AN ARGUS SPECIALIST PUBLICATION
APRIL 1984

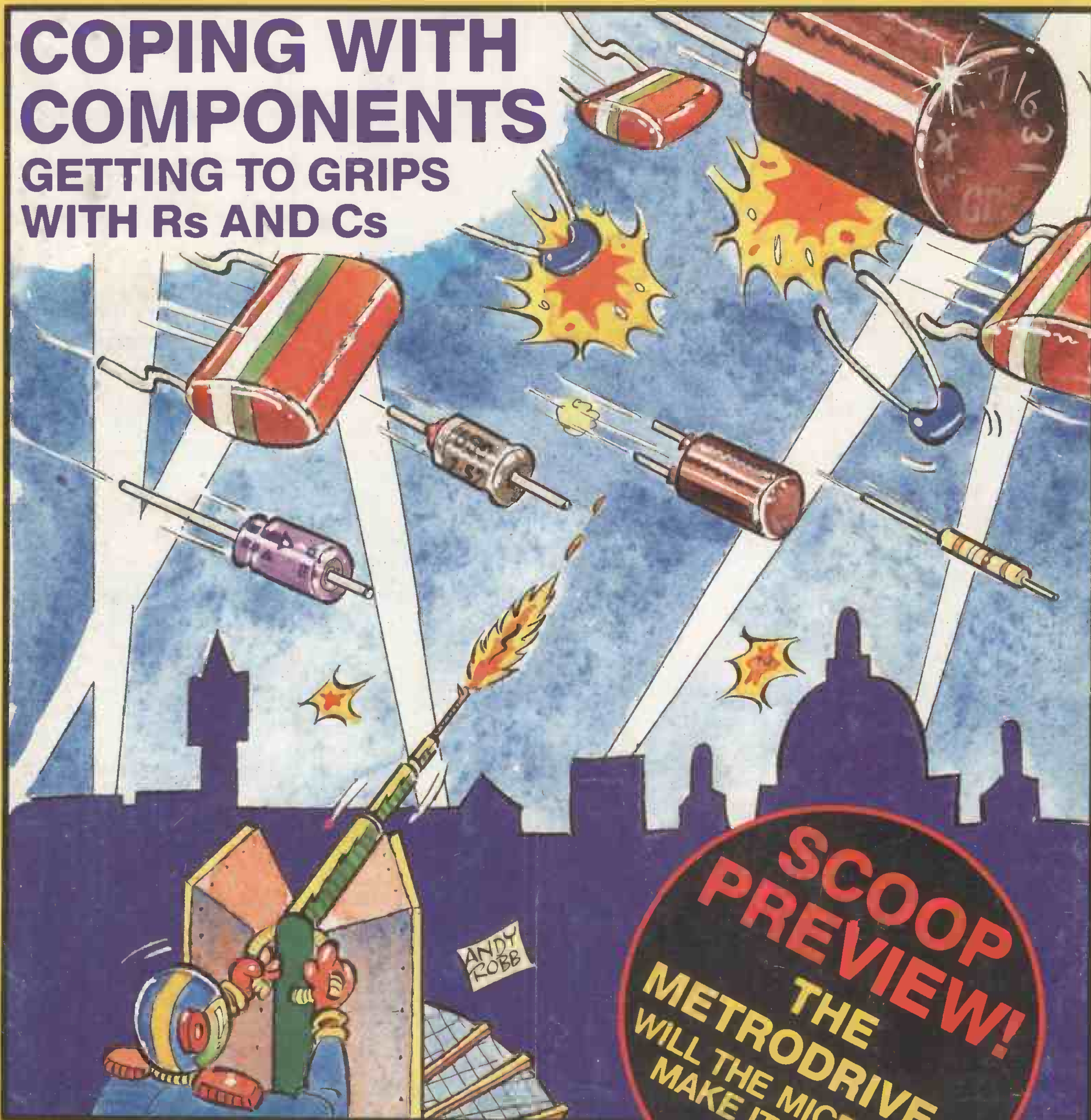
Hobby Electronics

Project Electronics For Everyone

90p

COPING WITH COMPONENTS

GETTING TO GRIPS WITH Rs AND Cs



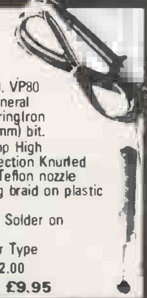
SCOOP PREVIEW!
THE METRODRIVE...
WILL THE MICROCAR MAKE ITS MARK?

Analogue test set to build

Time out: mains–switching timer project

BI-PAK BARGAINS

BI-PAK SOLDER – DESOLDER KIT



Kit comprises: ORDER NO. VP80
1 High Quality 25 watt General Purpose Lightweight Soldering Iron 240v mains incl 3/16" (4.7mm) bit.
1 Quality Desoldering Pump High Suction with automatic ejection Knurled anti-corrosive casing and Teflon nozzle
1.5 metres of De-Soldering braid on plastic dispenser
2 yds (1.83m) Resin Cored Solder on Card
1 Heat Shunt tool tweezer Type
Total Retail Value over £12.00
OUR SPECIAL KIT PRICE £9.95

BI-PAK PCB ETCHANT AND DRILL KIT

Complete PCB Kit comprises
1 Expo Mini Drill 10,000RPM 12v DC incl 3 collets & 3 × Twist Bits
1 Sheet PCB Transfers 210mm × 150mm
1 Etch Resist Pen
1 ½lb pack FERRIC CHLORIDE crystals
3 sheets copper clad board
2 sheets Fibreglass copper clad board
Full instructions for making your own PCB boards
Retail Value over £15.00
OUR BI-PAK SPECIAL KIT PRICE £9.95
ORDER NO. VP81

DIGITAL VOLT METER MODULE

3 × 7 segment displays Basic Circuit 0–2v ± instructions provided to extend voltage & current ranges Operating voltage 9/12v. Typ. Power Consumption 50mA

O/No. VP99 Once only price £9.95

SINGLE SIDED FIBREGLASS BOARD

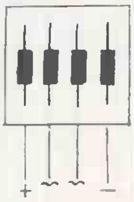
Order No	Pieces	Size	Sq. Ins	Price
FB1	4	9 × 2½"	100	£1.50
FB2	3	11 × 3"	100	£1.50
FB3	4	13 × 3"	156	£2.00

DOUBLE SIDED FIBREGLASS BOARD

FB4	2	14 × 4"	110	£2.00

SILICON BRIDGE RECTIFIERS

Comprising 4 × 1½ Amp rectifers mounted on PCB.
VRM – 150 vlts
IFM – 1.5 Amps



Size: 1 inch square
10 off £1.00
50 off £4.50
100 off £7.50

ORDER NO: 4R1 B Rect.

INTRUSION ALARM

The DOOR BIRD DB 2000 alerts you before your door is opened. Just hang on the inside door knob – alarm is activated as soon as the outside door knob is touched.
ONLY £3.95

OPTO 7–Segment Displays

Brand new 1st Quality
LITRONIX DL 707R 14-pin

Red 0.3" Common Anode Display 0-9 with right hand decimal point TTL compatible 5v DC Supply. Data supplied

IN PACKS OF		
	5 pieces £3	(60p each)
	10 pieces £5	(50p each)
	50 pieces £20	(40p each)
	100 pieces £35	(35p each)
	1,000 pieces £300	(30p each)

THE MORE YOU BUY – THE LESS YOU PAY

VALUE PACKS

Pak No.	Qty	Description	Price
VP1	300	Assorted Resistors Mixed Types	£1.00
VP2	300	Carbon Resistors ¼ ½ Watt Pre-Formed	£1.00
VP3	200		
VP4	150	¼ Watt Resistors 100 ohm-1M Mixed	£1.00
VP5	200	Assorted Capacitors All Types	£1.00
VP6	200	Ceramic Caps Miniature – Mixed	£1.00
VP7	100	Mixed Ceramics Disc. 1pf – 56pf	£1.00
VP8	100	Mixed Ceramic Disc. 68pf – .015pf	£1.00
VP9	100	Assorted Polyester/ Polystyrene Caps	£1.00
VP10	60	C280 Type Caps Metal Foil Mixed	£1.00
VP11	100	Electrolytics – All Sorts	£1.00
VP12	60	Bead Type Polystyrene Min Caps	£1.00
VP13	50	Silver Mica Caps Ass. 5.6pf – 150pf	£1.00
VP14	50	Silver Mica Caps Ass. 180pf – 4700pf	£1.00
VP15	50	High Voltage Disc. Ceramic 750v – 8Kv Mixed	£1.00
VP16	50	Wirewound Res. 9W (avg) Ass. 1 ohm – 12K	£1.00
VP17	50	Metres PVC Covered Single Strand Wire Mixed Colours	£1.00
VP18	30	Metres PVC Covered Multi Strand Wire Mixed Colours	£1.00
VP19	40	Metres PVC Single/ Multi Strand Hook-Up Wire Mixed	£1.00
VP20	6	Rocker Switches 5 Amp 240v	£1.00
VP21	20	Pcs. 1 – 2 & 4 mm Plugs & Sockets Matching Sizes	£1.00
VP22	200	Sq. Inches Total, Copper Clad Board Mixed Sizes	£1.00
VP23	20	Assorted Slider Pots. Mixed Values	£1.00
VP24	10	Slider Pots. 40 mm 22K 5 × Log. 5 × Lin	£1.00
VP25	10	Slider Pots. 40 mm 47K 5 × Log. 5 × Lin	£1.00
VP26	20	Small .125" Red LED'S	£1.00
VP27	20	Large .2" Red LED'S	£1.00
VP28	10	Rectangular .2" Green LED'S	£1.00
VP29	30	Ass. Zener Diodes 250mW – 2W Mixed Vlts. Coded	£1.00
VP30	10	Ass. 10W Zener Diodes Mixed Vlts. Coded	£1.00
VP31	10	5 Amp SCR's TO-66 50-400v Coded	£1.00
VP32	20	3 Amp SCR's TO-66 Up To 400v Uncoded	£1.00
VP33	200	Sil. Diodes Switching Like IN4148 DO-35	£1.00
VP34	200	Sil. Diodes Gen. Purpose Like OA200/ BAX13/ 16	£1.00
VP35	50	1 Amp IN4000 Series Sil. Diodes Uncoded All Good	£1.00
VP36	8	Bridge Rects. 4 × 1 Amp 4 × 2 Amp Mixed Vlts Coded	£1.00
VP37	8	Black Instrument Type Knobs With Pointer ¼" Std	£1.00
VP42	10	Black Heatsinks To Fit TO-3, TO-220 Ready Drilled	£1.00
VP43	4	Power-Fin Heatsinks 2 × TO-3 2 × TO-66 Size	£1.00

SEMICONDUCTORS FROM AROUND THE WORLD

100 A collection of Transistors, Diodes, Rectifiers & Bridges SCR's, Triacs, I.C.'s & Opto's all of which are current every-day useable devices.

Guaranteed Value Over £10 Normal Retail Price.

Data etc in every pack. Order No. VP56

Our Price £4.00

BI-PAK'S OPTO SPECIAL

A selection of large and small sized LED's in various shapes, sizes & colours, together with 7 Segment Displays both anode & cathode plus photo transistors emitters and detectors. Cadmium Cell ORP12 and Germ. photo transistor OCP71 included. In all a total of 25 Opto pieces valued over £12 Normal Price

Order No. VP57
Our Super Value Price Just £5.00

HYBRID LED COLOUR DISPLAYS

Red, Green, Yellow – .3/.5/.6 inch Mixed types and colours NUMERIC & OVER-FLOW Common Anode/Cathode. GaAsP/GaP. Brand New, Full Data incl.

10 pieces (our mix) ..£4.00
Normal Retail Value Over £10.00
Order No. VP58

TECASBOTY

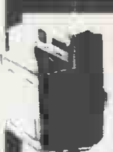
THE ELECTRONIC COMPONENTS AND SEMICONDUCTOR BARGAIN OF THE YEAR!

This collection of Components and Semiconductors for the hobbyist is probably the most value-packed selection ever offered, it consists of Resistors, carbon and wirewound of various values. Capacitors: All types, sorts and sizes including electrolitics. Potentiometers – single, dual, slider and preset. Switches, Fuses, Heatsinks, Wire, P.C.B. Board, Plugs, Sockets etc., PLUS a selection of Semiconductors for everyday use in popular Hobby Projects. These include: SCR's, Diodes, Rectifiers, Triacs & Bridges as well as a first class mix of Transistors and I.C.'s. In all, we estimate the value of this in current retail catalogues to be over £25! So, help yourself to a great surprise and order a Box TODAY for **just £6.50** ONLY at BI-PAK. Remember, stocks are limited so hurry! You can call us on 0920-3182/3412 and order with your Barclaycard or Access Card – 24hr Answerphone Service NOW. Order No. V.P. 85.

TRANSISTOR CLEARANCE

All Sorts Transistors. A mixed Bag NPN-PNP Silicon & Germ. Mainly Uncoded You To Sort Pack includes Instructions For Making Simple Transistor Tester. Super Value. Order No. VP60
100 **£1.00**

POWER SUPPLY OUR PRICE £3.25



Power supply fits directly into 13 amp socket Fused for safety. Polarity reversing socket. Voltage switch. Lead with multi plug Input – 240V AC 50HZ. Output – 3, 4, 5, 6, 7.5, 9 & 12V DC Rating – 300 ma MW88.

IC BARGAINS

VP40. 30 Assorted 74 Series TTL I.C.'s Gates, Flip-Flops & M.S.I.'s + Data Book. All New. Normal Retail Value Over £6.00. Our price £2.50

VP41. 30 Assorted CMOS I.C.'s CD4000 Series. Pack includes 00/09/12/14/18 /21/23/25/28/30/35/44/68 AY/TE Types Plus Data Sheet Value Over £8.00. Normal retail £2.50

YOU MAY ORDER any ONE TYPE of the above CMOS at £2.00 per 25 pieces ORDER AS VP41 + type number required.

MULTITESTERS

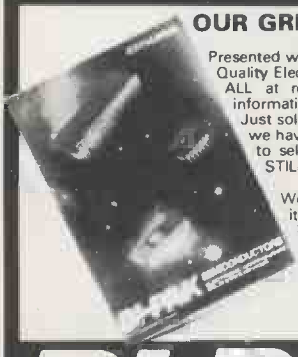
1,000 opv Including test leads & Battery
AC volts · 0-15-150-500-1,000
DC volts · 0-15-150-500-1,000
DC currents 0 1ma 150ma
Resistance · 0-2 5 K ohms 100 K ohms
Dims · 90 x 61 x 30mm

O/No.1322.OUR PRICE £6.50 ONLY

RATCHET SCREWDRIVER KIT

Comprises 2 standard screwdriver blades 5 & 7mm size. 2 cross point size 4 & 6. 1 Ratchet handle. 5-in-1 Kit. £1.45 each. O/No 329B

OUR GREAT NEW CATALOGUE



Presented with a Professional Approach and Appeal to ALL who require Quality Electronic Components, Semiconductors and other Accessories ALL at realistic prices. There are no wasted pages of useless information so often included in Catalogues published nowadays. Just solid facts i.e. price, description and individual features of what we have available. But remember, BI-PAK's policy has always been to sell quality components at competitive prices and THAT WE STILL DO.

We hold vast stocks "in stock" for fast immediate delivery, all items in our Catalogue are available ex stock. The Catalogue is designed for use with our 24 hours "ansaphone" service and the Visa/Access credit cards, which we accept over the telephone.

To receive your NEW 1983 BI-PAK Catalogue, send 75p PLUS 25p p&p to:-

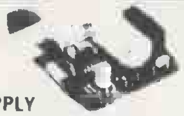
ELECTRONIC SIREN

12v DC

Red plastic case with adjustable fixing bracket. Emits high-pitched wailing note of varying pitch - 100 cycles per minute. Dims - 90mm (dia.) 60mm (depth). Power - 12v DC.

Our Price: £5.50

REGULATED VARIABLE *Stabilised* POWER SUPPLY



Variable from 2 30 volts and 0 2 Amps Kit includes
1 VPS30 Module 1 . 25 volt 2 amp transformer
1 0 50v 2" Panel Meter, 1 0 2 amp 2" Panel Meter,
1 470 ohm wirewound potentiometer, 1 4K7 ohm wirebound potentiometer Wiring Diagram included. Order No. VPS30 KIT **£20**

MINIATURE FM TRANSMITTER

Freq: 95-106MHz. Range: ¼ mile
Size: 45 × 20mm. Add: 9v batt.
Not licenced in U.K.
Ideal for: 007-MI5-FBI-CIA-KGB etc.
ONLY £5.50

BI-PAK

Send your orders to Dept **HE4** BI-PAK PO BOX 6 WARE, HERTS
SHOP AT 3 BALDOCK ST, WARE, HERTS
TERMS CASH WITH ORDER. SAME DAY DESPATCH. ACCESS BARCLAYCARD ALSO ACCEPTED. TEL (0920) 3182. GIRO 388 7006
ADD 15% VAT AND 75p PER ORDER POSTAGE AND PACKING

Use your credit card. Ring us on Ware 3182 NOW and get your order even faster. Goods normally sent 2nd Class Mail.
Remember you must add VAT at 15% to your order.
Total Postage add 75p per Total order.

Hobby Electronics

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Vol 6 No 4

PROJECTS

FEATURES

SPECIALS

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We are not normally able to deal with technical enquiries by 'phone, so please don't ring. Write to us with an SAE.

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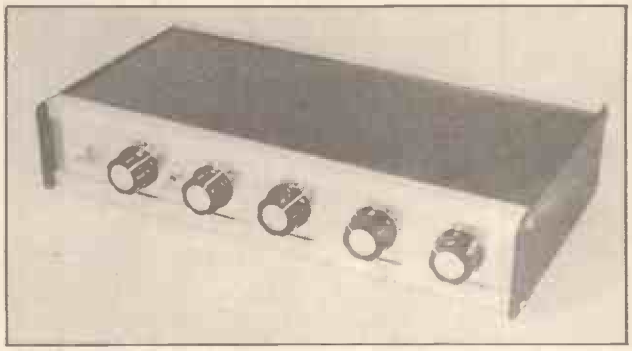

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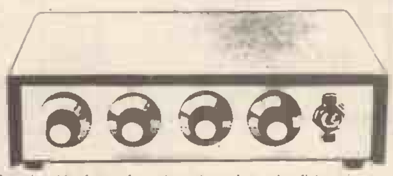
PREVIOUSLY ADVERTISED STILL AVAILABLE

Tape punch and reader	£22.50
Bench isolating transformer 250 watt	£7.75
BOAC in-flight stereo unit	£1.50
Drill assortment 4 each 25 sizes between .25mm & 2.5mm	£11.50
Battery condition tester, less box	£1.75
Nicad chargers, mains	£0.75
Flourescent Inventor 13 watt from 12v	£3.50
Ten digit stitch pad-pb phone etc.	£1.95
Uniselector 2 pole 25 way	£4.60
Water valve mains operated	£2.50
Counter 6 digit mains operated	£1.15
ditto 12v resettable	£3.45
Double glazing clear PVC sheet, 23½" wide-per running ft.	£0.15
Locking mechanism with 2 keys	£1.15
Magnetic Clutch	£4.50
Mouth operated suck or blow switch	£2.30
Solenoid with slug 8 - 12v battery op.	£1.82
ditto 230v mains	£2.30
Timer Omron STP NH 110v AC Coil	£6.90
Key switch with 2 keys dp mains	£1.75
Air valve mains operated	£3.75
Latching relay mains operated	£3.50
Dry film lubricant aerosol can	£0.65
Coin op switch, cased with coin tray	£4.60

8 POWERFUL MODEL MOTORS (all different)
for robots, meccanos, drills, remote control planes, boats, etc. £2.95.



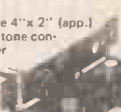
Complete kit of parts for a three channel sound to light unit controlling over 2000 watts of lighting. Use this at home if you wish but it is plenty rugged enough for disco work. The unit is housed in an attractive two tone metal case and has controls for each channel, and a master on/off. The audio input and output are by ¼" sockets and three panel mounting fuse holders provide thyristor protection. A four pin plug and socket facilitate ease of connecting lamps. Special price is £14.95 in kit form or £25.00 assembled and tested.

12 volt MOTOR BY SMITHS
Made for use in cars, etc. these are series wound and they become more powerful as load increases. Size 3½" long by 3" dia. They have a good length of ¼" spindle – Price £3.45.
Ditto, but double ended £4.25.
Ditto, but permanent magnet £3.75.

EXTRA POWERFUL 12v MOTOR
Probably develops up to ¼ h.p. so it could be used to power a go-kart or to drive a compressor, etc. £7.95 + £1.50 post.

THERMOSTAT ASSORTMENT
10 different thermostats. 7 bi-metal types and 3 liquid types. There are the current stats which will open the switch to protect devices against overload, short circuits, etc., or when fitted say in front of the element of a blow heater, the heat would trip the stat if the blower fuses; appliance stats, one for high temperatures, others adjustable over a range of temperatures which could include 0 – 100°C. There is also a thermostatic pod which can be immersed, an oven stat, a calibrated boiler stat, finally an ice stat which, fitted to our waterproof heater element, up in the loft could protect your pipes from freezing. Separately, these thermostats could cost around £15.00 - however, you can have the parcel for £2.50.

MINI MONO AMP on p.c.b., size 4"x 2" (app.)
Fitted volume control and a hole for a tone control should you require it. The amplifier has three transistors and we estimate the output to be 3W rms. More technical data will be included with the amp. Brand new, perfect condition, offered at the very low price of £1.15 each, or 10 for £10.00.



– BARGAIN OF THE YEAR –
The AMSTRAD Stereo Tuner.
This ready assembled unit is the ideal tuner for a music centre or an amplifier, it can also be quickly made into a personal stereo radio – easy to carry about and which will give you superb reception.

Other uses are as a "get you to sleep radio", you could even take it with you to use in the lounge when the rest of the family want to view programmes in which you are not interested. You can listen to some music instead.

Some of the features are: long wave band 1-15 – 270 KHz, medium wave band 525 – 1650KHz, FM band 87 – 108MHz, mono, stereo & AFC switchable, tuning meter to give you spot on stereo tuning, optional LED wave band indicator, fully assembled and fully aligned. Full wiring up data showing you how to connect to amplifier or head-phones and details of suitable FM aerial (note ferrite rod aerial is included for medium and long wave bands. All made up on very compact board.

Offered at a fraction of its cost: **only £6.00** + £1.50 post + insurance.

THIS MONTH'S SNIP

If you order 4 Amstrad Stereo Tuners, as described in bottom left-hand column, you can have them for £20.00 including post. Offer closes April 30th.

REVERSIBLE MOTOR with control gear Made by the famous Framco Company this robust motor is approx 7½" long, 3½" dia. 3/8" shaft. Very powerful, almost impossible to stop. Ideal for operating stage curtains, doors, ventilators, etc. Even garage doors if properly balanced. Offered complete with control gear as follows:
1 Framco motor with gear box
1 manual reversing & on/off switch
1 circuit diag. of connections
1 push to start switch
2 limit stop switches
ONLY £19.50 + postage £2.50.

FOR SOMEONE SPECIAL
Why not make your greeting card play a tune? It could play 'Happy Birthday', 'Merry Christmas', 'Wedding March', etc. or 'Home Sweet Home', etc. Wafer thin 3 part assemblies, for making cards musical. Mini microchip speaker and battery with switch that operates as the card is opened. Please state tune when ordering. Complete, ready to work £1.25.

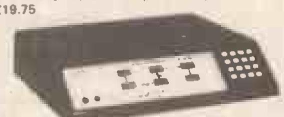
JOYSTICK
WHY PAY £10 OR MORE – Make yourself a Joystick – full details were given in Dec/Jan 'Sinclair Projects'. We will supply complete kit for £2.30. Although designed for the Spectrum or ZX81 it is equally suitable for any home computer.

TELEPHONE ITEMS

Plug and Wall socket – 4 pin or 5 pin	£3.45
Plugs only 4 pin or 5 pin	£1.15
Modern desk telephone	£7.50
Heavy black old type	£5.50
External bell unit	£6.50
Bell ringing power unit	£4.50
Pick up coil	£1.15

STABILISED POWER SUPPLY (Mains Input)
By LAMDA (USA) – Ideal for computer add-ons, d.c. output. Regulated for line volts and load current. Voltage regulation .1% with input variations up to 20% – load regulation 1% from no load to full load – or full load to no load. Complete in heavy duty case – Models available: 5v - 9A £23. 12v - 1.5A £13.25. 15v - 1.2A £13.25. 24v - 2A £23.

PRESTEL UNIT – brand new and complete except for 7 plug in IC's – Price: £19.75 + £2.00 p&p.
Note: British Telecom may not connect this equipment as there is no manufacturer to guarantee it, however it is well worth buying for its immense breakdown value – sold originally at over £150.



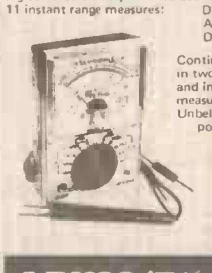
25A ELECTRICAL PROGRAMMER
Learn in your sleep: Have radio playing and kettle boiling as you wake – switch on lights to ward off intruders – have a warm house to come home to. You can do all these and more. By a famous maker with 25 amp on/off switch. Independent 60 minute memory jogger. A beautiful unit at £2.50.

FROZEN PIPES. Can be avoided by winding our heating cable around them – 15 mtrs connected to mains costs only about 10p per week to run. Hundreds of other uses as it is waterproof and very flexible. Resistance 60 ohms/metre. Price 28p/metre or 15m for £3.95

24 HOUR TIME SWITCH – Made for control of Randall Central Heating Boilers these give 2 on/offs per 24 hrs. Equally suitable for control of immersion heaters of heating systems. £4.60.

50 THINGS YOU CAN MAKE
Things you can make include Multi range meter, Low ohms tester, A.C. amps meter, Alarm clock, Soldering iron minder, Two way telephone, Memory jogger, Live line tester, Continuity checker, etc. etc., and you will still have hundreds of parts for future projects. Our 10Kg parcel contains not less than 1,000 items - panel meters, timers, thermal trips, relays, switches, motors, drills, taps, and dies, tools, thermostats, coils, condensers, resistors, neons, earphone/microphones, nicad charger, power unit, multi-turn pots and notes on the 50 projects.
YOURS FOR ONLY £11.50 plus £3.00 post.

MINI-MULTI TESTER Deluxe pocket size precision moving coil instrument, Jewelled bearings - 2000 o.p.v. mirrored scale.
11 instant range measures: DC volts 10, 50, 250, 1000. AC volts 10, 50, 250, 1000. DC amps 0 – 100 mA.



Continuity and resistance 0 - 1 meg ohms in two ranges. Complete with test prods and instruction book showing how to measure capacity and inductance as well. Unbelievable value at only £6.75 + 60p post and insurance.

FREE Amps range kit to enable you to read DC current from 0 - 10 amps, directly on the 0 - 10 scale. It's free if you purchase quickly, but if you already own a Mini-Tester and would like one, send £2.50.

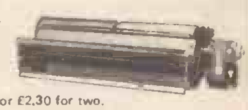
J. BULL (Electrical) Ltd.
(Dept. EE), 34 - 36 AMERICA LANE, HAYWARDS HEATH, SUSSEX RH16 3QU. Established 30 YEARS

MAIL ORDER TERMS: Cash, P.O. or cheque with order. Orders under £12 add 60p service charge. Monthly account orders accepted from schools and public companies. Access & B/card orders accepted day or night. Haywards Heath (0444) 454563. Bulk orders: phone for quote. Shop open 9.00 – 5.30, mon to Fri, not Saturday.

STORE CLOSING SALE
All stocks must go from one of our big warehouses. 10,000,000 items, everything from AERIALS to ZENER will be cleared at fantastically low prices - if you are a manufacturer you can save yourself a fortune - send for our Sale List, not for small buyers as minimum order £100.

EXTRACTOR FANS – MAINS OPERATED
Woods extractor.
5" – £5.75, Post £1.25.
6" – £6.95, Post £1.25.
5" Plannair extractor £6.50. Post £1.25.
4"x 4" Muffin 115v. £4.50. Post 75p.
4"x 4" Muffin 230v. £5.75. Post 75p.
All the above ex-computer, those below are unused.
4" x 4" £8.50. Post 75p.
9" American made £11.50. post £2.00.
Tangential Blower 10x3 air outlet, dual speed £4.60. Post £1.50.

TANGENTIAL BLOW HEATER
by British Solartron, as used in best blow heaters. 2Kw approx 9" wide £5.95, 3Kw either 9" or 12" wide (your choice) £6.95 complete with 'cold' 'half' and 'full' heat switch, safety cut out and connection dia. Please add post £1.50 for 1 or £2.30 for two.



2.5 Kw KIT Still available: £4.95 + £1.50 post.

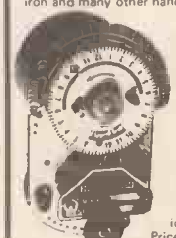
MINIATURE WAFER SWITCHES
2 pole, 2 way – 4 pole, 2 way – 3 pole, 3 way – 4 pole, 3 way – 2 pole, 4 way – 3 pole, 4 way – 2 pole, 6 way – 1 pole, 12 way.
All at 25p each or 10 for £2.00

BLEEP TONE These work off 12v and have an unusual and pleasant bleep 69p each.

CONNECTING WIRE PACK 48 lengths of connecting wire, each 1 metre long and differently colour coded, a must for those difficult interconnecting jobs. 85p the lot.

RED LEDS 10 for 69p. 100 for £5.75. 1000 for £52.

IN LINE SIMMERSTAT Ideal heat controller for soldering iron and many other hand-held appliances. £2.30. 10 for £17.25.



VENNER TIME SWITCH
Mains operated with 20 amp switch, one on and one off per 24 hrs. repeats daily automatically correcting for the lengthening or shortening day. An expensive time switch but you can have it for only £2.95. These are without case but we can supply a plastic case - £1.75 or metal case - £2.95. Also available is adaptor kit to convert this into a normal 24 hr. time switch but with the added advantage of up to 12 on/offs per 24 hrs. This makes an ideal controller for the immersion heater. Price of adaptor kit is £2.30.

IONISER KIT
Refresh your home, office, shop, work room, etc. with a negative ION generator. Makes you feel better and work harder – a complete mains operated kit, case included.
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Radio stethoscope – fault finding aid	£4.80
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Drill control kit	£3.95
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Interrupted beam kit	£2.50
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Radio Mike	£6.90
FM receiver kit – for surveillance or normal FM	£3.50
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Microvolt multiplier – measure very low currents with ordinary multitester	£3.95
Pure Sine Wave Generator	£5.75
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NEW an exciting range of projects to build on the EXP300 breadboards.
NOW anybody can build electronic projects using "Electronics-by-numbers", its as "Easy as A, B, C with G.S.C!"

FREE project

MUSICAL DOORBELL OF THE 3RD KIND

You've seen the film, now haunt your visitors with the tune!
Each time the doorbell is pushed the eerie tune plays out, then switches off to conserve battery power.

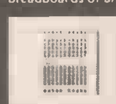
HOW DO YOU MAKE IT.

Our FREE project gives you clear "step-by-step" instructions. For example "take Resistor No.1 and plug it into hole numbers B45 and B47".
"Take IC No.1 and plug it into hole numbers E35 to E42 and F35 to F42, (pin 1 on the IC goes into F35)"
"Take. . ."Well! why not "clip-the-coupon" and get your FREE step-by-step instruction sheet and your FREE 12 projects with each EXP300 bought and your FREE catalogue and. . . . .

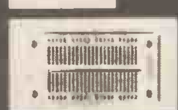
EXPERIMENTOR BREADBOARDS

The largest range of breadboards from GSC.
Each hole is identified by a letter/number system
EACH NICKEL SILVER CONTACT CARRIES A LIFE TIME GUARANTEE.

All modular construction means that any Experimentor breadboard can be 'snap locked' together to build breadboards of any size.



EXP325
The 'one-chip' breadboard
Takes 8, 14, 16 and up to 22 pin IC's
Has 130 contact points including 2 bus bars.



EXP350
The 'beginners-breadboard'
For limited period you can have FREE 12 'Electronics by Numbers' PROJECTS

EXP300

The most 'widely-bought' breadboard
Don't miss out on our 'NEW AND FREE' projects
They can be built on the EXP300

EXP600
The Hobbyist microprocessor' board

EXP650
The 'one-chip microprocessor' board

EXP4B
'Snaps on" four extra bus bars

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The ultimate breadboard kit

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Exp 350	£4·83	
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MONITOR

Maplin Catalogue

The 1984 edition of "The Maplin Buyer's Guide To Electronic Components And Home Computers" is now available. The annual Maplin catalogue features this year nearly 500 pages. This reflects the ever expanding range of products supplied.

A major feature of the new catalogue is the recently introduced range of fully documented kits and educational course from the world's most famous name in electronics kits, **Heathkit**. The kits range from security alarms, digital clocks, personal weather stations and micro programming courses to the user friendly robot "Hero I". Other kits included in the 1984 Maplin catalogue is the "Matinee Organ" which offers scope for reproducing such sounds as flute, cello, or clarinet in a variety of tempos including waltz, slow rock or Bossa Nova.

The 37 pages of book listings and 60 pages of computer products reflect the ever increasing growth in these areas. On special offer is a comprehensive range of Atari micro software. Unlike previous editions, the 1984 Maplin Catalogue lists prices alongside the products on each page. Prices are guaranteed to at least February 1984 when a new price change leaflet will be issued. Maplin are a major supplier of electronic components and leading distributor of home and hobby computer products. The catalogue is £1.35 (£1.65 to include p&p), available from **Maplin, Rayleigh and Maplin** stores in Birmingham, Hammersmith, London, Manchester, Southampton and Southend or branches of **W. H. Smith**.

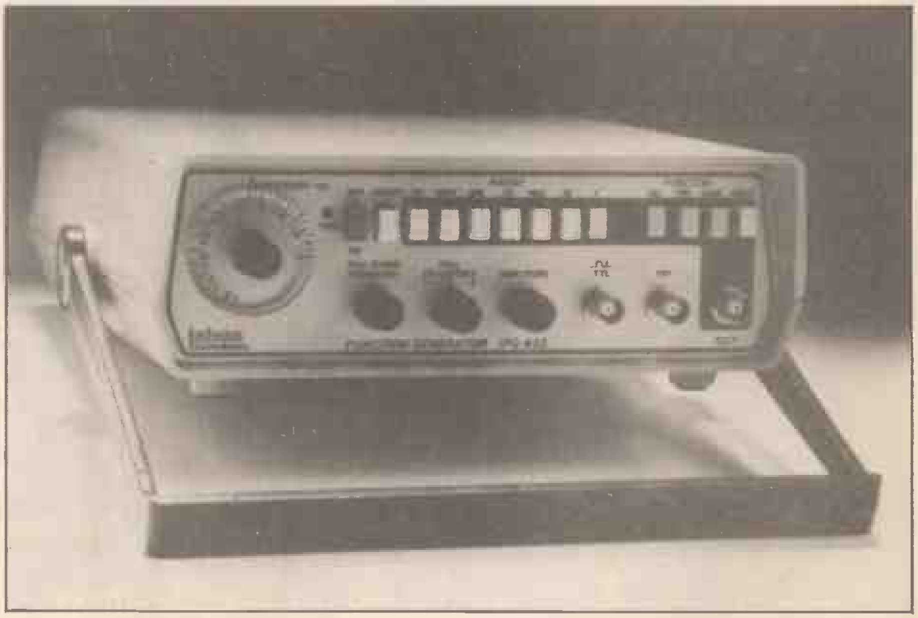
Probing The Values

House Of Instruments are supplying two new **logic probes** from **Trio**: the DP-71 for TTL, and CMOS up to 50MHz, and the DP-70 for TTL up to 30MHz.

These probes are sensitive to input frequencies up to 50MHz and pulse widths down to 20ns — achieved, say hi!, by the very short ground leads used. The logic state of the circuits under test is indicated by three LEDs, one for logic high (1), one for logic low (0) and one for a continuous pulse. With the probe in Memory mode, single pulses of as little as 20ns, via leading or trailing edges, can be detected.

The probes' inputs are protected up to ±100VDC continuous, and ±250VDC or 175VRMS up to 15s. The DP-70 has a 50kR input impedance and operates from internal batteries, while the DP-71 has a 1MR impedance and may be powered from a 4V5-to-19VDC source. The DP-70 costs £24 and the DP71 costs £49, but both prices are exclusive of carriage and VAT.

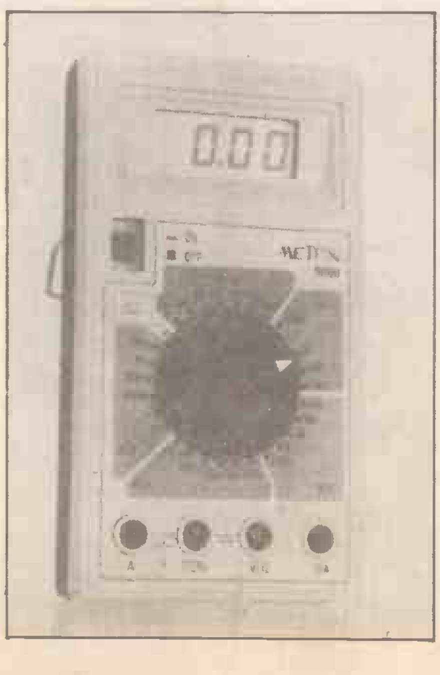
Hi! and their distributors claim that the Metex type 3000 hand held DMM is probably the 'best value for money' of its kind at £29.50 (ex VAT but inclusive of carriage). The 3000 has thirty ranges to



1000V, 10A, 20MR, diode test and zero check. The measurement systems incorporate CMOS circuitry with a dual slope integration A/D converter system: Zeroing, over-range, polarity and low battery are catered for automatically. Normal overload protection and high voltage surge are provided.

The units have a ½in LCD, measure 88 x 102 x 36mm, weigh about 340 gms, run from a 9V battery and come with test leads, battery, spare fuse, carrying case and operation manual.

The IFG **function generator**, costing £195 (ex VAT and carriage) gives sine, square, triangle, ramp and pulse waveforms over 0Hz1 to 2MHz in seven decade ranges. Output is continuously variable to 20V peak to peak from and into 50R with switchable DC offset to ±10V. Main, square and TTL outputs meet the requirements of digital



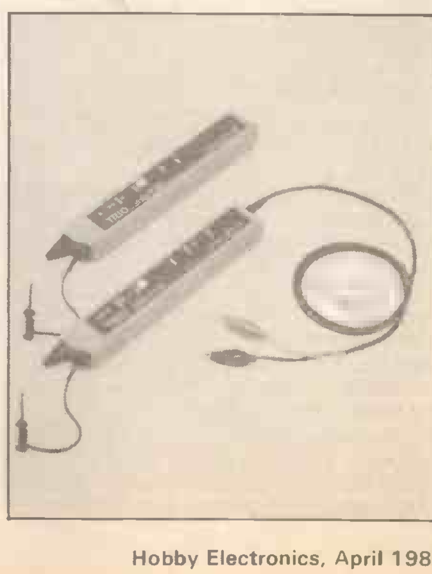
circuitry. The unit measures 233 x 80 x 300mm and weighs about 1.5kg and is fully guaranteed for one year.

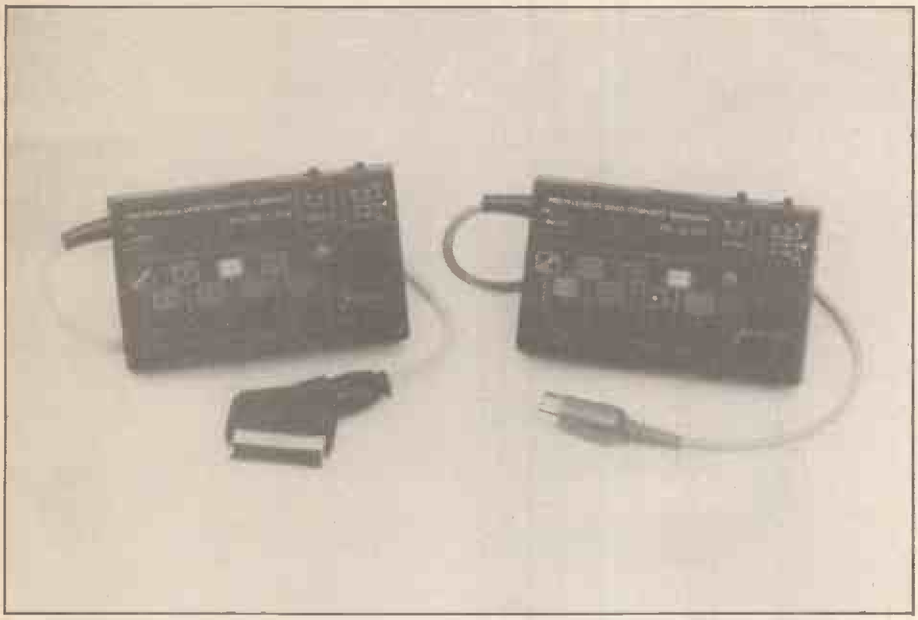
For further information and leaflets contact **House Of Instruments, Clifton Chambers, 62 High St., Saffron Walden, Essex CB10 1EE. Tel: (0799) 24922.**

O Solent Mio

Solent Component Supplies have issued a new catalogue detailing their range mostly of tools, test equipment, connectors, switches, lamps and LEDs and buzzers, with other construction accessories. Manufacturers and distributors include Ambit International, Bulgin (who own both Ambit and Solent), Roxburgh, Cooper Tools (Weller and Xcelite) and others.

Enquire **Solent Component Supplies, 53 Burrfields Rd., Portsmouth, Hants PO3 5EB. Tel: (0705) 669021).**





Volunteer Wanted

We have had this request for "semi-voluntary" help by a charitable organisation which hopes to generate more work for unemployed persons. If you are interested, check out the exact requirements and terms with the ITDG.

The **Intermediate Technology Development Group**, the Charity founded by E. F. Schumacher, author of "Small is Beautiful", is seeking the help of a creative person whose personal interests closely conform to the subject material of this magazine.

Ideally, they are seeking someone with the skills and facilities required for the construction of the self build articles who is willing to spend a few hours each week researching through back numbers. Later they will require several models to be constructed at low cost for demonstration purposes.

It would be helpful, though not essential, for such a person to be located within easy access of Waterloo Station in London.

Please reply to **Mr. R. Padgett, Head of ITDG UK Unit, 6 Avonmouth Street London SE1 6NX.**

Videotester

A video pattern generator by **Sadelta** is available from **House Of Instruments** at £117 plus VAT and carriage. The VC11 series are hand held and battery operated for field or workshop servicing of composite video monitors and standard TVs, colour or black and white. The units are available for several PAL and SECAM standards, and provide eight patterns for screen adjustments, plus audio, including stereo, testing facilities. The composite video output is 1V peak to peak with the audio output at 10 mV. Six pin DIN and 21 pin PERITV outputs are standard for **PAL** and SECAM respectively, but a free optional BNC connector is available.

The units come with rechargeable NiCads, battery charger/mains adaptor, and connecting cable, as well as the carrying case. Dimensions are 131 x 81 x 23mm and weight is about 270gms. Hi! carry a range of Sadelta TV and video test equipment.

For information contact **House Of Instruments, Clifton Chambers, 62 High St., Saffron Walden, Essex CB10 1EE. Tel: (0799) 24922.**

The Key To Learning . . .

Micro manufacturers are turning to the field of education in a big way. **Star Microterminals** are marketing their Concept keyboard as an aid to making educational computing easier for young pupils to grasp, and to provide a simplified introduction to using a computer.

The keyboard is designed to hold a variety of A4 overlays which redefine

the keys according to the appropriate use. The 'keys' thus achieved are large and clear enough for very young or even visually or physically handicapped pupils (imagine someone with impaired movement or eyesight trying to operate the keyboards on one or two of our favourite micros . . .); the keyboard itself comprises an 8 x 16 unit matrix of touch-sensitive areas, each producing a seven bit ASCII code which the programmer can define as required. Also provided are a bleeper, and two extra user-dedicated touch pads. Full documentation, a universal connecting lead ('for the majority of micros') and demonstration software is provided.

For prices and information contact **Star Microterminals Ltd., 22 Hyde St., Winchester, Hants. Tel: (0962) 51422.**

Micro-Robotics And Mice

The **1984 Micro-Robotics Conference** is to be held at Central Hall, Westminster, on 21 April. The venue is in conjunction with the Association of London Computer Clubs' Easter Fair, and many of the stands will have a Robotics flavour.

Subjects planned for the Conference range from hobby interests to commercial applications, with talks and demonstrations by representatives of some of the leading manufacturers. The Micromouse maze will be featured, and a "friendly" competition has been arranged. Novice constructors are encouraged to see how their mice perform against the old hands. The Robot Arena will also be there, with demonstrations and advice for home constructors.

This is the second such Conference held by the ACC, and promises to be even more of a success than the original in 1981.

Enquiries to **R. E. Moyle, 69 Uplands Court, Greenview Av., Shirley, Surrey CR0 7QW.**

Hobby Herald

Bicc-Vero Electronics have issued their 1984 "Hobby Herald" **catalogue** of connectors, enclosures, etching kits, tools, etc., including their famous Veroboards. The catalogue costs 50p. According to our survey in HE February '84, Bicc-Vero now operate a £25 minimum order, so this is not the place for one-off mail order items. They do however have local stockists and will advise on whereabouts. The catalogue we have doesn't contain any prices or ordering information, but the phone number below is advertised for enquiries.

Contact the **Retail Department, Bicc-Vero Electronics Ltd., Industrial Estate, Chandlers Ford, Hants SO5 3ZR. Tel: (04215) 62829.**

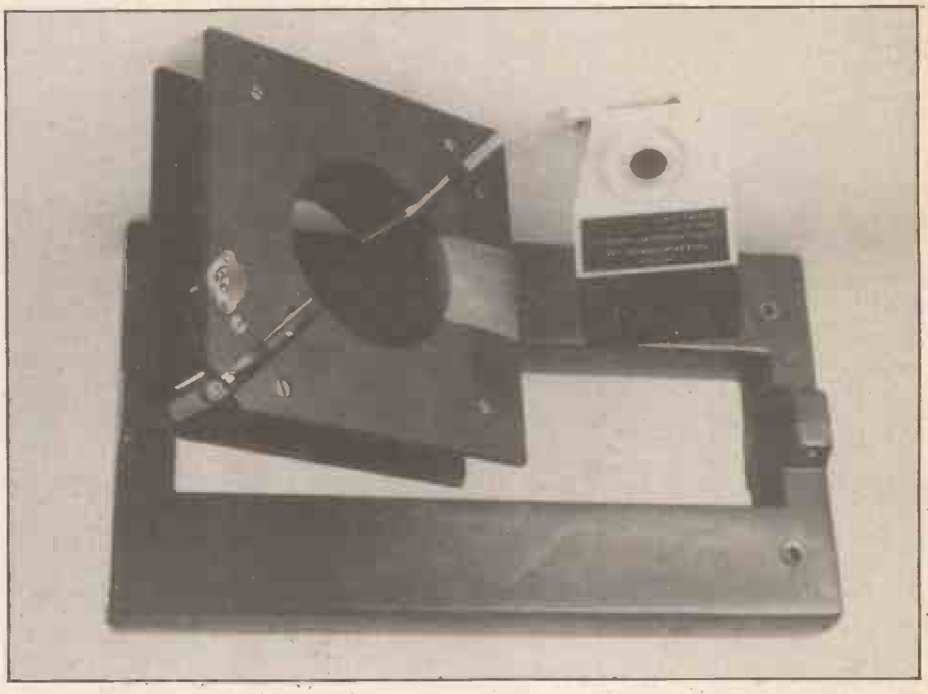
MONITOR

Around The Hall

HEME International, who specialise in Hall Effect technology for contactless RMS measurement, have available transducers using the Hall Effect. Types available suit current ranges from 10A to 10kA, with a variety of analogue output signals (eg. 4 to 20mA) with a frequency range in DC to 12kHz. True RMS or true average measurements can be provided.

HEME claim that in certain cases the accuracy obtained using their transducers is considerably greater than with current transformers or shunts.

Enquiries to **HEME International Ltd., Whelmar House, Southway, Skelmersdale, Lance WN8 6NN. Tel: (0695) 20535.** HEME would also like to hear of people's requirements in this respect so that they can provide the most suitable range.



Optocoupler Source

The full range of 4N series of industry-standard optically coupled isolators is available ex-stock from **Isocom Ltd.**, the Hartlepool-based UK specialist opto-coupler manufacturer. The series, from 4N25 to 4N37, includes a wide range of isolation voltages, up to ±2500V and DC current transfer ratios, from 10% for the 4N27/28 up to 500% for the 4N32/33. All models are single channel, 6-pin DIL types, except the 4N29, 30, 31, 32 and 33, which utilise an NPN photodarlington output circuit for higher current gain. Operating temperatures range from −55 to +100 degrees C, with overall power consumption of 250mW.

This series is just one of a very wide range of opto-couplers available from Isocom Ltd., which also offers a full custom service on opto-couplers, covering all major parameters and packaging styles. With the benefit of a sophisticated IC ATE system, Isocom can select on virtually any parameter, including current transfer ratio, isolation voltage, switching speed and leakage current. If the coupler is capable of performing the necessary task, then Isocom can select to that specification.

For further information please contact, **Customer Service, Isocom Ltd., Titan House, Park Road, Hartlepool, Cleveland TS26 9HL. Tel: (0429) 221431.**

Astro Winners

Toolmail have contacted us with the results of their Astro Tracker Computer Competition, held at Breadboard '83.

Of the three days, Friday's winner was Alan Thirlwall from March, Cambs, with a score of 10805, Saturday's winner was G. Cook from Edmonton, London, with 10915, and Sunday's winner was Robin Northway of Dulwich, London, with 13990. Practising all weekend, eh?

Computer Syntax

Sinclair Research have been collaborating with **Macmillan Education** one of the world's leading educational publishers, to produce educational software for children between 5 and 12 years. Initially, there is a five-program series on learning to read, based on a Macmillan primary school reading course already in use, and a four-program series called 'Science Horizons'.

The reading course is for very young children, starting with letter recognition and working up to 'positional language' such as 'inside' and 'in front of'. The teaching is done through games and with animal characters, and uses a reward system so that the children can see their achievements mounting up. (We aren't told what the hi-score is . . .).

The four science programs, *Glider, Survival, Magnets* and *Cargo*, teach scientific principles and the manipulation of various factors to achieve certain aims (like keeping the glider in flight). The programs are £9.95 (inc. VAT) each. Schools can get the programs from their normal suppliers or direct from **Macmillan Education, Houndsmill, Basingstoke, Hants RG21 2XS.** Otherwise, obtain the programs from the usual dealers or direct from Sinclair Research.

Sinclair have launched six spelling and punctuation programs by **Blackboard Software** to teach basic writing skills, using moving graphics with the intention of capturing the child's imagination and attention more effectively. The programs include step-by-step exercises, with the possibility of vocabulary changes to allow for individual progress, followed by a game section to keep the pupil amused and provide additional practice and instruction.

In the *Early Punctuation, Speech Marks* and *The Apostrophe,* animated figures drop punctuation into place where the user tells them to — rather like space invaders with commas. Three other programs on capital letters, spelling and the alphabet also use games to give the pupil practice in the principles they teach. These programs are aimed at 5 to 12 year olds, require a 48K Spectrum and cost £7.95 inc. VAT from Sinclair Research and major software dealers.

Perhaps Blackboard could do the national language a service by developing *The Apostrophe* into a major TV serial to be broadcast on ITV on Saturday nights in sixteen parts. I would'nt choo'se to exci'se the much-abuse'd blip's but it make's my brain's ache when I see how otherwi'se approve'd writer's misu'se the mi'serable little thing's's' (Thats' enough — 'Ed.).

For older persons, a microcomputer version of the advanced logic programming language PROLOG, developed for Sinclair by **Logic Programming Associates**, is available for the Spectrum under the name micro-PROLOG.

PROLOG, a language used by the Japanese for artificial intelligence machines, has not been adapted for micros before. It uses simple 'English' phrases for dialogue between the user and the computer, using what Sinclair call "familiar concepts and ideas" rather than "sequences of instructions to the computer". As I couldn't work out what this meant, I obtained some expert assistance to explain it to me. They eventually concluded that it was a non-information-containing method of imparting that this is a teaching language, intended to help people grasp the methods used by actual programm-

ing languages to instruct the computer. Until I have a more concrete sample I'll suspend judgement. The program, complete with user manual and primer, is £24.95 (inc. VAT), and a separate manual for advanced for advanced users will become available.

Enquiries and mail orders to **Sinclair Research Ltd., Stanhope Rd., Camberley, Surrey GU15 3BR.** Tel: **(0276) 685311.**

Sound Boost

Zeal Marketing have designed and are producing a **sound booster** for the Sinclair Spectrum computer. The unit comes complete with leads and a load-save facility which obviates the need for constant plugging and unplugging. A hefty 3in loudspeaker is incorporated, and a volume control for the sound input. The device requires no batteries and all connections to the computer are made externally thus ensuring no invalidation of any guarantee.

At £14.99, the unit is available direct from the company. Full details are available to readers on request. Contact **Zeal Marketing Ltd., Vanguard Trading Estate, Storforth Lane, Chesterfield S40 2TZ. Tel: (0246) 208555.**

Cap This

The CM200 from **Thurlby Electronics** is a **Digital Capacitance Meter** which has a maximum delay between connecting a capacitor and getting the first valid reading of less than half a second.

The CM200 has a 4½ digit liquid crystal display with a maxiumum reading in excess of 25,000 counts. It measures capacitance between 1pF and 2,500uF to an accuracy of 0.2 %.

Very low power consumption enables the CM200 to operate for several hundred hours from batteries. Alternatively it can be operated from the AC line adaptor supplied with it. The CM200 is housed in a rugged bench/portable case with built-in tilt stand and is lightweight and fully portable for field use.

A special input socket arrangement allows for the direct connection of a wide variety of capacitors, or for the connection of standard test leads. A zero calibration control enables the user to null out up to 25pF of test lead capacitance.

The CM200 is designed and built in Britain and costs £89 plus VAT. Details from **Thurlby Electronics Ltd., New Road, St Ives, Cambs. Tel: (0480) 63570.**

Getting Bigger

Basicare Microsystems' Basicare Modular Expansion System is designed to increase the 'real world' capabilities of the Commodore 64 (it is also available for the ZX81 and Spectrum).

The basic unit of the system is a plug-in **expansion interface**, called the C64 Persona, which marries up with a series of control, memory expansion and other modules, according to requirements.

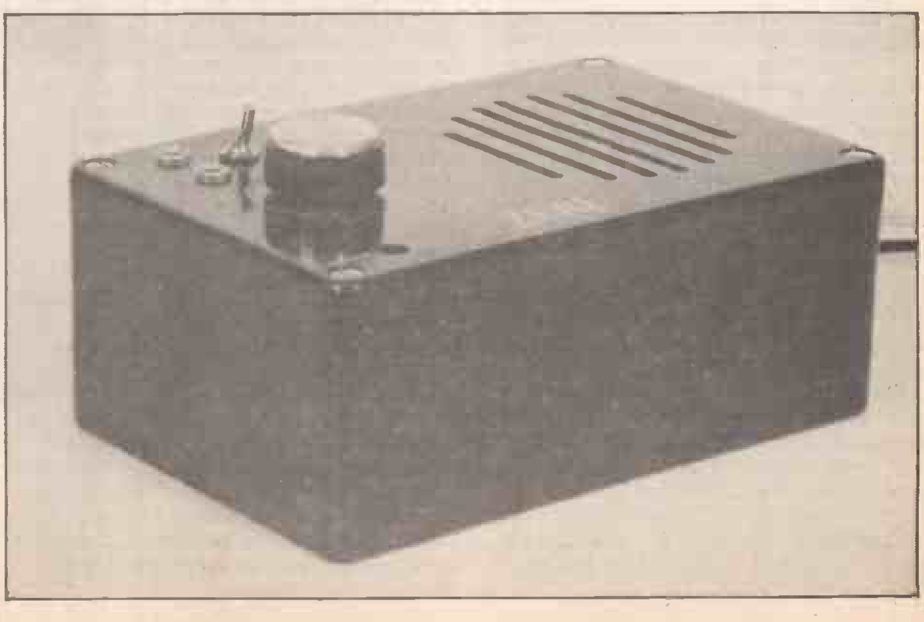
The C64 Persona plugs into the expansion port, and has four ROM cartridge slots, soft switched to provide immediate access to user software. There is 8K of additional software in ROM, with some additional functions, including extensions to Commodore BASIC, a machine code assembler, a sound chip controller, and easier use of the Commodore's hi-res graphics.

Expansion modules available from Basicare include memory expansion up to a theoretical 1Mbyte, a Minimap module which can address blocks of memory in 8K sections, to analogue to digital converter called Link, and a real time clock module, as well as a series of control modules under the name of Pericon. The Basicare modules can also be used with the ZX computers for which Personas are available.

Enquiries to **Basicare Microsystems, 12 Ricketts St., London SW6 1RU. Tel: 01 385 2135.**

Charity Radio

The **QTI Talking Newspaper** for blind and partially sighted radio amateurs has been granted full charity status by the Charity Commission, no. 326454. Enquiries, donations etc. to **Mr. J. Feeley G4MRB, Chairman, 79 Narrow Lane, North Anston, Sheffield S31 7BJ. Tel: (0909) 566301** between 10 am and 4 pm, Monday to Thursday.



BIBs Keep You Clean

Bib Audio/Video Products Limited have announced the introduction of their new VHS VCR head cleaner, which may be used wet or dry. Bib claim that this cleaner is the safest and easiest to use cleaner yet devised. They have designed this cleaner to make VCR head cleaning as simple as possible and have eliminated the need for replacement belts, fluids and other parts that are sometimes associated with these types of cleaners.

Developed in the Bib Laboratories over the last two years, this cleaner has many special features, the most important being the type of non-abrasive cleaning tape, which is special spun bonded polyester, made to Bib's own specification, which is also friction-free, with excellent cleaning properties.

Bib recommend preventative video maintenance as the key to good quality pictures. VCR heads should be cleaned regularly after 40 to 50 hours playing time, as oxide particles and dust accumulate. These stick to tape heads, drum and guides and other parts causing "snow" in the picture, poor tape handling and even tape damage.

Packed in a descriptive carton, this new cleaner has a recommended retail price of £9.98 including VAT. Enquiries to your local retailers, or **Bib Audio/Video Products Ltd., Kelsey House, Wood Lane End, Hemel Hempstead HP2 4RQ.**

Women Lose Out In Computer Race, Acorn Research Reveals

Women are seriously falling behind in the race to computer literacy, according to research being carried out amongst educationalists by Acorn Computers, makers of the BBC Micro and Electron home microcomputer.

Teacher's fears that "girls could jeapardise their job prospects if they don't learn about the micro" are backed up by figures from the latest AGB (Audits of Great Britain) 'Home Audit' survey, which reveals that of all households owning microcomputers, boys are thirteen times more likely than girls to be using them. Moreover, only 4% of micros are used by their mothers.

Acorn's research consisted of interviews with teachers and computer education specialists in primary and secondary schools, education authorities and computer camps around the country.

According to Chris Curry, Joint Managing Director of Acorn, the crux of the problem rests with the use of micros in the home. "Many teachers in our survey pointed out how many more boys out how many more boys than girls use micros at home. This has two effects. First, boys get ahead of girls in computer studies. Indeed, the evidence shows that for young teenagers, boys are probably spending more time on computer studies at home than they are at school. Second, as the boys race ahead, the girls lose both interest and confidence — a situation aggravated by the relatively small number of machines so far in schools."

Acorn believe the consequences of this sex bias in computing are serious. Says Chris Curry: "Britain is in danger of losing half its talent if girls don't acquire vital computer skills. It is clear that much of the problem is due to parents giving home computers to their sons rather than to their daughters. This leg-up for boys means that girls are neither able to compete with their more knowledgeable brothers in school, nor in the ever fewer jobs outside".

He continues: "We are attempting to do something about this problem by aiming our products as much at women as at men. For instance, for the new Electron home micro, we are developing software that is more relevant and more useful to women, to encourage them to take the micro more seriously.

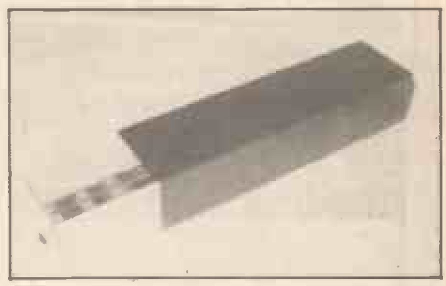
"We have already produced a gardening program for the BBC Micro called 'The Magic Garden' based on the Shirley Conran book. By getting the parents interested, we hope girls of school age will be encouraged not to fall behind in computer studies. Ironically all the evidence from our research shows that girls are just as able as boys in using computers. What they need is more encouragement, and more help. And that task will have to rest with the parents, and the way they use the home micro."

At least Acorn's researchers don't provide ammunition for the school of thought which says (to paraphrase an industrialist a few months ago) that "girls don't like computers because they don't come in pretty colours."

Both attitudes overlook the fact that most kids learn about computers not for any practical purpose but, for the (more or less) creative fun of playing games (or writing games) on them. Adults and children alike tend to do what their friends do in their leisure hours, and girls still suffer from the adult attitude that little boys like machinery and little girls don't; by the time they are teenagers, years of gentle non-encouragement to achieve practical results will have put a lot of females off wasting further time playing around for no purpose.

Not a few of those girls will end up as computer operators, or word processor operators, but the chances are they won't end up as programmers, or even understanding and enjoying their computer work as much as the males, who have had more enjoyment and kudos out of computers.

Likewise, I don't expect very many women about the home will be using computers until someone demonstrates that the computer can do the required job more easily and efficiently than a pencil and paper. That's the challenge facing Acorn and other micro makers.



EPROM Erasers

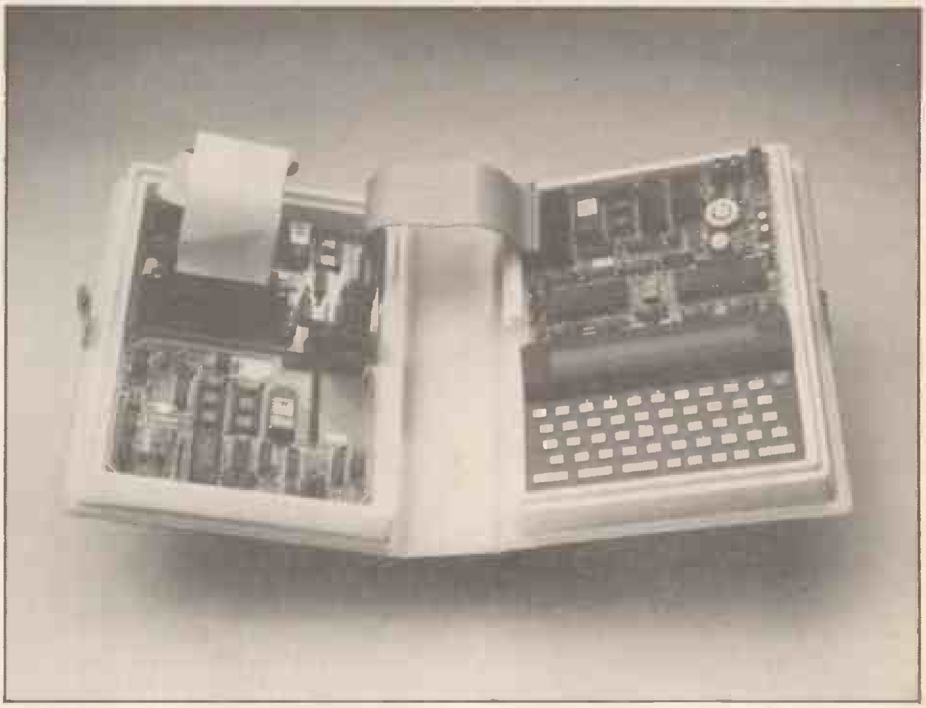
Three new low cost EPROM erasers have been specifically designed for use in the laboratory, classroom and by the hobbyist. All three versions use the same simple drawer construction which allows easy access. The anodised aluminium unit measuring 320 x 87 x 60mm weighs under 650g. The drawer section with high density antistatic foam holds either twenty EPROMs, model 82, or forty EPROMs models 84 and 84T. A low power dissipation light source has been used keeping the unit cool yet emitting the correct light level to the EPROMs. The tube is fully enclosed.

A timer version, 84T is available to ensure that you do not over expose the EPROMs. The switch selectable timer gives the user the choice of erasure times between 10 and 30 minutes. An LED indicator shows when the unit is erasing. All erasers come fully tested, with light fitting instructions at very competitive prices: basic unit 82, (twenty Eproms without timer) £31.25; basic unit 84, (forty Eproms without timer) £44.95; basic unit 84T (forty Eproms with timer) £54.95.

Further information from **J. P. Designs, 37 Oyster Row, Cambridge CB5 8LJ. Tel: (0223) 32234.**

Micro Mouse

One of our readers was asking about the Micromouse Association a few months ago. Apparently there is no Association as such, but the contact for anyone interested in Micromice or wanting to participate in the international micromouse trials should write to **John Billingsly, Department of Electric and Electronic Engineering, Portsmouth Polytechnic, Anglesey Building, Anglesey Rd., Portsmouth.** Help the cause by including an SAE.



Professor Plus

The name 'Microprofessor' is moderately familiar to anyone who takes more than a cursory interest in teaching-computers. **Multitech Industrial Corporation** makes a whole range of computers bearing this overall designation (a fact which has clearly caused some confusion). One of their popular single-board computers, the MPF-1B, is now being produced in a more advanced version, called the MPF-1Plus.

This is essentially a student machine. Designed to run without a monitor, the micro has a twenty character, fourteen segment phosphorescent display, a cassette interface, a switchable battery pack, a QWERTY keyboard and five accessory boards as additional extras.

The micro is based on the good old Z80 and has Z80/8080/8085 machine code, Z80 assembler, 2 x 4K CMOS 6116 RAMs and access to 48 system I$O lines. 8K of BASIC interpreter and 8K Forth are available on extra ROMs.

Extra boards available are a twenty character thermal printer, an intelligent EPROM programmer board, a speech synthesiser board, a sound synthesiser board and an I/O board.

There are three manuals for educational use: a user manual, an experiment manual, and a monitor source listing program.

The basic package costs £140 plus VAT and carriage. For futher information, contact **Flight Electronics Ltd., Flight House, Quayside Rd., Bitterne Manor, Southampton, Hants SO2 4AD. Tel: (0703) 34003.**

Quick On The Draw

A program to help 48K Spectrum owners to fully utilise the graphics capabilities of their micros comes from **Melbourne House**. Called 48K Melbourne Draw (or is that a cocktail?), it has been designed to enable much faster and more detailed graphics programming. The program enables a portion of the screen to be magnified for easier viewing and accurate placement of fine detail. The program boasts that the user will have full control of the screen and will be able to create animated characters, structured diagrams, vehicle designs, maps and floor plans, indeed 'any illustration or picture' and that it is easy to use as well as powerful. Cost: £8.95.

The Spectrum's cartoon character Horace is being made available for the Commodore 64 and Dragon 32, and others are planned to follow. There are three games in the Horace series, *Hungry Horace, Horace Goes Skiing*, and *Horace And The Spiders*, and they were once described as constituting 'a genre by themselves'. Ask a Spectrum owner. Cost: £5.95 each.

Programs available from retailers, or **mail order from Melbourne House, 131 Trafalgar Rd., Greenwich, London SE10.**

Dual Disk Software

A "dual format" disk system that allows a diskette to be read by both forty and eighty track drives without modification has been launched by Acornsoft.

BBC micro users are upgrading to eighty track drives. The new dual format disk allows Acorn to meet their needs and those of the existing forty track drive users without having to publish separate packs.

In future all newly published titles will be released on dual format diskettes and titles already being sold on standard disks will be made available in dual format versions. Dual format disks will cost the same as the single format versions they replace.

Enquiries to **Acornsoft Ltd., 4a Market Hill, Cambridge CB2 3NJ.**

Logical Step

A free booklet 32-page on programmable logic is available from **MSS**. This covers all aspects of programmable logic, including comparisons with fixed-function LSI/MSI and custom logic. One section goes step by step through a design example which shows how to generate the required Boolean equations, how to prepare the fuse tables, device programming and testing for specification.

Anyone who grappled with Keith Brindley's expositions on Boolean algebra in HE December '83 may find something to stretch their imaginations here. To obtain the booklet free of charge, contact **Microsystem Services, PO Box 37, Lincoln Rd., Cressex Industrial Estate, High Wycombe, Bucks. Tel: (0494) 41661.**

Programming With A Bang

New books from **Melbourne House Publishers** include *Supercharge Your Spectrum*. This is a collection of machine language routines for Spectrum users who want to use the full power of their micros without learning machine code. The routines are designed to help the user get much faster programs and effects from the machine, more extensive graphics, fast screen rolling, more power all round and 'realistic explosions' — without having to leave the computer switched on overnight, that is.

Other useful features are said to include program renumbering, protection against BREAKing and assistance with debugging. The book includes a program illustrating the use of many of the routines. Cost: £5.95.

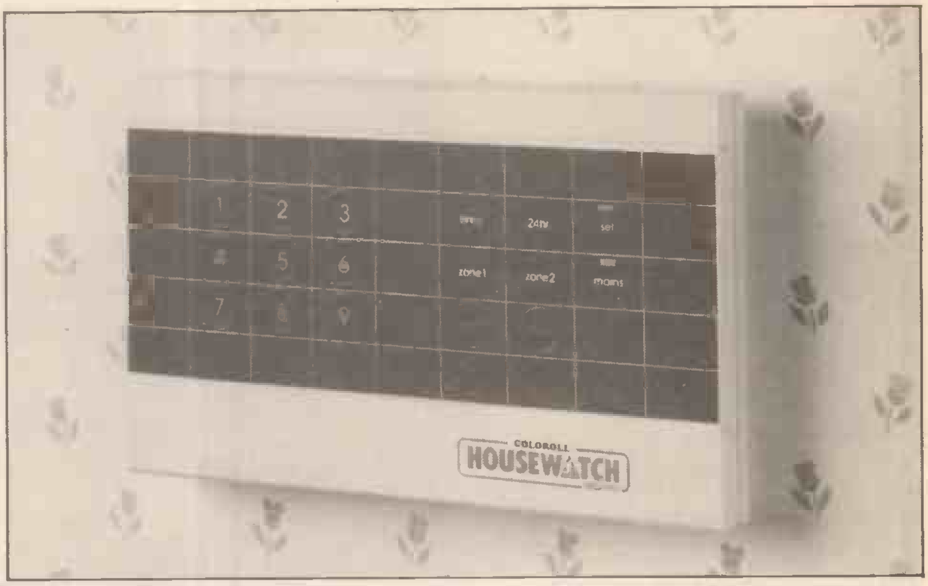
The *Spectrum Microdrive Book* by Ian Logan is an in-depth look at the new Sinclair Microdrive and its capabilities, along with sample programs, including the linking-up of as many as sixty four Spectrums into one system. The book covers business, educational and games-playing uses. Cost: £5.95.

Two 'Exposed' books, *VIC 20 Exposed* and *Commodore 64 Exposed*, claim to explain these two machines well beyond the extent of the users' manuals, with tables of memory locations and programming variables and demonstration programs. The VIC 20 book in particular boasts a comprehensive section on hardware operation. Aimed at all users from beginners to programmers, these two manuals cost £6.95 each.

The *Dragon 32 Programmers Reference Guide* is another manual-beyond-the-manual, and includes both BASIC and machine code programming and demonstrations on how to get faster routines and save memory space. Cost: £6.95.

A collection of thirty programs, from utility programs to games, appears in *Meteoric Programming* (nice title, that). These are designed to be easy to follow, and include for each one an explanation of how and why it runs, with pictures of the screen display for added understanding. Tips have been included for experienced programmers to develop their own Oric programs. Cost: £5.95.

All books from leading retailers or by mail order from Melbourne House **Publishers, Castle Yard House, Castle Yard, Richmond TW10 6TF. Tel: 01 940 6064.**



DIY Security System

A new fully electric DIY burglar alarm system for homes has been introduced by **Coloroll Ltd.** (who are better known for their wallpapers, as it happens). Called Housewatch 2000, it will be on sale in DIY, electrical and hardware stores for around £175. The system is designed to be simple to install and operate, and is tailored to home rather than say shop premises requirements. The electronics were developed in conjunction with Munford and White PLC, who are security systems specialists.

The complete kit contains a touch-button control panel, tamper proof external siren, a personal attack button, one surface and five flush mounted magnetic contacts, an under-carpet pressure pad, manual and all cables, screws, adaptor, etc.

The control panel operates five circuits: one zone for the sleeping area, one for the living area, points of exit and entry, the personal attack button(s), and one circuit controlling a tamper alarm in case the system is interfered with. A more, or less, comprehensive set-up can also be installed.

If no information is available from your local dealers, enquire to **Hill and Knowlton (UK) Ltd., Hesketh House, 43-45 Portman Sq., London W1H 9FG. Tel: 01-468 9021.**

Great Penguins From Little Acorns Grow

Acorn Computers Ltd., who make the BBC Micro and Electron microcomputers, and **Penguin Books Ltd.**, who enjoy one of the highest reputations in the world for quality paperbacks, have jointly produced a series of books and software packages under the title (appropriately) *The Penguin Acorn Computer Library*.

The Library will, unsurprisingly, follow the kinds of format used in Acornsoft's software production. Acorn boast that these aim to extend users' horizons and give facilities like sound and graphics a practical context which can be useful in office, home or schools. Joining in the enthusiasm for educational software, the Library will include a series of "child development packages" to show how computers can be used to enhance regular education. This is very much in line with Acorn's efforts to get micros into the hands of ordinary, non-technically-minded users instead of appealing only to raving enthusiasts.

The first two titles are (another non-surprise) concerned with Acorn's new wonder-child, the Electron: these are *The Acorn Guide To The Electron* by Neil and Pat Cryer, and *Games And Other Programs For The Acorn Electron* by Lee Calcraft. Eight more projects are promised for the first year, including *How To Write Arcade Games* by Jonathan Griffiths, in which machine code programming is described by one of Acorn's top games writers, and *How To Write Adventure Games* by Peter Killworth. (If I recall rightly, there was a wizard feature on just that subject in November '83's issue of *Computing Today*, by games master Pete Green. That's just by the way . . .).

The package will be available through the usual Acornsoft dealers. Further information can be had from **Robert Blood, The Quentin Bell Organisation, 18 Tower St., Covent Garden, London WC2H 9NN.**

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2N3704	10p
2N3705	10p
2N3706	10p
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CA3161E	150p
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CA3189E	300p
CA3240E	110p
CA3280G	200p
LF347	150p
LF351	48p
LF353	85p
LF355	88p
LF356	85p
LF357	110p
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LM310	120p
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LM318	150p
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LM324	30p
LM324Z	90p
LM335Z	140p
LM339	50p
LM348	65p
LM380	78p
LM381N	145p
LM382	115p
LM384	150p
LM386	90p
LM387	120p
LM389	95p
LM393	100p
LM3900	50p
LM3909N	65p
LM3911	125p
LM3914	250p
LM3916	250p
LM3918	250p
LM13600	110p
MC1310P	150p
MC1445	250p
MC1458	38p
MC1495L	350p
MC1496	70p
MC3340P	120p
MC3403	65p
NE531	140p
NE544	150p
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NE558	45p
NE564	420p
NE565	120p
NE566	155p
NE567	140p
NE570	410p
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0A200	9p
0A202	9p
1N914	4p
1N916	7p
1N4148	4p
1N4001	5p
1N4004	6p
4007	7p

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SWITCHES

Slide 1A	
DPDT	14p
DPDT c/off	15p
Sub-min Toggle	
SPST on/off	54p
SP c/over	60p
DPDT	75p
DPDT c/off	68p
Push Button	
Push to Make	15p
Push to Break	25p

RIBBON CABLE
Grey/meter

10-way	40p
16 way	60p
20 way	65p
26 way	120p
34 way	160p
40 way	180p
50 way	200p
64 way	280p

DIL SOCKETS

Pin	Low Prof	Wire Wrap
8	8p	25p
14	10p	35p
16	10p	40p
20	22p	50p
24	24p	65p
40	30p	100p

D-CONNECTORS

No of Ways	9	15	25	37
Male				
Solder	80p	105p	160p	250p
Angled	150p	210p	250p	385p
Female				
Solder	105p	160p	200p	335p
Angled	165p	215p	290p	440p
Hoods	90p	85p	90p	100p

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	Plug	Skt
DIN41617		
21 way	160p	185p
31 way	170p	170p
DIN 41612		
2x32 way St. Pin	220p	275p
2x32 way Ang. Pin	275p	320p
3x32 way St. Pin	260p	300p
3x32 way Ang Pin	375p	350p

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16 pin	50p	110p
24 pin	100p	150p
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PCB Mounting

3VA	200p
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12VA	295p
24VA*	330p

* Also 24-0-24

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	clad	plain
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2½ x 5"	83p	—
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5 x 2¾ x 2½"	130p
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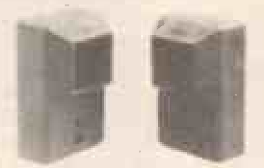

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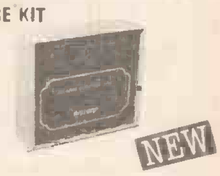

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CB Radio Microphone

A basic FM transmitter project built up as a low-power radio microphone which can transmit on any CB frequency.

A. Armstrong

THIS radio microphone is actually a very simple low power FM transmitter that can be tuned to any CB channel by means of a screwdriver adjustment The deviation is controlled by your speaking distance from the microphone, and the power can be preset at the time of construction.

It has a very limited range, but it is an excellent way of finding out how a FM transmitter functions.

A look at the circuit diagram, **Figure 1**, shows that the transmitter has only two stages, the oscillator and the output amplifier. The oscillator also receives a signal from a microphone, which modulates its frequency.

Considering the oscillator first, it is an LC type — nary a crystal in sight. From the point of view of radio frequencies (RF), the transistor has its base firmly decoupled to ground via C3.

The feeback path is from collector to emitter of Q1 via C4. The purpose of C5 is more apparent if the circuit of the oscillator is redrawn as the RF 'sees it' (ignoring the power supply for the moment). This is shown in **Figure 2**.

As far as the RF is concerned, the positive power supply is equivalent to the ground, since the power supply is well decoupled by C3 and C7. This redrawing shows that C4 and C5 form a low impedance tap on the tuned circuit, creating the same effect as tapping an inductor.

This matches the feedback signal from the collector of the transistor (high impedance) to its emitter (low impedance), in order to transfer power efficiently.

A small voltage variation on the emitter will produce a substantial current variation and this, in turn, will result in a larger voltage change on the collector. At the oscillation frequency, the collector load impedence is high, so the collector signal will be much larger than the emitter signal.

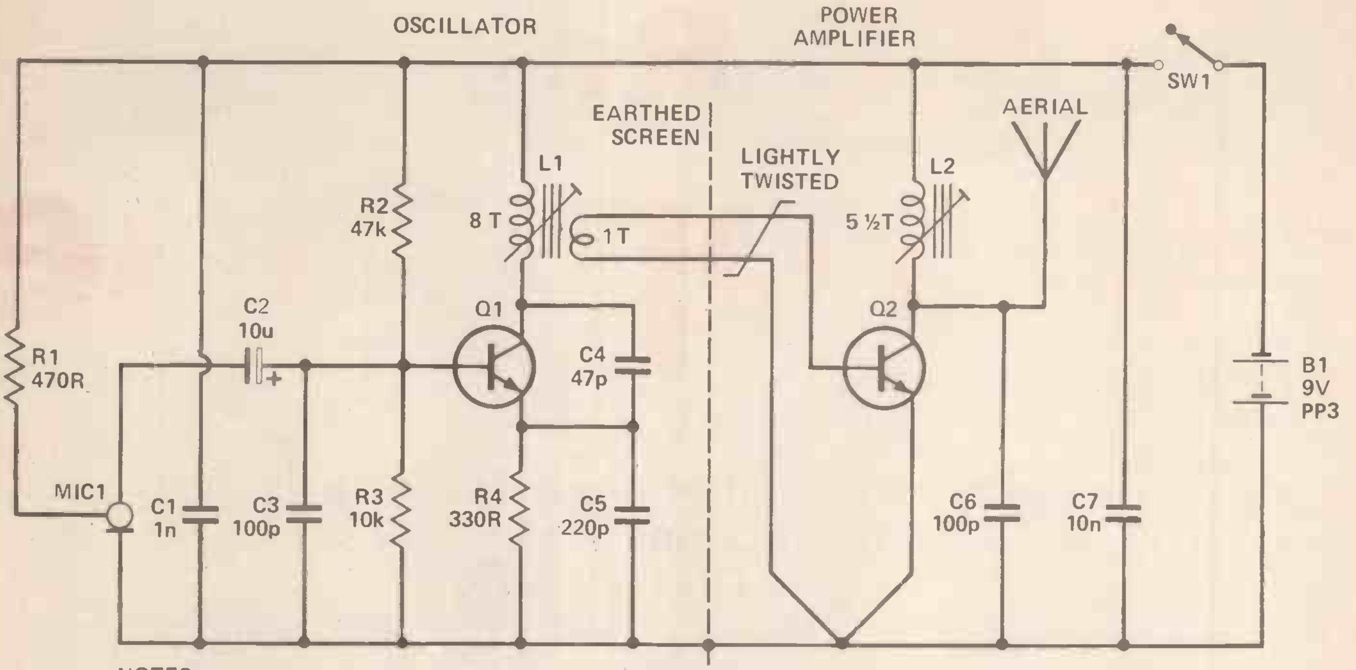
The feedback applies some of the collector signal to the emitter, so the process of oscillation continues. If the transistor has excess gain over that required to sustain oscillation, the frequency of the oscillation will change from the resonant frequency of the tuned circuit sufficient so that losses in the tuned circuit "mop up" the excess gain.

This is the electronic equivalent of a car gearbox being used to obtain reasonable efficiency from the engine. The electronic "gearing" has to be fairly accurate or the oscillator will be overloaded and just sit there, uselessly.

Simple

The microphone is coupled to the base of Q1 or by C2, and varies the base voltage of the transistor, and hence its emitter current. As the emitter current varies, so the transistor gain will vary (some transistors do this more than others), and as explained above, the gain of the transistor has an effect on the frequency of oscillation, so this provides frequency modulation. It is not a particularly advanced technique, but it's simple and it works!

The oscillator stage, could in fact, give out enough power for the purposes of this transmitter, but the variable loading imposed by an aerial wafting in the breeze would change the frequency, and you would be forever re-tuning.



NOTES:
Q1,2 = BSX20 or 2N2369
COILS WOUND ON 3/16" DIA
FORMERS FITTED WITH VHF SLUGS
UNIT CONSTRUCTION ON A PIECE
OF UNETCHED PCB, ON THE COPPER SIDE

Figure 1. The Circuit is a simple two-stage circuit, and is built up "freehand" on a piece of unetched PCB — a common enough technique in radio, but not often seen in HE.

Buffer Stage

Therefore a separate stage has been incorporated to serve as a buffer. This enables the oscillator to be run at a low power and to be unaffected by the varying loading of the aerial, while a reasonable number of milliwatts are delivered to the aerial. RF energy is drawn from the collector circuit of Q1, via a loose inductive coupling, to drive the base of Q1. Q2 operates in a mode known as 'class C'.

In this mode it is switched on and conducting for less than half the cycle. (the waveforms are shown in **Figure 3**).

The transistor is driven hard, and operates as a switch, and thus is operating fairly efficiently. Note that the input signal to Q2 is distorted, as the base draws current. It is as well, therefore, that the coupling to L1 is fairly loose, and the operation of the oscillator is not greatly disturbed by the distortion.

The tuned circuit consisting of L2, C6 and the capacitance of the aerial, form a circuit which is resonant at the transmitter output frequency. Transistor Q2 tops up the energy in this circuit once every cycle, when it draws a pulse of collector current through L2.

The effect here can be likened to somebody pushing a swing. The swing will keep going for a number of cycles if not pushed, but can be made to continue to swing evenly if it is nudged, even if only briefly, at one end of its travel. Thus, the waveform of the collector of Q2 is more or less an even sine wave, though the collector current is anything but sinusoidal!

A tuned circuit load of this kind is sometimes referred to as a "tank circuit", since it stores energy, and needs to be kept topped up. In fact this simple arrangement is not very efficient at rejecting harmonics, so that in a higher powered transmitter something more sophisticated would be used. Also, a more efficient way of matching the signal to the aerial would be required.

Construction

This transmitter is built on the copper face of a plain piece of PCB (this is common practice for small RF circuits of a semi-experimental nature). Before doing any soldering at all, it is as well to get the mechanical preparations out of the way. First of all, the coil winding.

The coils should be wound with 0.25m wire, the turns being tightly wound on the plastic formers, and retained with "super glue". The tighter and more secure the coil windings the better, especially the oscillator coil, since any slack in this will cause frequency instability. Do not use two-part epoxy adhesive to stick down the windings, for two reasons: 1) Some two part epoxy adhesives are lossy at radio frequencies.

2) Your fingers will get tired holding the coil before the glue sets!

As an aid to keeping the wire in place until the glue does set, a small

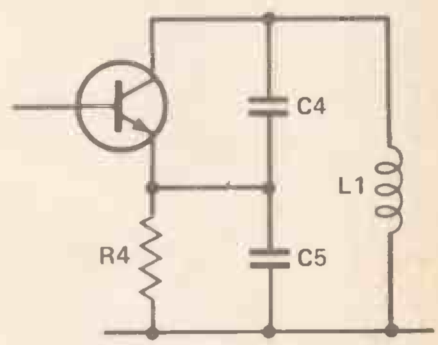


Figure 2. A diagrammatic layout of the oscillator stage.

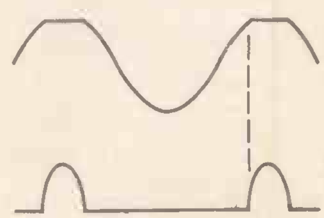


Figure 3. Waveforms for the operation of Q2 in class C.

Caution

The publishers of Hobby Electronics would like to point out that this Radio Microphone does not conform with the MPT 1320 specification for 27MHz CB equipment, and that use of the project would be in contravention of the Wireless Telegraphy Act. It is not the intention of the publishers to incite, encourage or condone the use of non-approved CB equipment.

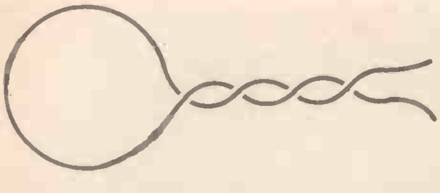


Figure 4. The coupling link should be wound quite loosely and cut to length without placing tension on the link (1½ — 2in).

strip of thin double sided adhesive tape (*Not* the thick sticky pads) can be used to stick the wire down, as it is wound. The only reason the output coil is 8½ turns instead of 8 is to have the wire leaving the coil in the right direction, leading to where it is to be soldered. At this stage the 2-turn coupling link on the oscillator coil should be wound, just loosely enough so that it can slide up and down on the former for adjustment. Leave a couple of inches of twisted wire on it for connection.

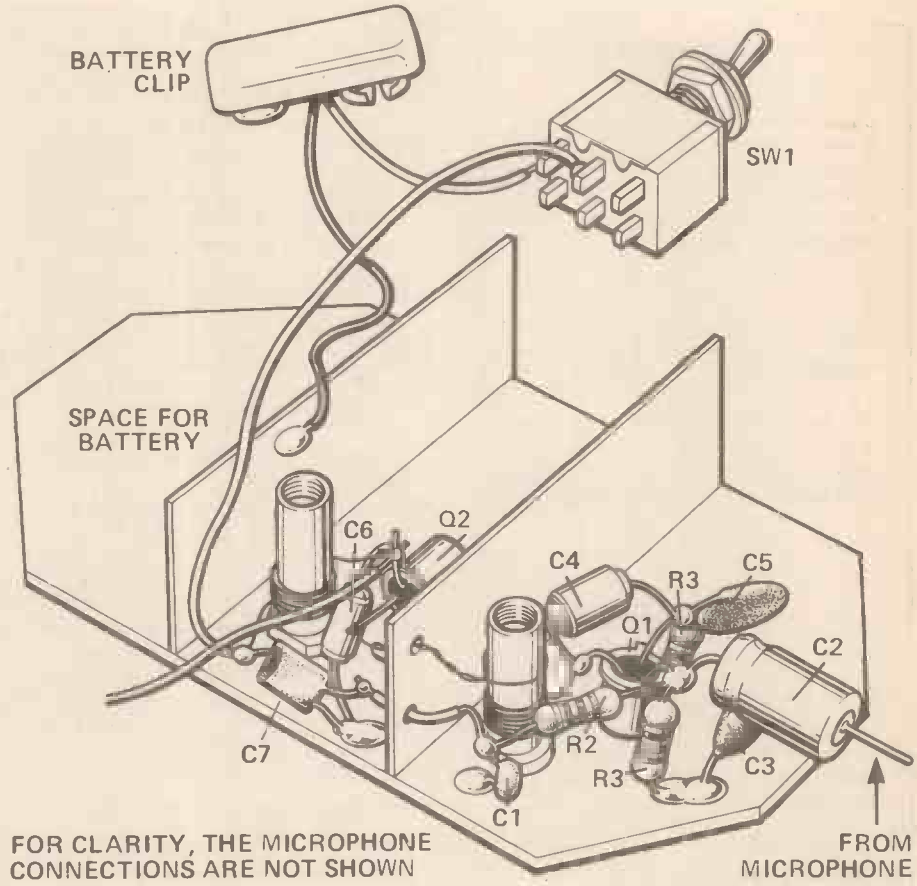


Figure 5. The construction diagram. The "up in the air" construction needs care to ensure that leads are not cut too short and that short circuits do not occur. It is not as hair-raising as it looks, however — and it is a technique worth practising.

Parts List

RESISTORS

R1	470R
R2	47k
R3	10k
R4	330R

CAPACITORS

C1	1n polystyrene
C2	10u 16V electro
C3, 6	100p ceramic plate
C4	47p ceramic plate
C5	220p ceramic plate
C7	10n polyester

SEMICONDUCTORS

Q1, 2	BSX20

MISCELLANEOUS

L1, 2	see text and Buylines
SW1	DPOT toggle
B1	9V PP3
MIC1	electret condenser type

One plain single sided printed circuit board; one double sided plain pcb; connection wire, solder etc.

BUYLINES .... **page 26**

Cut And Fit

The next job is to cut and drill the pieces of PCB. The base of the unit may be single or double sided, but the screens need to be made of double sided board. The very thin board that is sometimes available is most suitable for the screens, and can be cut with tinshears. Failing this, a very straight sawcut, cleaned up with a file, is needed for the edge of the which solders down to the base (groundplane).

Drill the holes for the coils slightly undersize and then file them out carefully to ensure a tight fit. If the coil former has locating pips, file the cutouts for these with reference to the direction in which the wire leaves the coils.

The next job is to solder the components together as shown in the diagram, **Figure 4**. The easiest way is to start with the components which are soldered to the ground plane, as these form the support for the other components. Build the oscillator first, fitting the coil L1 last. Put a drop of super glue on its base to hold it firmly in place. Then solder the screen in place, put the twisted wire from L1 and the power supply wire through the appropriate holes, and commence building the output stage. Once again fit the coil last, then the second screen, which is there to retain the battery. Finally, attach about 18 inches of wire as an aerial.

Now wire up the switch and the battery clip and you are ready to start testing. *To avoid damage, space the two turn link on L1 well away from the main part of the coil before switching on.* Get the CB transceiver intended for use as the receiver, and tune it to the channel to be used. Insert a short piece of wire into the aerial socket, and dangle it somewhere near the oscillator. Switch on the radio microphone and tune the slug in the oscillator until the signal is heard. This is a delicate operation, and is best carried out with a plastic trimming tool, as a metal tool will affect the frequency, or may break the slug.

Next, connect a milliammeter in series with the battery, and adjust the position of the two turn link on L1 to obtain a reading of between 5 and 15mA (don't worry if the frequency changes). The more current, the more power, but the less the life of the battery. Carry out the adjustment carefully, as too much current may burn out the output transistor.

When the position of the link is decided, fix it in place with superglue. Now adjust the slug in L2 until a

More About Tuned Circuits

When tapping a tuned circuit capacitively, the voltage step-down is simply the ratio of the impedance of the bottom capacitor to the total impedance of the two in series. The voltage step down ratio is

$$\frac{X_{C5}}{X_{C5} + X_{C4}}$$

While XC (the reactance of a capacitor = 1/2πFC, where F is the frequency. Since we only want a ratio, the 2πF parts can be ignored. Thus the ratio of the voltages is easily calculated as

$$\frac{1/C5}{1/C5 + 1/C4}$$

In this circuit the voltage at the junction of the two capacities is 0.176 x the voltage on the top of the tuned circuit. The impedance is lower, by 0.176^2, which equals 0.031 times the impedance of the whole tuned circuit.

So what is the impedance of the tuned circuit? Well, with perfect component and no loading from the transistor, the impedance of a parallel tuned circuit is infinite! However, an inductor has resistance, and hence has losses, and finite impedance. This effect can be represented either by a parallel resistance or a series resistance, though in an inductor the effect is caused by the series resistance of the windings. However, to calculate the impedance, which you need to know is the equivalent parallel resistance. That is, the resistance which, if put in parallel with the inductor, would waste as much energy as the actual resistance of the windings! This is simple. If the impedance (XL) of the inductor is N times its series resistance at a particular frequency, then the equivalent parallel resistance is N times the impedance of the inductor.

Impedance of an inductor XL + 2πFL.

Now we need to know L. The circuit is resonant at 27MHz, and the formula for resonance is:

$$F = \frac{1}{2\pi\sqrt{LC}}$$

Following this,

$$C = \frac{1}{1/C4 + 1/C5}$$

(a standard formula)

$$= \frac{1}{1/220 + 1/47} = 38.726F$$

Shuffling the resonance formula:

$$\sqrt{L} = \frac{1}{2\pi F\sqrt{C}}$$

$$L = \left(\frac{1}{2\pi F\sqrt{C}}\right)^2$$

= 879 nanohenries

(A nanohenry + 10_2^9 henries. No, this isn't an April fool.)

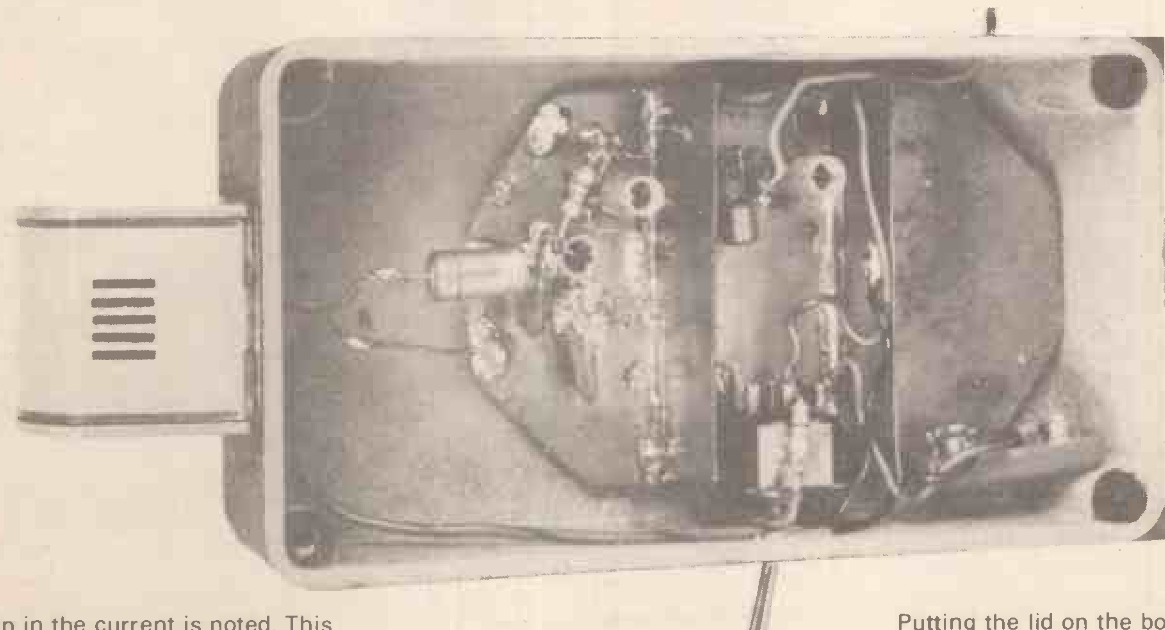
At resonance, the impedance of the inductor has the same value as the impedance of the capacitors (but in the opposite phase).

The equivalent series capacitance is 38.726pF, which gives an impedance of 152R, so if the inductor had 1R resistance, (improbably high) then the equivalent parallel resistance would be 152 x 152 = 23.104 kR.

In practice, in this type of circuit, other losses dominate the situation, and the collector impedance of the transistor, and the loading of the coupling coil to the equivalent series resistance may be about 2kR.

By the impedance matching figure calculated earlier, this means that the impedance seen by the emitter is about 62R, which is a bit on the high side, but well within a workable range.

These principles can be applied to many other radio circuits.



slight dip in the current is noted. This indicates resonance, but is affected by the length of aerial. It should not need adjusting if the frequency is changed by a few CB channels either way.

The microphone insert and which should now be mounted in the metal case of the transmitter, and the transmitter board mounted in the box using double sided adhesive pads.

Hole And Complete

Now connect the microphone to the rest of the works, and tune in the oscillator once more to check that all is working.

Putting the lid on the box will of course shift the tuning off channel (law of conservation of misery), so drill a hole in the lid just over the oscillator coil first. Then, after fitting the lid, readjust the oscillator to the right channel. The radio microphone is now ready for use, so now all you disco lovers . . . ("hey is that the DJ at the back of the hall?"), HE

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Although these articles are being prepared for the next issue, circumstances may alter the final content.

A Question of Balance

Balance is an important quality for ice skaters, bicycle riders or football players. It is no less important in audio output circuits.

Vivian Capel

IF you have ever attempted to ride a bicycle, or received a bank statement with the last figures in red, or maybe been the unfortunate recipient of a plate of soup from a careless waiter's tray, you will appreciate something they all lack — balance!

Indeed, as it is a desirable quality in so many aspects of life, balance is no less important in many electronic circuits, particularly amplifier output stages.

One of the most common types of circuit is the complementary push-pull arrangement, shown in **Figure** 1, although there are many variations on it. The two transistors, one PNP (Q2) and the other NPN (Q1), are connected, apparently, in series across the supply. Both are driven from the collector circuit if the driver transistor Q3, hence the phase of the driving signal is the same for both of the output devices. However, as these are of opposite polarity, one is driven further into conduction, while the other is cut off. On the next half-cycle the situation is reversed. Output is taken from the junction of their emitters via a coupling capacitor, C1.

Now many folk, including some technicians of my acquaintance seem to have difficulty in understanding just how this circuit can work. In a series circuit, the current must be equal in all parts, so as the output pair are in series, how can one be passing a heavy current while the other is passing none at all?

The answer is that they are in series only as regards the steady quiescent supply current through them. The situation is quite different when the signal comes along, because now, the output capacitor puts them virtually in a parallel configuration.

Current Paths

Let's see what happens (**Figure 2**). If say Q2 conducts first while Q1 is cut off, current is drawn through the loudspeaker from the positive supply to increase the charge in the capacitor (it is already partly charged, to half the supply rail voltage).

However, as the capacitance is very large, the half-cycle finishes before it can be fully charged. Now, Q2 is cut off and Q1 conducts (**Figure 3**). This completes a circuit back to the positive rail through which the capacitor begins to discharge. The discharge current also flows through the loudspeaker.

So, one transistor keeps charging the capacitor and the other keeps discharging it, and the ebb and flow passes through the speaker which thereby responds to both half-cycles.

If the capacitance is insufficient, the capacitor will fully charge or discharge before the end of the half-cycle. This means that the long wave-length low frequencies will not be reproduced, and those in the mid-region, which utilise a significant proportion of the capacitance, will be distorted. This is because the rate at which a capacitor charges and discharges is not linear. Comparative linearity is obtained only by restricting the charging to a small portion of the total capacity.

Problems of this nature are rare, unless due to faulty components, as electrolytics of sufficiently high value are readily available.

Transistor Gain

In the days of valve push-pull circuits it was always the practice to match a pair of output valves to achieve balance, as the mutual conductance of new valves of the same type differed over a certain range. A characteristic of transistors that has not yet been beaten by the makers is a spread of gain values which is far wider than that of valves. The spread can be up to eight times between minimum and maximum h_{FE} specifications, which can be quite a headache for the designer. In some cases, the range is narrowed by the suffix letters A, B, or C which denotes bands of increasing gain values, but only a few devices are so identified.

What, then, is the effect of unmatched transistors in a complementary output circuit? Much will depend on the precise form the circuit takes, and its refinements, but there are certain general observations that can be made. Firstly we note that the devices are operating as emitter followers, the load being in their respective emitter circuits, and the collectors being taken to +VE and OV.

Now the voltage gain of an emitter follower is always less than one, its virtue lying in its amplification of current, which is what is required for an output stage. The internal resistance of output transistors is always much less than the load, around a fraction of an ohm, so the maximum current available is never taken. Hence variations in the maximum current available caused by differences in the current gains of the two transistors, would have no effect.

Any difference in voltage would though, as these would produce differences of current through the load, hence power variations.

Formulae

So what effect does discrepancies in transistor h_{FE} have on the voltage applied to the loudspeaker? Voltage gain for an emitter follower is

$$(V = Z_L/(Z_L = (Z_S/Z_L))$$

where Z_L is the total load and Z_S is the source impedance.

It can be seen that the source impedance, which is the output impedance of the driver stage, affects the result. In accordance with the basic law governing the coupling of audio stages, the input impedance of one stage should be fed from an output impedance of the preceding stage that is much lower. This poses the question as to what is the input impedance of each of the output transistors. The formula is:

$$Z_{in} = h_{FE} \times Z_L$$

Let us put some values to these expressions. The speaker impedance is eight ohms, say, but added to this is the reactance of the series capacitor, and also the value of the emitter resistor. Reactance will change with frequency, but we can reckon a nominal value of two ohms for reactance and resistance, thus giving a total load of ten ohms.

So, for an h_{FE} of 20, the input impedance is 200, for 40 it is 400, for 60 it is 600 and so on. Thus a low h_{FE} means a corresponsingly low input impedance, and the output impedance of the driver stage must be lower still.

Let us see how the source of impedance affects the voltage gain of the output transistor at different values of h_{FE}. Although the two output transistor inputs are in parallel, they can be regarded as a single transistor because one is only conducting at a time.

For a source impedance of 40 ohms and a h_{FE} of 40, the voltage gain will be:

$$10/(10 + (40/40) = 0.9$$

If the h_{FE} is halved, namely 20, the gain becomes:

$$10/(10 + (40/20)) = 0.83$$

Thus the drop is to 92 per cent of the former value, which is not as bad as may have been anticipated.

If the source impedance if 100 ohms, with the same 10 ohm load, the gain with an h_{FE} of 40 is:

$$10/(10 + (100/40)) + 0.8.$$

Halving the h_{FE} in this case produces a gain of:

$$(10/(10 + (10/20)) = 0.66$$

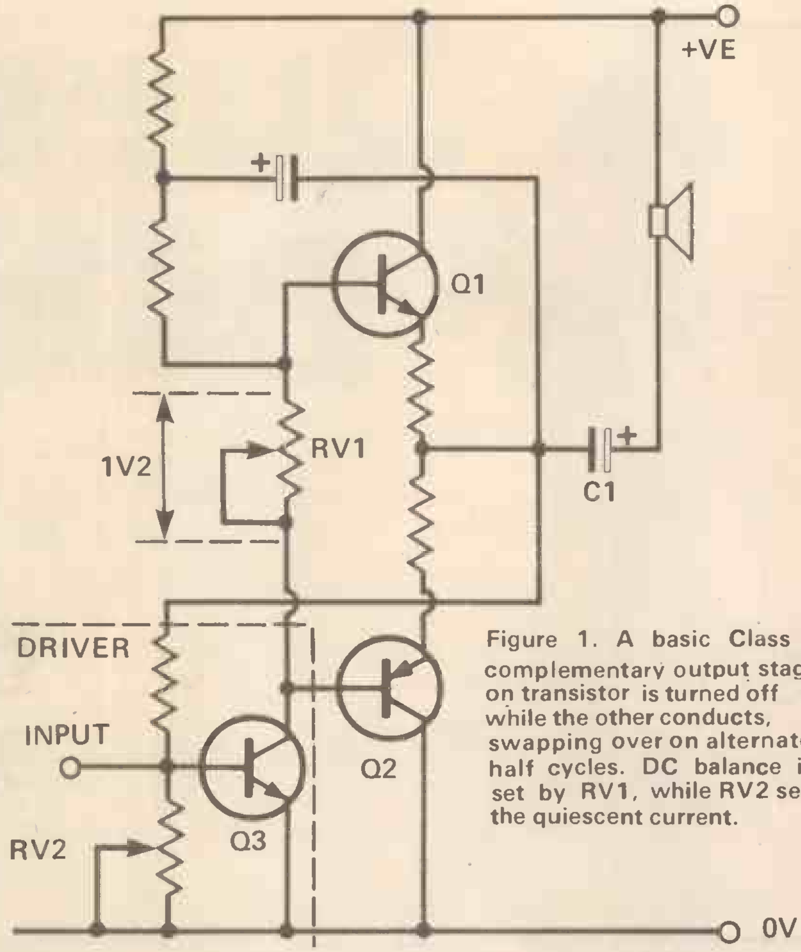


Figure 1. A basic Class B complementary output stage; on transistor is turned off while the other conducts, swapping over on alternate half cycles. DC balance is set by RV1, while RV2 sets the quiescent current.

So the reduction becomes 82.5 per cent of the previous figure. It can be seen from this that the effect of variations of h_{FE} on output voltage, hence on balance between the two outputs transistors, increases withan increase in source impedance.

Another factor already shown is that the input impedance of the output transistor drops in proportion to the decrease in h_{FE}. Should the h_{FE} be much below the parameter designed for, it could load the driver stage to the extent of increasing distortion there. While a good design should take into account the h_{FE} spread lowest value, not all do, and in addition, individual transistors are not uncommonly found to be below the specified spread.

One method often used to keep the gain of each output device high so as to minimise effects of h_{FE} variations and to present a high loading impedance to the driver stage, is to use a darlington pair for each output device.

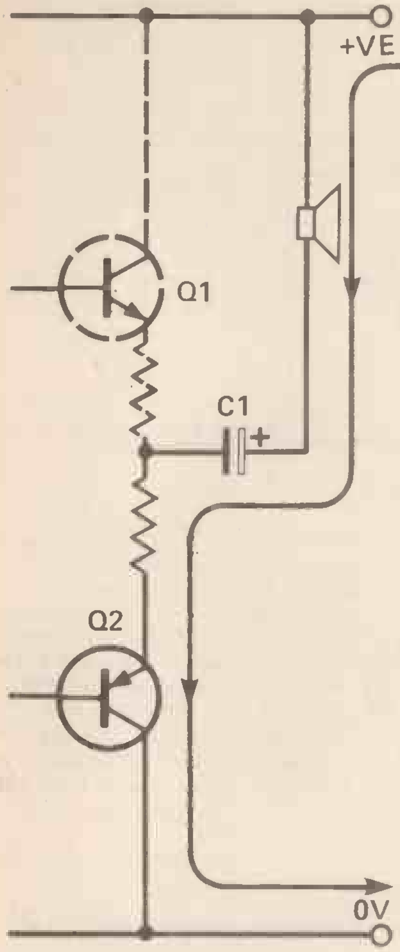
DC Balancing

The effects we have so far discussed are of the amplitude of each half of the signal waveform. There is also the effect on the quiescent DC current through the output stage to consider.

Bias is provided by direct connection to the collector of the driver transistor, but the two bases are separated in the potential divider chain from supply to driver collector by some 1V2, to overcome the base/emitter 0V6 potentials. If this potential is increased by increasing the resistance between the bases, the emitter/base voltage of both transistors will be greater and the quiescent current through both will rise. A preset resistor RV1 thus makes a convenient control for adjusting the output current.

Usually, a nearly saturated transistor Q4 takes the place of this preset resistor between the bases, as this offers a means of stabilising the current (Figure 4). Should the voltage across it rise for any reason and thereby increase the output transistor current, its own bias will be increased, turning it harder on and so lowering the voltage drop across it. Thus it self-compensates and keeps the output base voltages steady. It only does this of course, relative to each of the transistors Q1 and Q2, not relative to the negative supply, otherwise it would remove the incoming signal. A preset RV1 in the base circuit sets the conduction level and thereby the output stage current just as in the case of the simple base/base resistor.

If the output pair are unmatched, say Q1 has a higher h_{FE} than Q2, this preset can do nothing to balance things up as it adjusts the bias on both transistors at the same time. In such a case, the voltage appearing at



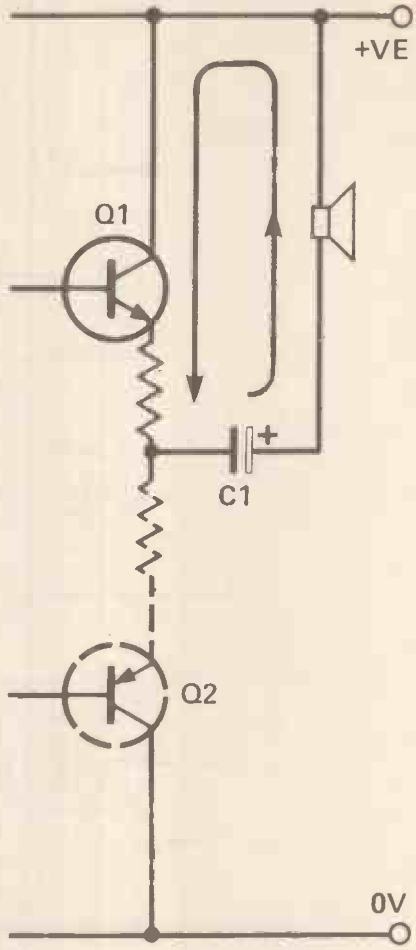


Figure 2 (left). When Q2 conducts (Q1 cut off), C1 charges through the loudspeaker and Q2.
Figure 3 (middle). When Q1 conducts and Q2 is cut off, C1 discharges through the loudspeaker and Q1. The two transistors are in series for DC, but not for AC.

the junction of the emitters, which should be a half that of the supply, will be higher because the upper transistor is turned on harder and so has a smaller voltage drop across it.

The lower emitter/collector voltage results in reduced power handling before clipping of the output commences. This is made worse by the higher voltage gain of this transistor, which drives the output into overload conditions sooner. Hence, one half wave is clipped long before the other and the total power without distortion is reduced.

Fortunately this can be adjusted without much difficulty. The output-pair bases are tied to the driver collector, and the output emitters are at the usual 0V6. Thus the junction voltage is partly governed by that of the driver collection. In addition to this, the biasing of the output transistors is affected. When the driver collector is low, that is, near to zero volts the bottom transistor base is more negative, hence the transistor, which is a PNP device, is turned harder on and the voltage across it decreases. At the same time, the upper transistor, an NPN type, has its base also made more negative which reduces its conduction so increasing the voltage across it.

The driver collector voltage can be readily adjusted by a preset in its base circuit, RV2. So, it should be remembered that this preset, or maybe one in an earlier DC coupled stage, sets the mid-point output voltage, while the one associated with the circuitry between the two output bases sets the output current.

There is a snag here, though. If the unbalance of the output pair is such as to necessitate a very low voltage on the driver collector to compensate, and bring the mid-point voltage right, it could impair its own power handling abilities. The driver must supply power to provide that low source impedance that we saw was so desirable, and it could easily be overloaded if its collector voltage was taken too low.

A further point is that wide discrepancies in h_{FE} of the output pair makes adjustment critical and tricky. It is also likely to change as the transistors warm up, by more than the usual amount. In any case such adjustments should be made after a short run at normal operating volume/levels.

Negative Feedback

It may be argued that the differences in amplitude of negative and positive cycles due to transistor unbalance can be corrected by amounts of negative feedback. True, negative feedback will reduce the discrepancies by a significant amount, but by its nature, distortion can never be completely eliminated. It is increasingly being found that a high negative feedback level brings its own problems.

Phase shift over the feedback loop can turn negative into positive feedbacks at high frequencies, with disasterous results; it also renders the amplifier vulnerable to transient distortion. When large values of feedback are employed, the gain of earlier stages must be made greater to compensate for the loss produced by it. If a sudden large amplitude transient arrives, the negative feedback signal appears too late to reduce the leading pulse, so it overloads the stage, thereby generating severe distortion.

The maxim for good amplifier design is to get it as near perfect as possible without negative feedback, then apply a moderate amount to improve performance still further. Some makers use it as wallpaper to cover the cracks, but this is never satisfactory.

So, it is highly desirable to use matched transistors in the output stage. Small differences may have no noticeable effect, but with the large spreads common with some types of transistor, you may get a pair from the top and bottom of the range. A pair of 2N3772s I obtained recently for a public address amplifier of which the specified h_{FE} was 15—60, actually measured 12 and 17, hardly a useable combination.

Class A

In order to avoid the troublesome crossover distortion of inherent with class B designs, many constructors and makers are going back to class A operation. There is no doubt that these are much superior for quality work, but have the disadvantage of taking high current through the output stage. This is less of a drawback now that transistors are avilable which have very large current ratings unheard of a few years ago.

The main difficulty now is getting rid of the excess heat, but large heatsinks are also obtainable that can handle the power. There are though, limitations when it comes to the very high powers, and for these, class B or a derivative is the most practical solution.

A typical class A circuit is shown in **Figure 5**, and at first glance it seems hopelessly unbalanced. The transistors are not complementary but both NPN types. The configuration is similar to the class B circuit, but whereas the top transistor is operating as an emitter follower, the bottom one is working as a normal grounded emitter. Thus while the voltage gain of the upper devices is less than unity, that of the lower one is proportional in its h_{FE}.

Balance is established by the way

the driver is connected. Notice that its emitter is taken directly to the base of the lower output transistor, hence its base/emitter input current flows also through the base/emitter junction of the output transistor in addition to the collector/emitter current. Thus, with respect to the lower output transistor, the driver behaves as an emitter follower giving a low-voltage gain.

For the upper transistor, this is not the case, and it is driven by the grounded emitter driver stage consisting of Q2 and Q3 with none of the driver's input current affecting its base/emitter junction. Thus the balance is neatly attained. As with the class B circuit, the voltage at the junction between the two transistors can be set to half the supply voltage by adjusting the bias on the driver using RV2.

The preset for setting the current through the output pair RV1, is connected not between their bases, as with the class B complimentary circuit, but in the collector feed to the driver. This is because the bases of both transistors, being of the same polarity, need to be made either more positive or negative to increase or decrease the collector respectively. With the complementary circuit one had to be made more positive while the other was made more negative.

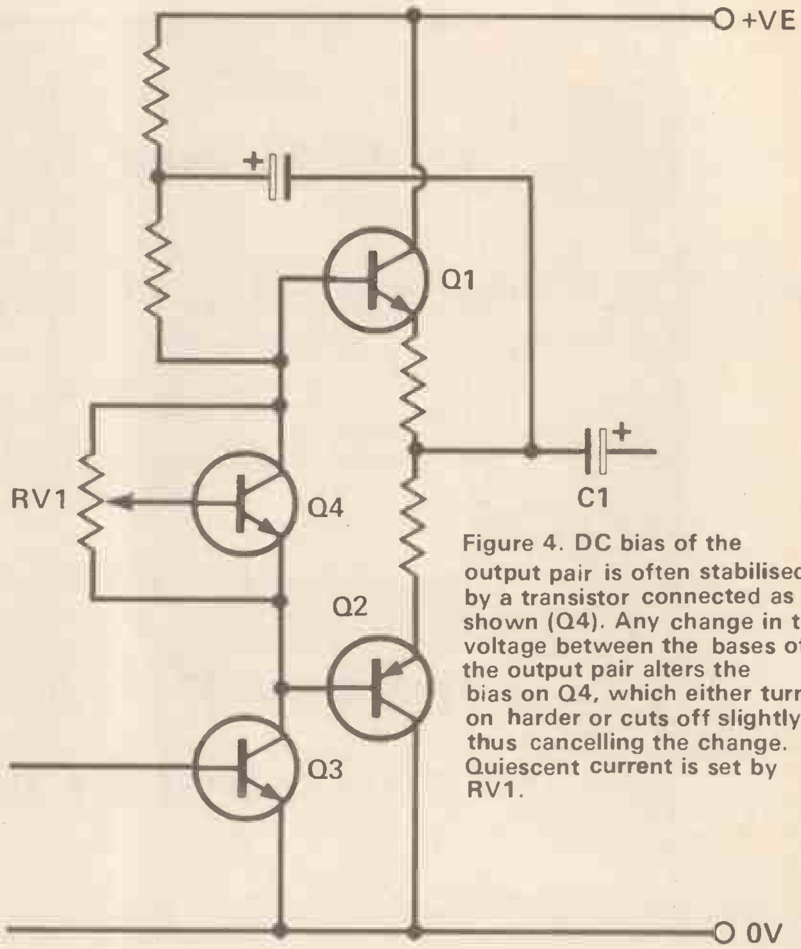


Figure 4. DC bias of the output pair is often stabilised by a transistor connected as shown (Q4). Any change in the voltage between the bases of the output pair alters the bias on Q4, which either turns on harder or cuts off slightly, thus cancelling the change. Quiescent current is set by RV1.

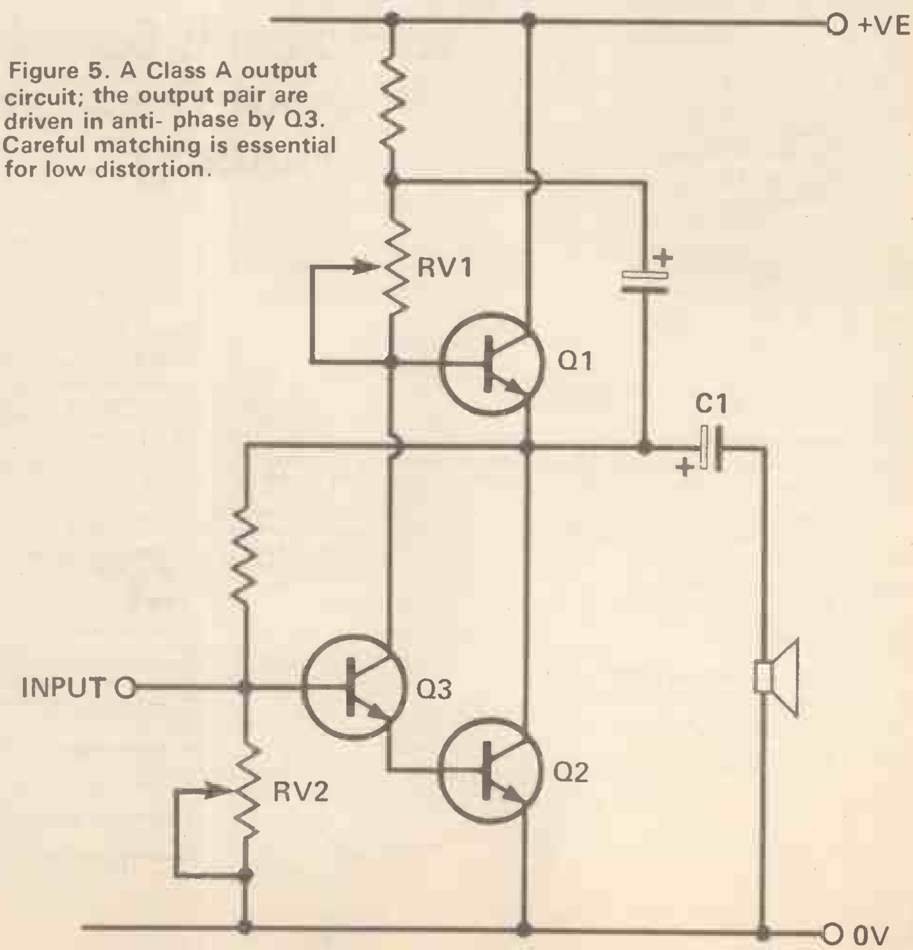
Matched Pairs

While a matched pair of output transistors is, as we have seen, desirable in a class B complementary circuit, it is *essential* with a circuit using class A operation. Any difference will have a greater effect on the distortion, and could also result in one transistor getting hotter than the other. Having a high quiescent current, they are likely to be running close to their limits anyway, and the ratings of one could easily be exceeded.

Now here we are faced with a major problem. Have you ever tried to purchase a matched pair? Apart from a few types which are supplied matched by the makers, they are just not generally available for the majority of suppliers. For the benefit of HE readers (as well as my own), I carried out a survey of mail order suppliers to find one who was prepared to match up pairs, even at a little extra cost. Of those contacted, only one expressed willingness to do so, and one well-known firm suggested that I order a quantity, say 25, match up a pair and return the others for credit (not a refund)!

The firm that will supply matched pairs (with h_{FE} values matched), is **Comtech Electronics, 205 Studes Rd., Leicester LE2 9FY**. I ordered two pairs of 2N3772s and received them a couple of days later. No extra charge was made, and on checking them found them very closely matched. In fact it would have been difficult to get closer! Their prices, in general, seem quite reasonable compared to many others too.

Figure 5. A Class A output circuit; the output pair are driven in anti- phase by Q3. Careful matching is essential for low distortion.



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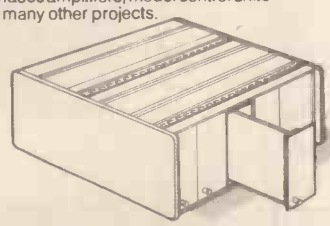

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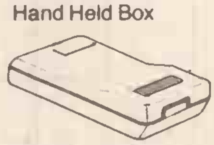
Hand Held Box

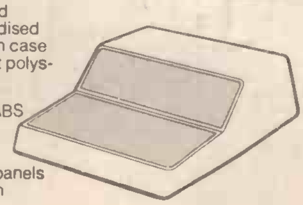


This box is moulded in two sections and has a textured finish. The battery compartment accepts a PP3 or nickel cadmium stack 25 x 45mm long. A circuit board 56 x 105mm may be mounted on three pillars in the base, location being provided by a 3mm spigot. The top moulding will accept a circuit board 71 x107mm.

- Material-Textured ABS
- Colour-Dark brown

Hi-Style Desk Top Case

Designed to house keyboards and displays on two 1,6mm silver anodised aluminium panels. The light brown case is manufactured from high impact polystyrene and has a textured finish.



- Casing-High Impact textured ABS
- Colour-Brown, front and base panels 1,6mm satin anodised aluminium

Plastic Boxes

Type A

Plastic boxes consisting of a top and bottom moulding with front and rear aluminium panels, positively retained in the two halves.

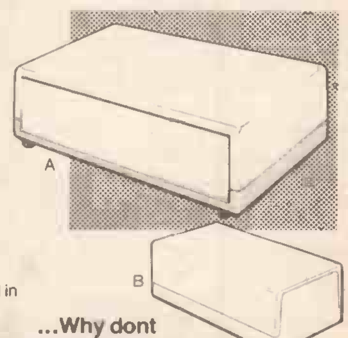
- Top and bottom moulding-High ABS.
- Colour-Light grey top: dark grey base.
- Front and rear panels-Satin anodised aluminium 1,6mm thick.

Type B

Constructed of high impact polystyrene, these handsome two-toned grey boxes are suitable for wall mounting and free standing instruments. The two halves of the box are held together by screws inserted from the base.

- Material-High impact polystyrene
- Colour-Top light grey: base dark grey
- Panels-Satin anodised aluminium

Send 50p for a copy of the catalogue with details of the full range available.



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BUYLINES

Audio Test Set

The XR2206 IC may be difficult to obtain, but can be obtained from **Electrovalue, 28 St Judes Road, Englefield Green, Surrey TW20 0HB** if no other supplier can be found.

The TBA820M can be purchased from **Maplin** amongst others. The capacitors are generally available, but the types used in the prototype are available from **Maplin**.

Estimated cost for the project is around £13, excluding the case and PCB. You can either make your own PCB or obtain one from HE's PCB service.

CB Radio Mic

The 0.25mm diameter wire used in this project for winding the coils is only available as "wire wrapping" wire. One source for this is **Maplin** under the order code BL77J. However, the wire is only sold in 25m reels and is rather expensive for the length that is actually used.

An alternative is to use 32swg enamelled copper wire which is slightly cheaper. Indeed you may even have a few short lengths in you spares box. Note however, that it may be necessary to slightly alter the number of turns put on the formers, because of the different diameters between the two types of wire.

Suitable formers and cores can be obtained from **Maplin** under the order codes LB19V and LB41U respectively. The microphone is a standard electret condenser type and is available from many suppliers. All other components are standard and should present no problem when buying.

Estimated cost is £3 excluding the following: single and double sided PCB, condenser microphone, case and wire.

Time Out

There should be no problem with this project — all components are standard and generally available from advertisers in HE. We suggest however that you buy the relay from **Maplin** — order code YX97F, and IC2 from **Enfield Electronics**.

Estimated cost excluding case, PCB and control knobs is £11. As usual the PCB can be obtained from HE's PCB service. Now a public service warning/advice so we don't lose readers!

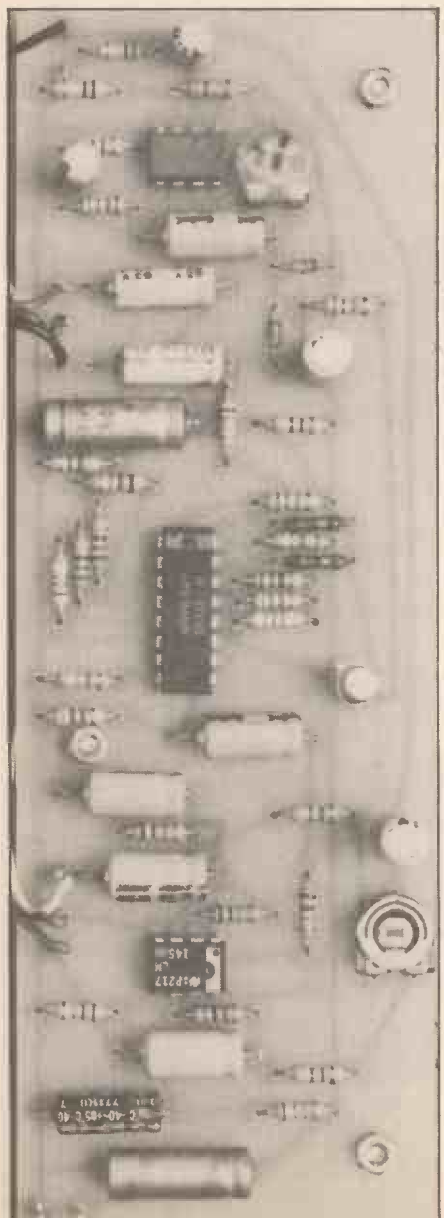
The author has suggested that the mains output lead be soldered directly via Veropins to the PCB. Obviously this is perfectly safe providing good strong soldered joints are made. For younger or less experienced readers the following might be a more safer alternative:

Using three short lengths of wire connect a three-way 10A plastic terminal block to the Veropins, mount the terminal block in the case and in a safe position. The mains output lead can now be wired directly to this. This same idea could be used for connecting the mains input lead to the PCB. This method provides a safe alternative and also means less trouble when the contolled equipment needs to be changed.

Coping with Components

Tony Bailey G3WPO

Come to terms with capacitors. Run rings round resistors. We tell you how to choose the right Rs and Cs for your projects, and how to tell them apart when you've chosen them.



How many times have you looked at a strange capacitor bearing a legend such as "102", or a resistor with more identifying bands than normal, and wondered what value it is? Or have you a collection of resistors and capacitors that you never use because you aren't quite sure what type they are, or whether they will be suitable for the application you have in mind?

In this article we hope to pass on enough information to enable selection and identification of suitable components for the job in hand. Those of you laying hands on a soldering iron for the first time will find this of special interest, and hopefully there is some information also for the seasoned constructor.

During the past decade, the changes in components have not been so much in their type, but the sizes, with such items as IF transformers now obtainable in cans 5mm square, whereas ten years ago, the standard was at least 1in square for most people — not that the smaller type weren't around, they were just virtually unobtainable for the average constructor.

A Little Change

The same happened with resistors and capacitors, with very small sizes now common, a result of the need to miniaturise for high density printed circuit work, together with the introduction of different constructions. Also, the power consumption of the active devices we now all use can be measured in microwatts, with commensurate decrease in the power dissipation of the passive devices supporting them. Consider that even on standby, the average valve consumed a good few watts of heater power alone, and a pair of 813s would need a massive 100 watts per pair just to keep the heaters going!

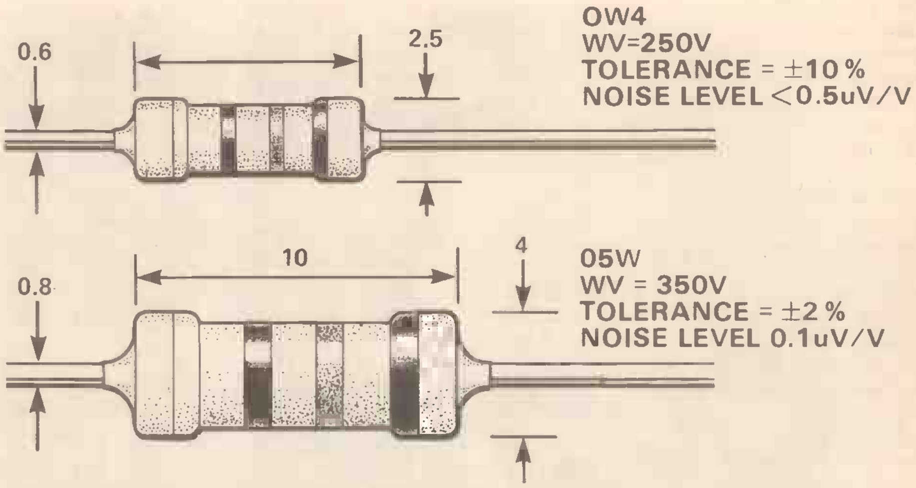
Another consequence of miniaturisation is that all the components needed for the higher power applications are increasingly difficult to obtain. The average constructor of a new linear amplifier has to attend rallies and surplus shops (Second World War surplus is of course also drying up) to find the air spaced capacitors he needs, and high voltage/current capacitors. Valve bases cost an arm and a leg, without even mentioning the valves themselves.

There are of course, many applications still requiring the higher power components. However, most of the constructional projects published today will use either discrete semiconductors, or an array of integrated circuits, with a requirement for suitable support components. It is here that the problems start.

The average junkbox may contain a high proportion of what appear to be 'almost' suitable components ie, "the circuit calls for a 330pF silver mica

capacitor, but I have a 330pF polystyrene which will fit into the same space, so lets use that." If value is the only consideration than this may well be suitable, but is probably another reason why the mica may have been specified. A good article should tell you of any critical needs, but very few actually do, and you are left to your own devices. Similarly, will a wirewound resistor do instead of the carbon composition specified?

So, with these points in mind let's have a look at the various classes of resistor and capacitor you are likely to come across and how to identify and select them. We will also quickly look at how they are manufactured and constructed.



Metal Film: General purpose high stability types with low temperature coefficient. Five-band colour code gives three significant figures, multiplier and tolerance.

Metal oxide: Used where a low noise figure is required.

Resistors

The humble resistor is an essential part of almost all electronic design, but comes in a variety of sizes and compositions, all intended for specific applications, but with a degree of overlap from the practical viewpoint.

One of the major points to remember when selecting any resistor is the power rating. As all resistors convert electrical energy into heat, care needs to be taken to ensure a safe rating within any circuit. For most solid state designs, this power dissipation is very small, and a 0W25 rating will usually suffice.

Table 1 Standard Colour Code

Band Colour	Figure	Multiplier	Tolerance(±)
Black	0	1	not used
Brown	1	10	—
Red	2	100	2%
Orange	3	1000	—
Yellow	4	10000	—
Green	5	100000	—
Blue	6	1000000	—
Violet	7	10000000	not used
Grey	7	.01	—
White	9	.1	—
Gold	—	—	5%
Silver	—	—	10%

No tolerance band colour = ±20%

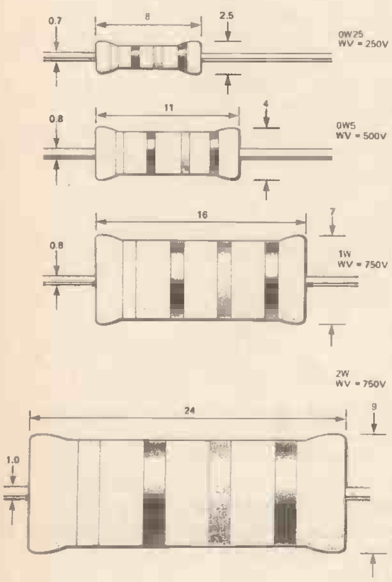
Metal film/oxide types have an additional value band to give the three significant figures rather than two, so that a standard 47k resistor would be coded yellow/violet/orange, whereas this type would be coded yellow/violet/black/red (ie 47, 000/4,7 0 00).

An alternative system uses letters to identify the multiplier as follows (recognise it from Hobby Electronics?):

0.22 ohms = R22
1.0 ohms = 1RO
2.2 ohms = 2R2
22 ohms = 22R
220 ohms = 220R
2.2k ohms = 2K2
220k ohms =220K
1.5 ohms = 1M5

If a letter follows the value, it indicates the tolerances:

F = ± 1%
J = ± 5%
K = ± 10%
M = ± 20%



Carbon Film: The standard "¼ watt 5% carbon" type, is has almost completely replaced older carbon composition resistors. Noise level is typically 1.0uV/V for any value, which is adequate for most purposes.
NB: All dimensions are in millimeters.

For higher power work, calculate the maximum power dissipation (P=12xR) and select a resistor rated at least two times this value if ventilation is good — higher if not. Several hot resistors placed next to each other will require a higher rating as radiated heat from resistor to resistor has to be taken into account. Bear in mind that the cooler a resistor can be kept (especially non-wirewound types) the longer its life will be, and adjacent components will not suffer from thermal effects (reduced drift in oscillators for example).

Carbon Composition

These are the cheapest resistor to manufacture, and were once the most common type, although generally carbon film types now see more usuage. They are reliable, and seldom suffer from failure, except through excessive heating, usually first seen as smoking followed eventually by total failure. A major advantage is in RF circuits, as they have very low inductance and capacitance, and are the type to choose when making dummy loads.

At audio, composition resistors generate appreciable noise, due to thermal and current effects between the carbon particles. If low noise is a requirement, use film types in preference.

For high voltage work, carbon composition types are better than film types, and the higher the wattage rating, the higher the voltage rating. A typical OW125 resistor may have a voltage rating of 150V, whereas a 2W type will be around 750V.

These resistors are manufactured from a compressed and bonded mixture of powdered graphite, a filler, and a resin binder — the more carbon the lower the resistance. A moulded case protects the inner core against environmental effects, although moisture pick-up can be a problem (moisture uptake can be removed by heating). Leads are inserted in each end for connection for the external circuit.

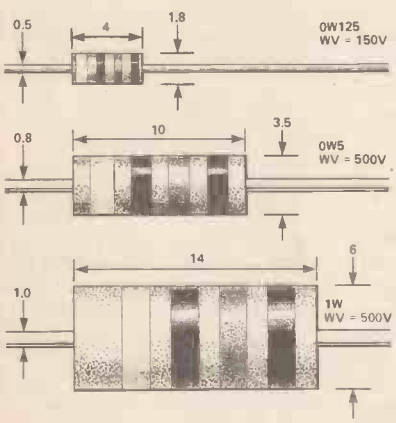
Carbon Film

For standard electronic work, the most common is the OW25 carbon film variety, and ordering a value of resistor without any further specification would probably result in supply of these.

As the name implies, this type is made by depositing pure carbon onto a ceramic rod used as a former, usually by high temperature decomposition of gaseous hydrocarbons. The thickness of the coating controls the resistance value, and without further treatment, values of up to 1000 ohms are possible.

To achieve higher resistance values, a technique known as spiralling is used. The tube element is rotated, and a very thin track (around ten thousandths of an inch wide) cut around the tube in a helical fashion, using a laser, or cutting wheel. This increases the path length through which the current flows, thus increasing the resistance.

Problems arising from this method of construction are that the resistor cannot withstand even small overloads, with the track fusing open circuit (although this effect can be used to



Carbon Composition: Older type resistor, for general use where temperature coefficient and tolerance not critical; noise levels generally greater than 2uV/V. Carbon comp resistors are not usually available in values below 10R.

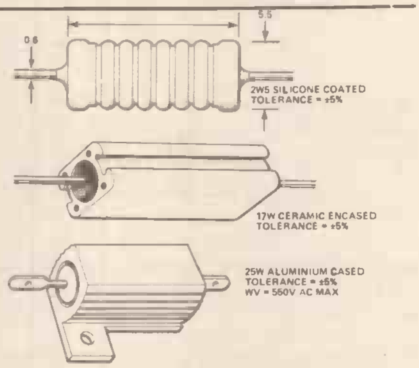
advantage). Also, above about 2MHz, the spiralling introduces capacitive reactance, which may be a problem at higher frequencies. However, the improved stability, low cost and lower resistance change over a long period make these a popular choice in solid state applications.

Metal Film/Oxide

For more precise values, these are the normal choice, and are easily available in two and one percent tolerance selections. Precision types come as low as 0.01%, depending on the exact construction, and of course you pay more for this sort of specification figure.

Like carbon film, a ceramic (or glass) tube acts as a former, with a thin film of metal, or metal oxide as the resistive element. Spiralling is normal, and the overload factor is better than that of carbon film. They are very reliable, and should be used where dependability and close tolerance are required.

A number of metal films can be used — nickel-chromium being usual, but



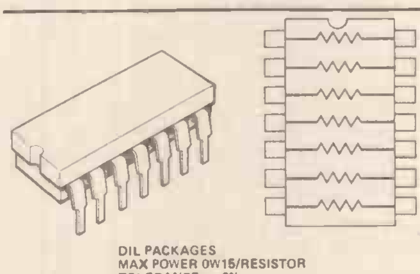
Wire wound: Silicone coated types (top) suitable for general use up to 10W rating. Ceramic encased (middle) types are useful where high insulation resistance is needed (eg mains circuits); also supplied at 4W, 7W and 11W ratings. Aluminium-clad resistors (bottom) will rarely be used by the home constructor!

cerment and tin oxides will also be met. Cermet resistors are exceptionally stable, generally found as high (megohm ranges) value types, and of value under adverse climatic conditions — more often met as variable preset types than fixed. These thick cermet film types are also used for the dual in-line package types, of value for high density PCB work, for instance as LED display dropping resistors.

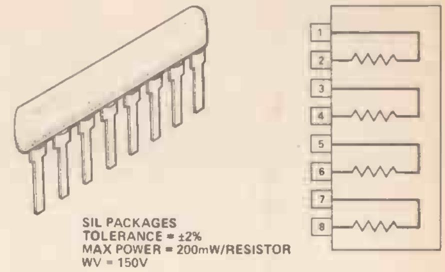
Again, capacitive reactance is a problem at higher frequencies. This type of resistor has a slightly different coding system to the composition and carbon film types, with an extra band introduced for the third figure (see Table 1) which makes the value decoding difficult if you haven't used them before.

Wirewound

For applications of high power ratings, low noise or low resistance values, the wirewound resistor, in one of its many forms is the answer. Also, high pulse currents are better handled by these.



DIL Package: Compact resistor form offering considerable space savings, and very convenient for eg current limiting LED arrays, 7-segment displays, pull-up/down in logic circuits etc. Also supplied containing 13 commoned resistors.

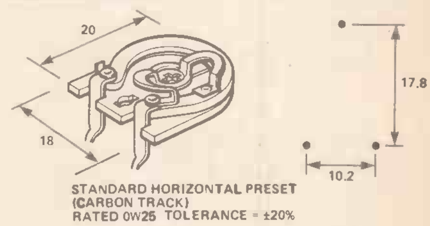


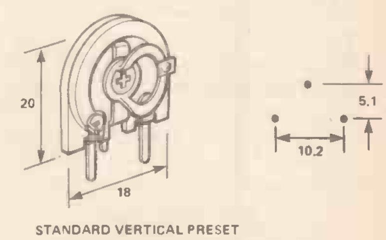
SIL Package: Also available with 7 or 8 commoned resistors. As with DIL resistors, values are limited, and all resistors in the package are the same value.

Tolerance values range from 10% down to .05% for precision work, such as divider networks on test instruments.

Construction is by using a spirally wound high resistance wire element on a ceramic former (sometimes fibreglass on low wattage types). The outer casing is very variable, depending on the application, but typically ceramic, vitreous enamel, plastic, or silicone. Types with metal sheathing, which can be screwed to a chassis are available with ratings up to 50 watts.

Power types, often seen as dropping resistors on TV chassis are primarily designed for heat dissiption rather than electrical performance, with wide tolerances. Types used in consumer applications are generally flameproof, for safety reasons, with an outer ceramic coating.





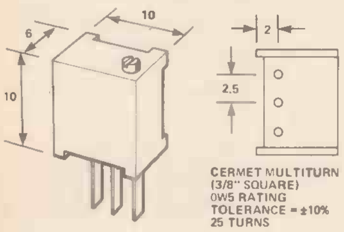
Standard Horizontal Preset (top): miniature types have pin spacings of 10.2 and 5.1mm in the same pattern.
Standard Vertical Preset (bottom): miniature variety pin spacing is 5.1 and 2.54mm, in the same pattern.

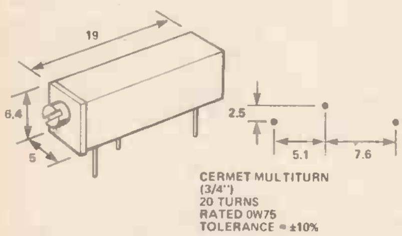
By the nature of the construction, wirewound resistors are highly inductive and should not be used in high frequency circuitry. It is possible to obtain non-inductive types, where two parallel windings are made on the same core, but in opposite directions, to reduce the inductance to around 1/100th of normal. Precision wirewound types are often made by this method, although a typical 0.1% value will set you back £2.00 or more each.

Variable Resistors

To vary the voltage in an electrical circuit, a variable resistor is required, otherwise known as a potentiometer or trimmer resistor. All function in a similar manner, having one terminal at each end of a resistive track, and another terminal connected to some form of flap that can be slid up and down the resistive element. One other form of potentiometer is the Rheostat which is strictly a two terminal device of high power capability, but the term is often applied to a three terminal device of similar high power. They are normally used for current limiting purposes.

Like fixed resistors, these come in a variety of shapes and sizes, often with switches attached. Caution should be observed when using switched types that the switch contacts are rated for the job in hand — especially when AC mains is involved as the DC rating is very different to the AC. Details of the rating will normally be found on a unit.



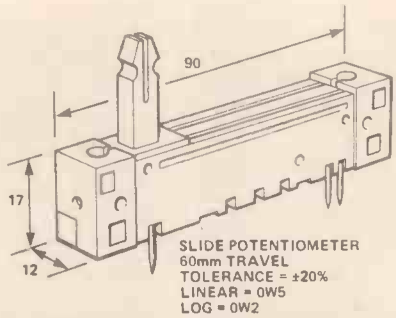


Cermet Multiturn Presets: Essential for precision adjustment. A large range of single-turn cermet trimmers are also available, eg square, vertical, horizontal and round.

Multiple section types are often encountered and used for such applications as ganged stereo balance controls. Many of the types imported from the Far East have additional features such as centre click stops, for the preceding application, or multiple click stops for the type of volume control now popular on hi-fi equipment.

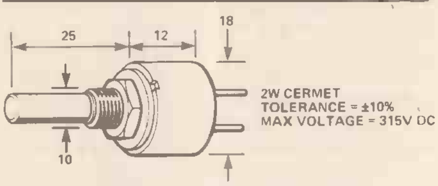
Selection of the variable resistor to suit the application will involve deciding the type of taper the device has. Taper is a term referring to the track law, or in what manner the resistance changes as the control is rotated. Linear types vary in a linear fashion so that the centre position would be expected to have half the total resistance. Logarithmic law varies slowly at first as the control is rotated from its fully anticlockwise position and then more and more rapidly as the other end is reached, thus obeying a logarithmic law (these are normally used in volume controls).

Reverse log laws vary in the same manner but in the opposite direction, and a mix of linear and log termed semi-log can be obtained for special purposes. There are other tapes but they are not frequently met by hobbyists. All of these tapers are formed by varying the mix used to form the resistive element over the element length.



Slide Potentiometers: Favoured for application where controls are being operated continuously.

The power rating of a potentiometer will vary with its size and construction. Unlike a fixed resistor, you cannot look at one and say what the power rating will be, so inspection of the manufacturers data is advised if in doubt.



Rotary Cermet: The cermet track provides good electrical and temperature stability, and linearity.

Carbon Composition

These were one of the earliest types to be introduced and can still be found plentifully. There are two types of construction — moulded and film coated. The former are made by filling a cavity in a moulded base with a carbon composition mix, with the slider formed as a pure carbon brush. The outer case is usually made as an environmental seal, making this type useful under adverse conditions. Track life is long, with low wiper noise.

Conductive Plastic

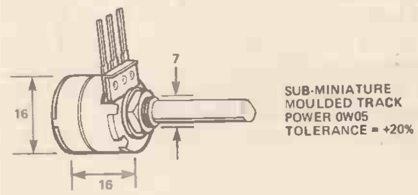
These are the type more normally met in day-to-day applications, usually in the form of a thick film carbon-resin mix screened onto a base of plastic, phenolic or ceramic material. The wiper is made from a variety of metals, depending on the specification, normally in the form of a spring loaded skeleton.

In use, the track eventually wears, producing erratic voltage variations, or noise in audio circuits. Very short term relief can be obtained by using switch or contact cleaning liquids, but it is usually best to replace the faulty unit without delay. Many of the low cost potentiometers of this type are not sealed against dust ingress which can lead to premature failure under adverse conditions, such as dusy environments.

Wirewound

For higher powers, wirewound types are a natural choice, but their inductive construction limits them to DC and some audio applications. All are made by winding a length of bare resistance wire round a core of insulating material, with the resistance value controlled by varying the type of wire, size of the core, turns spacing and/or wire diameter. A rotating metal wiper pressing on one edge of the former then acts as the resistance control.

The main disadvantage of this type of construction is that the resistive increment as the control is rotated will vary in discrete steps, termed the 'resolution'. This parameter is determined by the diameter and spacing of the wire, and by the contact area of the wiper. In many applications a fairly high resolution is required, as in varicap control voltage applications, and this can only be achieved by using finer wire with closer spacing, which means a more fragile winding. There is also a practical limit to the wiper size.



Sub-miniature Carbon: Suitable for panel or PCB mounting where space saving is important.

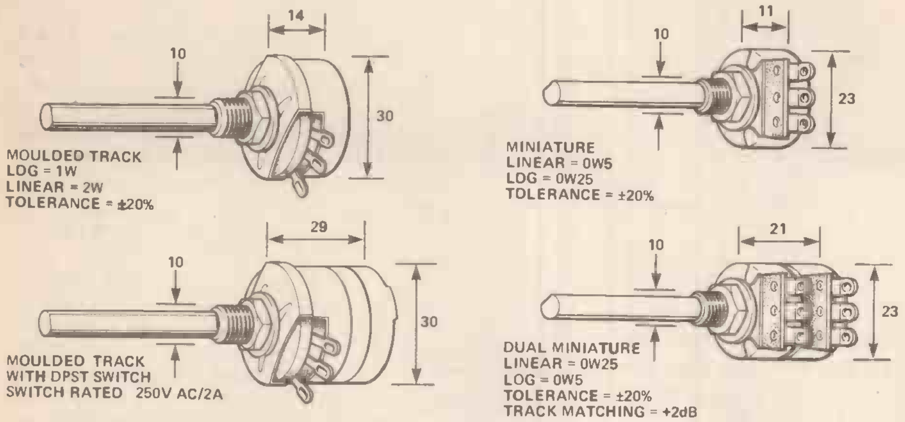
Precision Types

While single turn precision potentiometers are available (with much longer element lengths and special wipers) it is normally a multi-turn unit which will be encountered for precision applications. The construction and housing are varied, with the elements invariably made from wire, although it is possible to use cermet or conductive plastic in smaller types.

The housings usually incorporate much better shaft arrangements, often with ball bearings, and precious metal wipers. The method of winding the coil gives much higher resolution over single turn types, although there is still a practical limit — for a ten-turn unit, this would be about .01% for a 10kR value. The linearity of the winding is also vastly improved to about =0.25% at any point on the track.

Trimmer Resistors

Most of the preceding types of variable resistors have their small trimmer equivalents. Nowadays, virtually all trimmer types come as printed circuit board mounting types, with sizes varying down to 6mm in diameter. The skeleton preset is familiar to most readers, and is used in many non-critical applications. For higher reliability, cermet track types should be used — these also have a lower temperature coefficient.



Moulded Carbon Track: The usual potentiometer chosen for panel mounting in non-critical applications. Also available with DPST switch rated for mains voltage (bottom).

Miniature or "Midget": Carbon track potentiometers for general purpose. Dual (aka 'tandem' or 'ganged' pots) have closely matched tracks.

Totally enclosed types are available where environmental conditions are hazardous or where long life is required.

Multi-turn trimmers normally come in a long rectangular case, with a screwdriver adjustment at one end, and a slipping clutch arrangement to prevent damage to the unit. If you want to panel mount these types, it is possible to obtain special holders with a panel mounting bush. The actual sliding wiper is usually carried on a screw or wormgear arrangement. Note that all these types have a limited dissipation, and are not designed for continual adjustment — use a proper variable type if you continually need to adjust the value or the operational life will be poor.

Capacitors

A considerable variety of capacitor types are now available to the hobbyist, and most people will have a junkbox with many capacitors in which are of unknown types, or carry strange markings indicating the values. The tables given here should identify most of the values, and the text and illustrations the type of capacitor. It is important to select the correct type of capacitor for the job, as although there is some overlap in many applications, each variety has particular attributes which will make it more suitable for some purposes that others.

All capacitors are of course able to store electrical energy, and consist of two parallel conducting surfaces, separated by another material, which is an insulator, and known as the dielectric. The cheapest such dielectric is air, although the hobbyist will normally only meet this in variable capacitors (see later). The commonest dielectrics in fixed capacitors are mica, ceramics, paper, plastic and less commonly, oil, with other materials sometimes being used.

As DC current cannot flow through a capacitor, they are often used to separate DC and AC signals within a circuit. Nor does AC current actually flow through the capacitor — the movement of electrons from one electrode to the other only gives this appearance.

The amount of electrical energy which can be stored depends on the value of the capacitor, and the dielectric material used in its construction will determine the relative size for a particular value. A vacuum is used as a reference for the 'dielectric constant' with a value of 1 — higher values give the amount of energy stored per unit/volume as a ratio to this reference. Most plastic dielectrics such as polyester and polycarbonate have constants of around 3, mica around 6, and tantalum about 11. One material, barium titanate has a dielectric constant up to 15,000, and is used in the dielectric of many ceramic types to achieve the very high capacitance/volume ratios in a low voltages.

Temperature stability is often important, and especially in RF oscillator circuits, attention must be paid to this characteristic. It is usually expressed in parts per million (ppm) per degreee Centrigrade temperature change, and may be zero, positive or negative.

The tolerance against the marked value of any capacitor will depend on its construction — in the case of electroytic types this may be as much as -20/+80% in any unit. However, this is usually not a problem in electrolytic applications but should be borne in mind if the value has been calculated for any applications In the opposite direction, mica types are available with tolerances of 1 or 2%, but of much lower capacitance value.

Table 2 Capacitor Markings

Polyester *capacitors have the same coding as resistors with first significant figure of value at the top of capacitor. An additional band at the end will indicate the working voltage: brown* = 100V, red = 250V, yellow = 400v.

Ceramic capacitors are usually marked with their value in figures (the old band marking has virtually disappeared) ie 22p = 22pF or 2p2 = 2pF2.

The "n" system is also frequently met where if the "n" precedes the figure it is a multiplier of ie n22 = 220pF, or if it follows the figures it is a multiplier of 1000: ie 10n = 10,000pF, 220n = 220,000pF. Note that:

1500pF = .0015uF = 1n5

Also, another method is as two significant figures plus multiplier to the power of 10, ie:

104 = 100,000pF (100n or 0uF1)
102 = 1,000pF (1n or 0uF001)

Paper Capacitors

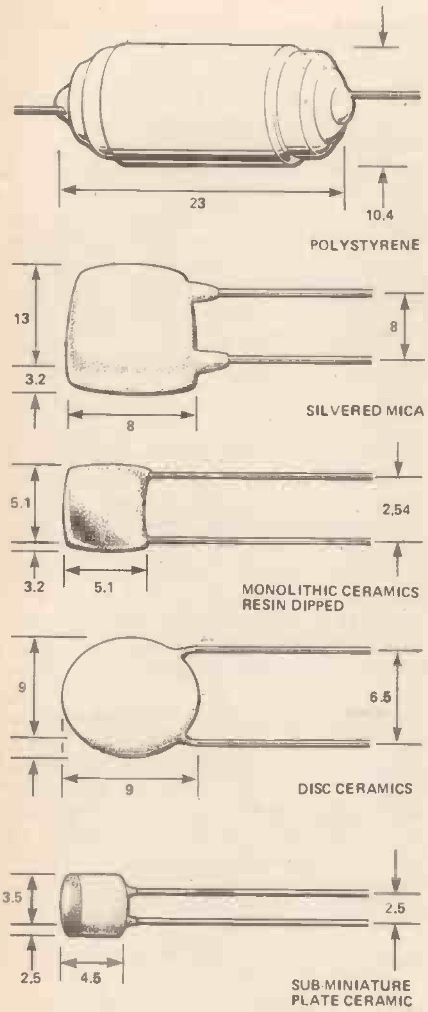
Common some years ago, these have tended to be less frequently used nowadays. They are constructed by winding alternating strips of metal foil and paper into a roll with leads attached, or inserted into each end, then impregnating with wax or a synthetic material, before environmental protection by means of an outer encapsulation.

The method above gives a capacitor with appreciable inductance — this can be reduced by a slight variation in the method of winding the layers when the foils are wound so that they can be crushed together at the ends, and the complete end is then soldered to the wire lead.

These capacitors are best in voltage work, althought the fact that paper will easily absorb moisture can lead to problems — the insulation resistance disappears quickly. Audio work was a common application at one time, but plastic based types are now normally used to their smaller size and better electrical characteristics.

Mica Capacitors

Mica is a natural mineral (although synthetic mica is now made) normally found in granite rock formations, and has the advantage of being totally inert, and a good insulator. It is also extremely stable (althought it does absorb moisture) making this material excellent for high stability work, with a temperature coefficient not exceeding

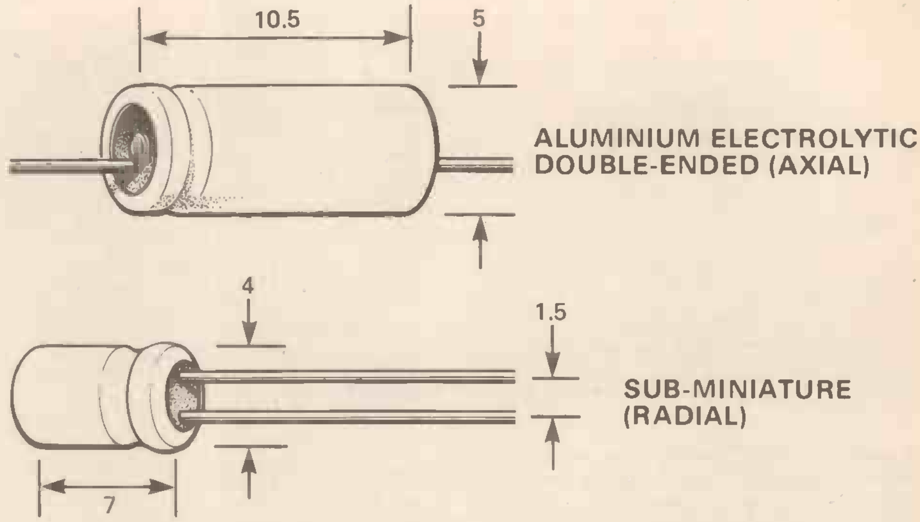


Polystyrene capacitors offer high insulation resistance with good electrical properties.
Mica capacitors are used where high stability is required.
Ceramic capacitors are available in a number of different forms, each suited to a particular application.
NB: All dimensions in millimetres.
All capacitor sizes vary according to the value; those shown are typical of each type.

around ±100 ppm, and it is capable of passing high RF currents.

Mica capacitors are constructed by assembling alternating sheets of mica and foil, with the foil overlapping the mica sheets at each end. Alternating foils are then wrapped together and leads attached to opposite sides, covering the whole assembly with a dipping of epoxy resin, or a moulding to prevent water ingress. Tolerance specifications vary from ±20 to ±1%. In the 1% ranges, capacities up to 50pF are often alternatively specified as ±0pF5, due to the practical difficulties in obtaining ±1% at low values.

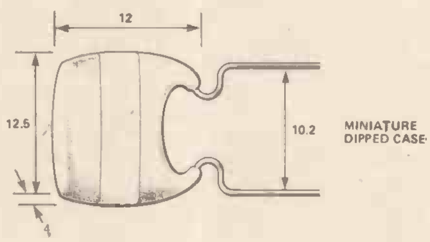
A particular variety of mica capacitors, normally referred to as 'silver mica' are widely used in RF oscillator circuits due to their excellent stability. The construction is different to the normal mica, as a thin film of silver is formed on each side of the mica sheet to act as electrodes, before impregnation, lead attachement and



Electrolytic Capacitors: Axial electrolytics (top) are available in values up to 4700uF and at voltage ratings to 450V. Radial types, either standard of subminiature (shown at bottom), are supplied in more restricted value and voltage ranges, but take less space on a printed circuit board.

epoxy-encapsulation. Temperature coefficients are around +30-50 ppm.

Where the leads inductance would be a problem, a specially cased version is available without leads where the layers are sandwiched between metal clamps. These can be soldered directly to a printed circuit board, and are often used in VHF/UHF RF transmitter applications ('UNELCO' type).



Polyester Capacitors: The example shown above is the familiar "C280 Polyester" capacitor. The dimensions are typical for values to 47n.

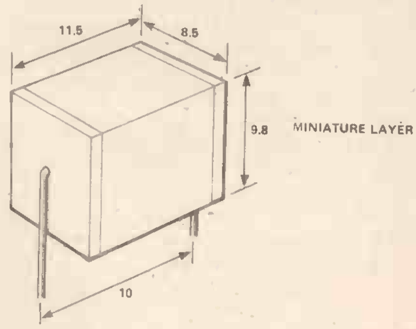
Ceramic Capacitors

For variety of case sizes, and confusing markings, it is difficult to beat the ceramic capacitor, probably most familiar in its round disc form. They are widely used in decoupling applications and at RF as they have low series inductance, and in nearly all lowish capacity (up to about 0uF1) non-critical applications. The dielectric material is normally an inorganic ceramic compound, with the higher capacitance types using one, or a mixture, of the higher dielectric constant substances such as barium titanate, mentioned earlier. Silvered electrodes are formed on each side of the dielectric to which leads are attached, prior to covering with an epoxy coating for protection.

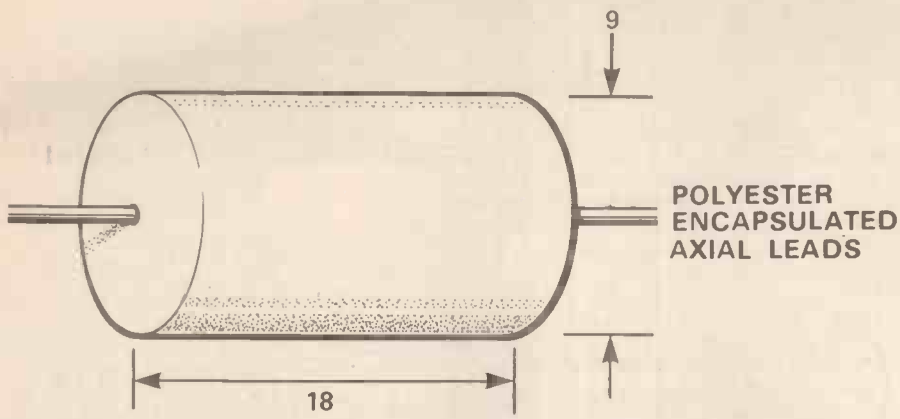
These high volume/ capacitance ratio types are often referred to as medium or high K types (K being the dielectric constant) and have a number of disadvantages over the lower value type (up to about 400pF) which use lower K materials. Their temperature coefficients are extemely high (tens of percent in some cases), and the capacitance is affected by the level and type of voltage (AC/DC) present. Although they are both excellent for decoupling in solid state circuits both for logic and RF, they have no place in RF frequency determining applications. Tolerances are often in the 20/+80% region.

When selecting a ceramic capacitor for RF decoupling purposes, use values of .01uF for use up to about 15MHz, .0047uF to about 80MHz, .0022uF up to 120MHz, and 1000pF (.001uF) to around 400MHz.

The smaller values have much more predictable tempterature coefficients and good stability, and are available in temperature coefficient groupings. The variation is from ±30 to ±1000 ppm, in groups, and as the change is linear,



Polyester Capacitors: The box-like, silver coloured capacitors are sometimes referred to in catalogues as "Siemens" type, after the manufacturer.

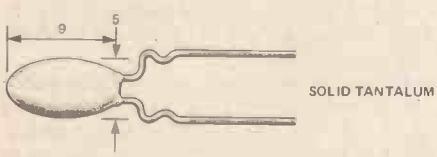


Polyester Capacitors: Axial polyester types are especially rugged and useful for high temperature environments; working voltages to 400VDC (200VAC).

they have considerable use for temperature compensation in oscillator circuits. The case is often rectangular or square (with a thin cross section) and a coloured top identifies the grouping — these are often referred to as plaquette types. Tolerance groupings can be as low as 2%.

One of the recent introductions is the monolithic ceramic capacitor, which can give a very high capacitance for a very small size, together with a low AC impedance, making them ideal for high density solid state coupling and decoupling work in logic circuits, although they are more expensive than other ceramics.

Construction is by sandwiching alternate layers of ceramic compounds



Tantalum Electrolytic: Preferred for accuracy in eg timing, filter circuits. They have very low leakage currents and good stability, but cannot withstand reverse voltages.

and resins and metal electrodes to form a large multi layer unit. After heat processing, the blocks are cut into small units, the area determining the capacity value, solderable end encapsulations added and in this form can be used as 'chip' capacitors (with minimal inductance and suited to automatic insertion) or have leads applied plus encapsulation to give a normal style capacitor. Besides the High K type, they can also be obtained in temperature compensating styles, and ultra stable forms. Tolerances ranges are similar to the other ceramic types.

Plastic Film

The most common type is the polyester film capacitor which find wide application in DC circuits. The most familiar type will be the Mullard C280 type, which is also metallised and which look like lozenges, encapsulated in a hard lacquer case. Tolerances are around 10 to 20%, with a high temperature coefficient of about 20% Construction is similar to that of paper types, with the plastic film replacing the paper.

Polycarbonate types find application in AC circuits as they have a very low power factor (power factor is the ratio of impedance to resistance). The temperature coefficient is very low. If you need to decouple AC mains input lines, this is the type to use.

Plystyrene is an extremely good material for capacitors, as it has excellent stability, and a very slightly negative temperature coefficient. The latter property can be put to good use in compensating for the positive temperature coefficient of mica capacitors in oscillators circuits. Care needs to be taken in soldering these at it is easy to damage the plastic and short out the metal layers, as polystyrene will melt at 90 degrees Centrigrade. Tolerances down to 1% can be obtained.

Metalised variants of some of the above are common — the plastic film is covered with a few microns thick layer of metal particles, often by vacuum deposition — and produce a higher capacity in a smaller volume. Use for DC applications.

Electrolytic Types

Everyone will be familiar with this type of capacitor, although modern technology has produced many variants under this general title. The major differnce betweene these and the previous types of capacitor is that we are now dealing with an electro-chemical construction, that than a passive one. They have many disadvantages, but despite this are widely used in virtually all high (greater than 1 microfarad) capacitance DC applications.

There are two main types of electrolytic capacitors — aluminium and tantalum.

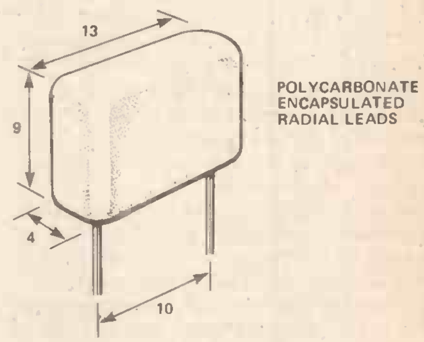
Aluminium Electrolytic

In these which are the traditional type, tow aluminium foils are separated by insulating paper and wound into rolls. These rolls are then impregnated with an electrolyte, and after electrical stabilisation, sealed into an aluminium (or sometimes plastic) container.

The normal types are 'polarised' ie, they have positive and negative terminals. The anode or +ve terminal is one of the aluminium foils, with a layer of oxide formed on this foil as the dielectric — the oxide is actually formed as DC current is passed through the capacitor. The type of foil used affects the capacitance, with an etched foil providing a greater contact area with the electrolyte which forms the cathode and therefore a much greater capacitance over plain foil types. The other foil contacts the electrolyte and connects to the outer world. In many cases the case is also the cathode, and may be covered in a wrap of plastic as insulation. The paper interleaves serve to prevent shorts between the two electrodes, and hold everything in close contact.

It is possible to obtain non-polarised verions, which can be used in AC or audio applications — you can make your own by connecting two polarised capacitors back-to-back. On on account apply AC voltages to polarised capacitors — you run the risk of an explosion, which can also occur if the capacitor is overloaded. If polarised electrolytics are to be used in AF applications, a DC bias must be applied which is greater than the peak AC voltage to prevent damage.

The electrolyte used depends on the



Polycarbonate: The material has better electrical characteristics than polyester and should be used, instead, in ore critical situations. A brass-encapsulated axial form is available for super-critical (eg high temperature) applications where price is of no concern!

application, but it should be able to repair any damage to the oxide film, and also to recombine any gases evolved by DC leakage current. If this does not happen, pressure will build up in the container with obvious results — larger units usually have a pressure relief arrangement to avoid danger.

Electrolytic capacitors have a large DC leakage current compared with other types and this factor may be important if the capacitor charge is critical, as say in timing circuits. After a period on the shelf not being used the oxide layer can start to disintegrate and allow a very large leakage current to flow. If full working voltage is applied in this condition the capacitor can be seriously damaged — it should be reformed first over a period of hours by passing a small current through the capacitor via a 10 — 15k resistor, until the leakage current has dropped to a low stable value.

Values of electrolytic types vary from 0uF1 to one farad, and the sizes from very small PCB mount types with wire terminations (either axial or radial) to be very large computer grade types (high reliability) with screw terminals. Working voltages are equally varied from 3V for high capacity miniature PCB types to 400/600V for power supply applications. Tolerance groupings are wide — often -20/+80% against nominal marked value.

Tantalum Electrolytic

This material is very popular in the form of tantalum bead capacitors, allowing miniature capacitors which are very stable and have long life — however, most cannot withstand reversed polarity to any extent. The construction of tantalum foil types is similar to that of aluminium types, but using tantalum in place of aluminium. In this case the size will be similar to an aluminimum one.

In wet-slug and solid electrolyte types, the anode is a pellet of masses of tiny tantalum beads partly fused together or a sintered pellet; covering these with a layer of oxide gives a vast increase in capacitance over aluminium types for a given size. The DC leakage current is greatly reduced and there are no shelf life problems together with the size reduction these factors make them very popular in high density solid state work, although their cost is appreciably greater. They are very useful for timing circuits.

Variable Types

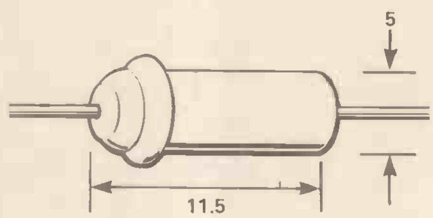
These are generally known as 'tuning' capacitors and are normally air spaced, although vacuum types are available for high power transmitting applications. The evolution of the transistor radio has also brought with it the plastic dielectric variable which offers high capacitance variation in a small, low cost package (sometimes referred to as 'poly-varicons'). Finding the larger high capacitance types is not so easy as it once was, as solid state has virtually eliminated the need for them, but rallies are useful sources if they are needed — otherwise they are expensive to buy new.

The air spaced types are available in a wide variety of sizes, capacitance, and voltage combinations. Multi section types ganged together are common, and one particular type allows one half of the gang to increase capacitance as the other half reduces. They are constructed from parallel sets of intermeshed plates, one set of which can rotate. The rotating plates are known as 'rotors' and the fixed plates as 'stators'. They are usually made of aluminium, brass, or copper and may be silver plated in the last two cases for high frequency applications. The capitance available is determined by the area of the plates, their number, and the air gap between them.

Varying the shape of the plates as they mesh is sometimes used to give a logarithmic response to the capacity/rotation curve as an aid to linear calibration curves on analogue tuning dials.

The air gap determines the voltage rating above which arcing will take place between the plates — .015 in gap will allow 600V DC working, while transmitting types may have air gaps as high as 0.25 in for 900V.

Maximum capacitance values vary from a few of tens of pF to about 400pF — the minimum capacitance for any unit depends on its construction, and could be around 3 to 5 pF for a 20-40pF maximum, to 20-40 pF for a 360pF version. This minimum unmeshed capacitance has to be taken into account when calculating oscillator or tuning coverages, and also the extra capacitance added by the wiring to the capacitor, usually referred to as 'stray capacitance'.



MINIATURE SLEEVED

Polyester: This is a metallised film capacitor used in computer circuits and for professional applications.

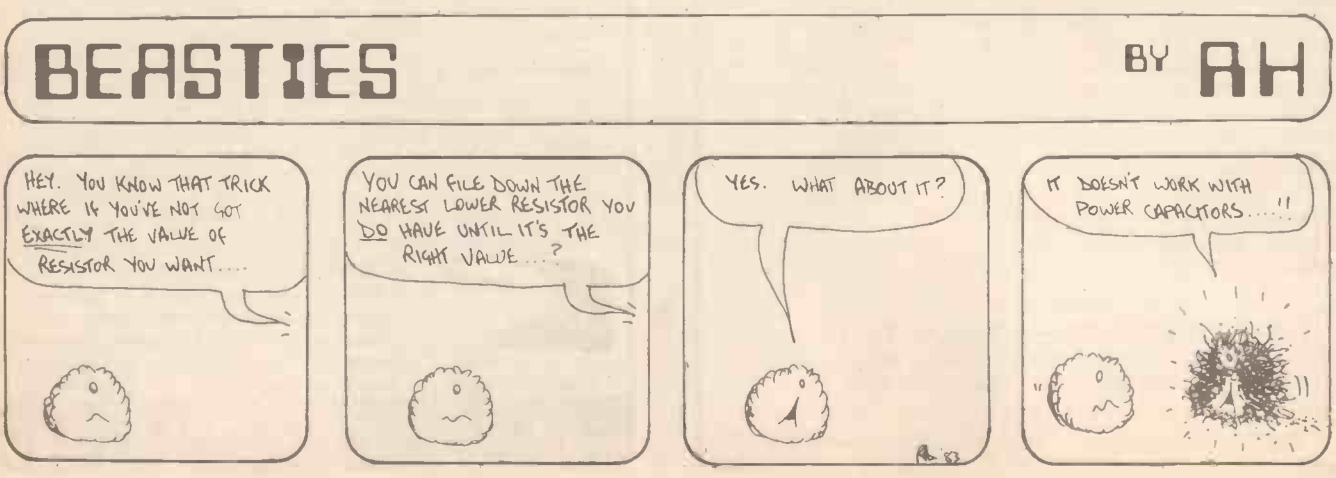
Trimmer Capacitors

Another area where styles vary immensely. The basic air spaced trimmer is a miniature version of its big brother, with the vanes sometimes cut for a solid slug, rather then made individually as in the largest types. Screwdriver adjustments is normal, rather than via a shaft, and the overall capacitance value is unlikely to be more than 50pF. If higher values are required up to several hundred pF, mica compression trimmers may be used. These consist of two flexible metal plates, between which is a layer of mica. An adjusting screw is inserted through holes in the plates, into a ceramic base — tightening the screw compresses the leaves together thus varying the capacitance.

Film dielectric trimmers are common now, and give miniature components of high stability — available up to about 60pF maximum.

Ceramic disc trimmers have the advantage of being extremely stable and are available in a wide range of values and sizes — sub miniature types of only a few mm in diameter can be seen in some watches. Construction is basically a rotor with an area of silver plate on its top surface as one electrode. The other stator plate has a similar plated area, and the two halves are held together by suitable spring pressure. The two mating surfaces are ground very flat for stability. As the rotor is turned, the area of overlapping plate is varied thus altering the capacitance. Maximum values are about 100pF — the temperature coefficient of these may be several percent of the marked values.

There are of course other types of resistor and capacitor which you may come across — however the preceding encompasses most types, and should help a better understanding of the limitations inherent in particular constructions.



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FORWARD BIAS

Questions, answers and errata from readers and writers.

A word for the anxious before we run this month's errata old and new. Forward Bias was instituted because some readers asked for a regular "spot", as featured in some other technical magazines, where they coulc be sure of finding any current errata. To make sure that this would be a *regular* column, we decided to re-run the entire Hobby Electronics errata box, as and when we have room for it, under the same heading. This is not, as one of our readers assumed, because we did not get around to publishing these errata as the time!

Likewise, when the need for a design modifiction has manifested itself over a period of time, we have taken the opportunity to re-scrutinise the whole project and improve it, while making the minimum changes to the original design. A prototype can work perfectly while being built and tested, but a small percentage of the "production run" may work less than perfectly, often due to slightly different components, or even components of fractionally different tolerances, being used. Unfortunately, we can't run an industrial six-day soak test on two dozen assorted prototypes. If we did, some things would still emerge — ask anyone who does electronics in industry! So instead we have: Forward Bias. Forward and onward.

First, not a correction but a suggestion:
Dear Sir,
My knowledge of electronics is relatively limited. I have recently constructed an electronic metronome from the HE February '80. Unfortunately, I have been unable to obtain a meter with direct readout of the frequency of the beats per minute as one may find on commercially available electronic metronomes. I wondered whether you have any suggestions as to possible solutions.
V. B. Petersen.

Adding a direct readout facility to an electronic metronome would increase its cost enormously (probably by more than the price of the metronome itself — see the author's comment on the Metronome in HE March '84 which is why you won't find one.

The solution is to make sure the metronome is accurately calibrated, which requires a moderately good frequency meter, such as the one in HE April '80.

However, unless you are a small orchestra reading sheet music to a very strict tempo, you should find that you quickly become used to the settings and can, say, increase your speed daily. An ordinary watch with seconds readout will give you an indication of whereabouts sixty sixty beats per minute is, and you can extrapolate from there.

Windscreen Wiper Delay
(HE November '83)

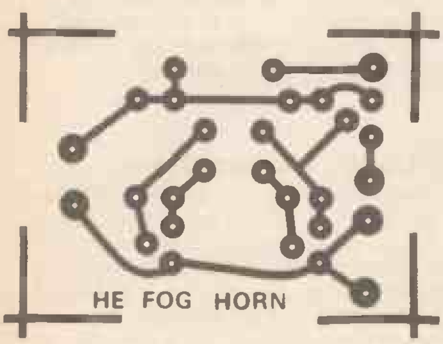
Q2, described as an MJ2995, should have been described as the MJ 2955.

COLLECTED BOOBS

Containing excerpts from the Hobby Electronics Errata Box

Fog Horn *(HE June '80)*

We said we were going to print the PCB. Here it is:



Radio Timer
(HE August '80)

On **Figure 3**, the positions of some components are shown incorrectly. Follow the solder connection as shown in **Figure 2**, which are correct (ie move Q1, R7, R8, IC1, C1, the wire links round IC1, and the connections to SW3, all one hole to the right).

Gas Detector
(HE August '80)

On **Figure 2**, two ICs are shown. The IC bottom left should be labelled IC1.

Guitar Phaser
(HE September '80)

In **Figure 1** there should not be a link where R9 to 'orange' crossed C10 to +9V (C10 is a decoupling capacitor across the the supply). The resistor from the gate of Q1 should be R14; the capacitor from the link of R6 and R8 to OV is C9.

In **Figure 3**, Q1 and Q2 are shown with the drain and source reversed. The pin-out diagram beneath Figure 1 is correct.

In the **Parts List**, RV2 should be 470k antilog as in Figure **1**.

Auto Probe
(HE September '80)

In **Figure 2** and the Parts List, Q1 can be any general-purpose PNP transistor, eg a BC179.

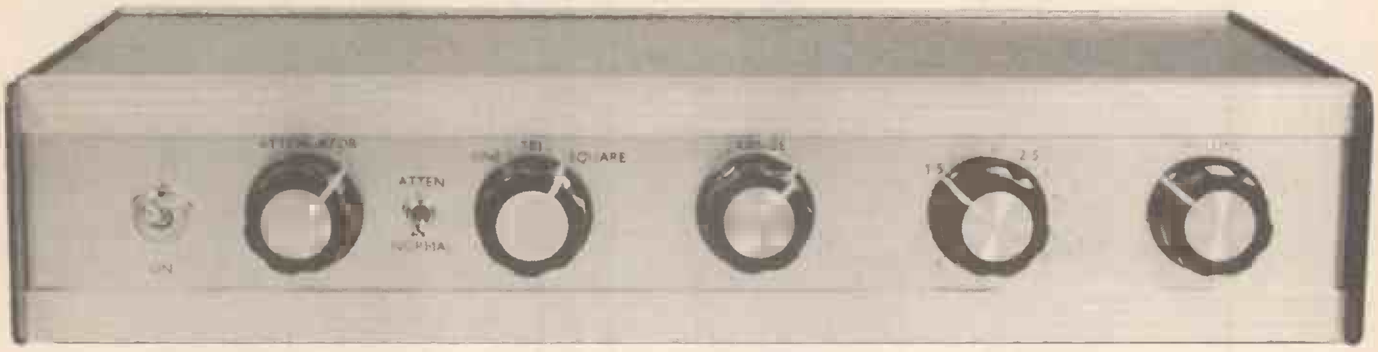
In **Figure 3**, IC1 should be inserted the other way round; LED1 and LED2 should be swapped over.

Micromix *(HE September '80)*

In **Figure 2**, the Component Overlay, RV1 (MIC) and RV2 (MUSIC) should be swapped over, and so should the corresponding input jacks.

In the **Parts List**, the values for C2, C3 and C4 are incorrect. The correct values are shown on the circuit diagram.

Analogue Test Set



An easy to build all-in-one test set designed for fault finding on audio circuits. With the addition of a simple multimeter, this project will cover just about every audio test and measurement situation

IN ORDER to make comprehensive performance checks on audio equipment a number of expensive pieces of test gear are needed, including such things as an AC millivolt meter, a high quality signal generator, and filters for distortion measurements. Such an array of test equipment, even if home constructed, is probably not a practical proposition for most amateur electronics enthusiasts. But probably few people require such a sophisticated set-up anyway. For the majority of testing all that is really needed is some sort of audio signal source, plus an audio signal tracer.

The unit featured in this article has a simple but very useful signal generator, plus an audio power amplifier for signal tracing. The signal generator covers a frequency range of under 10Hz to over 100Hz in four ranges: 10Hz — 100Hz, 100Hz — 1kHz, 1kHz — 10kHz, and 10kHz — 100kHz. Three output waveforms are available.:
available: sinewave, triangular and square. The sinewave output is the one that is required for general purpose testing, such as frequency response measurements. The maximum output voltage with the sinewave signal selected is nominally three volts peak to peak, or in terms of RMS voltage this is just over one volt.

The squarewave output gives a similar peak to peak output voltage level, but the figure for the triangle output is higher, at about five volts peak to peak. However, a variable attenuator control enables the output to be continuously adjusted down to zero, and an attenuator switch allows the output to be reduced by 40dB (a factor of 100). The latter is useful when trying to set very low output levels, and makes accurate adjustments of the variable attenuator much easier.

The output level remains almost constant over the full frequency range of the unit, with variations being no more than about 1dB. The unit has a low output impedance. The total harmonic distortion on the sinewave output is typically under one per cent, which is less than ideal for distortion measurement, but is more than adequate for most other testing, such as gain and frequency response measurements.

The audio amplifier section uses a very simple circuit based on a TBA8020M integrated circuit, which is the only active device used in this part of the unit. The amplifier has a maximum output power of about one watt RMS into an eight ohm impedance loudspeaker, an input impedance of about 400k, and an input sensitivity of approximately 20mV RMS for maximum output power. This enables an output at reasonable volume to be obtained from even a low level signal such as the output from a microphone.

Function Generator

There are two basic systems that can be used in a signal generator. One is to use a high quality sinewave oscillator, such as the popular Wien type, with a clipping circuit normally being used to additionally provide a squarewave output. This system works well in practice, giving a very high quality sinewave signal, but it has the disadvantage of relatively high cost and complexity. The second method is to use a function generator, which is based on a system along the lines of the block diagram shown in

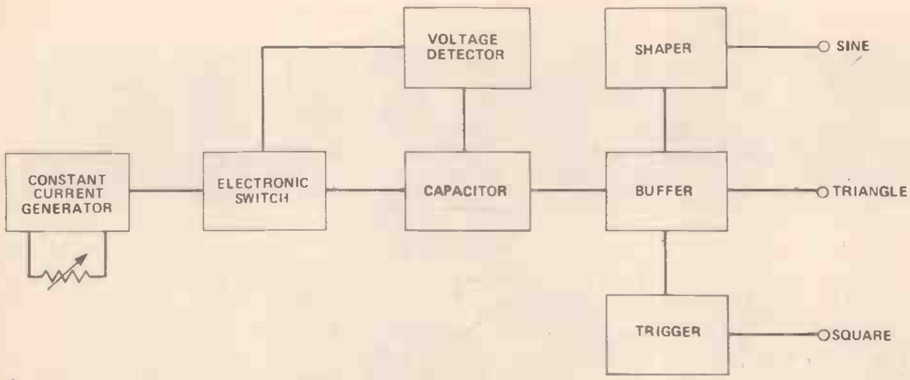


Figure 1. Block diagram of the function generator — all this on one chip!

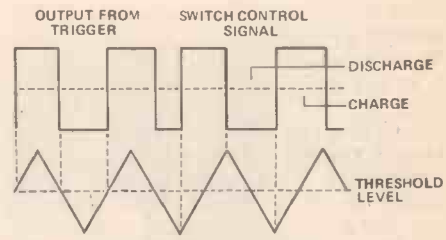


Figure 2. Generating a square wave from a triangular signal is quite easy. As shown in the block diagram (left), a trigger circuit is used to square the triangle (which is easier than squaring a circle) by switching rapidly between full positive and negative voltages whenever the triangle wave passes through a certain threshold voltage.

Figure 1. This gives sinewave, triangular and squarewave outputs, but the oscillator at the heart of the system is a relaxation type that produces the triangular signal.

This signal is generated by charging and discharging a capacitor from a constant current source. As the current is constant, so is the rate at which the charge voltage on the capacitor rises and falls, so that a triangular waveform of good linearity is generated. In a practical system, an electronic switch is used to control the charge/discharge cycle, and the charge/discharge currents are often controlled by separate circuits. A voltage detector is used to operate the electronic switch, setting it to the discharge mode when the charge voltage reaches a certain level, and then reverting to the charge mode when the voltage falls to a second threshold potential. In other words, a standard relaxation oscillator action.

The signal across the capacitor is at a fairly high impedance, and loading on the output could easily result in both a change in frequency and a degradation of the output waveform. A buffer amplifier is therefore included to ensure that excessive loading of the signal across the capacitor cannot occur. A variable resistor enables the charge/discharge current to be varied, and this acts as the fine frequency control. The operating frequency can also be changed by using different capacitor values, and using several switched capacitors enables several frequency ranges to be covered.

Sine, Triangle and Square

It is quite easy to generate a squarewave signal from a triangular one; and it is just a matter of using a trigger circuit to clip the triangular signal. **Figure 2** shows the way in which this system operates. If the triangular input signal goes above a certain threshold voltage the output of the trigger circuit quickly switches fully positive. If the input signal goes below the threshold level the output of the triggers almost instantly reverts to the fully negative state. Provided the correct threshold potential is utilized, exactly half way between the maximum and the minimum voltages of the triangular signal, the output from the trigger circuit will be a squarewave having an accurate one-to-one mark space ratio.

In many practical designs, rather than using a separate trigger circuit to provide the squarewave output, the signal used to control the electronic switch is used instead. This signal is high while the capacitor is charging, and low when it is discharging, giving an accurate one-to-one squarewave. Whether a separate trigger circuit is used or not, a high quality squarewave signal is easily generated.

Converting the triangular waveform to a sinewave one is less straightforward, and gives a less accurate output waveform. The system normally used is a non-linear amplifier which has a level of voltage gain that reduces as the input voltage on each half cycle rises. This reduction in gain round off the sharp peaks of both positive and negative half cycles, to give a reasonable sinewave output signal. Even using a fairly sophisticated shaping circuit the distortion on the output is far higher than that produced by a high quality sinewave oscillator, but a good shaping circuit will give less than one per cent total harmonic distortion, which is more then good enough for most purposes.

The amplifier obtains its non-linearity by the inclusion of diodes (or transistors connected as amplified diodes) in the feedback network. At low output voltages the diodes fail to conduct and the amplifier exhibits its full closed loop gain. At higher voltages the forward threshold voltage of one diode will be exceeded, it will start to conduct, providing additional feedback and a reduction in the voltage gain of the amplifier.

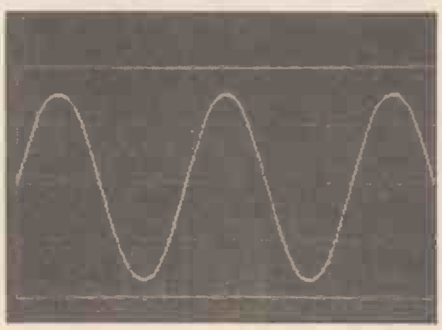
In a practical circuit, a fairly complex diode/resistor or transistor/resistor feedback network is needed in order to give good results, so that the input voltage increases as more diodes are brought into conduction. Futhermore, separate networks are needed to process negative and positive output half cycles.

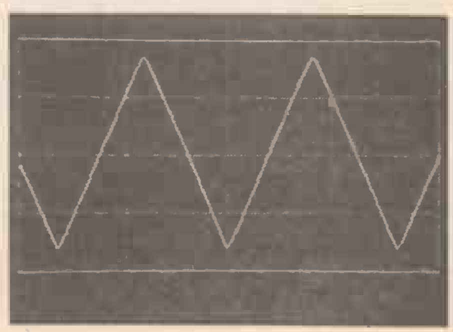
The Circuit

From the above description it will probably be clear that a function generator is a fairly complex piece of electronics. Fortunately there are several function generator integrated circuits available, and a unit of this type can be constructed using one of these plus a handful of discrete components. This unit is based on the XR2206 function generator integrated circuit, as can be seen from the circuit diagram of **Figure 3**.

The charge/discharge capacitor connects between pins 5 and 6 of IC1, and in this case four switched capacitors are used to give the unit its four frequency ranges. Variable resistor RV2 is the fine frequency control and C7 is a bypass capacitor for an internal circuit of IC1. The sinewave/triangular output is taken from pin 2 of IC1, and the output from this is normally the triangular

The output waveforms, while not perfect, are good enough for most purposes.





waveform. The sinewave signal is obtained by connecting a resistor (R6) between pins 13 and 14 of IC1.

Rather than having separate amplifiers for the triangular output buffer and the sinewave shaping circuit, the XR2206 uses the same amplifer for both functions, and switching in R6 connects the shaping components into the feedback circuit of the amplifier. This resistor could be replaced with a preset resistor, which would then be adjusted to optimise performance, but results should be more than adequate using the specified (fixed) value.

The squarewave output is available at pin 11 of IC1, and R4 is used as the load resistor, which also reduces the amplitude of the squarewave signal to match that of the sinewave output. Switch SW1b provides the output waveform switching.

The purpose of R1 to R3 plus C2 is to provide a bias current to IC1. The output amplitude from the sine/triangular output can be controlled by using a variable resistor in place of R3, but this is not very useful in this case, as it does not give control over the squarewave output. This facility is therefore left unused, and the output level is adjusted by means of an ordinary volume control type variable attenuator, RV1.

The second IC, IC2, is used as a unity voltage gain buffer stage which gives the circuit a reasonably low output impedance regardless of which output waveform is in use. C8 provides DC blocking at the output of the circuit while R7, R8, and SW3 are the –40dB attenuator.

Unfortunately the XR2206 does not work well from a nine volt supply, and a supply potential of about 12 to 15 volts is needed. Power is therefore obtained from two nine volt batteries in series via a 12 volt regulator, IC3. This gives a well stabilised supply and consistent results from the circuit.

Audio Amplifier

Figure 4 shows the full circuit diagram of the audio amplifier section of the unit. RV3 is the volume control, and this also biases the non-inverting input of IC4 to the negative supply rail. C12 provides DC blocking at the input of the amplifier and prevents any DC component on the input signal from affecting the biasing of IC4.

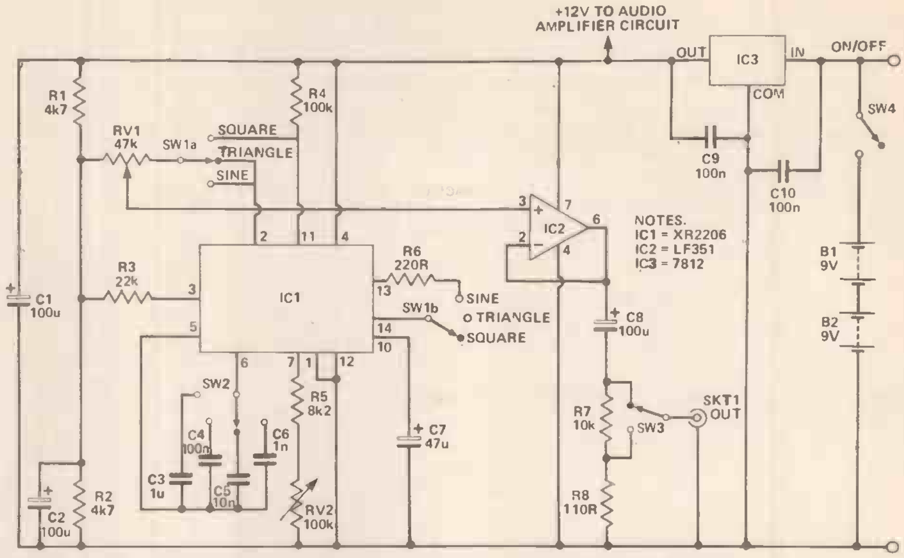


Figure 3. Circuit diagram of the signal generator section, IC1 does almost all the work, with IC2 included simply as a buffer to give a low output impedance for all three waveforms.

Apart from RV3, all the biasing is provided by internal components. The additional socket at the input, SK3 is to enable an input signal coupled to the input to be taken out to another item of equipment if desired. This is not a second input, and only one input signal should be coupled to the amplifier at one time.

Pin 2 is the inverting input of IC4, and there is an internal 6k2 feedback resistor between this and the output terminal of the device. Resistor R9 is a discrete feedback resistor, and the voltage gain of the amplifier is roughly equal to 6200 divided by the value of R9 (in ohms), or about 132 times with the specified value of 47 ohms. This represents about the highest voltage gain that can be used in practice, since higher gain could easily lead to instability, and the audio output quality would probably be significantly reduced.

Capacitors C14, C16, C17, and R10 are all needed to prevent instability. The amplifier is powered from the stabilised 12 volt supply, like the signal generator section. It would be possible to have separate on/off switches for the two circuits, but as each one has a stand-by current consumption of a few milliamps, and most of the time both sections will probably be used together, this was not thought worthwhile and a single on/off switch is used.

Construction

A metal instrument case measuring about 300 x 160 x 60mm is used for the prototype, but this is somewhat larger than is really necessary. However, it would be difficult to make the unit very much smaller than this since a fair amount of panel space is needed to take all the controls and sockets, and internally there are additionally the component panel and two batteries to be accommodated.

The general layout of the unit can be seen from the photographs, and it is advisable to keep to roughly the same overall layout. The use of a metal case is strongly recommended as this will help to shield the audio amplifier from mains hum and other sources of electrical interference. Details of the printed circuit board and component layout and wiring are provided in **Figure 5**.

Start by fitting the resistors, capacitors, and the single link wire. Close tolerance resistors and capacitors should be used where specified in the components list. Also C3, C4, C5, and C12 should be the specified polycarbonate (or sub-miniature polyester) type if they are to fit onto the printed circuit board properly. Next the four integrated circuits are fitted to the board; be careful to get them the right way round. IC1 is a fairly expensive device,

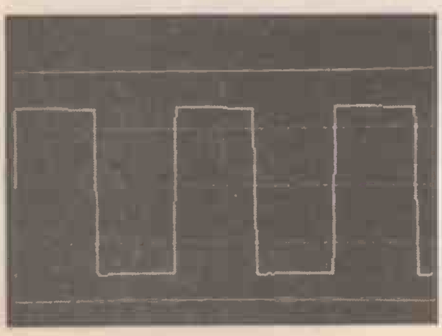
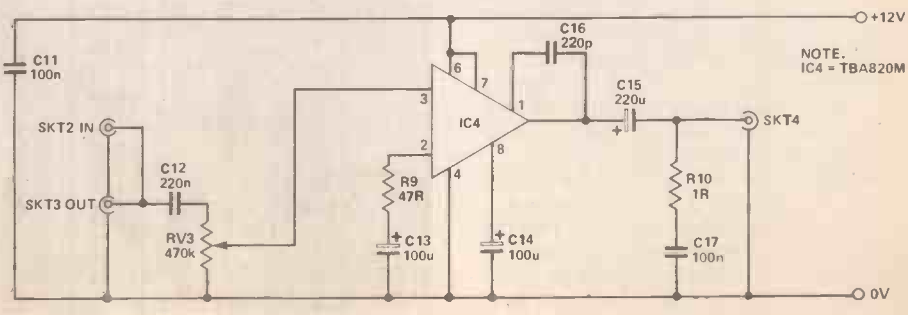


Figure 4. The audio amplifier circuit. This section will prove useful for tracing signals, or testing small audio generator circuits.



and it is probably worthwhile using a 16 pin DIL IC socket for this, even if sockets are not used for IC2 and IC4. The audio amplifier IC3 does not have to dissipate much power and it does not require a heatsink.

Finally, Veropins are fitted to the board at the places where connections to offboard components will eventually be made, and it is then mounted on the base panel of the case using 6BA or M3 fixings. Spacers about 6mm long are used to keep the underside of the board clear of the metal case so that there is no danger of accidental short circuits here. With the board completed and installed it then only remains for the point-to-point wiring to be added.

This is shown in **Figure 5**, and it is completed using ordinary multistrand hook-up wire or ribbon cable if preferred. The only exceptions are the two leads from the board to SKT2/3 and it is preferable, although not essential, to use a screened cable here, to minimise stray pick-up by the amplifier.

No earth connection to SK1 is shown, and in most cases this connection will be made via the case and the other sockets. Of course, if insulated sockets or a plastic case are used it will be necessary to use an insulated lead to connect the earth tag of SK1 to the negative supply rail.

The unit is intended for use with an external loudspeaker, and a small, inexpensive, bookshelf type is ideal. Of course, if preferred an internal loudspeaker can be fitted, but be careful to use a type which can take up an output of power of at least one watt RMS. Whether an internal or external loudspeaker is used, it should not have an impedance of less than eight ohms. A higher impedance can be used, but would give a reduced maximum output power.

A couple of PP6 batteries are used to power the prototype but if the unit is likely to receive a great deal of use it would probably be more economic to use larger nine volt batteries, such as PP7s or PP9s. However, note that these both use the larger type battery connectors, and not the PP3 type.

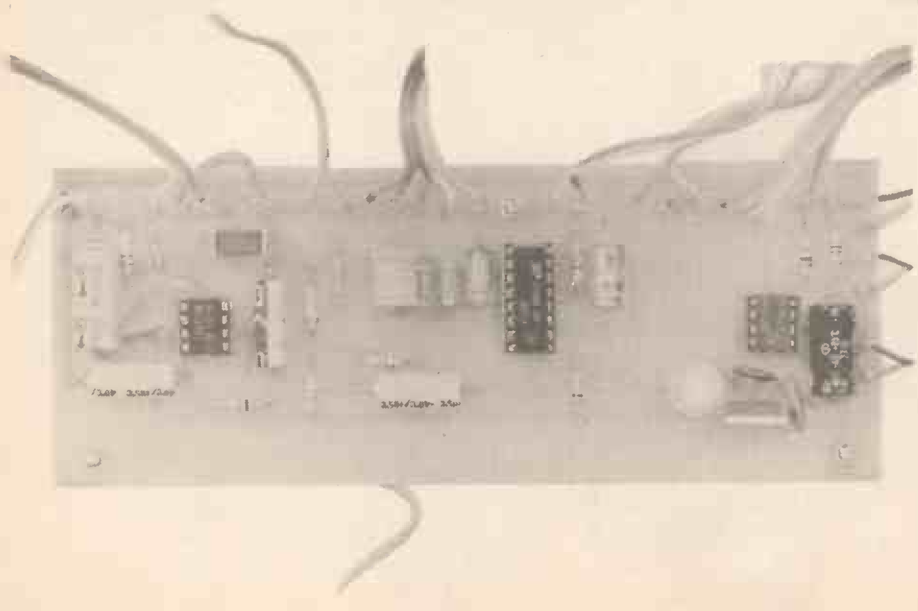
Testing And Use

The obvious way of testing the unit is to couple the output from SK1 to the input of the amplifier at SK2. Start with the output level controls of the signal generator and the volume control of the amplifier set well back, so that overloading of the amplifier is avoided. A little experimentation with the output level, frequency, and volume controls should reveal whether they are all functioning properly.

If an oscilloscope is available this can be used to check the output waveforms. If not, set the frequency controls to produce a low audio output frequency, and set SW1 for sinewave output. A sinewave gives a pure tone which does not contain any harmonics (signals at multiples of the fundamental frequency). This gives a very distinctive sound which should become more harsh when the unit is switched for triangle output. A squarewave has an even stronger harmonic content and consequently an even harsher sound.

For the signal generator to be of maximum use a simple frequency scale should be marked around the control knob of RV2. If a calibrated signal generator is available, this can be used to provide reference tones against which the unit can be calibrated. Similarly, the unit is easily calibrated if you can gain access to a frequency meter which is suitable for audio frequency use.

In the likely event of neither being available to you, an alternative is to use a musical instrument to provide reference tones. For example, the G below middle C is at a frequency of 196Hz, which is close enough to 200Hz for most practical purposes.



Parts List

RESISTORS
(¼ watt 5% carbon except where noted otherwise)

R1, 2	4k7
R3	22k
R4	100k
R5	8k2
R6	220R
R7	10k 0.4 watt 1%
R8	110R 0.4 watt 1%
R9	47R
R10	1R

POTENTIOMETERS

RV1	47k 1in carbon
RV2	100k 1in carbon
RV3	470k log carbon

CAPACITORS

C1	100u 16V radial electro
C2, 8, 13, 14	100u 16V axial electro
C3	1u polycarbonate, 5%
C4	100n polycarbonate, 5%
C5	10n polycarbonate, 5%
C6	1n polystyrene, 5%
C7	47u 16V axial electro
C9, 10, 11, 17	100n ceramic disc
C12	220n polycarbonate
C15	220u (16V axial electro
C16	220p ceramic plate

SEMICONDUCTORS

IC1	XR2206 function generator
IC2	LF351 JFET op-amp
IC3	uA7812 12V1A regulator
IC4	TBA820M audio power amp

MISCELLANEOUS

SK1, 2, 3, 4	¼ jack sockets
SW1	3 way 4 pole
SW2	4 way 3 pole rotary switch
SW3	SPDT miniature toggle switch
SW4	SPST toggle switch
B1, 2	9 volt, PP6, PP7, etc.

Case, about 300 x 160 x 60mm; printed circuit board; five control knobs; 6BA or M3 fixings; battery connectors; 8 ohm 1W loudspeaker in enclosure plus lead and plug; 16 pin DIL IC socket, wire, solder, etc.

BUYLINES ....page 26

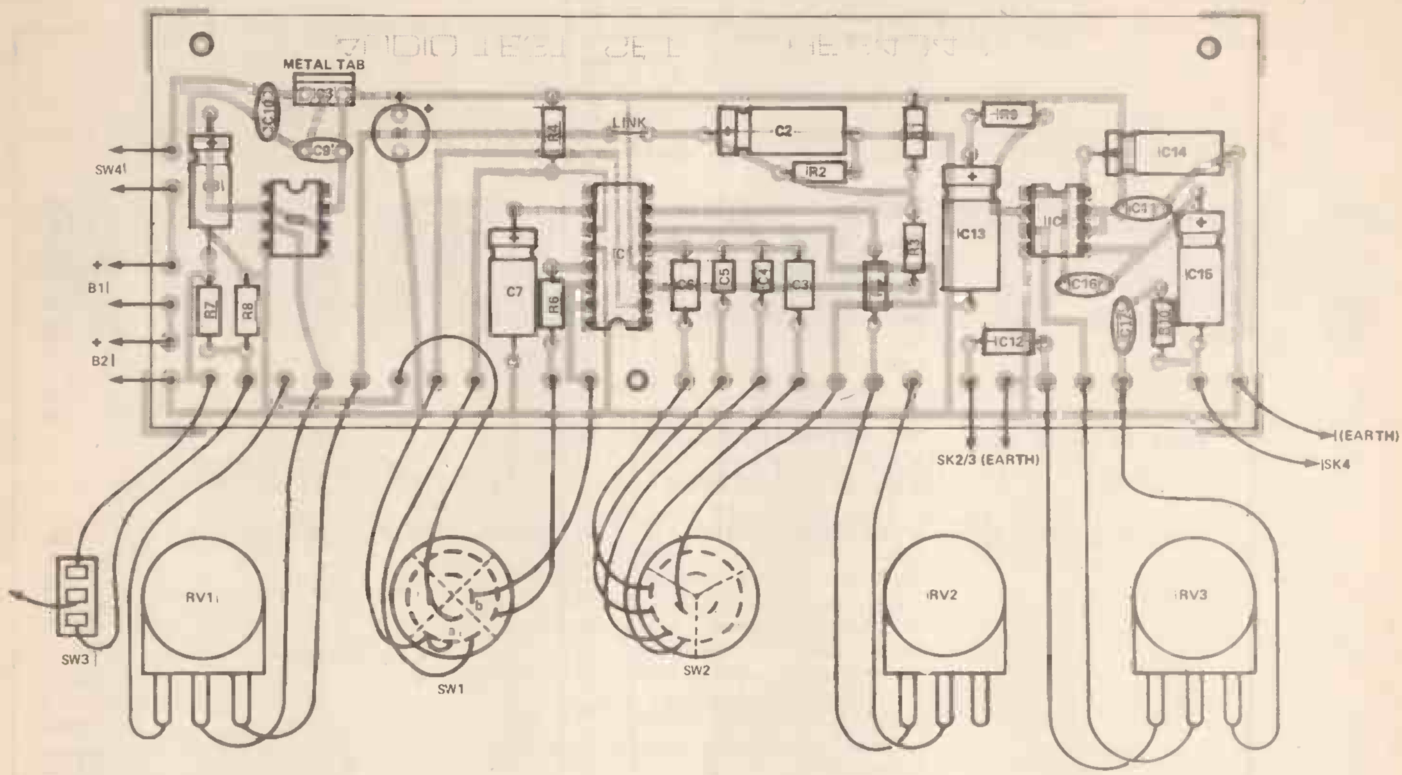
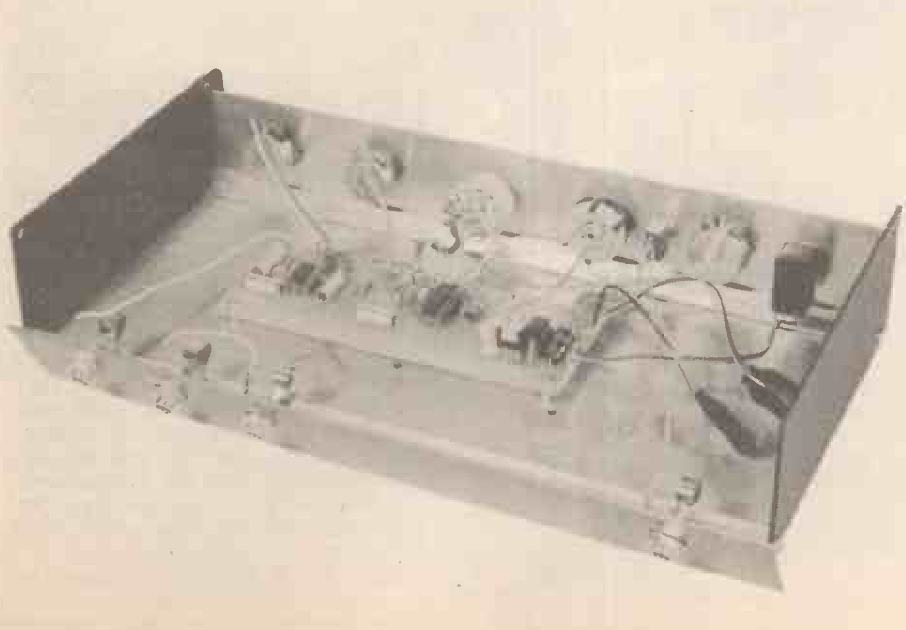


Figure 5. All components, with the exception of panel mounted controls, fit onto a single small printed circuit board (see page 64 for a full-sized foil pattern). Details of the connections from the PCB to the controls are also shown in the photographs below, and on the preceeding page.

The Gs an octave higher and lower than this are at (near enough) 400Hz and 100Hz respectively. The first B above middle C is within a few Hertz of 500Hz, and the B an octave higher is within a few Hertz of 1kHz. The nearest note to 300Hz is the D above middle C, which at 294Hz has an error of only about 6Hz. The F two up from middle C is only 1.5Hz below 700Hz, which is an insignificant error. The D below middle C is the closest note to a frequency of 150Hz (147Hz to be precise).

The frequency control of the generator is set at the correct frequency by simply listening to the output of the unit and carefully adjusting the control for the same tone as that produced by the musical instrument. Anyone with reasonably musical ear should not find this too difficult. Only one scale is required for all four ranges, since switching from one range to another simply alters the frequency by a factor of ten, and a scale for one range is easily used on any other range.



There is inevitably a small amount of breakthrough from the generator to the amplifier, and this will be most noticeable when the generator is set for a middle audio frequency. When the amplifier is connected to a single source this breakthrough will almost invariably disappear completely, and it is not something that should be a problem when the equipment is in use.

In order to make frequency response measurements some form of audio level indicator is required , and an AC millivoltmeter would normally be used for this. A simple alternative is to use an ordinary multimeter switched to a low AC voltage range, as most power amplifiers and preamplifiers can produce a high enough output signal level to drive a multimeter, most of which have a flat response over and beyond the audio frequency range. Beware of some digital instruments though.

Use a sinewave signal for frequency response measurements. The square and triangle outputs are of most use in conjuction with an oscilloscope. A squarewave signal can be used to test equipment for instability on fast waveforms, and this instability usually shows up in the form of a high frequency signal modulated onto the output of the equipment under test. A low level triangle signal can be used to test for cross-over distortion in class B power amplifiers. This manifests itself as kinks in what should be the straight lines of the triangular signal.

HE

A Hobby Electronics Hard Case review . . .

METRODRIVE

Up the Wall . . . Round the Bend . . . Back to the Front . . . Round and Round . . . this revolutionary machine will drive you to places yet undriven.

by our Motoring Correspondant

AFTER fifteen years of research Lady Clair Sinclive has finally revealed the car that we will drive into the nineties. Priced at just £999.95, the new Metrodrive is a most original vehicle. From its characteristic black plastic bodywork to its unusual wheel-less design, the Metrodrive challenges all we have come to expect from a car.

The car was delivered in an enormous expanded polystyrene box. Unpacking the box reveals a flat black car, held together by four screws at front and rear. The screws at the front have been positioned for easy access when entering and leaving the vehicle. Early Metrodrives are only available by mail-order, although most High Street stores are expected to stock them later in the year.

The Drive Unit

The Metrodrive uses a continuous-loop caterpillar track instead of the circular wheels favoured by other car makers. Its all-electric motor is welded directly onto the chassis, rather than bolted and socketed in the usual manner. Sinclive explained that this enables the motor to dissipate heat more readily — the Metrodrive tends to run warm, and the manual warns that it should only be driven on well-ventilated roads.

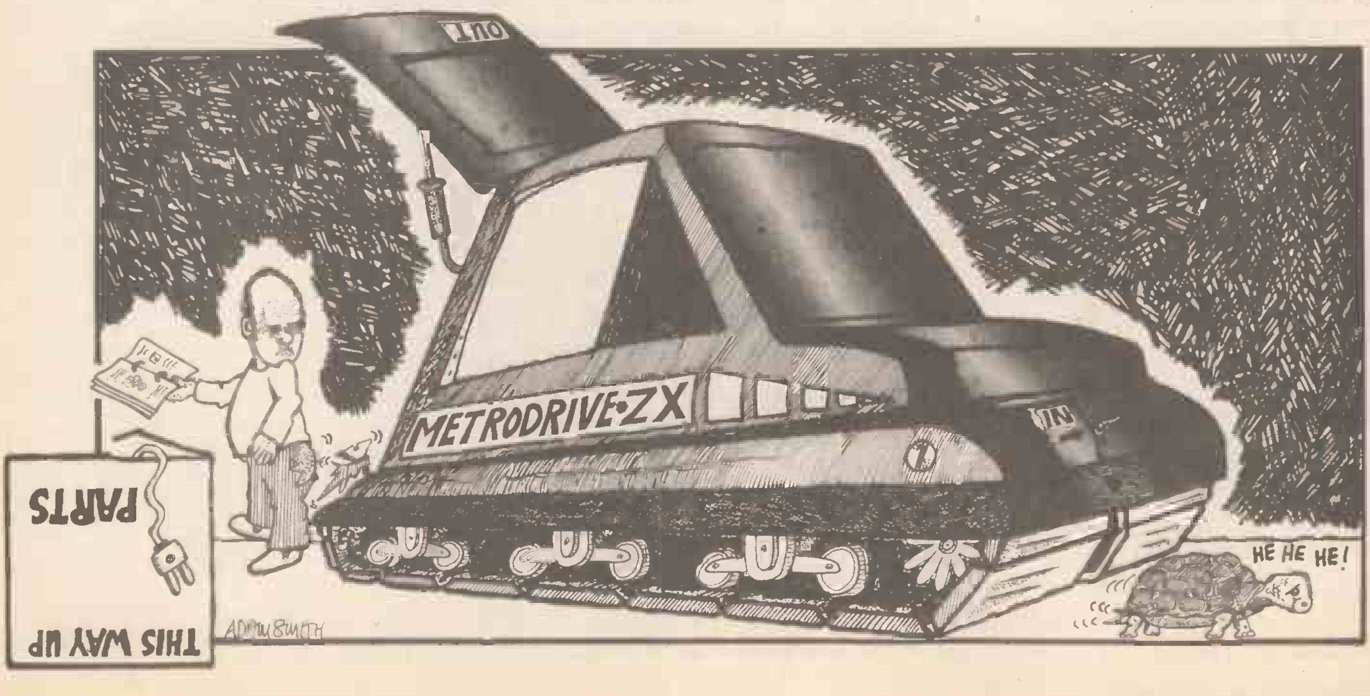
Benchmark Timing

FOR MPH=0 TO 30 :
NEXT MPH 55 seconds

Performance

Performance is all we have come to expect from a Sinclive design. The car has two speeds, labelled FAST and SLOW. At the slow speed you can travel at a maximum of about 10 miles per hour. The fast speed is about four times quicker, but it has the disadvantage that

SCOOP! Our Technical Artist in the field has despatched this exclusive representation of the Metrodrive prototype undergoing speed and stability tests at a secret location at 55 Acacia Ave., Cheltenham.



Another exclusive: the Milspec version of the Metrodrive was snapped in action by our man as he fled Acacia Avenue at a stiff walk. Now in hospital recovering from severe turtle bites, he commented: "In this business you expect trouble from small animals. Gerbils, for instance." The snapper snapped?

the windscreen goes blank until you select SLOW again. Sinclive recommend that FAST should only be used on uncongested, well-known stretches of road — SLOW should always be used when approaching junctions and roundabouts.

The range of the standard model, the ZX Metrodrive 1K, is rather limited. You can travel about one mile on a freshly-charged power pack, although it is possible to go futher if you are prepared to put up with a reduced windscreen size.

The add-on power pack, the Metrodrive 16K, will soon be available. This extends the range to sixteen miles and fixes the windscreen at its full size. The pack, priced £899.95, simply hooks onto the back-bumper. Reports from within Sinclive suggest that the design of the 16K unit is still being finalised, due to the unit's tendency to spontaneously disconnect itself, often with frustrating consequences, especially during motorway driving.

Controls

The internal controls of the car show another break with tradition. The usual gearstick has been omitted — instead you may select SLOW speed by pressing the brake and clutch buttons together, and FAST by pressing the clutch and accelerator. Although logical, this scheme tends to lead to some rough gearchanges.

The usual steering-wheel has been replaced with a set of damp rubbery pads on the dashboard. Pads on the left turn the car in that direction, unless the window is open, in which case they work the electric indicators. The opposite pads work similarly, giving control over right-turns and the single, roof-mounted headlight.

Also on the black plastic roof you find the brake lights (positioned there to minimise wiring lengths) and the two electric indicators. These have been place one behind the other to reduce wind resistance.

The Add-Ons

Drivers who find the unusual control layout off-putting will be pleased to hear that add-on companies have already started work on alternative controls. Daytronix are testing their new externally fitted steering wheel, and Motek have announced an interface which allows you to control the car with a standard Atari or Commodore joystick.

Every Metrodrive has a car radio fitted as standard. The loudspeaker is just half an inch in diameter, however, which means that reception is normally drowned by the continuous high-pitched hiss of the engine. There is no volume control, although add-on amplifiers are becoming available.

The Competition: in the White Corner, Ford's UFO can now achieve 2519 miles per gallon at an average speed of 24 km/h (15 mpg) on only three wheels. "The most slippery Ford ever made" is the Company's proud commment. Can this spell bad news for the all-electric vehicle?

Maintainance

Recharging the power pack of the Metrodrive is a simple procedure — you merely connect the power inlet lead (an extra, priced £49.95) to a normal household 719 volt DC socket, and the vehicle recharges itself automatically. Sinclive warn that the Metrodrive may be incompatible with certain makes of electricity, although no problems were experienced in practice.

The Manual

The manual supplied with the car is a hefty 300 page ring-bound volume. It sports a dramatic picture of a cloud mutating into a cash-register on the cover. Inside, the care and maintenance of the car is explained in detail, along with a tutorial course in driving, with graduated difficulty levels and exercises at the end of each chapter.

The contents of the manual are mostly good, although the section on looping (at roundabouts) is rather unconventional and the explanation of parking in bus lanes may prove confusing to the beginner.

Conclusion

The ZX Metrodrive is a revolutionary car at a revolutionary price. Only time will tell whether or not its more unusual features will catch on. **HE**

POINTS OF VIEW

Feel like sounding off? Then write to the Editor stating your Point of View!

A New Issue

Dear HE,
I would like to build the I/O Interface as featured in HE August and September '82. However, I was wondering if it would work on an issue two Spectrum as well as an issue one. Also, have you published any other computer add-ons for ZX computers? I would be very grateful if you could help me.
Yours sincerely,
M. Harvey,
Bradford-on-Avon,
Wilts.

PS. SAE enclosed

PPS How about a "sound through the television" project to amplify the Spectrum beep?

We know of no reason why the Spectrum I/O board should not work with any computer. But here's a tip on constructing the project: make sure you make the connections appropriate to operation with a Spectrum, not those for the ZX81 alternative. This was a dual-purpose I/O board with options for the Spectrum or ZX81, and several readers have had problems because they did not read the article carefully enough, and constructed the wrong version!

We have published two Spectrum add-ons since the I/O board: a sound-generator in June 1983, and a programmable joystick interface in August 1983. And in the first issue of *Digital & Micro Electronics* you'll find two Spectrum add-ons: a circuit to allow the computer to control colour photographic processing, and a scanning digitiser project. A versatile speech synthesiser for the Spectrum or ZX81 was published in No. 2 of D & ME, and a small amplifier with a built-in programmable noise source (for effective explosions, gun shots, etc.) will appear in No. 3, which is out on 16th March.

Lost And Found

Referring to POV, January '84, the reader enquiring about Doram Electronics: this company was originally set up by Electrocomponents, the parent company of RS, to cater for the hobbyist. In the summer of 1981, the Dutch owners of the company, De Boer Electronika, decided to close the firm down. Referring to Monitor, about Microbooks — new company? The address is that of Greenweld Electronics.
R. Ormston,
Hythe,
Hants.

Could this be yet another hardware company branching out into computer publishing? Do editors go to the pub at lunchtime?

Mr. Ormston is also vexed by people behind the components counter in certain dealers who smoke and exchange banter about the customers. While HE feels that it has done enough about customer relations just lately to be taking sides, the point is a good one. Why don't your write and tell them?

No Joy

Dear Sir/Madam,
I enclose a copy of a letter concerning an order placed in good faith in response to an article/advertisment in your magazine (HE August '83).

As you can see from the letter I am experiencing extreme difficulty in obtaining either completion of my order, or indeed any communication, from Cambridge Computing.

Could you possibly investigate this matter on my behalf?

Thanking you in anticipation.
Yours faithfully,
F. J. Street,
Reading,
Berks.

We have had several letters from readers disturbed because they have not received goods ordered from mail order suppliers, including Cambridge Computing.

Upon contacting the companies concerned we have discovered a common reason behind the complaints. There is, at the moment, a world-wide shortage of digital integrated circuits, particularly TTL 74 series and dynamic RAM chips. This has made it somewhat difficult to supply projects, and desperate measures have been taken to obtain the components. Cambridge Computing have gone direct to source, ordering components from Japan.

There is no easy answer, then for readers still awaiting goods, except to be patient in confidence that the order will be filled when the components arrive. In a situation where demand is so much greater than supply, there is not much alternative.

We have also heard from Cambridge Computing concerning a problem that many people have had interfacing the Intelligent Joystick to a Spectrum while running a Microdrive.

The explanation is that a detailed technical specification for the interface was not available when the Joystick was designed, and when the Sinclair interface was released, it turned out to be incompatible.

However, the problem has been solved, and Microdrive compatible Joysticks are now being supplied to new buyers. A new program tape for use with old joysticks is also available from Cambridge Computing for a nominal charge of 50p.

Back, Back

Dear Sir,
I enclose a snippet taken from the motoring column of a recent Sunday paper. It describes a reversing aid for cars, with an ultrasonic emitter/sensor at the back, which gives an audible warning to the driver when he gets as close as six inches to an obstruction. The trouble is, it cost £150.00 (yes, the point is in the right place — Ed*). Is there any chance of publishing a project for something like this?*
Yours faithfully,
F. B. Laitwood,
Redhill,
Surrey.

This is an idea which gets kicked around the office from time to time. While it's quite a good idea as such, it always turns out to be a bit more difficult in practice (as indicated by the price tag on the device you mention, perhaps). However, we'll keep on kicking it around. Perhaps someone will come up with a design which HE readers (and HE) can afford, although the specification, obviously, won't be anything like as rigorous as the commercial one.

Not Funny Any More

Dear Sir,
In the January '84 issue of Hobby electronics you printed a letter i sent you, But you missed out the important sentence, which was:- instead of reprinting old letters i.e. Personal Project' which was first in Hobby electronics July '83 issue and then in October '83 issue. The rest of the letter was just a joke, (You remeber jokes the first person say's something, then the second person makes a funny sound it's called Laughing, People used to Laugh alot you know). And who said anything about the Hobby errata box or original errors, i did'nt. I would like to congratulate Ian Sinclair on his into electronics components series and the very interesting famous names series.
your's sincerly
P.Greenhouse.

Thanks for the compliment. Now to business. We cut bits out of letters (and projects, features, specials and news items, including the ones we write ourselves) to keep the number of errors, inconsistencies, irrelevancies, obscurities and obsolecencies to a minimum. If we didn't, you'd soon notice. Well, you did, didn't you? Personally, I thought the point about reprints was a good one, ditto CD, and worthy of a reply. The bit about the errata was a j***, whatever one of those is . . .

Now on to some entertainment:

Famous Claims

In December '83 (*I Almost Met*) we asked if readers had any Famous Names whom they had particular reason to remember. Here is a selection of responses.

Famous Names — D. T. N. Williamson
I wonder if anybody remembers that the gentleman named above was the genius who invented hifi by producing a huge unorthodox output transformer which revolutionised the reproduction of music. I worked as a toolmaker with Ferranti Ltd. in Edinburgh during and after the war, and though I enjoyed my job I was fascinated by the electrical amplification of music. I contrived as often as possible to leave my bench in order to sneak into the laboratory to chat to the experts, BScs and mechanics, all about things electronic.

When I first heard the experimental set-up utilizing the new output tranny — eight speakers of all sizes — I was stunned by the clarity. Needless to say I strove desperately with PX4 or 646 PP outputs at home to get the same results, but without that transformer, it was a waste of time.

I understood that DTN had no letters after his name, but used to argue forcibly in Wireless World's letter page on subjects certainly over my head. I left Ferranti in 1957 for Bristol and sadly we have never seen his name mentioned, though it deserves to be.
Yours faithfully,
John Fraser,
Nairn,
Scotland.

Dear Sir,
I enjoyed Ian Sinclair's chatty articles "I Almost Met" in HE December '83, and wholeheartedly agree with his choice of genius, W. Amadeus Mozart.

Now to almost meeting people. I think I almost met Monty in the last years of the war, at a Variety Show for the forces in Brussls. He looked just as I had expected, and I was very impressed. Now *I realise that if I had met him, it probably would not have been him anyway! For we have since been told that his double was about. When I think of the circumstances, the Variety Show itself, and being hugged and kissed very demonstratively at the start by a gorgeously bedecked and perfumed Evelyn Laye! I suspect that the real Monty would most likely have wriggled smartly out of something like that. But I suppose I'll never know, or could someone out there . . . ?*

I did meed a very different sort of character earlier in the war though. I was a Bombadier in charge of a G. L. Section (very early A. A. radar) on a Heavy A. A. gunsite in Croydon. We had this visit from a beautiful, and beautifully dressed (male) civilian who was to sit in with us during a night action. "Christ" we thought as he squeezed into our little revolving cabin, "What on Earth have we got?"

However, Jerry arrived, so we got going, furiously winding handles, shouting things you should and shouldn't shout, the 3.7in Mobiles banging away. Then when things had eased off a couple of hours later our immaculate visitor gently extricated himself from his seat. "Thank you, chaps," he said, again beautifully and jumped gracefully out into the not now so noisy night. Give him his due, he hadn't turned a hair (that's probably why he'd refused a tin hat!) It transpired that he was Godfrey Winn, doing a story on London's defences. He was quite something. But I never saw what he wrote about us.
Yours faithfully,
D. C. Emmerson,
Northampton,

Dear Editor,
When I was at University College in London, I was just in time not to meet R. V. Jones, who we think now was the same Prof. R. V. James who later wrote a very interesting and well-known book on codes and warfare, but we cannot be 100% certain as at this time he had not written his book and had not become well known.

However, we knew he had been around because one of my colleagues found a discarded door-plate from the electronics department, which said "R. V. Jones". We knew it had belonged to someone significant, so we decided to keep it as a souvenir, but we couldn't think where to put it. Then some bright spark had the idea of putting it on the door of the "Gents". For a long time afterwards, to "visit R. V. Jones" had a quite specialised meaning which doubtless some contemporaries of mine at UCL will still remember. However any historians wanting to know where R. V. Jones had done his secret research may have been misled to an answer that they didn't expect! Perhaps, after all, it wasn't the same R. V. Jones, but I like to think it was!
Yours faithfully,
Ali Taalf,
Solihull,
West Midlands.

Fame cannot be denied: so I did a bit of asking around to see what we were dealing with here.

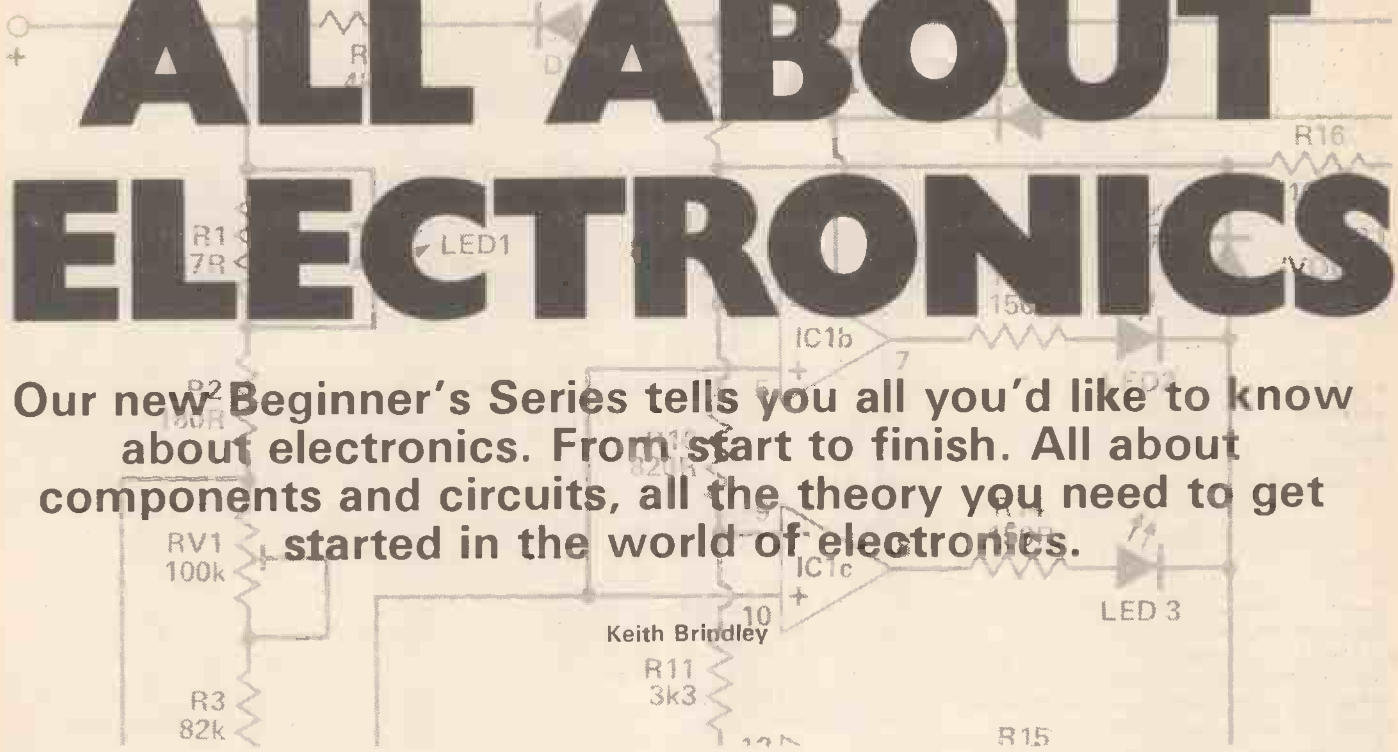
I can offer no advice as to the authenticity of Monty in Brussels, but would be delighted to hear from anyone who can, provided it does not contravene the official secrets act . . .

Ferranti in Edinburgh confirm that D. T. N. Williamson did indeed develop a device known as the "Williamson Amplifier" which revolutionised hifi by providing a transformer which generated far less noise than anything previous. He also worked on record arm pickups and loudspeakers, before going on to work on the computer control of machine tools. He was eventually made a Fellow of the Royal Society, so, yes he did get those letters after his name.

University College deny that they have any record of an R. V. Jones on their staff who would warrant a door plate, or that such a door plate has been seen (recently, at any rate) on the Gents. Prof. Jones, apparently, worked in the Department of Natural Philosophy (no comments, please) at Aberdeen University. How a door plate with his name on it worked its way south to London is anybody's guess.

Does anybody have a yellowing newspaper article by journalist Godfrey Winn on London's anti-aircraft defences during the war? As a closing word on the subject, the HE team have had their moments of almost-glory, for instance, sharing a bill with The Police in a small club in Australia and not asking for Sting's autograph in quadruple, failing to recognise Rick Parfitt in the Camden Palais time to say anything intelligible (unless 'gerk' is intelligible), and not meeting the Queen "because she only had time to speak to the odd person, and I wasn't odd enough". Which isn't a claim you hear all that often, around here . . . **HE**

ALL ABOUT ELECTRONICS



Our new Beginner's Series tells you all you'd like to know about electronics. From start to finish. All about components and circuits, all the theory you need to get started in the world of electronics.

Keith Brindley

As man evolved, from caveman to civilised city-dweller, he has always needed to communicate to his contemporaries. It is only through communications that ideas are passed down, from generation to generation, so that they are not forgotten. Obviously it is this communication of ideas which prevents us from re-inventing the wheel every few years.

Of course, early communications came only in the form of sign language — shaking a fist means anger, waving a hand means goodbye — but then came speech. Speech allows two people to actually tell each other, in quite explicit terms, what their ideas are. (*Spend a day in the office and you'll see what we mean — Ed.*) Later on, it became possible to write down the ideas, thus making a more permanent method of carrying ideas accurately and repeatability.

All forms of communications — typified by the following three examples — have the same principal: a sender of information relays the information in some way to a receiver of information. The information to be sent and received must be sent in a form which is understood by the receiver. For example, it would be useless if two cavemen were fighting over territory and the anger expressed in the shaking of a fist by one was interpreted by the other as meaning "I love you"; likewise, no meaningful information will be received by a Frenchman listening to a German if both could only speak and understand their native languages, and it would be equally futile for me to write the rest of this article using the Russian alphabet! The *signalling* method used must be understood by both the sender and the receiver for meaningful information to be communicated.

Speed And Distance

Electronic communications began with the invention of the telegraph system, a simple version of which is shown in **Figure 1**. The sender is the key, operating a switch which makes the circuit when pressed and breaks the circuit when released. The receiver is the buzzer which buzzes whenever the circuit is made. By using an agreed signalling method, understood by the people at each end of the telegraph, for example Morse code, meaningful information can be transmitted from sender to receiver.

The telegraph is a good example of electronic communications because it typifies two important and advantageous points:

- high speed — the buzzer buzzes when the key is pressed.
- long distance — telegraphy can be used over hundreds of miles.

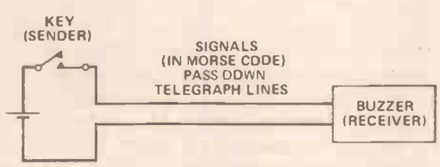


Figure 1. A simple telegraph system, illustrating the principle of communication: a sender (the key); a receiver (the buzzer) and an agreed code (Morse code).

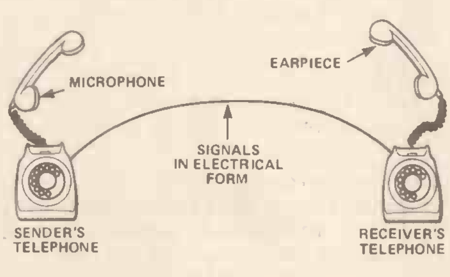


Figure 2. The telephone as a communcations system.

In the previous examples of human communications, distance limited communications to line-of-sight or within earshot. Speed was restricted to how fast the sender could run with a sheet of paper to the receiver. Electronic communications overcame these disadvantages — and, in fact, to help show this, electronic communications are often simply called telecommunications.

As telecommunications have evolved, a large number of methods of transmitting the information from sender to receiver have been developed: some of these, like the telegraph, are digital in that the signalling procedure contains pulses of information (ie, when a pulse is present the buzzer buzzes, when no pulse is present the buzzer is silent). Other signalling methods are linear (ie, constantly varying between totally on and totally off). The prime example of a linear telecommunications system is one in which the information is transmitted as an electrical signal which is an analogue of the amplitude of the sender's spoken information — the telephone **(Figure 2)**, although as you will later see other signalling methods are used in a modern telephone system.

In the telephone, the microphone at the sender's end acts as a transducer which converts incoming sound pressure waves into the electrical signal which is then, of course, directly analogued to the sound waves. The electrical signal passes down the line to

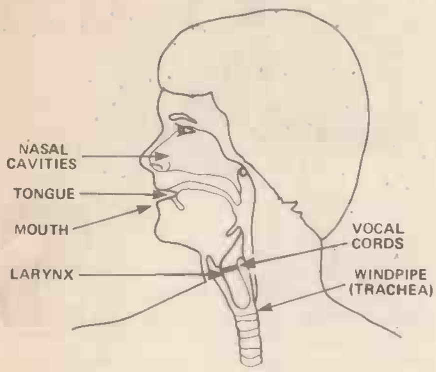


Figure 3. A cross section of the head, showing the mouth, tongue, larynx and vocal chords, which allow us to speak.

the earpiece at the receiver's end where the exact opposite occurs — the earpiece converts the electrical signal back to sound waves. Thus, the spoken word can be transmitted over a distance between sender and receiver.

Many different types of signalling procedures, both digital and linear, have been developed as telecommunications itself has developed. They are, in fact, too many for us to discuss all in detail here, but we'll see some of the more important types as we go on.

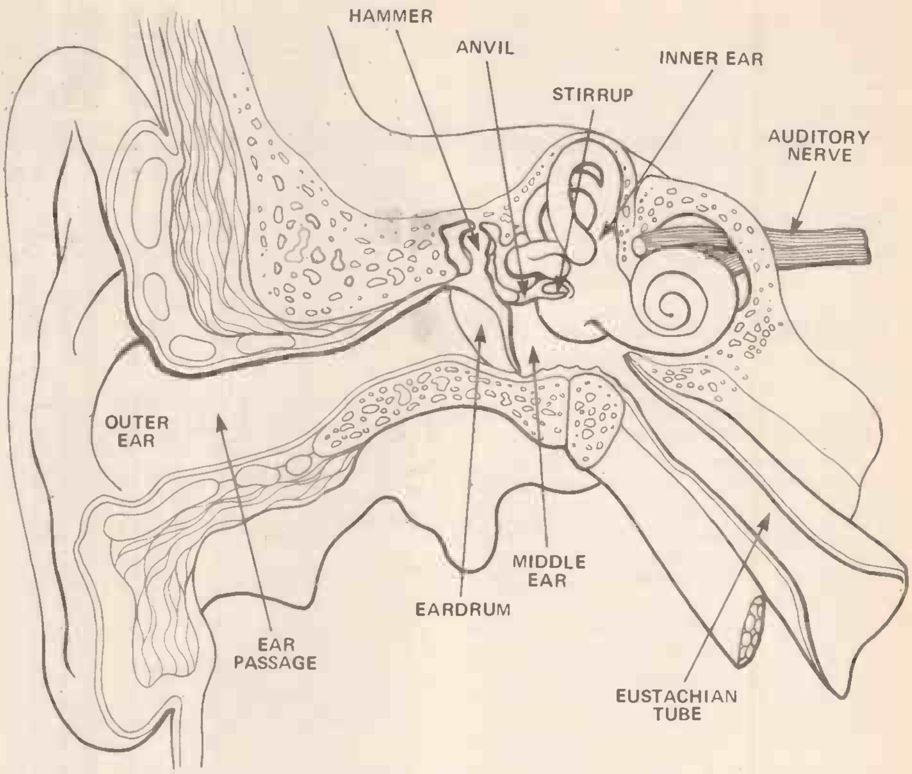


Figure 4. The inner ear. Sound waves in the air vibrate to the eardrum, which is connected via a number of very fine bones to the auditory nerves.

Eye Say, Ear 'Ere

There are many such electronic concepts involved in telecommunications but a lot of them have direct parallels in sight and sound so we could do worse than look at the human organs which enable us to speak, hear and see. **Figure 3** shows a cross-sectional view of the head. The vocal cavity, known as the larynx, is shown, holding the vocal chords. Air is exhaled up the trachia (or windpipe) from the lungs, passing through the vocal chords to the nose and mouth. The vocal chords consist of a pair of membranes fixed to the trenches, which can vibrate and affect the passage of air.

The sound of the human voice is quite simply the air itself passed through the vocal chords in a particular way. We can alter the frequency or pitch of the sound (with muscles which control how tight the membrane is), or we can alter the amplitude or loudness of the sound (by controlling the amount of air exhaled), or we can alter the timbre or shape of the sound (by changing the shape of the nose and mouth — the nose and mouth act as a resonant cavity which accentuates sounds of a certain frequency while diminishing others).

Thus by a combination of complex bodily functions we have complete control over sound — well, not quite 'complete' — there are limits:

1) the frequency range of the sound humans can make is approximately 100Hz to 6kHz — varying from person to person.

2) the amplitude of human sound varies from the quietest whisper to the loudest shout — but cannot, for example, be as loud as a jet engine.

3) the number of 'shapes' of sounds we can make is limited in complexity — you can't for example sound like a piano.

These limits are purely human limits and other sounds can obviously exist with frequencies, amplitudes and timbres outside the ranges of the human voice.

We have discussed how we make sounds, but how do we hear the sounds once made? The ear, of course, (**Figure 4**) does this job. Sound passes through air as a sequence of minute variations of air pressure (called waves) — rather like the waves which spread out if you drop a pebble into a pool of water. The frequency, amplitude and timbre of these air pressure varitations is dependent on the frequency, amplitude and timbre of the sound itself. The air pressure variations form a signal which is analogous to the original sound. The ear simply detects this signal and passes on the information about the sound to the brain, in the following way:

- the sound waves in the air by the auricle or outer ear into the middle ear where they hit the eardrum.

- the eardrum, which is a thin membrane, resonates in sympathy with the sound waves, thus it vibrates with the same frequency as the sound and with an amplitude dependent on the sound's amplitude.

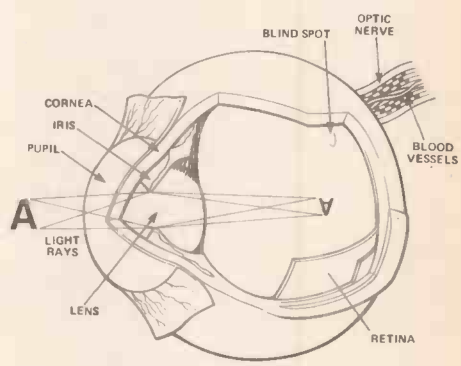


Figure 5. The eye: light waves reflected from an object are focussed onto the retina by the lens. This information is passed to the brain via the optic nerve (where it is subsequently re-inverted, so that we see the 'right way up').

- the vibration of the eardrum is coupled with via a number of small bones to the nerves in the inner ear which then transmit minute electrical signals to the brain.

Another part of the body allows communication in a visual way rather than the audible manner of the larynx and ear — that is the eye. The eye (**Figure 5**) performs a similar function to the ear in that it converts incoming signals into the electrical impulses which the brain can respond to. In the ear these incoming signals were carried by sound waves from the source of the sound. However, the eye receives only light waves from whatever source it looks at. These light waves enter the eyeball through the cornea at the front and are focussed by the lens onto the retina at the back. The optical nerves transmit electrical signals, corresponding to the image on the retina, to the brain and so we can see the source.

The Medium

These two human communication functions of sight and sound follow the general communications pattern discussed previously ie, there is always a source or sender of information and a receiver of information. However, the specific examples allow us to look closer at the concept and to discuss other ways of communication. **Figure 6** shows the concept of communications in greater detail.

In it you can see the source of the information eg, a person's larynx and the receiver eg, an ear, but you can also see that a particular part of the drawing is shown as the transmission medium. With human sight and sound this transmission medium is normally taken for granted (but still it must be considered in any study of telecommunications) and is the air itself in this simple example. We can use the study of human sound communications in air as a good example to discuss the transmission medium's limitations.

Figure 7 represents somebody talking to somebody else separated by a distance in air of, say, 10m. Speech frequencies are, as we've already seen, in a band of frequencies between about 100Hz to 6kHz. We say that the bandwidth of the transmission medium (ie, air) must be at least 100Hz to 6kHz for the speech information to be passed from the source to the receiver accurately and without change. Likewise, the attenuation (or loss) of the transmission medium must be small enough so that over the set distance the receiver can still hear the information. (At 10m there is no real problem but over, say, 100m or 1000m the problem becomes acute and the receiver will not be able to hear the information due to the attenuation). Finally, good communication between source and receiver will depend on there being a low enough level of noise so that the noise does not overshadow the signal: for example, if the two people were communicating from opposite sides of the road and a large lorry is driven past. The noise of the lorry could drown out the spoken signal.

These three characteristics: bandwidth, attentuation and noise, are of interest to us whatever transmission mediums we choose to use in telecommunications and we'll see why soon.

The Media

Basically, there are only three types of transmission media available, but these can often be divided into sub-groups depending on the signalling method chosen and the performance required. These three main types and typical uses are:

1) air — sound, light, broadcast radio and TV communications
2) cable — sound (eg, telephone) computer and digital communications, high-frequency (eg, cable TV). Wire in the form of cables giving us the most used transmission medium in use today
3) optical fibre — telephone, computer and digital, high-frequency, in fact most types of telecommunications. A new medium, expensive at present but because of its exceptional characteristics, destined to be the medium of the future.

We will concentrate on the use of cables as the main transmission medium but because some of the basic principles of their use (particularly when used with high-frequency signals) overlap with those of broadcast radio and TV communications we will also see another use of air as a transmission medium.

Figure 6. A general concept of communication: the source, the information, the transmission medium and the receiver.

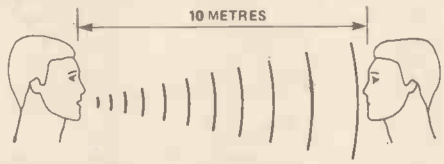


Figure 7. If the bandwidth of the air (transmission medium) is wide enough, the noise level low enough, and the attenuation low enough, the listener (receiver) will hear the speaker (source).

Figure 8. The traditional use of a twisted-pair telephone cable as the transmission medium in a simple telephone system.

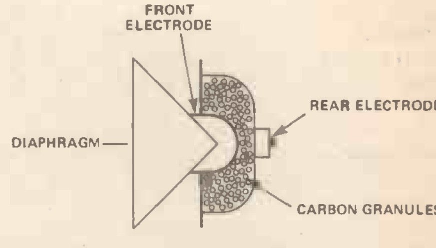


Figure 9. The principle of a carbon granule microphone used in a telephone handset: as the two electrodes move closer together the resistance between them decreases, reducing the voltage across them.

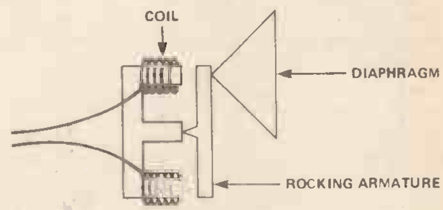
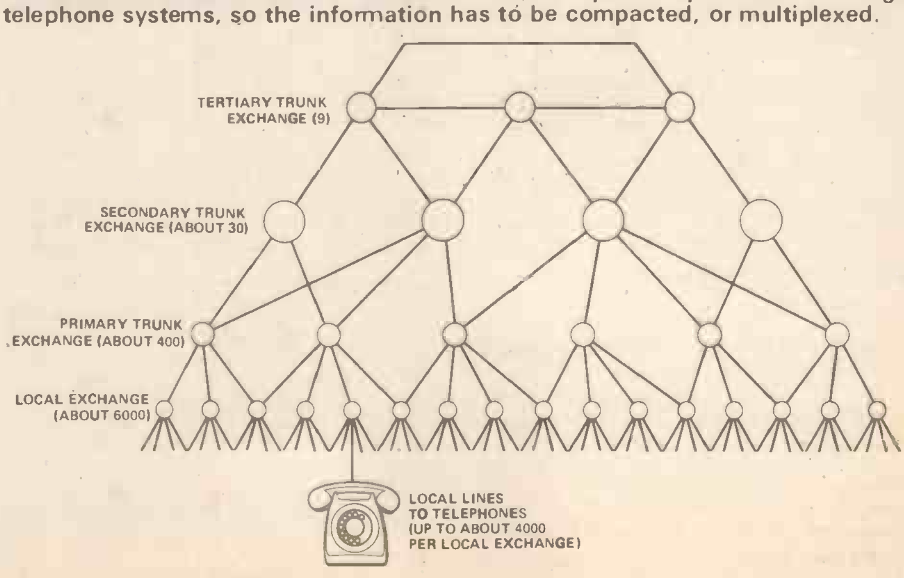


Figure 10. A telephone-type earphone. The input electrical signal from the microphone, which corresponds to the speech, causes a magnetic field around the coils. This attracts and repells the rocking armature, which therefore moves as the signal varies. The consequent movement of the diaghragm creates sound waves.

Figure 11. The basic organisation of the British telephone system, showing the approximate number of each type of exchange, at each level. Twisted-pair cables, suitable for short-distance communication, is quite impractical for large telephone systems, so the information has to be compacted, or multiplexed.



Cable is known as a bounded medium. The simplest cable consists of two separate wires within an insulating coating called a sheath. To communicate in the simplest manner between a source and a receiver using such cable, the signals representing the information are simply a changing series of voltages between the two wires forming the cable. Because electricity travels at a very high speed along conductors (actually at the speed of light; about $3 \times 10^8 ms^{-1}$) the signal out occurs at virtually the same instant as the signal in.

Telephone calling

One of the very best examples of the use of cable as the transmission medium is the telephone system. In its simplest form (**Figure 8**) communication is made between two telephone handsets along cable called *twisted pair cable*, ie, two thin wires, separately insulated with a layer of non-conductive plastic or rubber, twisted together. At some point in the circuit (not shown) is a source of voltage to provide power — this would perhaps be a battery at the exchange.

In a little more detail **Figure 9** shows the principle of the type of microphone generally used in a telephone handset — the carbon granule microphone. An alloy diaphragm vibrates in sympathy with the incoming sound (human voice). This movement acts on the carbon granules held in the body of the microphone, compressing or rarifying them, and hence altering the overall resistance between the two electrodes.

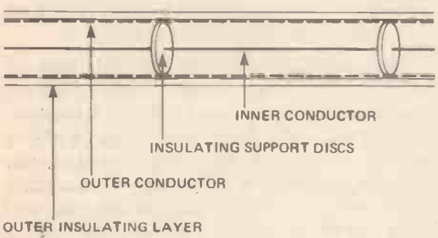


Figure 12. The construction of coaxial cable, with one conductor concentric with the other and insulated from it.

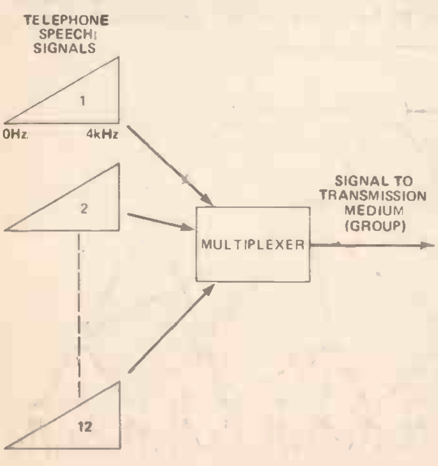


Figure 13. Twelve separate telephone speech signals multiplexed into a single group, for transmission over a single medium.

So, for a constant current (provided by the battery at the exchange) the voltage varies according to Ohm's law

$$V = I \times R$$

It is this varying voltage as the microphone picks up the sound of the voice which is transmitted along the twisted-pair cable to the other telephone handset.

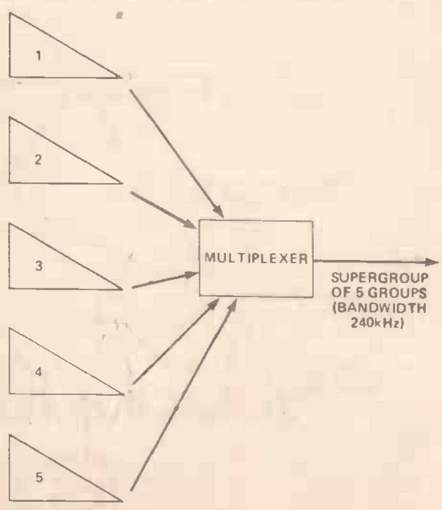
Keep On Rockin,

Figure 10 shows the principle parts of a telephone-type earphone. The diagram is of a light non-magnetic construction and is connected to one end of the rocking-armature. The voltage signal from the microphone is applied to the coils and the varying magnetic field attracts and repels the armature hence moving the diaphragm in sympathy with the applied signal. So, the diaphragm moves in accordance with the voice at the microphone, causing sound waves to occur which are received by the ear of the listener in the normal way.

One point to note about both the telephone microphone and the earphone is their frequency response ie, their bandwidth. Both only work over the range of about 300Hz to 4kHz. Now, this may seem unsatisfactory when, as we have already seen, the bandwidth of the human voice is about 100Hz to 6kHz. But as we all know the telephone works very well indeed (even with this limited bandwidth) and speech is still clearly distinguishable, although the effect of limited bandwidth is to make the received speed sound a bit 'tinny'. Artificially limiting the bandwidth like this has advantages too, as we'll see shortly.

The use of twisted pair cables is all very well in short-distance communications, say, from your house to the local exchange, but suffers from two main disadvantages if such cables were to be used over all the telephone systems, world-wide.

Figure 14. Five telephone groups multiplexed into a supergroup of sixty speech channels (see over the page).



Firstly, as the bandwidth of a twisted-pair cable is quite low (about 0Hz to 5kHz) many thousands of such cables would be needed for the many thousands of links between telephone exchanges. **Figure 11** gives some idea of the organisation of the UK telephone system and the approximate number of exchanges. If all these transmission paths were to be made using twisted pair cables then an almighty number and quantity of cables would be required.

Secondly, attenuation of signals over twisted pair cables is quite high. So, if a twisted pair cable is used over a distance of more than just 10km or so, an amplifier would be required to regenerate the signal to its original level. Thus a telephone call over the country from north to south (a distance of, say, 800km) would need about eighty amplifiers. If a hundred people wished to make similar calls simultaneously then about eight thousand such amplifiers are needed. When you learn that there are in the region of thirty million telephones in the UK you will see that the expense of required amplifiers would be very high if the whole system used only twisted pair cables

These two facts make a national system based on twisted pair cabling impractical. So, generally speaking, twisted pair cables are used only for local lines ie, between local exchanges and each telephone, and sometimes up to primary trunk exchange level.

Decomplexed

On long distance routes between exchanges, higher quality cables with low attenuation and high bandwidth are used. Individual signals are multiplexed or combined onto single cables in such a way that they can be demultiplexed back into separate signals at the far end. Thus many signals can pass along a single cable trunk. This makes a much more efficient method of producing a telephone network by reducing the physical wiring problem of a large system and reducing the large amount of metal required by a considerable factor, keeping down overall cost.

These cables are generally coaxial cables (see **Figure 12**) having a central conductor insulated from an outer conductor by plastic support discs. The bandwidth of such coaxial cables is very high (over 100MHz) and by careful multiplexing and demultiplexing methods, over ten thousand speech paths can be transmitted along a single length of coaxial cable.

Figure 13 shows, in principle, how twelve individual telephone speech paths are multiplexed together into a group of speech paths. Note that the bandwidth of each speech path (approximately 4kHz) means that if twelve paths are to be multiplexed together a final signal of bandwidth 48kHz (ie, 12 x 4kHz) will be required.

Because the group bandwidth of 48kHz can be divided down by the number of signals in the group, this process of multiplexing and demultiplexing is known as frequency division multiplexing (FDM), and one particular form of FDM is used here — single sideband FDM.

FDM is also the process used in radio and TV telecommunications systems — the difference between these and telephones being the transmission medium used for each. Telephone systems generally use cable (although radio links and fibre optics are used to a small degree) while radio and TV utilise the electromagnetic radiation properties of air. We'll talk about FDM telecommunications in more depth shortly.

To enable more speech paths to be combined together onto one cable, further multiplexing of groups can be done as in **Figure 14**. Here, five groups are shown combined into a supergroup with a bandwidth of 240kHz.

Supergroups can be multiplexed together into hypergroups and so on until as many speech paths are obtained over a single cable as are required (generally at 60MHz with over 10800 simultaneous signal paths!).

Everything In Modulation

The process of multiplexing is usually undertaken by modulating the message signal (ie, the signal from the source) in some way. In FDM the message signal is modulated with a second signal known as the carrier. Very simply, we can think of FDM as being a process whereby a signal (the carrier) carries another signal (the messsage signal) "piggy-back" from the source to the receiver over the transmission medium. The simplest form of modulation in an FDM telecommunications system is known as amplitude modulation (AM). In AM the carrier signal is generally a high frequency sinewave generated by an oscillator. Such an AM system is shown in **Figure 15**. The carrier signal is applied to the signal input of a voltage controlled amplifier (VCA), which is controlled by the voltage at its control input. In the system of **Figure 15**, the message signal is applied to the VCA control input therefore the output carrier amplitude is controlled by the message signal amplitude — this is AM.

The output signal of this system can be applied to any of the three transmission media previously listed (cable, air, or fibre optic) such that at the receiver the signal can be demodulated to two signals, message and carrier. The carrier signal can be discarded leaving the required message signal.

But, this still doesn't explain how more than one message signal can pass down a single transmission medium. The answer can be found, however, if we look at what are called *spectra* of all the signals involved. A spectrum is quite simply a graph of all the frequency components found in the signal against the amplitudes of those components. The spectrum of a sample telephone

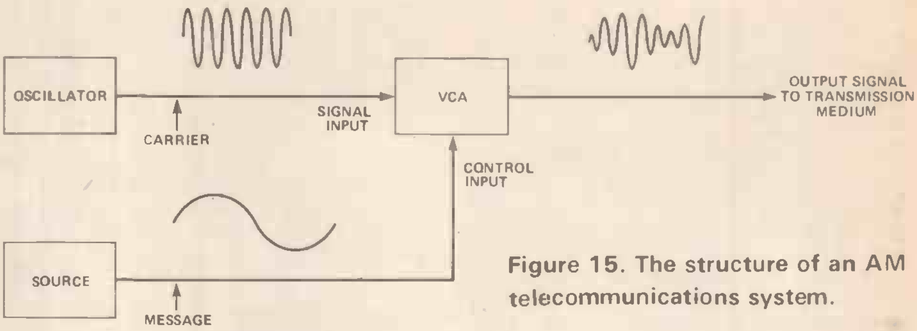


Figure 15. The structure of an AM telecommunications system.

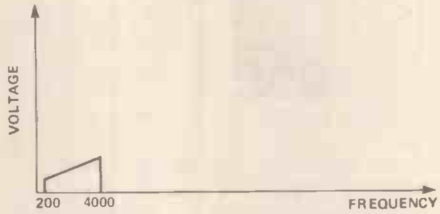


Figure 16. A typical spectrum of a telephone-style speech signal width bandwidth 200Hz to 4kHz.

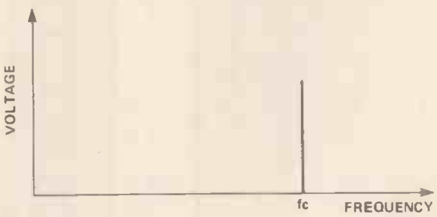


Figure 17. The spectrum of a carrier of frequency fc.

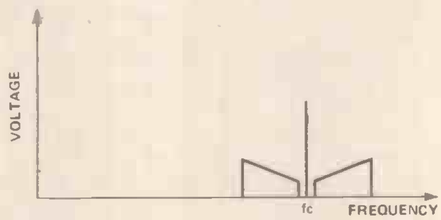


Figure 18. The possible spectrum of an AM telecommunications signal, generated by the system in figure 15, above.

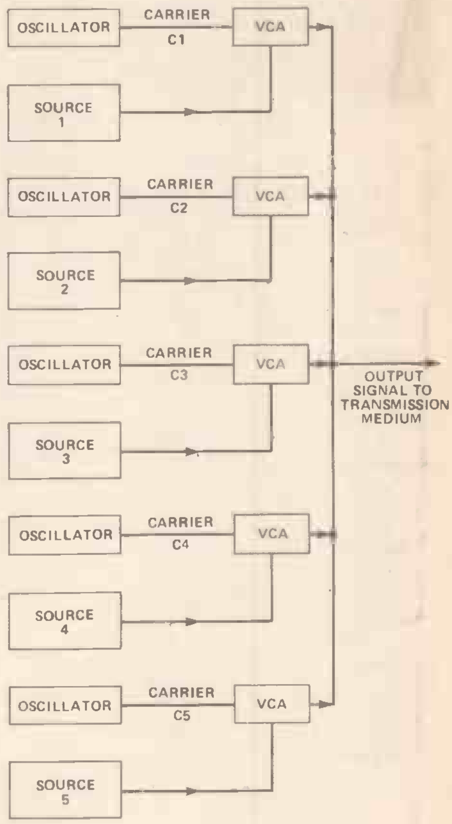
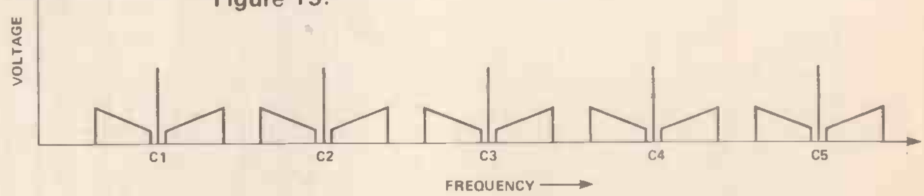


Figure 19. Five AM signals, frequency division multiplexed onto a single transmission medium.

Figure 20. The spectrum of the output signal generated by the system in Figure 19.



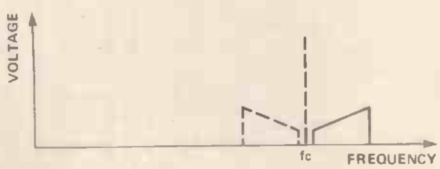


Figure 21. The spectrum of a single sideband AM signal, obtained by filtering out the carrier signal and lower sideband (shown in broken lines), leaving only the required upper sideband.

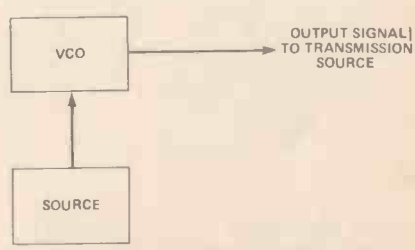


Figure 22. The principle of FM telecommunications.

speech signal is shown in **Figure 16**, and is seen to vary in a band between 200Hz and 4kHz. The spectrum of a carrier signal is shown in **Figure 17** and is a single component at the carrier frequency, fc.

The output signal after AM has taken place is shown in **Figure 18**. This shows that the output signal is in a different form to those at the input. You see the carrier frequency component is still present, and you can see that the band of the message signal is present above the carrier (ie, displaced at a frequency fc, higher than its original spectrum). There is also a mirror image of the message band below the carrier component. Even though it is a mirror image this is still nevertheless the message brand transposed at a higher frequency. These two message bands are given the name sidebands and are further classified as upper and lower sidebands.

This is the secret of how we can multiplex many message signals in an FDM from onto a single transmission medium — say for example we have five message signals from five sources, as in **Figure 19** and we use these message signals to modulate five different carrier frequencies (C1, C2, C3, C4, C5), then the output signal to the transmission medium is a frequency division multiplexed combination of all five message signals. The spectrum of the total signal might look like that in **Figure 20** which shows that all signals are still physically separate in terms of frequency, even though they are all combined on the same medium. At the receiver end of the telecommunications system it is a simple task to pick out one frequency-range of our choice and demodulate it to pick out the message signal required — this is all you are doing as you tune your transistor radio in to the required radio station.

Listen To The Band

One thing you might have noticed about the spectrum of **Figure 2** is that for every message signal you need over twice the bandwidth of the original message. This is because the system described here is more correctly known as double sideband AM. There is another method available (that used in telephone systems — which uses less bandwidth. Single sideband AM) can be obtained by simply filtering out the unwanted frequency components of one sideband and the carrier to obtain the spectrum of **Figure 21**.

The broken lines indicate where the unwanted sideband and carrier were before filtering. This leaves a single sideband with only the bandwidth of the original message signal, thus more message signals can be multiplexed together onto the available bandwidth of the transmission medium. Single sideband AM is sometimes used in radio systems with air as the medium but the corresponding radio receivers tend to be a great deal more complex and expensive than double sideband AM radio receivers. This is not the case in a cable system however.

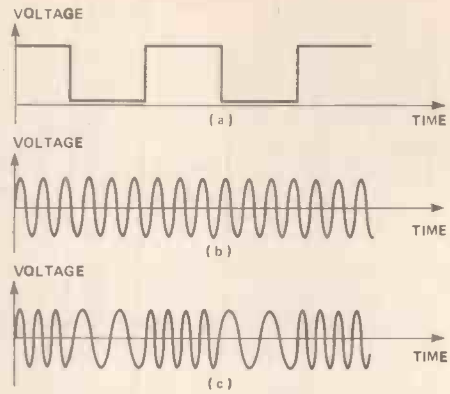


Figure 23. Signals within a typical FM telecommunications systems such as that of Figure 22: a) message signal (eg a squarewave); b) the carrier's centre frequency; c) the output signal to the transmission medium.

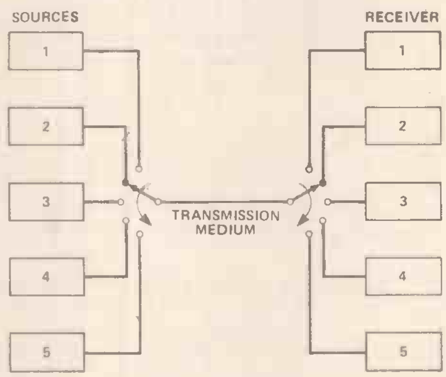


Figure 24. The principle of time division multiplexing. (TDM).

One other form of modulation used in FDM telecommunications systems is frequency modulation (FM). This is similiar to AM but instead of varying the amplitude of the carrier with the message signal, the carrier frequency is varied instead. **Figure 22** shows in principle how this is done, using a voltage controlled oscillator (VCO) as the carrier signal generator. The voltage of the message signal is used as the VCO's control input to control the carrier frequency. The oscillator's output is used directly as the signal to the transmission medium in the same way as in the AM system. **Figure 23** shows possible signals involved in such a system. **Figure 23a** is the message signal, a squarewave. **Figure 23b** is the VCO's centre frequency, which is the carrier. **Figure 23c** is the VCO output signal. You can see that when the message signal voltage is high the VCO is at a higher frequency than the carrier frequency, and when the message signal voltage is low the VCO output is at a lower frequency than that of the carrier. If a continuously varying signal were used as the message, eg the signal from a human voice, or music, then the VCO output would be a continuously varying range of frequencies centred around the carrier frequency.

FM is used in high-quality radio transmissions because it has an inbuilt resistance to interference. Such interference (ie electrical noise) from electrical machines, switches etc, tends to cause rapid amplitude variations of the transmitted signal. Because the FM transmitted signal relies on frequency variation to relay the message signal, the message signal is therefore largely unaltered in its progress to the receiver. An AM transmitted signal, however, because the message signal relies on amplitude variations is highly susceptible to electrical noise. Any 'blip' or 'click' caused by noisy electrical equipment can cause the receiver to pickup the noise as part of the AM signal. This is one reason why the FM section of your tranny radio always sounds clearer than the AM section.

Time Division Multiplex

FDM isn't the only way that many different signals can be combined onto a single transmission medium. Another way is to combine signals by time division multiplexing (TDM) — where instead of dividing the available bandwidth up into specific frequency slots as in FDM, TDM divides the bandwidth into specific timeslots. For example, **Figure 24** shows the principle of a TDM telecommunications system which uses a single transmission medium to transmit five different signals by allocating a fifth of each time cycle, t, to each signal. A rotating switch at each end of the transmission medium allocates the time that each source is connected to its receiver via the medium. Obviously, the switches (which in a real system would be electronic — not mechanical) must be synchronised so that they operate at the same time and in step with each source and receiver, but the principle is nevertheless apparent in this simple illustration.

Certain parts of the telephone system use TDM techniques. Most modern private branch exchanges (PBX) are based on TDM and certain trunks (operating at frequencies for example of 120MHz and carrying 1920 channels) are operational, and many more will be so in the future because of the higher quality obtainable.

TDM is basically a digital telecommunications method because the information sent along the transmission medium is in the form of pulses. There are various ways in which these pulses can be modulated with the message signal (in the same way that the carrier

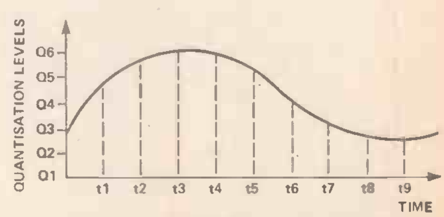


Figure 25. Digitising an analogue linear signal by sampling it and taking the value of the quantisation level which the signal is nearest to at each sample (see overleaf).

frequency in FDM can be modulated in various ways) but in TDM the whole process relies throughout on the fact that the message signal (often an analogue linear signal such as speech) can be digitised, ie made into a digital signal which represents the analogue message signal. **Figure 25** shows how this can be achieved. Basically, **Figure 25** shows a graph of voltage against time for an ordinary linear signal. However, the voltage axis has been split into six levels (known as quantisation levels) and the time axis is split into a number of timeslots. To digitise the message signal it is a simple matter to take the quantisation level which the linear signal is nearest to at each successive timeslot. So, the digitised signal is Q4 at tl, Q6 at t2, Q6 at t3, etc, etc. The process is often called sampling and a simple rule exists to ensure that the message signal is sampled often enough to allow an accurate reconstruction of the message signal at the receiver end of the telecommunications system. This rule is known as the *Sampling Theorem* and very simply says that any signal of bandwidth X Hz can be characterised by 2X samples per second. So, for example, going back to the telephone system which we have used so far to illustrate the various telecommunications principles: a speech signal has an allowed bandwidth of 200Hz to 4kHz, therefore the sampling frequency should be at least 8kHz.

Finally, this last section gives details of the common modulation techniques used in TDM systems. **Figure 26** shows examples of three types (pulse width modulation, pulse amplitude modulation and pulse position modulation) and **Figure 27** shows a final type — a pulse code modulation.

Modulation Techniques

Pulse Width Modulation (PWM)
PWM is **a** form of TDM modulation where the quantisation level at each timeslot is converted into a pulse, the *width* of which is dependent on the value of the quantisation level. **Figure 26a & b** give examples of a message signal (the same as in **Figure 25**) and an unmodulated pulse train (equivalent to the carrier of an FDM system) which may occur in such TDM systems. **Figure 26c** is the PWM signal and you can see that the widths of the pulses varies with the quantisation level.

Pulse Amplitude Modulation (PAM)
A PAM signal is shown in **Figure 26d**. and although the width of all pulses is constant, the *amplitude* varies as a direct consequence of the quantisation level.

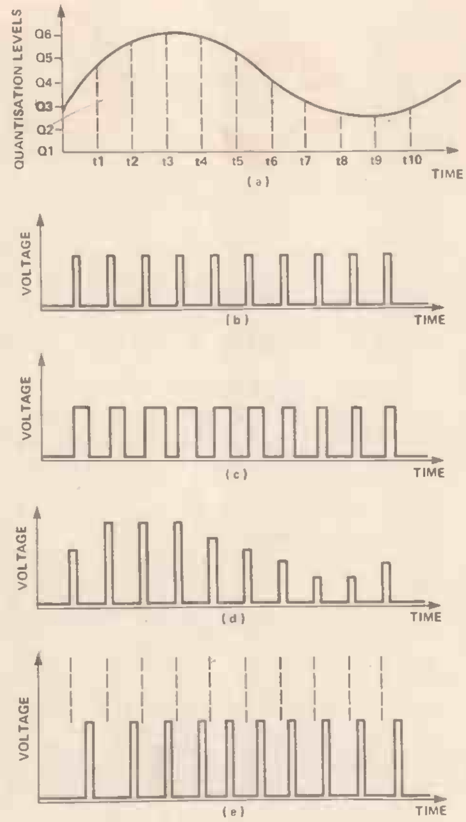


Figure 26. Various methods of modulating a signal in a TDM telecommunications system:
a) the quantised linear signal
b) unmodulated pulse train
c) pulse width modulation (PWM)
d) pulse amplitude modulation (PAM)
e) pulse position modulation (PPM).

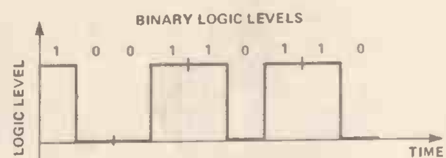


Figure 27. A pulse code modulated (PCM) signal corresponding to the first three sampled values of the linear analogue signal of Figure 26a.

Pulse Position Modulation (PPM)
Figure 26e shows a PPM signal and the broken lines close to each pulse indicate the leading edge of each pulse of the unmodulated pulse train of **Figure 26b**. The *position* of each pulse in relation to the unmodulated leading edge varies according to the quantisation levels.

Pulse Code Modulation (PCM)
The last example is of PCM. In PCM each message signal quantisation level is sent as a binary *code* word formed by a series of pulses. Thus for example, the first three samples of the message signal of **Figure 26a** could be sent as the binary code:

sample 1
quantisation level 4
binary code: 100

sample 2
quantisation level 6
binary code: 110

sample 3
quantisation level 6
binary code: 110

ie, the PCM signal is: 100110110 and is shown in **Figure 27**. PCM is the digital transmission method used in the telephone system. Although I have used only six quantisation levels to show the principle of PCM, in fact, more levels are used in the telephone system.

Many pulse modulated signals can be multiplexed into a single transmission medium simply by dividing the available time into as many timeslots as required and transmitting a single pulse (whichever modulation method is chosen) per timeslot. For example, timeslots of 0.5us duration (ie, 2048000 timeslots/s) are used to transmit thirty two simultaneous speech channels: likewise 120000000 timeslots/s are used to transmit 1920 simultaneous speech channels, on the telephone system using PCM telecommunication techniques.

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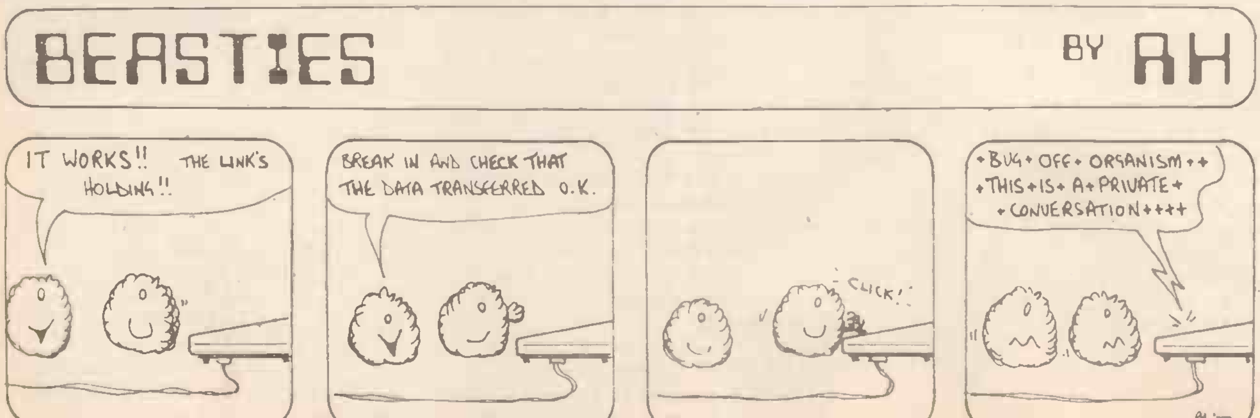


Time Out

A general purpose mains timer with a basic range from ten to sixty minutes, modifiable for other ranges. Don't switch off — let the HE Time Out do it for you.

R. A. Penfold

ELECTRONIC TIMERS are amongst the most simple of electronic projects, but they are nevertheless very useful and are not the type of project that is likely to be built one day and forgotten the next. This design is for a general purpose mains timer which has a timing range that is continuously variable from 10 to 60 minutes, although this range can easily be modified to suit individual requirements. The PCB mounting relay, despite its small size is capable of controlling loads of up to 10 amps, which at the UK mains voltage corresponds to 2.5kW. This should be more than sufficient for most requirements, but higher current loads can be accommodated using a larger chassis mounted relay.

The unit is very easy to use, and the time is automatically triggered at switch-on. The load can be switched off before the end of the timing period simply by switching off the timer. A bypass switch enables the load to be switched off as desired, when the timer is not in use.

C-R Timers

With the exception of some highly sophisticated digital timers, most circuits of this general type are based on a simple C-R charging circuit of the kind outlined in **Figure 1.** At switch-on, C1 will be discharged and the non-inverting (+) input of the operational amplifier will be at zero volts. The inverting (–) input is biased by Ra and Rb to typically about two thirds of the supply voltage. The operational amplifier is really used in this application as a voltage comparator, and with the inverting input at the higher potential the output goes low.

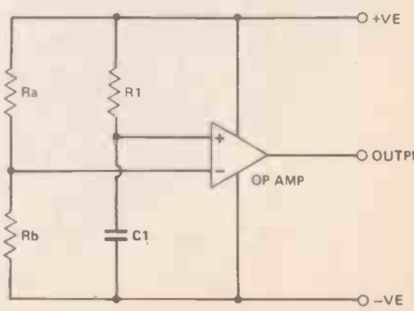
Capacitor C1 gradually charges via R1 until the charge potential on it exceeds the bias voltage produced by Ra and Rb. With the non-inverting input now at the higher voltage the output switches high, and the timing period is finished.

Practical timer circuits are usually somewhat more sophisticated than the basic arrangement of **Figure 1**, but a C—R charging circuit still forms the basis of most designs, and the inherent limitations of such a circuit still prevail.

Maths Time

The output time for a given set of C—R values varies from one design to another, but it is usually in the region of about 1CR seconds — 1.1CR

Figure 1. The capacitor/resistor circuit on which the Timer is based.



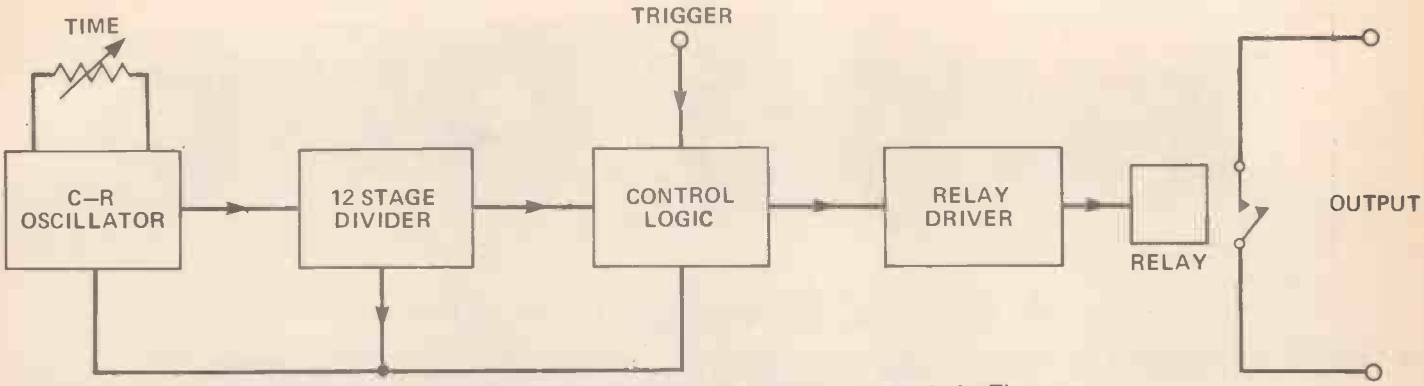


Figure 2. The block diagram shows the internal blocks of IC2, a ZN1034E, on which the Timer is based.

seconds in the case of the popular 555 device for example. This is perfectly satisfactory for output times of few seconds or less, but results are normally rather poor at longer timing periods. The cause of this is the high timing resistance and capacitance values that are needed.

An output pulse of 30 minutes (1800 seconds) in duration would require typical timing component values of, say 10M and 180u. With a value as high as 180u the capacitor would need to be an electrolytic type, but its leakage current would probably be so high that much of the charge current would be leaked away, and results would be inaccurate and unreliable even without taking into account the large tolerances of electrolytic capacitors. In an extreme case the leakage current might eventually equal the charge current, so that the charge potential ceased to rise, and the timing period lasted indefinitely.

Precision Timer

For output times of more than a few seconds there are strong advantages in using a precision timer device such as the ZN1034E, which is used in this design. **Figure 2** shows the timer in block diagram form. The ZN1034E provides the oscillator, divider, and control logic stages — the relay driver is a discrete transistor.

Under stand-by conditions the oscillator is gated off by the control logic stage, but when the unit is triggered the oscillator is enabled and the output of the circuit is set high. The oscillator is a stable C—R type, and a variable resistor enables the operating frequency to be adjusted. The output is fed to a 12 stage binary divider, and after 4095 counts, the divider via the control logic block, disables the oscillator and sets the output low again. The time delay depends on the opening frequency of the oscillator, with the frequency control acting as the time delay control.

Although the length of the timing period is still dependent on a C—R network, with this arrangement the output pulse duration is a few thousand CR seconds, rather than just one CR second. If we return to our earlier example, and assume a timing period of 3600CR seconds, an output time of 1800 seconds could be achieved with a timing resistance of 500k and a capacitance of 1u. These are much more realistic values, and it would not even be necessary to use an electrolytic capacitor.

Although a relay driver and a relay may seem to be a rather old fashioned way of controlling the load, a relay does have advantages over solid state control devices where just simple on/off switching is required. Firstly there is complete electrical isolation between the timer circuit and the mains supply. Secondly, a relay produces no significant heat or power loss, and does not require a heatsink.

The Circuit

Use of the ZN1034E enables a very simple circuit to be achieved as can be seen from the full circuit diagram of **Figure 3.**

Components T1, D1, D2, and C1 form a straightforward non-stabilised mains supply which gives an output of 12 volts. The ZN1034E requires a stabilised 5 volt supply, and it has and integral 5 volt shunt regulator. However, this is only effective if the input supply does not vary too

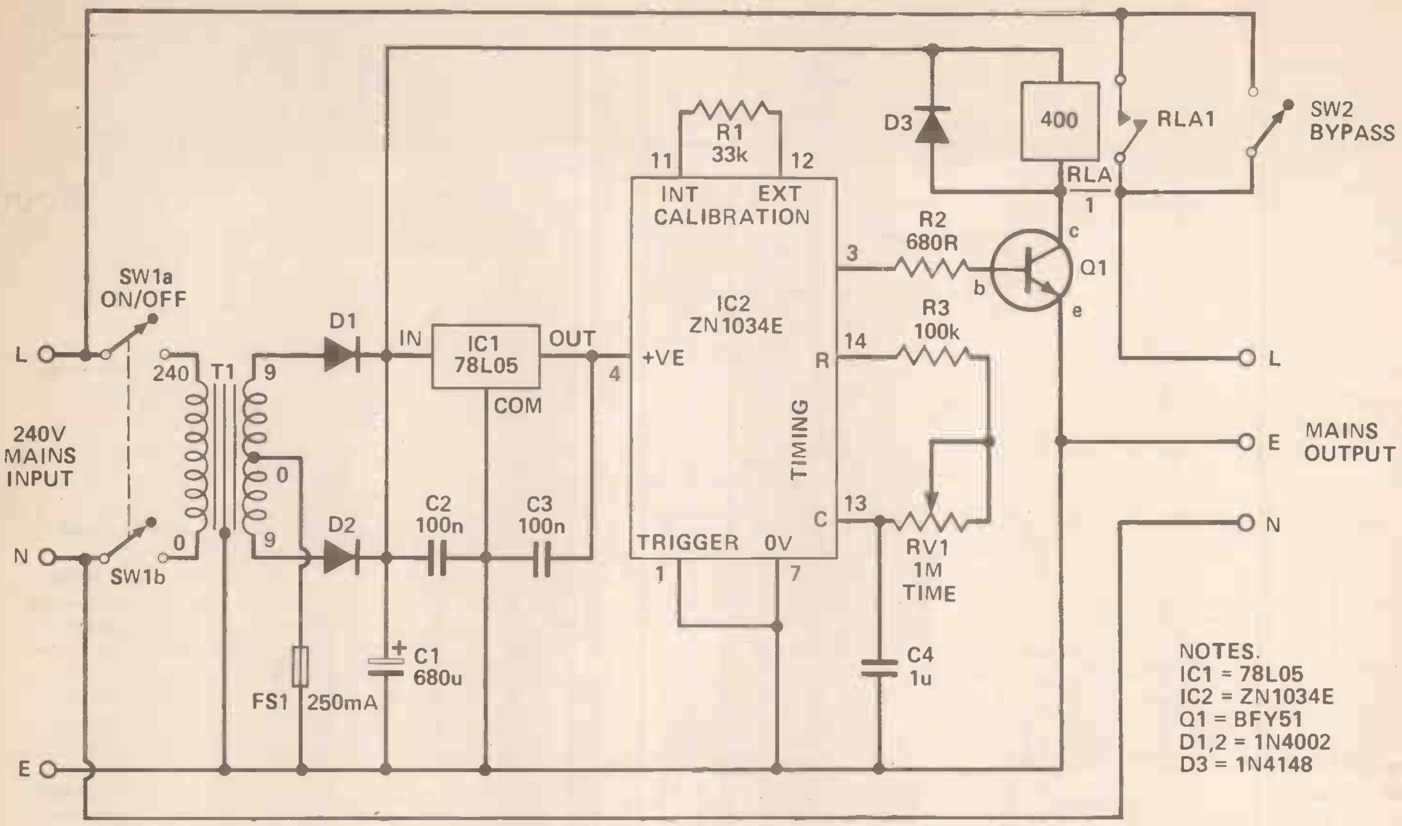


Figure 3. The use of the ZN1034E allows a very simple circuit to be used.

drastically, but in this case there can be a substantial change in supply stability when the relay switches on or off. A small monolithic voltage regulator, IC1 is therefore used to supply a well stabilised supply to the ZN1034E timer. The relay and driver transistor are powered from the non-stabilised supply.

The timing resistance is made up from the series resistance of R3 and RV1, while C4 is the timing capacitor. The length of the timing period can be anything from 2500 to 7500CR seconds, depending on the calibration resistance used. In this case this resistance consists of an internal 100k resistor and R1 in series, and this gives a timing period of 3600CR seconds. This corresponds to a timing range of 6 minutes (360 seconds) with RV1 at minimum resistance, to 66 minutes (3960 seconds) with RV1 at maximum resistance. The timing range has purposely been made somewhat wider than the required 10 to 60 minutes to allow for errors due to component tolerances, etc.

Parts List

RESISTORS
(All 0.25W 5% carbon)
R1 .... 33k
R2 .... 680R
R3 .... 100k

POTENTIOMETERS
RV1 .... 1M
1in carbon

CAPACITORS
C1 .... 680u 6V
axial electro
C2, 3 .... 100n
polyester
C4 .... 1u
5% polycarbonate

SEMICONDUCTORS
IC1 .... 78L05
5V 100mA regulator
IC2 .... ZN1034E
precision timer
Q1 .... BFY51
NPN transistor
D1, 2 .... 1N4002
1A rectifier
D3 .... 1N4148
silicon diode

MISCELLANEOUS
T1 .... 9-0-9V 250mA
chassis transformer
RLA .... 12V, 400R coil
10A contacts
SW1 .... DPDT
rotary mains switch
SW2 .... SPST
toggle or rotary
F1 .... 250mA fuse
Metal case 152 x 114 x 44mm; printed circuit board; 20mm chassis fuseholder; 14 pin DIL IC holder; control knobs; 6BA hardware; Veropins; connecting wire etc.

BUYLINES .... **page 26**

The ZN1034E has both Q and Q outputs, and in this circuit it is the Q output that is utilised. This output drives the common emitter driver transistor Q1 via current limiting resistor R2. A pair of normally open relay contacts are used to connect the live mains supply through to the output during the timing period. Silicon diode D3 protects Q1 against the high reverse voltage which would otherwise be generated across the relay coil each time it was switched off. Switch SW2 is the bypass switch, and this merely connects the live mains supply through to the output regardless of whether the relay is switched on or off.

Construction

Details of the printed circuit board and wiring are shown in **Figure 4**.

Start by fitting the resistors and capacitors, and then add the relay and semiconductors. Be careful to fit C1 and the semiconductors the right way around. Although IC2 is not a MOS device and is not vulnerable to damage by static charges, it is an expensive component and it is advisable to fit it in a 14 pin DIL IC socket.

If loads of no more than 10 amps are to be controlled by the unit, it is advisable to fit the specified relay on the board. There are other printed circuit mounting relays that will

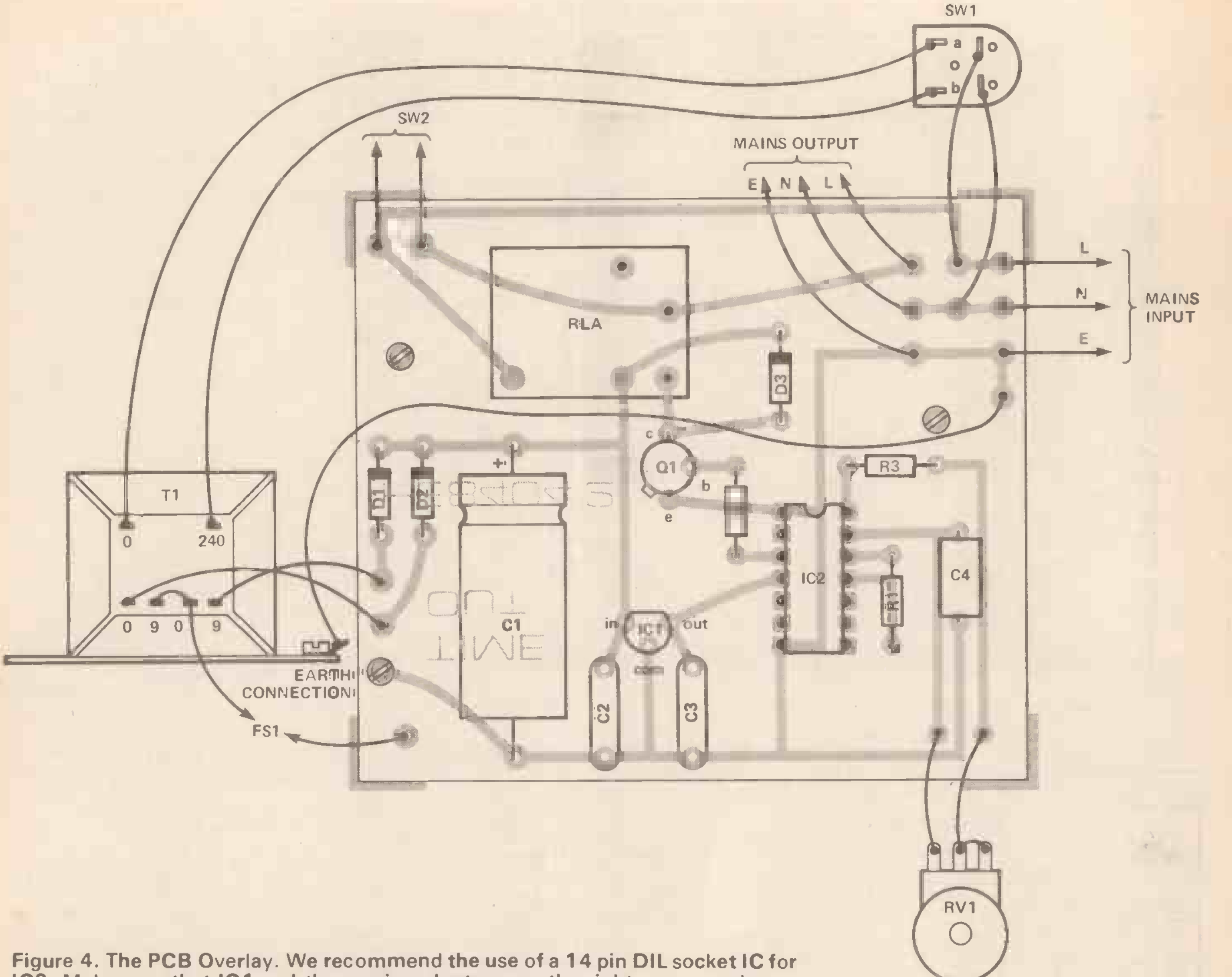


Figure 4. The PCB Overlay. We recommend the use of a 14 pin DIL socket IC for IC2. Make sure that IC1 and the semiconductors are the right way round.

operate in the circuit, but due to physical differences these would not fit onto the printed circuit design without some modifications being made. Use of the specified relay is strongly recommended, especially for constructors of limited experience.

High Amps

For higher load currents an off-board mounted relay must be used, such as a 15 amp RS type. The relay must, of course, have a 12 volt coil if it is to work properly in this circuit. The relay driver and power supply can provide plenty of current and can drive any normal 12 volt relay coil. As the relay is controlling the mains supply it must be well mounted so that it does not constitute a safety hazard. Fit Veropins at points on the printed circuit where off-board connections will eventually be made.

Case In Point

A case measuring about 152 x 114 x 44mm will comfortably accommodate all the components. The three controls are mounted on the front panel, and the rear panel is drilled to take the mains input and output leads. These holes should be fitted with grommets to protect the cables. If the timer is to be used with more than one item of equipment it would be preferable to have a mains outlet mounted on the case, so that any desired piece of equipment could be plugged into it.

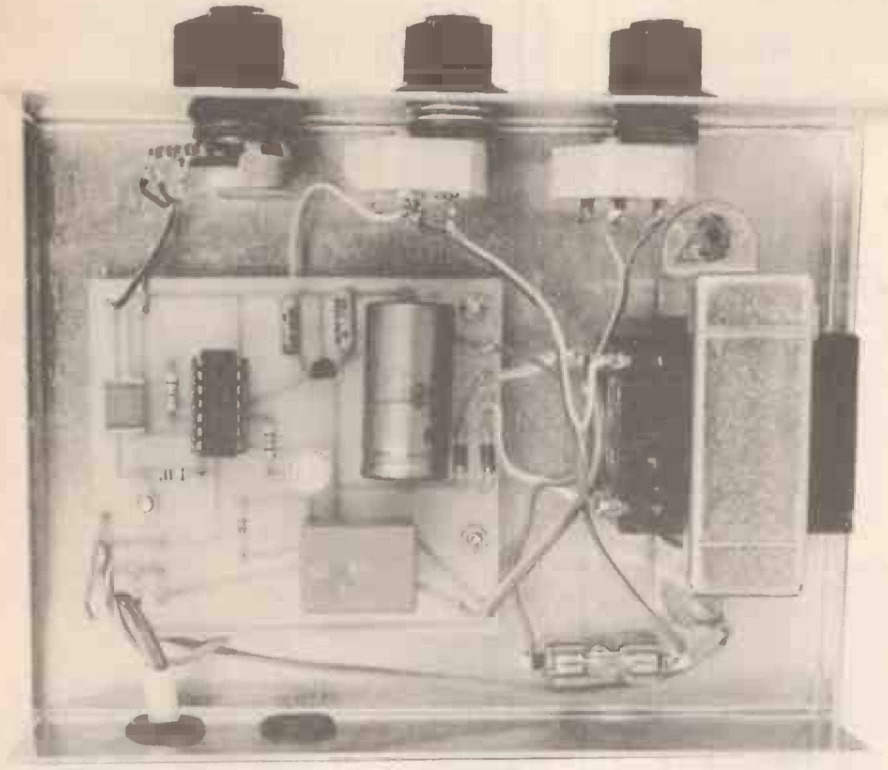
However, this would probably necessitate the use of a larger case, and mounting a mains outlet on the case could prove a little difficult as a large, irregular shaped cutout would be needed. It is therefore better to wire the controlled equipment direct to the board if it is the only piece of equipment that will be used with the timer. Either way, for reasons of safety use a metal case earthed to the mains supply.

The transformer is mounted on the base panel of the case on the left hand side. A solder tag is fitted on one of the mounting bolts to provide a chassis connection point. Any 9-0-9 volt transformer having a secondary current rating of at least 250 milliamps is suitable, or a type having twin 0-9 volt secondaries rated at 250 milliamps can be used. In the wiring diagram it has been assumed that a twin secondary transformer is used as these are the most common type these days. The printed circuit board is mounted on the right side of the base panel using M3 or 6BA hardware. Spacers about 6 or 12mm long are used to keep the underside of the board well clear of the base panel.

The timer is then completed by adding the point to point wiring using ordinary multistrand wire. Be very careful not to make any mistakes, *and thoroughly check the wiring a few times before connecting the unit to the mains supply and switching on.* Apart from the risk of components being damaged if there is a wiring error, it could also make the unit dangerous.

Checking

When you are sure all the wiring is correct, set RV1 fully anticlockwise,



place SW2 in the off position, and switch on the timer. This should result in the controlled equipment being turned on. If not, switch off at once, disconnect the unit from the mains, and recheck the wiring.

If all is well the relay and the controlled equipment should be automatically switched off after about six minutes. To start a new timing run, switch the timer off, wait a moment or two, and then switch on again. Adjusting RV1 in a clockwise direction should give longer switch-on times, with a maximum time of just over an hour. If the time range falls short of the maximum required time of one hour, increasing the value of R1 should rectify the problem. However, remember to unplug the unit from the mains supply before undertaking any work on it. The timer will be more useful if a scale of switch-on times is marked around the control knob of RV1, but as the only way of finding out the calibration points is by trial and error, this would be a rather time consuming business.

Other timing ranges can easily be produced by altering the values of the timing components, and as explained earlier, the nominal time obtained is 3600CR. Note that the timing resistance should be between 5k and 5M, and that the timing capacitance should not be less than 3n3.

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9" MONITOR. Cased. Non-Standard With Infor £20 ea.
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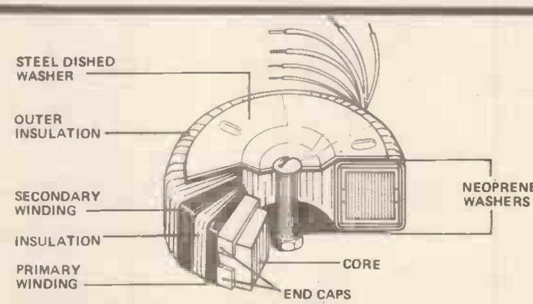

15 VA — 62 x 34mm — 0.35Kg — Regulation 19%

SERIES No	SECONDARY Volts	RMS Current
0x010	6+6	1 25
0x011	9+9	0 83
0x012	12+12	0 63
0x013	15+15	0 50
0x014	18+18	0.42
0x015	22+22	0.34
0x016	25+25	0 30
0x017	30+30	0 25

(encased in ABS plastic)

30 VA — 70 x 30mm — 0.45Kg — Regulation 18%

1x010	6+6	2 50
1x011	9+9	1 66
1x012	12+12	1 25
1x013	15+15	1 00
1x014	18+18	0 83
1x015	22+22	0 68
1x016	25+25	0 60
1x017	30+30	0 50

50 VA — 80 x 35mm — 0.9Kg — Regulation 13%

2x010	6+6	4 16
2x011	9+9	2.77
2x012	12+12	2.08
2x013	15+15	1.66
2x014	18+18	1 38
2x015	22+22	1.13
2x016	25+25	1 00
2x017	30+30	0 83
2x028	110	0 45
2x029	220	0 22
2x030	240	0 20

80 VA — 90 x 30mm — 1Kg — Regulation 12%

3x010	.6+6	6 64
3x011	9+9	4 44
3x012	12+12	3 33
3x013	15+15	2 66
3x014	18+18	2 22
3x015	22+22	1 81
3x016	25+25	1 60
3x017	30+30	1.33
3x028	110	0 72
3x029	220	0 36
3x030	240	0 33

120 VA — 90 x 40mm — 1.2Kg — Regulation 11%

4x010	6+6	10.00
4x011	9+9	6.66
4x012	12+12	5.00
4x013	15+15	4.00
4x014	18+18	3 33
4x015	22+22	2 72
4x016	25+25	2.40
4x017	30+30	2 00
4x018	35+35	1 71
4x028	110	1.09
4x029	220	0.54
4x030	240	0 50

160 VA — 110 x 40mm — 1.8Kg — Regulation 8%

5x011	9+9	8.89
5x012	12+12	6.66
5x013	15+15	5 33
5x014	18+18	4.44
5x015	22+22	3 63
5x016	25+25	3.20
5x017	30+30	2.66
5x018	35+35	2.28
5x026	40+40	2.00
5x028	110	1.45
5x029	220	0.72
5x030	240	0 66

225 VA — 110 x 45mm — 2.2Kg — Regulation 7%

6x012	12+12	9 38
6x013	15+15	7 50
6x014	18+18	6 25
6x015	22+22	5.11
6x016	25+25	4.50
6x017	30+30	3.75
6x018	35+35	3 21
6x026	40+40	2 81
6x025	45+45	2 50
6x033	50+50	2 25
6x028	110	2 04
6x029	220	1.02
6x030	240	0 93

300 VA — 110 x 50mm — 2.6Kg — Regulation 6%

7x013	15+15	10 00
7x014	18+18	8.33
7x015	22+22	6 82
7x016	25+25	6 00
7x017	30+30	5 00
7x018	35+35	4 28
7x026	40+40	3 75
7x025	45+45	3 33
7x033	50+50	3 00
7x028	110	2 72
7x029	220	1 36
7x030	240	1 25

500 VA — 140 x 60mm — 4Kg — Regulation 4%

8x016	25+25	10 00
8x017	30+30	8.33
8x018	35+35	7.14
8x026	40+40	6.25
8x025	45+45	5.55
8x033	50+50	5 00
8x042	55+55	4.54
8x028	110	4.54
8x029	220	2.27
8x030	240	2 08

625 VA — 140 x 75mm — 5Kg — Regulation 4%

9x017	30+30	10 41
9x018	35+35	8.92
9x026	40+40	7 81
9x025	45+45	6.94
9x033	50+50	6 25
9x042	55+55	5 68
9x028	110	5 68
9x029	220	2 84
9x030	240	2 60

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120	4	11.73	625	9	31.63

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Circuit ideas from Hobby Electronics readers.

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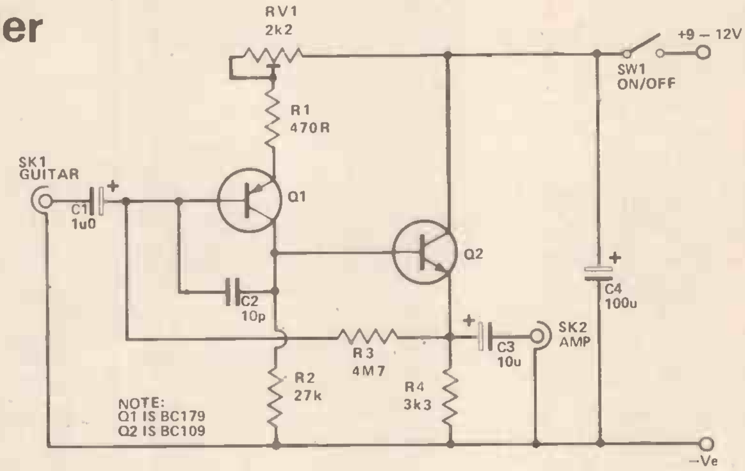
Guitar Practice Preamplifier



When practicing the guitar at home the obvious piece of equipment to use as the guitar amplifier is the amplifier (and speakers) of the family hi-fi system. Unfortunately it is unlikely that simply connecting the guitar to an input of the amplifier will give satisfactory results.

The solution to the problem is to use a simple preamplifier to boost the output from the guitar to a high enough level to drive a high level amplifier input. The simple two transistor circuit shown here has a low noise level and has a voltage gain which is adjustable from ten times (20dB) to over fifty times (30dB), and it should therefore be able to match any normal guitar pick-up to any normal hi-fi amplifier.

Transistor Q1 is used as a common emitter amplifier, and this provides all the voltage gain of the amplifier. It uses a low noise transistor operated at a fairly low collector current (about 150uA) in order to produce a good signal to noise ratio. The negative feedback provided by RV2 and R1 reduces the voltage gain of the amplifier to the required level, with maximum resistance of RV1 giving maximum feedback and minimum gain. Capacitor C2 rolls off the frequency response of Q1 at high frequencies outside the audio range, and this helps to avoid problems with instability and radio frequency breakthrough.

The output impedance of Q1 is fairly high, and so Q2 is used as an emitter follower buffer stage at the output which gives the unit a low impedance so that there is no danger of an inadequate output level due to loading of the output. The current consumption of the unit is only about 1.5mA, and a small 9V (PP3 size) battery is therefore a suitable power source. It is advisable to use a metal case for the unit so that the circuitry is screened from sources of mains hum and other electrical interference.

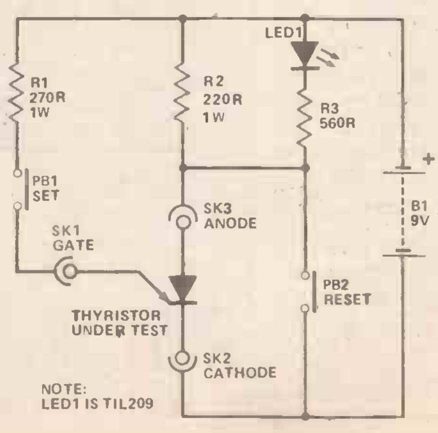
R. A. Penfold
Essex

Thyristor Tester

A simple circuit to sort out the "duds".

Thyristors, (also known as silicon controlled rectifiers or just SCRs) can be rather difficult to test as they have rather unusual characteristics, but they are easily checked using this very simple and inexpensive tester which is very useful when sorting through untested packs of thyristors.

In normal use a thyristor has its cathode connected to the negative supply and its anode terminal connected to the positive supply via the load. In this circuit, the load is formed by LED1, R2, and R3. With no signal applied to the gate terminal the thyristor should be in the "off" state and only a minute leakage current should flow between the anode and cathode terminals. LED indicator LED1 should therefore not light up at this stage. A thyristor can be switched on by an input current of about 20 to 30 mA to the gate terminal, and such an input current can be produced here by operating PB1. With the device switched on, LED1 will of course light up. Thyristors have a sort of built in latching action so that once triggered they remain on, provided the anode and cathode current does not fall below some threshold level (normally about 10 to 30mA). The load impedance in this circuit has been made sufficiently low to ensure that the latching action is produced, and LED1 should remain switched on when PB1 is released.



If PB2 is briefly operated, the current that formerly passed through the thyristor will be diverted through PB2, reducing the current through the thyristor to practically zero so that it switches off and extinguishes LED1.

The test procedure is therefore as follows:

1. Connect the test device, LED1 should not light (device under test is short circuit if LED1 does light).
2 Briefly operate PB1, LED1 will switch on and remain on if the device under test is functioning properly.
3 Briefly operate PB2, LED1 should switch off as PB2 is released if test device is fully operational.

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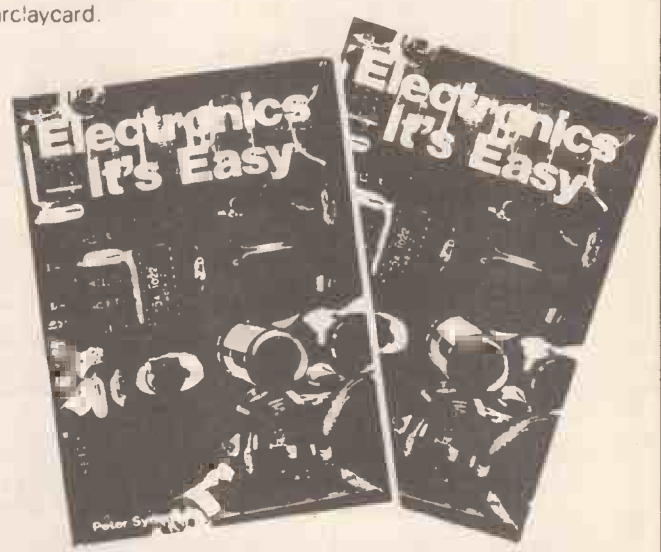

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Apart from the PCBs for this month's projects, we are making available some of the popular designs from earlier issues. See below for details. *Please note that only boards for projects listed below are available*: if it isn't listed we can't supply it.

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PCB FOIL PATTERNS

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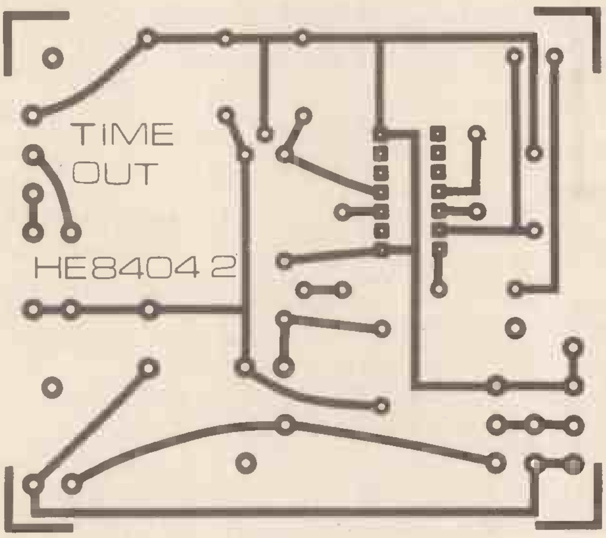
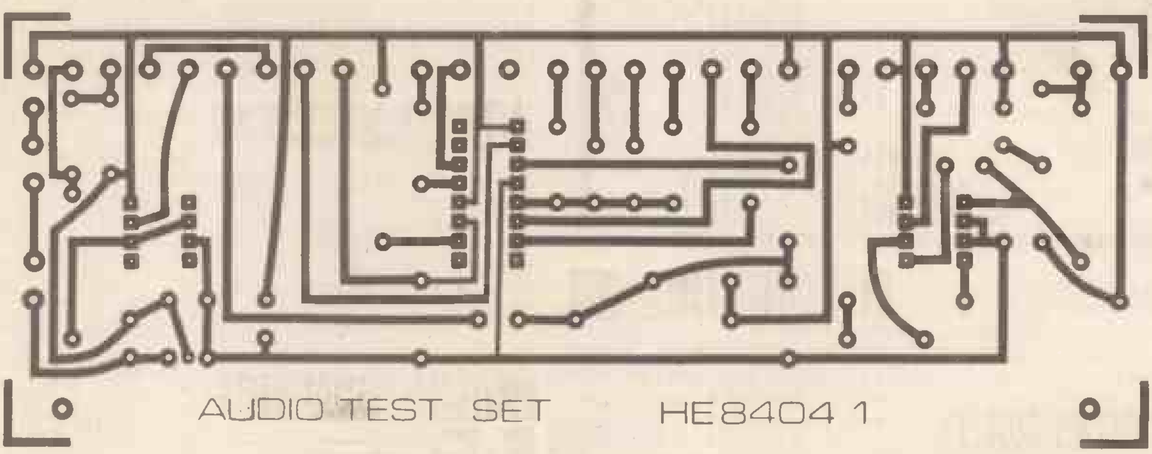
Note the name of the Analogue Test Set PCB has been changed to protect the innocent!



The PCB foil pattern for the Time Out.



The PCB mask for the Analogue Test Set.

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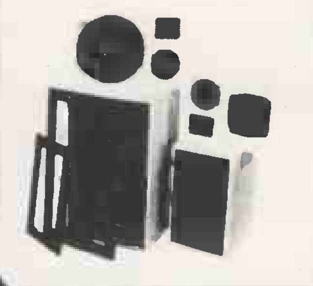
MULLARD SPEAKER KITS



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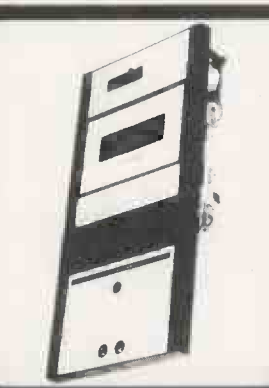

Comprising of a top panel and tape mechanism coupled to a record/play back printed board assembly. Supplied as one complete unit for horizontal installation into cabinet or console of own choice. These units are brand new, ready built and tested.

Features: Three digit tape counter. Autostop. Six piano type keys, record, rewind, fast forward, play, stop and eject. Automatic record level control. Main inputs plus secondary inputs for stereo microphones. **Input Sensitivity:** 100mV to 2V. **Input Impedance:** 68K **Output level:** 400mV to both left and right hand channels. **Output Impedance:** 10K. **Signal to noise ratio:** 45dB. **Wow and flutter:** 0.1%. **Power Supply requirements:** 18V DC at 300mA. **Connections:** The left and right hand stereo inputs and outputs are via individual screened leads, all terminated with phono plugs (phono sockets provided). **Dimensions:** Top panel 5¼in x 11¾in. Clearance required under top panel 2¼in. Supplied complete with circuit diagram and connecting diagram. Attractive black and silver finish.
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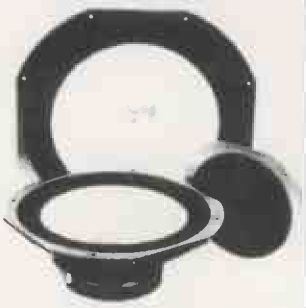

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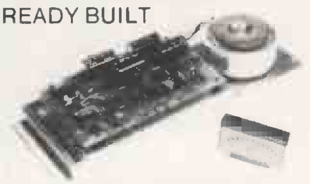
OMP POWER AMPLIFIER MODULE

READY BUILT



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Improved specification

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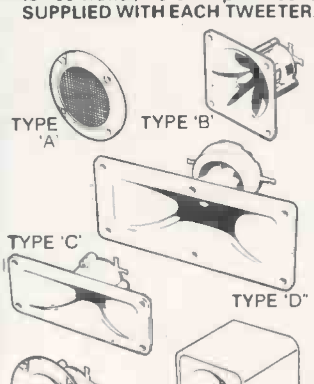

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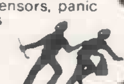

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BC182	12p	BU205	200p	ZTX108	12p	2N918	30p	3N202	125p
BC182B	14p	BU208A	220p	ZTX109	12p	2N930	30p	40406	80p
BC182L	12p	MJ2955	90p	ZTX300	15p	2N1131	30p	40407	80p
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TTL

		7417	28p	7447	75p	7486	35p	74119	70p	74160	65p	74190	58p
		7420	20p	7448	55p	7489	140p	74121	35p	74161	55p	74191	55p
		7422	28p	7450	21p	7490	37p	74122	41p	74162	46p	74192	55p
7400	18p	7425	28p	7451	20p	7491	45p	74123	41p	74163	46p	74193	55p
7401	18p	7426	28p	4753	21p	7492	40p	74126	70p	74164	46p	74194	52p
7402	18p	7427	30p	7454	21p	7493	41p	74132	65p	74165	60p	74195	52p
7403	18p	7428	30p	7460	21p	7494	41p	74135	50p	74166	60p	74196	55p
7404	18p	7430	26p	7470	25p	7495	41p	74141	51p	74167	185p	74197	55p
7405	18p	7432	26p	7472	25p	7496	41p	74144	250p	74170	195p	74198	95p
7406	32p	7433	35p	7473	30p	7497	60p	74145	575p	74173	120p	74199	95p
7407	32p	7437	30p	7474	35p	74100	95p	74147	125p	74174	65p	74221	60p
7408	25p	7438	30p	7475	40p	74104	58p	74148	65p	74175	65p	74279	60p
7409	25p	7440	23p	7476	35p	74105	58p	74150	70p	74176	46p	74284	95p
7410	18p	7441	51p	7480	30p	74107	30p	74151	46p	74177	55p	74285	95p
7411	25p	7442	40p	7481	110p	74109	30p	74153	46p	74180	50p	74366	64p
7412	26p	7443	71p	7482	70p	74110	41p	74154	81p	74181	121p	74390	325p
7413	26p	7444	95p	7483	58p	74111	70p	74155	46p	74182	70p	74393	100p
7414	37p	7445	71p	7484	81p	74116	70p	74156	46p	74184	105p		
7416	28p	7446	71p	7485	75p	74118	65p	74157	35p	74185	105p		

LS TTL

		74LS27	21p	74LS83	51p	74LS138	40p	74LS169	98p	74LS243	81p	74LS293	46p
		74LS28	21p	74LS85	52p	74LS139	39p	74LS170	86p	74LS244	65p	74LS353	71p
74LS00	17p	74LS30	21p	74LS86	23p	74LS147	121p	74LS173	63p	74LS245	86p	74LS362	110p
74LS01	17p	74LS32	21p	74LS90	39p	74LS148	86p	74LS174	58p	74LS247	65p	74LS365	35p
74LS02	17p	74LS33	21p	74LS93	35p	74LS151	46p	74LS175	52p	74LS248	66p	74LS366	35p
74LS04	17p	74LS37	21p	74LS95	46p	74LS153	52p	74LS181	115p	74LS249	66p	74LS367	35p
74LS05	17p	74LS38	21p	74LS96	109p	74LS154	120p	74LS183	201p	74LS251	40p	74LS368	35p
74LS08	18p	74LS40	21p	74LS107	46p	74LS155	46p	74LS190	58p	74LS253	46p	74LS373	70p
74LS09	20p	74LS42	37p	74LS109	35p	74LS156	46p	74LS191	55p	74LS257	40p	74LS374	70p
74LS10	20p	74LS49	63p	74LS112	32p	74LS157	40p	74LS192	55p	74LS258	43p	74LS375	52p
74LS11	20p	74LS51	21p	74LS113		74LS158	40p	74LS193	55p	74LS259	67p	74LS386	130p
74LS12	23p	74LS54	21p	74LS114	32p	74LS160	40p	74LS194	52p	74LS260	30p	74LS390	55p
74LS13	28p	74LS55	21p	74LS122	46p	74LS161	40p	74LS195	52p	74LS266	32p	74LS393	55p
74LS14	32p	74LS63	138p	74LS123	46p	74LS162	40p	74LS196	52p	74LS273	63p	74LS395	96p
74LS15	21p	74LS73	25p	74LS124	166p	74LS163	43p	74LS197	52p	74LS275	145p	74LS398	310p
74LS20	21p	74LS74	25p	74LS125	37p	74LS184	48p	74LS221	63p	74LS279	40p	74LS541	130p
74LS21	21p	74LS75	28p	74LS126	35p	74LS185	60p	74LS240	81p	74LS280	110p	74LS629	200p
74LS22	21p	74LS76	25p	74LS132	41p	74LS166	81p	74LS241	75p	74LS283	46p	74LS669	160p
74LS26	21p	74LS78	25p	74LS136	28p	74LS168	97p	74LS242	80p	74LS290	60p	74LS670	120p

CMOS

		CD4015	46p	CD4035	55p	CD4054	100p	CD4093	40p	CD4503	46p	CD4569	80p
		CD4016	30p	CD4038	125p	CD4060	80p	CD4099	140p	CD4511	52p	CD4572	80p
		CD4017	40p	CD4040	50p	CD4066	30p	CD4160	75p	CD4512	60p	CD4581	80p
CD4000	15p	CD4018	52p	CD4041	50p	CD4068	20p	CD4161	75p	CD4514	140p	CD4582	80p
CD4001	15p	CD4019	30p	CD4042	45p	CD4069	20p	CD4162	75p	CD4515	200p	CD4583	60p
CD4002	15p	CD4020	52p	CD4043	46p	CD4070	16p	CD4163	75p	CD4516	65p	CD4584	60p
CD4006	60p	CD4021	46p	CD4044	46p	CD4071	18p	CD4175	75p	CD4518	52p	CD4585	110p
CD4007	16p	CD4022	46p	CD4045	120p	CD4072	18p	CD4402	75p	CD4520	60p	CD40100	200p
CD4008	45p	CD4023	20p	CD4046	55p	CD4075	25p	CD4412	75p	CD4528	81p	CD40106	80p
CD4009	30p	CD4024	40p	CD4047	46p	CD4076	60p	CD4419	75p	CD4538	100p	CD40109	100p
CD4010	35p	CD4025	18p	CD4048	45p	CD4077	30p	CD4445	75p	CD4539	78p	CD40114	200p
CD4011	15p	CD4026	100p	CD4049	30p	CD4078	25p	CD4446	75p	CD4541	100p	CD40174	80p
CD4012	20p	CD4027	25p	CD4050	30p	CD4081	25p	CD4449	75p	CD4555	60p		
CD4013	25p	CD4028	45p	CD4052	70p	CD4082	25p	CD4501	35p	CD4561	110p		
CD4014	55p	CD4029	55p	CD4053	60p	CD4085	72p	CD4502	70p	CD4568	80p		

RIBBON CABLE

(Priced per 33cm)

WAYS	COLOUR
10	26p
20	53p
26	76p
34	100p
	GREY
10	18p
20	25p
26	50p
36	60p
40	80p

DIODES

		OA200	9p	1N5060	18p
AA119	15p	OA202	9p	1N5062	20p
AA215	16p	1N823	5p	1N5400	11p
BAX13	10p	1N914	5p	1N5401	12p
BY100	30p	1N916	6p	1N5402	14p
BY127	18p	1N4000	5p	1N5403	15p
BY133	20p	1N4001	5p	1N5404	16p
BY206	30p	1N4002	5p	1N5405	17p
BY207	30p	1N4003	6p	1N5406	18p
BY299	40p	1N4004	6p	1N5407	22p
BYX10	18p	1N4005	7p	1N5408	25p
OA47	10p	1N4006	7p	1S44	5p
OA90	8p	1N4007	8p	1S921	7p
OA91	8p	1N4148	5p	1S922	7p
OA95	8p	1N4448	6p	1S923	7p

LINEAR

		CA3090	415p	LM339	80p	LM3911	140p	SAA5020		TDA1008	347p	TL074	117p
		CA3130	105p	LM348	90p	LM3914	285p	SN76013N	295p	TDA1022	570p	TL081	40p
CA1310E	185p	CA3140	52p	LM358	62p	LM3915	285p	TAA621A	290p	TDA1024	120p	TL082	65p
CA1350E	90p	CA3240	125p	LM380	85p	LM3916	285p	TAA661B	175p	TDA2002	150p	TL083	92p
CA3020	230p	ICM7555	105p	LM381	170p	MC1458	70p	TBA120B	70p	TDA2003	345p	TL084	65p
CA3028	110p	ICM7556	200p	LM382	130p	MC1488	80p	TBA120S	68p	TDA2020	350p	UA748	40p
CA3035	270p	LF347	200p	LM384	160p	MC1489	90p	TBA120U	98p	TDA2030	340p	ZN414	95p
CA3043	305p	LF351N	55p	LM386	100p	NE555	20p	TBA540Q	161p	TDA2102		ZN424	150p
CA3055	85p	LF353N	100p	LM387	140p	NE556	55p	TBA651		TDA2522		ZN425	400p
CA3065	150p	LM224	150p	LM389	110p	NE564	405p	TBA800	95p	TDA9400		ZN426	345p
CA3080	80p	LM301	30p	LM732	55p	NE566	173p	TBA810S	110p	TL061	50p	ZN427	715p
CA3081	225p	LM308	100p	LM747	75p	NE567	161p	TBA820	81p	TL062	75p	ZN1034	230p
CA3085	145p	LM311N	81p	LM1458	45p	NE570	391p	TBA920Q	175p	TL064	150p	ZN1040	750p
CA3086	65p	LM318N		LM3900	70p	NE571	387p	TCA270S	171p	TL071	50p		
CA3089	230p	LM324	50p	LM3909	92p	SAA5010		TDA1004	345p	TL072	60p		

D CONNECTORS

PLUGS		SOCKETS	COVERS
9 way	90p	125p	110p
15 way	125p	190p	110p
25 way	190p	230p	125p

I.C. SOCKETS

LOW PROFILE D.I.L Type	Price	TURNED PIN D.I.L. Type	Price
8 pin	10p	8 pin	35p
14 pin	12p	14 pin	50p
16 pin	14p	16 pin	60p
18 pin	18p	18 pin	65p
20 pin	24p	22 pin	75p
22 pin	25p	24 pin	80p
24 pin	30p	28 pin	100p
28 pin	32p	40 pin	150p
40 pin	35p		

ZENER DIODES

BZX61C/1.4 watt: 3V3, 3V6, 3V9, 4V7, 5V6, 6V2, 7V5, 8V2, 10V, 11V, 12V, 13V, 15V, 18V, 20V, 22V, 24V, 27V, 30V, 33V, 36V, 39V, 43V, 47V, 56V, 68V, 75V, 82V, 100V, 180V, 200V 16p each

BZY88C/0.4 watt: 1V3, 2V7, 3V, 3V3, 3V6, 3V9, 4V3, 4V7, 5V1, 5V6, 6V2, 7V5, 8V2, 9V1, 10V, 11V, 12V, 13V, 15V, 16V, 18V, 22V, 24V, 27V, 30V, 33V, 36V 10p each

LEDs

5mm:	Red	10p	113:	Red	
	Green	13p		Red	20p
	Yellow	13p		Green	25p
3mm:	Red	10p		Yellow	25p
	Green	13p	323:	Tri	
	Yellow	13p		Red	20p
COX21:	Red			Green	25p
flashing		65p		Yellow	25p
251:	Rect/stack		503:	Square	
	Red	20p		Red	20p
	Green	25p		Green	25p
	Yellow	25p		Yellow	25p

REGULATORS

LM304H	180p	UA723C	77p	78H12 (3A/5V)	
LM309H	80p	7805A	50p		460p
LM309K	130p	7812A	50p	78L05	35p
LM317K	350p	7812Kc	121p	78L12	35p
LM317T	130p	7815A	50p	78L15	35p
LM320/5	65p	7818A	50p	78L18	35p
LM320/12	65p	7824A	50p	78L24	35p
LM320/15	65p	7905A	55p	78L62	35p
LM320/24	65p	7912A	55p	79L05	45p
LM337T	180p	7915A	55p	79L12	45p
LM1469	324p	7918A	55p	79L15	45p
UA78P (8A/5V)	450p	7924A	55p	79L18	45p
				79L24	45p

RECHARGEABLE BATTERIES

HP2, 1.2v, 4.0AH	£3.95
HP2, 1.2v, 1.2AH	£2.60
HP11, 1.2v, 1.2AH	£2.40
HP7, 1.25v, 500mAH	£1.00
AAA, 1.2v, 180mAH	30p
PP3, 8.4v, 110mAH	£4.50

ALUMINIUM BOXES

3 1/16" × 1 9/16" × 8 1/8"	
80 × 50 × 25	80p
100 × 65 × 50	1.20
100 × 70 × 40	1.20
100 × 100 × 40	1.20
135 × 70 × 40	1.20
135 × 105 × 40	1.40
180 × 125 × 65	1.95
205 × 155 × 75	2.50

VERO PLASTIC BOXES

White 71 × 49 × 25	60p
Blk 71 × 49 × 25	60p
Blk 120 × 80 × 35	1.10
Blk 180 × 110 × 55	1.75

VERO BOARDS

127 × 63	1.10
95 × 63	95p
431 × 63	3.17
127 × 95	1.20
95 × 95	1.15
431 × 95	4.20
454 × 119	5.50
63 · 25 pk of 5	1.30

THYRISTORS

				600mA/200V	45p	5A/400V	60p
				1A/50V	40p	5A/600V	70p
BT101	104p	T05 1A/400V	104p	1A/100V	45p	5A/800V	80p
BT102	104p	2N1599	40p	1A/200V	50p	7A/100V	55p
BT106	104p	2N4441	170p	1A/400V	60p	7A/200V	60p
BT107	132p	2N4444	150p	1A/600V	75p	7A/400V	70p
BT108	143p	2N5060	36p	1A/800V	90p	7A/600V	80p
TIC44	20p	2N5061	33p	3A/50V	46p	7A/800V	90p
TIC106D	40p	2N5062	42p	3A/100V	53p	10A/50V	55p
TIC106M	77p	2N5063	47p	3A/200V	58p	10A/100V	60p
TIC126D	99p	2N5064	47p	3A/400V	71p	10A/200V	65p
TIC206D	80p	600mA/20V	21p	3A/600V	79p	10A/400V	70p
TIC226D	90p	600mA/30V	24p	3A/800V	99p	10A/600V	88p
TIC246D	130p	600mA/100V	30p	5A/50V	43p	10A/800V	115p

TRIACS

2A/200V	50p
2A/400V	60p
2A/600V	60p
4A/400V	60p
6A/100V	80p
6A/200V	80p
6A/400V	90p
8A/400V	80p
10A/100V	80p
10A/200V	100p
10A/400V	110p
10A/400P	100p

BRIDGE RECTIFIERS

1A/50V	30p	6A/50V	75p
1A100V	30p	6A/100V	75p
1A/200V	35p	6A/200V	80p
1A/400V	40p	6A/400V	100p
2A/50V	35p	10A/200V	200p
2A/100V	45p	10A/400V	200p
2A/200V	50p	25A/200V	250p
2A/400V	55p	25A/400V	300p

Dalo Etch resist
£1.10

SOLDER

20 swg. 3 core
500g 495p

POTENTIOMETERS

Carbon track, ¼ watt log & linear values:

Range	Price
470R-2.2MR (single track)	40p
4.7K-2.2MR (dual gang)	100p
4.7K-2.2MR (single gang D/P switch)	90p

SLIDER POTS

60mm track, log & linear values:

Range	Price
5K-500K	80p

PRESETS

Pre-set pots ¼ watt

Range	Price
50R-4.7MR (mini vert. & horiz.)	10p

RESISTORS

High stability, ¼ watt, 5%

Range	Price (1-99)	(100 -)
1R-10MR	2p	1p

High stability, ½ watt, 5%

Range	Price (1-99)	(100 -)
1R-10MR	3p	1.5p

CAPACITORS

CERAMIC 1pF, 2p2, 2p7, 3p3, 3p9, 4p7, 5p6, 6p8, 8p2, 10pF, 12pF, 15pF, 18pF, 22pF, 27pF, 33pF, 39pF, 47pF, 56pF, 68pF, 82pF, 100pF, 120pF, 150pF, 180pF, 220pF, 270pF, 330pF, 470pF, 560pF, 680pF, 820pF, 1000pF, 1n5, 1n8, 2n2, 3n3, 3n9, 4n7, 5n6, 6n8, 8n2, 10nF, 22nF, 47nF, 100nF 6p each

MYLAR: 100V 1nF, 2n2, 3n3, 4n7, 6n8, 10nF 7p each. 15nF, 22nF, 33nF, 47nF 9p each, 68nF, 100nF 11p each. 220nF 15p. 330nF 18p. 470nF, 20p.

POLYSTYRENE 22pF, 47pF, 68pF, 82pF, 100pF, 120pF, 150pF, 220pF, 270pF, 330pF, 390pF, 470pF, 680pF, 820pF, 1000pF, 1200pF, 1500pF, 1800pF, 2000pF, 2200pF, 3300pF, 4700pF, 5600pF, 10nF 8p each

TANTALUM BEAD 3V: 100uF, 150uF, 220uF, 330uF 64p each. 470uF 110p. 680uF 160p. 6V3: 6u8, 12p. 10uF 13p. 33uF 33p. 47uF 25p. 100uF, 220uF 77p each. 470uF 160p. 10V: 15uF, 22uF 20p each. 33uF 33p. 47uF 40p. 68uF 63p. 220uF 110p.
16V: 2u2, 3u3 20p each. 4u7, 6u8 25p each 10uF 32p. 22uF 35p. 16V: 33uF 40p. 47uF 60p. 100uF 95p. 220uF 105p. 25V: 15uF, 22uF 40p each 47uF, 68uF 60p. 35V: 0.1uF, 0.22uF, 0.47uF 16p each. 1uF, 1u5 18p each. 2u2 25p. 3u3, 4u7 20p each. 6u8 30p. 10uF 40p 47uF 60p

ELECTROLYTIC Axiel or Radial 16V: 10uF, 22uF, 33uF 10p each, 47uF, 68uF, 100uF 12p each. 125uF, 220uF 14p each, 330uF 18p. 470uF 24p. 680uF 36p. 1000uF 30p. 1500uF 40p. 2200uF 50p. 25V: 1uF, 10uF, 22uF, 47uF 10p each, 100uF 12p. 220uF 20p. 470uF 30p. 1000uF 40p. 2200uF 55p. 4700uF 115p. 35V: 120uF, 250uF 20p each. 40V: 6u8 10p. 470uF 30p. 1000uF 45p. 50V: 0.47uF, 1uF 8p each. 1uF (small) 12p. 220uF 35p. 63V: 1uF, 2u2, 4u7 7p each. 10uF, 22uF 10 each. 47uF 12p. 100uF 20p. 220uF 30p. 100V: 4.7F 48p. 160V: 10MF 32p. 250V: 0.01uF, 0.047uF, 0.1uF 10p each. 0.22uF 11p. 0.47uF 12p. 1uF 18p. 2u2 26p. 10uF 23p. 100uF 35p. 400V: 0.47uF 35p. 600V: 0.022uF, 0.047uF 30p each. 0.22uF, 67p. 1000V: 0.0022uF 27p. 0.022uF, 0.1uF 39p each.

POLYESTER C280 250V 01, 022, 033, 068, .1 8p. .15, .22, .33 10p .47 12p. .68 20p. 1uF 26p. 2.2 50p.

SILVERED MICA 2p2, 3p3, 5pF, 10pF, 18pF, 20pF, 22pF, 25pF, 27pF 13p each 30pF, 33pF, 39pF, 47pF, 50pF, 56pF, 68pF, 75pF, 82pF, 100pF, 120pF, 150pF, 180pF, 200pF, 220pF, 250pF, 270pF, 300pF 15p each. 330pF, 390pF, 470pF 19p each. 500pF, 560pF, 680pF 22p each. 820pF 24p. 1000pF 27p 1500pF 32p. 1800pF 42p. 2200pF 45p. 2700pF 48p. 3600pF 55p. 3900pF 68p. 4700pF 83p. 5000pF 98p. 6800pF 115p. 8200pF 120p. 10000pF 125p.

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