 15R 22R 33R 47R 68R 100R 150R 220R 470R 680R 1K 2K2 3K3 4K7 6K8 i0	0.17
	10K	0.18
	15K	0.21
17 WATT	1R 1R5 2R2 3R3 4R7 6R8 10R 15R 22R 33R 47R 68R 100R 150R 220R 470R 680R 1K 3K3 4K7 6K8 10K	0.24
	15K 22K	0.25

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WW—024 FOR FURTHER DETAILS

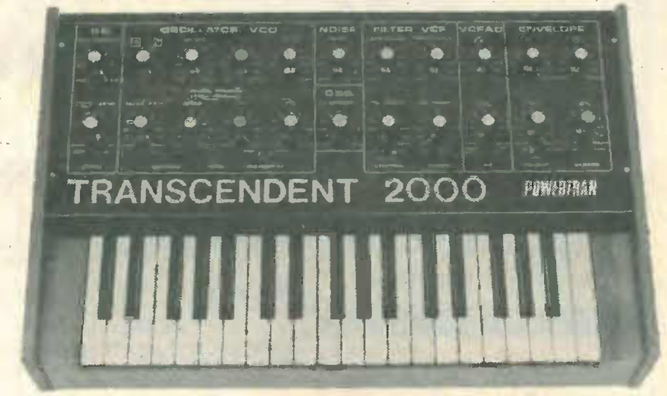
TRANSCENDENT 2000 SINGLE BOARD SYNTHESIZER

Designed by consultant Tim Orr (formerly synthesizer designer for EMS Ltd.) and featured as a constructional article in ETI, this live performance synthesizer is a 3 octave instrument transposable 2 octaves up or down giving sweep control, a noise generator and an ADSR envelope shaper. There is also a slow oscillator, a new pitch detector, ADSR repeat, sample and hold, and special circuitry with precision components to ensure tuning stability amongst its many features.

The kit includes fully finished metalwork, fully assembled solid teak cabinet, filter sweep pedal, professional quality components (all resistors either 2% metal oxide or ½% metal film), and it really is complete – right down to the last nut and bolt and last piece of wire! There is even a 13A plug in the kit – you need buy absolutely no more parts before plugging in and making great music! Virtually all the components are on the one professional quality fibreglass PCB printed with component locations. All the controls mount directly on the main board, all connections to the board are made with connector plugs and construction is so simple it can be built in a few evenings by almost anyone capable of neat soldering! When finished you will possess a synthesizer comparable in performance and quality with ready-built units selling for many times the price.

Comprehensive handbook supplied with all complete kits! This fully describes construction and tells you how to set up your synthesizer with nothing more elaborate than a multi-meter and a pair of ears!

COMPLETE KIT ONLY £168.50 + VAT!



Cabinet size 24.6" × 15.7" × 4.8" (rear) 3.4" (front)

NEW! TRANSCENDENT POLYSYNTH

Cabinet size 31.1" x 19.6" x 7.6" (rear) 3.4" (front)

EXPANDABLE POLYPHONIC SYNTHESIZER AS FEATURED IN ELECTRONICS TODAY INTERNATIONAL

By brilliant design work and the use of high technology components the Polysynth brings to the reach of the home constructor a machine whose versatility and range of sounds is matched only by ready-built equipment costing thousands of pounds. Designed by synthesizer expert Tim Orr and being published in Electronics Today International, this latest addition to the famous Transcendent family is a 4-octave (transposable over 7½-octaves) polyphonic synthesizer with internally up to 4 voices making it possible to play simultaneously up to 4 notes, whereas conventional synthesizers handle only one at a time.

The basic instrument is supplied with 1 voice and up to 3 more may be plugged in. A further 4 voices may be added by connecting to an expander unit, the metalwork and woodwork of which is designed for side-by-side matching with the main instrument. Each voice is a complete synthesizer in itself, with 2 VCOS, 2 ADSRS, a VCA and a VCF (requiring only control voltages and a power supply, the voice boards are also very suitable for modular systems). One of these voices is automatically allocated to a key as it is operated. There are separate tuning controls for each VCO of each voice. All other controls are common to all the voices for ease of control and to ensure consistency between the voices.

COMPLETE KIT ONLY £320
+ VAT (Single Voice)
Extra voices, £52 + VAT or £48 + VAT if ordered with kit.

EXPANDER, COMPLETE KIT £295
+ VAT

Although using very advanced electronics the kit is mechanically very simple with minimal wiring, most of which is with ribbon cable connectors. All controls are PCB mounted and the voice boards fit with PCB mounted plugs and sockets. The kit includes fully finished metalwork, solid teak cabinets, professional quality components (resistors 2% metal oxide or metal film of 0.5% and 0.1%), nuts, bolts, etc.

TRANSCENDENT DPX MULTI-VOICE SYNTHESIZER

Another superb design by synthesizer expert Tim Orr published in Electronics Today International

COMPLETE KIT ONLY £299 + VAT!

Cabinet size 36.3" × 15.0" × 5.0" (rear) 3.3" (front)

The Transcendent DPX is a really versatile 5 octave keyboard instrument. These are two audio outputs which can be used simultaneously. On the first there is a beautiful harpsichord or reed sound – fully polyphonic, i.e. you can play chords with as many notes as you like. On the second output there is a wide range of different voices, still fully polyphonic. It can be a straightforward piano as a honky tonk piano or even a mixture of the two! Alternatively you can play strings over the whole range of the keyboard or brass over the whole range of the keyboard or should you prefer – strings on the top of the keyboard and brass as the lower end (the keyboard is electronically split after the first two octaves) or vice-versa or even a combination of strings and brass sounds simultaneously. And on all voices you can switch in circuitry to make the keyboard touch sensitive! The harder you press down a key the louder it sounds – just like an acoustic piano. The digitally controlled multiplexed system makes practical touch sensitivity with the complex dynamics law necessary for a high degree of realism. There is a master volume and tone control, a separate control for the brass sounds and also a vibrato circuit with variable depth control together with a variable delay control so that the vibrato comes in only after waiting a short time after the note is struck for even more realistic string sounds.

To add interest to the sounds and make them more natural there is a chorus / ensemble unit which is a complex phasing system using CCD (charge coupled device) analogue delay lines. The overall effect of this is similar to that of several acoustic instruments playing the same piece of music. The ensemble circuitry can be switched in with either strong or mild effects.

As the system is based on digital circuitry digital data can be easily taken to and from a computer (for storing and playing back accompaniments with or without pitch or key change, computer composing, etc., etc.)

Although the DPX is an advanced design using a very large amount of circuitry, much of it very sophisticated, the kit is mechanically extremely simple with excellent access to all the circuit boards which interconnect with multiway connectors, just four of which are removed to separate the keyboard circuitry and the panel circuitry from the main circuitry in the cabinet.

The kit includes fully finished metalwork, solid teak cabinet, professional quality components (all resistors 2% metal oxide), nuts, bolts, etc., even a 13A plug!

POWERTRAN MANY MORE KITS AND ORDERING INFORMATION ON PAGE 91

All projects on this page can be purchased as separate packs, e.g. PCBs, components sets, hardware sets, etc. See our free catalogue for full details and prices.

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200 Mixed Diodes – mainly Germ OA81-91-1N34/60 GC61/62 etc. Case DO-7. Coded and uncoded – You to test – Value all the way!
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As above but with coiled lead and rotary volume controls.
O/No. 884. £7.00

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7 metre Headphone Extension Lead.
O/No. 136. £1.50

ANTEX
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O/No. 1931. £4.00
ST3 Iron Stand – Suitable for above – OUR Sale Price
O/No. 1939. £1.25 each

POPULAR (CMOS)
CD4001, CD4007, CD4011, CD4017, CD4081 – 1 of each, normal price £1.80 for 5 – Our price £1.30 for 5
O/No. SJ1245

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Set of 4 1-metre Colour coiled leads with phono plug ends – ideal for audio and test use. Outstanding Value.
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1mm Plugs & Sockets in Red & Black.
O/No. SJ123. 5 prs £1.00

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SJ11	150 Caps. mixed types & values.	£0.50
SJ12	60 Electrolitics all sorts mixed.	£0.50
SJ13	40 Polyester/polystyrene capacitors mixed.	£0.50
SJ14	50 C280 type capacitors mixed.	£1.00
SJ15	Polystyrene Caps 1,160v	£0.50
SJ16	40 Low volts electrolitics mixed values up to 10v.	£0.50

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No.	Secondary	
2021	6v-0-6v 100mA	£0.75
2023	12v-0-12v 100mA	£0.95
2035	240v Primary 0-55v 2A Secondary	£5.50

BC108 FALLOUTS
50 NPN BC107/108 SJ124 £1
Manufacturers out of spec on volts or gain or neither – Metal TO18 case – You test.
50 PNP BC177/178 SJ1244 £1

DIODES
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NPN – like 2N706/2N2369
You select by test!
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EPROM 2516/2716 @ £6.00
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741P	5 for £0.80	
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BD131 TO-126-NPN untested.
O/No. SJ84. 25 for £1.00

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TO66 SCRs 5 Amp – ALL good – untested for volt – good yield 400.
O/No. SJ130. 10 for £1.00

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SJ38	11	16 pin	SJ43	4	28 pin
SJ39	8	18 pin	SJ44	3	40 pin
SJ40	7	20 pin			

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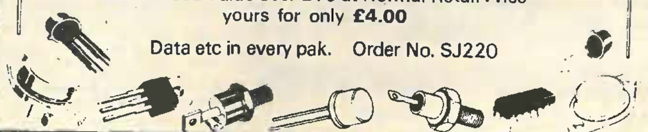

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Push-to-break as above.
O/No. SJ132. 4 for £0.50
Silicon Heat Sink Compound
3mL in syringe £0.25

SILICON TRANS.
SJ25 100 Silicon NPN transistors all perfect & coded – mixed types with data – equivalent sheet – no rejects £2.50
SJ26 100 Silicon PNP transistors all perfect & coded – mixed types and cases, data & equivalent sheet £2.50
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S122 10.125 RED £0.50
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SJ72 4 2N3055 silicon power NPN transistors TO3 £1.00

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SJ23 Siemens 220v AC relay DPDT contacts 10 amp rating – housed in plastic case. £1.00

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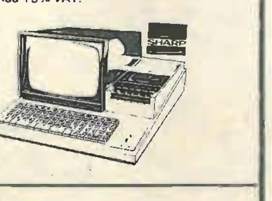

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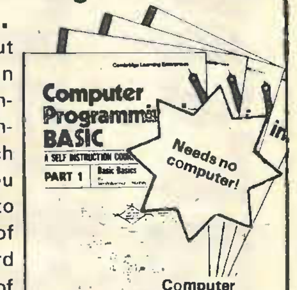

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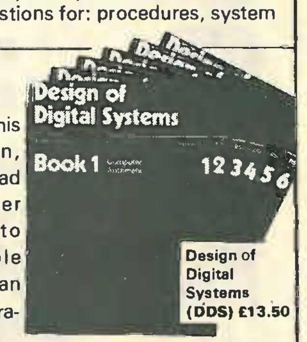

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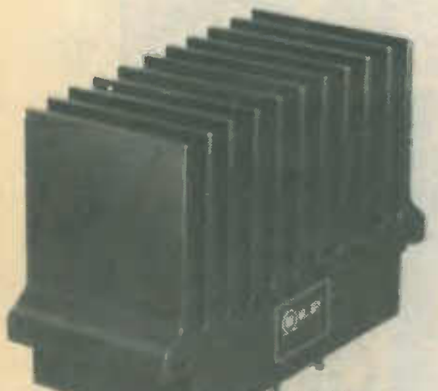

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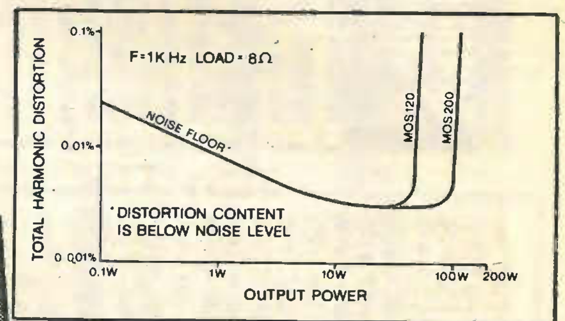

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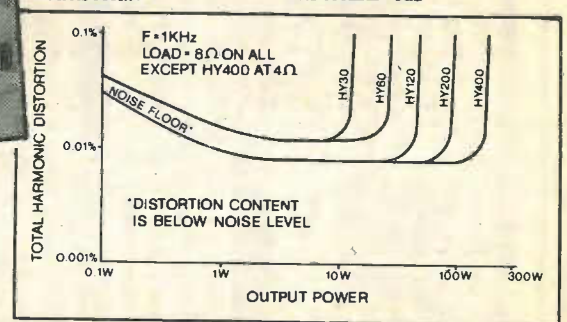

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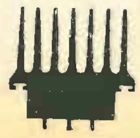

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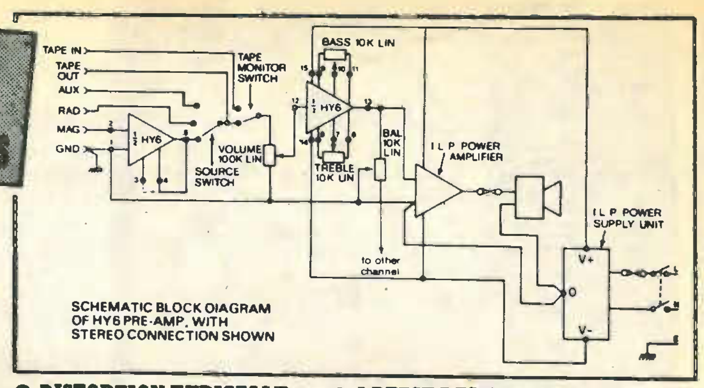

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DIAMOND H CONTROLS ROTARY SWITCH. Single pole 10-way. Printed Circuit Mount. **New 10p ea.** 100 for **£7.50**

PULSE TRANSFORMER. Sub min. Size ½ × 5/16 × ¼". Secondary centre tapped. **New 20p ea.**
REMO TV TYPE MULTIPLIER. Two high voltage outputs and focus. **£1 each.**
DON'T TAKE CHANCES. Use the proper EHT CABLE. **10p per metre** or **£7.50 per 100 metre/drum.** P&P £2.
PHOTOGRAPHIC LAMPS. Pearl 230V 500 watt. Screw cap **75p ea.** Box of 12 **£6.50.** P&P £1.50.
RAPID DISCHARGE capacitors 8mfd 4kV **£5 each.** P&P £2.
MYSTERY IC PACK. Some 40 pin — good mixture — all new devices. **25 ICs for £1.** P&P 50p.
DECOUPLING CAPACITORS
0.05mfd 10V; 0.01mfd; 0.047mfd 250V; 33K, 330pf. All values 100 for **£1.50.**
E.H.T. Capacitor 500pf 8KV 20p each.
10-way MULTI COLOUR RIBBON CABLE. New 40p per metre. 10 metres for £3.
GEC UHF 4-button tuner **£1.50 each.**
CENTAUR 115V FANS 4½ × 4 × 1½" **£4.50 ea.**
EX-USED equipment, tested, **60p each.**
CONTACTORS. Heavy Duty 24V DC 5 make **£1 each.**
GEC UHF/VHF 6-button tuner **£2 each.**
931A PHOTO MULTIPLIER £2 each. P&P £1.
RANCO 250V 16A THERMOSTATS with Control knobs calibrated 50-200 degree C **£2.50 each.**
SOLID STATE UHF TUNERS. 30 acs **£1 each.**
BRAND NEW blue wire wrap. 30 metres for **£1.** P&P 25p.
SLIDER CONTROL 500K Log. Single track. Complete with knob. Length 3½". **25p each.**
TRANSFORMERS
AUTO 240V input 115V. 1 Amp output **£1.25 each.** P&P £1.25.
240V input. Sec. 6V. 1.86A. Size 2½ × 2 × 2". Good quality. **£1.50 ea.** P&P £1.
240V input Boc. 12V 0.92A. Size 2½ × 2 × 2". Good quality, **£1.50 ea.** p&p £1.
240V input 12V 100MA. Size 50 × 40 × 42mm. **50p each.**
240V input. Sec. 12-0-12V 50MA. Size 53 × 45 × 40mm. **£1 ea.**
115V input. Sec. 5V 250MA. Size 1 11/6 × 1.5 × 1¼". **2 for 50p.**
115V input. Sec 10-0-10V1A. Size 2½ × 2 × 2". 2 for **£1.50.**
SEMICONDUCTORS
1N4005 — **5p;** 1N4002 — **3p.**
At 5p each.
BC147, BC148B, BC157, BC158, BC237, BF197, OA90, OA81, BA154, BA243.
At 25p each.
TIP31, TIP41A, 2N5296, AF139, 2TX341.
BY127 **10p.** BF181 **20p;** BD239 **49p;** BD241 **40p;** MA343AT **49p;** BD228 **50p;** BD233 & BD234 Comp Pair 25W — **80p per pr. at 50p each.**
REGULATOR TBA625 8to 20V in — 5V out 100MA TO5 Con. **50p each BF256C 20p.**
TV AMPLIFIER TBA 120 **20p each**

Integrated Circuits					
		74H74	**12p**	75325	**£1**
7453	**5p**	74H51	**7p**	SN15862	**4p**
7451	**5p**	74538	**10p**	MC4028	**69p**
7402	**12p**	74502	**12p**	7417	**14p**
7476	**20p**	74154	**70p**	7441	**40p**
7495	**35p**	74C02	**16p**	74C86	**50p**
74122	**12p**	74C04	**18p**	74C161	**24p**
74C00	**17p**	74C74	**18p**		

MOTOROLA DUAL in Line 6 pin Opto Coupler **30p each.** Gold plate tester version **50p each.**
EPROMS 2708 **£5.50 each.**
SMITHS encapsulated transistorised AUDIBLE WARNING DEVICES 4V-12V. Can be driven from TTL **65p each.**
ELECTROSTATIC VOLTMETER. 7.5KV **£8. ea.** P&P £1.50. Other ranges available — please enquire.
TRIMMERS. Sub min. 0.25 to 1.25 pf. 1 to 4.5 pf. 7 to 45 pf. **All at 5p each.**
HONEYWELL humidity controllers **50p each.**
THYRISTOR TIMER. Solid State. 15 secs adjustable (reset) in plastic relay case. Standard 7-pin base. Series delay **50p each.**
MINIATURE PC MOUNT SLIDE SWITCH. Single pole 3-way **10p each.**
4 DIGIT 7 SEGMENT per digit plus a figure one to the left plus a centre minus sign to the left of the figure one with decimal places between digits. Good brilliance at 1.5V. 15 connections **£2.50 each.** Some E.H.T. Transformers and Capacitors available. Please enquire.
TELEPHONES 706 style black; grey or blue **£5.50 ea;** 746 style black or grey **£7.50.** Older style black **£2.50 each.** Discoloured grey 706 **£4 ea** P&P £1.50 per telephone.
DC SERVO MOTOR 110V 2.5Amp continuous. Double shaft. Brand new. 4 wire. 4 brush **£25 ea.** Plus carriage.
PC Mount POTS. Wire wound with knob 200 ohm & 10ohm. **10p ea.**
MIN. RELAY 24V. 2 pole c/o. Brand new **75p each.**
TIME DELAY RELAY 0.1 to 10 secs. 115V AC. DPDT **£5 each.**
CAPACITORS at **5p each.** 0.1uf 400V. Small rec. block PC Mount German class; 3300pf; 220nf250V; 0.01mfd 160V.
INSERT can be used as Microphone/Earpiece (Like used as insert in telephone but superior quality) Ex-Min. Brand new wrapped **75p** each, or 10 for **£6.**
TORODIAL TRANSFORMERS. Input 0-120-240 Volts. Output 0-12V; 0-12V. 10VA per winding. Encapsulated — identical to R.S. Components at £8.90. OUR SPECIAL PRICE **£5 ea.** P&P £1.50.
TANTALUM CAPACITORS —All at 10p each — 100 off **£7.50.** 22mfd 6V; 39mfd 10V; 22mfd 35V; 1mfd 35V.
MINIATURE SLIDE SWITCHES. Single pole 2 way **10p** each, 10 off **80p.**
HEAVY DUTY RHEOSTAT. 7.5Ohm 5.5Amp. Diameter 5". Standard ¼" shaft **£2.50 each.** P&P £1.50.

LARGE EX-MINISTRY SPEAKERS. OUTSIDE 15 ohm or 500 ohm. Tested £25 each or 5 for £100.

MINIMUM ORDER £3 VALUE OF GOODS. MINIMUM P&P £1 — where P&P not stated please use own discretion — excess refunded.
£5 CARRIAGE ON ALL UNITS. P&P or CARRIAGE and VAT at 15% on total MUST BE ADDED TO ALL ORDERS.
CALLERS VERY WELCOME STRICTLY BETWEEN 9am-1pm and 2-5pm Monday to Saturday inc.
BARCLAYCARD (VISA) and ACCESS taken. Official orders welcome.

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NORWOOD ROAD, READING **TELEPHONE NO. READING 669656**
(2nd turning left past Reading Technical College in King's Road then first right — look on right for door with "Spoked Wheel")

POPULAR KITS AND PARTS

TRANSMITTER SURVEILLANCE
Tiny, easily hidden but which will enable conversation to be picked up with FM radio. Can be made in a matchbox — all electronic parts and circuit **£2.30.**

RADIO MIKE
Ideal for discos and garden parties, allows complete freedom of movement. Play through FM radio or tuner amp **£8.50.**

SAFE BLOCK
Mains quick connector will save you valuable time. Features include quick spring connectors, heavy plastic case and auto on and off switch. Complete kit **£1.95.**

LIGHT CHASER
Gives a brilliant display — a psychedelic light show for discos, parties and pop groups. These have three modes of flashing, two chase-patterns and a strobe effect. Total output power 750 watts per channel. Complete kit. **Price £18.** Ready made up **£4 extra.**

FISH BITE INDICATOR enables anglers to set up several lines then sit down and read a book. As soon as one has a bite the loudspeaker emits a shrill note. Kit. **Price £4.90.**

6 WAVEBAND SHORTWAVE RADIO KIT
Bandspread covering 13.5 to 32 metres. Based on circuit which appeared in a recent issue of Radio Constructor. Complete kit, includes case-materials, six transistors, and diodes, condensers, resistors, inductors, switches, etc. Nothing else to buy, if you have an amplifier to connect it to on a pair of high resistance headphones. Price **£11.95.**

SHORT WAVE CRYSTAL RADIO
All the parts to make up the beginner's model. Price **£2.30.** Crystal earpiece **65p.** High resistance headphones (give best results) **£3.75.** Kit includes chassis and front but not case.

RADIO STETHOSCOPE
Easy to fault find — start at the aerial and work towards the speaker — when signal stops you have found the fault. **Complete kit £4.95.**

INTERRUPTED BEAM KIT
This kit enables you to make a switch that will trigger when a steady beam of infra-red or ordinary light is broken. Main components — relay, photo transistor, resistors and caps, etc. Circuit diagram but no case. Price **£2.30.**

OUR CAR STARTER AND CHARGER KIT has no doubt saved many motorists from embarrassment in an emergency you can start car off mains or bring your battery up to full charge in a couple of hours. The kit comprises: 250w mains transformer, two 10 amp bridge rectifiers, start/charge switch and full instructions. You can assemble this in the evening, box it up or leave it on the shelf in the garage, whichever suits you best. **Price £11.50** + £2.50 post.

G.P.O HIGH GAIN AMP/SIGNAL TRACER. In case measuring only 5¼in x 3¼in x 1¼in is an extremely high gain (700B) solid state amplifier designed for use as a signal tracer on GPO cables etc. With a radio it functions very well as a signal tracer. By connecting a simple coil to the input socket a useful mains cable tracer can be made. Runs on standard 4½v battery and has input, output sockets and on-off volume control, mounted flush on the top. Many other uses include general purpose amp, cueing amp etc. **An absolute bargain at only £1.95.** Suitable 80 ohm earpiece 69p.

VU METER
Edgewise mounting through hole size 1¾ × ⅛" approx. These are 100 micro amps f.s.d. and fitted with internal 6 volt bulb for scale illumination, also have zero reset. The scale is not calibrated but has very modern appearance. **Price £2.88.**

BALANCE METER. Edgewise mounting 100 UA centre zero. **Price £2.30.**

1⅞in SQUARE PANEL METER. Eagle full vision plastic front, 50 UA, **Price £4.60.** 1mA **Price £4.03.**

WATERPROOF HEATING WIRE. 60 ohms per yard. This is a heating element wound on a fibre glass coil and then covered with p.v.c. Oozens of uses — around water pipes, under grow boxes, in gloves and socks. **23p metre.**

DIAL INDICATOR. As used in toolmaking and other precision measuring operations, the famous John Bull accurately shows differences of .01mm. A beautifully made precision instrument, price in most toolshops would be £12-£15. We have a fair quantity. **Price £9.20.**

COMPONENT BOARD Ref. W0998
This is a modern fibreglass board which contains a multitude of very useful parts, most important of which are: 35 assorted diodes and rectifiers including four 3 amp 400v types (made up in a bridge). B transistors, type BC107 and 2 type BFY51, electrolytic condensers, SCR ref. 2N 5062 25 Ouf 100v DC and 100uf 25v DC and over 100 other parts including variable, fixed and wire wound resistors, electrolytic and other condensers. A real snip at **£1.15.**

FRUIT MACHINE HEART. 4 wheels with all fruits, motorised and with solenoids for stopping the wheels with a little ingenuity you can defy your friends getting the "jackpot". **£9.95** + **£4** carriage.

DESOLDERING PUMP
Ideal for removing components from computer boards as well as for service work generally. Price **£5.35.**

4-CORE FLEX CABLE
White pvc for telephone extensions, discolights, etc. 10 metres **£2,** 100 metres **£15.** Other multicore cable in stock.

MUGGER DETERRENT
A high-note bleeper, push latching switch, plastic case and battery connector. Will scare away any villain and bring help. **£2.50** complete kit.

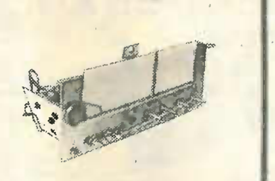
HUMIDITY SWITCH
American made by Honeywell. The action of this device depends upon the dampness causing a membrane to stretch and trigger a sensitive microswitch. Very sensitive breathing on it for instance will switch it on. Micro 3 amp at 250V a.c. Only **£1.15.**

HALF-PRICE CABLE OFFERS. We have good stocks of:

Size mm	Type	Price 100 metres	Carriage
1.5	Single	£4.00	£1.75
1.5	Flat twin	£6.50	£2.75
1.5	Flat 3-core & E	£0.75	£3.50
4	Single	£7.50	
4	Flat twin	£11.50	£4.00
6	Flat 3-core	£32.50	£5.00
16	Twin & E	£79.00	£10.00

MINI-MULTI TESTER
Deluxe pocket size precision moving coil instrument, jewelled bearings—2000 o.p.v. mirrored scale.
11 instant ranges measure:
DC volts 10, 50, 250, 1000.
AC volts 10, 50, 250, 1000.
DC amps 0-100 mA.
Continuity and resistance 0-1 meg ohms in two ranges. Complete with Test Prods and instruction book showing how to measure capacity and inductance as well. Unbelievable value only **£6.75 + 50p** post and insurance.

SUPER HI-FI SPEAKER CABINETS. Made for an expensive Hi-Fi outfit — will suit any decor. Resonance free cut-outs for 8in woofer and 4in tweeter. The front material is carved Decron, which is thick and does not need to be stuck in end the completed unit is most pleasing. Colour black. Supplied in pairs. **Price £6.90 per pair** (this is probably less than the original cost of one cabinet). Carriage £3 the pair.



RADIO CHASSIS BARGAIN. 3 waveband radio with stereo emplifier. Mede for incorporation in a high-class radiogram, this has a quality of output which can only be described as superb. It is truly hi-fi. The chassis size is approximately 14". Push buttons select long, medium, short and gram. Controls are balance, volume, treble and bass. Mains power supply. The output is 6+6 watts. Brand new and in perfect working order, offered at less than value of stereo amp alone, namely **£6.90.** Post £2.00.

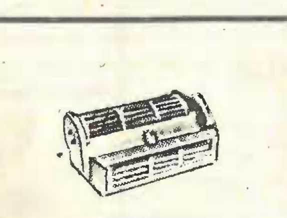
MULLARD UNILEX

A mains-operated 4 + 4 stereo system. Rated one of the finest performers in the stereo field this would make a wonderful gift for almost anyone. In easy-to-assemble modular form this should sell at about **£30**—but due to a special bulk buy and as an incentive for you to buy this month we offer the system complete at only **£16** including V.A.T. and postage.
FREE GIFT—Buy this month and you will receive a pair of **Goodman's** elliptical 8" × 5" speakers to match this amplifier.

THIS MONTH'S SNIP

THERMOSTAT ASSORTMENT
10 different thermostats, 7 bi-metal types and 3 liquid types. There are the CURRENT STATS which will open to protect devices against overload, short circuits etc. or when fitted say in front of the element of a blower heater, the heat would trip the stat, APPLIANCE STATS, one for high temperatures, others adjustable over a range of temperatures which could include 0-100C. There is also a THERMOSTATIC POD which can be immersed, an oven stat, a calibrated BOILER STAT, finally an ICE STAT which fitted to our waterproof heater element up in the loft could protect your pipes from freezing. Separately these thermostats would cost around about **£15** — however, you can have the parcel for **£2.50.**

WALL MOUNTING THERMOSTATS. The Danfoss, a handsome 2 tone, intended for living rooms but is just as efficient in a greenhouse or store. It is suitable for normal air temperature range 32F-80F. **Price £4.60.**



3KW MODEL
£8.95+£1.50 P & P

TANGENTIAL HEATER UNIT
A most efficient and quiet running blower-heater by Solatron — same type as is fitted to many famous name heaters — comprises mains induction motor, long turbo fan, split 2kw heating element and thermostatic safety trip. Simply connect to the mains for immediate heat. Mount in a simple wooden or metal case or mount direct onto base of, say, kitchen unit. Price **£5.95,** post £1.50. Control switch to give 2kw, 1kw, cold blow or off available 60p extra. 3kw model **£6.95.** Control switch **95p.**

3-CHANNEL SOUND TO LIGHT KIT
Complete kit of parts for a three-channel sound to light unit controlling over 2,000 watts of lighting. Use this at home if you wish but it is plenty rugged enough for Disco work.
This unit is housed in an attractive two-tone metal case and has controls for each channel, and a master on/off. The audio input and output are by ¼" sockets and three panel mounting fuse holders provide thyristor protection. A four-pin plug and socket facilitate as of connecting lamps. Special snip price is **£14.95** in kit form or **£18.95** assembled and tested.

AC CONDENSERS
For motor starters, power factor correction voltage droppers. The voltage quoted is ACRMS, or for DC at 2½ times the AC voltage.

1.5 mfd 440V	**64p**	6.25 mfd 250V	**£1.00**	12 mfd 440V	**£2.78**
2.5 mfd 440V	**87p**	8 mfd 250V	**£1.27**	13 mfd 275V	**£1.65**
3.4 mfd 440V	**£1.00**	8 mfd 440V	**£1.89**	15 mfd 325V	**£1.77**
3.5 mfd 250V	**77p**	11 mfd 275V	**£1.52**	20 mfd 275V	**£1.77**
5 mfd 570V	**£1.52**	12 mfd 250V	**£1.52**	32 mfd 250V	**£2.89**

SUPER CONSTRUCTOR'S SNIP
Here's a super bargain for you. 100 twist drills, regular toolshop price over £50, yours for **only £11.50.** With these you will be able to drill metal, wood, plastic, etc, from the tiniest holes in P.C.B. right up to about 5mm. Don't miss this snip — send your order today.

TERMS: Cash with order—but orders under **£10** must add **50p** to offset packing, etc.
BULK ENQUIRIES INVITED - PHONE HAYWARDS HEATH 54563
ACCESS & BARCLAYCARD WELCOMED

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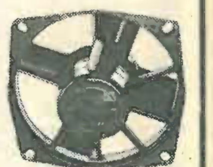
HAYWARDS HEATH, SUSSEX, RH16 3QU

IT'S FREE
Our monthly Advance Advertising Bargains List gives details of bargains arriving or just arrived—often bargains which sell out before our advertisement can appear—it's an interesting list and it's free—just send S.A.E. Below are a few of the Bargains still available from previous lines.

DUE TO THE HIGH & RISING PRICES OF FUEL many companies and probably many householders are looking around for ways of saving some of this cost. One Company bought a number of fans from us and fitted these in the ceiling of their workshops where the hot air tends to collect and they blow this hot air downwards. Another Company has bought fans from us to suck the exhaust from their oil fired central heaters through a zig zag of asbestos pipes, the asbestos pipes being in a separate chamber which becomes a hot air chamber, the hot air from this is blown through ducting to wherever it is needed. Basically, they have cut out the normal chimney and replaced this with one of our high power extractor fans. If you have any other good ideas on heat cost saving, let us know and we will pass it on to other readers.

EXTRACTOR FANS



Ex-COMPUTER MADE BY Woods of Colchester; idea also as blower; central heating systems, fule extraction, etc. Easy fixing through panel, very powerful 2,500 r.p.m. but quiet running. Choice of 2 sizes, 5 **£5.50,** 6 **£6.50;** post £1 per fan. All mains operated.

PING PONG BALL BLOWER-UPPERS
Have you got to organise a party or charity fund-raising event? Then one always popular way is to have ping pong balls going up and down and being caught. We have some powerful blowers and these should be ideal for this, and of course for more serious purposes. They are 4-stage blowers, coupled to synchronised AC mains motors of approximately ⅛ h.p. They have a terrific suction as well as a high velocity blow. Ex-computers, price **£29.**

RECHARGEABLE SOLID GEL BATTERY. 12V 5AH, new and unused, made by or for Elpower Corporation of California. Dimensions 6in. long, 3¾in. high and 2½in. wide. Regular price of similar batteries, R.S. Components, is **£26.** Limited quantity available at **£15 ea.**

E.H.T. UNITS. One of our specialities has always been E.H.T. transformers, and we probably have bigger stocks than most of our contemporaries. It is surprising what uses these high voltages can be put to — killing flies and weeds, lighting central heating boilers, lifting paper, extracting dust, etc. A new one this month is 14.5 KV (dc) 0.5mA. Made by ADVANCE ELECTRONICS, this unit is completely enclosed and has input and output sockets — size of the unit is approximately 6in. x 3in. x 3¾in. Price is **£16.30,** post £1.
To remind you of the E.H.T. Transformers we stock, here is a list:

3-4 KV 3 mA ex equipment	**£2.77**
5 KV 5 mA ex new equipment	**£7.78**
5 KV 5 mA with outer casing and E.H.T. outlets	**£9.45**
8.5 KV 10 mA totally enclosed with E.H.T. outlets	**£12.85**

SUPER BREAKDOWN PARCEL with free gift of a desoldering pump, perhaps the most useful break-down parcel we have ever offered. Consists of 50 nearly all different computer panels on which you will find: over 300 ICs, over 300 diodes, over 200 transistors and many hundred other parts, resistors, condensors, multi turn pots, rectifiers, SCR etc. etc. for only **£8.50,** which when you deduct the value of the desoldering pump, works out to just a little over 4p per panel, + **£1.27** VAT + £2 post (it's a big parcel).

300 WATT MERCURY VAPOUR LAMP. Mazda, ref 90-3104 MAT/V blended. These give a really powerful light but, of course, have to be used with their correct control gear. We are expecting to get this control gear early in the New Year. Price of the lamp is **£3.38 +25p. Post 50p.**

ANTI-FROST THERMOSTAT. The normal refrigerator type thermostat switches off as the temperature falls and so is not suitable for anti-frost devices. However, we have the Ice-stat — this switches on as the temperature falls and is set to switch on just above freezing point. It is a skeleton type stat so would require boxing but the price is modest at **£1.10.**

THIN CONNECTING WIRE 500 metre drums, 7 stranded copper core p.v.c. covered available in 10 different colours. Price **£7.15.**

EXTENSION LEAD BARGAIN. We all know how especially in the cold weather, p.v.c. leads lose a lot of their flexibility, in fact some poor grade p.v.c can be quite stiff and awkward, and will not stay put. We have an extra flexible twin round cable. This is highly suitable for lead lamps, vacuum cleaners, in fact any portable device which does not need an earth. The regular price of this very flexible cable which is suitable for up to 7.5 amps is 30p per metre, and that is buying 1,000 metres at a time. However, this month you can buy 50 metres for **£7.35** inc. post or 250 metres for **£28.50** inc. post.

EXTRA LIGHTWEIGHT HEADPHONES. Stereo, but these weigh only 50 grams (approx. 2oz.) Intended for use whilst playing your instrument in a band, or in normal headphone operation. Japanese made, and extremely good quality. **£7.95 + £1.10.**

COMPUTER PRINTER TERMINAL UNIVAC reference DCT1000, this is a floor standing mains operated printer, which takes a 14" wide paper complete with electronics — in a good clean condition, but untested. Price: **£73 + £11.25, plus delivery at cost.**

8-BIT PUNCH AND READER UNIVAC. Combined is a neat case, this is their model no. 09235-15. Made by the Roytron Company of America, Roytron number being 572-1. This is a desk standing instrument with input and output leads made for 115v operation. The case has a perspex view window and drawer below to hold the tape. Complete with electronics and in very clean condition. Price **£25 inc. post.**

UNIVAC KEYBOARD MODEL NO. F1308-00. A neat keyboard, probably made to be used with the 8 bit punch and reader. Has 57 encoded keys and 10 function switches on a line along the top. The legends on these switches are: auto-manual, monitor off, run-stop, on-line-off-line, keyboard off, printer off, reader off, punch-off, card reader-off, card punch-off,. We have only a few of these, in as new condition. Price **£25.**

AUTO TRANSFORMER 250v to 115v, 1.1KVA in silvered metal case. Used but in perfect order and fully guaranteed. **£13.50.**

BIG ELECTROLYTICS. Bargain parcel of big electrolytics 8 for **£3.30 post paid.**

To obtain further details of any of the coded items mentioned in the Editorial or Advertisement pages of this issue, please complete one or more of the attached cards entering the reference number(s). Your enquiries will be passed on to the manufacturers concerned and you can expect to hear from them direct in due course. Cards posted from abroad require a stamp. These Service Cards are valid for six months from the date of publication.

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(691)

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SOUTH-EAST

Instrumentation Laboratory (UK) Limited is a market leader in the design and manufacture of a range of sophisticated instruments used extensively in clinical and industrial laboratories.

We currently have a vacancy for a Field Service Engineer to cover the S.E. London, Kent, Surrey and Sussex area to install, maintain and repair our range of Biomedical instruments.

Applicants should have a sound background in electronics (C. & G. Final, H.N.C., etc.) and a flair for practical work. A knowledge of microprocessors or computer systems would be an advantage, although not essential. Comprehensive training will be given to the successful applicant on all aspects of the Company's products.

An attractive salary will be offered, together with considerable additional benefits, including Company car, pension scheme, and B.U.P.A. membership.

Applicants who reside within the area or are prepared to move should telephone or write to:

Miss S. M. Houghton
INSTRUMENTATION LABORATORY (UK) LIMITED
Kelvin Close, Birchwood
Warrington, Cheshire, WA3 7PB
Tel: 0925 810141

(843)

INSTRUCTORS

BROADCAST VTRs AND CAMERAS

The Group Training Department in Reading, England, need Instructors to specialise in training courses in broadcast television colour cameras and videotape recorders. Key requirements are:

— Experience as (or the personality to become) an expert instructor with the talent to impart technical information to engineers of many nationalities and varying depth of knowledge

— Practical experience of broadcast television or similar equipment

— Theoretical knowledge of advanced electronics (A knowledge of languages is an advantage)

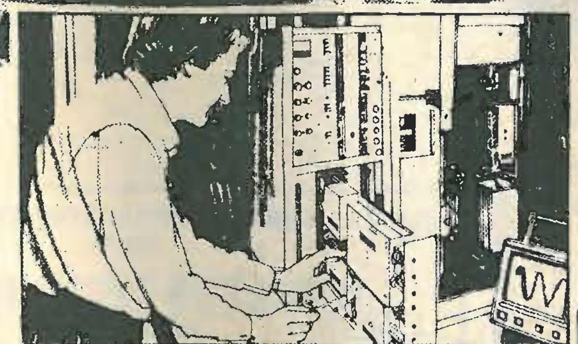
This is an opportunity to join a company in the forefront of technological innovation in a position offering overseas travel and contact with engineers of many countries. Attractive salary, pension, life assurance and permanent health schemes.

AMPEX

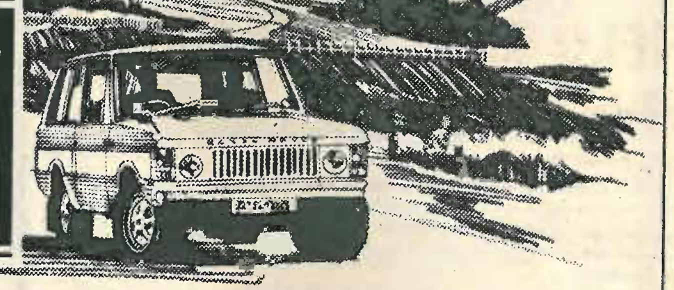
Contact: Maureen Brake
AMPEX GREAT BRITAIN LTD.
Acre Road, Reading, England
Tel: Reading (0734) 85200

Broadcast Transmission Engineering

To ensure that broadcasting services are of consistently high quality provides far greater challenge than you may have realised. It is essential that viewers and listeners can rely on good television and radio reception and at the IBA we have a firm commitment to achieving these superior standards. We operate a network of over 570 transmission stations nationwide, servicing Independent Television and Local Radio, services which we are steadily expanding. An increasing number of transmitting stations and the addition of the fourth channel all mean that ours is the environment to assure your future – we can offer both security and scope. We rely greatly on the skills of our highly trained engineers to maintain our Transmitting Stations so that they are reliable in operation and transmit services of the expected high standard.



Trainee Broadcast Transmission Engineers



We have opportunities for Engineers (male or female) ideally at the HNC/HTC or equivalent level, to join us on our next training programme which commences this summer. Consideration will also be given to applicants at the City & Guilds Full Tech. to CNAA pass degree level. This comprehensive and carefully devised training, in collaboration with a leading Polytechnic, can result in a nationally recognised diploma, and is a step beyond traditional learning, combining theoretical and practical studies to give you a grounding in broadcast engineering that is second to none. During the course we will pay your fees, accommodation and meals and, if you do not already possess a full driving licence, we will arrange and pay for your instruction. Your salary, on satisfactory completion of the training, will be £6,752, and will then rise annually to £8,372 per annum, with further progression to £9,433 per annum. Your initial salary while training will be in the range of £5,000/£5,400 per annum.

Additionally we offer you a generous range of benefits, including free life assurance and personal accident schemes, a contributory pension scheme, generous relocation expenses and subsidised mortgage facilities.

To receive our illustrated information package and application form please write to or telephone Mike Wright, Personnel Officer – Engineering Regions, IBA, Crawley Court, Winchester, Hants, SO21 2QA. Telephone Winchester 822574 or 822273.

IBA INDEPENDENT BROADCASTING AUTHORITY

(841)

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A challenging and full career in Government Service.
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(589)

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Medical Physics Technician Grade IV or III
(ELECTRONICS)

We require a technician to work in a small but busy department which provides a comprehensive medical electronics/physics service to this leading cardio-thoracic hospital.

Within the department the technician will be engaged mainly in electronics work but other scientific or engineering skills would be an advantage. In addition the technician will be required to work in clinical areas trouble shooting and advising staff in the use of equipment.

Salary within the range of £4931-£7277 inclusive depending on experience. For further information contact Chief Technician, Mr. P. Butler, ext. 4252.

For application forms and job description contact Personnel Manager, Miss J. A. Jenks, Brompton Hospital, Fulham Road, London, SW3. Tel. 01-352 8121, ext. 4357.

(900)

CENTRAL SERVICES DEPARTMENT OF THE SCOTTISH OFFICE

WIRELESS TECHNICIANS
(£5,300-£7,060)

Applications are invited for three posts of Wireless Technician in the Central Services Department of the Scottish Office. The posts are based in Inverness, Edinburgh and Montreathmont, Forfar. Candidates must hold an Ordinary National Certificate in Electronic or Electrical Engineering **or** a City and Guilds of London Institute Certificate in an appropriate subject **or** a qualification of a higher or equivalent standard and have three years' appropriate experience.

A clean current driving licence and ability to drive private and commercial vehicles are essential.

Application forms and further information are obtainable from Scottish Office Personnel Division, Room 110, 16 Waterloo Place, Edinburgh EH1 3DN (quote ref. PM(PTS) 2/13/80 (031-556 8400 Ext. 4317 or 5028).

Closing date for receipt of completed application forms is 11 February, 1981.

(897)

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We wish to appoint a LOGIC ENGINEER to form a solid state repair department with practical experience of fault finding on microprocessor controlled logic and TV monitors.

The position offers interesting and varied work in the leisure field with good prospects for the right person, who would also enjoy the benefits of a good salary plus company car.

Please write or telephone for an application form to:

Miss D. Sitch
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Telephone: 01-720 1127

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(9257)

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36¼ hour week. Post superannuable.
Application forms and further particulars are obtainable from the Personnel Officer, Preston Polytechnic, Corporation Street, Preston.
Reference No. NT/80/81/49.
Closing date: 14 days after appearance of advert.

(898)

Sony Broadcast success story means even more career opportunities!

Tremendous growth and success has created the need for even more first class staff for one of the world's leaders in professional television broadcast equipment.

During 1981 some 60 to 70 jobs must be filled, most of which are available now and based at our European Headquarters at Basingstoke, plus several more in other parts of our marketing territory.

If you like the thought of enjoying the success of world leadership then write in strict confidence to Barry White, Personnel Manager, Sony Broadcast, now! And please don't forget the c.v.

Regional Sales Manager – Southern Europe
Reporting to the General Manager, Sales, the successful candidate for this substantial assignment will probably be a qualified television engineer with several years experience in Sales, Marketing and allied areas of commercial activity.

Working from the Basingstoke H.Q. the position offers extensive travel in the Southern European territory. A knowledge of at least one European language apart from English is desirable. This position offers the opportunity for significant career development as part of a talented and highly motivated team.

Sales Manager – Africa
This is a challenging position for an experienced sales engineer or sales manager with a good knowledge of the radio and TV broadcast industry. Knowledge of the African market or other overseas sales territories is highly desirable. The successful candidate, who will be based in Basingstoke, will be expected to spend a substantial part of the time travelling in the territory. The high degree of initiative and self-motivation demanded by this job will be reflected in an above-average salary.

Sales Engineer
We require competent engineers who are experienced in video cameras and/or VTR's to supplement our sales force. A number of vacancies exist in this area, some calling for extensive overseas travel. Successful candidates are likely to be in the age range 25–30 and should be highly motivated and able to work on their own initiative. Experience in selling or dealing with customers would be an advantage but the main requirements are a pleasant personality and ability to get along with people. The salaries will be above average and even better for those willing to travel frequently to West Africa and the Middle East.

Senior Proposals Engineer
Reporting to the Sales Operations Manager. The successful applicant will have a technical background in television engineering preferably in the broadcast industry. He will be required to understand individual equipment as well as overall broadcast systems and will enjoy working with the minimum of supervision, often under pressure.

The work will include the assessment of customer's specifications and the preparation of the company's response to both the technical and commercial conditions. A knowledge of foreign languages would be useful although not essential.

Assistant Product Managers and Product Engineers
We have vacancies for Assistant Product Managers and Product Engineers in each of our four equipment groups: TBC and Editing Systems, Cameras, 1 inch VTR's and U-matic VTR's.

Candidates for the Assistant Manager posts will ideally be graduate engineers with some years of experience in video technology, whereas applicants for the Product Engineers vacancies will probably be less experienced. However, at both levels we are willing to consider the right kind of experience in lieu of formal qualifications.

Successful candidates will receive suitable in-house training to enable them to provide technical product support both within Sony Broadcast and externally to customers.

Lecturer
The successful candidate would conduct theoretical and practical training courses on our major products, be able to write circuit descriptions and produce training manuals with lucid block diagrams.

Ideally, candidates should have in-depth experience of video tape recorders, digital circuits and a practical up-to-date knowledge of the broadcast industry, especially measurement techniques. In addition it is essential that he or she can present ideas clearly and answer the most difficult and unexpected questions. Knowledge, or an ability to master the techniques of video cameras, digital audio equipment and the application of microprocessors to broadcast equipment will be an advantage, although we are prepared to provide the necessary additional training. Promising young graduates will be considered.

R & D Engineers
Sony is now established as the world leader in digital video recording technology. Development is still in the formative stages but rapidly progressing to the new era of the 'All Digital Studio'. The R & D Section is involved in long term investigations into the application of high speed digital techniques to video processing, and in conventional product design. Being part of an international R & D team, the successful applicant may expect occasional opportunities for overseas travel. Applications are invited from engineers offering experience in high speed digital processing or video engineering. Alternatively, a well qualified recent graduate could be considered.

Project Engineers
For our young and enthusiastic Special Projects Team. They will be involved in the design, manufacture and commissioning of static and mobile television systems, and in modifications and accessories. The successful applicant will have a thorough knowledge of sound and television principles. Ideally he or she should also have experience in operational television or its allied manufacturing industry.

QA Technician
Candidates should be experienced in the repair of modern television equipment and also be familiar with digital circuitry. Activities will include the testing and commissioning of advanced broadcast television equipment. A relevant HNC level qualification is desirable.

Service Engineers
Two openings exist, one at a more senior level, for qualified engineers with broadcast television engineering experience in operations and maintenance. The positions will entail responsibility for the repair and test of sophisticated broadcast television equipment, together with minor development work. Some travel within the UK and overseas is anticipated. Candidates for the senior appointment will have had several years experience working in a broadcast environment or for a television broadcast equipment manufacturer, during which time he or she will have worked on VTR and camera equipment. The second position should appeal to engineers with less experience who are now seeking a progressive environment.

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City Wall House
Basing View, Basingstoke
Hampshire RG21 2LA
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(844)

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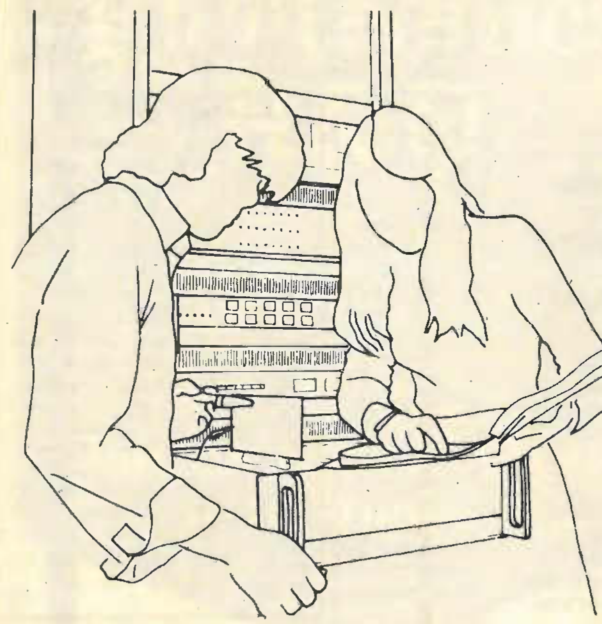

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(Clinical Measurements)
Ref: MPT CM

Applications are invited from suitably qualified persons for the above post based at the Leicester Royal Infirmary.

Duties will consist of providing technical assistance throughout the full range of activities of this section of the department including

i) Ophthlmic Electrodiagnosis
ii) Audiometric Electrodiagnosis
iii) Blood flow studies
iv) Urodynamic measurements

For appointment at Grade III, 3 years' experience is required in at least two of the above categories, preferably i) and ii).

Further information may be obtained by telephone (Mr. S. Bentley) Leicester 541414, ext. 469.

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(Electronics Servicing)
Ref: MPT ES

Applications are invited from suitably qualified persons for the above post. The successful applicant will join the servicing section of the Medical Physics Department and will complete a team of five technicians responsible for the repair and maintenance of a wide range of electromedical equipment throughout the Leicestershire Area.

For further information contact Mr. R. V. Foxon on Leicester 541414, ext. 467.

Candidates for both posts should possess O.N.C./H.N.C. (or equivalent) in a relevant subject. For appointment at Grade IV experience, whilst desirable, is not essential as in post training will be provided.

Salary scales: IV £4404-£5790
III £5223-£6750

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Application forms are available from the Personnel Department, The Leicester Royal Infirmary, Infirmary Square, Leicester, LE1 5WW. Telephone Leicester 541414, ext. 5137/8.

Please quote the relevant reference when applying.

Closing date for applications: February 4, 1981.

Leicestershire Health Service
(899)
LEICESTERSHIRE AREA HEALTH AUTHORITY (TEACHING)

ENGINEER FOR VIDEO COMPANY

We are a fast expanding professional video company dealing with a range of specialist products. Currently we require staff with electronics knowledge to act as service/installation engineers and sales engineers.

Previous knowledge of the video/TV industry is not essential but a good grounding in electronics is required plus a willingness to travel throughout Europe occasionally. Salary negotiable.

Contact: Peter Rowsell at Polar Video Ltd., 36-38 Hanway Street, London W1P 9OE. Phone: 01-631 4080.
(846)

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Salary c £8,500

IAL, based near Heathrow, has a vacancy for a Systems Planning Engineer. Applicants must be suitably qualified and experienced in radio system planning, survey and customer liaison.

Salary dependent upon experience and qualifications. Benefits include relocation expenses, pension scheme and four weeks' leave, plus other amenities.

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Posts in Computers, Medical, Comms, etc. ONC to Ph.D. Free service:
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A Telecommunications Manager is required to control the Communications Division employing 40 people. He will be responsible for maintaining and servicing the equipment and will work closely with the company's consultants throughout the installation period.
An electrical/electronic engineering qualification at least to HNC level, management competence and a minimum of seven years' experience maintaining telecommunication/telephone equipment as specified are essential.
A highly competitive salary will be negotiated plus 15% end of contract gratuity, discretionary bonus and education allowances (where applicable). 60 days' annual leave, passages paid. Free air conditioned accommodation, services and medical attention. Sports and club facilities.
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(6012—£10,539 (Bar)-£11,295)

Candidates will be concerned with the teaching of:

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b) Electronics
or
c) General Electrical and Electronic Engineering

Relevant industrial experience with an appreciation and/or experience of computer engineering to some branch of electrical/electronic engineering, desirable.

Further details and form of application from The Assistant Director (Administration), Trent Polytechnic, Burton Street, Nottingham, NG1 4BU. Forms to be returned as soon as possible.
(903)

TRENT POLYTECHNIC NOTTINGHAM

UNIVERSITY OF BRISTOL

Applications are invited for a post as

ELECTRONICS TECHNICIAN

in the Electronics Laboratory of the Department of Physics at the University of Bristol.
The person appointed will work as a member of a group which is responsible for the design, construction and maintenance of electronic equipment used by the research groups and the teaching laboratories in the department.
The appointment will be made at a level up to, and including, Grade 5 with a starting salary in the range £4306 to £6129. Grading according to skills, qualifications and experience.
Applications, giving full details, should be sent to Dr. R. R. Hillier, Department of Physics, University of Bristol, before 30th January, 1981.
(895)

TECHNICIAN

Grade 6

(Salary scale £6020-£7191 increasing to £6532-£7802 on 1.7.81) required to provide wide-ranging electronic support; maintain and repair sophisticated and complex equipment; design, construct and commission equipment, etc. Applications stating qualifications, age and present salary, and giving the names and addresses of two referees to the Administrator, Department of Metallurgy and Science of Materials, Parks Road, Oxford OX1 3PH.
(901)

WARWICKSHIRE COUNTY COUNCIL
COUNTY ENGINEER'S DEPARTMENT

SALE OF USED MOBILE RADIO EQUIPMENT

The following Used Mobile Radio equipment is for sale by tender:
(1) Base station complete.
(2) 42 transistorised mobile Trans/Receivers Lowband.
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(4) Plus many other items.

Tender documents and appointment to view may be obtained from Mr. T. Inkester, County Engineer's Department, Warwickshire County Council, P.O. Box 50, Shire Hall, Warwick CV34 4RJ. (Telephone Warwick 43431, extension 2373) and tenders should be returned by not later than Monday, 16th March, 1981.

John W. M. Vallis, County Engineer, Shire Hall, Warwick.
(902)

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CRAFT INSTRUCTOR

Salary:
£4437-£5808 p.a. incl.
Michael Flanders Centre
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A person with enthusiasm and initiative required to provide instruction and stimulation for physically handicapped and elderly people at this 75-place day centre.
Knowledge of basic electronics and other forms of suitable arts/crafts/social activities would be useful.
The initial appointment will be on a temporary basis until September, 1981.
For further information contact Neville Davenport on 01-993 1054.
Application form from the Personnel Office, Room A202, Town Hall Annexe, Ealing W5 2BY. Tel. 01-599 2424 Ext. 3350.
Out of hours ansaphone 01-840 1995.
Please quote reference No. 416SS.
Closing date: 30.1.81.
(896)

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