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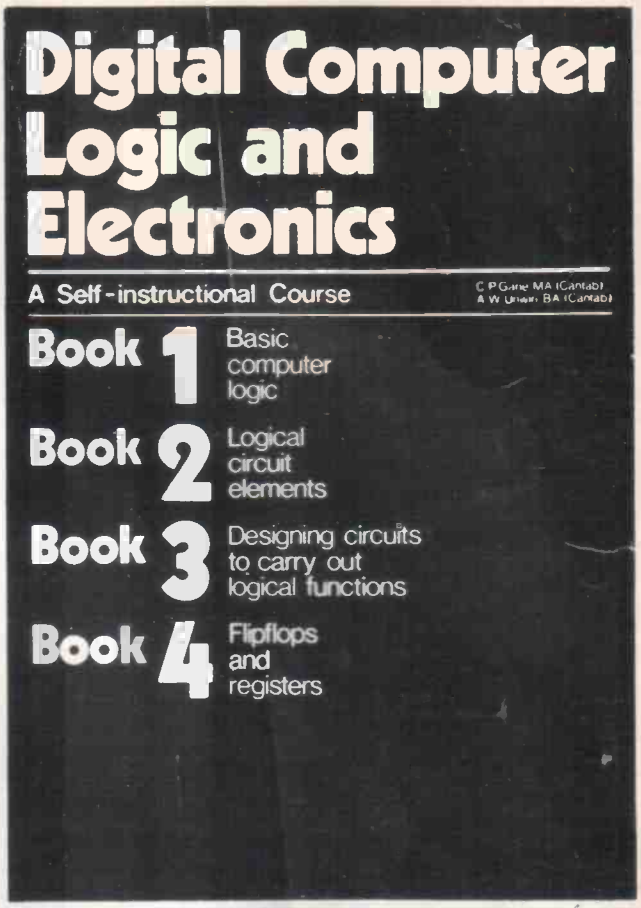

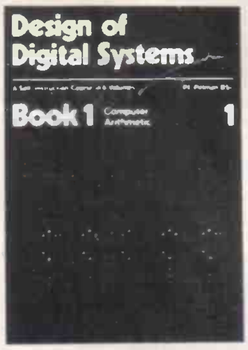

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PS 29	Jack Stereo Plastic	0.28
PS 30	Jack Stereo Screened	0.35
PS 31	Phono Screened	0.17
PS 32	Car Aerial	0.20
PS 33	Co-Axial	0.20

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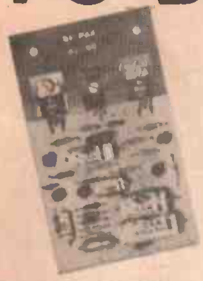

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£13.20

MK 60 AUDIO KIT

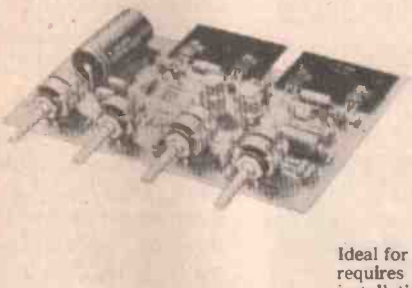
Comprising: 2 x AL60, 1 x SPM80, 1 x BTM80, 1 x PA100, 1 front panel, 1 kit of parts to include on-off switch, neon indicator, stereo headphone sockets plus instruction booklets.

COMPLETE PRICE: £27.55 plus 45p postage.

TEAK 60 AUDIO KIT

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

KIT PRICE: £9.20 plus 45p postage.



STEREO 30 COMPLETE AUDIO CHASSIS

7 + 7 WATTS R.M.S.

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

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

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

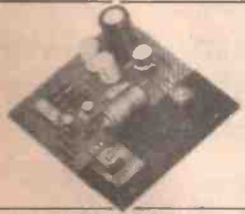
PRICE £15.75 Plus 45p postage & packing

TRANSFORMER £2.45 plus 45p postage & packing

TEAK CASE £3.65 plus 45p postage & packing

PLEASE ADD V.A.T. AT 25% TO ALL ITEMS EXCEPT
*** ADD 8%**
 # NO V.A.T.

GIRO NUMBER
388-7006



AL 10/AL 20/AL 30

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

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

AL10 £2.30, AL20 £2.65, AL30 £2.95

SPEAKERS

E.M.I. LEK 350 Loudspeakers Enclosure kit in teak veneer. Including speakers. Rec. retail price £4.50 per pair.
OUR SPECIAL PRICE
ONLY £27.75 per pair P&P £3
WHILE STOCKS LAST!

HEADPHONES

4-16 ohms impedance frequency response 20 to 20,000 Hz stereo/mono switch and Volume Control £4.55

FRONT PANEL

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

M.P.A.30

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

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

Supplied with full, easy to follow instructions.

PRICE £2.65

STORAGE-CARRY CASES

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

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

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

CARTRIDGES

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

DYNAMIC MICROPHONE

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

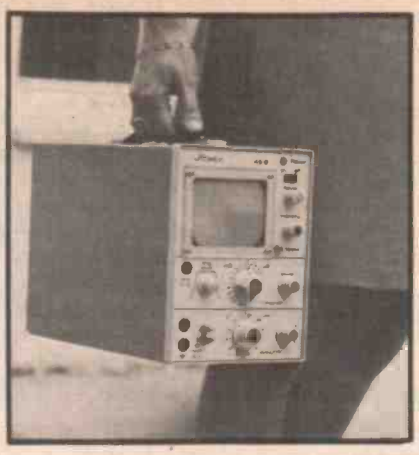
JUST OUT!

STEREO FM TUNER

WRITE *NOW* FOR FULL DETAILS

news digest

NEW SCOPE



Although only formed three years ago, Scopex have managed to take a very nice share of the U.K. oscilloscope market. It is now believed that this company is the only British company making 'scopes now that Advance have been taken over by the U.S. Gould company.

The latest addition to the Scopex range is a truly low-cost unit: price tag is £88 (plus VAT). However this does not mean that every normal facility is reduced to minimum spec. Screen size is a respectable 6cm x 8cm and the unit has a bandwidth of DC—6MHz with 10mV sensitivity. Even included is a 'beam-locate' button — extremely useful for laboratory or experimental work. The circuit includes a really excellent trigger control — this is not a Scopex claim but showed up when ETI had a chance to play with one briefly.

Scopex feel that their main market is education and service engineers but we feel that at this price, with these facilities that the amateur may well be interested.

Scopex Instruments Ltd, Pixmore Industrial Estate, Pixmore Avenue, Letchworth, Herts.

ETI/DORAM COMPETITION

Readers are reminded that the ETI/ Doram Competition with £500 in prizes is still open until the end of October.

Details were given in the September issue - and all you need apart from this is the latest Doram Catalogue. Back numbers of September with the entry coupon in are available from ETI for 35p plus 10p postage.

POLICE 5

For the second time in a year ETI's offices in Ebury Street have been burgled. Amongst the number of items taken was an Advance Executive calculator without a serial number. This is unique, we believe, and anyone coming across one should contact ETI. Fortunately the thief missed the Sinclair Programmable reviewed in this issue.

NEW SCHOTTKY BARRIER DIODES

A new series of Schottky Barrier Diodes are now available in quantity from Ferranti Limited.

The ZC2800 and ZC5800 series of devices are intended primarily for use in R.F. mixer applications. Also, as these are essentially high speed devices, they are eminently suited to pulse shaping applications.

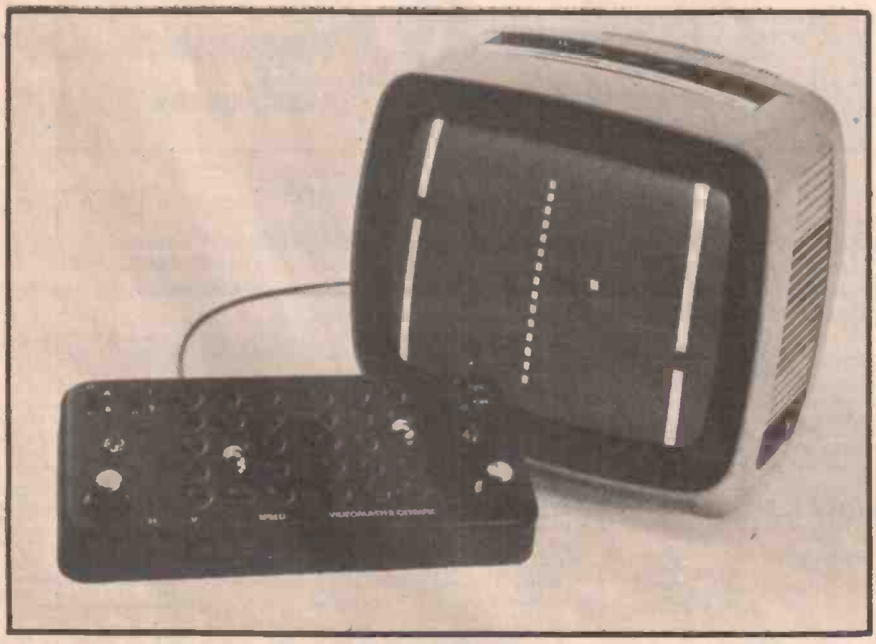
Ferranti Limited, Oldham, Lancs.

TV GAMES COME OF AGE

It is just over two years since the first TV games started to appear in pubs - since then a lot has happened in this field with a large number of small companies marketing various units by a variety of methods. Although the TV games have received a considerable amount of publicity they have not yet caught on in a big way.

"No one who has ever played TV games has ever said anything derogatory about the concept", Richard Fairhurst of Videomaster Ltd., told ETI, 'they may not like the price or the packaging but they always like the idea".

TV games units cost from just under £30 to over £60 in the main but the current trend is for prices to fall and the sophistication of the games to improve.



'Trapper' is just one of the six games that can be played on the Videomaster Olympic. The simple but ingenious scoring method is by moving giant ball-bearings along dents in the top of the case.

Videomaster Ltd., of 119-120 Chancery Lane, London, WC2 appear to be the front runners in this new field. They have just introduced a 6-game unit known as the Olympic - three for two players, three for one player only. The unit operates from a PP3 battery (only 20mA is drawn) and the output plugs into the TV socket operating on UHF channel 36 (unused). Eleven I.C.s and 5 transistors are used in the circuit.

An attraction of the Olympic is that some of the games are far from easy - a serious drawback of the earlier Tennis games. Retail price is expected to be around £38.

The same company have a more sophisticated model: Videomaster Mk 1. This includes an extraordinarily realistic football game including tackling, dribbling, automatic kick-off and two tone scoring note.

Videomaster now have a kit (advertised in this issue) costing about £20 which could well tap a large market.

The UK rights to the TV games chip (News Digest August 1975) have now reportedly been sold to Videomaster but just when the chip will be available for commercial units remains to be seen.

HENRY'S IN NOTTINGHAM

Latest addition to the Henry's chain of stores is one in Nottingham (94/96 Upper Parliament Street, Nottingham, Telephone 40403). The new store will carry all the catalogue range of components and equipment.

AMBITIONS?

Seen outside ETI's offices was a car with the registration 1TT. The accusations that ITT are powerful enough to be a sovereign state gained something when it was noticed that the car also carried a CD plate (used only by Embassies with Diplomatic Immunity)!

NORTH SEA COMMUNICATIONS SYSTEM

Marconi has won a large order to supply tropospheric scatter communications equipment for the offshore oil industry.

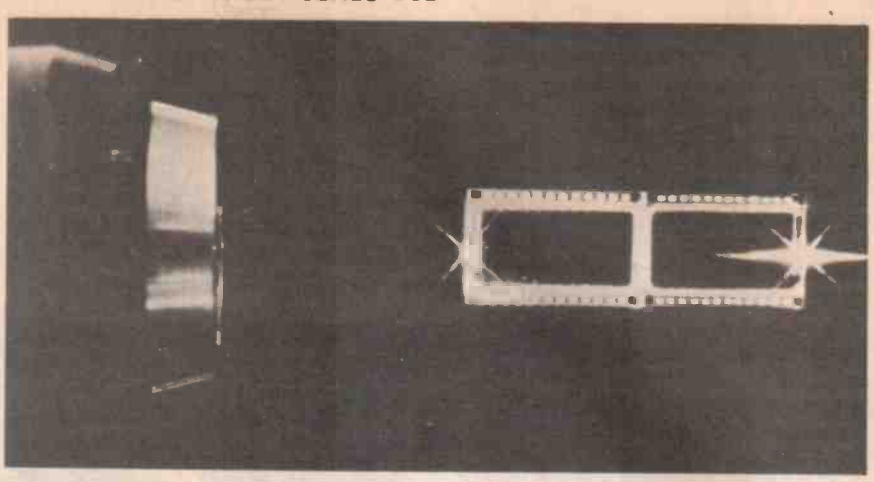
The order, worth around £1 million, comes from Phillips Petroleum - operators for one of the biggest oil consortia in the North Sea. It calls for the supply of equipment to establish a communications network along the line of a pipeline which will run from the Phillips Group field production facilities at Ekofisk to Emden in West Germany. This link is scheduled to be operational by late 1976.

On the Phillips' 1.75 acres of man-made "island" at Ekofisk, gas will be separated from extracted oil in a series of separators and dehydrators. The oil will then be pumped ashore in the U.K. on Teeside and the gas will be directed to Emden. In 1973 Marconi Communication Systems Limited signed a contract worth nearly £¾ million for the supply of a tropo link to serve the former part of this operation. When implemented, the new contract, together with the one just announced to provide a tropo link between the Phillips platform in the Cod field and Ekofisk, will complete the major communications requirements of the Ekofisk complex.

The new tropo system will span the 270 miles of North Sea between Ekofisk and Emden in three stages: stage one will link Ekofisk with a compressor station (CS1) on the gas pipeline some 90 miles away to the south east; stage two will link this compressor station with a second (CS2) some 90 miles further away to the south east; and stage three will link the second compressor station to the gas processing facilities at Emden. In all, six tropospheric scatter terminals will be used in the system. These will be based on the new Marconi type H3212/H3412 receiver and will operate at 2 GHz. Initially the system will carry 24 voice channels although, in fact, it has been engineered to carry 72.

The latest order follows a series of contracts announced by Marconi Communication Systems Ltd., over the past three years to supply similar systems to British Petroleum, Burmah Oil, Occidental, Mobil, Signal and Total Oil Marine Ltd., who are also operating in the North Sea area. It brings the total value of tropo equipment sold to the offshore oil industry in that time close on £5 million.

LASER HERMETICALLY SEALS LCD

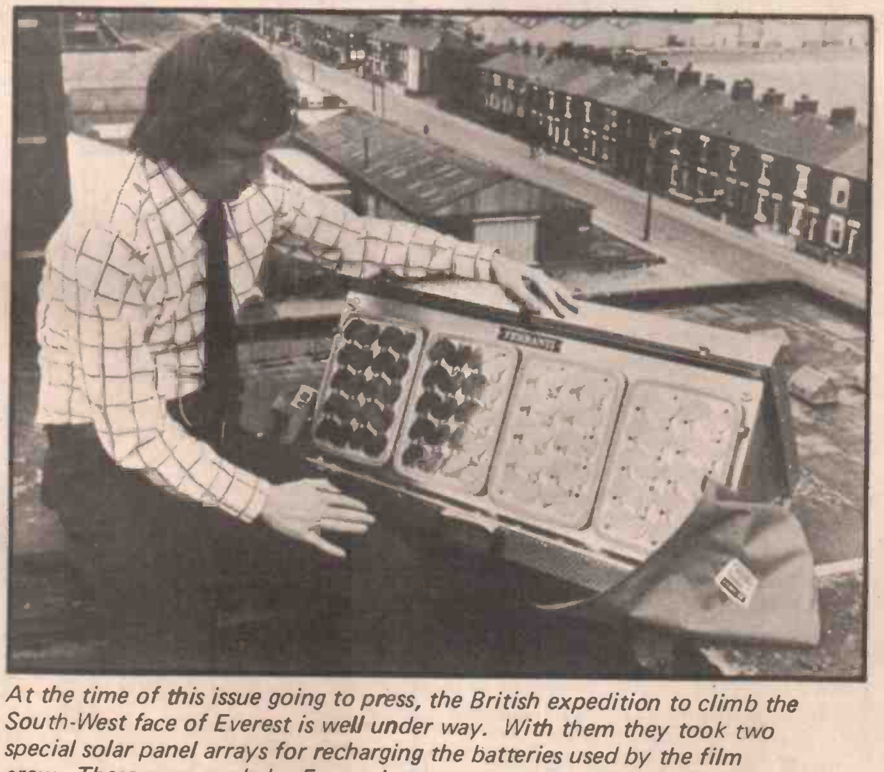


A fully hermetic glass seal for liquid crystal displays, which has been announced by AMI Microsystems, greatly strengthens the position of LCD technology in the highly competitive electronic digital watch market.

This development, which uses glass fused by a carbon dioxide laser to seal the display completely, is claimed to be a significant advance in the production of robust, long-life displays. Theoretically, the lifetime of the display is now limited only by the purity and stability of the liquid crystal material used.

Compared with other approaches to the final sealing of the LCD, the glass seal is not only chemically inert but mechanically and thermally compatible with the glass package which forms the display. This, coupled with the extremely low power consumption of the displays, less than 200nA at 3V adds further to their reliability.

AMI Microsystems Ltd., 108A Commercial Road, Swindon, Wilts.



At the time of this issue going to press, the British expedition to climb the South-West face of Everest is well under way. With them they took two special solar panel arrays for recharging the batteries used by the film crew. These were made by Ferranti.

BUMPER CATALOGUE

The long awaited Henry's Catalogue is now out but its been worth the delay. Although marginally smaller than recent editions there seem to be few if any omissions. Prices include VAT making ordering much simpler.

Due to the instability of prices in these days of inflation, Henry's will be issuing a quarterly price revision supplement available on request.

The Catalogue costs 50p - a sum which must be far less than the cost of production - and includes a 50p voucher which can be used with orders worth £5 or more.

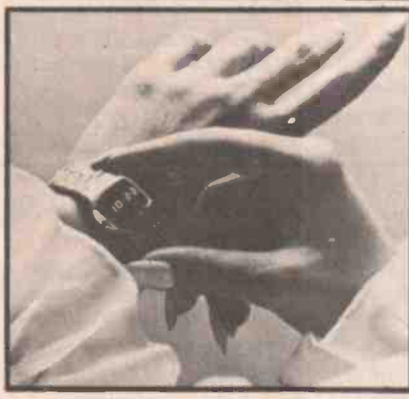
James Lines, Managing Director of Rank Radio International Limited, watches the latest news on a Rank Teletext Receiver. A limited number of units are being produced for selected customers such as the broadcasting companies and government departments. These units display both the BBC's Ceefax and IBA's Oracle Teletext data systems as well as normal television programme material.

SLIMMEST-EVER ELECTRONIC WATCHES

A wide range of electronic digital watches has been introduced in the U.S. by Fairchild.

Initially available in six mens and three ladies styles, the new watches are slimmer than any other electronic watches currently available. This has been achieved by advances in the miniaturised electronic circuitry, and a new module design permitting the use of smaller batteries.

The watches are accurate to within 60 seconds a year, and use LED displays. Five functions are provided through the operation of a single button which is pressed once and released. The first press displays the time in hours and minutes; the next gives a numerical display of the month and date, and the third press gives a seconds reading. Each display is held for 1½ seconds after the button is released, with the seconds display continuing sequentially as long as the button is depressed.



These watches are the first product from Fairchild's newly formed Consumer Products Group.

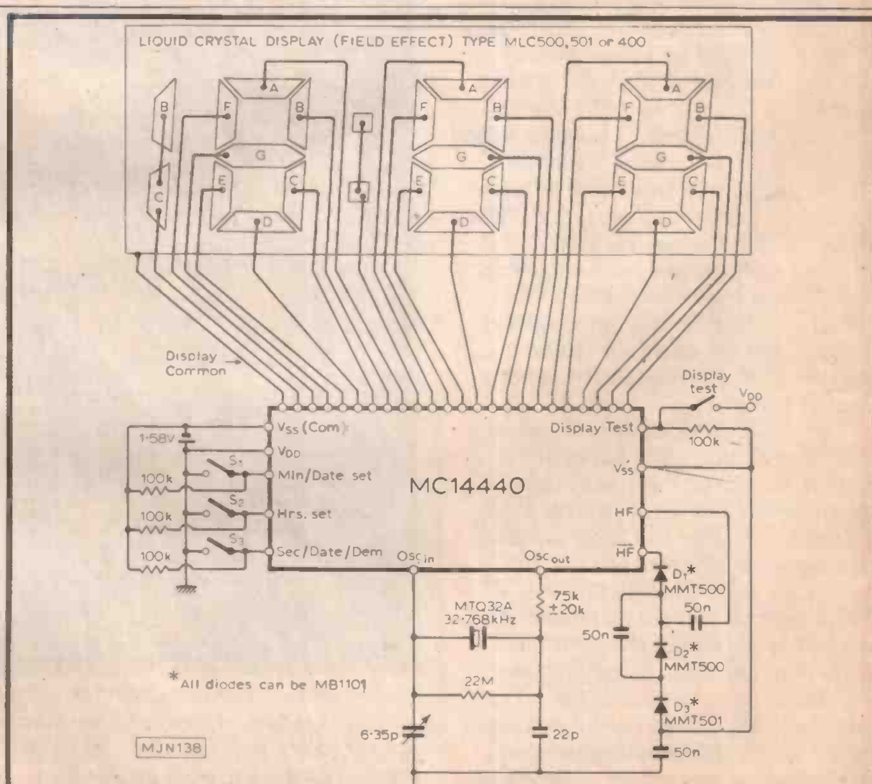
Plans to market Fairchild digital watches in the UK and Europe are being considered.

Continued on page 76

NEW CMOS WATCH CHIP

The latest of Motorola's new 14400 digital sub-system CMOS family is the MC14440 - a versatile watch/clock circuit that can directly drive a 4-digit 7-segment liquid crystal display. To manufacture a complete clock or watch with the new device requires the LCD display, three switches, a 32.768kHz crystal, three diodes, five resistors, three capacitors and a 1.58V battery.

During normal operation the LCD display will indicate the time in hours and minutes, and the colon will flash on and off twice per second. When the seconds/date demand switch is closed, seconds are displayed on the two right hand digits of the display, the colon remains on and the left hand digits are blanked. Returning the seconds/date demand switch to its normal position will result in the date being displayed on the two central digits of the display for two to three seconds. While the date date is being displayed the outer display digits and the colon are blanked.
Motorola Ltd., York House, Empire Way, Wembley, Mddx.



AMTRON KITS

UK 302	Radio Control Transmitter 4 channel £17.50
UK 105/C	FM Microtransmitter £8.07
UK 325	R/C 'Gxc2' Channel Splitting Unit 1000 ∝ 2000Hz £8.34
UK 330	'Gxc2' Channel Splitter Unit 1500 ∝ 2500 Hz £8.34
UK 220	Signal injector £3.53
UK 345/A	Superhet R/C Receiver £8.81
UK 555	R/C 27mHz Field Strength Meter £9.65
UK 780	Electronic Metal Detector £11.65
UK 875	Capacitive Discharge Electronic Ignition Unit Neg. Earth £17.33
UK 230	AM/FM Antennea Amplifier £4.16
UK 285	DHF/UHF Antennea Amplifier £8.87

LITRONIX DISPLAYS

DL704 Common Cathode

(See ETI Digital Frequency Meter in this issue)

£1.80 each 4 for £7

DL707 (Common Anode)

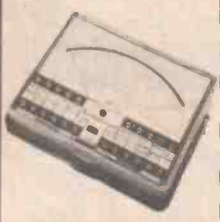
£1.80 each 6 for £10

MACK'S ELECTRONICS FOR MOTOROLA McMOS

MC14001CP Quad 2 Input NOR	20p
MC14002CP Dual 4 Input NOR	20p
MC14009CP Hex Invertor Buffer	98p
MC14011CP Quad 2 Input NAND	20p
MC14015CP Dual 4 Bit Static Shift Register	£1.26
MC14017CP Decade Counter	£1.22
MC14021CP 8 Bit Static Shift Register	£1.26
MC14023CP Triple Three Input NAND	20p
MC14027CP Dual J-K Flip Flop	86p
MC14042CP Quad Latch	£1.26
MC14046CP Phase Locked Loop	£1.85
MC14510CP BCD Up-Down Counter	£1.40
MC14511CP BCD 7 Segment Latch Decoder Driver	£2.12
MC14528CP Dual Monostable	96p

ALL PRICES INCLUDE V.A.T.
Please allow 20p to cover P. and P.

The revolutionary SUPERTESTER ICE 680R



outstanding features:

- 20,000 ohm per volt sensitivity
- Fully screened against external magnetic fields
- Scale width and small case dimensions (128 x 95 x 32mm)
- Accuracy and stability (1% in D.C., 2% in A.C.) of indicated reading
- Simplicity and ease of use and readability
- Full ranges of accessories
- 1000 times overload on the ohmetric ranges only
- Printed circuit board is removable without desoldering
- 10 fields of measurement & 80 ranges

£19.95

FAIRCHILD 723 14 Pin Dil var. voltage Regulator	55p
FAIRCHILD 741 8 Pin Dil Op Amp	30p
SIGNETICS NE555v 8 Pin Dil Timer	60p
FERRANTI ZN 414 Radio Chip	£1.25
MOTOROLA MC 1310P 14 Pin Dil Coiless Stereo Decoder	£2.10
MOTOROLA MFC4000B ¼-Watt Audio Amp	75p
NATIONAL SEMICONDUCTOR LM380 14 Pin Dil 2 Watt Audio Amp	£1.20
NATIONAL SEMICONDUCTOR LM380-8 8 Pin Dil 1 Watt Audio Amp	£1.05
NATIONAL SEMICONDUCTOR LM1303 14 Pin Dil Stereo Pre-Amp	£1.65
NATIONAL SEMICONDUCTOR LM3900 14 Pin Dil Quad Amp	69p
NATIONAL SEMICONDUCTOR MM5314 24 Pin Dil Clock Chip	£4.35

MACK'S ELECTRONICS

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TEL: 01-262 8614
Callers welcome
Open 9.30-6.00, Mon.-Sat.

PATENT PENDING

Sparkrite mk2

The tried, tested, proven, reliable, complete, professional, capacitive discharge,

Electronic Ignition Kit

Sparkrite was voted best of 8 systems tested by Popular Motoring Magazine

ORDER NOW

TO ELECTRONICS DESIGN ASSOCIATES DEPT ETI 11
82 Bath Street, Walsall, WS1 3DE. Phone 33652.

FROM Name ____________________

Address ____________________

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Qty.

	SPARKRITE MK 2 DIY Assembly kits @ £10.93
	SPARKRITE MK 2 Ready Built Negative earth @ £13.86
	SPARKRITE MK 2 Ready Built Positive earth @ £13.86
	Ignition changeover switches @ £2.79
	R.P.M. Limit systems in the above units @ £2.42

I enclose cheque/P.O.s for £ ____________________

Cheque No ____________________

(Send SAE if brochure only required)

Sparkrite MK2 is a high performance, high quality, capacitive discharge, electronic ignition system.

Because of the superb design of the Sparkrite circuit it completely eliminates problems of the contact breaker. There is no misfire because contact breaker bounce is eliminated electronically by a pulse suppression circuit which prevents the unit firing if the points bounce open at high R.P.M. Contact breaker burn is eliminated by reducing the current to about 1/50th of the norm. It will perform equally well with new, old, or even badly pitted points and is not dependent upon the dwell time of the contact breakers for recharging the system. Sparkrite incorporates a short circuit protected inverter which eliminates the problems of SCR lock on and therefore eliminates the possibility of blowing the transistors or the SCR. (Many capacitive discharge ignitions are not completely foolproof in this respect.)

Sparkrite can therefore give you:–
up to 20% better fuel consumption, instant all weather starting, cleaner plugs – they last up to 5 times longer without attention, faster acceleration, higher top speeds, longer coil and battery life, efficient fuel burning and less air pollution, smoother running, continual peak performance.

THE KIT COMPRISES EVERYTHING NEEDED
Ready drilled pressed steel case coated in matt black epoxy resin, ready drilled base and heatsink, top quality 5 year guaranteed transformer and components, cables, coil connectors, printed circuit board, nuts, bolts, silicon grease, full instructions to make the kit negative or positive earth, and 10 page installation instructions.

OPTIONAL EXTRAS

Electronic R.P.M. limitation.
This can be included in the unit to prevent over revving, an advantage to most companies, hire firms, high performance drivers etc.

Electronic/conventional ignition switch.
Gives instant changeover from 'Sparkrite' ignition to conventional ignition for performance comparisons, static timing etc., and will also switch the ignition off completely as a security device. Includes: switch connectors, mounting bracket and instructions. Cables excluded.

PRICES
D.I.Y. assembly kit £10.93 incl. V.A.T. post and packing
Ready built unit £13.86 incl. V.A.T. post and packing
(Both to fit all vehicles with coil/distributor ignition up to 8 cylinders.)
Switch for instant changeover from 'Sparkrite' ignition to conventional ignition £2.79 incl. V.A.T. post and packing
R.P.M. limiting control £2.42 incl. V.A.T. post and packing
(Fitted in case on ready built unit, dashboard mounting on kit.)

CALLERS WELCOME

eti project

SIMPLE FREQUENCY COUNTER

Inexpensive unit works to 1 MHz.

WE CONTINUE our series of simple units based on the ETI 333 Display Module (October 1975 issue) by describing a simple frequency meter. The unit is easy to construct and quite inexpensive.

DESIGN FEATURES

We originally considered that this project would only take a short time to develop — but were we ever wrong! Just about everything that could have gone wrong did so, and we became convinced that Murphy, was not only alive and well but was living in ETI's workshop.

The first problem was to choose suitable timebase circuitry. As the project had to remain fairly economical to build, the use of a crystal timebase was ruled out. We eliminated a mains referenced timebase because it was considered that the possibility of battery powered operation was a definite advantage. Especially as control tones on the mains can cause problems.

An NE555 timer was tried for the 10 second timebase but it soon became apparent that the device just was not stable enough even when the power supply was regulated. The change in frequency due to supply changes was about 1.5%/volt. And even with a regulator the stability was not good enough to allow more than four digit readings. The error occurs because the NE555 output stage does not go exactly to the supply rails but only 0.6 V away from them. The same applies to the discharge transistor which has a fixed saturation voltage.

We considered many oscillator designs in an effort to find one with a stability of better than one part in 10 000 and ultimately chose the one shown in the circuit diagram. This type of oscillator is well known but is not normally considered to have good accuracy and stability. This is because in a conventional op-amp IC there is normally a base-emitter junction at the output, as in the 555. However in the new CA 3130 device this problem has been eliminated as the output stage is CMOS and appears as a resistance (about 500 ohms) and not as a voltage drop. A further advantage of this IC is the extremely high input impedance which eliminates any inaccuracies due to loading effects. On the prototype the frequency change was less than one part in 10 000 with a supply voltage change of from 8 to 16 volts. The main source of error is now due to the temperature coefficient of R10. The expected error, using good quality metal-film resistors would be around 0.01% per degree C.

The CA3130 IC is also ideal for the input stage, because of its high input impedance, and also because it allows a 0 V reference to be used thus eliminating the centre-tap point normally required for conventional operational amplifier circuits.

SPECIFICATION

INPUT IMPEDANCE	470 k // 47 pF
INPUT SENSITIVITY 10 Hz to 10 kHz	< 50 mV rising to 1 V at 1 MHz
RANGES	99.9 Hz to 999 kHz
DISPLAY	3 digits (no overload indication)
ACCURACY	as calibrated.
STABILITY	0.01% can be expected but depends on resistor stability.
OVERLOAD PROTECTION	
up to 100 kHz	50 Vac.
100 kHz to 1 MHz	dropping from 50 Vac to 10 Vac
	50 Vdc.
POWER	240 Vac or 12 Vdc at 100 mA.

SIMPLE FREQUENCY COUNTER

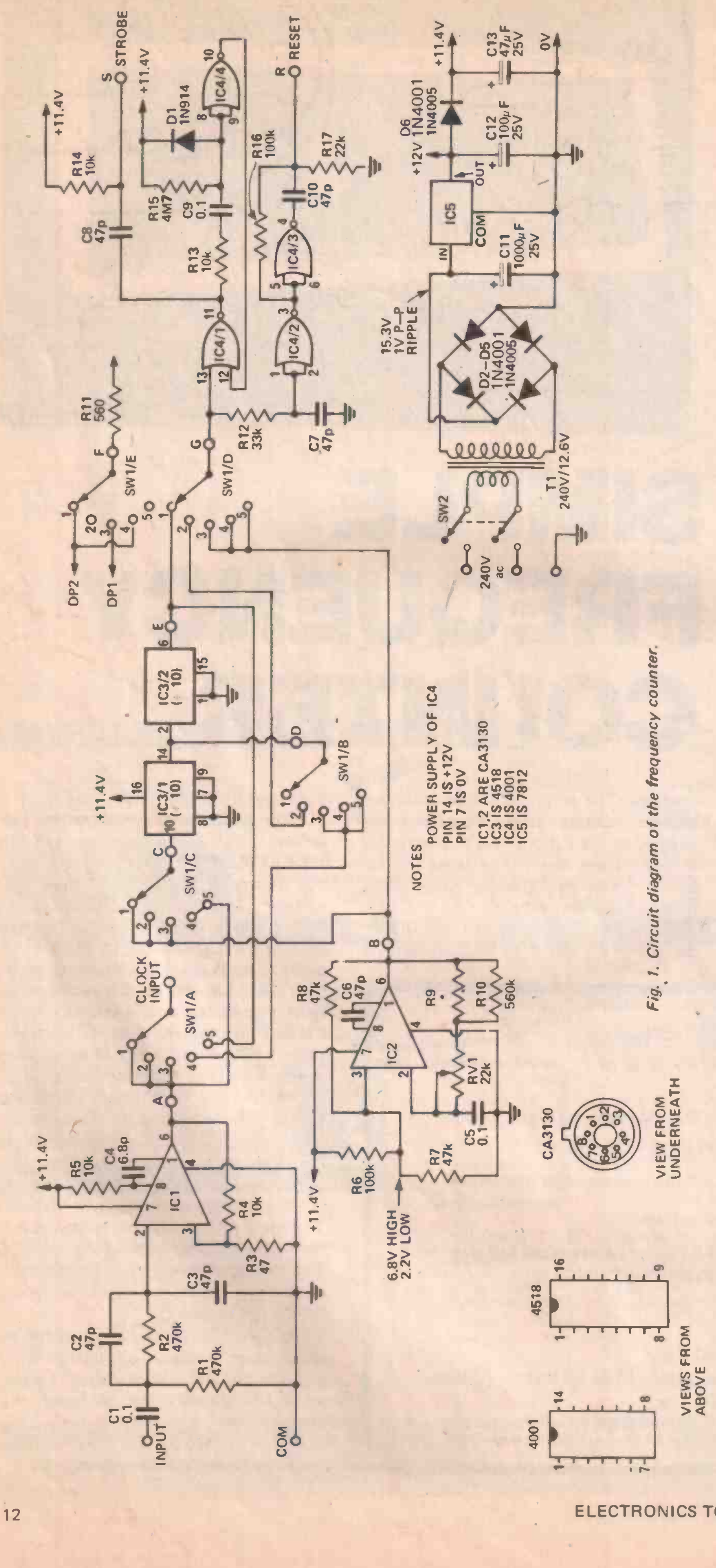


Fig. 1. Circuit diagram of the frequency counter.

PARTS LIST

R3	Resistor	47 ohm	¼W	5%
R11	"	560	¼W	5%
R4,5,13,14	"	10 k	¼W	5%
R17	"	22 k	¼W	5%
R12	"	33 k	¼W	5%
R7,8	"	47 k	¼W	5%
R6,16	"	100 k	¼W	5%
R1,2	"	470 k	¼W	5%
R10	"	560 k	¼W	2%
R15	"	4M7	¼W	5%
R9 (See table 1)				
RV1		22k preset		
C4	Capacitor	6.8 pF ceramic		
C2,3,6	"	47 pF ceramic		
C7,8,10	"	47 pf ceramic		
C1,5,9	"	0.1 µF 100v polyester		
C13	"	47 µF 25 V		
C12	"	100 µF 25 V		
C11	"	1000 µF 25 V		

D1 Diode IN914 or similar
D2-D5 " 1N4001, 1N4005, or similar

IC1,2 Integrated Circuit CA3130 (AWV)
IC3 " " 4518 (CMOS)
IC4 " " 4001 (CMOS)
IC5 " " 7812 (plastic pack).

SW1 Rotary switch 6 pole 5 position
SW2 toggle switch DPDT (miniature)
T1 transformer 240 V/12.6 V 150 mA

PC Board ETI 118
Case Vero 75-1411D, see page 15.

Shield as per Fig. 7.
Front panel as per Fig. 5.
3 plain spacers 6.4 mm long insulated
3 plain spacers 19 mm long
3 1/8 whit. spacers 25 mm long
One 8 way tag strip
3 core flex plug, grommet and clamp pc board pins
3 25 mm long 1/8 whit. screws
9 12 mm long 1/8 whit. screws
6 1/8 nuts.
Two input terminals (red-black)

GETTING THE COMPONENTS – SEE BOX ON PAGE 15.

HOW IT WORKS – ETI 118

The frequency counter may be divided into several basic sections.

a. Input amplifier – Schmitt trigger.
b. 10 Hz oscillator.
c. Two divide by 10 networks.
d. Strobe and reset circuitry.
e. Power supply.
f. Display module (ETI 533).

The input amplifier is a CA3130 connected as a Schmitt trigger. Resistors R3 and R4 provide positive feedback whilst resistor R2 provides protection for the input of the IC. The resistor R5 is used to increase the negative slew rate of the amplifier thus increasing the range of operation to one megahertz.

The 10 Hz oscillator is another CA3130 where positive feedback is applied by R8 and negative feedback by R10. When the output is high the voltage at pin 6 is about 6.8 volts. The capacitor C5 charges via R10, and when it reaches 6.8 volts the output goes low. The voltage now set at pin three is 2.2 volts and the output remains low until C5 has discharged to this point at which the output goes high again. Preset RV1 varies the oscillator frequency by

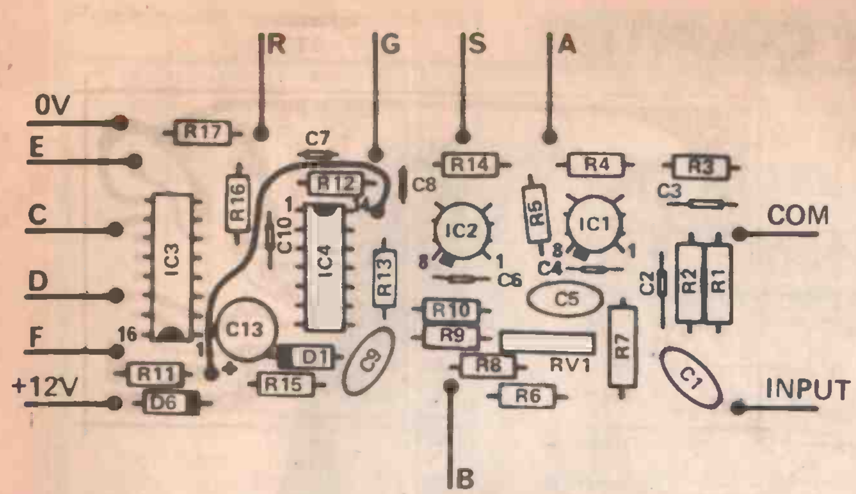
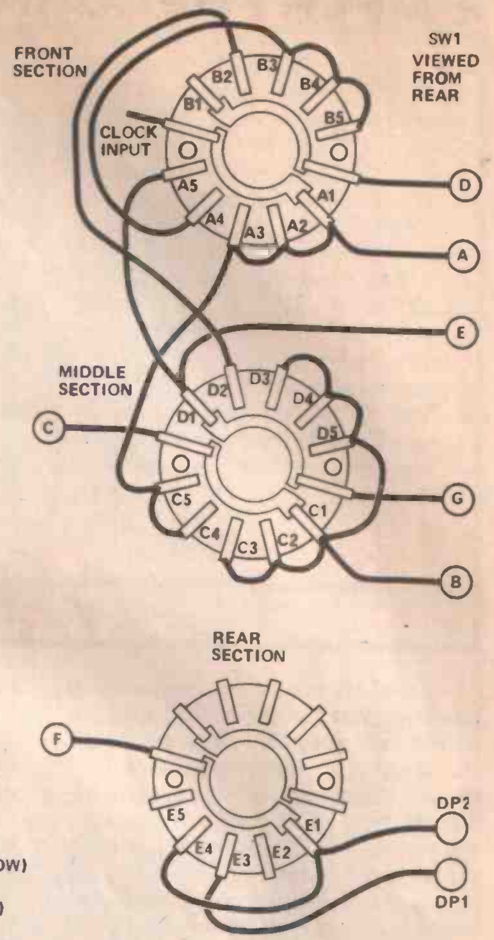


Fig. 2. Component overlay.



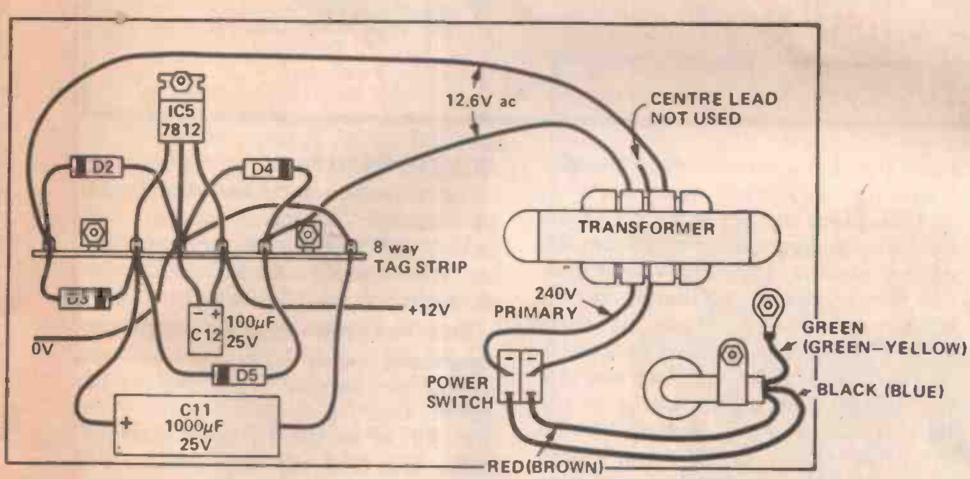


Fig. 3. Wiring of the range switch.

Fig. 4. How the power supply is mounted on the back panel and interconnected.

about 4% and a parallel resistor, R9, is required to set it within the required adjustment range. A higher value preset could be used but it becomes difficult to adjust with accuracy.

The divide by ten circuitry is simply a 14518 IC which contains two decade counters. It can be switched to divide the input frequency (100 k, 1 M ranges) or the timebase (100 Hz, 1 kHz ranges) by means of the range switch SW1.

The timebase, be it ten seconds, one second or 0.1 seconds, is coupled by SW1/d to IC4/1 pin 13. When this voltage goes high the output of IC4/1 goes low and C1 couples a short negative going pulse into the strobe terminal of the display module. After a short time, due to R12 and C7, the output of IC4/3 goes high and C10 couples a short positive pulse into the reset terminal of the display module. When the output of IC4/1 goes low the output of IC4/4 goes high and the output of IC4/1 remains low irrespective of what now occurs at pin 13. After about 350 milliseconds C9 recharges via R15 releasing IC4/1 to the control of the timebase. This procedure removes three out of every four strobe pulses when using the 10 Hz timebase, making the display easier to read.

The resistor R16 is used to raise the steady-state voltage at the reset terminal to about 1.8 volts, thus ensuring that the reset pulse goes high enough to give reliable tirggering. The voltage at the strobe terminal sits at about 10.4 volts due to the 100 k input impedance of the display module.

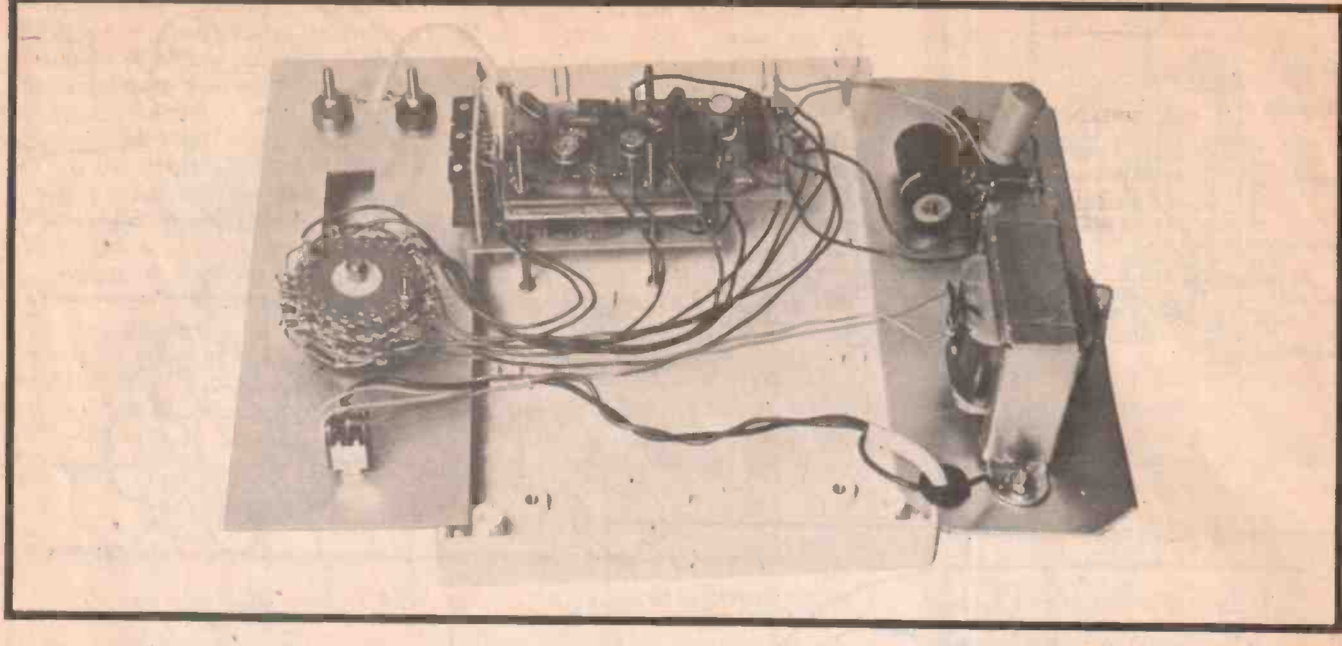
The power supply is a full-wave rectifier and capacitor filter supply which is regulated down to 12 volts by a 7812 regulator IC. The control circuitry is isolated by a diode D6 and capacitor C13 to prevent any ripple appearing on the 12 volts due to the current drawn by the display module.

The display module contains a three decade counter-store-decoder and display as published in the October 75 issue of ETI.

To measure frequency all that is needed is to count the number of pulses occurring over a given period of time. If we count the number of input pulses over a one second period we can measure to the nearest one cycle, or one hertz. If a three digit display is used then the maximum reading will be 999 Hz. However if the frequency happens to be, say, 156254 Hz the display will read 254 and ignore the 156. To measure a higher frequency, either a shorter timebase must be used, or, the input frequency must be divided down. For the 10 kHz range we simply use an 0.1 second timebase giving 10 Hz resolution. For the 100 kHz we divide the input by 10 and use an 0.1 second timebase, whilst for the one megahertz range the input is divided by one hundred. For the 100 Hz range a ten second timebase and no division is used.

If we use the one megahertz range to measure our 156254 Hz, we display 156. Switching to 100 kHz we get 563, on 10 kHz we get 625 and finally 254 on the 1000 Hz range, thus the frequency can be read to the nearest hertz but the accuracy depends on the accuracy of the initial setting up and the fact that temperature variations cause an error of one part in 10 000 per degree C.

SIMPLE FREQUENCY COUNTER



Initially the maximum frequency of operation was limited to 200 kHz due to the slow, negative slew-rate of the IC. Looking at the internal circuit of the IC it was decided to increase the bias current in the second stage by adding a resistor between the positive supply and pin 8. This allows the frequency response to be extended to beyond one megahertz. A small compensating capacitor was found to be necessary to eliminate the effects of a small amount of coupling from the 10 Hz oscillator. The resistor to pin 8 also alters the offset voltage but this does not affect the operation of this circuit.

Another problem that occurred was in the strobe and reset pulse network.

Using an 0.1 second timebase the display changes too rapidly for ease of reading. Therefore IC4/4, which is connected as a 350 millisecond monostable, is used to eliminate three out of every four strobe pulses thus making the display more readable. However it was discovered that, when using this delay, the timebase changed frequency by about four parts in 10 000. Since the power supply to the control circuitry was isolated from the display module, the circuitry is mainly CMOS, and the oscillator rejects supply rail change, none of these factors could be suspected as a cause of the trouble. The problem was due to the fact that IC4/4 works in the linear mode and can draw 10 to 20 mA. This modulates the power supply by up to 20 millivolts. The cure is to power IC4 directly from the 12 volts. This explains the use of the link on the board.

Some coupling between the display board oscillator and the input stage occurred and was cured by adding an aluminium shield between the two boards.

To obtain all five ranges with only two divide-by-ten sections necessitates a more complex switch. This was considered to be justifiable as the alternative was to use a switch with one less wafer but add one more 4518 IC.

CONSTRUCTION

The display module should be constructed as described in last month's ETI. The value of resistors R5 to R11 should be 560 ohms for operation on the 12 volt supply.

The control board should be assembled with the aid of the component overlay Fig. 2. Use printed circuit board pins for all outputs and for R9 as an aid to later assembly. Make sure that the link between +12 volts and pin 14 of IC4 is installed.

Wire switch SW1, in accordance with Fig. 3, and leave the leads long enough to reach the printed circuit board. Assemble the power supply onto the tag strip and the back panel of the box as detailed in Fig. 4. There is no need to insulate the tag of the regulator from the rear panel as it is the common terminal which should be earthed. The rear panel itself is earthed via the mains cable.

The front panel has to be cut and drilled as shown in Fig. 5. A piece of polarized or red plastic can be used to

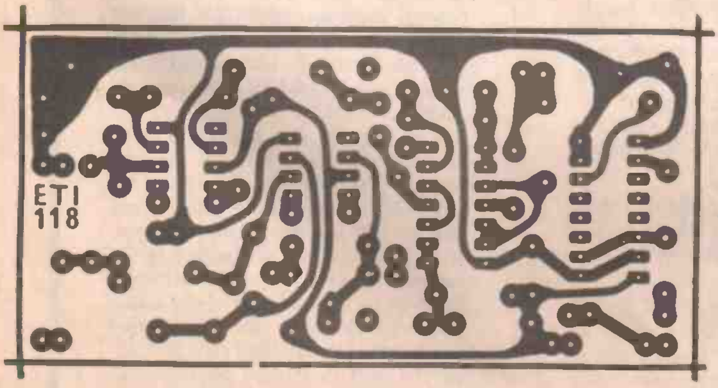


Fig. 6. Printed circuit board for the counter. Full size 90 x 45 mm.

TABLE 1

Frequency with RV1 at minimum 50 Hz input	Value of R9 to allow RV1 to calibrate
48.1 – 50	–
49.8 – 51.8	15 Meg
51.3 – 53.4	8.2 Meg
52.7 – 55.0	5.6 Meg
54.7 – 57.1	3.9 Meg
56.7 – 59.3	3.0 Meg
58.8 – 61.7	2.4 Meg

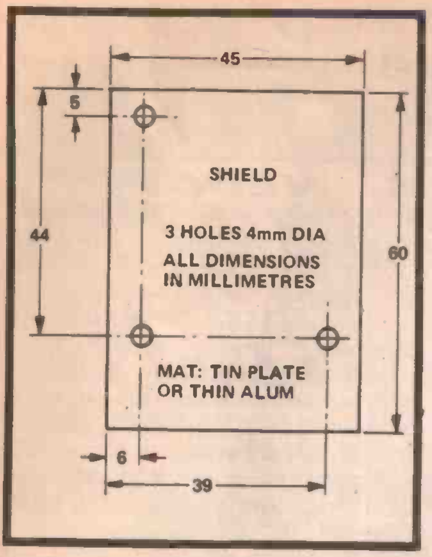


Fig. 7. Drilling details of the shield plate.

protect the displays.

Fit the rear panel in to the box and then mount the input terminals to the front panel (the rear of the screws of the terminals may have to be shortened to clear the display module mounting spacers). The rotary and toggle switches should also now be mounted to the front panel. Connect a short length of coaxial cable to the input terminals (about 150 mm) for later connection to the control board. Connect leads to the positive volt, zero volt, strobe, reset and input clock inputs on the display module and assemble the display board, shield and control board as shown in Fig. 8.Make sure that the spacers do not touch the copper tracks on any of the boards, (except for the front spacer on the control board). If any of the spacers are too close to the tracks add a piece of insulation material under the spacer. The whole assembly can now be mounted in to the box.

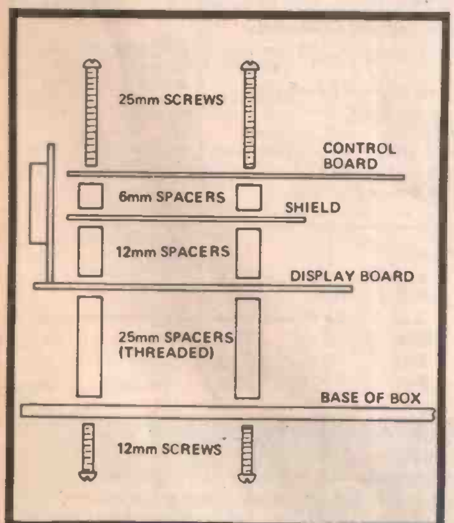


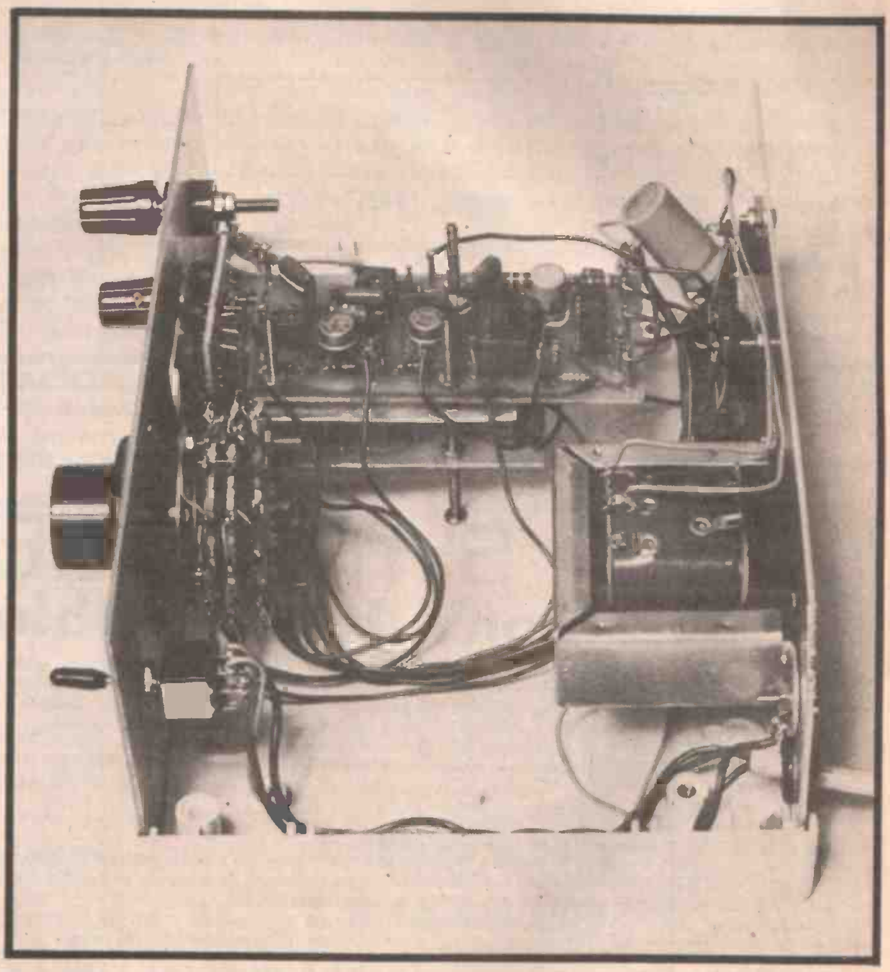
Fig. 8. The best way to assemble the counter and display boards.

On the display module the power rails are taken direct to the power supply whilst the 'reset' and 'strobe' go to the control board and the clock to the rotary switch. On the control board the power rails also go direct to the power supply whilst all other leads, with the exception of the coaxial cable, go to the rotary switch.

Finally connect the power switch and insulate it with plastic tape to prevent accidental personal contact.

CALIBRATION

Apply about 6 volts ac at 50 Hz, from the secondary of a power transformer to the input of the counter. Select the 100 Hz range and set the trimpot, RV1, to its minimum resistance position. Wait for the reading to settle (there is about ten seconds between readings) and using this reading look up the corresponding value of R9 from Table 1. Instal this resistor and again check the reading, it should now be just under 50 Hz. The trimpot RV1 can now be adjusted to give a reading of exactly 50.0 Hz. If a more accurate frequency source than the mains is available it can be used instead of the 50 Hz for final calibration. Due to the effect of soldering upon the value of resistors final calibration should be left until several hours after R9 is soldered into position so that the resistor may stabilize.



GETTING HOLD OF THE COMPONENTS

THE CASE: shown on the cover is from a new range by Vero. These cases are 204mm wide, 140mm deep and come in three heights — 40mm, 75mm and 100mm. Prices (inc. VAT) are £2.44, £2.74 and £3.55. From Vero, School Close Industrial Estate, Chandlers Ford, Hants.

THE ICs: Marshalls will give ETI readers special discount if they buy IC packs for this project. The five ICs in the frequency counter come in a pack for £5.50 (inclusive of VAT and P & P). The two ICs used in the display module are packed with the three LED displays for a special price of £12.75. Marshalls will sell both packs for £17.50 (inclusive).

THE PCBs: These are available from Ramar Consrtuctor Services, 29 Shelbourne Road, Stratford-on-Avon, Warwicks. Send £1.30 for the display boards (ETI533), and £1.02 for the frequency meter board (ETI118). If you are also building our DVM you can buy the boards (excluding display) for £1.64 (ETI117).

BRIAN CHAPMAN EXPLAINS . . .

AUTO-CORRELATION

CORRELATION is a measure of the similarity between two quantities. As applied to electronic waveforms it is a statistically based process of recovering signals buried in noise.

Until fairly recently the use of correlation has been complex – involving data recording and computer analysis, and the technique has therefore been limited to such esoteric applications as recovering signals from noise in deep-space communications.

Auto-correlation is a technique in which a signal is multiplied by a time-delayed version of itself to produce an output called the correlated function. If the signal is noise-like there will be no correlation, ie similarity, between the two waveforms – and the correlation function will be low. However if the signal is sinewave-like the two signals will be highly correlated and the correlation function will be high. The averaged correlation function may now be used as a control signal to alter the gain of an amplifier such that noise signals are attentuated and wanted signals are passed with full gain.

All sounds that occur in nature have a correlation function somewhere between '0' (no correlation) and '1' (100% correlation is pure sine wave). Examples of high-correlation sounds are the sound of a harp, a plucked guitar, a piano and some vocal sounds.

Examples of sounds that have a low correlation are sibilance, the hiss of air through your teeth, wire brushes, multitudinous handclapping, waves crashing against a beach and the sound of rushing water.

The correlation function of music is thus a function which varies from moment to moment and it is necessary for the processing circuits to continuously determine the value of the correlation function.

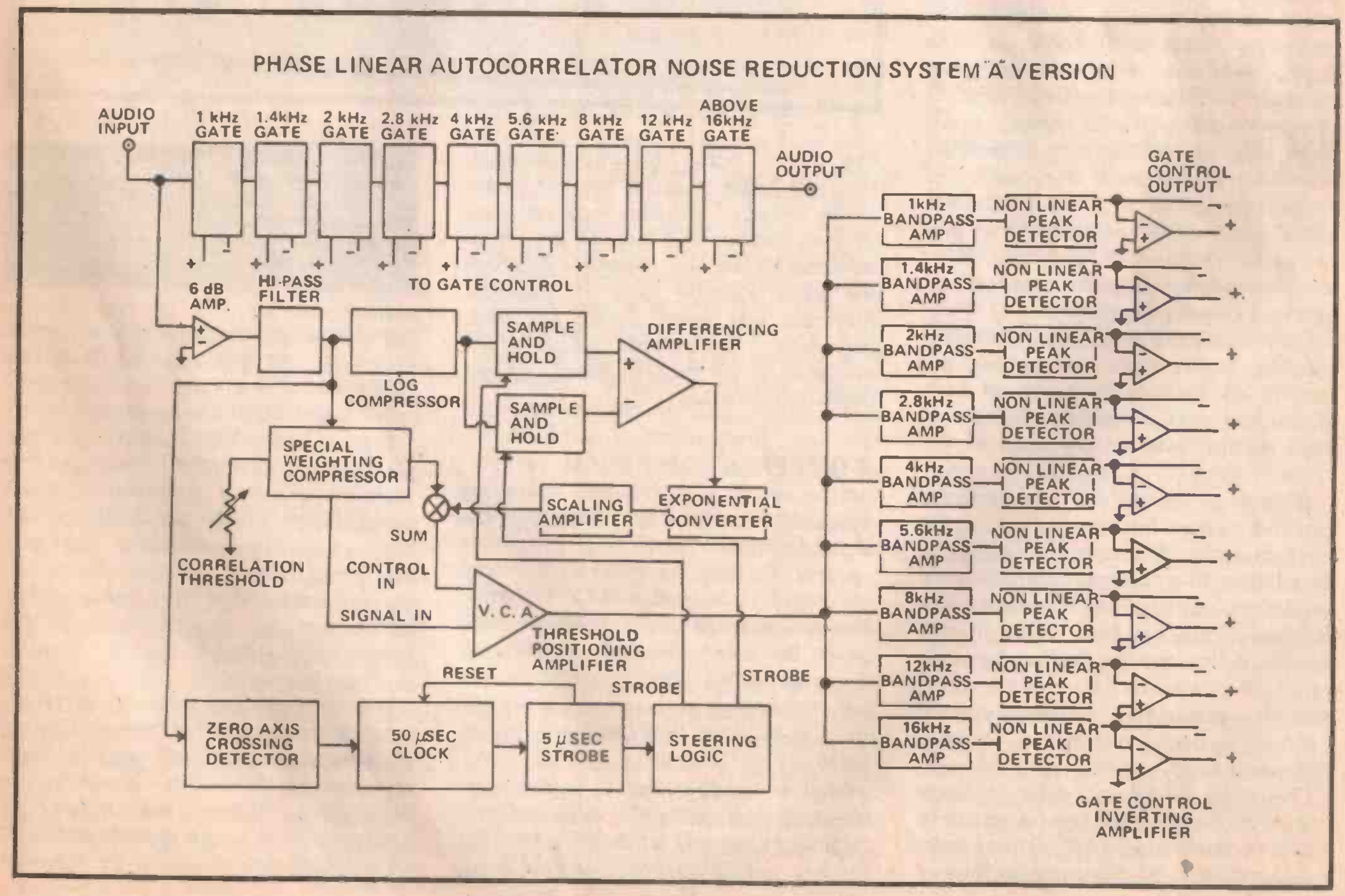
Correlators intended for scientific use cost tens of thousands of pounds and can recover signals buried deep in noise (even a –60 dB signal buried in +10 dB of noise). The Phase Linear Auto-correlator cannot do that, but it can considerably enhance the signal-to-noise ratio from conventional disc recordings.

There are two versions of the Phase Linear Auto-correlator, an 'A' version which is intended for professional applications and which we understand is not yet on the market, and a 'B' version intended for domestic applications – incorporated in the Phase Linear 4000 Preamplifier.

THE 'A' VERSION

The block diagram of the 'A' version (one channel only) is given in Fig. A. It can be seen that the incoming audio is split into two paths, one path goes to the programme circuits, the other to the control circuits. The correlation function is estimated by the sample-and-hold gates and differencing amplifier. The sample-and-hold gates store the signal amplitude for 50 microseconds after successive zero crossings of the signal. The difference between these two signals is proportional to the correlation function. The correlation function is then used to control the gain of an amplifier (VCA) to the signal which has been high-pass filtered and compressed logarithmically in the spectral weighting compressor.

The output of the VCA then goes to 9 bandpass filters followed by non-linear peak detection to produce a



push-pull control voltage for each bandpass region. These control signals control associated notch filters in the programme signal path.

The system effectively examines the incoming signal and, when a fundamental note is present, opens gates for the harmonics of the fundamental. If a fundamental is not present the harmonic gates remain closed thus reducing the hiss level by up to 10 dB.

THE 'B' VERSION

In the consumer version, as fitted to the Phase Linear 4000 Preamplifier, only four, one-octave wide gates are used which results in somewhat reduced resolution.

In addition the complex correlation function estimating circuit has been simplified. The sample-and-hold gates, differencing amplifier, zero crossing detector, clock and steering logic have all been omitted. The system now relies on the fact that the spectral energy of music *approximates* its correlation coefficient. Additionally only one control circuit is used which is common to both channels.

The 'B' version thus does not track as well as the 'A' version, that is, it mistakes noise for music and music for noise on occasions. These effects are minimal however and must be listened for very carefully in order to be heard.

Note however that the simplification of the system has been taken so far in the 'B' version that it cannot really be called an auto-correlator. Nevertheless the system does effectively reduce hiss without sacrificing high frequency content. ●

PHASE LINEAR 4000 "AUTO-CORRELATOR" PREAMPLIFIER

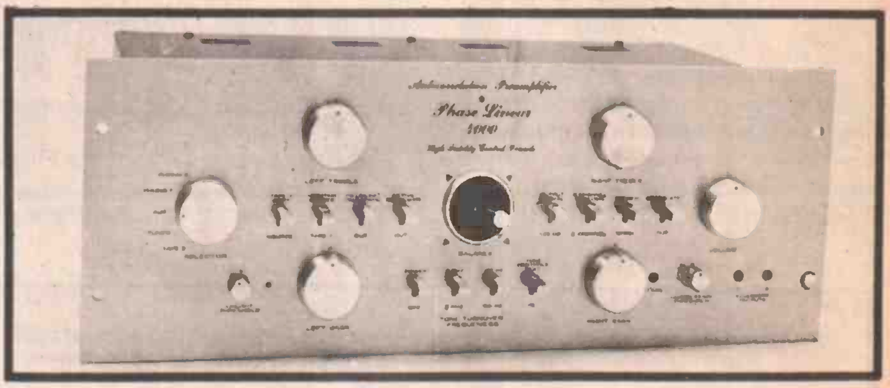
ALTHOUGH HI-FI equipment quality continues to improve, it is ironical that the quality of recorded programme has not kept pace. In fact many people hold that record quality is progressively becoming worse.

There are two major problems in recorded material — dynamic range and signal-to-noise ratio. The two factors are interrelated because, to keep signal-to-noise ratio high, recording engineers compress the peaks and raise the level of quiet passages — thus substantially limiting the recorded dynamic range. Apart from this, whilst recording techniques have vastly improved, the quality of record pressings has not. Shorter press cycle times, recycled vinyl and increased number of pressings from the one master degrade the residual surface noise on a pressing.

Thus whilst recorded musical quality may be higher than ever before, the quality of records in terms of hiss, clicks and pops is widely variable — even within different pressings of the same record.

Whilst it should be theoretically possible to improve the noise performance of records it must be faced that most record companies are unlikely to do so. Even if surface noise *is* dramatically lowered — it will still be a problem, and the limited dynamic range which can be accommodated on records may still make dynamic compression necessary during recording.

The same problems exist in tape recording but a great improvement in signal-to-noise (up to 10 dB) has been made possible by the introduction of the Dolby noise reduction process. However tapes must be recorded via a Dolby encoder and then replayed via a similar decoder. Thus Dolby is a two-step process — it *cannot improve the signal-to-noise ratio of material that has not been Dolby encoded.* Although Dolbyized tapes *are* available, as yet records have not been similarly processed.



Recommended Retail Price: £425 plus VAT.
Distributed by: C.E. Hammond & Co. Ltd., Lamb House, Church Street, Chiswick, London W4.

A DIFFERENT APPROACH

A number of different units are available which can improve the signal-to-noise ratio of *existing* records. Perhaps the most well known of these is the dbx 117 Dynamic Range Enhancer which does precisely what its name implies; it increases dynamic range thus allowing lower volume settings to be used — resulting in a subjective improvement in hiss level.

What is needed then is a means of restoring the dynamic range of the original music and of reducing the hiss level without sacrificing high-frequency response. A tall order but these are precisely the problems that Phase Linear have tackled in their new model 4000 stereo pre-amplifier.

Bob Carver of Phase Linear Corporation researched the necessary techniques and is responsible for the basic design of the pre-amplifier. His aim — to obtain excellent signal-to-noise and distortion performance from the pre-amplifier itself, and to provide facilities for overcoming the record defects outlined above.

The design approach is different from the conventional, although some of the conceptual approaches were investigated by Beranck et al in the 40's. Bob Carver expounded his approach in a paper presented to the 51st Convention of the Audio

Engineering Society, the title of the paper being *"An Autocorrelator Noise Reduction System"*. A feature of note is the inclusion of what Bob Carver describes as 'peak unlimiting'. This circuitry not only expands signals which are *greater* than a presettable level but also compresses (reduces gain) signals *below* a fixed level, the mid-level signals being unaffected. This circuit thus increases dynamic range and reduces subjective noise.

A second and perhaps more significant circuitry proposal is the use of a correlation technique and correlation co-efficient estimation to detect the presence (or absence) of uncorrelated distortion products. It should however be appreciated that the 'Auto-Correlator' pre-amplifier described in this review does not actually incorporate an auto-correlator circuit — rather the noise reduction circuit indirectly estimates the value of the correlation co-efficient. The end result is very effective but we must query Phase Linear's use of the term 'Auto-Correlator' in this context. (A parallel is describing a weighing machine as a 'Volume Measurer' if it is used to monitor liquid volume by weight).

The Phase Linear 4000 Stereo Pre-amplifier is a four-channel SQ plus logic decoder pre-amplifier capable of driving four amplifier channels, or two, as desired by the user.

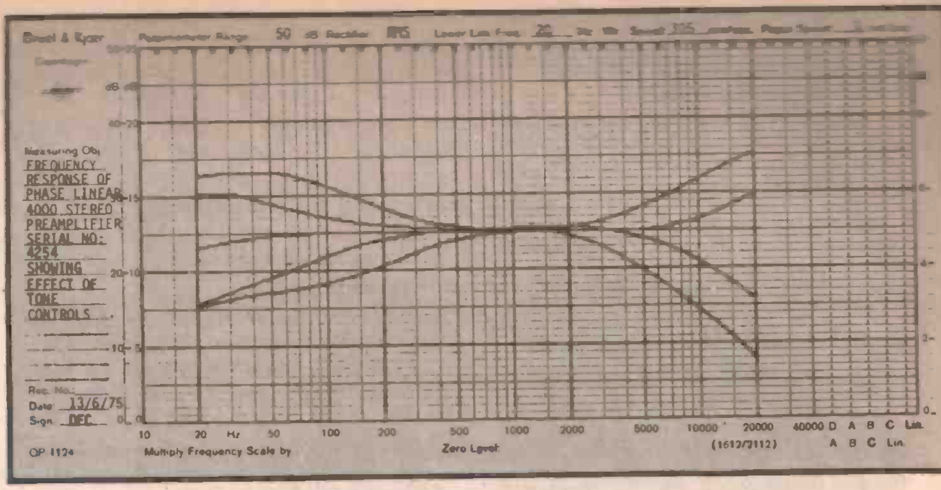
To cope with this requirement the unit features a joystick type balance control right in the middle of the front panel.

MECHANICAL DETAILS

Measuring 482 mm wide (19" standard rack mounting) by 178 mm high and 254 mm deep, this unit is the largest hi-fi pre-amplifier that we have seen since type 80 rectifier valves went out in the early 40's. The reason for its size appears to be Bob Carver's desire to have a unit which matches the size of a 700B or 400 Phase Linear Amplifier.

The pre-amplifier has two tape recorder inputs with unusual switching arrangements which enable the user to monitor the output of one of them whilst recording from the second machine, even if one desires to listen to a completely separate third programme whilst this is taking place!

On the lateral centre line of the unit set between the six large knobs are a set of lever key switches which provide facilities from left to right of: Tape 2-Copy or Source; Monitor-Source or Tape 1; Peak Unlimit and Downward Expander-in or out; Active Equaliser-in or out; and on the right hand side of the four channel joystick balance control is an attenuator



output normal or –20 dB; Four-channel SQ+Logic or Two Channel; Stereo or Mono; and Correlate-in or out.

On the bottom row, at the left hand side of the unit, is a small rotary knob for peak unlimit and downward expander threshold selection together with its adjacent solid state bezel light. In between the left bass and right bass control are the power on-off switch, the turnover frequency switches for treble (at 8 kHz or 2 kHz) and bass (at 40 Hz and 150 Hz). On the right hand side of this is a switch which cuts all tone controls out of circuit. On the right hand side of the right hand bass control is an aperture for providing access to a present potentiometer. This is for initially calibrating and adjusting the threshold setting of the low frequency dynamic filter to match the output of the phono cartridge. Next to this is a small knob which adjusts the 'auto-correlation' threshold. This only needs to be set by ear for large changes in the source background noise level.

The Phase Linear 4000 Stereo Pre-amplifier has a number of unusual controls. We will deal with each of these in turn. First the Peak Unlimiter and Downward Expander. The Peak Unlimiter provides a maximum of 4 dB increase in output relative to input for signals which exceed the zero level threshold set by the Unlimit Threshold control knob. Such a control is intended to provide part of the performance that a device such as the dbx 117 Dynamic Range Enhancer provides. Whilst not as flexible as the dbx our subjective and instrument measurements showed that it achieves what it is supposed to.

At the other end of the dynamic range the downward expander once again emulates a small proportion of the dbx's performance by providing maximum attenuation of 5 dB to compensate for gain increases deliberately introduced by the recording engineer to improve signal to noise ratio during low level passages.

The second major control activates the 'correlator' circuitry. It is here that we think the title 'auto-correlation' is misused, for whilst the proposed Type A Phase Linear Pre-amplifier is apparently a true correlator, the Type B or consumer version is not. Whilst the average man on the street has no concept of what a correlator is, professionals and serious amateurs may well do, and we think that the choice of the term 'auto-correlation pre-amplifier' for the consumer version is a misuse of a professional term. There are major differences from a purely technical viewpoint between the proposed professional Type A Phase Linear Pre-amplifier and the consumer unit. The most important of these is undoubtedly in the means by which the noise minimisation is achieved in the two different circuits. Without delving into the theory of operation of either of the two versions, it is necessary to point out that differences exist and that small but nonetheless measurable and subjective differences must result.

We would however like to make it quite clear that we are in no way condemning the Phase Linear 4000 or its performance but rather pointing out that the title given to it, and some of the literature presented with it do not accurately portray its true mode of operation.

The system which we used for the subjective evaluation consisted of an Elac 50H Record Player fitted with an Elac D44E Cartridge, a Phase Linear 4000 Stereo Pre-amplifier driving a Phase Linear 700B Amplifier, and two pairs of speakers — Fisher ST550's and ESS amt 1s.

The combination was selected to provide a highly critical combination capable of highlighting any possible factor which would show up the limitations of the pre-amplifier. (We had previously tried to evaluate the pre-amplifier driving an amplifier with

PHASE LINEAR 4000 "AUTO-CORRELATION" PREAMPLIFIER

lesser performance than the Phase Linear 700B, and the results were not entirely to our satisfaction).

We carried out our major subjective evaluation at night time after children had gone to bed and with a background noise level in the listening room close to the normal threshold of hearing. Under these conditions the background level produced by the amplifier and pre-amplifier, with the volume control set at our peak listening level, without programme content, was about 25 dB(A). With good clean records and a peak music level close to 105 dB(A) the background noise level on the blank tracks did not exceed 28 dB(A)! — an almost indiscernable increase! This was most heartening and indicative of the sort of performance of which the pre-amplifier is capable.

MEASURED PERFORMANCE OF PHASE LINEAR 4000 STEREO PREAMPLIFIER SERIAL NO: 4254

Maximum Output:	8 volts rms
Frequency Response:	−2 dB 20 Hz
Reference 1 kHz	−1 dB 20 kHz
Gain:	16 dB auxiliary input
Noise:	−75 dB re 2 volts output
Auxiliary input	−89 dB A-weighted
Total Harmonic Distortion:	
(1 volt rms output maximum gain)	100 Hz .16%
	1 kHz .01%
	6.3 kHz .25%
(8 volts rms output maximum gain)	100 Hz .13%
	1 kHz .08%
	6.3 kHz .15%
Cross-Talk:	20 Hz −34 dB
	1 kHz −49 dB
	20 kHz −26 dB

We took special care in setting up the major controls on the pre-amplifier, most particularly the unlimit threshold, correlation threshold, and the low frequency calibration setting.

This operation was painless and certainly well within the capabilities of the below average user: it is adequately described in the fourteen page handbook provided.

In the quiet conditions of our test environment the switching in and out of the peak unlimiter provided a most satisfactory expansion of the dynamic range, although not as good as that achievable with the dbx. Notwithstanding, we were pleased with the result and felt that it was adequate for the majority of listening situations and programme content that the average user would call for.

One limitation, however, was that when correctly set up, the peak unlimiter responds noticeably, if not savagely, to scratches on records providing a totally unwanted dynamic expansion of something which would obviously be better compressed! We noticed this when forced to play two childrens' records just before the children went to bed, and the condition of these were typical of most childrens' records. It was obvious to us that the downward expander is intended for normal scratchy records but never conceived as a cure for badly scratched records.

The first serious record which we played was *Sheffield Lab-1 (SL5/SL6) "Lincoln Mayorga Volume III"* which has a dynamic range greater than any other record which we know. The background noise level on this record was completely inaudible when compared with the natural amplifier noise level in the absence of signal input. Under the conditions of our test the dynamic range which we achieved was in excess of 80 decibels and obviously superior to any other subjective evaluation which we have ever conducted. With the peak unlimiter set to respond to just the absolute peaks of the programme content, the clarity of sound achievable was quite outstanding.

We played a number of other records recorded in the conventional manner, including *E.M.I. Q4.Two.400 "Mandingo"* which is a record featuring over forty instruments, of which more than half are percussion instruments. The results were electrifying, and the record, which we had previously appreciated, took on an entirely new and much wider perspective.

The next round which we used for evaluation was an electronically synthesized record. Surprisingly, at first this did not sound substantially better when played through the Phase Linear 4000. The reasons for this are not hard to find in that the manner in which the music is produced is totally dissimilar to conventional recorded content. Bob Carver himself highlights the difference in his A.E.S. Paper. This is primarily a result of very fast rise and decay times, which are generated by conventional acoustic instruments in a normal recording environment. The circuitry of the Phase Linear 4000 offers little benefit when playing such music and cannot respond adequately to such music nor does the smaller dynamic range of such records benefit from the peak unlimiter and downward expander.

So if your musical taste begins and ends with synthesizers — forget this unit!

MEASURED PERFORMANCE

The total distortion, with voltages of less than one volt output is better than .02% at all frequencies between 50 Hz and 10 kHz. The signal to noise ratio on phono input (which we regard as the most important one) is substantially better than 85 dB. The tone controls offer a smaller degree of control than we have become used to in other pre-amplifiers and combined pre-amplifier-amplifiers, but are nonetheless more than adequate.

The active equaliser provides a 6 dB per octave boost below 50 Hz and certainly flattens out the low frequency response below 30 Hz of the speakers that we were using.

The peak unlimiter works remarkably well and certainly provides a maximum peak unlimited performance gain of +5 dB above the adjustable threshold limit.

The inside construction of the unit is very very interesting. The large numbers of printed circuits, which are all interconnected back into a mother board via printed circuit sockets, hold 45 transistors, 9 integrated circuits, and 57 signal diodes.

Each of the cards has obviously been individually calibrated and checked out during the manufacturing process to optimise performance and provide the promised results.

With regard to mechanical construction we should comment on the method chosen for printed circuit card restraint which is simply two large blocks of urethane foam glued to the inside of the top cover and which deform to prevent lateral card movement.

Also, we were surprised to note on removing the cover, the presence of unprotected live terminals on a relay in the power supply circuit, which were remarkably close to the side panel.

In all other respects the unit is well made and offers many more facilities than the average user will call for.

Subjectively, the auto-correlator (so called) noise reduction system works remarkably well, but we were unable to devise a measurement technique satisfactorily to quantify the performance.

We spent considerably more time on the subjective evaluation of this pre-amplifier than we have ever spent on any other piece of electronic equipment which we have reviewed — this was undoubtedly one of the most pleasant tasks that we have had in a long time!

Our overall impression of the Phase Linear 4000 Stereo Pre-amplifier is of a unit which offers unparallelled performance. When coupled to an amplifier of the calibre of the Phase Linear 400 or 700B, fed by a good programme source, and driving good speakers, the unit's performance is truly outstanding. ●

CONTROLLED TEMPERATURE SOLDERING

What does it have to offer?

CONTROLLED temperature soldering tools have been used for quite a while, though until recently their use was largely confined to critical applications such as life support equipment, communications, weapons, aero-space, etc.

They are more expensive than the conventional 'single-temperature' tool; so what does the man who simply wants to build an amplifier or repair the neighbour's TV get for the extra money?

Firstly, let us go back a few years to the pre-printed circuit, pre-integrated circuit era. Then electronic gear was like the motor car of that era — built like a tank. Resistors and capacitors (called condensers then) were soldered, via heavy pigtails, to terminal pins on valve and coil bases large enough to anchor a small boat, other components were mounted on tag strips strong enough to support a house — or that's the way it seems, in retrospect.

In those days the soldering iron bit (why do we persist in calling it a soldering *iron* and a soldering *bit?*) was a great lump of copper rod, little different from that used by a plumber.

With the steady reduction in sizes of components, and the advent of printed wiring and integrated circuits, the heat requirements for soldering have shrunk in proportion. At this point, however, we must define what we mean by 'heat'.

HOW MUCH HEAT?

Just as high electrical power can be obtained from low voltage and high current, so can high thermal power be obtained with low temperature and high thermal capacity. So when we say 'more heat', we don't necessarily mean 'higher temperature'. We may simply mean *more* heat *volume* at a temperature high enough to rapidly melt solder . . . and 60/40 solder at that, since we are talking electronics. As a matter of interest, the optimum working temperature range for 60/40 solder is 245°C to 272°C. (This should not be confused with the melting point, which is 185—188°C).

The Adcola Unit 222 controlled temperature iron. A sensor near the bit feeds back to the control unit. Cost of the system is about £40 but extra irons cost about the same as conventional ones.

HEAT ABSORPTION

Every time a soldering tip is placed on a termination, heat is absorbed by that termination, and the temperature of the tip drops. The ability of the soldering tool element to replace that heat determines its recovery rate. Obviously, a heavy chassis joint or a long sequence of joints will draw a substantial amount of heat from the tip, with the result that the temperature may drop too low for satisfactory soldering — particularly with a small, low mass tip.

Without some form of temperature control, there is inevitably a wide variation in the tip temperature, depending on the mass of the terminations and the frequency of soldering.

This problem was overcome in the blunderbus era by that massive big 'bit' we mentioned, but this is quite impossible with today's high density circuitry and miniature componentry. The only answer, therefore, is some means of rapidly replacing the heat as it is drawn out.

HIGH IDLING TEMPERATURES

In an attempt to compensate for the inevitable temperature reduction, particularly in production soldering, higher initial (idling) temperatures were frequently used, on the principle that the average operating temperature would be more acceptable. So it was — but the first few joints of every soldering sequence were then exposed to an excessively high temperature.

The penalties of elevated temperatures can be quite severe, and they are not all immediately obvious: insidious latent faults in circuits and components frequently result in call-backs.

HIGH TEMPERATURE PENALTIES

Some of the more obvious results of excessive temperatures include:

* Flux preactivation: the flux vaporises and fails to do its job.
* Solder spatter: a short circuit hazard in high density circuitry.
* Printed circuit track and pad delamination: a fault which may not be immediately obvious.
* Excessive oxidation of tip and destruction of tip tinning: makes soldering harder instead of easier.
* Reduced element life: element wire oxides rapidly.
* Damaged insulation: plastic insulation can be damaged, or will 'shrink back', even from the radiated heat.
* Component damage: this is the greatest hazard in today's circuitry, due to the predomination of solid state componentry.

COMPONENT DAMAGE

Both the electrical and mechanical properties of semi-conductor devices are often temperature dependent and excessive heat, even if it does not cause immediate failure, will generally accelerate ultimate failure. It can, for example, cause shear stress along the bonded interface between two dissimilar materials (silicon to ceramic for example) due to their different coefficient of expansions. FETs and integrated circuits based on MOS or CMOS technologies are particularly susceptible to thermal damage during soldering. Excessive soldering temperature, therefore, may well ruin relatively expensive components; or at least reduce component life, undermine reliability, and degrade performance.

Even abnormally low temperatures do not remove this hazard. This simply entails leaving the soldering tip on the termination for an unduly long period, during which the component can soak up more heat than with a hotter tip and a quicker soldering operation.

TOOLS AVAILABLE

Three basic types of controlled-temperature soldering tools are readily available. One of these, the Weller, operates on the Curie principle, whereby a mechanical switch is operated by a magnetic pull. A tip with a specified temperature is first inserted in the tool. Below this specified temperature, the tip attracts the magnetic switch assembly, closing the element circuit. On reaching the elected temperature the magnetic force is reduced and the switch mechanism, via the spring, is released. To change temperature another tip, with the required Curie point, is substituted.

Weller temperature controlled iron. The stand incorporates a transformer in the box. Operating temperature is selected simply by changing the tip.

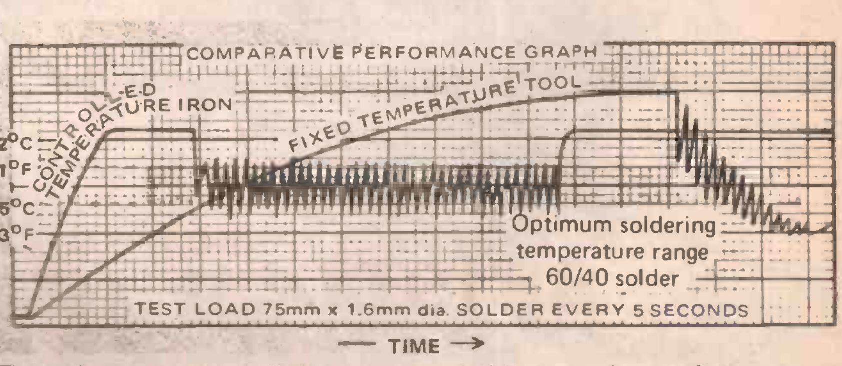
The second type operates on a push-rod system: this is used by Onyx and and Litesold. As the metal expands a bell-crank switches the current on and off.

The third types is the recently developed Unit 222 from Adcola which is entirely electronic. The iron itself contains a wire-wound sensor positioned in front of the heating element. This is fed back to the separate control unit with the electronic switching circuitry.

The temperature can be set between 180 and 420^{o}C and is maintained within 3% of that selected. The 222 is totally earthed from the supply input to the soldering bit to provide maximum safety against leakage currents.

For safety reasons, the iron is operated from 24V and is designed to fail 'cold!

The major benefits of controlled temperature soldering tools will now be evident. In addition to the temperature *control* aspect, there are obvious benefits associated with the temperature *selection* feature. Low temperatures can be selected for specially critical work with low-melting-point solders. Higher temperatures can be selected for soldering self-fluxing wire, where surface oxide retards heat flow at soldering temperatures. For long sequences of heavy chassis joints, higher temperatures may also be permissible.



The graph compares a controlled temperature tool with a conventional tool. Note that the heat up time is only a fraction of that required for the fixed temperature tool, which also cools down progressively under identical load conditions.

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2N457A	1.20	2N3391A	0.29	2N5298	0.50	AF118	0.35	BC212K	0.16	BF163	0.32	LM380	1.10	OC71	0.17
2N490	3.16	2N3392	0.15	2N5457	0.49	AF124	0.30	BC212L	0.16	BF166	0.40	LM381	2.20	OC72	0.25
2N491	4.38	2N3393	0.15	2N5458	0.45	AF125	0.30	BC214L	0.18	BF167	0.25	LM702C	0.75	OC81	0.25
2N492	3.00	2N3394	0.15	2N5459	0.49	AF126	0.28	BC237	0.16	BF173	0.27	LM709T099	0.48	OC83	0.24
2N493	5.20	2N3402	0.18	2N5492	0.58	AF127	0.28	BC238	0.15	BF177	0.29	8DIL	0.38	ORP12	0.55
2N696	0.22	2N3403	0.19	2N5494	0.58	AF139	0.65	BC239	0.15	BF178	0.35	14DIL	0.40	R53	1.80
2N697	0.16	2N3440	0.59	2N5496	0.61	AF186	0.46	BC251	0.25	BF179	0.43	LM710	0.47	SL414A	1.80
2N698	0.82	2N3441	0.97	2N6027	0.45	AF200	0.65	BC253	0.25	BF180	0.35	LM3900	0.70	SL610C	1.70
2N699	0.59	2N3442	1.40	2N5777	0.45	AF239	0.65	BC257	0.15	BF181	0.36	LM723C	0.90	SL611C	1.70
2N706	0.14	2N3414	0.10	3N128	0.73	AF240	0.90	BC258	0.16	BF182	0.35	LM741T099	0.40	SL612C	1.70
2N706A	0.16	2N3415	0.10	3N139	1.42	AF279	0.70	BC259	0.17	BF183	0.55	8DIL	0.40	SL620C	2.60
2N708	0.17	2N3416	0.15	3N140	1.00	AF280	0.79	BC261	0.25	BF184	0.30	14DIL	0.38	SL621C	2.60
2N709	0.42	2N3417	0.21	3N141	0.81	AL102	1.00	BC262	0.25	BF185	0.30	LM747	1.00	SL623	4.59
2N711	0.50	2N3638	0.15	3N200	2.49	AL103	1.00	BC263	0.25	BF194	0.12	LM748 8DIL	0.60	SL640C	3.10
2N718	0.23	2N3638A	0.15	40361	0.40	BC107	0.14	BC300	0.38	BF195	0.12	LM7805	2.00	SL641C	3.10
2N718A	0.28	2N3639	0.27	40362	0.45	BC108	0.14	BC301	0.34	BF196	0.13	14DIL	0.73	SN76003N	2.92
2N720	0.57	2N3641	0.17	40363	0.88	BC109	0.14	BC302	0.29	BF197	0.15	LM7805	2.50	SN76013N	1.95
2N914	0.39	2N3702	0.11	40389	0.46	BC113	0.15	BC303	0.54	BF198	0.18	LM7812	2.50	SN76023N	1.60
2N916	0.28	2N3703	0.12	40394	0.56	BC115	0.17	BC307	0.17	BF200	0.40	LM7815	2.50	SN76033N	2.92
2N918	0.32	2N3704	0.15	40395	0.65	BC116	0.17	BC308A	0.15	BF225J	0.23	LM7824	2.50	ST2	0.20
2N929	0.37	2N3705	0.15	40406	0.44	BC116A	0.18	BC309C	0.20	BF244	0.21	MC1303	1.50	TAA300	1.80
2N930	0.22	2N3706	0.15	40407	0.35	BC117	0.21	BC327	0.27	BF245	0.45	MC1310	2.92	TAA263	1.10
2N1302	0.19	2N3707	0.18	40408	0.50	BC118	0.14	BC328	0.28	BF246	0.58	MC13300P	0.90	TAA350	2.10
2N1303	0.19	2N3708	0.14	40409	0.52	BC119	0.29	BC337	0.20	BF247	0.65	MC1351P	0.80	TAA550	0.60
2N1304	0.26	2N3709	0.15	40410	0.52	BC121	0.35	BC338	0.20	BF254	0.19	MC1352P	0.80	TAA611C	2.18
2N1305	0.24	2N3710	0.15	40411	2.25	BC125	0.16	BCY30	0.80	BF255	0.19	MC1466	3.50	TAA621	2.03
2N1306	0.31	2N3711	0.15	40594	0.74	BC126	0.23	BCY31	0.85	BF257	0.47	MC1469	2.75	TAA661B	1.32
2N1307	0.30	2N3712	1.20	40595	0.84	BC132	0.30	BCY32	1.15	BF258	0.53	ME0402	0.20	TBA641B	2.25
2N1308	0.47	2N3713	1.20	40601	0.67	BC134	0.13	BCY33	0.85	BF259	0.55	ME0404	0.13	TBA651	1.69
2N1309	0.47	2N3714	1.38	40602	0.61	BC135	0.13	BCY34	0.79	BFR39	0.24	ME0412	0.18	TBA810	1.50
2N1671	1.54	2N3715	1.50	40603	0.58	BC136	0.17	BCY38	1.00	BFR79	0.24	ME4102	0.11	TBA820	1.15
2N1671A	1.67	2N3716	1.80	40604	0.56	BC137	0.17	BCY39	1.50	BFS21A	2.30	ME4104	0.11	TBA920	4.00
2N1671B	1.85	2N3771	2.20	40636	1.10	BC138	0.24	BCY40	0.97	BFS28	0.92	MJ480	0.95	TIL209	0.30
2N1711	0.45	2N3772	1.80	40669	1.00	BC140	0.68	BCY42	0.28	BFS61	0.27	MJ481	1.20	TIP29A	0.49
2N1907	5.50	2N3773	2.65	40673	0.73	BC141	0.68	BCY58	0.30	BFS98	0.25	MJ490	1.05	TIP30A	0.58
2N2102	0.66	2N3779	3.15	AC126	0.20	BC142	0.23	BCY59	0.32	BFX29	0.30	MJ491	1.45	TIP31A	0.62
2N2147	0.78	2N3790	2.40	AC127	0.20	BC143	0.25	BCY70	0.17	BFX30	0.27	MJ2955	1.00	TIP32A	0.74
2N2148	0.94	2N3791	2.35	AC128	0.20	BC145	0.21	BCY71	0.22	BFX84	0.24	MJE340	0.48	TIP33A	1.01
2N2160	0.90	2N3792	2.60	AC151V	0.27	BC147	0.14	BCY72	0.15	BFX85	0.30	MJE370	0.65	TIP34A	1.51
2N2218A	0.22	2N3794	0.10	AC152V	0.49	BC148	0.14	BD115	0.75	BFX87	0.28	MJE371	0.75	TIP35A	2.90
2N2219	0.24	2N3819	0.37	AC153	0.35	BC149	0.15	BD116	0.75	BFX88	0.25	MJE520	0.60	TIP36A	3.70
2N2219A	0.26	2N3820	0.38	AC153K	0.40	BC153	0.18	BD121	1.00	BFX89	0.90	MJE521	0.70	TIP41A	0.79
2N2220	0.25	2N3823	1.42	AC154	0.25	BC154	0.18	BD123	0.82	BFY50	0.23	MJE2955	1.20	TIP42A	0.90
2N2221	0.18	2N3904	0.27	AC176	0.30	BC157	0.16	BD124	0.67	BFY51	0.23	MJE3055	0.75	TIP29c	0.60
2N2221A	0.21	2N3906	0.27	AC176K	0.40	BC158	0.16	BD131	0.40	BFY52	0.21	MP8111	0.32	TIP30c	0.85
2N2222	0.20	2N4036	0.67	AC187K	0.35	BC160	0.60	BD132	0.50	BFY53	0.18	MP8112	0.40	TIP31c	1.00
2N2222A	0.25	2N4037	0.42	AC188K	0.40	BC167B	0.15	BD135	0.43	BFY90	0.75	MP8113	0.47	TIP32c	1.25
2N2368	0.25	2N4058	0.18	ACY18	0.24	BC168B	0.15	BD136	0.49	BRY39	0.48	MPF102	0.30	TIP33c	1.45
2N2369	0.20	2N4059	0.15	ACY19	0.27	BC168C	0.15	BD137	0.55	BSX20	0.21	MPSA05	0.25	TIP34c	2.60
2N2369	0.22	2N4060	0.15	ACY20	0.22	BC169B	0.15	BD138	0.63	BSX20	0.21	MPSA06	0.31	TIP41c	1.40
2N2646	0.55	2N4061	0.15	ACY21	0.26	BC169C	0.15	BD139	0.71	BSX21	0.29	MPSA12	0.35	TIP42c	1.60
2N2647	0.98	2N4062	0.15	ACY28	0.20	BC170	0.15	BD140	0.87	BU104	2.00	MPSA55	0.26	TIP49	0.70
2N2904	0.22	2N4126	0.21	ACY30	0.58	BC171	0.16	BD529	0.80	BU105	2.25	MPSA56	0.31	TIP53	0.53
2N2904A	0.24	2N4289	0.34	AD142	0.57	BC172	0.17	BD530	0.80	C106D	0.65	MPSU05	0.65	TIP2955	0.98
2N2905	0.25	2N4919	0.95	AD143	0.68	BC177	0.28	BFR39	0.24	CA3180A	0.85	MPSU06	0.58	TIP3055	0.50
2N2905A	0.26	2N4920	1.10	AD149V	1.20	BC178	0.27	BFR79	0.24	CA3020A	1.80	MPSU55	0.63	TIS43	0.28
2N2906	0.19	2N4921	0.80	AD150	0.63	BC179	0.30	BDY20	1.05	CA3028A	0.79	MPSU56	0.80	ZTX300	0.13
2N2906A	0.21	2N4922	0.83	AD161	1.15	BC182	0.12	BF115	0.36	CA3035	1.37	NE555V	0.70	ZTX301	0.13
2N2907	0.22	2N4923	1.00	AD162	1.15	BC182L	0.12	BF117	0.55	CA3052	1.62	NE556	1.30	ZTX302	0.20
2N2907A	0.24	2N5190	0.92	AD161	pr	BC183	0.12	BF121	0.35	CA3046	0.70	NE560	4.48	ZTX500	0.15
2N2924	0.20	2N5191	0.96	AD162	1.05	BC183L	0.12	BF123	0.35	CA3048	2.11	NE561	4.48	ZTX501	0.13
2N2926	0.20	2N5192	1.24	AF106	0.60	BC184	o.13	BF125	0.35	CA3089E	1.96	NE565A	4.48	ZTX502	0.18
2N3053	0.25	2N5195	1.46	AF109R	0.40	BC184L	0.13	BF152	0.20	CA3090Q	4.23	OC23	1.35	ZTX530	0.23
2N3054	0.60	2N5245	0.47	AF114	0.35	BC186	0.25	BF153	0.25	LM301A	0.48	OC28	0.76		
2N3055	0.75	2N5294	0.48	AF115	0.35	BC187	0.27	BF154	0.16	LM308	2.50	OC35	0.80		

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SN7403	0.16	SN7416	0.35	SN7441AN	0.85	SN7470	0.33	SN7485	1.25	SN74118	1.00	SN74157	0.95	SN74190	2.30
SN7404	0.19	SN7417	0.35	SN7442	0.65	SN7472	0.26	SN7486	0.32	SN74119	1.92	SN74160	1.10	SN74191	2.30
SN7405	0.19	SN7420	0.16	SN7445	0.90	SN7473	0.36	SN7490	0.45	SN74121	0.37	SN74161	1.10	SN74192	1.15
SN7406	0.45	SN7423	0.29	SN7446	0.95	SN7474	0.36	SN7491	0.85	SN74122	0.50	SN74162	1.10	SN74193	1.15
SN7407	0.45	SN7425	0.29	SN7447	0.95	SN7475	0.50	SN7492	0.45	SN74123	0.60	SN74163	1.10	SN74196	1.60
SN7408	0.19	SN7427	0.29	SN7448	0.90	SN7476	0.35	SN7493	0.45	SN74141	0.85	SN74164	2.01	SN74197	1.58
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ETI REVIEW

THIS YEAR EVERYBODY is buying scientific calculators, and it looks like next year everyone will want to buy programmable scientifics. Sinclair Radionics have scooped the field by producing a programmable for under £30 and ETI have had one in operation for a while.

What is a programmable? Basically it is a standard calculator — usually a mathematical or scientific type with extra memory space — which can memorise the sequence of keystrokes needed to solve a particular problem. Hence it can be used to find the values of "x" which satisfy $ax^2 + bx + c = 0$ for several sets of values of a, b and c. The sequence of operational keystrokes needed is stored in the extra memory. When the program is run the values of a, b and c are fed in as data (via the keyboard) and the calculator replays the mathematical operations required to extract the roots of the equation. The same program may be run many times with different values for the variables. Thus many long and repetitive calculations may be carried out in a short time. The era of cheap programmable calculators is now with us, giving everybody access to the powerful problem-solving and decision-making machines that were until now available only to the privileged few in the computer industry.

The program memory may be either an interchangable magnetic card, as found in the Hewlett-Packard HP65 (£470), or it may be a separate IC as in other HP models (HP55: £230; HP 25: £119) and National Semiconductor (Novus 4515: £99.95, Novus 4525: £119.25). Several other manufacturers plan to introduce programmables within the next few months. The basic difference between the capabilities of the various machines is the maximum number of program steps that may be stored. These range from 24 steps to over 100 steps in the machines mentioned. The ability of the machine to make decisions ($x>0, x=0$ etc) and to make branches and conditional branches from the main program are other factors to consider.

THE SINCLAIR PROGRAMMABLE

Well how does the Sinclair fit in? Being the cheapest programmable calculator on the market at the moment it lacks some of the features of the more sophisticated machines. The program memory (which is a semiconductor memory) has a capacity of 24 keystrokes which although not as many as one might desire still makes the Sinclair a powerful machine capable of solving quite complex problems.

The calculator is mounted in the same case as the Oxford range with the same keyboard layout of 19 keys plus the on/off switch, mounted in five rows of four keys. The display is a green, fluorescent type having a total of nine digits mounted at an angle to the plane of the keyboard so that the display is easily read over a large angle. The basic calculator, is very similar to the Sinclair Scientific with Reverse Polish Notation on input and all answers displayed in scientific notation only (separate mantissa and exponent). The display gives a five digit mantissa and a two digit exponent with signs for each. Fifteen of the keys are dual function with the following direct functions available: sin x, cos x, arc tan x, $\sqrt{x}$, antilog x, log x, l/x, and x^2. There also are keys for the separate data memory: store, recall, and x-memory interchange. Because the machine uses RPN there is no = key but there is a "enter" key (the second function of the zero key — of which more later). There are also four keys which will only be found on a programmable calculator: ", B/E, EXEC, and VAR. Thus there are several useful keys missing from the usual scientific repertoire: arc sin, arc cos, tan and the constant π (all to be found on the Sinclair Oxford 300 scientific). The logarithms are all to base 10 as in the original Scientific, whereas in the Oxford 300 the base is e. The loss of arc sin, arc cos, and tan is certainly a disadvantage. The handbook does give routines to find them but these take between 9 and 12 keystrokes instead of the usual one or two. All trigonometric functions are in radians only and are limited in argument range to 0 to $\pi/2$.

APPRAISAL

As a standard scientific calculator the machine was a little disappointing because of the lack of functions and the compromises which had to be made to the key layout to incorporate the programming controls. The lack of a separate "enter" key means that a simple multiplication (2x3, for instance) requires 5 keystrokes: "2", "▲", "enter", "3" and "x" (although a key stroke may be saved by using the "+" key as an enter key). Any calculator, even one with the additional feature of programming must first and foremost be a calculator. Why then did Sinclair not make the "enter" key a separate "first function" key — perhaps combined with the execute key as its second function? After all they have a lot in common. When data is entered the key marked ./EE/- has an interesting function. When first pressed during number entry it will set the decimal point in the mantissa. When pressed again during the entry of the same number it will set any further digits in the exponent range of the number. With the third or subsequent operation of the key it will change the sign of the exponent.

As a programmable calculator the Sinclair is good, although some features are rather disappointing. With only a 24 step program, memory keystrokes are at a premium. Yet any constants that may be required to be entered must be preceded, and followed, by a quote mark: each of which counts as a keystroke. Because only integer constants can be entered (ie no decimal points or exponents) there are problems if the constants ''e'' or

π are used in a program. The constant ''e'' is entered as 878 ÷ 323 and (because each digit counts as a separate keystroke) this uses 12 steps of program space ('',8,7,8,'', enter, '',3,2,3,'', ÷) or half the total program capacity.

The program to tabulate the function e^x for any x will occupy 14 steps of memory (B/E, enter, '',8,7,8,'',x,',3,2,3, ÷ ,VAR). This function is available as a single keystroke on many scientifics. If the function being tabulated is $f(x) = \sinh x = e^x - e^{-x}/2$ then there is not enough program space to allow direct calculation of sinh x. The program given in the program library first calculates e^x and then $1/e^x$ $(=e^{-x})$. These are then subtracted and then the sign of the answer is changed. The last two operations require double operation of the '-' key and then finally this intermediate answer is returned to the control of the program (operate the ''Exec'' key again) where it is divided by two and the displayed answer is at last ''sinh x''.

Thus by adding the programmable feature to a fairly basic scientific calculator Sinclair give the option of having access to several functions only available on scientifics several times the price of the programmable. However these additional functions will have to be programmed in whenever required and may still need several keystrokes before they are evaluated.

PROGRAM LIBRARY

The program library supplied with the machine covers a fairly wide range of subjects and is impressively printed on high quality cards. The only criticism of the library is that the given programs are rather short on explanation. The lack of program memory space has been compensated for by some very ingenious programs but the owner will need to spend considerable time with pencil and paper working out the relevance of each program step or he will feel like the ''trained monkey'' just following the given instructions knowing that at the end he will get the reward of a correct answer. If the calculator is to be widely appreciated by its owners then more explanation is needed for program writers.

The handbook supplied with the machine is reasonably good although here again more program examples would be welcome. The machine is generally well constructed; the keyboard has a good positive feel to it although the on/off switch was almost impossibly stiff on our example. The machine is advertised as a mains/battery device but the current drain from a PP3 battery is nearly 100mA. The handbook statement that only occasional use on battery is recommended must be emphasised. Low battery volts show up as either ''rubbish'' answers or as a lock-up into the program mode with data fed in never reappearing.

Summing up then the Sinclair Programmable Scientific is a very good attempt to produce a programmable at the lower end of the price range. Because of the attempt to stay under £30 some of the facilities are rather limited and operation can be somewhat inconvenient. For all our criticism however, Sinclair are to be congratulated on this model which will no doubt prove a useful introduction to programmable calculators for many people and it will act as a spur to other manufacturers to produce low price programmables (just as the original Sinclair Scientific acted as a spur to both sales and design of standard scientifics). The year ahead should prove very interesting for observers of the calculator market.

Programmable calculators

NEW! Sinclair Scientific Pro

Three or four years ago, personal scientific calculators revolutionised the work of scientists, engineers and mathematicians.

With a wide variety of pre-programmed functions – logs, trig, $\sqrt{x}$, $\frac{1}{x}$, x^2 and many more complex functions – they took a lot of the drudgery out of calculations.

They were expensive.

But they were infinitely faster and normally more accurate than slide rules or tables.

Programmable calculators – unlimited power

Personal scientific calculators had limitations: the number of functions was determined by the number of keys that could be crammed onto a keyboard; and every extra function meant extra cost.

Programmability overcomes both limitations – and makes a calculator vastly more powerful. With a programmable calculator, the number of functions which can be performed is unlimited.

It becomes a true miniature computer.

Sinclair Scientific Programmable: fastest, cheapest, most convenient

The two or three personal scientific programmable calculators on the market so far have cost hundreds of pounds.

The Sinclair Scientific Programmable is a technological breakthrough.

As a straightforward scientific calculator, it's remarkable. It gives access to the full range of scientific and mathematical functions. It uses true scientific notation. And it's the fastest personal scientific machine on the market – *all* functions are to all intents and purposes instantaneous.

It has an exceptionally convenient 19-key keyboard.

It's completely self-contained – even program-entry takes place through the keyboard.

And it costs only £29.95!

Functions and features of the Scientific Programmable

Keyboard-entry programmability
Programs up to 24 steps entered simply by keying in a sequence equivalent to calculation. No program takes longer than 30 seconds to enter.

Scientific notation
Full scientific notation, with floating-point entry option. Post-fixed operators (reverse Polish) for convenience in handling complex calculations. Exponent range: 10^{-99}, to 10^{+99}.

Log and trig functions
Sin, cos, arctan (radians); $\log_{10}$, antilog_{10}; other functions immediately derivable.

Mathematical functions
+, −, ×, ÷
$\sqrt{x}$, $\frac{1}{x}$, x^2, sign change.

Three-function memory
Store, recall, exchange.
Program store can be used to give up to three extra memories.

Large green display

Mains/battery option

Program library
Over 400 standard programs.

One-year, no-quibble guarantee

Size
156 mm × 77 mm × 33 mm. Weight: 200 g.

Sinclair Scientific Programmable – a personal computer for under £30

The Sinclair Scientific Programmable is startingly good value.

It represents a tremendous design achievement: all the functions of the calculator are packed onto a single chip – an outstanding example of large-scale integration.

Other calculators use up to five or more chips – expensive to produce, and expensive to assemble.

The unique single Sinclair chip means that the Scientific Programmable – the fastest personal scientific calculator in the world – can be sold for £29.95 including VAT.

10-day no-ob

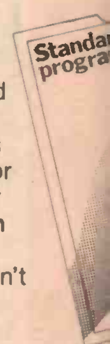
There's a lot more to this remarkable machine – far more than one advertisement can describe.

You need to see it and handle it... to program it yourself in a few seconds to save you hours... to check its performance against tables and graphs... to see the full range of standard programs.

It's not everybody's calculator – and as yet, it's not in the shops.

So we're offering you a 10-day trial. Use the order form below and send us a cheque or your Access, Barclaycard, or American Express number. We'll send you a calculator direct. Or if you prefer, phone your credit card number to Ann Dent on St Ives (0480) 64646.

Use it for 10 days – and if you don't feel it's £29.95 well spent, send it



–dramatic breakthrough!

grammable. For under £30!

Programmability–what it is... what it offers

Any calculation consists of a series of operations performed on constant or variable numbers.

With a non-programmable calculator, every step demands at least one key-stroke.

With a programmable calculator, constants and operations can be stored in the right sequence in the calculator, ready to operate on the variables as they are entered. (The calculator becomes a miniature computer.)

The task of the operator is reduced to entering the appropriate variables at the appropriate points.

Programs may be taken from the program library or devised by the operator. Either way, they are entered simply by keying in a sequence equivalent to the calculation.

This means

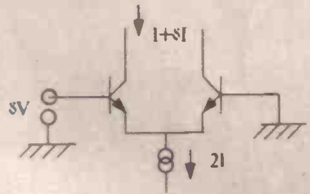
1. *unlimited power*–any function can be entered as a program;
2. *enormous time-saving*–for repetitive or iterative calculations *only* the variables need be entered;
3. *consistent accuracy*–eliminates risk of operator error during program execution;
4. *flexibility*. The Sinclair Scientific Programmable offers the choice of mains or battery operation–and once programmed can even be given to an operator who does not understand the program.

How the Scientific Programmable saves you time

This is most evident in repetitive calculations and in iterative procedures like the Newton-Raphson method of successive approximation.

Typical examples of repetitive calculations

1. An electronics engineer needs to plot the theoretical output waveform of a long tailed pair with current source tail for a sine wave input of peak value V pk.



The change of output current is described by the formula:

$$\frac{\delta I}{I} = \frac{(10^{\frac{\delta V}{60}}-1)}{(10^{\frac{\delta V}{60}}+1)} \text{ where } \delta V \text{ is in mV}$$

By storing a 24-step program, from the program library, he can rapidly construct a plot of the output waveform by entering V pk in mV plus a series of linear steps corresponding to the time axis of the graph.

With no further instructions, the machine calculates the sinusoidal input waveform, applies it to the transfer function given, and displays the normalised change in output current.

If the calculation had to be performed step by step each time, graphing any substantial number of values could take hours. With the Scientific Programmable, each plot is instantaneous.

2. An accountant raising a loan may have a number of quotations giving different repayment terms and interest rates. He can enter a standard program from the program library to calculate annual repayments for any number of combinations in a matter of minutes.

Typical example of iterative process

Solve the equation tan x = 1 + x.

By storing as a program the formula for solution by successive approximation, the solution can be obtained with high accuracy in a matter of seconds.

Over 400 standard programs

The procedures above are derived from some of over 400 standard programs in the Sinclair program library. Other programs include:

General
Fahrenheit to centigrade and centigrade to fahrenheit conversion
Degrees minutes and seconds conversion to radians

Finance
Compound interest
Loan repayment
Cashflow

Electrical and electronic engineering
Field variation from aerials
Reactance frequency chart
Transistor noise minimisation
Determination of values for ladder attenuators

Statistics
Sample mean
Chi² test

Geometry
Solution of a triangle
Surface area of a cone

Mathematics
Equation solving
Hyperbolic functions
Evaluation of polynomials
Roots of quadratic equations (real and imaginary parts)
Decimal to binary and binary to decimal conversion
Resolution of forces via parallelogram law
Beam deflection analysis
Critical loading of struts
Moments of inertia of square section torroids

Thermodynamics
Heat conduction shape factor of a cylinder

Fluid mechanics
Flow rate in a venturi

Materials
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Please send me ....(qty) Sinclair Scientific Programmable calculators, at the introductory price of £29.95 each (to include calculator, carrying case, battery, mains adaptor, full instructions, program library, VAT, postage and packing–no more to pay).

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200W BRIDGE AMPLIFIER

413x2

How to connect two ETI 413 100 watt amplifiers to double the output.

NO MATTER how big an amplifier you design — someone always wants a bigger one! We have certainly found this to be true, for hundreds of our ETI 413 Guitar Amplifiers have been built, and the only complaint that some builders have is that they would like even more power — especially into eight ohms.

Whilst a 200 watt amplifier can quite readily be designed, special high-voltage, high-power output transistors and a large and expensive power transformer are required. Fewer people require such power and hence, for commercial amplifiers, this means even higher cost in terms of £-per-watt of output power.

Here is a way to couple two ETI 413 amplifiers together to obtain 200 watts into 8 ohms.

The ETI 413 was first described in February of 1973. That issue of ETI is long out of print but was reprinted in Project Book No. 1 which is still available from us for 85p inc. postage.

Normally the ETI 413 provides 100 watts into 4 ohms or 65 watts into 8 ohms. By connecting the two amplifiers in a bridge configuration each amplifier effectively sees an 8 ohm load as 4 ohms. Their combined output will therefore be 200 watts. The only additional components required, apart from the two amplifiers are four resistors and three capacitors.

CONSTRUCTION

Construction of the individual 100 watt amplifiers is detailed in Project Book No. 1. If two existing amplifiers are to be interconnected they should be mounted end-to-end on a common base such that the connections between the two printed circuit boards are as short as possible. Of course, if the amplifiers are being specially built for the purpose, it is preferable to mount them in a common box.

For 200 watts into eight ohms two complete power supplies will need to be constructed and their outputs commoned. This is cheaper than buying a larger transformer to supply both amplifiers. A larger transformer will certainly cost more than two individual transformers but, if one is available, it may be used together with a single rectifier bridge. If the amplifier is to be used to supply 100 watts to a speaker load of 16 ohms minimum, one single supply (as for the normal amplifier) will be sufficient.

Before modifying the amplifiers for bridge connection set up and test each of them separately.

To modify the amplifiers add the series 0.1 microfarad and 4.7 ohm network across the output of each amplifier and add the series 0.01 microfarad and 10 ohm network from the base of transistor Q6, in the second amplifier, to ground. Using

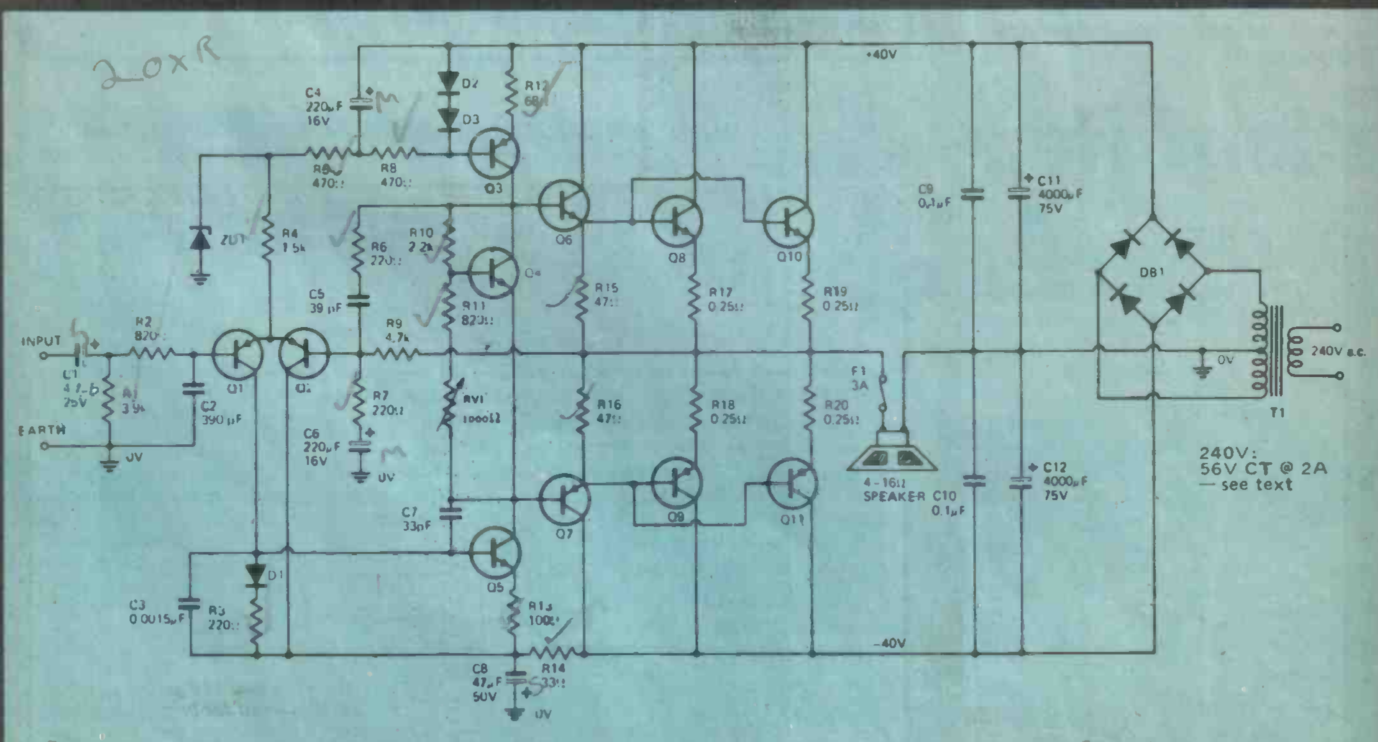

Fig. 1. Circuit diagram of the ETI 413 amplifier. Full constructional details of this unit are given in Top Projects No. 1. Send 85p to: ETI Top Projects No. 1, ETI Magazine, 36 Ebury Street, London SW1W 0LW.

23/0076 wire (or heavier) link each of the +40 V, 0 V and −40 V, of one amplifier, to the corresponding rails of the other amplifier. The 4.7 k ohm resistor may now be installed between the output of the first amplifier and the base of transistor Q2 in the second amplifier. Use insulated wire to extend the resistor leads. The input of the second amplifier should be shorted out to prevent noise pickup. The speakers may now be connected (with a fuse in series) between the outputs of the two amplifiers.

Note that if it is possible to use two separate amplifiers, each delivering 100 watts into separate four ohm loads, this is preferable to a bridge amplifier supplying 200 watts into an eight ohm load. In a bridge amplifier if one of the amplifiers fails then all output is lost. Thus from a reliability point of view the bridge amplifier should only be used where the eight ohm load cannot be separated.

The most queries arising from the original article concern the availability of the transformer. 56V centre-tapped types are not common however 25–0–25 and 30–0–30 types at 2A are widely available and are perfectly suitable. The values of C11 and C12 can also lie between 2500 and 5000μF.

SPECIFICATION

OUTPUT POWER		
	8 Ohms	200 watts
	15 Ohms	120 watts *
	Loads less than 8 ohms not recommended.	
INPUT IMPEDANCE		3.9 k
INPUT SENSITIVITY		1 volt

*A single transformer may be used for 15 ohm loads in which case the power output will be 100 watts.

HOW IT WORKS – ETI 413x2

One of the amplifiers is driven normally such that the output signal is in phase with the input. The second amplifier is driven from the output of the first and is connected as a unity-gain inverting amplifier. The second amplifier is changed to an inverting amplifier by injecting the signal, via a 4.7 k resistor, into the base of transistor Q2. The differential pair, Q1 and Q2, always tries to balance the voltages at the bases of the transistors by means of a change in output voltage. In the unmodified amplifier if the input voltage increases, the output voltage must also increase by the ratio of (R9+R7)/R7 (gain determining components). In the inverting mode the voltage on Q1 is constant and therefore, to keep the voltage at the base of Q2 constant, the current in the new 4.7 k resistor (from the output of amplifier 1) must be balanced by an equal current through R9 in amplifier 2. Therefore the output of amplifier 2 is identical to that of amplifier 1 except that it is out of phase by 180 degrees. The speaker, being connected between the two amplifiers, receives twice the output voltage that could be delivered by one amplifier alone.

Some additional stabilizing networks are needed when working in this mode and these consist of a 4.7 ohm resistor and an 0.1 microfarad capacitor in series across each output. Also required is a 10 ohm resistor and an 0.01 microfarad capacitor in series from the base of Q6 to ground on the second amplifier only. The power rails (+40 V, 0 V and −40 V) should also be linked between the two amplifiers.

SEMICONDUCTORS:	
Q1,Q2,Q3	BFX30
Q4,Q5	BFY50
Q6	BD139
Q7	BD140
Q8,Q10	2N3055
Q9,Q11	MJ2955
D1,D2,D3	1N4005
ZD1	15V, 1A
DB1	4A, 200V diode bridge

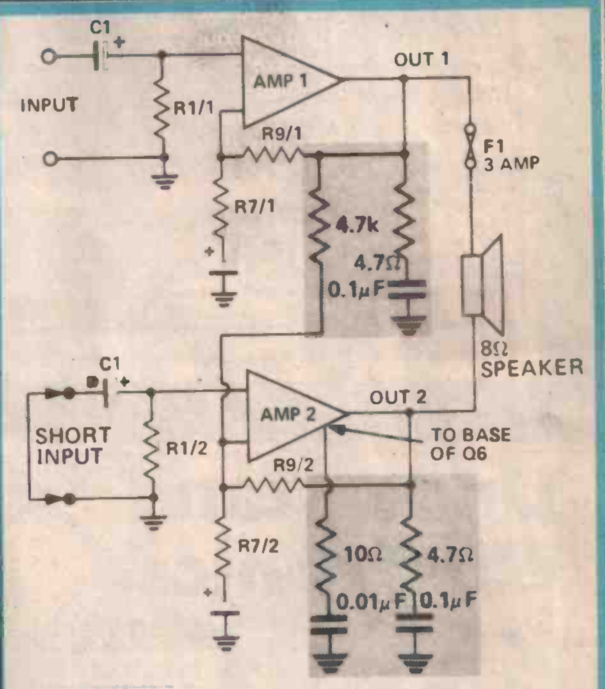

Fig.2. Method of interconnecting two 413s to obtain 200 watts into eight ohms. Additional components required are shown within the tone blocks.

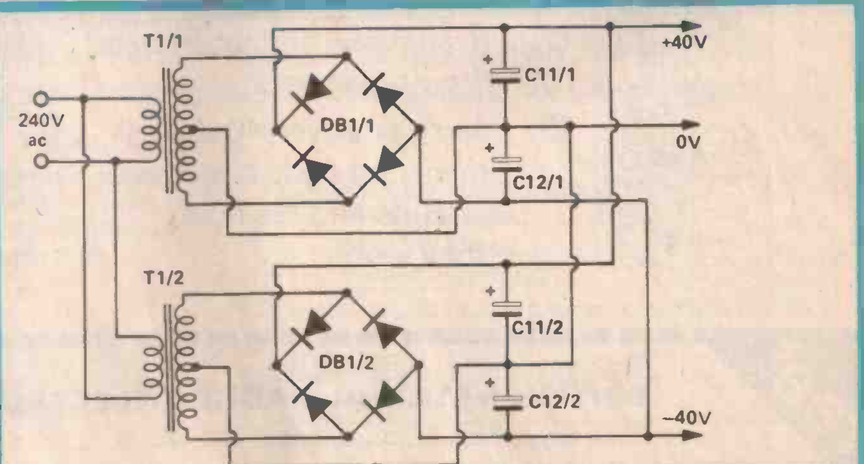

Fig.3. How the two 413 power supplies are interconnected for bridge amplifier operation.

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November 75

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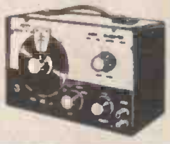

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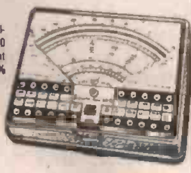
ICE 680R



Compact Precision multi-meter 20KΩ/V. 10 fields of measurement and 80 Ranges 1% accuracy. Damped movement. Mirror Scale. Supplied with Loads. Accessories and shatterproof case.
£19.98

Accessories for 680R

ICE 6603 Electronic Adden Amp	£22.68
ICE 662 Transistor and Diode Tester	£12.90
HiVoltage Probe	£6.42
Temperatures Probe	£12.90
Gauss Meter	£12.90
Current shunts 5-100 A	£4.86

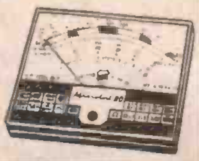
TE-65 Vacuum Tube Voltmeter
6" scale. 1 5-1500V. Resistance Range to 100 mΩ.

Appearance similar to TE-40	£24.30
RF22 RF Probe for TE-65	£3.18
HV20 30KV Probe for TE-65	£3.78

TE-15 Grid Dip Oscillator

Absorption Wavemeter 440 KHz-280mHz in 6 Ranges. Battery operation.
£21.54

Microtest 80



Pocket Precision Multimeter 20KΩ/V. 2% Accuracy. 40 Ranges. Shatterproof Case. Mirror Scale. Auto-zeroing ohms range.
£11.88

UHF TV TUNERS

625 line receiver UHF transistorised tuners UK operation. Brand new. (Post/packing 25p each).

TYPE A variable tuning. Slow motion drive £3.50.
TYPE B 4-button push-button (adjustable) £4.60.
TYPE C variable tuning £2.90.
TYPE D 6-button UHF/VHF £5.20.

EMI SPEAKERS SPECIAL PURCHASE

13 in x 8 in chassis speakers. (Carr./packing 30p each or 50p pr.)

'150 TC 10 watts 8 ohms twin cone	£2.53
450A Built-in tweeter 8 ohms	£4.43
EW 15 watt 8 ohm with tweeter	£6.61
350 20 watt 8.15 ohm with tweeter	£10.96 each

'Polished wood cabinet £6.00 carr., etc. 35 p each or 50p pair.

STOP PRESS

VIDEO SPORT NOW AVAILABLE AS A KIT
FULL KIT AND PARTS WITH INSTRUCTIONS
ONLY £19.50. C+P 50p

DM1 DIGITAL MULTIMETER

3½ Digit multimeter reading AC & DC Volts and current and Resistance
Reads from 1mV to 1000 V DC (10mA i/p resistance)
Polarity indicator
1mV to 1000V AC (100K to 10m i/p resistance)
Current 1μA to 1A AC or DC
Resistance from 1Ω to 10 mA
Working, but may go out of calibration
£17.00

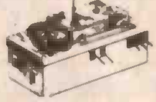
Also some not working, with circuits. No Guarantee
£6.50

SPECIAL PURCHASE MULLARD TYPE LP1179 AND LP1171 AM/FM TUNER MODULES

These two modules together form a high quality AM/FM tuner covering the long, medium and VHF broadcast bands. Requires only 16 resistors and capacitors and a switch to complete.

Supplied with circuits and spec data.

LP1179



FM Coverage 87-108 MHz
Bandwidth 300KHz
Selectivity 35 dB
Signal to noise at limiting threshold 40 dB
Audio output 75mV

LP 1171

AM Bandwidth 6-5kHz
Senstivity 1mV
Built-In AGC
Supply 6V negative earth

LP1179 and LP1171 £4.80 each or £8.63 pair. C+P 30p.
Suitable Ferrite Aerial 83p.

Mullard Modules

LP1157	AM/TYPE	£2.88
LP1135	10.7 I.F. Unit	£6.81
LP1186	10.7 F/M Tuner	£7.31
Gorler Perm. F/M Tuner		£5.03

HENRY'S NEW 1975 CATALOGUE

TWO NEW STORES NOW OPEN

If you live in the Midlands come and see our new components section at 94-96 UPPER PARLIAMENT STREET, NOTTINGHAM. Phone Nottingham 40403.
Components are back in Tottenham Court Road. Try our new store at 231 TOTTENHAM COURT ROAD. Phone 01-636 6688.

Henry's Radio
EDGWARE ROAD, W2

Electronic Centres Edgware Road
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354 Disco, Lighting & High Power Sound 01-402 5854
303 Special Bargain Centre
Also at 94-96 Upper Parliament St., Nottingham.
Nottingham 40403
231 Tottenham Court Road W1 01-636 6688

Phone or call for Best prices Barclay and Access welcome.

Tic Tac Radio

ETI project

THIS MEDIUM WAVE receiver measures about 60x36x15mm when constructed in a "Tic Tac" mint box. From the circuit in Fig. 1 it will be seen that the well-known TRF radio IC, ZN414, is used. This is followed by a single audio amplifier. This IC is often used alone for earphone reception, but the addition of an amplifier considerably boosts the volume.

The normal medium wave band is tuned by the compression trimmer VC1, which is available with a shaft fitted so that a standard control knob can be used. The audio output is to a 2.5mm jack socket via the isolating capacitor C4 (to ensure that the operating conditions for Q1 are not upset by the DC resistance of the phone or headset. A crystal earpiece can also be used.

COMPONENTS

An important consideration in building a miniature radio is the actual size of the components. C1 and C2 are easily obtained low voltage ceramic discs; C3 and C4 are small bead capacitors. The resistors are standard 1/3 or 1/4 watt.

Cut the board so that it will slip into the case. A part of the board is then cut away to allow the battery to fit. VC1 is fitted to the board by its bush, which is cut or filed down to avoid unnecessary projection.

The box lid takes the miniature slide switch with no modification to

Tic Tac Radio

the slot. Two small bolts hold the switch. The switch and jack are placed inside the lid as in Fig. 2.

FERRITE ROD

This will have to be cut from a longer rod. File a groove all round the rod 42mm from one end. The rod can then be broken by hand. Start to wind the 32swg enamelled wire 6mm from one end and fix with adhesive. Wind on eighty turns, side by side, and glue the wire again. Finally cement the rod to the perforated board.

WIRING

All leads etc can be seen in Fig. 2. It is important to keep the connections close to the board. Avoid large joints or the depth will prevent the radio fitting in the case. It is best to fix S1 and the jack to the lid before fitting the board.

Before S1 and the socket are fitted connect projecting leads for negative line, C4, and battery negative. Battery connections are soldered to the cell.

RESISTOR R2

Here 1.5k should be suitable. The actual layout of leads and components is likely to vary from that of the prototype and this increases the chances of instability. This would be manifest by IC1 oscillating so that whistles accompany reception with some signal levels, or on some frequencies. A check can easily be made before fitting the radio in its box. If reception is satisfactory (as is likely) R2 can be left at 1.5k. If R2 can be reduced in value, possibly to 1.2k or 1k, without whistles arising, this will increase gain. (R2 should not be less than 470 ohm).

BOX AND VC1

Push the receiver into its box and mark the position of the adjusting screw of VC1. Remove the radio and drill this point right through (so that

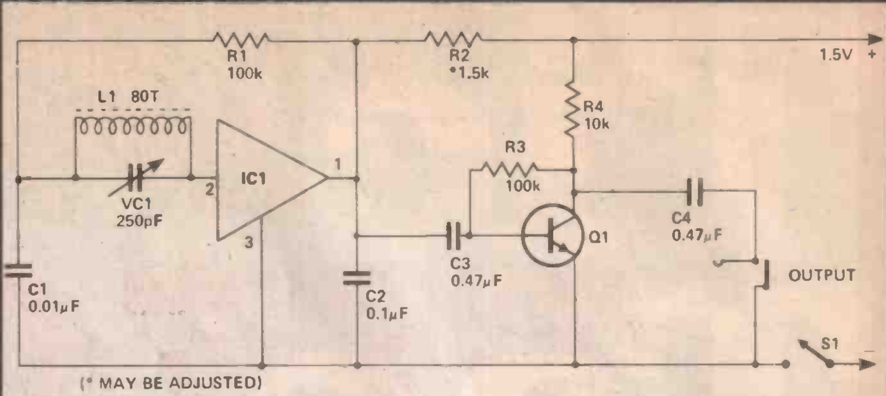

Fig. 1. Circuit of the miniature receiver.

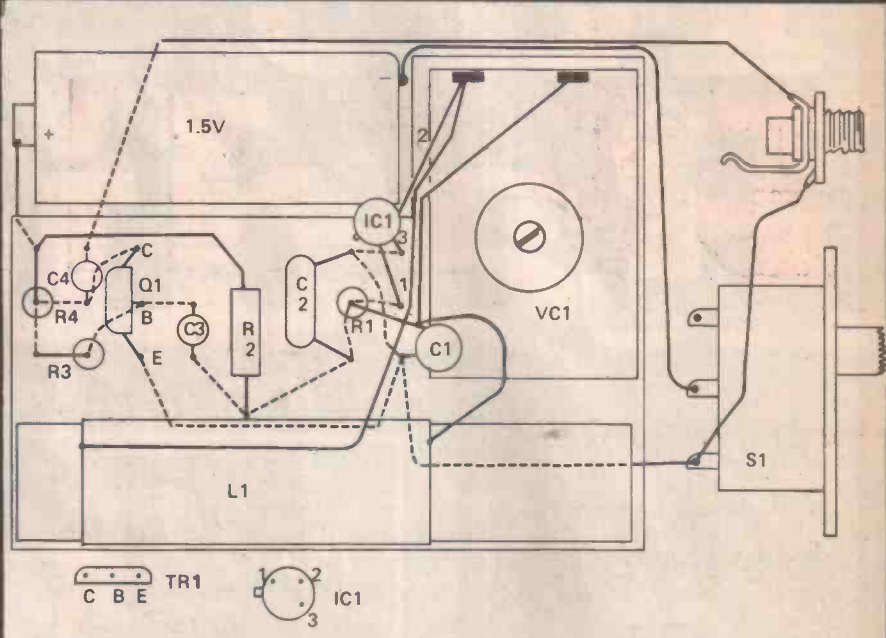

Fig. 2. Wiring and semi-conductor leads.

PARTS LIST

R1	100k	¼W	5%
*R2	1.5k	¼W	5%
R3	100k	¼W	5%
R4	10k	¼W	5%
C1	0.01µF disc ceramic		
C2	0.1µF disc ceramic		
C3	0.47µF tantalum bead		
C4	0.47µF tantalum bead		

* (may need adjustment)

VC1 Type TP4 250pF compression trimmer with Z236 spindle (Home Radio, Mitcham)
IC1 ZN414
Q1 ZTX300
L1 80 turns 32 swg enamelled wire on 42 x 9mm ferrite rod.
D23, 1.5V cell, small knob, 2.5mm jack socket, miniature slide switch, 42 x 30mm 0.15in matrix perforated board, "TIC TAC" mint box.

the bush and nut can fit in the bottom hole in the box). Use a sharp drill with light pressure, or ream out the hole. Be careful because the material is brittle.

With the receiver replaced, completely remove the adjusting screw, taking care not to displace the washers, and screw in the shaft. The latter is cut back to 6mm so that a small knob can lie near the box. This is a push-fit over a flat filed on the shaft.

PHONES

Best reception of all is with a good pair of high impedance headphones (the Heathkit GD-396, 2k impedance, will be ideal). Where a miniature earpiece is required, this should be a high impedance unit, or volume is to be severely reduced.

TWO GREAT SPECIALS FROM ETI

No. 1, now available only from ETI, (100 pages)

ETI Top Projects Books contain reprints of some of the most popular projects from past issues.

No. 1, with 21 projects, was originally published in October 1974 and No. 2, with 26 projects, in July 1975.

No. 2, from newsagents and ETI, (124 pages)

IF BOTH COUPONS ARE SENT TOGETHER, IGNORE POSTAGE! SEND ONLY £1.50.

TO: TOP PROJECTS NO 1
Electronics Today International,
36 Ebury Street,
London SW1W 0LW.

Please send me a copy of TOP PROJECTS NO 1.
I enclose a cheque/P.O. for 85p, payable to Electronics Today International, which includes 10p postage.

Name ____________________

Address ____________________

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November 75

TO: TOP PROJECTS NO 2
Electronics Today International,
36 Ebury Street,
London SW1W 0LW.

Please send me a copy of TOP PROJECTS NO 2.
I enclose a cheque/P.O. for 90p, payable to Electronics Today International, which includes 15p postage.

Name ____________________

Address ____________________

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November 75

Weller

INSTANT HEAT SOLDER GUN

ETI READER OFFER

When we first considered a Weller Solder Gun offer it was suggested that this tool is so useful that most of you will have one already! When we asked a group of readers we found that a large number had never tried.

The greatest advantage of a solder gun is that it heats up — and cools down — almost instantly: there's no waiting for your iron to heat up. The trigger is two-position; light pressure gives you a bit temperature of 450°C, press more and you get 600°C. And there's a bulb which lights up your work.

At ETI we always use two irons when constructing — a small 15W for semiconductors and our Weller for other work, that's why we've arranged this special offer.

SAVE OVER A THIRD!

usual price **£9.80**

ETI READER PRICE **£6.50**

Inc. VAT and P & P

Cut

TO: ETI/WELLER SOLDER GUN OFFER
Electronics Today International,
36 Ebury Street,
London SW1W 0LW.

Please find enclosed cheque/P.O. for £6.50 payable to Electronics Today International for a Weller Solder Gun.

Name . . . .

Address . . . .

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This coupon will be used to despatch the order. Please write in BLOCK LETTERS.

Name . . . .

Address . . . .

. . . .

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Offer closes November 30th. This offer is strictly limited to one solder gun per coupon. Please allow 28 days for delivery.

ON SALE NOVEMBER 7th

DECEMBER ETI

ENTER THE ETI/HEATHKIT COMPETITION

COMPETITION

Take part in our free competition next month and you can win yourself one of three Heathkit Scopes. First prize is the spanking new 10-4540 worth £99.90 — the second and third prizes are the 10-4560 selling at £69.90.

AND THERE ARE TWO BONUSES . . .

Firstly every entrant ticking the coupon will get the latest Heathkit catalogue — free, of course.

Secondly Heathkit are running some special offers open only to those who enter — details are supplied in the catalogue.

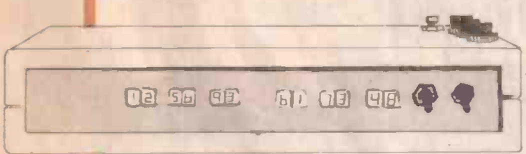
SCOOP TEST!

HEATHKIT'S 10-4540 5MHz SCOPE

So you'll know just how good the first prize of our competition is, we have got hold of the first available kits of the Heathkit 10-4540.

We'll be building it up and putting it through its paces.

DIGITAL STOPWATCH PROJECT



The problem with doing a digital stopwatch project is that the possible facilities and uses are as wide as the number likely to build it. Designed by one of Britain's experts in this field our project is almost modular — you choose the final design yourself!

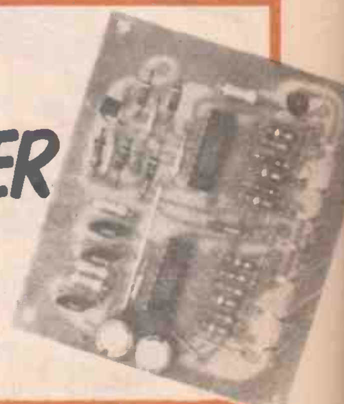
LOGIC PROBE & PULSER

The trouble-shooting and servicing of digital equipment is greatly simplified by using a logic pulser and probe. Next month we carry constructional projects for both.

SCIENTIFIC CALCULATOR OFFER: £15.95

Why the mystery? The reason is that this calculator is so new that it hasn't been announced — and won't be for another month. What we can say is that it is made by one of the world's largest calculator companies — has full scientific capability on an 8-digit display and includes a memory. Recommended retail price is expected to be an all time low for calculators of this type — about £23 — but for ETI readers — from the launch date — the price is £15.95.

ACTIVE CROSSOVER



As the cost of speakers and simple crossovers rise compared to amplifiers, the stage has been reached where it becomes advantageous to tailor the amplifiers for each speaker. This results in greatly improved fidelity for relatively low cost.

At the time of this issue going to press, the features mentioned here are in an advanced state of preparation. However, circumstances, including highly topical news, may affect the final contents.

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electronics today international

ETI DATA SHEET

NEW SERIES

The new series of ETI Data Sheets are arranged so that they can easily be removed from the magazine if required. It is planned to give details of between two and four devices each month, the emphasis being strictly on maximum information in the available space on I.C.'s and other semiconductors.

ETI Data Sheets are intended as an introduction to the devices, not as complete information though applications circuits will occasionally be modified to make it easier to build them up. All semiconductor manufacturers produce their own excellent data sheets but the majority of the information is not relevant to the enthusiast: we are concentrating on the data that is.

Internal circuits of I.C.'s will only be shown if it is felt that this will lead to a better understanding of the operation.

NE 504L POWER DRIVER — SIGNETICS

The 540 is a monolithic, class AB power amplifier designed specifically to drive a pair of complementary output transistors. The device features low standby current yet retains a high output current drive capability with internal current limiting. A wide power bandwidth and excellent linearity make this device ideal for use as an audio power amplifier.

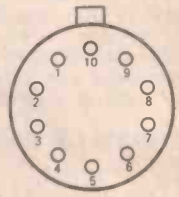
SPECIFICATION

Values are typical.

Supply Voltage	±5V to ±20V
Quiescent Current	13mA
Input Offset Voltage	7mV
Input Offset Current	0.5μA
Input Bias Current	2μA
Input Impedance (40dB Gain)	20kΩ
Current Gain	90dB
Frequency Response (40dB Gain ±1dB)	100kHz
Distortion (Output 3dB below maximum, $R_L = 600\Omega$)	0.5%
Equivalent Input Noise Voltage ($R_s = 600\Omega$, 50Hz to 500kHz)	1.0μV
Power Supply Rejection Ratio (40dB Gain)	80dB
Common Mode Rejection Ratio	90dB
Output Drive Current	±100mA

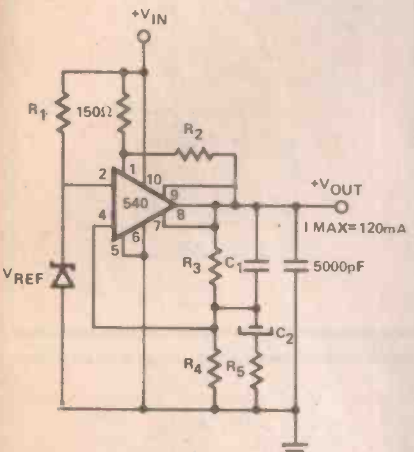
Typical Advertised Price £2.50 inc. VAT
Data supplied by Signetics.

L PACKAGE



1. Power Limit
2. Non Inverting Input
3. NC
4. Inverting Input
5. Power Limit
6. V^-
7. Output 1 (emmitter)
8. Output 2 (base)
9. Output 3 (collector)
10. V^+

POSITIVE VOLTAGE REGULATOR



$V_{OUT} = \frac{R_3 + R_4}{R_4} V_{REF}$

$R_1 = \frac{V_{IN} \cdot V_{REF}}{I_{ZENER}}$

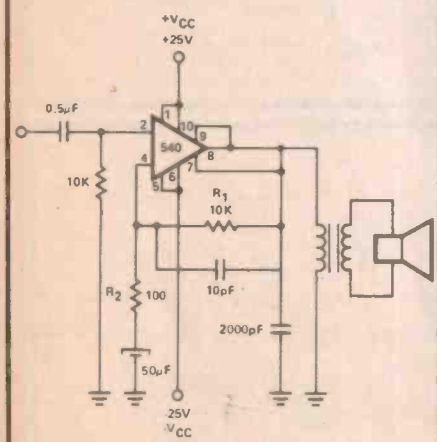
$R_2 = \frac{2 V_{IN} \cdot V_{OUT}}{4mA}$

$R_5 = \frac{R_3}{100}$

$C_1 = \frac{0.2}{R_3} \mu F$

$C_2 = 10\mu F$

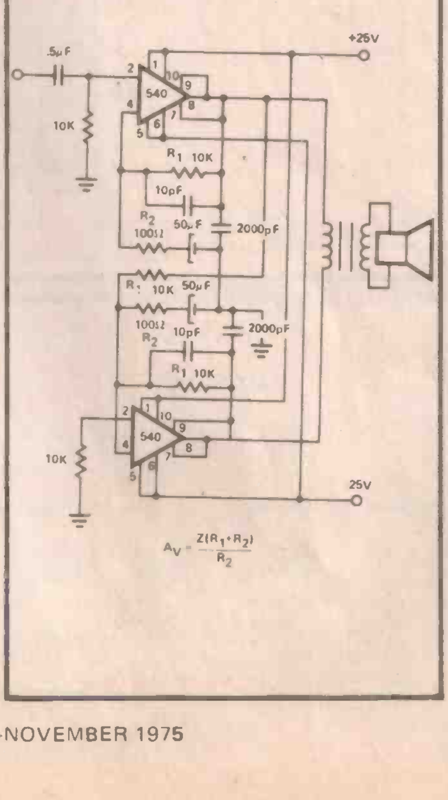
1W POWER AMP



VOLTAGE GAIN

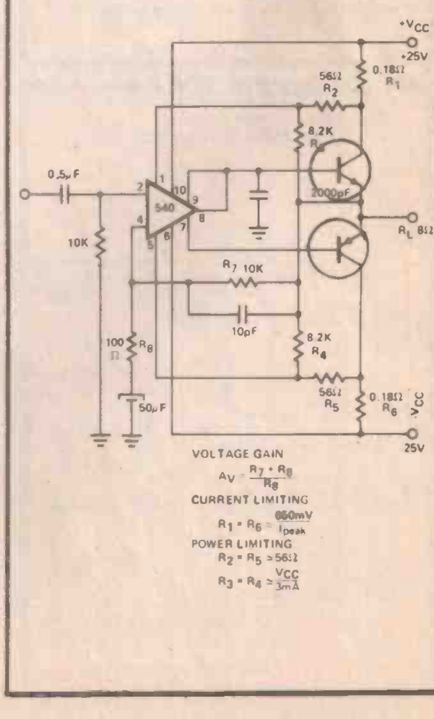
$A_V = \frac{R_1 + R_2}{R_2}$

3W POWER AMP



$A_V = \frac{2(R_1 + R_2)}{R_2}$

35W POWER AMP



VOLTAGE GAIN

$A_V = \frac{R_7 + R_8}{R_8}$

CURRENT LIMITING

$R_1 = R_6 = \frac{660mV}{I_{peak}}$

POWER LIMITING

$R_2 = R_5 \geq 56\Omega$

$R_3 = R_4 \geq \frac{V_{CC}}{3mA}$

The CA3130 series of operational amplifiers combines the advantages of both CMOS and bipolar transistors on a monolithic chip.

Gate-protected p-channel MOSFET (PMOS) transistors are used in the input circuit to provide very high input impedance, very low input current, and exceptional speed performance. The common-mode input-voltage capability goes down to 0.5V below the negative-supply lead, an important attribute in single-supply applications.

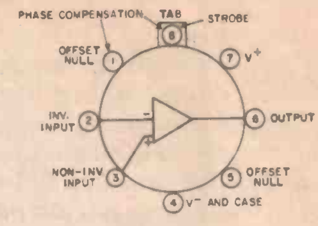
The CA3130 ICs operate at supply voltages ranging from 5 to 16V, or ±2.5 to ±8 volts when using split supplies. They can be phase compensated with a single external capacitor, and have terminals for adjustment of offset voltage for applications requiring offset-null capability. Provisions are also made to permit strobing of the output stage. The CA3130 series is supplied in either the standard 8-lead TO-5-style package (T suffix) or in the dual-in-line formed-lead TO-5-style package "DIL-CAN" (S suffix). The CA3130B is intended for applications requiring premium-grade specifications. The CA3130A offers superior input characteristics over those of the CA3130. Three Class A amplifier stages, provide the total gain of the CA3130. Care should be taken in handling the CA3130 — see "Handling CMOS' in ETI November 1974.

Offset-voltage nulling can be accomplished with a 100k pot connected across pins 1 and 5 with the slider connected to pin 4. The CA3130 was used in our DVM project last month and used in our Frequency Meter in this issue.

SPECIFICATION

Z_I	1.5 TΩ (1.5 x 10^{12}Ω)
I_I	5pA at 15V operation 2pA at 5V operation
Common-mode input-voltage	down to 0.5V below negative supply rail
Output signal swing	to either supply rail
V_{IO}	2mV max (CA3130B)
BW	15MHz (unity-gain crossover)
SR	10V/μs (unity-gain follower)
(I_O)	20mA
A_{OL}	320,000 (110dB)

LEAD CONNECTIONS

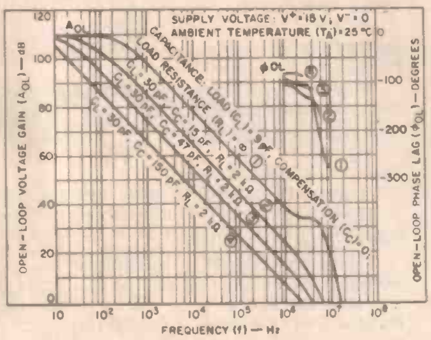


Functional diagram of the CA3130 Series.

MAXIMUM RATINGS

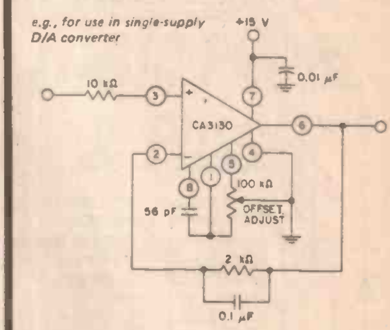
DC Supply Voltage	16V
Differential-Mode Input Voltage	±8V
Common-Mode DC Input Voltage	V^+ to (V^- −0.5V)
Input-Terminal Current	1mA
Device Dissipation Without Heat Sink	630mW
With Heat Sink	1.6W

Typical Advertised Price 90p inc. VAT
Data supplied by RCA.

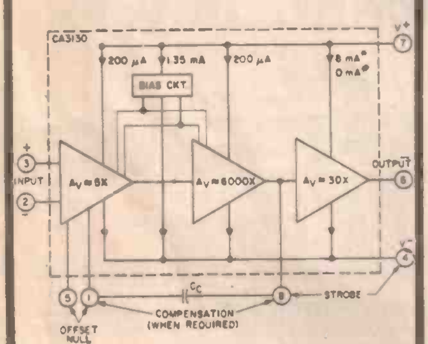


Open-loop voltage gain and phase shift vs. frequency for various values of C_L, C_C, and R_L.

SINGLE-SUPPLY VOLTAGE-FOLLOWER



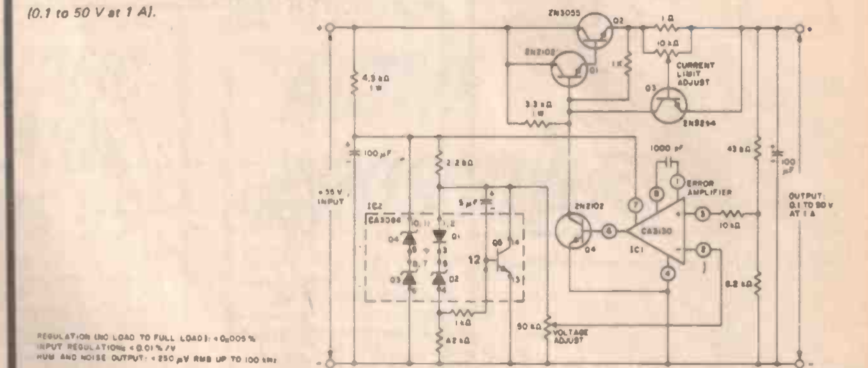
BLOCK DIAGRAM OF THE CA3130



TOTAL SUPPLY VOLTAGE (FOR INDICATED VOLTAGE GAINS) = 15 V
* WITH INPUT TERMINALS BIASED SO THAT TERM 6 POTENTIAL IS +7.5V ABOVE TERM. 4.
● WITH OUTPUT TERMINAL DRIVEN TO EITHER SUPPLY RAIL.

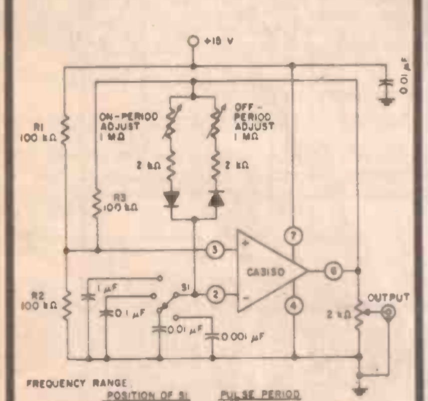
VOLTAGE REGULATOR

(0.1 to 50 V at 1 A).



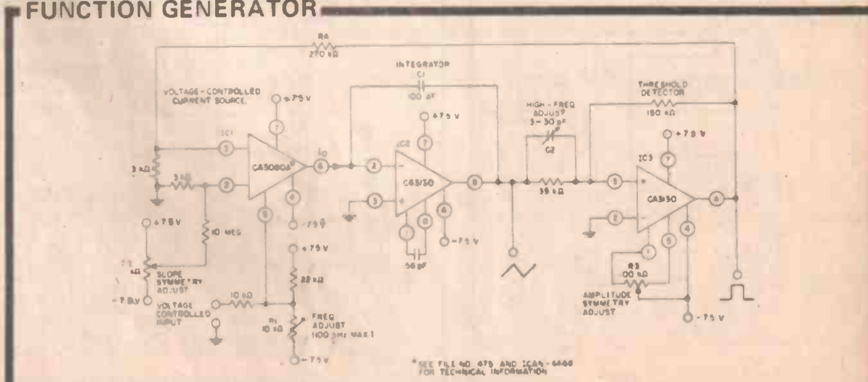
PULSE GENERATOR

(astable multivibrator) with provisions for independent control of "ON" and "OFF" periods.



FREQUENCY RANGE POSITION OF S1	PULSE PERIOD
0.001 μF	4 μs TO 1 ms
0.01 μF	40 μs TO 10 ms
0.1 μF	0.4 ms TO 100 ms
1 μF	4 ms TO 1 s

FUNCTION GENERATOR



(frequency can be varied 1,000,000/1 with a single control)

Continued on page 43

Electronic Reference Data

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NOVEMBER 1975

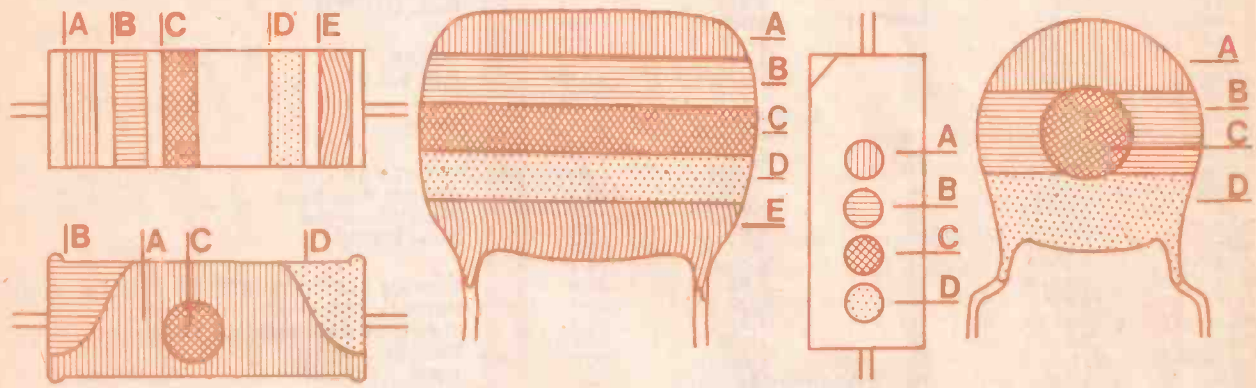
Common Abbrieviations

A	Ampere or Anode
AC	Alternating Current
Ae	Aerial
AF	Audio Frequency
AFC	Automatic Frequency Control
AGC	Automatic Gain Control
AM	Amplitude Modulation
ATU	Aerial Tuning Unit
AVC	Automatic Volume Control
b	Base of Transistor
B&S	Wire Gauge (U.S.)
BCD	Binary Coded Decimal
C	Capacitor, Cathode, Centigrade.
c	Collector
CCTV	Closed Circuit Television
c.g.s.	Centimetre-gramme-second
Ck	Clock
CMOS	Complementary Metal Oxide Semiconductor
CW	Continuous Wave
D	Diode
d	Drain (of FET)
dB	Decibel
DC	Direct Current
DCC	Double Cotton Covered
DF	Direction Finding
DIL	Dual-in-line
DIN	Audio Standard of German Standards Institute
DPDT	Double-pole double-throw
DPST	Double-pole single-throw
DSC	Double Silk Covered
DTL	Diode Transistor Logic
DX	Long Distance Reception
E	Sometimes used for Voltage
e	Emitter
EHT	Extra High Voltage
EMF	Electromotive Force
ERP	Effective Radiated Power
F	Farad or Fahrenheit
f	Frequency
FET	Field Effect Transistor
fhfb	Frequency at which current gain in common-base transistor mode is reduced by 3dB^{-1}.
FM	Frequency Modulation
f_T	Frequency at which current gain is unity in common-emitter mode
G	Giga (10^9)
g	Grid

H	Henry
HF	High Frequency
h_{fe}	Transistor small signal current gain
h_{FE}	Transistor large signal current gain
HT	High Tension
Hz	Hertz
I	Current
Ib	Base Current of Transistor
Ic	Collector Current of Transistor
IC	Integrated Circuit
Icbo	Collector-base current with emitter open circuit
IF	Intermediate Frequency
Igt	Gate Current to Trigger Thyristor
IIL	Integrated Injection Logic (also I^2L)
i/p	Input
i.p.s.	Inches per Second
K	Kilo (10^3) or Cathode
L	Inductance
LED	Light Emitting Diode
LF	Low Frequency
Lin	Linear
Log	Logarithimic
LS	Loudspeaker
LSI	Large Scale Integration
M	Mega (10^6)
m	Milli (10^{-3})
mA	Milliamp
mH	MilliHenry
mHz	Megahertz
mmF	Alternative to Picofarad
MOSFET	Metal Oxide Semiconductor FET
MSI	Medium Scale Integration
MOST	Metal Oxide Semiconductor Transistor
MPX	Multiplex
mV	Millivolt
mW	Milliwatt
n	Nano (10^{-9})
Ni-Cad	Nickel Cadmium
o/c	Open Circuit
o/p	Output
Op.Amp	Operational Amplifier
p	Pico (10^{-12})
PA	Public Address
PCB	Printed Circuit Board
p.d.	Potential Difference
PIV	Peak Inverse Working Voltage
PLL	Phase Locked Loop

P_{tot}	Maximum Total Power Dissipation
PU	Pickup
PUJT	Programmable Unijunction Transistor
Q	Transistor,'Goodness' factor of tuned circuit
R	Resistance
RAM	Random Access Memory
RF	Radio Frequency
RFC	Radio Frequency Choke
R_L	Load Resistor
r.m.s.	Root-mean-square
RTL	Resistor Transistor Logic
RV	Variable Resistor
Rx	Receiver
SCC	Single Cotton Covered
SCR	Silicon Controlled Rectifier
SPDT	Single-pole double-throw
SPST	Single-pole single-throw
SSC	Single Silk Covered
SSI	Small Scale Integration
SWG	Standard Wire Gauge
TRF	Timed Radio Frequency
TTL	Transistor Transistor Logic
TVI	TV Interference
Tx	Transmitter
uF	accepted alternative to μF
UHF	Ultra High Frequency
UJT	Unijunction Transistor
V	Volts
VA	Collector-emitter voltage with base open-circuit
V	Volts
V_{CEO}	Collector-emitter with base open - circuit
VA	Volt Amps
VCO	Voltage Controlled Oscillator
Veb	Base-emitter reverse voltage
Vf	Forward Voltage of Diode
Vgs	Gate - source Voltage of FET
Vgt	Gate Voltage necessary to trigger thyristor
VHF	Very High Frequency
VLF	Very Low Frequency
VR	Variable Resistor
W	Watts
X	Reactance
Xtal	Crystal
Z	Impedance
ZD	Zener Diode

Component Colour Codes



COLOUR	BAND A	BAND B	BAND C Multiplier		BAND D				BAND E	
			resistors	capacitors	resistors	capacitors up tp 10pF	capacitors over 10pF	tantalum working voltage	resistors	capacitors
BLACK	–	0	1	1	–	2pF	± 20%	10V	–	–
BROWN	1	1	10	10	± 1%	0.1pF	± 1%	–	–	–
RED	2	2	10^2	10^2	± 2%	–	± 2%	–	–	250V
ORANGE	3	3	10^3	10^3	–	–	± 2.5%	–	–	–
YELLOW	4	4	10^4	10^4	–	–	–	6.3V	–	400V
GREEN	5	5	10^5	–	–	0.5pF	± 5%	16V	–	–
BLUE	6	6	10^6	–	–	–	–	20V	–	630V
VIOLET	7	7	10^7	–	–	–	–	–	–	–
GREY	8	8	10^8	0.01	–	0.25pF	–	25V	–	–
WHITE	9	9	10^9	0.1	–	–	–	2V	–	–
SILVER	–	–	0.01	–	± 10%	–	–	–	–	–
GOLD	–	–	0.1	–	± 5%	–	–	–	–	–
PINK	–	–	–	–	–	–	–	35V	High Stability	–

NOTE: Adjacent bands, if the same colour are not always separated.

Preferred Values of Resistors

E12 Series (10%)

1.0 1.2 1.5 1.8 2.2 2.7 3.3 3.9 4.7
5.6 6.8 8.2 and their decades

E24 Series (5%)

1.0 1.1 1.2 1.3 1.5 1.6 1.8 2.0 2.2
2.4 2.7 3.0 3.3 3.6 3.9 4.3 4.7 5.1
5.6 6.2 6.8 7.5 8.2 9.1 and their decades

Decibel Table

The voltage and current figures are given on the assumption that there is no change in impedance.

Voltage or current ratio	Power ratio	⇦ – dB + ⇨	Voltage or current ratio	Power ratio
1.000	1.000	0	1.000	1.000
0.989	0.977	0.1	1.012	1.023
0.977	0.955	0.2	1.023	1.047
0.966	0.933	0.3	1.035	1.072
0.955	0.912	0.4	1.047	1.096
0.944	0.891	0.5	1.059	1.122
0.933	0.871	0.6	1.072	1.148
0.912	0.832	0.8	1.096	1.202
0.891	0.794	1.0	1.122	1.259
0.841	0.708	1.5	1.189	1.413
0.794	0.631	2.0	1.259	1.585
0.750	0.562	2.5	1.334	1.778
0.708	0.501	3.0	1.413	1.995
0.668	0.447	3.5	1.496	2.239
0.631	0.398	4.0	1.585	2.512
0.596	0.355	4.5	1.679	2.818
0.562	0.316	5.0	1.778	3.162
0.501	0.251	6.0	1.995	3.981
0.447	0.200	7.0	2.239	5.012
0.398	0.159	8.0	2.512	6.310
0.355	0.126	9.0	2.818	7.942
0.316	0.100	10	3.162	10.00
0.282	0.0794	11	3.55	12.6
0.251	0.0631	12	3.98	15.9
0.224	0.0501	13	4.47	20.0
0.200	0.0398	14	5.01	25.1
0.178	0.0316	15	5.62	31.6
0.159	0.0251	16	6.31	39.8
0.126	0.0159	18	7.94	63.1
1.100	0.0100	20	10.00	100.0
3.16×10^{-2}	10^{-3}	30	3.16×10	10^{3}
10^{-2}	10^{-4}	40	10^{2}	10^{4}
3.16×10^{-3}	10^{-5}	50	3.16×10^{2}	10^{5}
10^{-3}	10^{-6}	60	10^{3}	10^{6}
3.16×10^{-4}	10^{-7}	70	3.16×10^{3}	10^{7}
10^{-4}	10^{-6}	80	10^{4}	10^{8}
3.16×10^{-5}	10^{-9}	90	3.16×10^{4}	10^{9}
10^{-5}	10^{-10}	100	10^{5}	10^{10}
3.16×10^{-6}	10^{-11}	110	3.16×10^{5}	10^{11}
10^{-6}	10^{-12}	120	10^{6}	10^{12}

Dielectric Constants and Power Factor

	Dielectric Constant at 50Hz	Power Factor at 50Hz	Power Factor at 1MHz	Power Factor at 100MHz
Air (normal pressure)	1	–	–	–
Glass, Crown	6.2	–	1	–
Glass, Pyrex	4.5	–	0.5	–
Mica	2.5 – 8.0	0.2	0.2 – 6	–
Paper	2 – 2.6	–	–	–
PTFE	2	–	–	0.001
Polystyrene	2.5	0.02	0.02	0.03
Polythene	2.25	0.03	0.02	0.03
PVC	2.9 – 3.2	1.2	1.6	0.8
Vinyl resins	4	–	4.2	–

Mail Order Companies

with catalogues

ARROW ELECTRONICS LTD.
7 Coptfold Road,
Brentwood,
Essex, CM14 4BN

B.H. COMPONENT FACTORS LTD.
59 North Street,
Leighton Buzzard,
Beds. LU7 7EG

BI-PAK,
P.O. Box 6,
Ware,
Herts.

BI-PRE-PAK LTD.
222-224 West Road,
Westcliff- on- Sea,
Essex SS0 9DF

DORAM ELECTRONICS LTD.
P.O. Box TR8,
Wellington Road Industrial Estate,
Wellington Bridge,
Leeds, LS12 2UF

ELECTROVALUE LTD.
28 St Judes Road,
Englefield Green,
Egham,
Surrey TW20 0HB

HENRY'S RADIO LTD.
303 Edgware Road,
London W2 1BW

HOME RADIO (COMPONENTS) LTD.
240 London Road,
Mitcham,
Surrey CR4 3HD

MAPLIN ELECTRONIC SUPPLIES.
P.O. Box 3,
Rayleigh,
Essex SS6 8LR

A. MARSHALL (LONDON) LTD.
42 Cricklewood Broadway,
London NW2 3ET

S.C.S. COMPONENTS.
Northfield Industrial Estate,
Beresford Avenue,
Wembley,
Middlesex HA0 1YY

Wire Gauge Comparisons

Metric mm. (preferred sizes)	2.00	1.80	1.60	1.40	1.25	1.00	0.90	0.71	0.56	0.45	0.355	0.315	0.280	0.250	0.224	0.200	0.160	0.125	0.100	0.080
S.W.G. (nearest)	14	15	16	17	18	19	20	22	24	26	28	30	32	33	34	36	38	40	42	44
B&S (nearest)	12	13	14	15	16	18	19	21	23	25	27	28	29	30	31	32	34	36	38	40

Formulae

Capacitance

$$C = \frac{0.0885\,KA}{d}$$

C in pF

K is dielectric constant (air = 1)

A is area of plates in cm^2

d is thickness of dielectric

Frequency - Wavelength

$$f = \frac{300{,}000}{\lambda}\ \text{kHz}$$

$$\lambda = \frac{300{,}000}{f}\ \text{metres}$$

f is frequency in kHz

λ is wavelength in metres

Ohms Law

$$I = \frac{V}{R} \text{ or } V = IR \text{ or } R = \frac{V}{I}$$

I is current in amps.

V is volts

R is resistance in ohms.

Power

$$W = VI = I^2R$$

W is watts

Reactance

$$X_L = 2\pi fL$$

X_L is reactance of inductor.

f is specific frequency.

L is inductance in Henries.

$$X_C = \frac{1}{2\pi fC}$$

X_C is reactance of capacitor.

C is capacitance in Farads.

Resonance

$$f = \frac{10^6}{2\pi\sqrt{LC}}$$

L is inductance in microhenries.

C is capacitance in picofarads.

f is frequency in kilohertz.

Time Constant

For a combination of capacitance and resistance in series, the time constant (defined as the time necessary for voltage to reach 63% of final value) is:

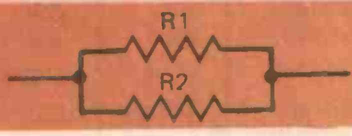
t = CR

t is time in seconds.

C is capacitance in Farads.

R is resistance in ohms.

Resistors in Parallel



R2 \ R1	10	12	15	18	22	27	33	39	47	56	68	82	100
10	5.00	5.45	6.00	6.43	6.88	7.30	7.67	7.96	8.25	8.48	8.72	8.91	9.09
12	5.45	6.00	6.67	7.20	7.76	8.31	8.80	9.18	9.56	9.88	10.20	10.47	10.71
15	6.00	6.67	7.50	8.18	8.92	9.64	10.31	10.83	11.37	11.83	12.29	12.68	13.04
18	6.43	7.20	8.18	9.00	9.90	10.80	11.65	12.32	13.02	13.62	14.23	14.76	15.25
22	6.88	7.76	8.92	9.90	11.00	12.12	13.20	14.07	14.99	15.79	16.62	17.35	18.03
27	7.30	8.31	9.64	10.80	12.12	13.50	14.85	15.95	17.15	18.22	19.33	20.31	21.26
33	7.67	8.80	10.31	11.65	13.20	14.85	16.50	17.88	19.39	20.76	22.22	23.53	24.81
39	7.96	9.18	10.83	12.32	14.07	15.95	17.88	19.50	21.31	22.99	24.79	26.43	28.06
47	8.25	9.56	11.37	13.02	14.99	17.15	19.39	21.31	23.50	25.55	27.79	29.88	31.97
56	8.48	9.88	11.83	13.62	15.79	18.22	20.76	22.99	25.55	28.00	30.71	33.28	35.90
68	8.72	10.20	12.29	14.23	16.62	19.33	22.22	24.79	27.79	30.71	34.00	37.17	40.48
82	8.91	10.47	12.68	14.76	17.35	20.31	23.53	26.43	29.88	33.28	37.17	41.00	45.05
100	9.09	10.71	13.04	15.25	18.03	21.26	24.81	28.06	31.97	35.90	40.48	45.05	50.00
120	9.23	10.91	13.33	15.65	18.59	22.04	25.88	29.43	33.77	38.18	43.40	48.71	54.55
150	9.38	11.11	13.64	16.07	19.19	22.88	27.05	30.95	35.79	40.78	46.79	53.02	60.00
180	9.47	11.25	13.85	16.36	19.60	23.48	27.89	32.05	37.27	42.71	49.35	56.34	64.29
220	9.57	11.38	14.04	16.64	20.00	24.05	28.70	33.13	38.73	44.64	51.94	59.74	68.75
270	9.64	11.49	14.21	16.88	20.34	24.55	29.41	34.08	40.03	46.38	54.32	62.90	72.97
330	9.71	11.58	14.35	17.07	20.63	24.96	30.00	34.88	41.14	47.88	56.38	65.68	76.74
390	9.75	11.64	14.44	17.21	20.83	25.25	30.43	35.45	41.95	48.97	57.90	67.75	79.59
470	9.79	11.70	14.54	17.34	21.02	25.53	30.83	36.01	42.73	50.04	59.41	69.82	82.46
560	9.82	11.75	14.61	17.44	21.17	25.76	31.16	36.46	43.36	50.91	60.64	71.53	84.85
680	9.86	11.79	14.68	17.54	21.31	25.97	31.47	36.88	43.96	51.74	61.82	73.18	87.18
820	9.88	11.83	14.73	17.61	21.43	26.14	31.72	37.23	44.45	52.42	62.79	74.55	89.13
1000	9.90	11.86	14.78	17.68	21.53	26.29	31.95	37.54	44.89	53.03	63.67	75.79	90.91

Popular Transistors

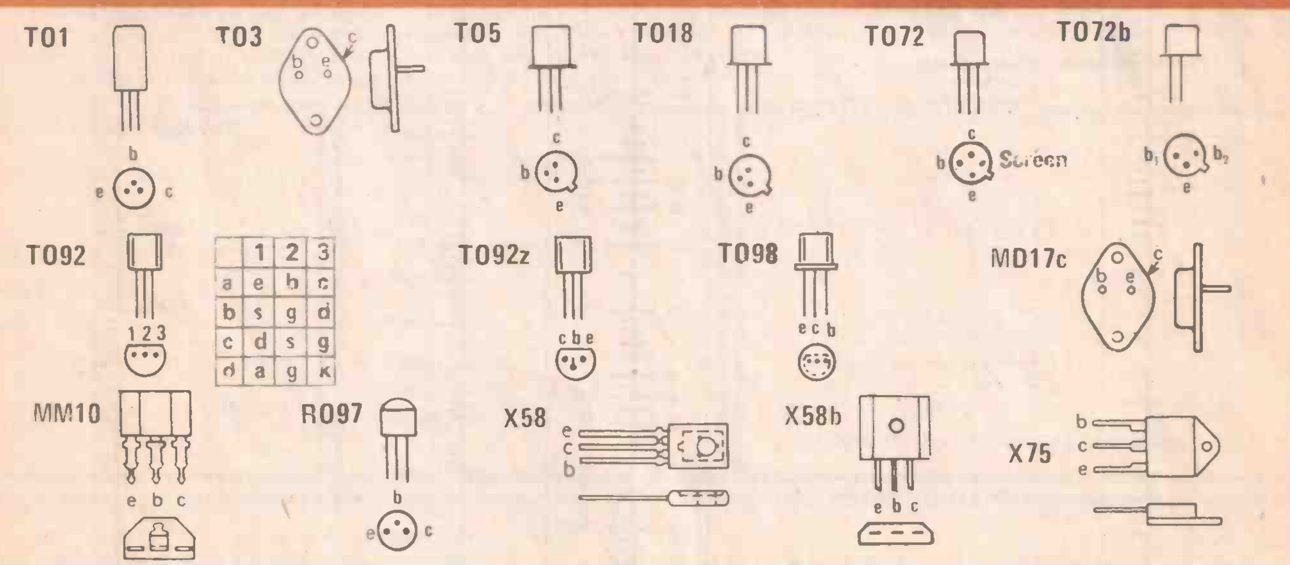
TYPE	PNP or NPN	P_t max Power mW	GAIN HFE	@ mA	fT (MHz)	VCEO (V)	OUTLINE	USUAL APPLICATION
2N2219	NPN	800	100	150	250	30	TO5	Medium power
2N706	NPN	300	50	10	200	20	TO18	G.P. Switching
2N2926G	NPN	200	470	2	120	18	TO98a	G.P. Audio
2N3702	PNP	200	60	50	100	25	TO92a	G.P.
2N3704	NPN	300	90	50	100	30	TO92	G.P.
2N3638	PNP	300	30	50	100	25	RO97	G.P.
2N3643	NPN	300	100	150	250	30	RO97	G.P.
AC127	NPN/G	200	25	500	1.5	32	TO1	
AC128	PNP/G	220	60	300	1.5	32	TO1	
AD161	NPN/G	4W	50	500	1	20	MD17c	Complementary Power
AD162	PNP/G	6W	50	500	1	20	MD17c	Germanium
AF239	PNP/G	60	50	2	800	15	TO72	UHF
BC107	NPN	300	125	2	150	45	TO18	G.P.
BC108	NPN	300	125	2	150	20	TO18	G.P.
BC109	NPN	300	240	2	300	20	TO18	Low Noise, High Gain
BC147	NPN	220	125	2	300	45	MM10	G.P.
BC148	NPN	220	125	2	300	20	MM10	G.P.
BC149	NPN	220	240	2	300	30	MM10	Low Noise, High Gain
BC157	PNP	220	125	2	300	45	MM10	G.P.
BC158	PNP	220	125	2	300	20	MM10	G.P.
BC159	PNP	200	240	2	200	20	MM10	Low Noise
BC177	PNP	300	125	2	300	45	TO18	G.P.
BC178	PNP	300	125	2	300	20	TO18	G.P.
BC179	PNP	300	240	2	200	20	TO18	G.P.
BC328	PNP	360	100	100	100	25	TO92zb	Low power
BC338	NPN	360	100	100	100	25	TO92zb	Complementary pair
BD131	NPN	11W	30	500	60	45	X58	High power
BD132	PNP	11W	30	500	60	45	X58	Complementary pair
BD139	NPN	8W	40	150	250	80	X58	High power
BD140	PNP	8W	40	150	75	80	X58	Complementary pair
BDY20	NPN	115W	20	4A	1	60	TO3	V. High power
BF180	NPN	150	50	2	675	25	TO72	UHF
BFR40	NPN	800	75	100	100	60	TO92	Complementary
BFR80	PNP	800	75	100	100	60	TO92	pair
BFX30	PNP	500	50	10	100	45	TO5	Medium power G.P.
BFX85	NPN	800	50	10	50	60	TO5	Medium power G.P.
BFX88	PNP	600	125	10	100	40	TO5	Medium power G.P.
BFY50	NPN	800	30	150	60	35	TO5	Medium power G.P.
BFY51	NPN	800	40	150	50	30	TO5	Medium power G.P.
2N3055	NPN	115W	20	4A	0.4	60	TO3	High power
MJ2955	PNP	115W	20	4A	0.4	60	TO3	High power
MJE3055	NPN	90W	20	4A	2	60	X58c	High power
MJE2955	PNP	90W	20	4A	2	60	X58c	High power
TIP31A	NPN	40W	20	1A	3	60	X75b	High power
TIP32A	PNP	40W	20	1A	3	60	X75b	High power
OC44	PNP/G	75	40	2	7.5	15	TO1	R.F. Low power
OC45	PNP/G	72	25	2	9	15	TO1	R.F. Low power
OC71	PNP/G	125	30	3	0.3	20	TO1	A.F. Low power
OC72	PNP/G	125	30	80	1	32	TO1	A.F. Low power
OC81	PNP/G	240	50	50	1	32	TO1	A.F. G.P.

P.U.T.'s	ANODE-CATHODE VOLTAGE (V)	VALLEY CURRENT Rg=1MHz (μA)	Rg=10kHz (μA)	MAX PEAK – POINT CURRENT Rg=1MHz (μA)	Rg=10kHz (μA)	OFF-SET VOLTAGE (V)	OUTLINE
2N6027 (D13TI)	40	50	70	2	5	0.2 1.6	TO92d

UNIJUNCTION TRANSISTORS	INTERBASE VOLTAGE (V)	VALLEY POINT CURRENT (mA) Min	Max	PEAK POINT EMITTER CURRENT (μA)	INTRINSIC STAND-OFF RATIO Min	Max	INTERBASE RESISTANCE (Ω) Min	Max	OUTLINE
2N2646	35	4	18	5	0.56	0.75	4.7k	9.1k	TO72b
2N2647	35	8	18	2	0.68	0.82	4.7k	9.1k	TO72b
2N2160	30	8		25	0.47	0.8	4k	12k	TO72b

FETS TYPE	N or P	Vds Max (V)	Drain to Source Current when Vgs=O (mA) Min	Max	Pt max Power (mW)	Gate-Source Cut-off Voltage (Vgs) (V) Min	Max	OUTLINE
2N3819	N	25	2	20	200	0.2	15	TO92b
2N3820	P	20	18 typical		200	4 typical		TO92b
2N5457	N	25	1	5	310	0.5	6	TO92c
2N5458	N	25	2	99	310	1	7	TO92c
2N5459	N	25	4	16	310	2	8	TO92c

Transistor Outlines



Transistor Codings

The preferred applications of many British and European semiconductors can be derived from their letter code. The first letter A describes a germanium device, a first letter B is for silicon devices. The second letter describes the following:–

A Diode low power
C AF low power
D AF low power
E Tunnel Diode
F RF low power
L RF power
P Photo type
S Switching low power
V Switching power
Y Diode power
Z Zener Diode

Reactance Chart

TO USE

Lay a ruler between any two parameters and read off the third eg. to find the reactance of a 10mH choke at 2000Hz. Lay a ruler between the two known parameters and read the answer (120 ohms) on scale A.

Note also that 0.7μF has the same reactance and a 0.7μF capacitor and a 10mH choke will resonate at 2000Hz. Resonance may only be read using scale A (values of inductance).

If inductance scales B or C are used, the corresponding reactance scale B or C must also be used.

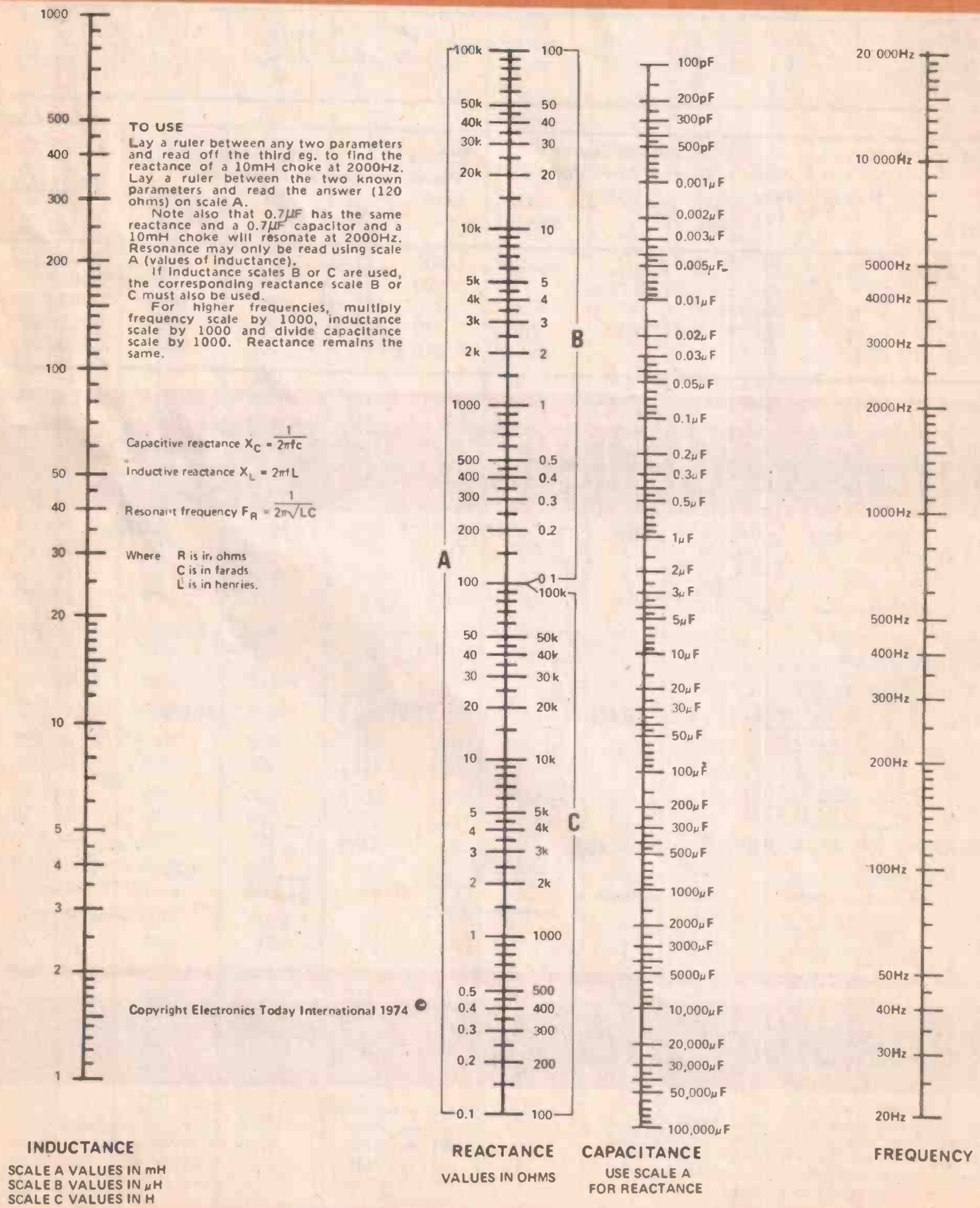
For higher frequencies, multiply frequency scale by 1000, inductance scale by 1000 and divide capacitance scale by 1000. Reactance remains the same.

Capacitive reactance $X_C = \frac{1}{2\pi fC}$

Inductive reactance $X_L = 2\pi fL$

Resonant frequency $F_R = \frac{1}{2\pi\sqrt{LC}}$

Where R is in ohms
C is in farads
L is in henries.



Continued from page 42

ZN1034E PRECISION TIMER

FERRANTI

The ZN1034E utilises digital and precision linear functions on the same chip to allow easy construction of simple precise timer modules.

The frequency of an on-chip oscillator is determined by an external capacitor and and resistor. Fine adjustment can be achieved by connecting a calibrating timing potentiometer. Pulses from the oscillator feed through a 12 stage binary divider which times out after 4085 counts. The IC incorporates its own voltage regulator. Two modes of operation can be used.

Supply Voltage Options: For operating from **TTL** supply rails connect pin 4 to positive. Connect a 0.1μF capacitor between pins 4 and 7. For operating from an unregulated supply (6V min) the on-chip regulator is used. Connect pins 4 and 5 together and connect the supply via resistor to pin 5. The resistor limits the current to 50mA if pin 5 is connected to a TTL supply rail otherwise the device will be destroyed. Excluding current drive to output loads, the current consumption is typically 5mA. With a DC supply a 0.1μF decoupling capacitor must be connected as possible to pins 5 and 7. For operation from the mains supply the circuit shown below can be used.

Calibration allows fine adjustment of the time period using fixed R_T and C_T. An external 250kΩ and 47kΩ resistor may be connected between pins 7 and 12 (pin 11 open circuit). Variation of the resistance between 50kΩ and 300kΩ will vary the time period between 2500 C_TR_T and 7500 C_TR_T.

Setting of Modes and Time Period. The timing sequence can be initiated at switch-on of the external supply by connecting pin 1 to earth. Alternatively the sequence can be initiated through external contacts by connecting them between pin 1 and earth (it is recommended that a 1000pF capacitor is connected between pin 1 and pin 14 in order to suppress contact bounce).

To set the time period the appropriate combination of C and R is connected between pin 14 and earth; pin 13 is connected between the timing C and R. Adjustment to the time period is then carried out by inspection of the oscillator frequency at pin 13 (T=4095 x oscillator frequency).

So that the measuring instrument connected to pin 13, causes a minimal change in the oscillator frequency being measured, an interface buffer amplifier is required.

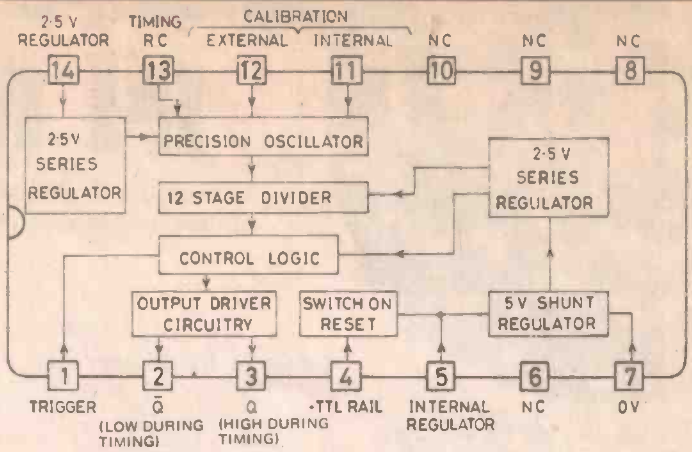
Timing Capacitor C_T. The maximum value of timing capacitor (C_T) that can be used depends upon the time period accuracy required (this is directly related to the timing capacitor leakage current. For timing capacitors <10μF, low leakage components are readily available. For greater values electrolytic capacitors have to be used and since their leakage currents are directly related to capacitance there will come a point where, for very long time periods and good accuracy, it will be necessary to use two ZN1034 circuits in cascade.

Example: 1 hour timer using one ZN1034E and external R_{CAL}.
The 12 stage counter 2^{12}=4096 and T = 4095kR_tC_t.
For R_{CAL}=150kΩ,k$\simeq$1.0
For T >30 secs. use R_t = 1MΩ

$$C_t = \frac{3600\ \text{(secs)}}{4095}\ \mu F = 0.9\mu F$$

Use C_t = 1μF and trim R_{CAL} external to give correct oscillator frequency on pin 13.

$$\text{Oscillator Period} = \frac{3600}{4095} = 879.1\text{ms}$$



SPECIFICATION

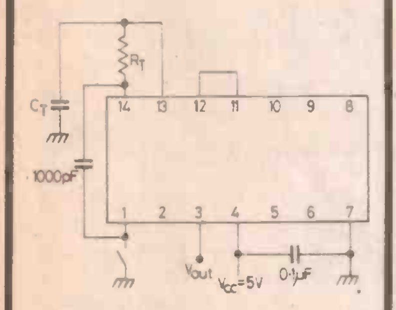
Typical Figures

Time Intervals	up to 7500 CR
Internal current consumprion	5mA
Output current drive	25mA max
Temperature stability	<0.01%/°C
Repetitive timing accuracy	0.01%
Outputs	complementary, TTL compatible
Calibration facility	Internal/External
Timing sequence initiation	mains, contact, or TTL triggered

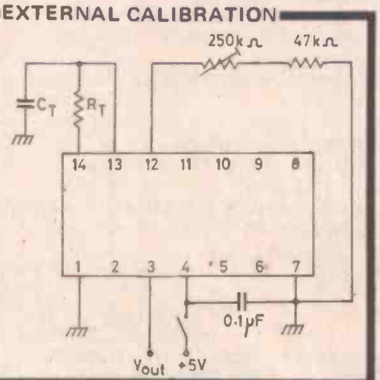
Repetitive and cascade operation possible
On-chip regulator or TTL supply option.

Typical Advertised Price £3.25 inc. VAT
Data supplied by Ferranti.

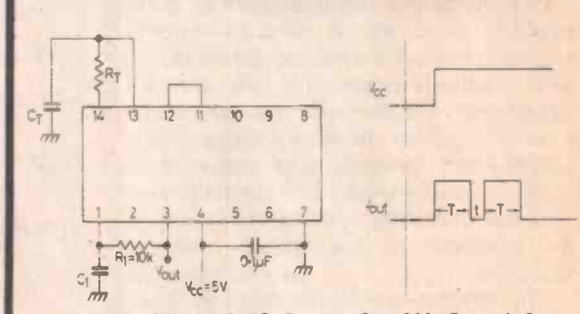
TIMING SEQUENCE INITIATED BY CONTACTS



EXTERNAL CALIBRATION

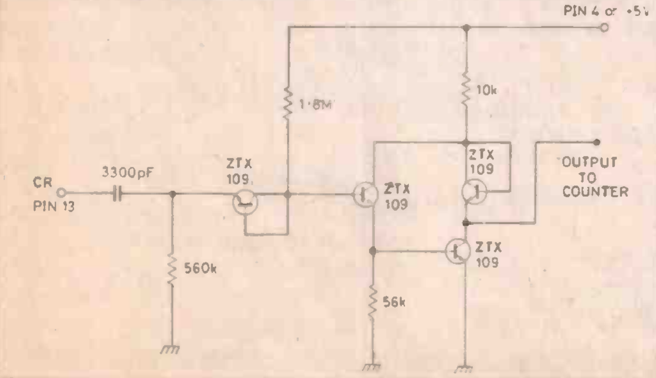


REPETITIVE OSCILLATOR

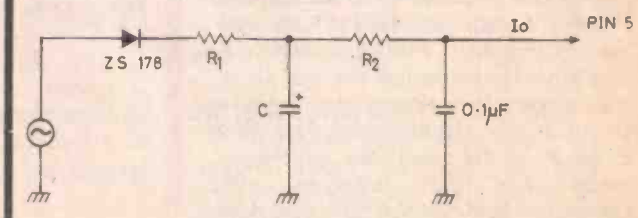


Pulse width, t ≃ 0·6C_1 R_1 e.g. C_1 = 220 pF, t = 1·3 μs

BUFFER AMP



OPERATING FROM THE MAINS



$C = 2I_o$

$R1 = \frac{100}{I_o}$

$R2 = \frac{20}{I_o}$

where, I_o is in mAmps
C is in μF
R1 and R2 are in kΩ

ELECTRONICS IN MEDICINE

The subject of this second part on measurement methods used in clinical pathology is nuclear medicine.

PART TWO

by Peter Sydenham

RADIOACTIVE ISOTOPES are trace elements that liberate a continuous stream of fast particles that can be detected with suitable instruments. The quantity and type of emitted particles depends upon the isotope. The strength of this process diminishes with time, reducing to half intensity in a time that is known as the half-life (denoted $T_{½}$). Some radioactive substances have half-lives of seconds, others tens of thousands of years.

An incredibly large number of radio isotopes can be made, and since 1896, when Becquerel first discovered radioactivity, they have found innumerable applications. Medicine is credited as being the first science to employ them for a useful purpose.

Isotopes are largely created by irradiating substances in the many forms of nuclear reactor that exist all over the world.

Their dominant use is as a tracer or marking substance. A suitable radio pharmaceutical (the isotope combined with other chemicals) is first introduced into the body itself or into a body specimen. Its flow path, or the accumulated strength at a particular spot, is monitored with detectors thereby providing information about the processes of the system under study.

This concept is well illustrated by an amusing yet profound use of an isotope which was probably the first ever application for detection. History has it that around 1910 Georg von Hevesy, a pupil of Rutherford, was having domestic problems with his landlady. He suspected she was using the scraps left in their plates to make the meat pies of subsequent days. One Sunday — the roast day — Hevesy seeded his meat left-overs with radioactive lead. On the following days he sampled the meals and tested them to find, indeed, the existence of radioactive lead. Hevesy, later in life, won a Nobel Prize for his work on radioactive indication.

SUMMARY USES OF NUCLEAR MEDICINE TECHNIQUES IN CLINICAL DIAGNOSIS

NERVOUS SYSTEM –
- A. BRAIN SCAN – NEOPLASTIC DISEASE – NON-NEOPLASTIC DISEASE
- B. DYNAMIC STUDIES – CEREBROVASCULAR DISEASE
- C. C.S.F. STUDIES – C.S.F. RHINORRHEA – SHUNTS

THYROID GLAND –
- A. UPTAKES – THYROTOXICOSIS – EUTHYROID – HYPOTHYROID
- B. IN VITRO STUDIES
- C. SCANNING – "COLD" NODULES – NEOPLASTIC
  – NON-NEOPLASTIC
  "HOT" NODULES
  METASTATIC LESIONS

PARATHYROID – PARATHYROID ADENOMAS – "HOT" NODULES

RESPIRATORY SYSTEM –
- A. PARTICLES – PERFUSION – PULMONARY EMBOLISM – OBSTRUCTIVE AIRWAYS DISEASE – CARCINOMA
- B. GASES VENTILATION

BLOOD –
- A. BONE MARROW – RED CELL PRECURSORS
  – RETICULOENDOTHELIAL
- B. IRON METABOLISM – ABSORPTION – TRANSPORT – UTILIZATION
- C. VITAMIN B_{12} METABOLISM
- D. BLOOD VOLUME
- E. RED CELL SURVIVAL
- F. SPLEEN SCANNING
- G. PLATELET

CIRCULATION – BLOOD POOLS – HEART, e.g. PERICARDIAL EFFUSIONS
  – PLACENTA, e.g. PLACENTA PRAEVIA

SKELETON –
- A. BONE SCANNING – NEOPLASTIC – NON-NEOPLASTIC
- B. BONE VIABILITY STUDIES

GASTROINTESTINAL –
- A. ABSORPTION – SUGARS – LIPIDS – VITAMIN B_{12}
- B. LOSSES – BLOOD – PROTEIN

LIVER –
- A. LIVER SCAN – NEOPLASTIC – PRIMARY
  – SECONDARIES
  – NON-NEOPLASTIC – ABSCESS, TRAUMA, CYSTS
  – DIFFUSE DISEASE – CIRRHOSIS
- B. LIVER BLOOD FLOW STUDIES

PANCREAS – PANCREATIC SCAN – NEOPLASTIC
  – NON-NEOPLASTIC

KIDNEY –
- A. RENAL SCAN – NEOPLASTIC – PRIMARY
  – SECONDARY
  – NON-NEOPLASTIC – TRAUMA – ABSCESS – RENAL ARTERY STENOSIS – CONGENITAL ABNORMALITIES
- B. FUNCTIONAL STUDIES
  – RENOGRAPHY – R.A.S.
  – OBSTRUCTIVE UROPATHIES
  – BLOOD FLOW STUDIES
  – R.A.S.
  – CYST OR TUMOUR

Fig. 1. Table summarizing the uses of nuclear techniques in clinical diagnosis.

Organ	Radionuclide or Radiopharmaceutical	Imaging Technique
Brain	^{99m}Tc (Sodium pertechnetate)	Gamma Camera
Ventricular System, Spinal Cord	^{131}I-HSA (Human Serum Albumin)	Rectilinear Scanner
Thyroid	(i) ^{131}I, or	Retilinear Scanner
	(ii) ^{99m}Tc (sodium pertechnetate)	Gamma Camera
Lung	(i) ^{131}I-MAA (Macroaggregated Albumin), or	Retilinear Scanner
	(ii) ^{113m}In-Fe $(OH)_3$	Rectilinear Scanner or Gamma Camera
Liver and Spleen	(i) $^{99m}Tc_2S_7$-S (Technetium-sulphur-colloid)	Gamma Camera
Kidney		
(a) Scan*	(i) ^{197}Hg-chlormerodrin, or	Rectilinear Scanner
	(ii) ^{99m}Tc-Fe ascorbate	Gamma Camera
(b) Renogram*	^{131}I-Hippuran	Gamma Camera
(c) Blood Flow*	^{99m}Tc-(Sodium pertechnetate)	Gamma Camera
* Generally performed as a combined study at one "sitting"		
Mediastinal Blood Pool	^{131}I-HSA	Rectilinear Scanner
Pancreas	^{75}Se-methionine	Gamma Camera and 1600 Channel Multi-parameter Analyser
Parathyroids	^{75}Se-methionine	Rectilinear Scanner
Placental site	(i) ^{131}I-HSA; or	Rectilinear Scanner
	(ii) ^{99m}Tc-HSA or ^{113m}In-gelatin	Gamma Camera
Bone or Skeletal Survey	^{18}F	Positron Camera

Fig. 3. List of organ studies and the isotope preparation used.

In diagnostic aspects of nuclear medicine the radio isotope of interest can be introduced into the live person – (called "in vivo") for a patient study. Alternatively, the radio isotope may be introduced into sampled biological material – called "in vitro" testing. The patient (or sample) is then subjected to tests that measure parameters such as concentration, take-up rate and distribution in the organ or area of interest. The size of a radioactive dose given today is minute; public fear of nuclear medicine is quite unjustified for there is no danger in the processes used.

A table of uses has been compiled for this feature – see Fig. 1. In each case the underlying principle is initially the introduction of a suitable isotope – by injection, inhalation, via food or by direct placement. The isotope may be conveyed away by physiological processes providing a marker as the isotope disperses. Alternatively, it can flow continuously coming to more or less permanent rest in different locations – cancerous (carcinoma) growths, for example, having a higher metabolism, take up more isotope than surrounding areas. In another type of use – respiratory investigations – the patient inhales isotope atomised into the breathing air intake. Where the individual lung cells accept air, isotope is deposited. Unhealthy lung tissue receives none. Detectors are then used to map the intensity of the static or dynamic distribution of the isotope – thus providing the diagnostic output required by the physician.

What happens to the radioactivity given in such dosing? The answer is simple. The isotopes used have comparatively short lives, for example, one Techetium isotope used, ^{99m}Tc, has a half life of just six hours. This means that six hours after initial preparation its radioactivity has fallen to half, twelve hours later to a quarter and so on. It is, therefore, only a comparatively short time before its energy is negligible, much less than the naturally existing background radio-activity in fact. All that remains is the original trace element which is removed by normal body processes.

Radio pharmaceuticals or radio nuclides are selected and manufactured in accordance with the sensing sensitivity available, the physiological characteristics that decide where the trace elements end up or pass through and the acceptability of the body to the trace chemicals. A second table, given in Fig. 2, lists some of those used in organ studies. Others based on chromium, cobalt and molybdenum are used in other tests. To give some idea of the dose, a patient needing a brain study is given 10 millicuries of ^{99m}Tc, this liberating a radioactive dose of roughly 0.14 rads. This is similar to that received during a routine chest X-ray. The choice of chemical, isotope and technique is a skilled task requiring highly specialised personnel.

RADIATION PRODUCTS EMANATING FROM ISOTOPES

Radiation products occur as three types of energy: alpha particles, beta particles and gammy rays, denoted by α' β, and γ.

Alpha particles are protons (atoms stripped of electrons). Being relatively large and possessing comparatively low kinetic energy, these are unable to penetrate much more than a thin sheet of paper.

Beta particles are electrons but, although only 1/1850th of the mass of the alpha particle, possess much higher kinetic energy by virtue of their far greater velocity. These can penetrate further than alpha particles but still only a little distance – a 0.5 mm thick piece of aluminium reduces their intensity by half.

Gamma particles are more adequately identified with electromagnetic EM radiation because they exhibit characteristics of X-rays of very short wavelength. These pass through most materials, the best common absorbing material being lead – a 13 mm thick shield provides 50 per cent loss. It is this radiation product that finds greatest use in nuclear medicine, for the former two have insufficient penetration for most applications – doses deposited in the interior of the body would not be easy to monitor externally due to the severe attenuation.

BASIC RADIATION DETECTION

Radioactivity was discovered by Antoine Henri Becquerel in 1895 when he observed its effect on photographic plate; it also causes fluorescence in certain substances (re-radiation at visible radiation wavelengths) and can also ionise gases. Direct photographic methods play

ELECTRONICS IN MEDICINE

little part in nuclear medicine as they require extreme exposure times for realistic safe dose levels.

The next simplest method of detection makes use of the ionising effect of radiation. The so-called Geiger counter uses a Geiger-Muller (G-M) tube which comprises an insulated wire anode placed inside an inert gas filled metal case which acts as the cathode – see Fig. 3. At one end is a "window" of beryllium, mica, nylon or other material that is adequately transparent to β and γ nuclear radiation products; α particles cannot pass into the chamber. These cells are particularly sensitive to β particles which ionise the normally conducting gas allowing a momentary current to pass through the cell. Gamma rays can be detected with the G-M tube but via a secondary effect in which they liberate electrons that start an ionising action. Ionisation detection is enhanced by the application of a steady dc potential of 500 to 3000 V (positive to the wire): this puts the gas closer to an ionisation state. Ionisation chambers and proportional counters are similar in structure to G-M tubes, the differences being in the magnitude of ionising potential applied in each case.

The output of each of these three alternatives is similar – as a series of pulses of different amplitude and frequency of occurrence with time. The actual characteristics depend on the mode used – the G-M tube is the most sensitive but lacks response time and all pulses have the same energy. Pulses produced in these detectors are counted over a chosen timing interval to provide a measure of radiation intensity – a faster count rate indicates higher intensity.

The practical difficulties and relatively insensitive characteristics of these detectors largely excludes them from nuclear medicine however, the dominant detector being the scintillation counter.

SCINTILLATION DETECTORS

The difficulty with ionisation style detectors is that the inherent energy of the radiation products is not used efficiently thereby reducing the available sensitivity. As well as this shortcoming is the practical problem of amplifying small signal levels of a signal having random noise characteristics: the amplifier will also amplify noise – not being able to distinguish between the two.

The scintillation counter makes use

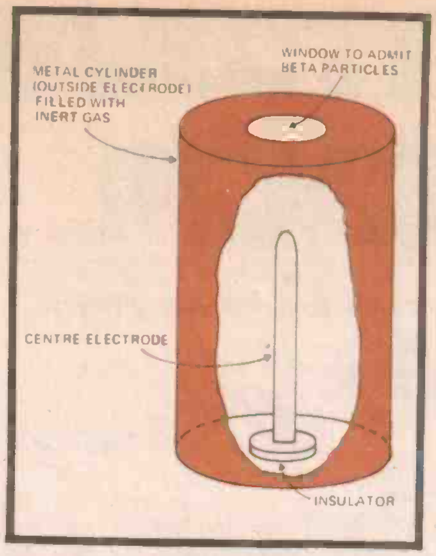


Fig. 3. Basic arrangement of ionisation kinds of radioactivity sensors – the G-M tube, ionisation and proportional detectors.

of the photo-multiplier detector which can provide excellent low-noise amplification of light energy (photons) – gains of 1 000 000 are used with negligible degradation of the signal/noise ratio.

Radiation products, however, are at a higher energy level than photons so a conversion process is used to transform the high frequency energy down to optical wavelengths. This is done in a scintillating crystal.

In these crystals, ionising radiation gives up its energy which is reliberated as scintillations at optical wavelengths.

The basic arrangement is shown in Fig. 4. The larger the crystal the better the "capture" of energy. The choice of crystal material (usually sodium iodide) and phosphor of the photo multiplier decides what radiation level the unit sees (the phosphor converts photons to electrons, another

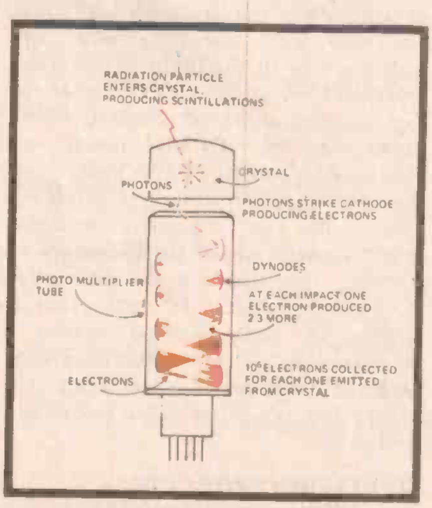


Fig. 4. In the scintillation counter a crystal absorbs the radioactivity energy liberating optical wavelength energy that is detected with a photo multiplier.

transformation stage, in the photo-multiplier).

The vast majority of the instruments used in nuclear medicine are based upon the scintillation counter which possesses extreme sensitivity along with the ability to allow analysis of the energy levels of the radiation pulses. As with the ionising tube style of detector, these also provide a pulse form of output. Pulses are formed from successive transformation stages – ionising radiation particles cause optical scintillations as photons which, in turn, produce electrons to form the current pulse that is detected.

Scintillation counters have found application in two distinct ways. First as single detector units that provide count levels at a chosen position or on a chosen sample. Secondly, as imaging arrays wherein as many as 37 scintillation detectors see the subject simultaneously providing a graphical two-dimensional picture of radiation intensity emanating from an area.

COUNTING UNITS

These are used either to study samples loaded into a machine or alternatively the sensor is taken to the patient and directed at the area of interest.

Housed together in the Counting Laboratory are several different kinds of sample counting devices – two automatic gamma counters, an automatic liquid scintillation spectrometer, a large-volume counter, a proportional counter and a gas flow detector.

This collection enables a wide variety of tests to be carried out that estimate the radioactivity liberated by gamma-emitting substances and also by weak and strong alpha and beta emitters. The instruments enable volumes ranging from 5 ml vials to containers holding two litres to be measured. The laboratory also has a 128-channel pulse height analyser for use with various detector assemblies.

Automatic gamma counters

The Nuclear-Chicago system 4216, is designed automatically to load, one by one, 100 preloaded vials into the measuring area where a scintillation detector determines the gamma radiation level. This is recorded on a printed output. The cross-section, shown in Fig.5, shows the well-type detector of this system. Effective shielding is vital, for the sample under test must not be contaminated by the others waiting above. Note particularly the thickness of steel, tungsten and lead that is used to ensure that the 50 mm or 75 mm diameter, thallium activated, sodium iodide crystal sees only the sample loaded into the well. It is impossible to

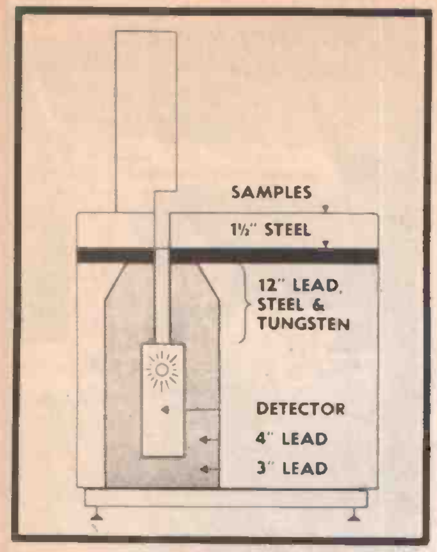


Fig. 5. The use of shielding is vital to obtain correct measurements in the gamma counting system.

eliminate all stray radiation; the aim of the shielding is to ensure that the background count remains constant as the vials and transport mechanism change position. This relatively small machine weighs around 500 kg!

Built into the console is a pulse height analyser that can be set to measure specific pulse energy levels. This enables the diagnostician to monitor specific isotopes, largely ignoring other unwanted ones that may be present in the sample. A typical count run would take around a minute, involving half a million individual counts. It is also possible automatically to subtract the background count.

A second counter, a Philips Model PW4003, performs a similar function for a 50 sample loading.

As these scintillation counters have pulse height analysis facilities, they can be used to measure specific wavelength gamma rays by much the same concept as an optical spectrometer which separates wavelengths. For this reason these systems are sometimes referred to as gamma spectrophotometers.

Liquid Scintillation Spectrometer

The low energy of beta radiation from isotopes such as 14_C and 3_H prevents the particles passing through the windows of normal detectors. Solid scintillation crystals are not very effective for this radiation for similar reasons. To overcome this practical defect, yet retaining the sensitivity of the scintillation method, the sample to be measured is mixed with a suitable liquid the whole forming a liquid scintillating medium which acts in a similar manner as a solid crystal.

This much done, the necessary detection process still requires special techniques to reduce the effect of thermal noise inherent in the photo multipliers and to reduce the influence of background count: beta radiation is less energetic than gamma. By placing the liquid in a differential detection arrangement — see Fig. 6, common-mode background counts are largely eliminated. To further aid signal detection the detectors can be cooled with refrigeration to around -20°C to reduce their internal noise levels.

Gas flow detector:

Another method for detecting weaker radiations is to place the radio-activated sample inside the ionisation chamber proper rather than placing it outside. The chamber is set up as a proportional counter. This avoids the problems of signal attenuation caused by a window but adds a difficulty in that the chamber has to be assembled each time and the ionisation gas added. Figure 7 shows a diagrammatic cross-section of a gas flow detector. Gas flows continuously to ensure the chamber is adequately purged of previous gas and air.

Large-volume counter:

Some tests require the measurement of the radio-activity of quite large samples — a litre or more in capacity as, for example, in investigation of internal bleeding which is detected by faeces collection over a period of time. This poses different kinds of problems for the difficulties of shielding such a large volume can be expensive and weighty. The method used by the AEI designers concentrates on providing detection that incorporates the already mentioned common-mode rejection of stray background by employing two large scintillation crystals, 75 x 75 mm each, one above and one below as can be seen in Fig. 8. The sample bucket is placed in through the side door.

So much for machines that count radiation levels in samples.

Scintillation probes:

A scintillation counter assembly

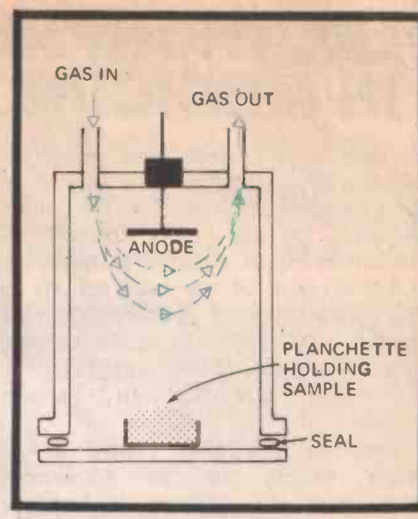


Fig. 7. In the gas flow detector gamma and beta radiation is monitored without the attenuation of windows.

Fig. 8. The large volume scintillation counter has detectors above and below the sample region.

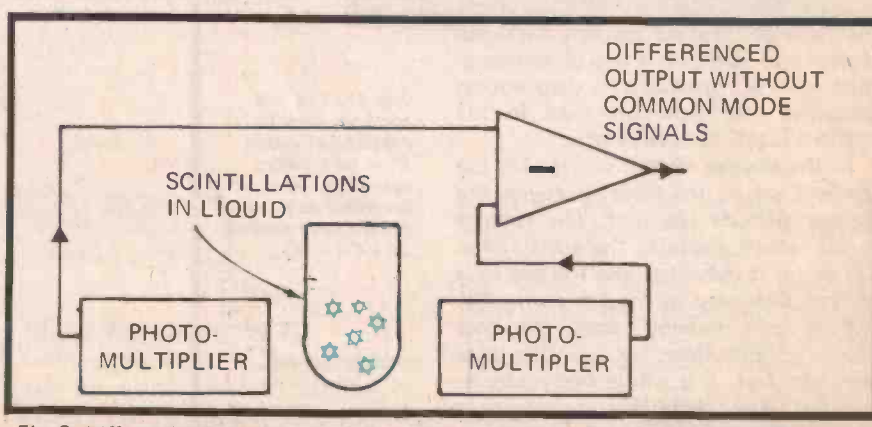


Fig. 6. Differential detection provides common-mode signal rejection in the liquid scintillation spectrometer.

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(crystal plus photo multiplier) is mounted on an adjustable framework that enables the detector to be placed adjacent to the area of interest, as shown in Fig. 9. Once set, the probe takes a count of the radio activity in the region chosen – for example, a test for thyroid gland iodine uptake. These Philips surface counting systems are fitted with 50 mm diameter crystals.

Facilities exist that enable several such probes to be monitored simultaneously, enabling the observer to study differential effects such as renal uptake and clearance in a patient. It also enables changes in radioactivity to be monitored in the liver and spleen after radionuclide-labelled blood cells have been injected.

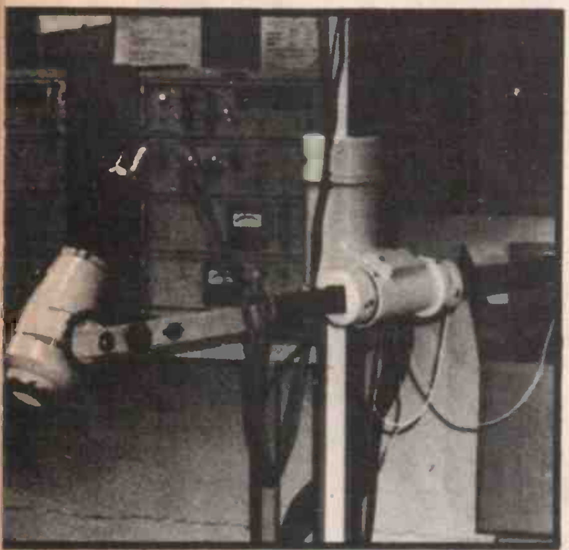

Fig. 9. The adjustable framework enables a sensitive scintillation counter head to be placed close to the area of interest.

IMAGING

Rectilinear scanning

If a single detector scintillation head, such as that shown in Fig. 12, is made to move over the still patient it is quite feasible to build up a two dimensional picture of radiation distribution provided the radiation level in the patient is satisfactorily static.

In the scanner shown in Fig. 13, the patient lies on the table to provide the image attitude required. The tubular head, which contains the scintillation detector, is moved across the bed by a driven slide-way in the cross arm, the whole arm moving along the bed. Given enough time, for counting rates are not fast, the whole body can be imaged. This technique is known as rectilinear scanning.

The output form for this machine can be of two kinds. First, as a Teledeltos paper picture in which dots are made on special paper by passing high voltage through it on demand – the more intense the radiation the greater the dot density and the blacker the area on the picture. Figure 11a shows the system schematic for this. The second method provides a photograph which is exposed, using Polaroid film, by a cathode ray tube produced image formed from light dots – see Fig. 11b. A direct copy of a case study – that of cancer of the prostrate – made with the latter display is shown in Fig. 12.

The gamma camera

The rectilinear scanner suffers from the major disadvantage that considerable time is needed to image an organ or the body. If more scintillation detectors were added, working simultaneously, this would reduce the time. This is the basis of the technique originally proposed by Dr. Anger which is now known as the gamma camera. His idea, however, is more profound, for the multiple sensors are combined to yield a 2-D display from a static array.

The "camera" is very large in size (close to a metre in diameter) and heavy (ships at just less than a tonne) shown in Fig. 13. Inside the 40 mm heavy steel and lead housing is one very large (300 mm x 12 mm) scintillation crystal which is sensed by as many photo-multipliers as can be fitted into the circle. Earlier models used 19 photo-multipliers, the latest have 37. A cross-section, given in Fig. 14, shows the arrangement. Note the collimator which, in the optical sense, ensures that the sensors see only rays emanating in a parallel direction from the source. The collimator shown is a lead disc machined with parallel holes through it.

Each photo multiplier has its own

Fig. 10. This rectilinear scanner moves the single scintillation counter over the stationary patient: A typical scan could take up to half an hour.

power supply and amplifier board mounted in the camera housing. The multiple channel information is combined with a resistor matrix on the basis that each sensor sees more than just its immediate frontal area – values are weighted for scintillations occurring anywhere in the crystal on the basis that their contribution falls off with distance. The combined "video" signal output leaves the camera as four lines which convey pulses and position information – not as a continuous signal form. The pulses are selected and sorted with the pulse height analyser (PHA), and other ancillary equipment to provide suitable drives for an oscilloscope display – this is shown in a simplified manner in Fig. 15. The output display

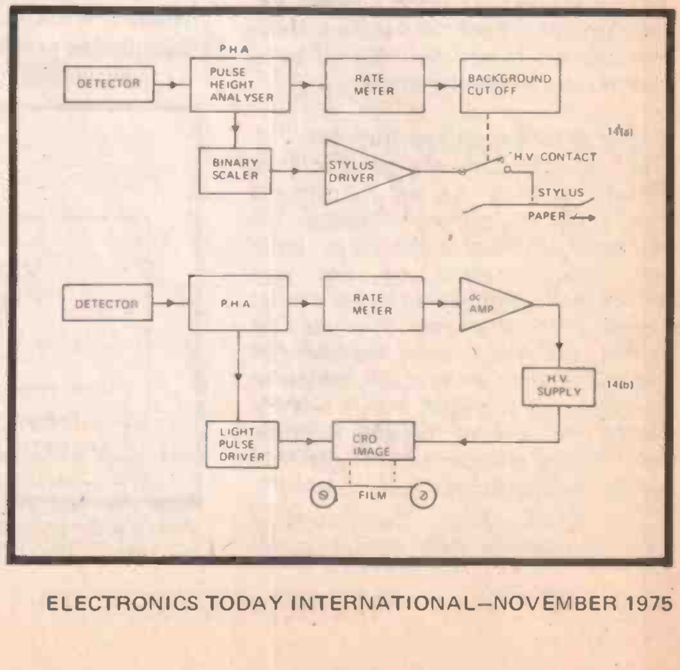

Fig. 11. The two methods used to produce an image from rectilinear scan data. (a) Dots are made on paper. (b) Dots are formed on a CRT.

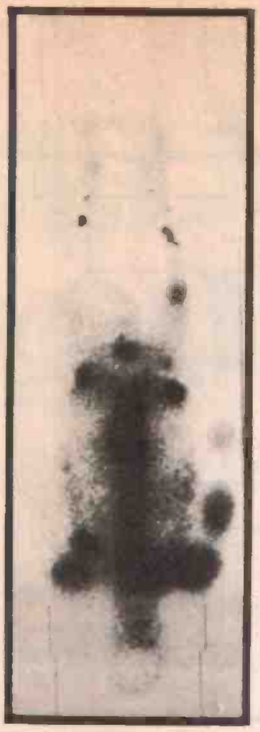

Fig. 12. This photograph is copied from the original made with the rectilinear scanning system. The darker the colour the greater the concentration of radio isotope take-up.

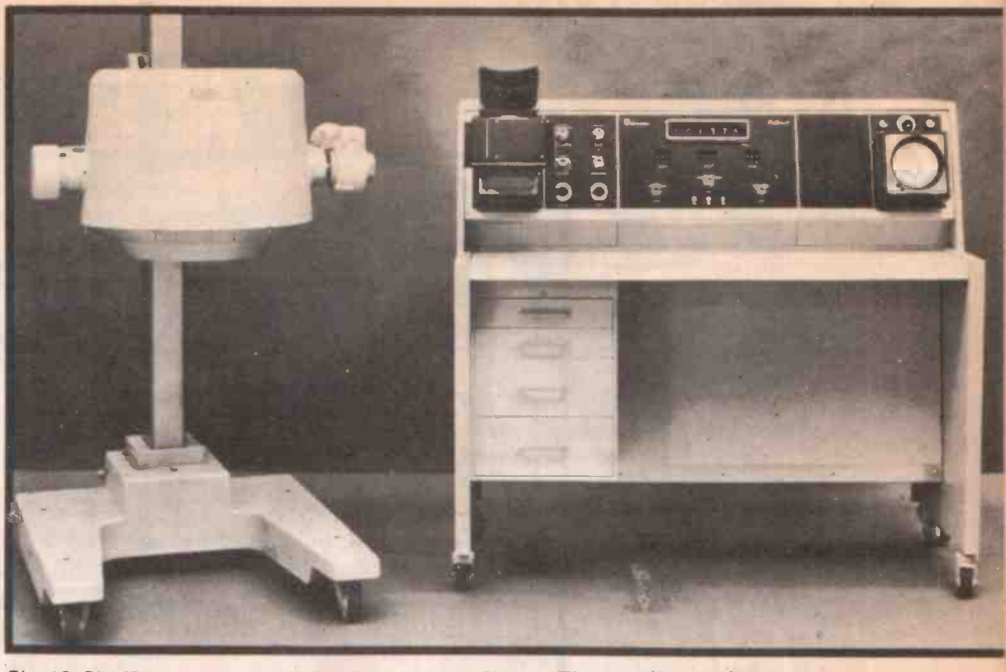

Fig. 13. Pho/Gamma III scintillation camera ready for use. These produce an image without need for scanning.

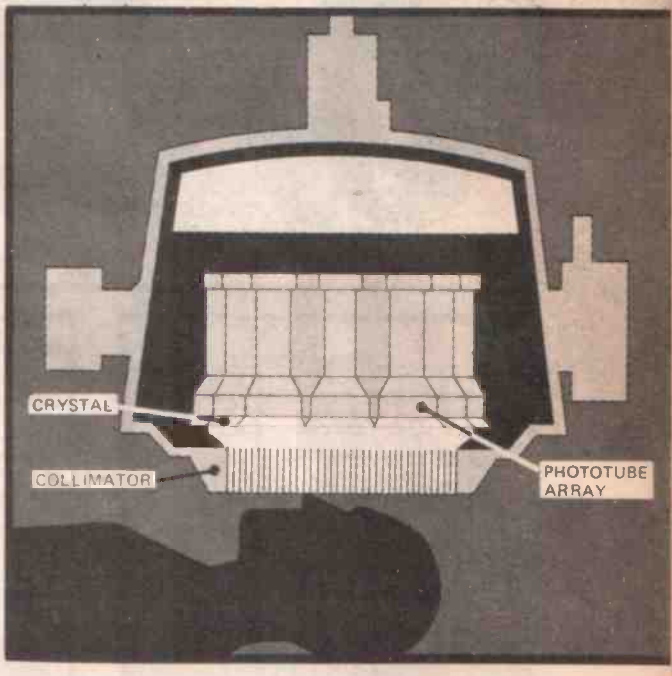

Fig. 14. Gamma cameras contain multiple photo multipliers viewing a single large diameter crystal. The outputs are combined to provide image data – see Fig. 18.

is built from individual dots.

Gamma-cameras produce an image much faster than rectilinear scanners – a liver image takes only a minute compared with 30 minutes using the scanner. With these short times it is far easier to exclude unwanted secondary effects such as a patient breathing which moves the organ relative to the camera.

The gamma-camera photograph, however, is still in the class of a fuzzy X-ray plate and correct interpretation is a matter of the clinician's skill. Providing the camera with improved resolution would not improve matters much for the organ is invariably masked by overlying body tissue; the radioactive emission process itself lacks detail. A typical image is shown in Fig. 16. This is from a study of the lung which is diagnosed to be multiple pulmonary emboli (blood flow obstructions). The label substance in this case was ^{131}I. It is usual to perform other tests to assist with the final diagonostic decision.

Whole body imaging:

The latest developments are to bodily move the patient past the stationary gamma-camera building up a whole body picture in the manner shown in Fig. 17. Electronic circuitry ensures that the scans are overlapped correctly to produce a total picture. Scanning is still, however, time consuming. The image shown in Fig. 18 took 19 minutes a side. Fig. 18b is of a person with metastatic meningioma (a tumour transferred from other parts of the body).

THE RADIO PHARMACY

Isotopes used as tracers in nuclear medicine have a short half-life, by necessity for the need to use only short-lived radiation sources in a patient's body. Furthermore, it is often the case that the isotope most suited, because it is naturally transported to the organ of interest, has short half-life. For example, Fluorine-18, one of the best for bone scanning, has $T½$ = 1.8 hours. As this must be produced originally in a reactor. In cases of short half-life a considerably stronger original amount is required to obtain the dose needed, when it reaches the patient.

ELECTRONICS IN MEDICINE

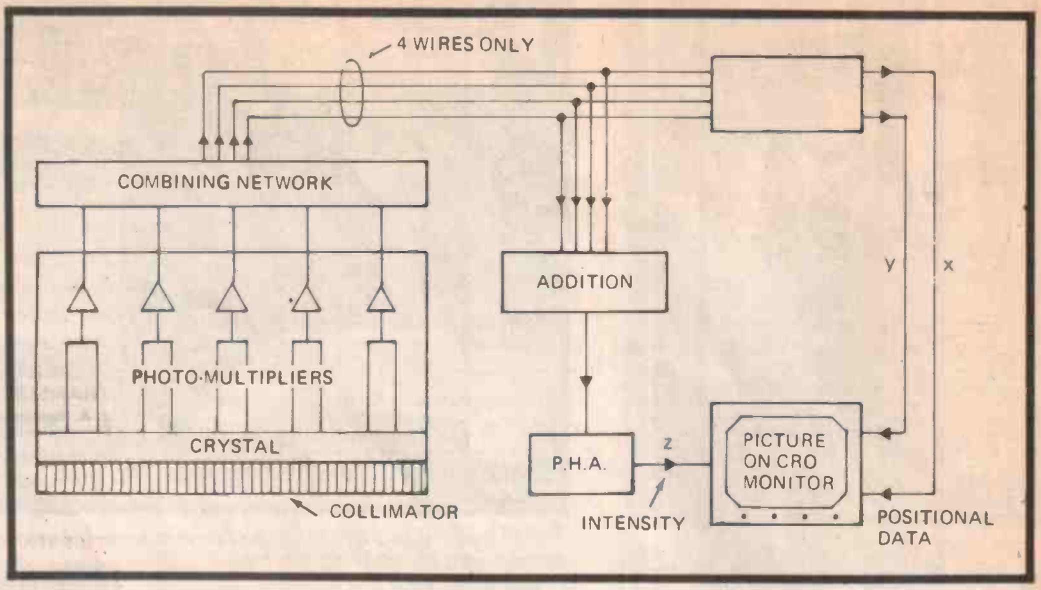

Fig. 15. Schematic of data handling in gamma camera system.

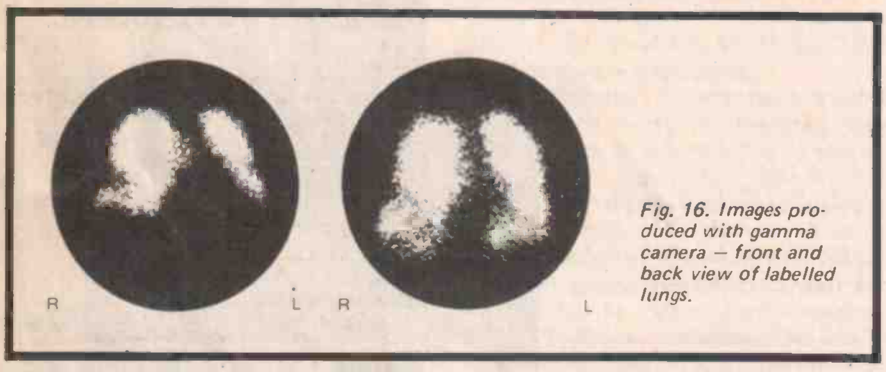

Fig. 16. Images produced with gamma camera — front and back view of labelled lungs.

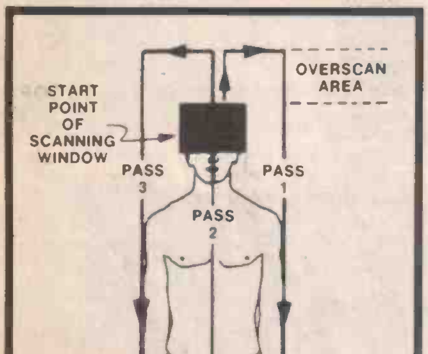

Fig. 17. The gamma camera is made to move relative to the patient (the patient is moved automatically) to expand the image size.

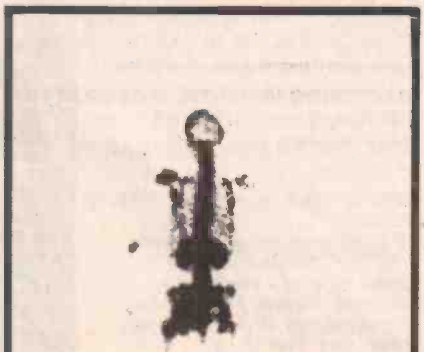

Fig. 18. Gamma camera scanned image (clinical case of metastatic meningioma).

One particularly interesting isotope is ^{99}Molybdenum-^{99m}Technetium (^{99}Mo-^{99m}Tc). The more useful isotope of the two is ^{99m}Tc but this has half-life of only six hours — direct shipment would be extremely costly. ^{99}Mo, however, has a half-life of 67 hours and it produces as part of its decay process the "daughter" isotope ^{99m}Tc. Separation is achieved by absorbing the parent ^{99}Mo on to an alumina column for which ^{99m}Tc has low affinity. When a saline solution is passed through the column it elutes the ^{99m}Tc as a pertechnetate ion of extreme purity. The column is called the "cow" which is "milked" each day to provide isotope for brain scanning.

Another cow used is ^{113}Sn which has a half-life of 119 days. This yields ^{113m}In chemicals which have only 1.7 hour half-lives.

In this two part feature we have looked at the internal workings of a well equipped clinical pathology centre.

We have not covered all of the measurement devices involved in the many thousands of tests made each day but we have we hope shown something of the great concentration of measurement effort involved in modern pathological medicine. ●

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MODERN FM RECEIVING TECHNIQUES

PART FOUR

In this final article on FM receiver circuitry Brian Dance continues his discussion of decoder ICs and looks at Stereo output filters

OTHER DECODER ICs

Another type of stereo decoder which requires no external inductance first appeared in 1972 as the Motorola MC1310P This is a phase locked loop device operating on similar principles to the CA3090AQ. The frequency is set by a preset resistor rather than an inductance.

The LM1310 (National semiconductor) device is a 14 pin dual-in-line circuit equivalent to the Signetics MC1310. Other equivalents are the RCA CA1310E and the Texas Instruments SN76115N. These devices can be used in type of circuit shown in Fig. 22.

Rather similar devices are available in 16 pin dual-in-line cases in which an emitter follower is included in each output circuit. The type of circuit which can be used with these devices is shown in Fig. 23. The de-emphasis components are in the pin 3 and pin 6 circuits, whilst the emitter follower outputs appear at pins 4 and 5. Devices of this type include the LM1301E from National Semiconductor, the MC1310E frolm Signetics, etc.

The National Semiconductor LM1800 device can also be used in the same circuit as that shown in Fig. 23, but has the additional advantage that it contains a built-in circuit for providing 45dB power supply ripple rejection. The RCA type CA758E and the Motorola MC1311P are similar devices.

The only adjustment which must be made to the circuits of Fig. 22 and 23 before use is the setting of the free running frequency of the phase locked loop by means of VR1. If a frequency counter is available, pin 10 of Fig. 22 or pin 11 of Fig. 23 may be connected to the input of the counter and VRI adjusted until the signal from the device has a frequency of 19kHz. (The amplitude of the signal is about 3V peak).

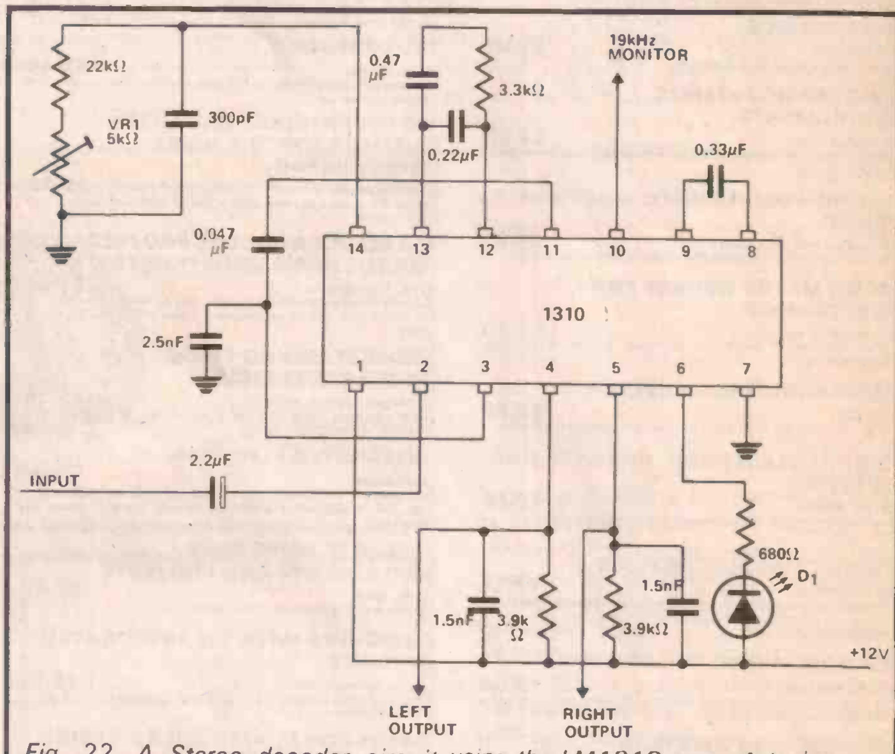


Fig. 22. A Stereo decoder circuit using the LM1310 type of device.

Most readers will find it easier to adjust VRI until the stereo indicator lamp remains illuminated at the lowest possible signal level. This adjustment is very easy and causes no problems whatsoever.

The capture range is typically 3%. It can be increased by reducing the capacitance from pin 14 of Fig. 22 or pin 15 of Fig. 23 to ground and increasing the resistors in parallel with this capacitor in proportion. However, these alterations are likely to cause increased beat note distortion at high signal levels due to oscillator phase jitter.

The capacitor between pins 8 and 9 of Fig. 22 (or between pins 9 and 10 of Fig. 23) controls the stereo-monaural switching delay. The switching time constant is equal to its value multiplied by about 53k. If pin 8 of Fig. 22 or pin 9 of Fig. 23 is earthed, the circuit operates only in the monaural mode.

There is some variation in the power supply ratings of the devices offered by various manufacturers. For example, the National Semiconductor devices are specified as operating over the range 10 to 24V and the Signetics devices 8 to 16V, whilst the RCA 1310E has a supply voltage rating of 8 to 14V and the CA758 of 10 to 16V. These ratings should be strictly obssrved for the particular device employed. The currend drawn is of the order of 30mA.

The audio output voltage is typically 485mV RMS from both the circuit of Fig. 22 and that of Fig. 23. The minimum value of the load resistors in Fig. 22 is affected somewhat by the power supply voltage. The circuit of Fig. 23 does not suffer from this limitation, since the emitter follower outputs provide a low output impedance.

Readers requiring further information on this topic are advised to consult individual device data-sheets and also to study the report by T. D. Isbell and D. S. Mishler "LM1800 phase locked loop FM stereo demodulator", National Semiconductor Application Note AN-81, June 1973.

STEREO OUTPUT FILTERS

The stereo decoder circuits discussed generate 19kHz, 38kHz and 76kHz waveforms. Although the decoder circuits incorporate about 25dB to 45dB rejection of these frequencies, they can still cause trouble when one wishes to feed the output to a tape recorder. Harmonics of these signals may beat with a harmonic of the tape recorder bias oscillator.

This problem can be solved by the addition of a suitable filter to the stereo decoder output. The Toko Company make a number of suitable filters which provide considerable rejection at 19kHz and 38kHz.

The Toko BLR-2011-N filter provides a maximum attenuation of 1dB at frequencies up to 15kHz and a minimm attenuation of 30dB at 19kHz and 38kHz. This filter is about 1.65 by 1.34 by 0.79 inches in size. The two inputs from the stereo decoder are connected to the filter, an earth connection made to it and the two outputs taken from the appropriate pins.

The Toko BLR-2007-N is a rather similar filter which provides an attenuation not exceeding 3dB at frequencies up to 15kHz and minimum attenuations of 20dB and 55dB at frequencies of 19kHz and 38kHz respectively. A third Toko low pass filter is the 170 BLR-3107N which has a maximum attenuation of 1.2dB at frequencies up to 15kHz and minimum attenuations of 26dB and 50dB at 19kHz and 38kHz respectively The crosstalk does not exceed —45dB between 50Hz and10kHz, whilst the ripple in the pass band has a maximum value of ±0.5dB.

HEATHKIT DIGITAL TUNER

We will conclude our review of modern FM receiver techniques by mentioning the Heathkit 'Computer' tuner. Perhaps the most striking aspect of this tuner is the tuning technique used together with the digital display of the frequency. The required frequency channel can be obtained by merely pressing the buttons corresponding to the digits of that frequency, the channel spacing being 200kHz. In addition, this receiver incorporates facilities for sweeping the FM band, stopping at any station whch provides a signal above a certain preset level.

The general performance is first class, being comparable with the best of the circuits discussed previously. The harmonic distortion is about 0.3% and the AM rejection about 60dB. Spurious signal rejection exceeds 90dB. ●

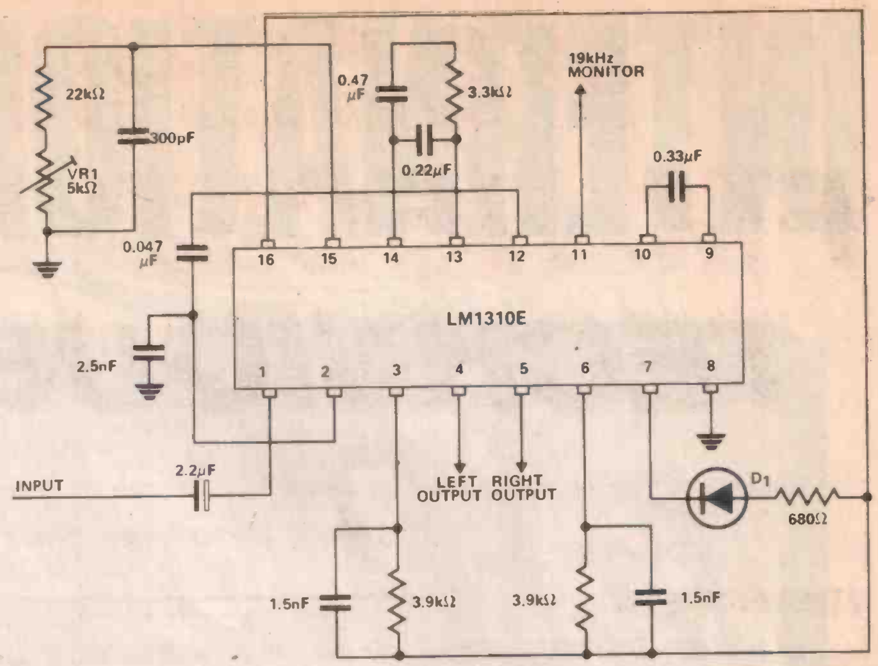
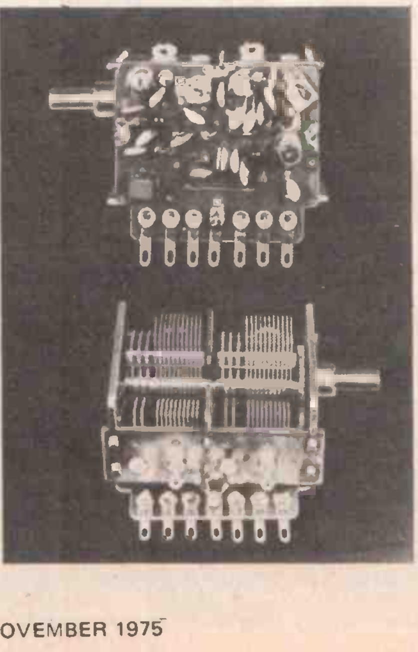
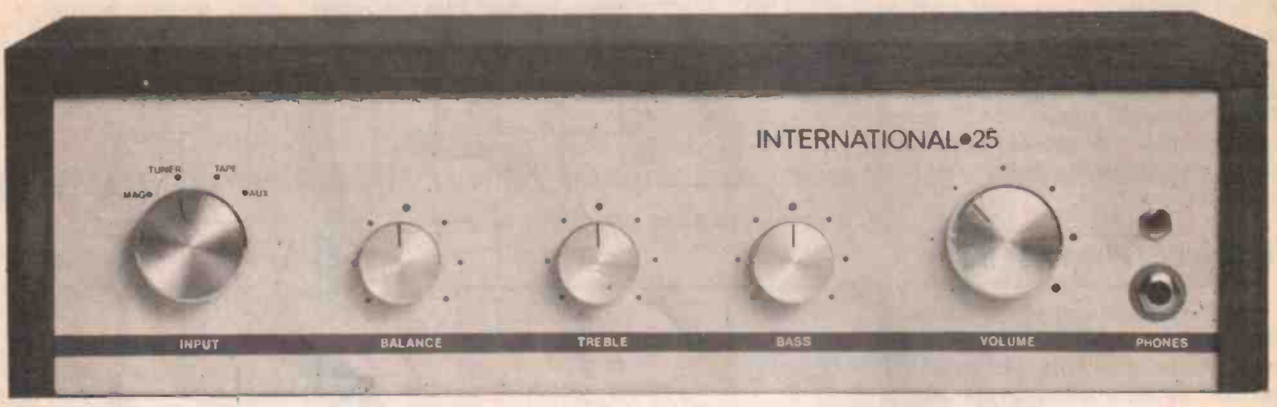


Fig. 23. A stereo decoder circuit using the LM1310E type of device.

The Heathkit Computer Tuner.



INTERNATIONAL·25



This second part completes the details for building the INTERNATIONAL·25 amplifier. This high fidelity 25W per channel amp matches the INTERNATIONAL·FM tuner in our September and October issues. This project is built on one pcb and does not require any advanced knowledge of electronics.

The component overlay diagram, Fig. 1, should be used when the components are soldered to the board. Do the linking wires first. There are two links which go under resistors R49 and R50 in the power amplifier and these should be insulated with sleeving. All other links may be tinned copper provided that they are kept straight and flat on the board.

Although the components can be mounted in any order it is usually easier to mount the smallest (lowest height) components first, ie, resistors and diodes. These should be mounted flush on the surface of the board. The capacitors may now be mounted taking care not to damage the small ceramic capacitors by bending the leads too close to the body of the device. Make sure that electrolytic capacitors are orientated correctly, i.e., the polarity is correct.

The transistors, apart from Q7,8,9,10,15,16,17 and 18 (which are on the heatsink) may now be fitted to the board.

The integrated circuits may now be installed making sure that orientation is correct as indicated by the mark on the IC which is at the pin 1 end. Then mount the relay by passing the pins through the holes provided in the board and then bend the leads flush with the copper and solder them to the tracks.

The chokes L1 and L2 are made by winding about 25 turns of 0.4 mm copper wire (insulated) onto the body of a 10 ohm 1 watt resistor terminating the ends of the wire on the resistor leads. These may now be mounted on the board.

The balance, treble and bass controls should now have lengths of copper wire soldered to each of the terminals. They are then mounted, by passing the leads through the holes in the board, but are not soldered in position as yet. The front bracket should now be attached to the *component* side of the printed-circuit board and the potentiometers mounted to the panel. The leads from the potentiometers should then be drawn through the board as far as possible and then soldered in position. Then mount the heatsink bracket to the rear of the board using 9.6 mm spacers and countersunk screws.

The output transistors have to be prepared in a couple of ways before installation. The leads are too close together, and since they are mounted close to the board the transistors may be damaged if the leads are just pulled apart. Figure 2 shows the lead bending process which should be done carefully with a pair of long nose pliers. After bending, a BC108 should be epoxyed with flat side onto the face of these transistors.

It is preferable to use one of the slow dry epoxies as they appear to withstand the elevated temperature better. If such epoxy is dried in the 100-130° range it will normall dry in about 30 minutes. Before gluing, however, it is best to scratch the type number on to the side of the output transistor to aid later identification.

When dry, the transistors can be mounted using insulation washers and a smear of silicon grease if available. The leads of the BC108 have to be bent out a long way but they should be long enough. If a small soldering iron is used these transistors can now be soldered in without removing the heatsink.

The rotary switch and volume control can now be mounted on to the front bracket. There are four links from the board to the rotary switch as shown in Figure 4, the rest of the connections going to the rear panel. There are also four links to the volume control and two coax cables which go from the volume control to the main-amplifier inputs.

The chassis can now be assembled by mounting the transformer (terminals on the outside), the front panel, the headphone socket, LED, speaker sockets, the 6-way phono sockets, the rubber feet, the grommet for the power cord and the power cord itself. The screw for the cable clamp also mounts one of the rubber feet.

The printed-circuit board module can

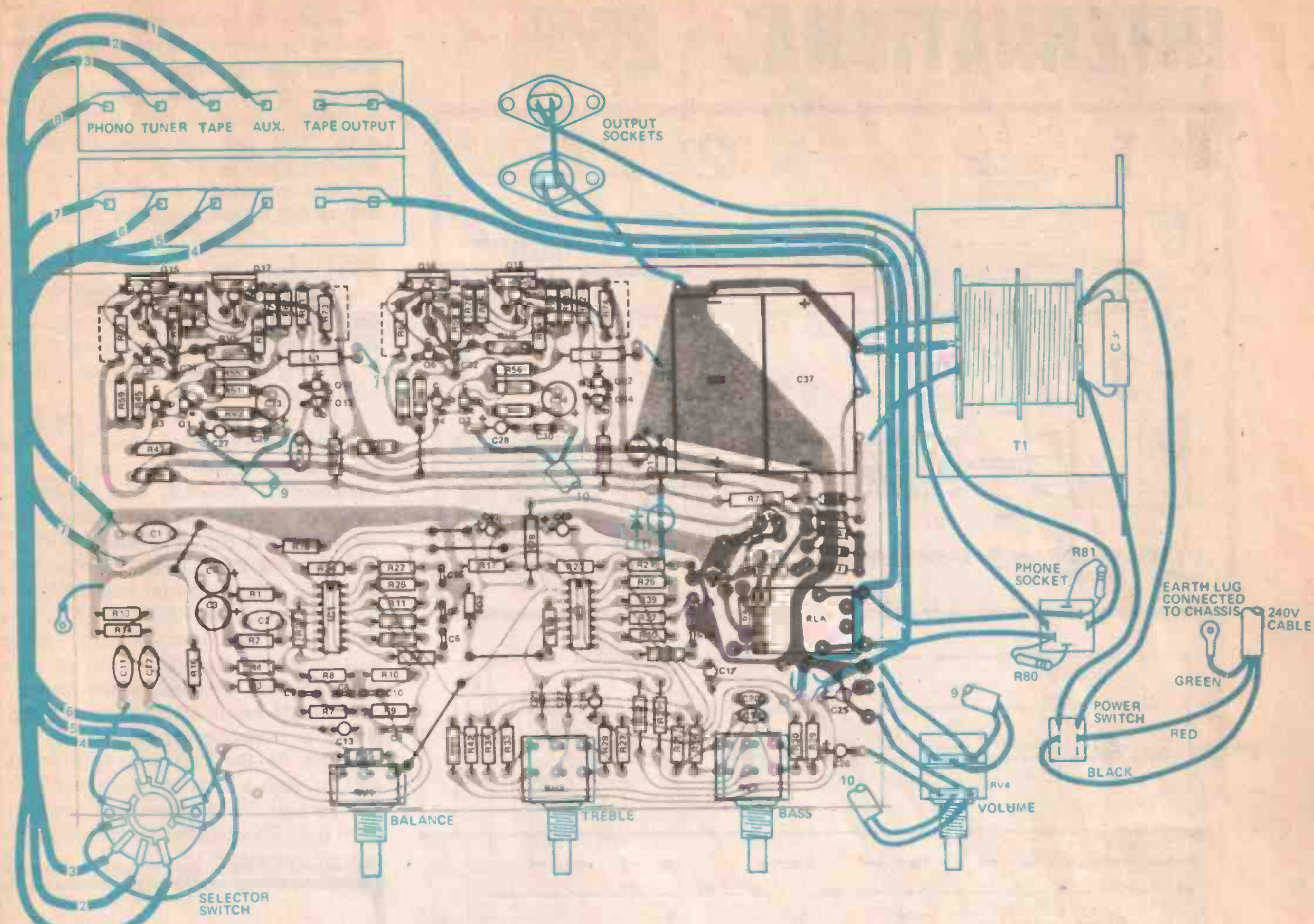


Fig. 1. The component overlay.

now be temporarily installed. If the potentiometers used have a long threaded portion (this depends on the brand) there may be room for extra nuts to hold the module and front panel on. If not, the nuts will have to be removed and refitted on the outside of the front panel. The module is held in by the potentiometer and by two self-tapping screws into the heatsink from the underside. Due to the variations in alignment of the mechanical parts, the location of the holes in the heatsink cannot be accurately determined. Therefore these holes have been left undrilled and can now be marked through the holes in the chassis. The unit can now be removed to facilitate drilling these holes to a size suitable for the self tappers. Be careful not to damage the printed circuit board, and to remove any shavings during this process.

Connect coax cable from the phono input and the tape output, long enough to reach the rear panel socket. Leads to join the output of the main amplifier to the relay, and leads from the relay long enough to reach the headphone socket can be installed along with the lead from the speaker common and the LED leads. To facilitate the assembly pins should be installed to the board where the transformer is connected.

The 240 V input cable can now be joined to the switch and then to the transformer primary along with the capacitor C35. The earth wire should be bolted directly onto the chassis as shown. To prevent possible personal injury the switch and the transformer primary terminals should be taped up with insulation tape.

Detail of power transistor assembly and installation. Note compensation transistors glued to output transistors (see text) and mica insulators between power transistors and chassis. Care should be taken with cooling Q15 and Q17 (the two transistors on the left). If the amp is likely to be driven hard these will need individual heatsinks.

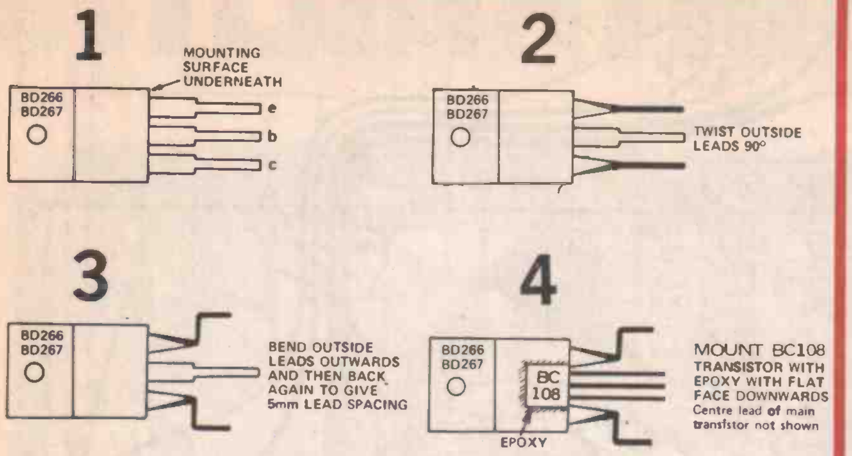


Fig. 2. How to prepare the power transistor leads for installation.

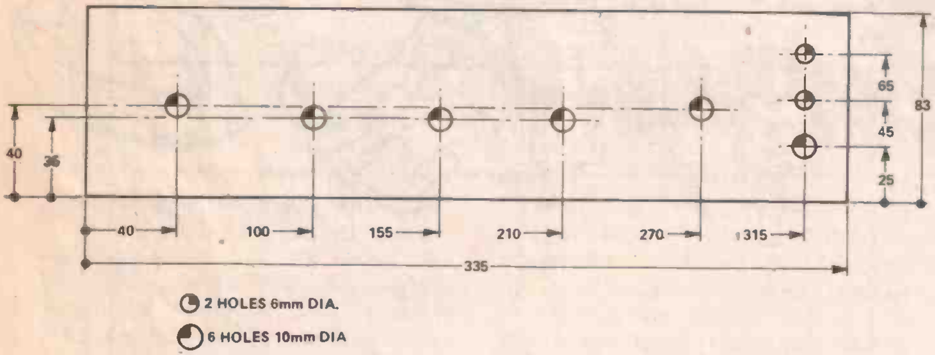
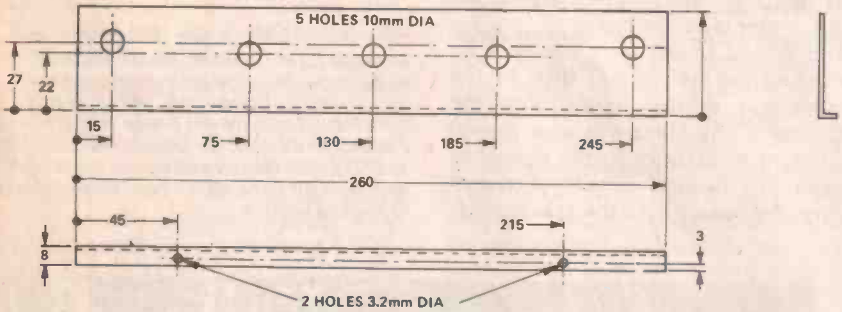


Fig. 8. Front panel details.



ALL DIMENSIONS IN MILLIMETRES

Fig. 9. Potentiometer support bracket.

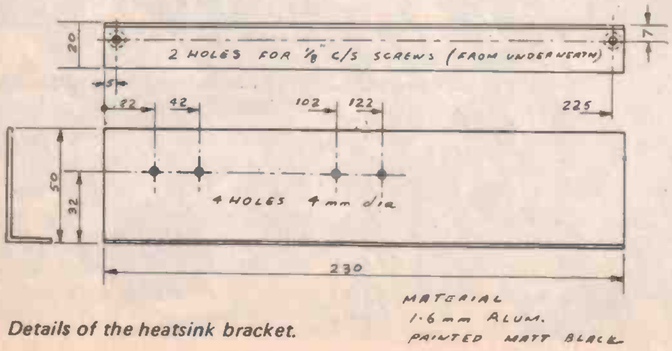


Fig. 10. Details of the heatsink bracket.

The printed-circuit board module can now be permanently reinstalled. The transformer secondary can now be connected and the rest of the wiring installed. The headphone socket along with R80 and R81 can be wired according to Fig. 1.

This completes the assembly of the unit which is now ready for testing.

TESTING

Providing all components are in the correct place and all interconnections are correct the only adjustment is that to set the bias current in the output transistors.

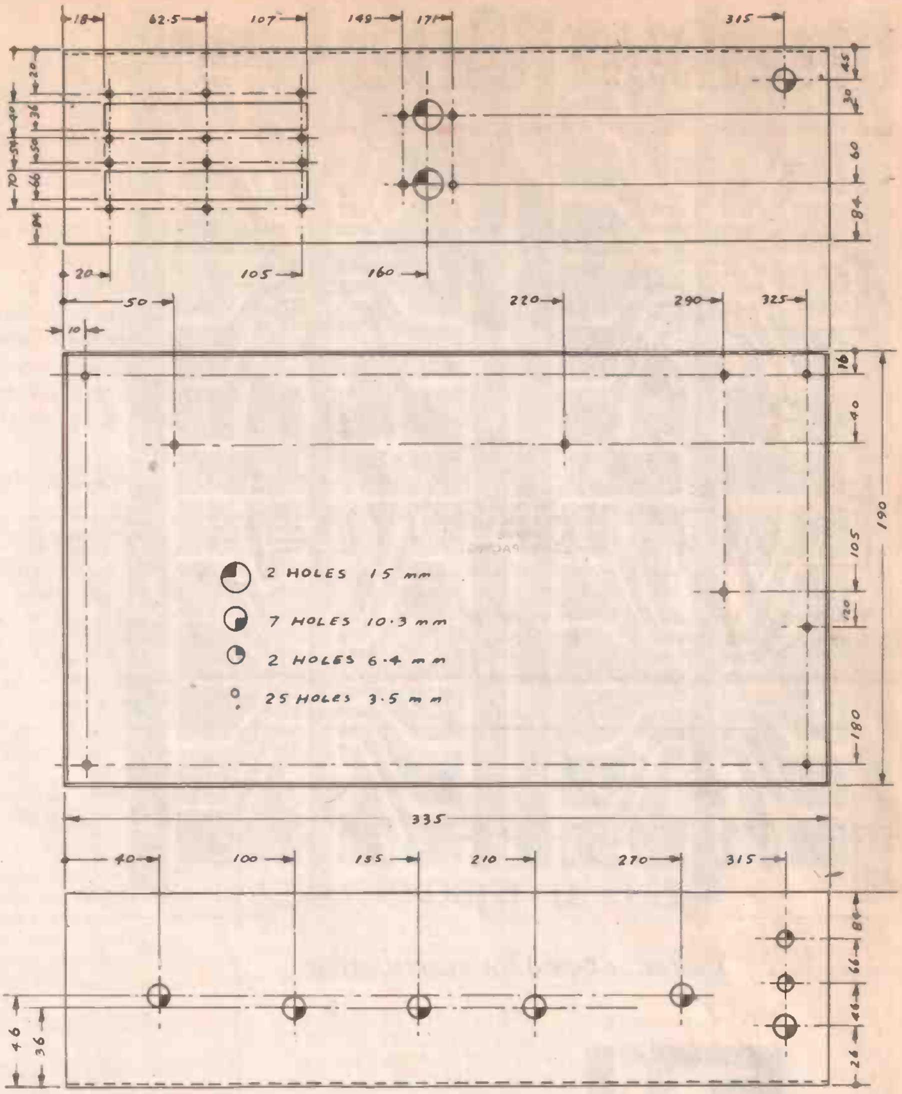
Before switching on rotate the trim potentiometers, RV5 and 6, fully clockwise i.e. toward the transformer. Switch on without speakers connected and measure the voltage across R63 and adjust RV5 to give about 3 volts. Repeat the process with the other channel and R64 and RV6. The resistors R63, 64, 73 and 74 can now be shorted out (after switching off) by short links of wire soldered onto the leads of the resistor.

If a fault exists in the output stage, either a transistor is shorted to the heatsink or the bias setting is faulty etc. In such a case the resistors R63, 64, 73 and 74 will overheat and may burn out. This effectively protects the output transistors. ●

FAULT

PROBLEM
R63 or R73 gets hot (only one)
R63 and R73 gets hot (both)
Bias current not adjustable down to within limits
Bias current too low or zero
Output voltage high (near supply rail)
Output voltage low
Main amplifier has no gain
Main amp appears OK but pre amp does not work

Fig. 11. Chassis details



FINDING

POSSIBLE FAULT AND CHECKS

shorted insulation on Q15 or Q17

bias current too high

Q7 and/or Q8 faulty or wrong polarity. Voltage between base of Q15 and base of Q17 should be about 2.3 Volts

check output voltage, if about 0V then possible shorted Q7 or Q8

check current source Q11 is working Voltage across R61 should be about 0.65V. Check voltage across R45 it should be almost 0V (output high) if it is suspect Q5. If not check voltage at base of Q1 and Q3. Q3 should be higher than Q1 if so suspect Q1 or Q3

check voltage across R45 should be about 0.7V if >0.7V suspect Q5. If less than 0.5V measure voltages at base of Q1 and Q3. Q3 should be lower than Q1 if so suspect Q1 or Q3

faulty or disconnected C33, R51 or R53 wrong value

check supply voltages or pin 6 (+10 V) and pins 9 and 16 (−6.6 V) Check output voltage of each individual amplifier. They should all be about 0V if not check components in local area.

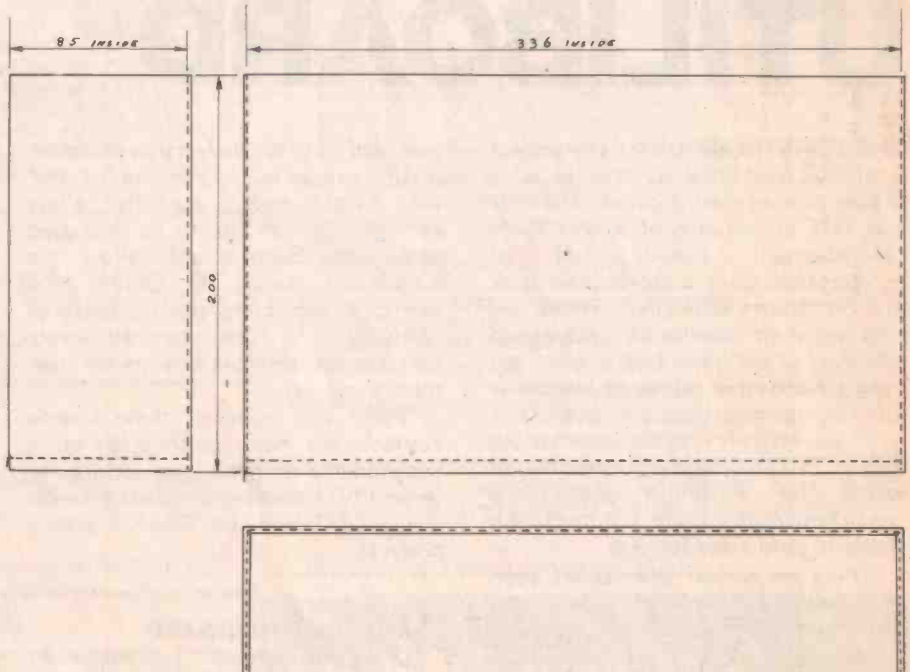
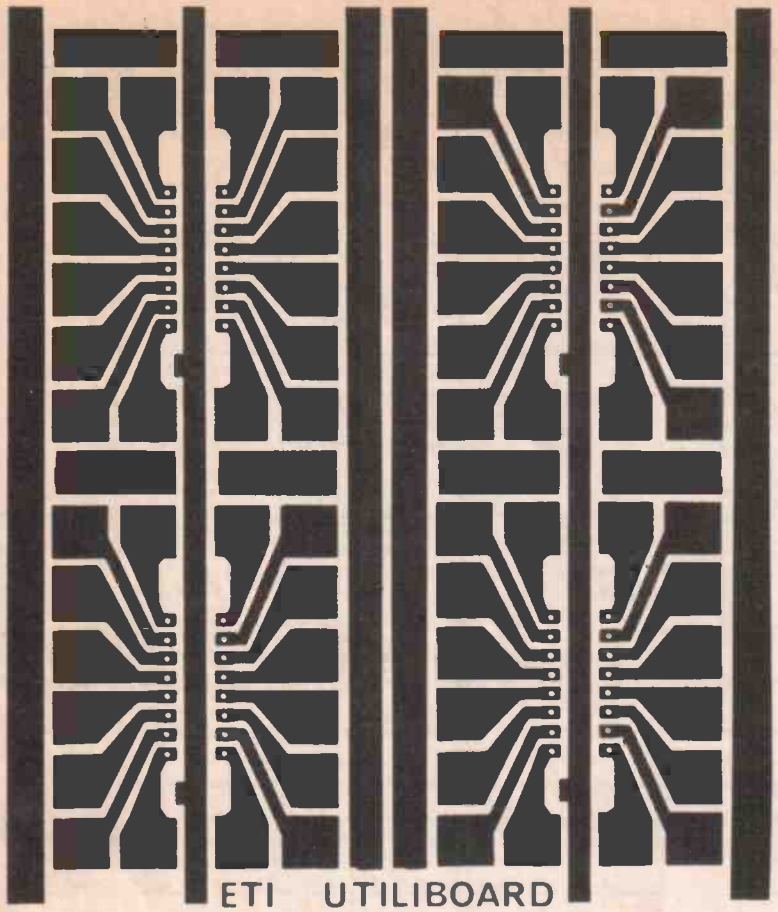


Fig. 12. Cover for the amplifier. This can be made from contiboard or from 16 gauge aluminium.



A versatile board for experimenters.

ETI UTILIBOARD

THE CONSTRUCTION of any project is always simplified by the use of a proper printed-circuit board. The neat and tidy appearance of a well made printed-circuit board, full of components, gives a professional look and is most satisfying. There are however some drawbacks. Each design requires a different board and you need a reasonable degree of knowhow and time to make your own boards.

Quite often it may be felt that the cost of a ready made printed circuit board, for a simple project, is unwarranted or it is just too much of a hassle to send away for one.

There are several alternatives, such as Veroboard and Matrix board, and many people are now using specially designed general purpose boards which are specifically made for versatility in the construction of general circuitry.

This latter approach has several advantages. The finished board looks neat and professional, fairly-complex circuits can be quickly assembled, and the large pads available allow experimental circuits to be debugged with ease. Such boards allow the builder to change the circuit of a particular project to suit his personal needs or, to use physically-larger components (eg junk-box parts) than those specified.

There are many of these boards available but many of them are quite expensive and some are lacking in versatility. Hence we decided to design our own board for use in simple projects.

USING THE UTILIBOARD

On conventional printed-circuit boards the components are always mounted on the non-copper side of the board and all our previous overlays have shown components in this way. However in experimental circuits it is more convenient to mount the components on the copper side. This allows components to be added, or shifted, without having to continually turn the board over.

Note that the board consists of four individual 16-pin dual-in-line IC pad-groups, each pin of which has associated with it a large pad to which several component leads can be soldered without the need for holes.

The broad lines through the centre of the pads, and on either side, are suitable for supply or earth connections. They are continuous so that the group of pads can be used together or the board may be sawn up into single or 2-way sections as required.

The broad line up the centre has indicator marks which point to pin I of an IC when it is mounted on the non-copper side of the board and the dot marker on the IC points to indicator-mark end of the board. Note that this central line is broad enough so that individual pads may be connected to it by solder bridging.

Of course any of eight, 14 or 16 pin DIL IC's can be mounted as required, or, discrete transistors may be inserted into appropriate holes. You will find this board extremely versatile and easy to use. ●

UNDERSTANDING COLOUR TV

In this final part, Caleb Bradley describes grey scale and decoder adjustments.

AT THE START of this series we showed that natural reproduction of each colour depends on three primary colours being combined in exactly correct ratio of strengths. Unfortunately the shadowmask tube cannot be guaranteed to be equally efficient for each primary colour; the efficiencies of the screen phosphors are unequal (red is usually much less efficient than the other two) and the situation is made more unpredictable by manufacturing tolerances in the electron guns which cause variations of gain and cut-off voltage. The relative performance of each gun of a particular tube might be as sketched in Fig. 56a.

GREY SCALE

The 'grey scale' adjustments are concerned with matching the three gun responses. Only when this is done can colours be correctly reproduced, in particular the *fully desaturated* 'colours', i.e. shades of grey or white, will be reproduced as perfectly neutral shades without any colour bias caused by relative excess or shortage of a primary.

To assess the grey scale quality of a colour receiver look at a monochrome programme and compare the picture colour with a neutral white source such as a typical overcast sky – *not* a tungsten lamp (too yellow) or a white object whose actual colour depends of course on its illumination. The cause of any overall tint can be found from Fig. 56b.

To confuse this, some receivers feature a rather spurious 'Tint' control which enables the viewer to upset the grey scale slightly to give a 'warm' or 'cold' picture impression – leave this control at mid position. Another point to watch is that a few sets have a special circuit associated with the decoder colour killer to give a deliberate blue tint to monochrome pictures. This is to resemble the appearance of normal monochrome sets since a monochrome picture displayed on a colour set in truly neutral grey seems somewhat 'warm' by comparison.

Besides relating any grey scale error to Fig. 56b one must decide whether it affects the dark greys, the light greys (whites) or both.

BACKGROUND AND HIGHLIGHT CONTROLS

In Fig. 56a it is necessary to match the three gun characteristics for both cutoff voltage and slope (gain). The grey scale controls for this are simplest on a receiver using colour-difference drive – Fig. 57.

When grey is being displayed the colour-difference voltages on the tube grids are equal; this was ensured by clamps in the decoder. To obtain neutral dark grey the cutoff voltages of the guns are equalized by the first anode (A1) voltage controls which are often called the background controls. If the grey scale is already approximately right it should only be necessary to trim one of these controls with reference to Fig. 56b, seeking neutrality exclusively in the *dark* greys and ignoring white. This is best done in a darkened room.

With correctly neutral background setting, the highlights may need balancing. In the circuit in Fig. 57a this is achieved by two potentiometers which allow the luminance drive from the valve output to the blue and green cathodes to be varied so that the differing slopes in Fig. 56a can be matched. The red gun permanently receives full drive since this usually has lowest overall gain due to the phosphor characteristic.

The lower end of each potentiometer is returned to a dc level which is approximately equal to the luminance black level, conveniently in this circuit the decoupled screen grid supply. This is to minimise the effect of highlight adjustments on the background settings.

The procedure is to look for any pastel tinting of picture whites and from Fig. 56a decide which highlight control to trim to remove it. As a tube ages, the gun efficiencies change and at some stage it may prove necessary to back off the drive to the red gun; if so it is easy to swap two cathode connections to put the full luminance

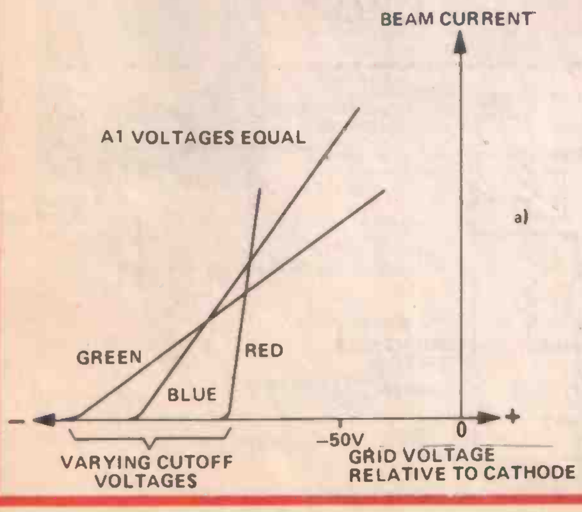


Fig. 56 (b)

GUN RESPONSE:	TOO STRONG	CORRECT	TOO WEAK
GUN			
RED	red-brown tint	NEUTRAL GREY OR WHITE	blue-green tint
GREEN	green tint		purple tint
BLUE	blue tint		yellow tint

Fig. 56 (a) Unequal responses of the primary colour guns need compensating by means of the grey scale controls for correct monochrome and colour pictures. (b) This diagram shows the effects on a desaturated (grey) picture area (e.g. any part of a monochrome picture) of incorrect gun response.

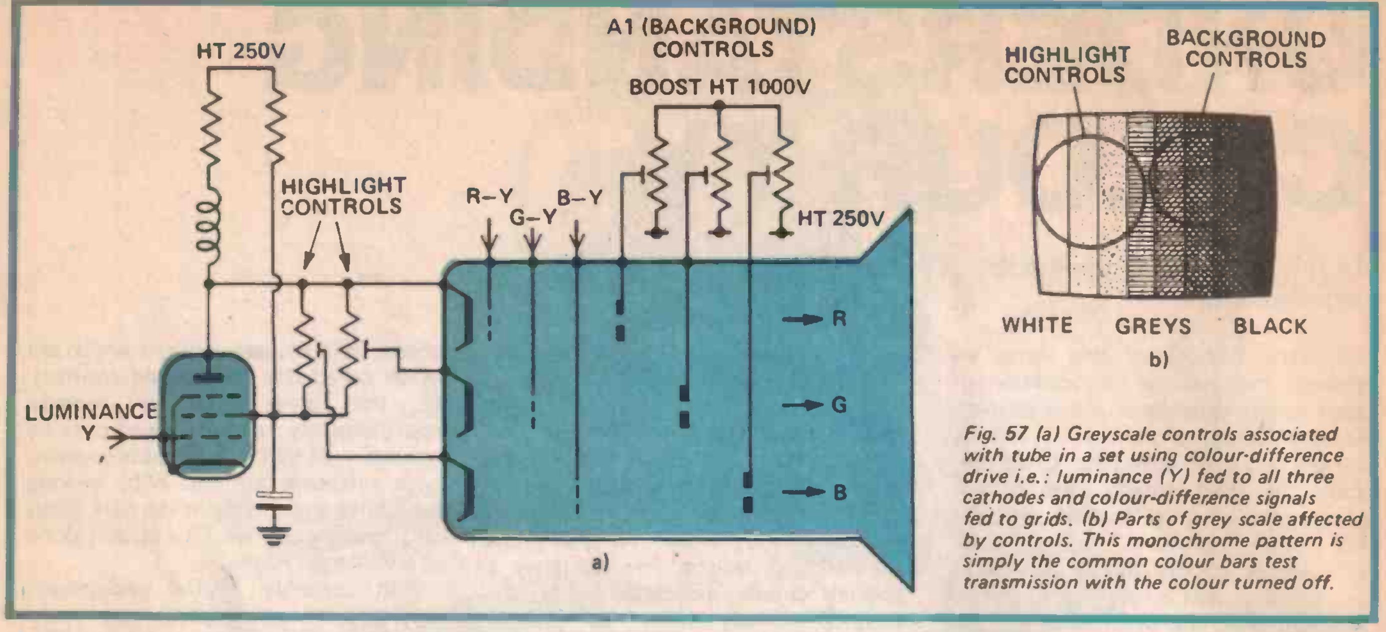


Fig. 57 (a) Greyscale controls associated with tube in a set using colour-difference drive i.e.: luminance (Y) fed to all three cathodes and colour-difference signals fed to grids. (b) Parts of grey scale affected by controls. This monochrome pattern is simply the common colour bars test transmission with the colour turned off.

drive to another gun. Avoid excessively bright (defocussed) whites where the least efficient gun, particularly of an old tube, may be driven into forward grid current which ruins the whole grey scale.

BEAM LIMITING

Besides ruining the picture, over-advancing the brightness control can in extreme cases cause damage by overheating the shadowmask so it distorts, or overloads an eht multiplier. To avoid this possibility most receivers incorporate some form of beam limiting device. Three representative circuits are shown in Fig. 58. Circuit a is common on early sets which use the bulky but efficient valve rectifier plus stabiliser circuit for eht. As beam current through the overwind and VR increases, the stabiliser grid is driven negative. Beam limiting is accomplished by diode D which conducts if it becomes excessive and pulls down the brightness control voltage. A similar circuit but with the diode connected to the contrast control has also been used.

Circuit b uses a low-value resistor to sense the emitter or cathode current in the line output stage – which increases with increasing beam current due to the internal stabilisation feedback. If the current becomes excessive the transistor turns on and again pulls down the brightness control voltage to keep the beam current in hand. The 'beam current' control should be set so this happens at a beam current of about 1 mA. The capacitors in this kind of circuit are important because they restrict the bandwidth of the control loop; they sometimes fail which causes symptoms of oscillating brightness and picture size.

Circuit c is much simpler and is connected in series with the tube cathodes (shown for one cathode only). Normally the diode is forward biased and provides a low impedance path for the luminance signal. However if the luminance drive goes too negative the diode blocks and the peak beam current is limited by VR. The capacitor prevents hf loss in the diode impedance.

DECODER

With correct grey scale established, the final step is to assess the decoder performance. As a colour transmission is tuned in, the picture should initially be monochrome and the colour suddenly pop in at the correct tuning point. This indicates correct action of the colour killer which enables the decoder only when adequate chroma is received. Distant (grainy) colour programmes will therefore be received in monochrome only.

Complete failure to receive colour calls for servicing action which we can only describe in a general way. The first step is to disable the colour killer so that demodulated chroma should be fed to the tube regardless of whether the reference oscillator is in lock. If doing this produces a perfect colour picture there is a simple fault in the killer stage itself. Another possibility is

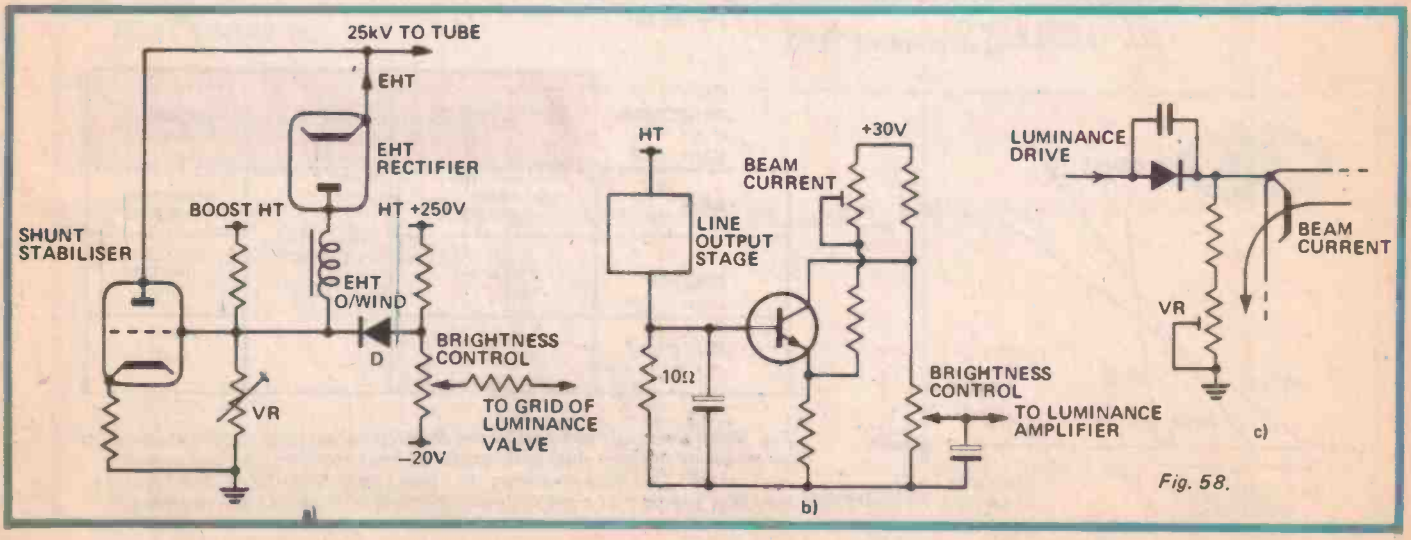


Fig. 58.

UNDERSTANDING COLOUR TV

that alternate picture lines will show different colours (like Hanover blinds but with more extreme differences). This means the PAL bistable has stopped working and should be easy to cure.

A common fault is the reference oscillator failing to lock to the burst. An unlocked oscillator produces a cyclic variation of colours from top to bottom of the screen, caused by it passing in and out of correct phase, with a large number of cycles if its frequency is far removed from the burst. The cure may be found by adjusting the oscillator frequency control to bring it into lock. Set it to the centre of the lock-in range which is best found by monitoring the varicap diode bias voltage. If lock cannot be obtained or is unstable the next thing to check is the timing of the pulse which gates the burst into the phase discriminator; usually this is determined by an adjustable coil. At this stage an oscilloscope becomes necessary for fault finding.

With a functioning PAL decoder it is child's play to assess the colour performance if a colour bar transmission is available. Switch on the red gun alone. Set contrast and colour saturation so the red bars of the pattern are equally bright. Then change to the blue gun alone which should also be producing equally bright bars. Likewise the green gun. The correct positions of the bars are shown in Fig. 59. Incorrect ident phase has the effect of reversing the red bars. If necessary trim the colour channel gains in the decoder to achieve equally bright bars across the screen from all three guns.

Check the colours for freedom from Hanover blinds (chroma delay amplitude and phase adjustments) and your PAL receiver is ready for action. ●

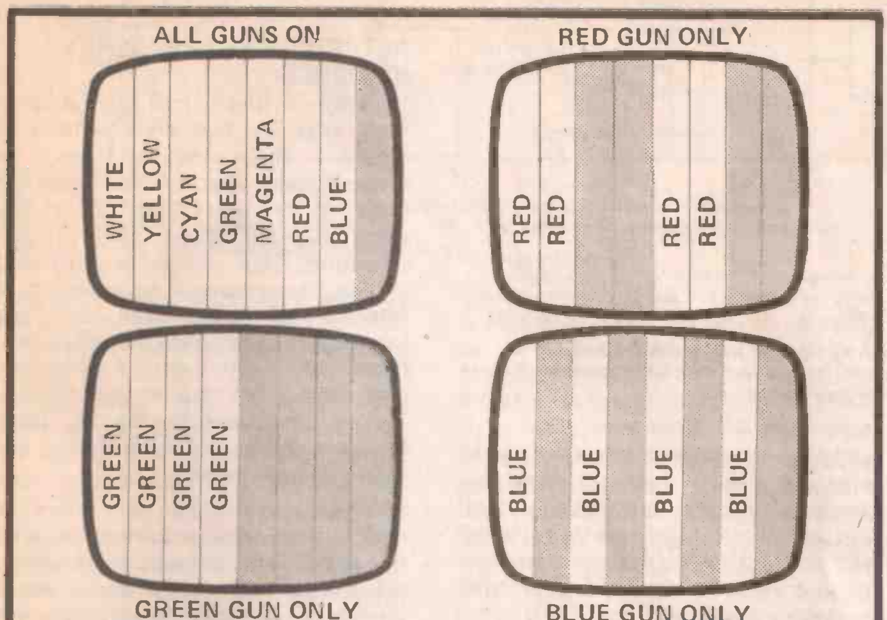


Fig. 59. Correct appearance of standard colour bars test pattern.

ELECTRONICS —it's easy! PART 21

All about electronic filters

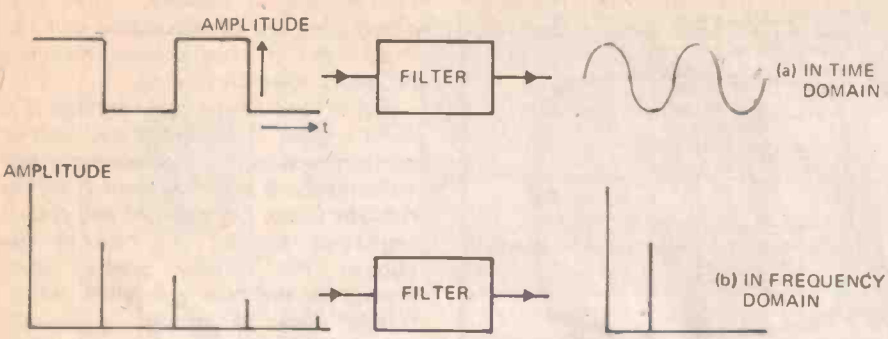


Fig. 1(a). A filter alters the frequency content of a signal. This means the wave shape is changed when displayed as an amplitude-time graph. (b). Using the frequency spectrum form of display the filter removes (or enhances) certain frequencies.

TO SEPARATE peas from boiling water, or dirt from engine oil, one must use an appropriate filter. When the term filter is used, in any discipline, the meaning is always the same – it is a device for separating or selecting something from an available mixture or range of things.

Filters are also extensively used in electronics where they are used to select a desired part of the range of frequencies which make up a particular signal. We have seen many examples of this throughout our course so far. For instance, in our discussion of multiplexed telephone systems, we saw how it is necessary to *separate* the various frequency channels and pass them to individual outlets. We also saw how an LC tuned circuit is used to *select* only one desired radio broadcast station from the many available.

Other examples of the use of filters are the crossover networks used in hi-fi speaker systems, to divide the audio bandwidth between two or more speaker drive units, the compensation stages in instrumentation control systems which improve performance by attenuating or enhancing relevant frequencies or the filters used to correct for the non-linear attenuation versus frequency which occurs with long-line telephone communications.

ALTERING THE FREQUENCY RESPONSE

Electronic filters, in a general sense then, alter the frequency content of signals. Their action can be comprehended first by considering the stage as a unit that alters the amplitude/time shape of an input waveform. This concept is illustrated in Fig. 1a where a square-wave is filtered to remove all but its fundamental sine wave. Alternatively, filters may be thought of as devices that change the frequency spectrum. This is illustrated in Fig. 1b. Both concepts are correct, each finding use to suit different needs.

We generally think of filters as devices which change the amplitude of the signal with frequency. However, filters may also change the phase of the signal. In many applications the phase shift is undesirable and must be considered when making the selection of filter type.

Unlike other circuit blocks which are available as built up units, filters are generally made specifically for the task.

Many filters are extremely simple – varying from two components to (say) ten and the design procedures of most are easily found in texts. This is not, however, to say that filters are trivial and not worth learning about. Filter designs may be grouped into two main classes – those called passive filters (Fig. 2a) that use passive components only – such as resistors, capacitors and inductors; and those called active filters (Fig. 2b) that are based upon an op-amp using single or multiple path feedback loops. Design procedures can be quite complicated but because of the universal need for a few basic types of response, most design is now a matter of applying simple formulae or using graphs to arrive at the component values.

By way of interest the design philosophy of filters – or any network requiring a given frequency response – can proceed two ways. First, one can propose a network configuration and then mathematically analyse it to get the generalised formula. This is called network analysis. The alternative and more modern approach (in the last few decades, that is) is to start with a mathematical expression of the

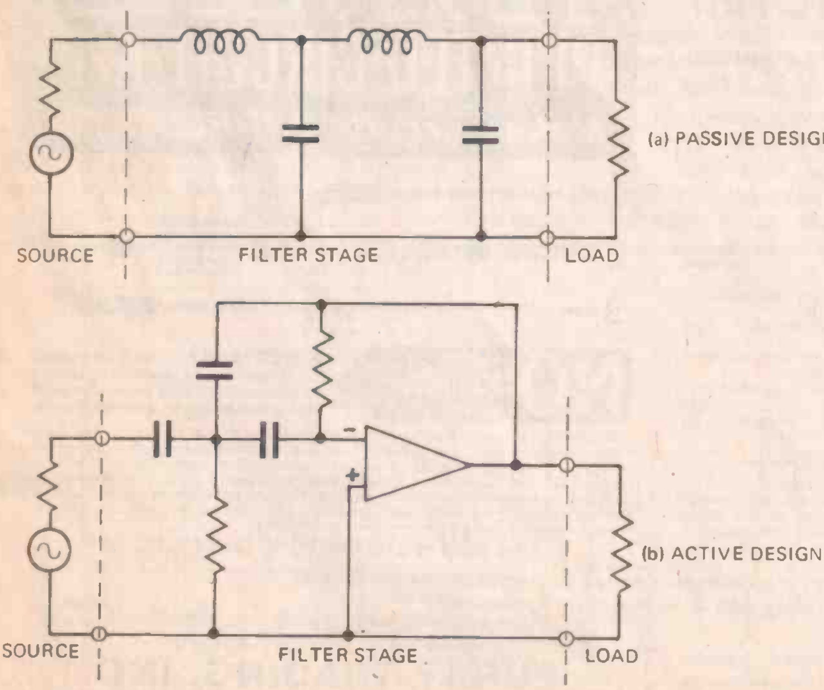


Fig. 2(a). Passive filters use R, L. and C components only. (b). Active filters incorporate active elements with passive elements to great effect.

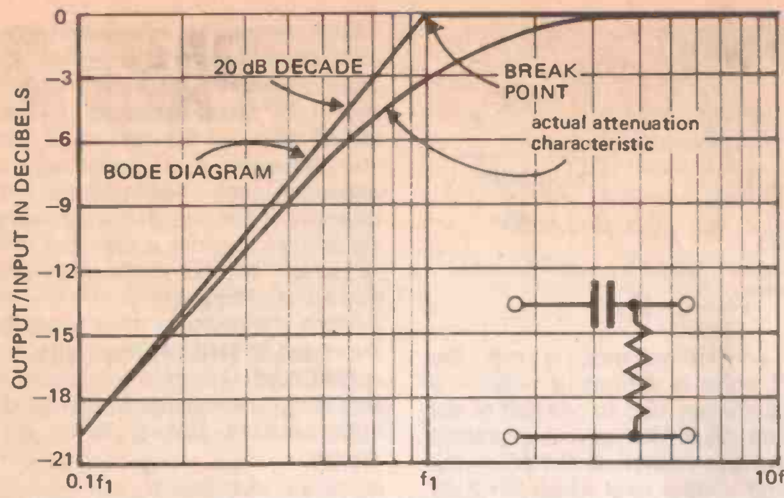


Fig. 3. Bode diagrams usually express amplitude (and phase) variation with frequency in terms of simplified responses consisting of straight lines turning at break points. The actual response will be more gradual near the breakpoint.

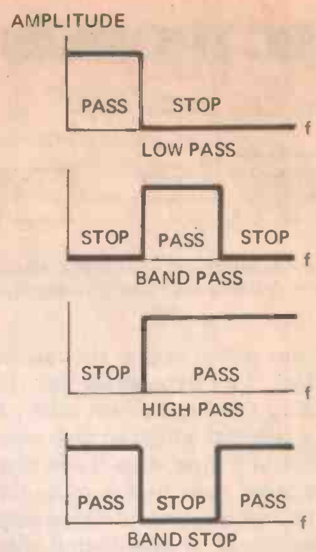


Fig. 4. Idealised responses of various categories of filter.

frequency response needed and, by using appropriate mathematical procedures, create on paper the circuit needed to provide such a response. This is called circuit synthesis. The latter method has a certain fascination because it provides the answer in a more logically direct manner than the cut and dried analysis process (although sometimes one ends up with a requirement for non-realisable circuit needs such as negative frequency!). On the other hand, however, synthesis requires mathematical ability and considerable experience.

In the following sections we will analyse a few of the more common filter stages.

THE BODE DIAGRAM

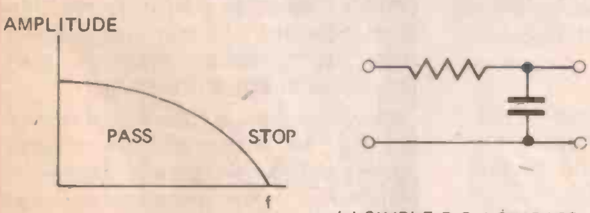
One of the, now classical, works on network analysis is a book "Network Analysis and Feedback Amplifier Design" by H. W. Bode published by Van Nostrand in 1945. Today Bode's work is mostly remembered by the graph which carries his name and relates the amplitude, or phase shift, to frequency for an amplifier, feedback system or a frequency modifying stage such as a filter. There is, at least, in principle, no distinction between the frequency response plots we have discussed to date and the Bode diagram. In practice, however, Bode diagrams are usually mathematical simplifications in that they are drawn with straight lines only, these lines changing direction at what are known as break-points and sloping at known rates.

The Bode diagram exemplifies the behaviour of a circuit as a tool, and is derived from mathematical knowledge of the system, not from actual tests. In truth, the linearization simplification is usually not far from reality, and we will meet Bode diagrams in our study of filters. Fig. 3 shows the difference between a Bode diagram and an actual response plot for an RC filter. The Bode diagram plots signal amplitude in decibels on a linear scale against frequency on a logarithmic scale.

TYPES OF RESPONSE

As with amplifiers, filter frequency responses are grouped into low-pass, band-pass and high-pass. Theoretically, ideal filters would have responses as shown in Fig. 4. There is also a constant need in electronic systems for a band-stop stage.

In reality it is impossible to obtain exactly square response curves. The response always rises or falls, within the transition region, with a rate of steepness that depends on the design used. A general rule is that the simpler the design (least number of components) the more gradual will be the transition. Also the more rapid the transition the more likely are effects of "ringing" encountered. Do not confuse these concepts of shape with amplitude-time wave shape graphs: these are amplitude (phase) — frequency curves. To illustrate this concept compare the two extremes given in Fig. 5. Figure 5a is for a most basic RC stage, Fig. 5b is for a response having rapid cutoff — a Chebyshev filter stage.



(a) SIMPLE R.C. LOW PASS FILTER STAGE

Fig. 5. As a general rule the more complex the filter circuit, the sharper the roll-off but the more variable the response in the passband region. (a) RC low pass stage. (b) Advanced Chebyshev stage.

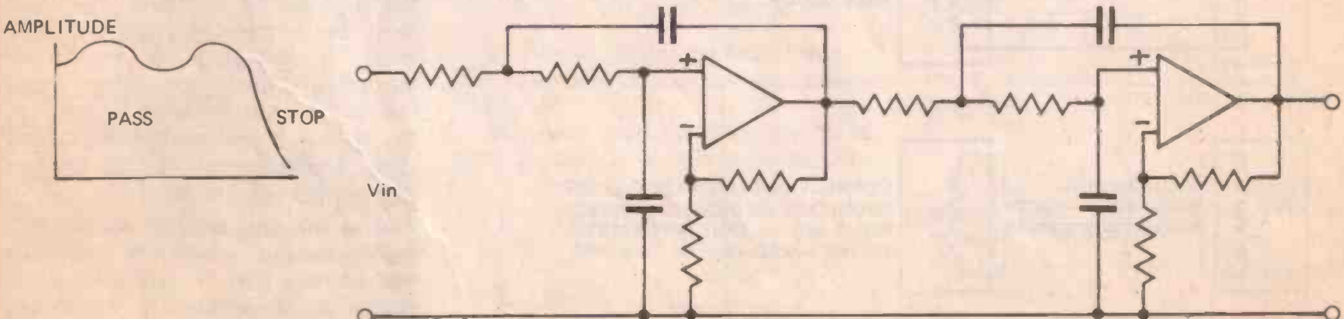


FIG. 5

(b) FOURTH ORDER CHEBYSHEV LOW PASS FILTER STAGE

ELECTRONICS -it's easy!

Fig. 6. By converting the electronic signals to mechano-acoustic form it is possible to make use of the extreme sharpness of mechanical resonant systems.

It is also worth noting that no filter is perfect, for frequencies are only attenuated relative to each other. If a signal appears at a high enough level at the input of a filter stage it will appear at a reduced level in the output and could be troublesome. Acknowledging this, the degree of attenuation chosen should be matched to the circumstances expected. It is pointless (and unnecessarily expensive) designing a stage to provide, say, 120 dB reduction of the unwanted frequency if it never reaches more than, say, 10 dB of the wanted frequency, apart from which an unwanted signal which is more than 60 dB down on the wanted one rarely causes problems.

DEFINING THE RESPONSE BANDWIDTH

As realistic filters fall short of being ideal there is no clear-cut point, where the response changes markedly enough, to use as the criteria for defining bandwidth. In some simple filters we could use the apparent position of the breakpoint but this would not hold for all filters.

The convention used is that the cut-off point is defined as where the response power falls to one-half of the passband value. Half power, expressed as a voltage change, is 0.707 of the passband voltage level which is –3 dB in decibel units. (Often called the '3 dB down' point.)

The bandwidth of bandpass (or bandstop) filters is, therefore, the frequency interval between the two cut-off points situated on each side of the bandpass (or stop) region. Bandwidth of a high-pass design has no real meaning as the frequency rises to infinity. Low-pass units have a band-width from zero frequency (dc) to the cut-off value.

In the case of complex designs the stated response often omits what happens at frequencies remote from the usual frequencies of interest. It is wise never to assume that, say, a bandpass filter only passes frequencies between the design points. It may well have "windows" much removed from that region. Additional stages are added in some system designs to exclude these effects.

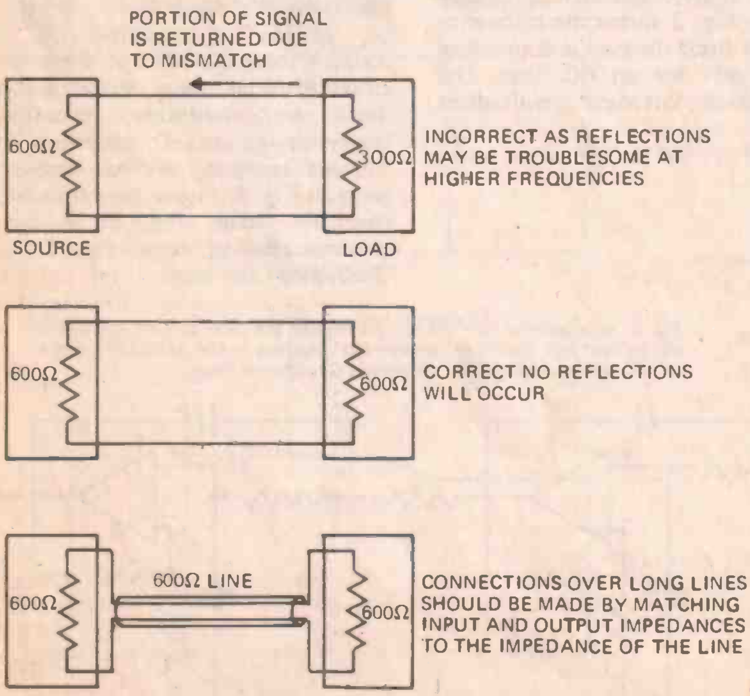


Fig. 7. Reflection of RF energy will arise if stages are not terminated into each other with the same impedance. Filter stages should observe this requirement.

Whereas the majority of filters used in electronic systems are made solely from electronic components there do exist circumstances where transduction to mechanical principles for filtering, and back again to electrical, are advantageous. One example is the use of tuned resonant reed filters, such as is depicted in Fig. 6, which exhibit extremely narrow band-pass characteristics.

Often the response of a bandpass is expressed in terms of its quality factor — that is the Q-factor of the peak. This definition was discussed when we dealt with resonant circuits earlier in the course.

THE EFFECT OF ADDING A FILTER

When the main purpose of adding a filter is to alter the frequency composition of signals it is not unexpected that the other effects brought about by its insertion might be overlooked.

As in any system changed by the addition of a cascaded 'box', the output of the preceding stage and the input of that following must be considered from the loading point of view. It is quite unrealistic to design a stage in isolation, unless the filter stage is adequately buffered, for the impedances connected to its input and output will alter the cut-off points — and hence different values will be required to achieve the designed characteristic.

The term 'Insertion Ratio' will often be encountered, it describes the ratio of output voltage with and without the filter, that is, the voltage Insertion Ratio = $\frac{\text{Vout (no filter)}}{\text{Vout (with filter)}}$

Expressed in decibels of loss we arrive at the term Insertion Loss = 20 $\log_{10}$ (Voltage Insertion Ratio). In practical cases, however, one may well design a stage to provide insertion gain (especially in active filter stages).

When matching a filter into a system it may be important to conserve power, voltage or current. To ensure maximized power transfer the input impedance to the filter must be of the same value as the output impedance of the stage before. Similarly, its output must be terminated into the same value. If voltage levels are to be maximized then the filter input impedance must be much higher than the output impedance of the driving stage. Current maximization requires the reverse relationship.

When the frequency of operation is high another problem becomes significant — that of reflections. When energy is launched into a network containing storage elements — a filter stage is such — some of the energy may be returned to the source which, in turn, may reflect it again, the final situation being that the net sum of all of these travelling waves of energy cause excessive power losses in the line (and distortion). This effect is very pronounced in radio-frequency transmission lines.

The extent to which a reflection occurs is decided by the degree of difference in the impedances seen in both directions at a system block junction. If a filter is terminated into the source with the same impedance in both directions there is no mismatch and no reflection occurs. This concept is depicted in Fig. 7.

As the two impedances differ in magnitude so does the amount of signal reflected. A similar situation applies at the output of the filter.

Mismatch terminations begin to generate noticeable spurious signals this way from megahertz frequencies upwards. This is the reason why wide-bandwidth amplifiers, such as videoamps, must be designed with output impedances that match the feeder cable. Coaxial cable can be shown to have a characteristic impedance set by the ratio of size and spacing of its conductors. It is invariant with length of cable. Typical coaxial cables have impedances of 50 or 75 ohm. Alternatively another kind of cable having two wires with a fixed separation between them may be used. Such transmissions lines have typical impedances of 200, 300 or 600 ohms. Whilst on this subject, one way of locating open-circuit and short circuit faults in cables is to send a sonic pulse (these travel much slower than electromagnetic waves) down the cable — timing the arrival of reflected pulses produced by the gross mismatch that exists at the fault.

Filter stages, as said before, also introduce phase shifts. A sine-wave input will appear at the output shifted in time by some fraction of the electrical cycle. In the compensation networks of feedback controllers phase shift must be carefully controlled, for a wrong value of phase shift may cause the system to become unstable. That is, if the phase shift approaches 180°, the feedback becomes positive, instead of negative, and the system oscillates.

PASSIVE DESIGNS

THE RC FILTER

The simplest passive electronic filter is the RC network set to act as a low-pass or high-pass stage. The two alternatives are shown in Fig. 8. In Fig. 8a it is easy to see that at low frequencies the capacitive reactance is very high and the output is the same as the input, provided the load

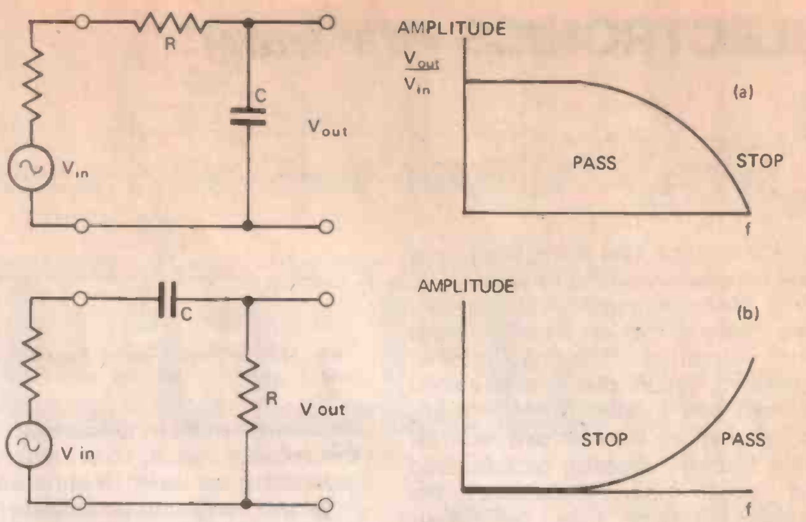


Fig. 8. Basic RC filter stages (a) low-pass (b) high-pass.

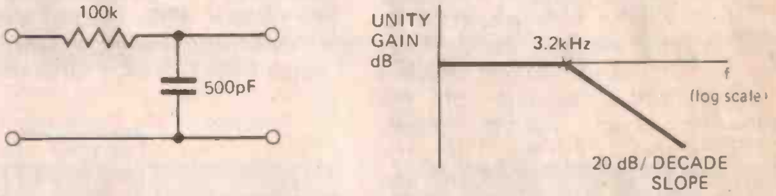


Fig. 9. Bode diagram for low-pass RC filter in which source and load are not significant.

impedance connected is significantly higher than the value R. As the frequency rises X_c decreases, lowering the output voltage. The reverse situation applies for the high-pass unit.

Mathematical analysis shows that the response plot — the Bode diagram — for these can be constructed by recognizing that there is just one break point and that the response falls away at 20 dB/decade change in frequency (ie 6 dB/octave). An octave change corresponds to 2 : 1 frequency ratio; a decade change is a 10 : 1 ratio. The jargon used is that the response rolls-off at the stated rate. Regardless of the values of RC chosen the roll-off rate stays the same. The break point occurs at $f_c = \frac{1}{2\pi RC}$.

To illustrate this consider the construction of the Bode diagram for a low-pass filter with R = 100 kilohms and C = 500 pico-farads. The break point occurs at

$$fc = \frac{1}{6.28 \times 100 \times 10^3 \times 500 \times 10^{-12}}$$

and it slopes downward from there at 20 dB/decade to give the plot shown in Fig. 9.

This much may seem almost trivial and, indeed, it is over-simplified. In

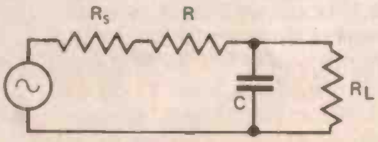


Fig. 10. Practical RC filter designs should allow for source and load resistances.

practice there will be a source and a load impedance connected to the filter terminals. Fig. 10 shows the practical case in general.

It is also not hard to reason out what happens when the source and load impedances are taken into account for Rs is in series with R and R_L is in parallel with C. By expanding our mathematics we find that the formula becomes

$$f_c = \frac{1}{2\pi\ [R_S + R)\ //\ R_L]\ C}$$

Hence, if the stage is not buffered the breakpoint can be quite different from that arrived at from the time-constant of the filter alone. For example if load and source impedances are both 1 k in our previous example the breakpoint changes from 3.2 kHz to 2.66 kHz. Further, the stage will introduce attenuation: the gain in the passband becomes

$$\frac{Vout}{Vin} = \frac{R_L}{R_S + R + R_L}$$

$$\text{for our example} = \frac{1000}{1000 + 5000 + 1000}$$

$$= 0.4$$

By use of appropriate values of source and load resistance it is possible, therefore, to set the attenuation and draw an appropriate Bode diagram.

The high-pass RC filter is considered in the same way — to arrive at

$$f_c = \frac{1}{2\pi\,(R_S + R\,//\,R_L)\,C} \text{ and}$$

$$V_{out} = \frac{R\,//\,R_L}{R_S + R\,//\,R_L}$$

for the practical case where source and load impedances cannot be ignored.

The observant reader will probably have realised that an amplifier stage with capacitive coupling has an equivalent circuit that is a combined highpass and lowpass filter with gain added between. The high-pass response arises from the coupling capacitor and the stage input impedance, the low-pass response from the output impedance and the stray capacitance existing to ground.

It is possible to combine a low-pass RC stage with a high-pass stage to arrive at a bandpass filter. These, however, are not particularly selective bandpass filters because of the relatively poor roll-off slopes (20 dB/decade). Further, if the bandwidth required is small, the two stages interact producing a non-constant passband gain. To obtain a satisfactory design it is important to ensure that the second stage resistance (the shunt of the high-pass stage) is at least ten times that of the first (the series resistance of the low-pass stage). Also the two break points should be at least a decade apart.

RC NOTCH FILTERS

Some applications call for rejection of a narrow band of frequencies, the reduction of 50 Hz or 100 Hz noise, for example. A very effective, yet, inexpensive technique makes use of a type of Wheatstone bridge which requires only resistors and capacitors and yet provides very sharp roll-off.

The Twin-T or parallel-T notch filter is such a circuit and is shown in Fig. 11. (It can be redrawn as a more-obvious bridge circuit and comprises two T circuits connected in parallel). At high or low frequencies it is easy to see that the capacitances either go to low or high reactances providing in both instances a virtually unaltered signal level through the stage. At the balance point, of a twin-T bridge, there exists a frequency — the so-called notch — at which the output falls very nearly to zero. This occurs for the circuit of Fig. 11 at

$$f_c = \frac{1}{2\pi RC}$$

Loading will reduce the depth of the notch.

In some applications it is desirable to be able to tune the notch to varying

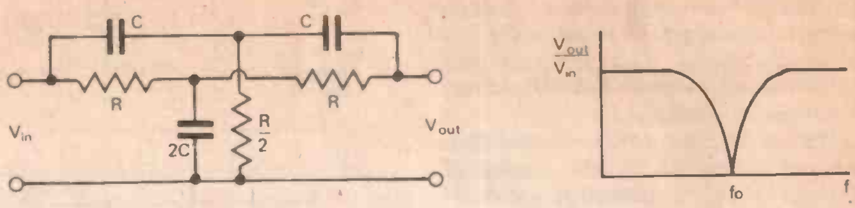


Fig. 11. The Twin-T notch filter provides very narrow rejection of a particular frequency.

frequency values. In the Twin-T design this requires that all three resistors (or capacitors) be varied simultaneously. A ganged multi-unit potentiometer or capacitance bank is used.

Other forms of bridge filter exist, each having its own particular feature. No simple RC circuits exist that exhibit the reverse characteristic of the notch filter — that is spike acceptance

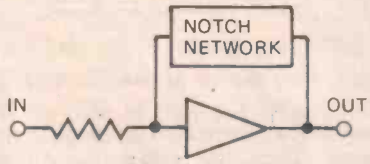


Fig. 12. Notch acceptance can be provided by using a notch-rejection circuit in the feedback of an op-amp.

of a particular frequency. This reponse however, can be provided by using a notch-filter as the feedback impedance in an op-amp that is set up as a simple inverter. This is shown in Fig.12. In this way the gain of the stage rises rapidly with increase in effective feedback resistance at the notch frequency.

IMPROVING THE ROLL-OFF

RC filters, apart from notch circuits, cannot provide much selectivity between signals due to their poor 20 dB/decade rolloff. This slope can be improved by cascading stages but this is not a preferred method for there exist other more economical designs.

The next stage of complexity is to use designs combining inductors and capacitors: no resistors are needed. That these provide improved roll-off is to be expected for we have seen earlier in this course that a resonant circuit can provide very sharp responses. By way of example a single stage LC filter can provide at least 12 dB and up to 25 dB/octave rolloff compared with only 6 dB/octave for an RC stage, and furthermore methods have been established (discussed in next part) that enable these to be cascaded without difficulty — a four stage unit can achieve 100 dB/octave rolloff! It is even possible to 'peak up' a specific frequency in the passband. In the next part we will also explain the virtues of adding amplifiers to form active filter circuits.

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Electronics Tomorrow

by John Miller-Kirkpatrick

THERE ARE A LOT of environments where it is necessary to control the temperature of a heating element to within a few degrees of the preset limitations. Examples are in tropical fish tanks, manufacture of some plastics and plastic materials, crystal ovens, hair curlers, etc. The usual method of control used to be a bi-metallic strip which bent and sprung in one direction as the temperature exceeded the upper limit and then clicked back into its normal position as the temperature passed the lower limit, the strip acted as a conductor and thus was used as a crude form of electrical switch. The problem with this sort of control is that the effective range is fixed in manufacture. Thus for use in different processes a wide range of strips has to be made.

BOILED FISH

Other problems with this type of control unit are contact erosion giving rise to sparking and subsequent RF interference and the fact that the temperature rise from the heating element can be faster than the strip can react to — how many tropical fishkeepers have had boiled fish as a result of an inefficient thermostat?

HAIR CURLERS

With the advent of power semiconductors the physical 'contact disappeared but we are still left with the problems of mains borne interference generated by old devices, much to the annoyance of digital clock owners! The problems of reaction time and the width of the temperature window (upper to lower temperature limits) are still with us and very important in some applications. Do you know that hair curlers should work at 130°C with very little tolerance on either side of this figure? Too hot and the hair is ruined and split, too cool and the hair will not keep its curl.

This problem, and specifically its application in hair curlers, has led to a new solution to the problem of controlled heating using electricity. Development engineers in the Netherlands working for the Elcoma division of Philips have come up with what appears to be a very simple answer in the form of a positive - temperature - coefficient thermistor. It's a single component heating device for electric hair tongs that, after a short warm-up period, maintains the heat at exactly the right temperature for making curls.

POSITIVE TEMPERATURE THERMISTOR

The device works like any other positive thermistor except that this one is a power unit as well. A normal thermistor is used to measure the temperature of its environment and to change its resistance as the external temperature changes, usually the resistance change is somewhat dramatic and happens at a predetermined temperature. This resistance change is usually sensed by a transistor which controls a cut-off or an alarm. In this new development the thermistor has a low resistance which rises very slowly until the preset limit (130°C) after which it suddenly increases to a very high resistance. The difference between this and other thermistors is that this thermistor is also a heating element; when the resistance is low the voltage applied across it causes the thermistor to heat up as any overcooked resistance would do. As the thermistor heats up to its limit the resistance suddenly rises, thus lowering the power dissipation and therefore the amount of heat generated. Once at its operating temperature the resistance changes linearly with the temperature which in turn is controlled by and derived from the resistance, and thus we have a closed loop control system which will hover at 130°C without any great variance or any great rate of change. You can try this for yourself if you can find a thermistor which is low resistance up to about 40 or 50°C and then changes rapidly to a high resitance. Work out the mathematics and apply a voltage directly across the thermistor, it should get warm or even slightly hot to the touch and then not change whereas a low value resistor would get hotter and hotter. If you double the voltage applied it will make very little difference except in the time taken to reach stability, in fact you can raise the voltage considerably wihout much change in the stable temperature until you get to the point where the termistor will continue to heat at its high resistance and then you will have a runaway situation. (If you do try this experiment use batteries otherwise you are more than likely to overload your power supply.)

PHYSICAL CONSTRUCTION

The thermistor that Elcoma are offering for this application will work at 110-250V and is insulated to withstand voltages in excess of 4000V. It is made of a semiconducting ceramic material embedded in a special insulating material. The element, about 1.5cm in diameter and 5 cm long, fits into a tube which, in turn, goes inside another tube. It is this outer tube, typically heated by the inner tube to 130°C, that contacts the hair. Apparently Elcoma have started marketing these curling tongs and so you may be able to show your beloved the advantages of solid-state electronics by buying her curling tongs for Christmas!

YET ANOTHER PROBE INTO DIGITAL LOGIC!

The first logic probes to come onto the market a few years ago were basically logic '1' detectors, if the lamp lights you have a logic '1' or a pulse train, if the lamp doesn't light then you have a logic 'O' or a power failure or a lamp failure. After this came the red and green indicators which could show High (red), Low (green), pulse train (both), high impedance or nothing (none). The problem is still high speed pulse trains or short pulses which are too fast for the human eye to detect.

I have an idea for a logic probe which some of you may care to play around with based on the fact that the ear is more sensitive to changes in frequency than the eye. You need a few 555 timers or similar units and a few logic gates, the power supply can be tapped off the unit under test and the probe should be able to test TTL, DTL and CMOS due to the voltage range of the 555s and CMOS gates used. The unit will probably become a little upset at frequencies in the 1MHz region without some further modification unless ICs other than 555s and CMOS can be used in the design.

SOUND PULSES

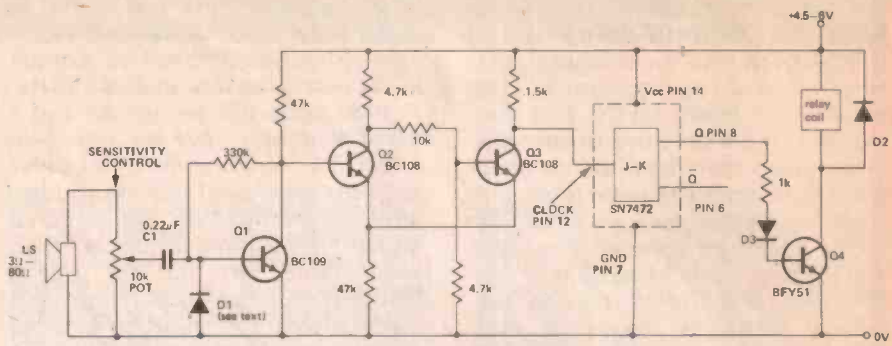
The probe input is connected to a pair of inverting gates to act as buffers, a switch can be included at this point to bypass the first these gates, thus effectively inverting the input for tracing negative going pulses. The output from these buffers is fed to a series of 555s which act as oscillators and pulse stretchers. The first 555 is set up as an astable with a frequency of about 1 KHz with pin 5 connected to the input buffers. If the test signal is logic '1' then the output tone will be 1kHz, for logic 'O' it will be a much lower note probably about 250Hz. A short pulse will be missed and a pulse train will have an unknown effect. To overcome the short pulse problem we should include a pulse stretcher by inputing the buffered signal into pin 2 of a 555 monostable set up for about 250-500mS, the output from this pulse stretcher is input to another astable set up at about 2kHz. A short pulse will now cause a short but noticeable 2kHz tone burst. A train of pulses will continuously trigger this part of the circuit and thus tend to give a continuous 2kHz tone. Frequencies between 2kHz and 15kHz can be heard directly by the ear but those above 15kHz would need a switchable divide stage to be included before they become audible. I was also trying to think of a simple circuit which could indicate the relative mark/space ratio of a pulse train but no genius ideas were forthcoming.

GATED

All of the oscillator outputs are gated together (possibly mutually exclusively) and then fed via a transistor to a high impedance speaker or earpiece. If you can use a 'tri-state' input gate on the probe then you would get no tone for no signal whereas a two state input will tend to pull towards logical '1' if it is not connected and thus give a 1kHz tone for a no signal condition. These are only ideas which might trigger somebody's brain into instant action, unfortunately I have no spare time at present to investigate the circuits in any detail. The basic idea seems to be good, the ear is a lot more sensitive than the eye, you can hear a difference between 50Hz and 60Hz or 6kHz but the eye would notice no difference in an LED displaying these frequencies. If any reader comes up with a working circuit I would be very interested in seeing it — you could even get yourself some money by putting it into Tech-Tips or a full article.

tech-tips

SOUND OPERATED TWO-WAY SWITCH



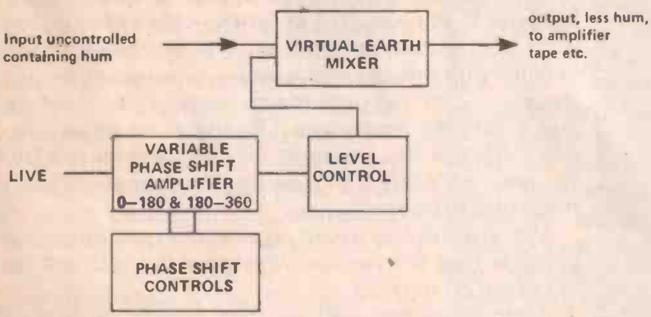
The circuit operates a relay each time a sound of sufficient intensity is made, thus one clap of the hands will switch it one way, a second clap will revert the circuit to the original condition. Q2 and Q3 form a Schmitt trigger. The JK flip-flop is used as a bistable whose output changes state every time a pulse is applied to the clock input (pin 12). Q4 allows the output to drive a relay.

Under quiescent conditions Q1 is on, holding the base of Q2 low and keeping the output of the Schmitt trigger low (Q3 collector). If a sharp noise is made (e.g. a clap) it will generate a pulse in the loudspeaker which is fed through C1 and switches Q1 off. D1 prevents any large pulses damaging Q1. As Q1 switches off, its output goes high causing the output of the schmitt trigger to go high. When the clap is finished Q1 again conducts, causing the output of the schmitt trigger to go low. Therefore each clap causes a high pulse at the Schmitt trigger's output which is fed to the clock of the JK flip-flop causing it's output to change state. This is used to turn a relay on and off. Because the circuit is only sensitive to sharp noises it is generally unaffected by talking or sounds caused by movement. (The sensitivity control can be adjusted to prevent such noises triggering the circuit if this does arise). A moving coil loudspeaker is used as a microphone as it can respond to sounds from any direction. It was found that any loudspeaker from 3–80Ω worked in the circuit. The $\overline{Q}$ output of the JK flip-flop could be used as well, allowing two relays to be switched on and off complementarily.

The circuit has limitless applications like turning on a radio or controlling motorised toys by clapping. The diodes can be any general purpose silicon types (1N914 etc) and the relay a 5–6V type with minimum resistance of 50 ohms.

HUM STOPPER

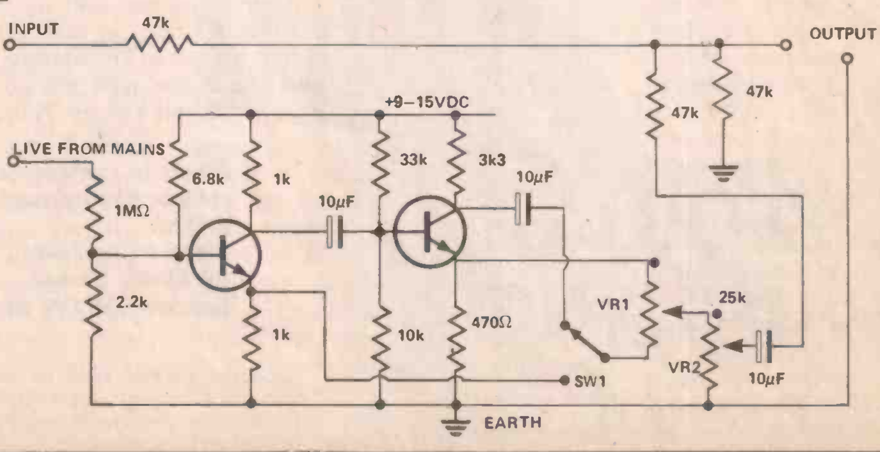
BLOCK DIAGRAM OF SYSTEM



Hum can be removed from an audio signal to great effect by mixing an antiphase hum of equal level.

In the circuit below all the transistors can be cheap or surplus npn (low or high gain) types.

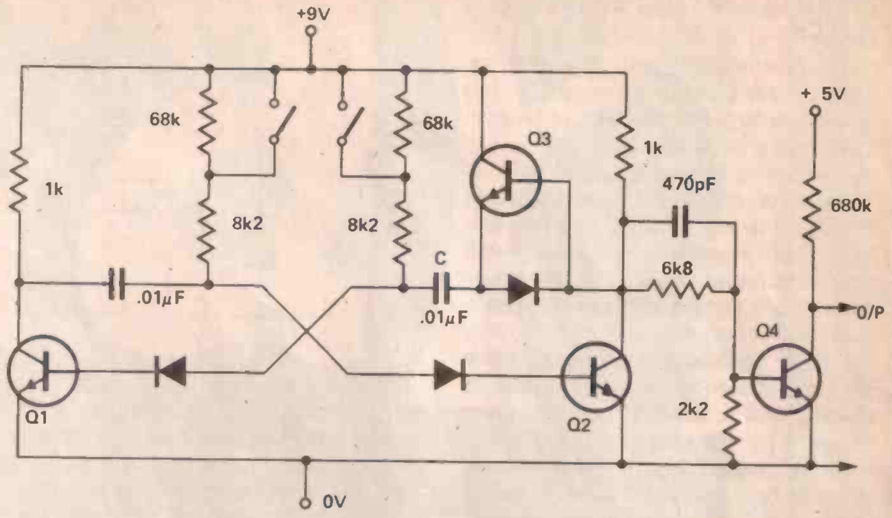
VR1 is adjusted with VR2 low (not off) until the hum is at a minimum, SW1 may have to be changed over, then the level VR2, is altered until the hum is removed.



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

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

FAST-EDGE SQUARE-WAVE GENERATOR



The circuit shown above generates a clean square-wave with very fast rise and fall edges; such a signal is essential for some applications such as the testing of amplifier transient responses, and the reliable driving of TTL.

The multivibrator circuit shown is unusual in that it produces a waveform with fast risetime as well as fast fall time. The standard astable multivibrator has a slow risetime as capacitor C is charged relatively slowly through the collector load of Q2; in the modified circuit C is charged very quickly through Q3. Diode D ensures that Q3 is only turned on when Q2 is off. The final stage (Q4) increases rise and fall speed still further; at the output the rise time is 100 nanosec. and the fall time 300 nanosec. When the output is used for driving TTL the collector load must be returned to a voltage no greater than +5V.

The two-pole switch gives an output at about 1kHz when open and about 10kHz when closed; these two frequencies being standard for checking the stability of audio amplifiers.

REDUCED RIPPLE AT LOW CURRENT

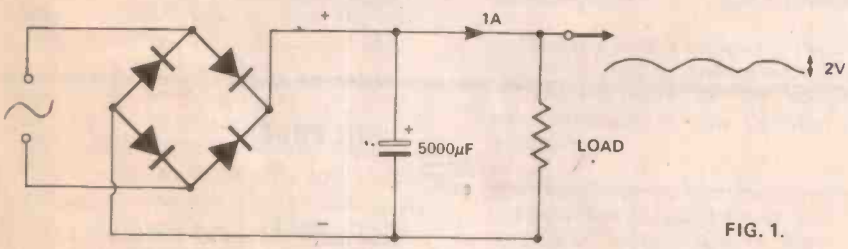


FIG. 1.

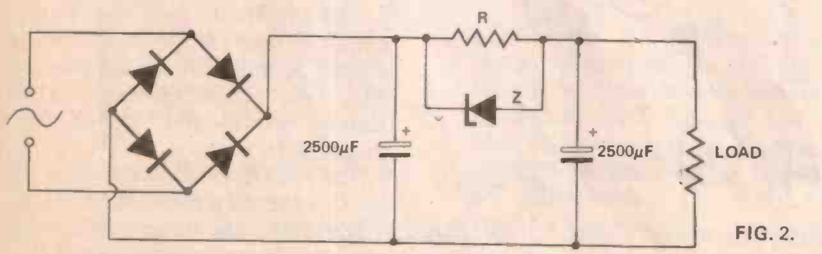


FIG. 2.

In the normal circuit (Fig. 1) the ripple at 1 amp is at least 2 volts. Cheap power amps use this circuit (with low supply ripple rejection) and produce annoying amounts of hum at low signal levels.

In the circuit in Fig. 2 the ripple is considerably reduced at low levels and at high currents the supply voltage is only minimally affected.

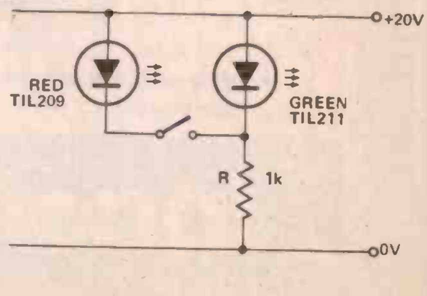
Maximum low ripple current (Im) = Vz/R where Ptot R must be more than Vz^2/R = Im Vz. IM = maximum total current so P_{tot} = IM-Im Vz. A typical set of values for Im = ½Amp is Vz = 3V, R = 1½ ohms.

LED CHANGEOVER CIRCUIT

This configuration allows a green LED to be turned off and a red LED turned on by the operation of one 'make" contact only, thus simplifying the design of circuitry to indicate, for example, safe/unsafe or standby/on states.

The circuit relies on the fact that a green LED has a slightly higher "on" voltage than a red LED of the same size, and hence is turned off when the red LED is paralleled with it.

For the diode types shown, R should be chosen to give a current drain of about 20mA from the chosen supply rail voltage.



tech-tips

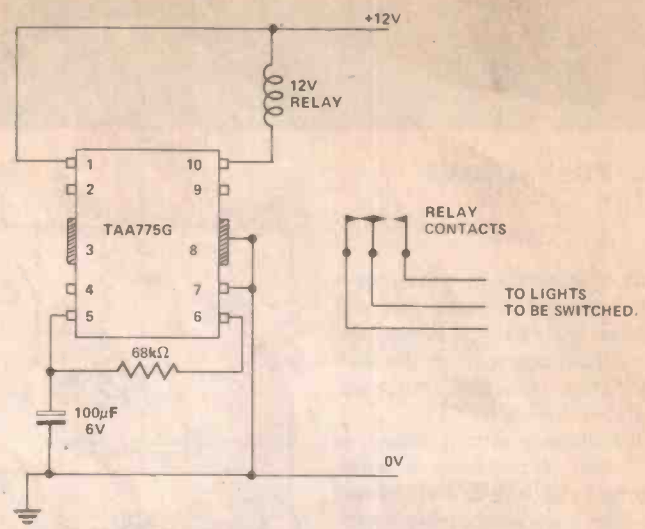
SIMPLE FLASHER CIRCUIT

A simple circuit which will cause a relay to open and close with a period of about 4 seconds is shown. This type of circuit has obvious applications in shop window lighting and in the lighting of Christmas trees. For shop windows it will normally be driven from a mains power pack, but if used in toys for children, a battery supply may be safer.

When the voltage at pin 6 is in its 'high' state, no current passes through the relay to pin 10 of the device and the 100μF capacitor charges through the 68k ohm resistor. After about two seconds the internal voltage comparator circuit connected to pin 5 switches the mode of operation of the device so that the potential at pin 6 falls to about +0.2V and a current flows through the relay to pin 10.

The capacitor now discharges through the resistor into pin 6. After about another two seconds, the voltage at pin 5 will have fallen to a value which is low enough to cause the device to switch back to its former state where the voltage at pin 6 is 'high' and no current flows through the relay.

The 'high' voltage at pin 6 is stabilised at about 4.6V. The rate of charging (and hence the period of oscillation) is therefore independent of the supply voltage.



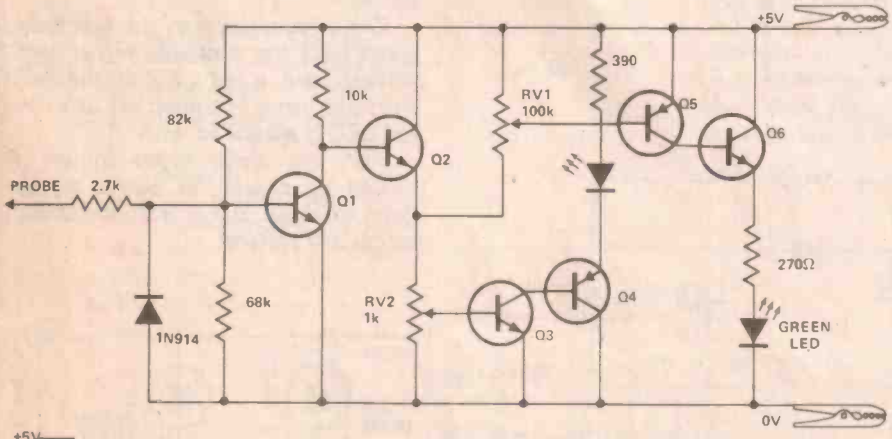
The maximum output current which should be allowed to flow into pin 10 is 150mA. A 12V relay which can switch up to 10A at 240V a.c. normally requires a current of about 100mA and it is therefore easy to switch over 2.5kW of power with this circuit. A smaller relay may be used to reduce the power consumption of the circuit if the current to be switched is smaller than 10A. If the relay has a pair of change over contacts, one or more lights can be switched on as another set of lights is extinguished.

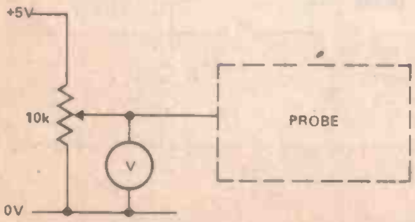
The frequency of oscillation is given by the approximate equation:

$$f = \frac{800}{R\ C}$$

where R and C are the value of the resistor in kilohms and of the capacitor in microfarads connected in the pin 5 circuit. In practice most electrolytic capacitors have a value above that marked on their case, so a lower frequency than expected may be obtained.

LOGIC PROBE





CIRCUIT TO ADJUST THRESHOLDS

Transistors Q1 and Q2 form a simple voltage buffer, providing the probe with a reasonable input impedance.

Q3 and Q4 form a level detecting circuit as the voltage across the base-emitter junction of the Q3 rises above 0.6V the transistor turns on thus turning on Q4 and lighting the red (high) LED.

Q5 and Q6 perform the same function but for the green (low) LED.

Q1, Q4, Q5 are all pnp general purpose silicon transistors (BC178 etc). Q2, Q3, Q6 all pnp general purpose silicon transistors (BC108 etc). The threshold Low $\leqslant$0.8V, the threshold High $\geqslant$2.4V.

news digest

Continued from page 8

NEW PYROMETER FOR SOLDERING IRONS

The new Litesold Pyrometer is designed as a simple, accurate and convenient means of checking the effective bit temperature of soldering irons. The instrument uses an Iron/Constantin thermocouple in conjunction with a

specially calibrated high quality moving coil meter which incorporates automatic cold junction compensation. The range of the pyrometer is from zero to 500 degrees Celcius with a scale marked every twenty degrees.

Light Soldering Developments Ltd., 97-99 Gloucester Road, Croydon, CRO 2DH.

HIGH POWER GaAs LIGHT SOURCE

Tungsten lamps have been used for many years for all types of light sources associated with photocell applications but recently the trend has been to change to Gallium Arsenide Light Sources. These new devices have the advantage of longer life, no filament sag, low drive current, smaller size, faster switching and the ability to match the peak spectral of modern silicon photocells.

A new unit is now available from Photain Controls Ltd., Unit 18, Hangar 3 The Aerodrome, Ford, Sussex which has an improved power output and yet will still operate with low drive current at room temperature. It is a hermetically sealed unit in a metal can with glass window and is designed for printed circuit board applications. It will withstand severe shock and vibration. Price is £2.00 to £3.00 each depending on quantity.

OPTICAL WAVEGUIDE PROVED AT 10KM

It is reported that Corning Glass in its research laboratories have fabricated a 10 kilometer length of optical waveguide having attenuation of 5.4dB per kilometer at 799-nanometer wavelength and a pulse broadening of only one nanosecond per kilometer; the light source was a laser.

The waveguide demonstrated capability of signal transmission of 100MHz over 10km (6.2 miles) without intermediate amplification or enhancement, Corning claim. This is equivalent in capacity to the transmission of 33,000 telephone conversations half across the area covered by the London postal code district, without repeaters, in a cross-sectional area the diameter of a human hair.

It was in the Corning laboratories, in 1970, that scientists first lowered attenuation to 20dB/km. This research achievement provided the impetus for the present work around the world in developing optical communications systems.

ETI HELPING HAND COMPETITION

In last month's issue we gave details about our open competition which is to find solutions for problems facing the deaf.

This closing date for Helping Hand is March 31st 1976 so readers who missed last month's details have plenty of time. Already the number of enquiries has demonstrated considerable interest in this.

ETI and the Royal National Institute for the Deaf (RNID) are co-operating fully in the organisation of this competition.

Three problems are shown on the right: we invite individual readers, clubs, schools, universities, companies, in fact anybody, to develop a practical solution. The rules are as basic as possible and impose virtually no restriction apart from insisting that any Patent Royalties are waived if the idea is produced.

The prizes, three in all, will be a silver trophy specially designed for ETI. At the close of the competition the magazine will hand over £250 to the RNID to help with development costs. There is a £1.00 entry fee (payable to RNID) and this will be added to the £250.

Background information has been prepared to help readers avoid obvious traps and to say what is already known — and has been done in the particular field. This is available from ETI on receipt of a large stamped, self-addressed envelope. This should be sent to:

Helping Hand,
ETI Magazine,
36 Ebury Street,
London, SW1W 0LW.

THE PROBLEMS

1 A sick person is being looked after by a deaf person. The deaf person has no useful hearing and requires to know whether the sick person is all right and above all needs to know if the sick person is in a state of distress anywhere in the sick room.

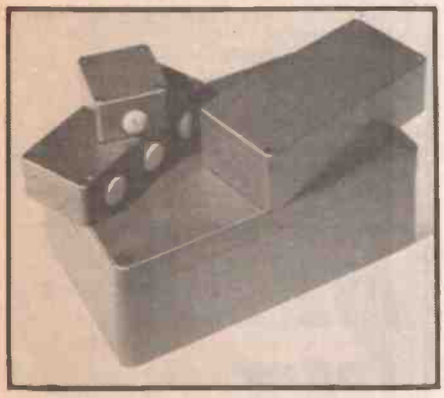
2 A hard of hearing person is attending a College of Further Education and has considerable difficulty in understanding what the lecturer says due to his distance from the lecturer and to the background noise in the room. A device is required to enable him to make the best possible use of his hearing.

3 Many deaf people have great difficulty in using the telephone and in fact many of them cannot use the telephone at all. The development of a writing tablet which would allow them to write a message on a small pad and for this to be communicated over the telephone line to a pad at the other end would have many great advantages. In addition the communication should be two way so that the person can receive a message or an indication that the message has been received.

DIECAST BOXES

West Hyde are now marketing a wide range of diecast aluminium "work boxes" under the BOPAL trade name. The mounting screws are inside the case, but outside the enclosure and, like the captive stainless steel fixing screws for the lid, are outside the gasket area which is recessed to protect the seal against mechanical damage.

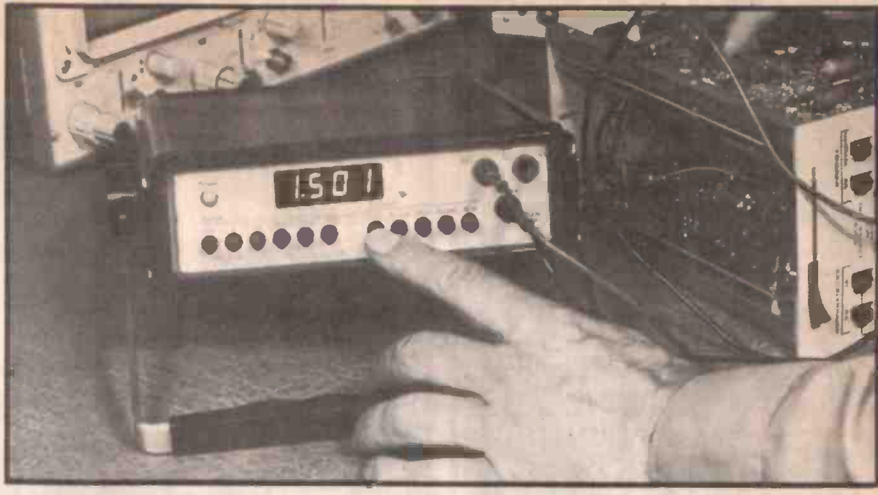
There is a wide range of sizes from approx. 0.1 litre to 24 litres. Pads and



earthing screws are provided for fixing terminal strips or mounting chassis. The finish is blue stove enamel hammer. Prices range from £1.39 to £52.19 including postage and packing.

West Hyde Developments Ltd., Ryefield Crescent, Northwood, Middlesex, HA6 1NN.

HIGH-STABILITY DIGITAL MULTIMETER



A new 3½ digit, 5-function digital multimeter from Gould Advance, the DMM7, is aimed at the general-purpose medium-accuracy market. It features very high stability and accuracy, and includes an automatic zeroing feature to eliminate offset errors. Polarity and decimal points are automatically displayed, and overrange is indicated by the display flashing. The DMM7 uses p-MOS LSI for both analogue and digital functions, and is housed in a metal case measuring 63 x 272 x 216 mm.

D.C. voltages ranges go from ±199.9mV to ±1200V full-scale. The same ranges are available for a.c. voltage measurements.

Five d.c. current ranges are available from ±199.9μA to ±1999mA full scale and six resistance ranges are included from 199.9Ω to 19.99MΩ.

The price of the DMM7 is £138 (plus VAT).

Gould Advance, Instrument Division, Roebuck Road, Hainault, Essex.

SUPER-HEAVY ELEMENT IS FOUND

Traces of a super-heavy element of atomic number 113 have been found in meteorite fragments by Russian geochemist Georgi Goncharov.

The deduction was made after computer analysis of some thousands of examinations of meteorite material, which showed an excess of Xenon-136.

The report lends strength to the theoretical calculation that an island of stability might exist for elements of atomic number 108 to 126.

None of these have yet been made or found in nature.

NEW CMOS LOGIC PROBE

A new CMOS logic probe has just been announced by Kurz-Kasch.

Available through Nimrod Electronics Ltd., the units work from 5 to 15 volt by automatically keeping the threshold at 30% of supply voltage for a "low" and 70% of supply for a "high".

These new probes maintain the excellent noise immunity built into the CMOS logic. The high input impedance of 2.7 Meg ohm for a high or low state prevents circuit loading or false triggering.

The probes are available with memory option and gating options. Two styles of read-out are offered - an incandescent read-out or an LED digital read-out. The LED style digits uses separate displays to indicate a "0" and "1" while relative intensities yield duty cycle information.

Nimrod Electronics Ltd., 85 High St., Billinghurst, West Sussex, RH14 9QX.

BROCHURE DESCRIBES FUNDAMENTAL TRANSDUCER TECHNOLOGY

The many different technologies applied to instrument transducers are simply described, outlining their advantages and disadvantages, in the introductory pages of a new brochure from SE Labs (EMI) Ltd., of Feltham, Middlesex.

Entitled 'A Guide to your transducer requirements' the sixteen-page brochure illustrates the full range of SE's aerospace and industrial devices for the measurement of pressure, displacement, acceleration, vibration, and force.

Copies of the brochure are available from: The Sales Department, SE Labs (EMI) Ltd., Spur Road, Feltham, Middlesex.

GETTING IN TIME

After the Russian revolution in 1917, that country had to lose several days to get their calendar to fall in line with the rest of the world.

It has just become known that they have had to do it again because of the Soyuz-Apollo link-up but on this occasion the difference was not large enough to cause much loss of sleep - in fact one-thousandth of a second!

The Soviet standard clock is accurate to one millionth part of a microsecond but this differed from U.S. time. The exact matching was necessary due to the extraordinarily accurate timing of the mission.

ERRATA

DIGITAL DISPLAY - OCTOBER 1975

The transistors shown in the circuit and in the Parts List are wrong. BC178 or similar silicon PNP types should be used, not BC108 as shown. Additionally on Q3 the collector and base are labled wrongly in Fig.1.

INTERNATIONAL-FM SEPTEMBER

In Fig.4, the component overlay, R20 and R21 are transposed, so are C6 and C7. Both ar hown correctly in the circuit.

BUILD THE

TREASURE TRACER MK III

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EMI 13 × 8, 150 d/c, 8 ohm	£2.94
EMI 13 × 8, 350, 8 or 15 ohm	£9.56
EMI 13 × 20 watt bass	£7.69
EMI 2¼" tweeter 8 ohm	£0.77
EMI 8 × 5, 10 watt, d/c, roll/s 8 ohm	£3.44
Elac 59RM 109 15 ohm, 59RM114 8 ohm	£3.44
Elac 6½" d/c roll/s 8 ohm	£4.06
Elac TW4 4" tweeter	£1.75
Fane Pop 15 watt 12"	£5.25
Fane Pop 25T 12" 8 ohm	£7.50
Fan Pop 50 watt 12" 8 ohm	
Fane Pop 55 12" 60 wat; 8 ohm	12.95
Fane Pop 60 watt 15" 8 ohm	£13.75
Fane Pop 100 watt 18" 8 ohm	£25.95
Fane Crescendo 12A of B, 8 or 15 ohm	£34.50
Fane Crescendo 15, 8 or 15 ohm	£47.50
Fane Crescendo 18, 8 or 15 ohm	£62.95
Fane 807T 8" d/c, rolls/s, 8 or 15 ohm	£4.62
Fane 801T 8" d/c roll/s 8 ohm	£8.12
Goodmans BP 8 or 15 ohm	£5.50
Goodmans 10P 8 or 15 ohm	£5.80
Goodmans 12P 8 or 15 ohm	£13.95
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Goodmans 12P-G 8 or 15 ohms	£15.95
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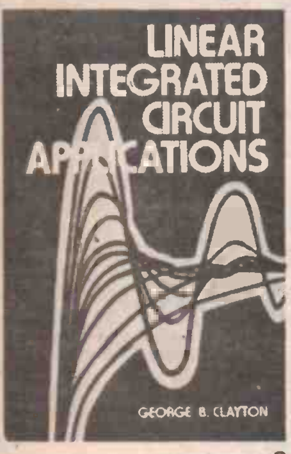

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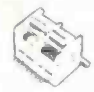

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