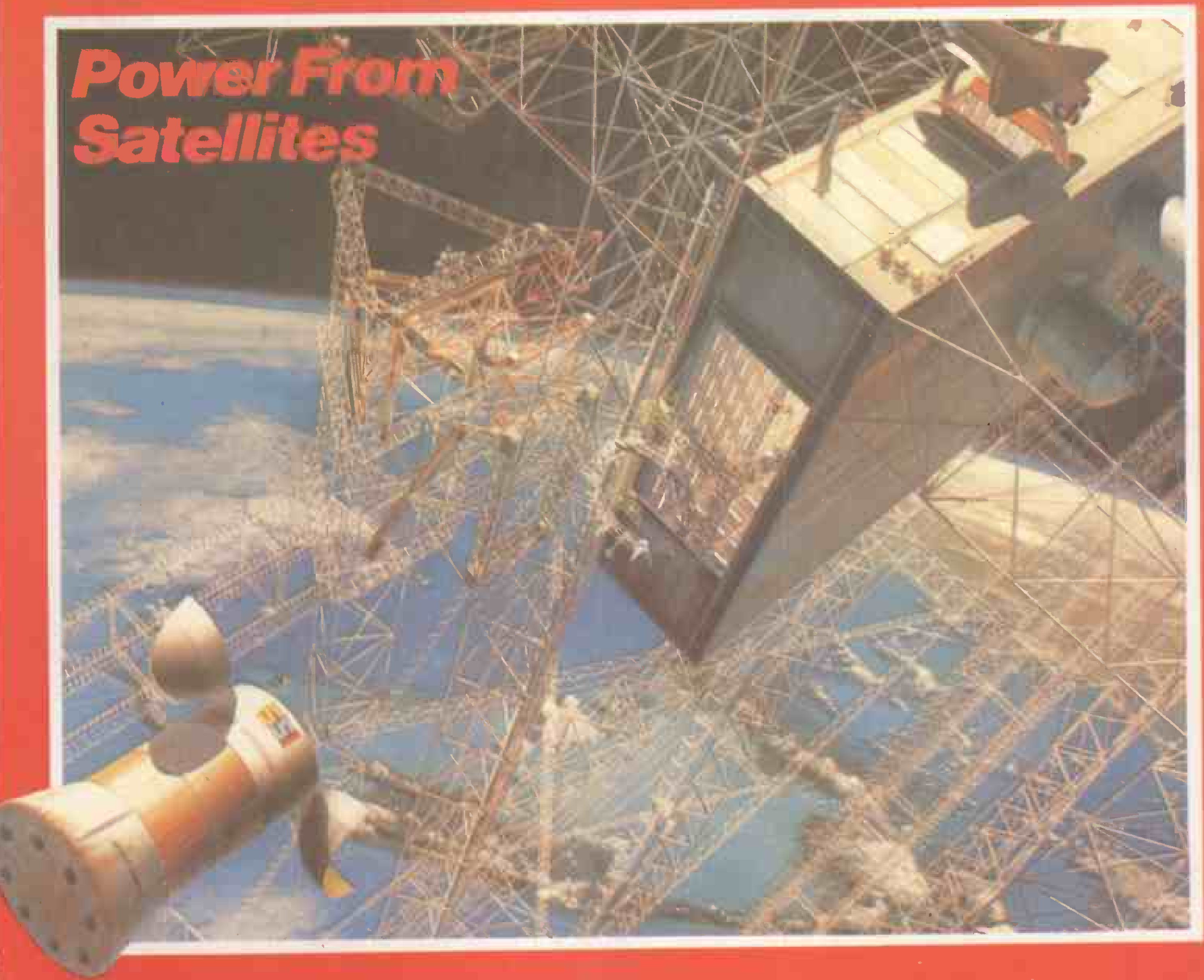
ISSN 0142-6192

Hobby Electronics

August '79
45p



Constant Volume Amp
Compressed Sound

Burglar Alarm
Preventive Medicine

Tools
Starting A Collection

Variable Resistors
A Potted History

Injector/Tracer
Simple Test Gear

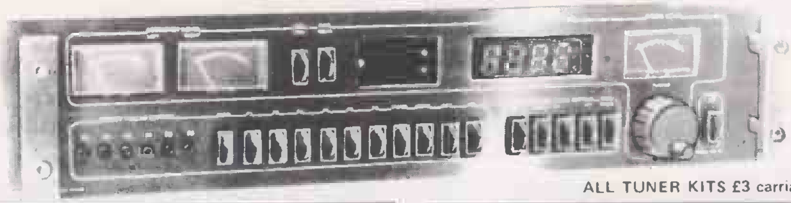
Competition
Two Calscopes To Be Won

Tecknowledgey for sale.

The Mark III FM Tuner

DIY Hi-Fi will never seem the same again. Ambit's Mark III tuner system is electrically & visually superior to all others. Some options available, but the illustrated version with reference series modules: £149.00 + £18.62 VAT

With Hyperfi Series modules £185.00 + £23.12



ALL TUNER KITS £3 carriage

Features of the system:

* Precision construction & design of all parts
* Time frequency display
* State of the art performance with facilities for updates, using modular plug in systems.
* Deviation level calibrator for recording
* All usual tuner features

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

A multiband superhet tuner, constructed using a single IC for RF/IF processing - but with all features you would expect of designs of far greater complexity. The FM section uses a three section (air gang) tuned FET tunerhead, with ceramic IF filters and interstation mute; AM employs a double balanced mixer input stage, with mechanical IF filters - plus a BFO and MOSFET product detector for CW/SSB reception. Styled in a matching unit to the Mark III FM only tuner, employing the same degree of care in mechanical design to enable easy construction. MW/LW reception via a ferrite rod antenna.

Electronics only (PCB and all components thereon)	£33.00 + £4.12 VAT
Complete with digital frequency readout/clock-timer hardware	£99.00 + £12.37 VAT
Complete with MA1023 clock/timer module with dial scale	£66.00 + £8.25 VAT

Hardware packages are available separately if you wish to house your own designs in a professional case structure. Please deduct the cost of electronics from complete prices.

LW/MW/FM LCD Digital Frequency Display - July PW feature

Update your old radio, or build this into a new design. Or use it as a servicing aid - this low power unit with LCD display reads direct frequency in kHz/MHz, or with usual AM/FM IF offsets for received frequency. Low power LCD means no RFI - 15-20mA at 9v even with the divide by 100 prescalar. FM resolution is 100kHz, AM 1kHz. Sensitivities better than 10mV

Complete kit £19.50 +*£1.56 VAT. Built and tested version £24.00 +*£1.92 VAT

Various other DFM systems described in our catalogue part 2 - including a one chip solution to providing digital display of FRG7 kHz dial, combined with clock/timers etc.

PW SANDBANKS PI METAL LOCATOR

Maintaining our professional approach to home constructor kits, we offer the pulse induction 'Sandbanks'. Now with injection molded casing for greatly improved enviromental sealing. £37.00+ *£2.96vat.

VHF MONITOR RX WITH PLESSEY IC

4/9 channel version of the PW design - but using standard 3rd OT crystals, and TOYO 8 pole crystal filter with matching transformers. Coil sets from our standard range to cover bands from 40 to 200MHz. Complete module kit £31.25 +£3.90vat

ETI - REMCON RADIO CONTROL

A tried and tested RC system with a full set of supporting hardware from a well known manufacturer. Please send for details - and watch our ads for further news of developments in RC products.

Radio and Audio Modules : The biggest range/ best specs:

EF5801/3/4 6 stage varicap tunerheads with LO feed and various levels of sophistication. New 5804 include pin AGC loop 'on board'. 5801:£17.45+£2.18vat - 5803:£19.75+£2.47vat 5804:£24.95 +£3.18vat. *Frequencies in 40-180MHz on appcn.*

EF5402 4 stage varicap with TDA1062, compound FET/Bipolar input stage, low noise, balanced mixer, pin agc, osc output. A worthy successor to the 5400. £10.75+£1.34vat

The 5402 is available centred on a wide range of frequencies from 30MHz to 180MHz. Non standard units £14.75+£1.84 - 3 weeks.

8319 4 stage varicap tunerhead from Larsholt using MOSFET RF and mixer stages. New temperature compensated oscillator for wide ranges of ambient temperature £13.45+£1.68vat

7252 Complete Larsholt FM tuner less stereo decoder. £26.50+£3.31vat

7253 Stereo FM tunerset from Larsholt with FET head. (as 7252)

944378 Hyperfi stereo decoder. The very best. £19.95+£2.49vat

911223 Pilot cancel stereo decoder, priced to make the MC1310 as obsolete as it now deserves to be.£12.50+£1.56vat

Inotec 1-A fully DC tuned and switched LW/MW/FM stereo tuner to interface with synthesiser control etc.A first! Details OA

COMPONENTS for Radio and Audio ICs, HMOS etc.

The list is too long to attempt here, but AMBIT specializes in all types of semiconductor for radio reception, including devices operating from OC to 5GHz. New low cost SBL1 diode ring mixers (equiv case MO108 etc) -first with HMOS fets, now with a PCB for DC amplifier, and offset sense and protection relay for speakers. See catalogue and updates for most info, pse send an SAE for information on anything you cannot find in catalogues.

Radio ICs	cost	+ vat
CA3089E	1.94	24
CA3189E	2.45	30
HA1137W	2.20	27
SN76660	0.75	9
TDA1090	3.35	42
TOA1083	1.95	24
TDA1220	1.40	17
SL6640	2.75	34
MC3357	3.12	39
HA1197W	1.40	17
MC1496	1.25	16
LM373/4	3.75	49

Stereo ICs	cost	+ vat
MC1310P	1.50	19
uA758	2.20	27
CA3090A	2.75	34
HA1196	3.95	49
HA11223	4.35	54
KB4437	4.35	54
KB2224	2.75	34
Preamp ICs/switches		
TDA1028	3.50	44
TDA1029	3.50	44
TDA1074	4.14	52
KB4438	2.22	28

AF power ICs	cost	+ vat
LM380N	1.00	12
TBA810AS	1.09	14
TDA2002	1.95	24
TBA820M	0.75	9

from the general list:
LEOs:all colours and low prices
2SJ48/2SK134 HMOS 9.90 +£0.80 vat(Pair)
Signal fets/transistors and TOKO COILS & FILTERS!

OSTS: Remember all OSTS stocks are obtained from BS9000 approved sources - your assurance that all devices are very best first quality commercial types. Some LPSN TTL is presently in great demand, so please check by phone before ordering.

TTL:Standard AND LP SchattkY

All prices listed in pence *

	'N'	'LSN'
7400	13	20
7401	13	20
7402	14	20
7403	14	20
7404	14	24
7405	18	26
7406	38	
7407	38	
7408	17	24
7409	17	24
7410	15	24
7411	20	24
7412	17	
7413	30	
7414	51	
7415		24
7416	30	
7417	30	
7420	16	24
7421	29	24
7422	24	24
7423	27	
7425	27	
7426	36	27
7427	27	29
7428	35	32
7430	17	24
7432	25	24
7433	40	32
7437	40	24
7438	33	24
7440	17	24
7441	74	
7442	70	99
7443	115	
7444	112	
7445	94	
7446	94	
7447	82	89
7448	56	99
7449		99
7450	17	
7451	17	24
7453	17	
7454	17	24

	'N'	'LSN'
7455	35	24
7460	17	
7463		124
7470	28	
7472	28	
7473	32	38
7474	27	38
7475	38	40
7476	37	38
7478		38
7480	48	
7481	86	
7482	69	
7483A		110
7484	97	
7485	104	99
7486		40
7489	205	
7490	33	90
7491	76	110
7492	38	78
7493	32	99
7494	78	
7495A	65	99
7496	58	120
7497	185	
74100	119	
74104	63	
74105	62	
74107	32	38
74109	63	38
74110	54	54
74111	68	
74112		38
74113		38
74114		38
74116	198	
74118	83	
74119	119	
74120	115	
74121	25	
74122	46	57
74123	48	73
74124		137
74125	38	44

	'N'	'LSN'
74126	57	44
74128	74	
74132	73	78
74133		29
74136		40
74138		60
74139		60
74141	56	
74142	265	
74143	312	
74144	312	
74145	65	97
74147	175	
74148	109	191
74150	99	
74151	64	84
74153	64	54
74154	96	
74155	54	110
74156	80	110
74157	67	55
74158		60
74159	210	
74160	82	130
74161	92	78
74162	92	130
74163	92	78
74164	104	130
74165	105	
74166		
74167	20	
74168		
74169		200
74170	230	200
74172	625	
74173	170	
74174	87	120
74175	87	110
74176	75	
74177	78	
74180	85	
74181	165	350
74182	160	
74183		210
74184	115	

	'N'	'LSN'
74185	134	
74188	275	
74190	115	92
74191		
74192	105	180
74193	105	180
74194	105	187
74195	95	137
74196	99	110
74197	85	110
74198	150	
74199	160	
74247		90
74248		90
74249		93
74251		90
74253		105
74257		108
74258		153
74259		420
74260		153
74261		353
74266		40
74273		124
74275		312
74279		52
74283		120
74290		90
74293		95
74295		120
74298		100
74324		157
74325		242
74326		247
74327		237
74352		100
74353		100
74362		715
74365		49
74366		49
74367		43
74368		49
74373		77
74374		77
74375		60

	'LSN'
74377	124
74378	93
74379	130
74368	37
74390	140
74393	140
74395	139
74396	133
74398	180
74399	150
74445	92
74447	90
74490	140
74668	110
74670	249

VOLTAGE /PSU REGULATORS

7800 series	95p
7900 series	£1
78M series (TO220 pack)	90p
78LCP series	35p
78MGT2C	175p
79MGT2C	175p
723C	65p
NE550A	73p
L200	195p

MAINS FILTER

1Amp IEC	4.83
6Amp IEC	5.83
5A wirein	3.87
All BS approved	

Requests for the next issue of the catalogue now being "booked" for despatch immediately it is ready (about November). Please send 50p to reserve a copy. (Part 3)

IMPORTANT: ALL OSTS PRICES EXCLUDE VAT - CURRENTLY 8% - BUT MAY BE CHANGED BY THE TIME YOU READ THIS. PLEASE REMEMBER TO ADD VAT, and 25p POSTAGE !!

CD4000 CMOS

4000	17p
4001	17p
4002	17p
4006	109p
4007	18p
4008	80p
4009	58p
4010	58p
4011	17p
4012	17p
4013	55p
4014	95p
4016	52p
4017	80p
4018	80p
4019	60p
4020	93p
4021	82p
4022	90p
4023	17p
4024	76p
4025	17p
4026	180p
4027	55p
4028	72p
4029	100p
4030	58p
4031	250p
4032	100p
4033	145p
4034	200p
4035	120p
4036	250p
4037	100p
4038	105p
4039	250p
4040	83p
4041	90p
4042	85p
4043	85p
4044	80p
4045	150p
4046	130p
4047	99p
4048	60p
4049	55p
4050	55p
4051	65p
4052	65p
4053	65p
4054	120p
4055	135p

4059	563p
4060	115p
4063	109p
4066	53p
4067	400p
4068	25p
4069	20p
4070	20p
4071	20p
4072	20p
4073	20p
4075	20p
4076	90p
4077	20p
4078	20p
4081	20p
4082	20p
4085	82p
4086	82p
4089	150p
4093	50p
4094	190p
4096	105p
4097	372p
4098	110p
4099	122p
4160	90p
4161	90p
4162	90p
4163	90p
4174	104p
4175	95p
4194	95p
4501	23p
4502	91p
4503	69p
4505	51p
4507	55p
4508	248p
4510	99p
4511	149p
4512	98p
4513	206p
4514	260p
4515	300p
4516	125p
4517	382p
4518	103p
4519	57p
4520	109p
4521	236p

4522	149p
4527	157p
4528	102p
4529	141p
4530	90p
4531	141p
4532	125p
4534	614p
4536	380p
4538	150p
4539	110p
4541	141p
4543	174p
4549	399p
4553	440p
4554	153p
4556	77p
4557	386p
4558	117p
4559	388p
4560	218p
4561	65p
4562	530p
4566	159p
4568	281p
4569	303p
4572	25p
4580	600p
4581	319p
4582	164p
4583	84p
4584	63p
4585	100p

Micromarket

6800 series	
6800P	6.50
6820P	£6
6850P	2.75
6810P	£4
6852	3.65
8080 series	
8080	6.30
8212	2.30

8216	1.95
8224	3.50
8228	4.78
8251	6.25
8255	5.40
MEMORIES	
2102	£1 70
2112	£3 40
2513	£7.54
4027	£5 78

2114	£10
2708	£
Development	
MEK6800	£220
TK80	£306

AMI, Signetics TI, Intersil, Harris etc OA

MISC. LSI/Scalars/DVMs

NE555 30p NE556 78p NE558 180p
LM3909 72p 95H90DC /320MHz 780p
11C90DC /650MHz £14 00
ICM7216BIPI 8 decade 10MHz DFM/timer with direct LED drive and all-counter features £19.82

ICM7217AIBI 4 decade programmable cntr	£9 50
ICM7207 clock pulse generator IC	£4 95
ICM7208 7 decade counter/display driver	£14 95
ICM7106CP LCD DVM IC (3½ digit)	£9 55
ICM7106CPK LCD DVM KIT	£24 80
ICM7107CP LED DVM IC	£9 55
ICM7107CPK LED DVM KIT	£20 65
SP8629 divide by 100 200MHz scalar	£4 20
MSL2318 divide by 100 to 175MHz min divide by 10 to 45MHz min	£4 20

PLEASE REMEMBER TO AOD 8% VAT TO ITEMS LISTEO UNDER OSTS

LINEARS non consumer

BIMOS	
CA3130E	84p
CA3130T	90p
CA3140E	
CA3140T	72p
CA3160E	90p
CA3160T	99p
Op amps	
LM301AH	67p
LM301AN	30p
LM308H	121p
LM308N	97p
LM318H	279p
LM318N	224p

LM324N	71p
LM339N	66p
LM348N	186p
LM3900N	60p
709HC to5	64p
709PC dil	36p
710HC to5	65p
710PC dil	59p
723CN	65p
741CH to5	66p
741CN 8dil	27p
747CN	70p
748CN	36p
NE531T	120p
NE531N	105p

OPTO 7 seg displays

0.43" High Efficiency HP:

5082	7650	red CA	233p
5082	7653	red CC	
5082	7660	yellow CA	
5082	7663	yellow CC	
5082	7670	green CA	
5032	7673	green CC	

0.3" Standard HP

5082	7730	red CA	147p
5082	7740	red CC	

0.5" Fairchild

FND500 red CC	150p
FND507 red CA	150p

Current news: Work continues apace on our HMOS PA kit, and by the time this is published - we expect to be about to launch the product in a style that matches the Mark III system. The unit uses separate transformers and power supplies, and includes a DC offset sensing circuit combined with slow switch-on using a relay. We introduce the HyperFi FM IF with this advert - and a separate leaflet is available on request with an SAE. All new pricelist revision also available with an SAE. The Mullard DC controlled tone/volume and switch ICs with a 'more than HiFi' specification are in stock at last - together with reams of data (over 50 pages now). Also, RC enthusiasts will be interested to learn that we are supplying parts for various kits now.

Terms: CWO please. Account facilities for commercial customers OA. Postage 25p per order. Minimum credit invoice for account customers £10.00. Please follow instructions on VAT, which is usually shown as a separate amount. Overseas customers welcome - please allow for postage etc according to desired shipping method. Access facilities for credit purchases.

Catalogues: Ambit. Part 1 45p. Part 2 50p 90p pair. TOKO Euro shortform 20p. Micrometals toroid cores 40p. All inc PP etc. Full data service described in pricelist supplements.

Hours/phone: We are open from 9am -7pm for phone calls. Callers from 10am to 7pm. Administrative enquiries 9am to 4.30pm please (not Saturdays). Saturday service 10am to 6pm.

ambit® international

AMBIT catalogues are guaranteed to contain the most up-to-date and best informed comment on modern developments and advances in the field of radio and audio. There is no competetive publication that even approaches the broad range of parts/information on modern techniques.

2 Gresham Road, Brentwood, Essex.

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Monitor

EDIBLE MEMORIES

There was talk some years ago of making certain parts of space-craft from edible material (seriously) so in the event of an accident the luckless astronauts could survive by eating non-essential equipment until help arrived. Today we have definite proof of this advance in the shape of edible ICs. They're called 'Silly-Con-Chips' and according to the manufacturers 'Hannah's of Johnstone', they are coated with 'pearl of wisdom', the more you eat the wiser you get. We get to hear of most new advances but we must admit defeat over this one, an educated guess from one of our experts assures us that they're a development of bubble (gum?) memories.

Being diligent researchers we decided to put these new devices to the test, we ate the lot, the things we do for HE.

OPEN LETTER TO HE

We are dismayed that you have encouraged an illegal network of CB operators with scant reference to the hazardous effect on the legitimate users of the 27 MHz waveband.

While we recognise the value of CB as a genuine hobby interest and support your claim for legislation of an authorised channel, we condemn any policy which is calculated to seek recognition by swamping the established licensees. Many valuable models have already been lost to interference, some at risk to life and limb. Any encouragement on your part to sustain this intrusion into the established rights of a law abiding community will be seen through the eyes of the modellers as an irresponsible act of aggression. Only by concerted action on the part of recognised Associations and the Government Authority can we possibly hope to recover from this clash of interests, and for our part, the Model Associations and the Trade Federation are already fully engaged in discussions.

The Editors
Radio Control Models and Electronics

ACID TEST?

For those of you not familiar with chemistry, it's possible to measure electronically the strength of acids and alkalis. The concentration of these substances are measured in pH units on a scale of 0-14. Semat Ltd have just introduced a new range of digital and analogue pH meters.

Pictured here is the CD 60 LCD meter with a 13mm display. The quoted accuracy is in the order of 0.02 pH units when used with standard electrodes. Other products in their range include a large bench version which also incorporates a millivoltmeter, both instruments are available with either LED or LCD display elements. For further information contact Semat (UK), 89 Lakeside Road, London N13 4PS.

IRISH THERMOMETER

Have you heard the one about the Irish digital thermometer it had three digits, to be sure, to be sure, to be sure. Sorry about that, especially to all our Irish readers, it was an old joke after all. Anyway back to business, the Digital thermometer we're featuring really does come from the Emerald Isle its made by EireLec Ltd. They boast an impressive range of features, the range for instance is from −150°C to +1150°C to an accuracy of 0.2% of reading.

The instrument is based upon a purpose designed CMOS IC, the IC is responsible for linearisation of the thermocouple input (Wot, no thermistor???), auto zeroing, indication of probe failure (a bit pessimistic) and battery check.

The power department is looked after by our old friend the venerable PP3, it's interesting to see they've made the resolution switchable for either 0.1° or 1.0°C, the thermometer comes complete with warranty and a choice of either thermocouple (at last!) or platinum resistor probe. Interested? Then EireLec will be only too glad to help, you can find them at: Coe's Road, Dundalk, Co Louth, Ireland.

CB AGAIN

We actually received a press release from the CBA this month, inside was a copy of a letter sent to the PM, and guess what a reprint of an article from Cu . . om . C.r magazine. Huh. . . .

BUBBLE ETCHER

It's not our fault, really, the price for the Bubble Etcher in last month's Monitor (from Mega Electronics) should have read £55 + Post and Packing + VAT (at 15%).

HIGH TECHNOLOGY TEA TRAYS

Following in the success of Du-Ponts coating for frying pans to enable them to withstand the tremendous heat of re-entry from earth orbit, Siemens have developed a range of tea trays that actually generate their own electricity. They claim that in bright sunlight they will develop over 15 watts, most impressive. As with most new technology precise applications are somewhat confused but we're sure it will prove to be another boon to the housewife.

POSTAL DELAYS

Anyone whose sent us any letters or orders may have experienced delays. We have noticed that even 1st class letters have taken up to four weeks to get in. This is due to the well publicized Post Office problems — and we're in the worst-affected area.

MASSIVE CALCULATOR SHORTAGE

It looks like the calculator industry has folded at last. For the first time in living memory we haven't received one single calculator. We should have seen it coming, we got nothing from Casio last month, and that's got to be a worlds first (or last). So if any calculator manufacturers are still in business why not drop us a line and tell us about any redundant stock you may have going cheap.

WE'VE MOVED

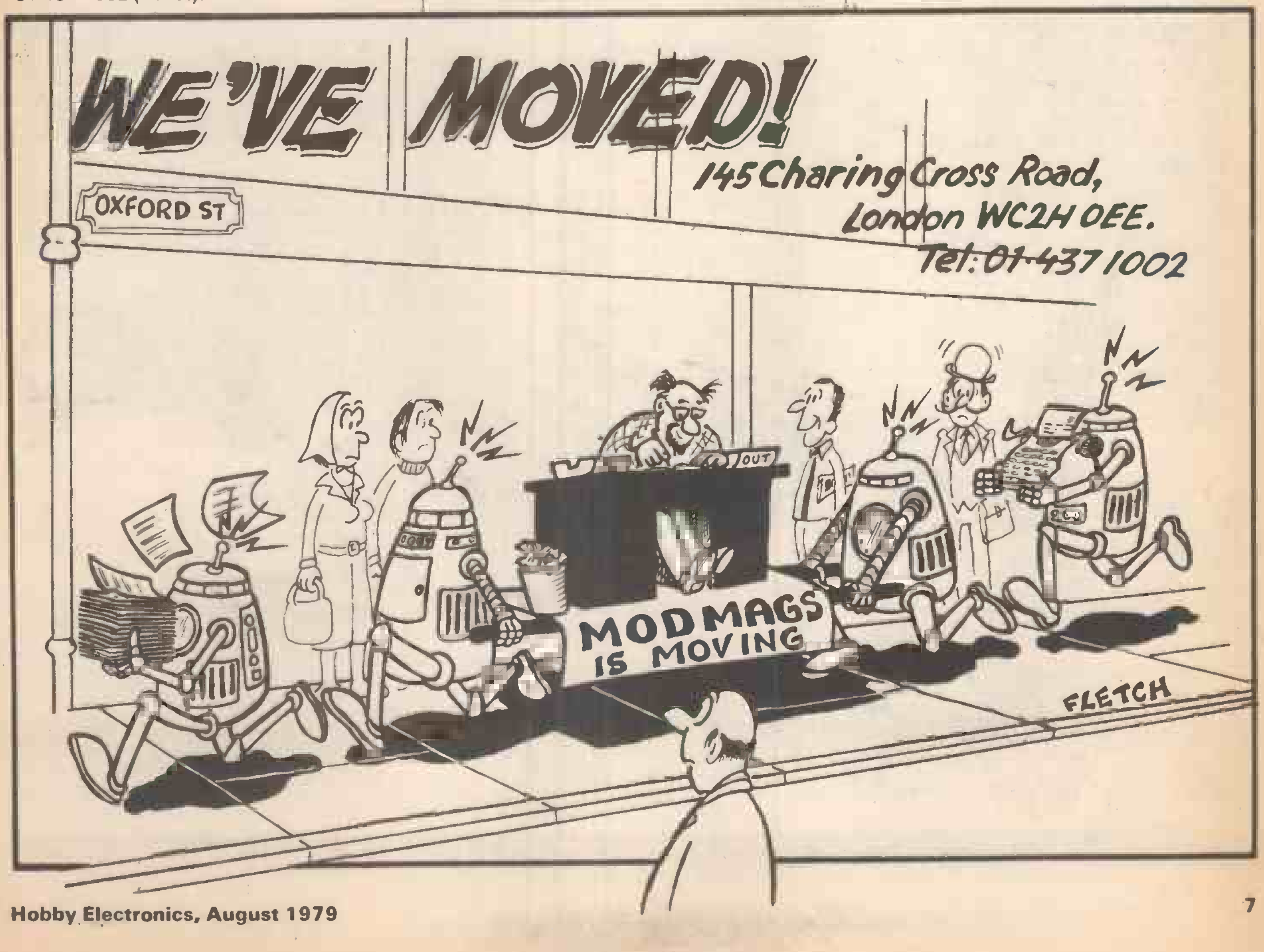
By the time you read this we will have moved, along with our sister magazines Electronics Today International and Computing Today to larger offices in Charing Cross Road. The new offices are only about 100 yards from our old Oxford Street offices. Our new address is: 145 Charing Cross Road, London WC2H 0EE. Our new phone number for Technical queries etc is 01-437 1002 (4 lines).

NEW CATS FOR OLD

Stevenson Ltd, component suppliers of this parish have just sent us their latest catalogue. Good to see it has got considerably fatter due to their increased range. When we reviewed the last catalogue from Stevenson in our April issue it came out as one of the best for value, glad to see that hasn't changed. It's still free on request, send your name and address to: Stevenson, 76 College Road, Bromley, Kent BR1 1DE.

JAWS IN TIME

We forgot to credit last months cover photo of the Shark to Ardea Ltd and Ron Taylor who took the pic, sorry about that.



Home Security System

Protect your private castle against fire, thieves, thugs and thingies with this HE anti-disaster unit.

THE HE HOME SECURITY UNIT forms the heart of a general-purpose house or office protection system. When it is coupled to suitable input sensors (microswitches, pressure mats, window foil, thermostats, etc) and an output sound generator (a siren or bell) it gives a high degree of protection against burglars and frontdoor thugs, as well as giving fire protection.

The unit is designed around a single low-cost CMOS chip, and draws a very low quiescent current from its HP1 12 volt battery power supply. Particular care has been taken to ensure that the design has good operational reliability, and consequently it has a high degree of immunity against false alarms from lightning strikes, radio interference, etc.

The HE valuables amassed together, we had to scour the offices for this little lot, burglars please note we've installed the system in our new offices, so beware, it works very well.

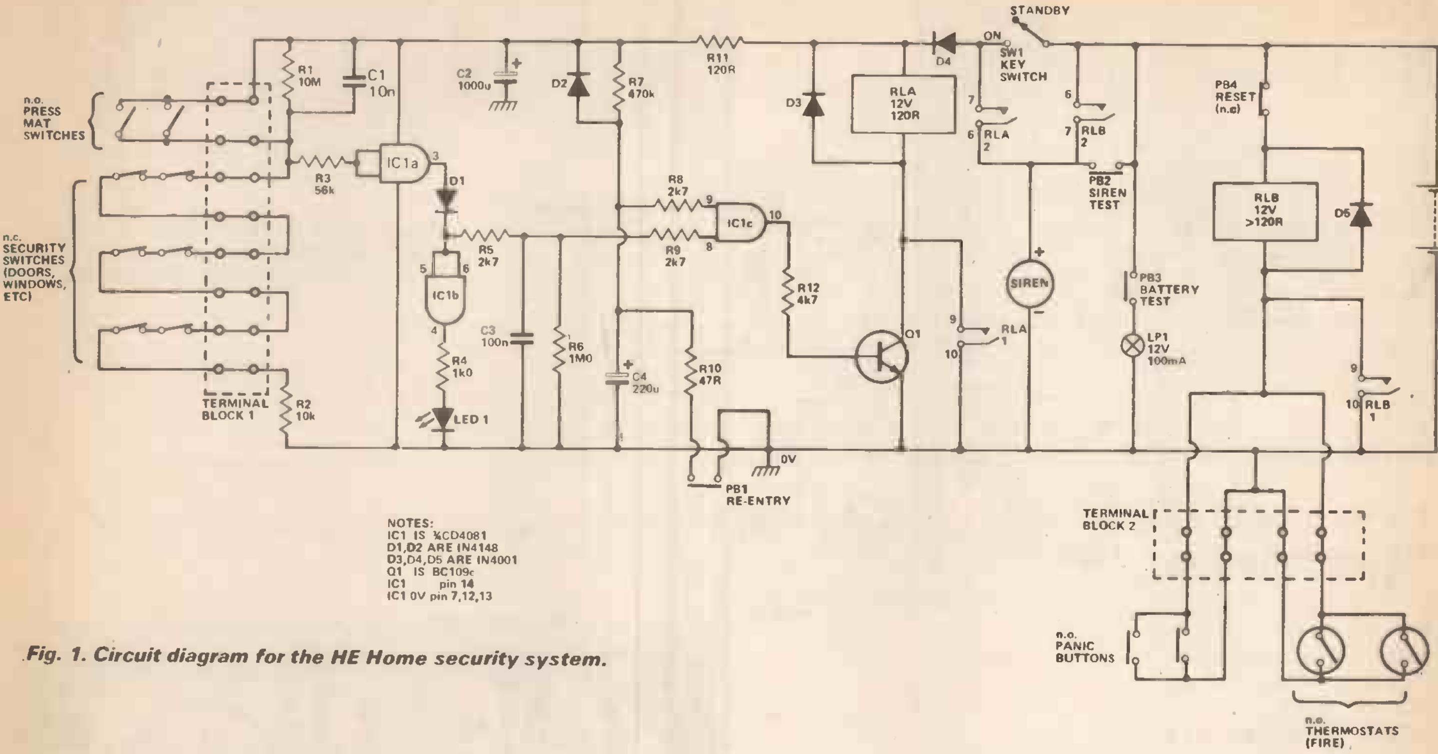


Fig. 1. Circuit diagram for the HE Home security system.

How It Works

The circuit of the unit can be broken down into two discrete sections, with the PANIC and FIRE alarm circuitry to the right of SW1, and the burglar alarm system to the left. The panic and fire section of the unit is permanently enabled, and basically comprises relay RLB and the parallel-connected normally-open fire and panic 'switches', which are wired in series with the coil of RLB across the power supply. If any of these switches become closed the relay turns on and is self-latched via contacts RLB/1, and activates the siren via contacts RLB/2. Relay RLB can be unlatched and turned off again, provided that all sensor switches are open, by momentarily opening normally-closed RESET switch PB4. The siren can be given a non-latching test at any time by closing PB2, and the battery condition can be roughly checked via LP1 by closing PB3.

The anti-burglar section of the unit is designed around IC1-Q1 and relay RLA, and is supplied with power via the D4-R11-C2 decoupling and smoothing network, which ensures that the circuit is not adversely affected by large supply line transients generated by the siren. IC1 is a CD4081 quad 2-input AND gate CMOS chip. Only three of the available gates of the IC are used in this application.

IC1a is used as a high-impedance non-inverting input buffer. It's input (and output) is normally held at near-zero volts via R1-R2 and the normally-closed security switches, but is pulled high via R1 if any of the NC switches go open circuit, or is pulled high directly if any NO input switches are closed. The output of IC1a is fed to LED 1 via D1 and IC1b, and is also fed to one of the input terminals of AND connected IC1c via D1 and the R5-R6-R9-C3 network. The other input of IC1c is derived from a simple time constant network formed byC4 and R7, which disables IC1c for the initial 50 seconds after turn-on of the unit. The output of IC1c is fed to the relay via Q1. The complete sequence of operations is as follows.

At the moment of system turn-on IC1c and the relay are disabled via the C4-R7 network, but IC1a and IC1b are enabled. If any of the input sensors are defective at this time, the input and output of IC1a go high and LED 1 is driven on via IC1b. If no sensor faults are present, the owner has 50 seconds in which to pass through 'protected' areas before the alarm will sound. If, at the end of this period, any sensor is activated, the input of IC1a will go high and drive relay RLA on via IC1c and Q1. Once it is activated, RLA self-latches via contacts RLA/1 and activates the siren via contacts RLA/2. The siren then continues to sound until the supply battery runs flat: this mode of operation is considered to have considerable practical advantages over the time-controlled auto-turn-off systems adopted in some commercial alarm units.

Note in the circuit that R1-C1 and R6-C3 are used as simple transient-suppressing networks, and protect the circuit against false-triggering

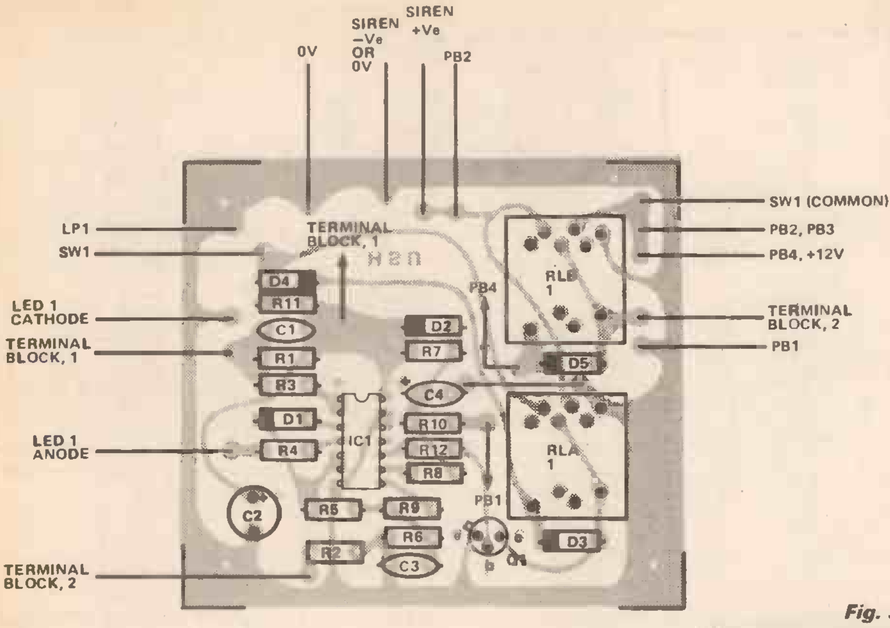
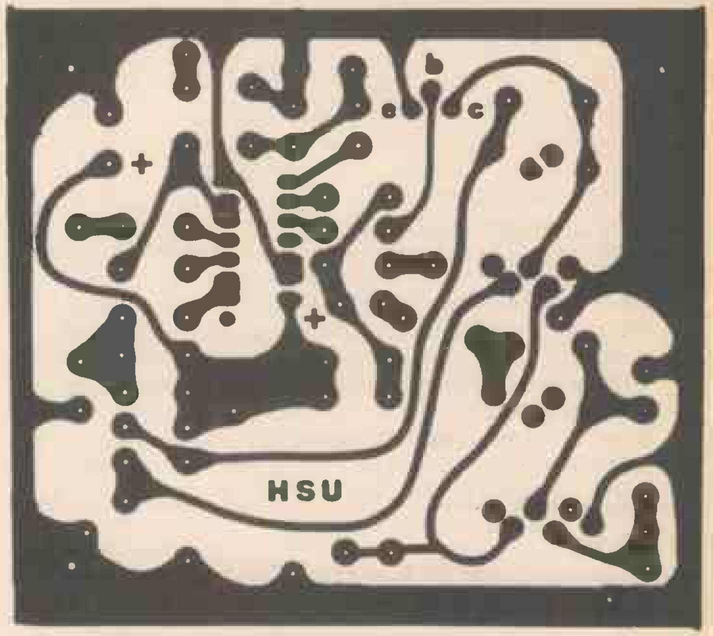


Fig. 2. PCB overlay for the Home Security System, note the position of all polarised components.

Fig. 3. PCB foil pattern for the Home Security system.



THE BASIC UNIT

The basic unit incorporates the system's power supply and all the electronic circuitry, including two siren-driving relays, and is intended to be used in conjunction with a number of external sensors and a siren or bell. The unit uses a 12 volt HP1 battery as its power supply, and this battery is capable of powering the system for about one year if the siren is not activated. The unit is designed to give self-latching alarm operation, so once it is activated it continues to sound until it is turned off by the owner or until the supply battery runs flat (which takes about six hours from a fresh battery).

The siren can be activated via either of two relay circuits. One of these is associated with the 'burglar alarm' side of the home security unit, and is only active when the unit is turned to the full ON mode. The other relay is permanently enabled, i.e., when the unit is in either the STANDBY or the ON mode, and can be activated via either thermostat FIRE sensors or via push-button PANIC switches scattered around the house. These panic buttons give a high degree of protection against front door thugs, etc.

Among the many features of the unit are a STANDBY/ON keyswitch on the front panel, a siren test button, a battery test button and lamp, a reset button, and a LED sensor-fault indicator.

Another important feature is a 50 second delay facility, which ensures that the anti-burglar system does not become fully enabled until 50 seconds after initial switch on, thus giving the owner plenty of time to check that there are no sensor faults via the panel-mounted LED, and then walk over pressure mats or through *armed* doors without sounding the alarm. The system becomes fully enabled at the end of the 50 second period, and the alarm then sounds and self-latches instantly if any sensor is subsequently activated. The system can be temporarily disabled for another 50 second period, to facilitate building re-entry, etc., by momentarily operating a remote RE-ENTRY switch, which can take the form of either a key or a concealed push button

SENSORS AND SIRENS

The Home security Unit can be used with a variety of types of input sensors, which can be coupled into the system via terminal strips mounted on the rear of the unit. The anti-burglary sensors can take the form of normally-open parallel-connected devices such as pressure mats, and normally-closed series-connected devices such as microswitches, magnetically-activated reed relays, and window foil strip, etc. Fire protection can be ontained by wiring normally-open thermostats in parallel, and thug protection can be obtained by wiring normally-open push-button PANIC switches in parallel.

The system's output sound generator can be any 12 volt electro-mechanical or electronic siren or bell. Figure 2 shows the practical circuit of an electronic siren that produces a warbling sound similar to that of an American ambulance or police car, and which generates about 4 watts into an 8 ohm speaker or 1.2 watts into a 3 ohm speaker.

Parts List

RESISTORS (All ¼W 5%)

R1	10M
R2	10k
R3	56k
R4	1kO
R5, R8, R9	2k7
R6	1MO
R7	470k
R10	47R
R11	120R
R12	4k7

CAPACITORS

C1	10n polycarbonate
C2	1000µ Electrolytic (PCB mounting)
C3	100n polycarbonate
C4	220µ electrolytic (PCB mounting)

SEMICONDUCTORS

IC1	CD4081
Q1	BC109C
D1, D2	IN4148
D3, D4, D5	IN4001

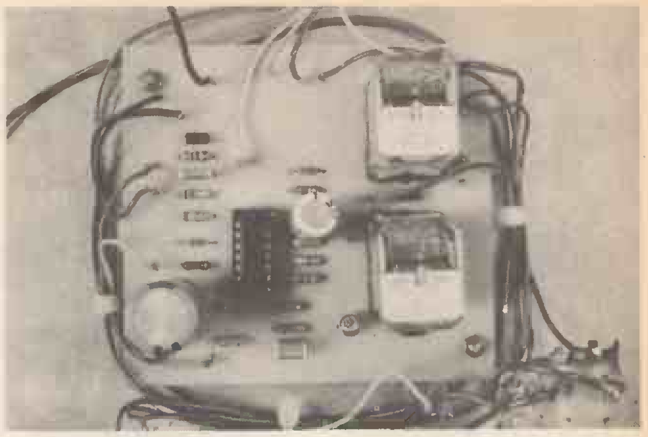
MISCELLANEOUS
Siren (see text)
2 off — RLA, RLB, 12V 7120R (continental series relays)
SW1 — Key switch.
PB1, PB2, PB3, push button switches (momentary action)
PB4 push button switch (normally closed contacts)
12V battery HP1.
8 way + 3 way terminal blocks.
Case to suit.

Buylines

Most of the electrical/electronic parts for this project, including the relays, key switch and siren, are available from the larger mail-order advertisers in this magazine: if you haven't got their catalogues, buy them now.

The HPI battery should be available from most large electrical retailers. Anti-burglar sensors and devices such as window foil, microswitches, magnet/reed-relay combinations, pressure mats, alarm bells and enclosures, etc, are available from:— STRATHAND SECURITY, 44 St. ANDREW'S SQ., GLASGOW G1 5PL. Their catalogue, which also gives details of alarm techniques, costs £1, plus P and P.

The systems siren or bell must be mounted external to the main unit, and can be tested at any time by pressing a non-latching SIREN TEST button mounted on the main unit.



Close up of the electronics, in circuits of this type always use the best quality components, false alarms are both irritating and embarrassing.

CONSTRUCTION

The major part of the electronic circuitry, including the two relays, is assembled on a single PCB, and construction should present few problems so long as care is taken to observe polarities of the electrolytic capacitors and the semiconductor devices. The two relays, which are miniature plug-in 'continental' types, are mounted on the board via 0.1 inch PCB mounting sockets. The relays are 12 volt types with coil resistances greater than 120R (185R on our prototype).

The completed PCB must be mounted in a suitable case, together with the HP1 supply battery that measures 5¼ x 5¼ x 2½ inches. We built our prototype unit into a case with overall dimensions of 6 x 11 x 3 inches. Components SW1, PB2, PB3, PB4, LP1, and LED 1 are mounted on the case front panel, and two screw-type terminal strips or blocks are mounted on the rear to facilitate connections to the systems sensors, etc.

Pay special attention to the circuit interwiring, taking care to relate the component overlay to the circuit diagram. When construction is complete, wire a suitable siren or bell in place, and give the unit a functional check by turning key switch SW1 to the ON position, with no anit-burglar sensors in place. LED 1 should illuminate, but extinguish when a short is placed between R2 and the junction of R1 and R3. The alarm should operate and self-latch approximately 50 seconds after initial switch-off if this short is removed. This timing period is determined by the C4 value.

With the key switch SW1 in the STANDBY position, the alarm should operate and self-latch when a momentary short is placed across the PANIC BUTTON or THERMOSTAT connections of the sensor terminal strip, and turn off again when PB4 is momentarily opened. When the above tests are satisfactory the unit is ready for installation in the home.

If you want to build the electronic siren circuit of Fig 2, do so at this stage. Construction of this circuit should present no problems.

INSTALLATION AND USE

The installation of a home security system is a fairly major undertaking, with many fine points to consider and individual decisions to be made regarding the degree of protection that is required and the types of sensors that are to be used, etc. An article outlining the principles of installation is presented after this project and should be read in conjunction with the present story. In short, however, it is up to the individual reader to work out the details of his own sensor and alarm generator networks, and then couple those networks up to the main Home Security Unit.

The HE Home Security System connected up to motorised siren, we can vouch for the units loudness, the ringing is still in our ears.

The anti-burglar sensors must be coupled to the unit via terminal block 1, and the fire and panic sensors must be coupled via terminal block 2. Any number of normally-open (NO) sensors can be wired in parallel, and any number of normally-closed (NC) sensors can be wired in series.

The main unit is best mounted in a central part of the home, such as on a landing or at the foot of the stairs, so that it can be operated with maximum convenience. The alarm sound generator should be mounted fairly close to the unit, to minimise power losses in the connecting leads, and these leads should either be concealed or mounted in armoured sleeving so that they can not be readily cut. Excessive attention does not need to be given to the matter of making the unit and the sound generator super-secure, however, since the system will already have failed in its prime purpose if an unauthorised person is able to get close enough to disable its heart.

If a re-entry switch is mounted on the front door of the house, the wiring between the switch and the main unit should be carefully concealed. If required, a number of re-entry switches can be wired in parallel so that, for example, the system can be temporarily disabled from either the front door or the main bedroom.

The alarm system is very simple to use. The PANIC and FIRE alarm side of the circuit is permanently enabled, and can be operated at any time. The anti-burglar section is enabled only when the main key switch is moved to the ON position. If the panel-mounted LED lights at the moment of turn-on it means that part of the sensor system is either open or closed when it should not be, possibly due to an open door or a chair resting on a pressure mat, etc. The fault must be rectified before the system is put to full use.

If you leave the house or pass through a protected area after turning the system on, remember to use the re-entry facility before returning to the unit, or you'll sound the alrm and annoy the neighbours. **HE**

How it Works

IC1, an NE556, contains two so-called 'timer' circuits of the 555 type. One of these timers is available via pins 1 to 6 on the left side of the IC, and the other is available via pins 8 to 13 on the right side of the IC. Pins 7 and 14 are the supply ground and supply positive terminals respectively of the IC.

In the electronic siren circuit, both timers are configured as free-running astable multivibrators. The left hand astable is used as a square wave generator, using timing components R2-R3-C1. It oscillates at a centre frequency of about 950 Hz, and has its output fed to the speaker via R4 and power transistor Q1.

The right hand astable is used as a triangle-wave generator, using timing components R5-R6-C2, and oscillates at about 2.5 Hz. The triangle-wave output is taken from across C2 via emitter follower Q2 and is fed to 'control voltage' pin 3 of the left hand astable via R1, where it modulates the frequency of the left hand astable and causes its frequency to sweep through the range 800 Hz to 1100 Hz two and a half times per second. The resulting output sound of the speaker resembles that of a modern Aerican ambulance or police siren.

The speaker used in the circuit can have any impedance in the range 3RO to 8RO. The circuit output power depends on the speaker impedance, and is about 4 watts on 8RO or 12 watts on 3RO. Diode D1 is used to damp the back EMF of the speaker, and protects Q1 against possible damage. D2 and C3 ensure that the main oscillator circuitry is not influenced by the speaker transients.

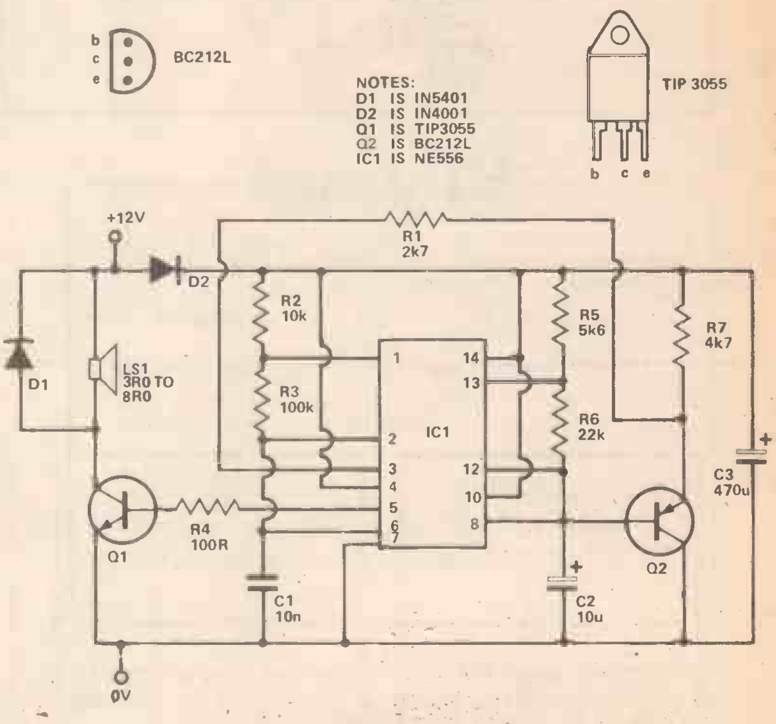


Fig. 4. Circuit diagram for the optional electronic siren.

Parts List

RESISTORS (All ¼W 5%)	
R1	2k7
R2	10k
R3	100k
R4	100R
R5	5k6
R6	22k
R7	4k7
CAPACITORS	
C1	10n Polycarbonate
C2	10µ Tantalum
C3	470µ Electrolytic
SEMICONDUCTORS	
IC1	NE556
Q1	TIP3055
Q2	BC212L
D1	IN5401
D2	IN4001
MISCELLANEOUS	
LSI	3RO-8RO

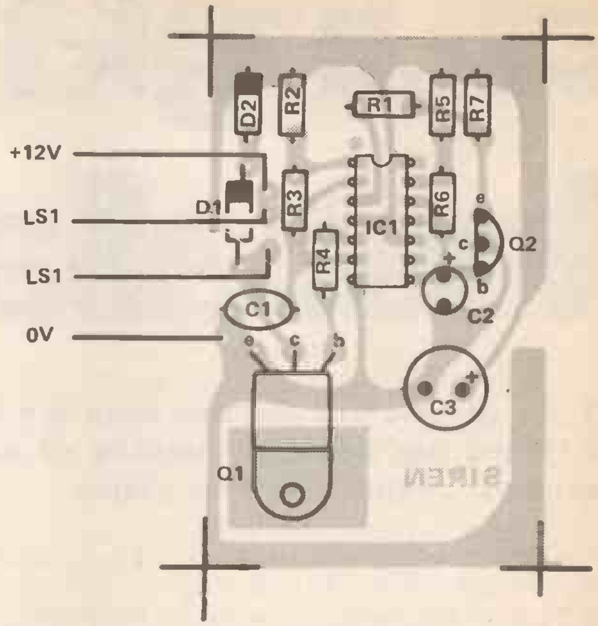
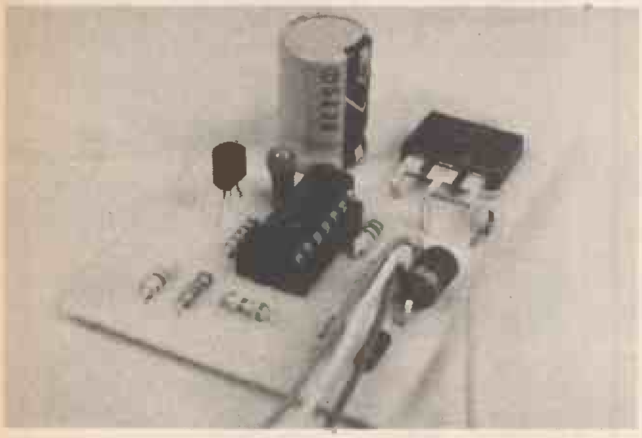
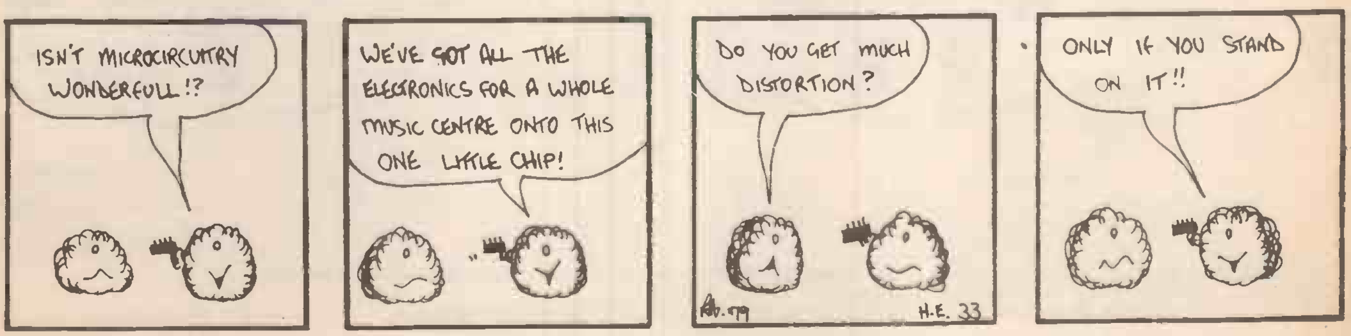


Fig. 5. Overlay diagram for the optional electronic siren.



The assembled siren board, it will either fit in the case or in a remote location with the speaker.

Fig. 6. PCB foil pattern for the optional electronic siren.



Burglar Alarm Installation

If you decide to build this month's HE Home Security Unit project, you'll need to learn the basic principles of security system installation. Ray Marston explains in the next few pages.

STATISTICS SHOW THAT the average Englishman has a one-in-four chance of being burgled, beaten up, or burnt in his own home at least once in his lifetime. The chances of such disasters occuring can be greatly reduced by taking a few simple security precautions, such as fitting good locks on all external doors and closing all windows at night and when the house is empty. The chances can be reduced even more by installing a well thought out home security system. With the latter option in mind, let's look at some of the basic principles of home security system installation.

DON'T GET YOUR FINGERS BURNT.

The disasters most likely to strike you at home are fire, thuggery, and burglary. Most home fires are caused by daft things like lighted cigarettes, pieces of smouldering coal falling onto rugs, overheated electrical appliances, and carelessly placed tea cosies or towels igniting from the heat of gas pilot jets, etc.

The first line of defence against fire is common sense, and the second line is a fire alarm system. The fire alarm system can be a sophisticated affair, including smoke

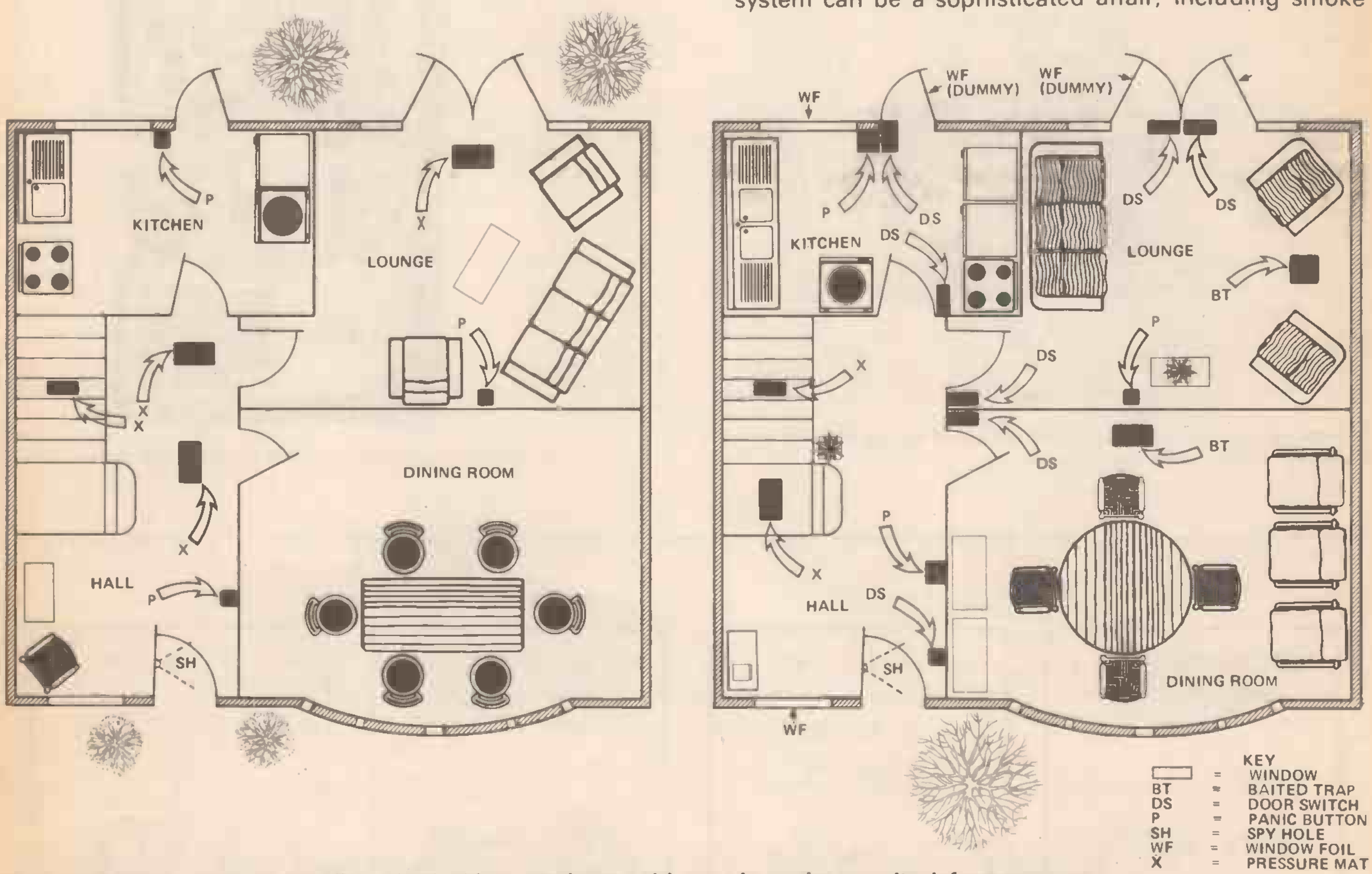


Fig 1. Ground-floor plans of a medium-sized mid-terrace house with two alternative security defence systems.
(a) House with minimal 'SPOT' and 'PANIC' defences.
(b) House with a high level of 'PERIMETER' and 'SPOT' defences, plus minimal 'PANIC' defences.

and gas detectors, or a simple outfit consisting of a number of normally-open thermostats, all mounted at ceiling height and connected in parallel, and arranged so that they complete an alarm circuit if any of them close. Any type of fire alarm system is better than none at all, provided that the system is reliable. The HE Home Security Unit has a fire alarm facility, and is designed for use with any number of parallel-connected thermostats.

LOOK OUT, LOOK OUT, THERE'S A THUG ABOUT!

Thuggery is a very real menace to the householder. It normally occurs when one or more males attack the occupier as he (or she) either opens the front door in response to a call, or occurs shortly afterwards when the strangers have gained entry to the house on the pretext of reading a gas meter or selling insurance, etc. Occasionally, the attacks occur late at night following a break-in.

The first line of defence against the thuggery menace is common sense and possibly a 'spy hole' device and a security chain fitted to the front door. An excellent second line of defence is a permanently armed system of PANIC buttons positioned close to likely attack points (front and rear doors, the TV lounge, and the main bedroom) and arranged to activate a self-latching alarm when they are momentarily activated. The HE Home Security Unit is designed for use with any number of parallel-connected normally-open PANIC button switches (ordinary push-button switches).

SYSTEM RELIABILITY

The most important parameter of any security system is it's reliability, or immunity to false alarms. Ninety-nine percent of all burglar alarm soundings are false alarms. Systems that frequently give false alarms tend to be ignored by both the police and their owners.

'Sophisticated' systems, such as radar, ultrasonic, and light-beam types, tend to be significantly less reliable than the 'cruder' types that depend on the activation of microswitches and reed-relays, etc., for their operation. Many alarm systems can be false-triggered by electrical interference from lightning flashes, near-by electric motors, or electric lighters operated close to their sensors. The HE Home Security Unit has been designed to have a high reliability factor.

Fig 2. A good quality key switch is an essential item in any home security system.

PROTECTING YOUR CASTLE.

So let's assume that you've decided to fit the super wonderful reliable HE Security Unit in your home, and have formed some idea of the degree of protection that you need. How do you go about planning the layout of your security switches and sensors?

Any building can, for our present purposes, be regarded as a box that forms an enclosing perimeter around a number of interconnected compartments. This perimeter 'box' is the shell of the building, and contains walls, floors, ceilings, doors and windows. To commit any crime within the building the intruder must break through the perimeter, which thus forms the owners first line of defence.

Once an intruder has entered the building he can move from one room or 'compartment' to the next only along paths that are pre-determined by the layout of internal doors and passages. In moving from one compartment to the next he must inevitably pass over or through certain 'spots' in the building, as is made clear in Figure 1a, which shows the ground-floor plan of a medium-sized mid-terrace house. Thus, to move between the kitchen (a likely break-in area) and the lounge he must pass through three 'spots' comprising the kitchen door, adjacent point 'X', and the lounge door. These typical 'spot' points form the owner's second line of defence.

The house owner can thus obtain protection by using full or partial 'perimeter' defence, or by using 'spot' defence, or by using a combination of these two methods.

'Perimeter' defence sensors include microswitches or reed-relay/magnet combinations which can be fitted to external doors and windows, and window foil which can be fitted to the glazing on external doors, windows, and skylights. 'Spot' defence sensors include pressure mat switches that can be fitted under rugs or carpets, microswitch or reed-relay/magnet door switches, and 'baited traps' comprising an attractive item (such as a clock) placed on top of a concealed microswitch that activates when the item is removed.

When planning the installation, the house owner must try to think like a burglar. Normally, the burglar enters a house from an easy access point that is obscured from the view of the neighbours, ie, a back door or window. Often, he breaks in using tools 'borrowed' from the owner's shed or garage, so these two places should

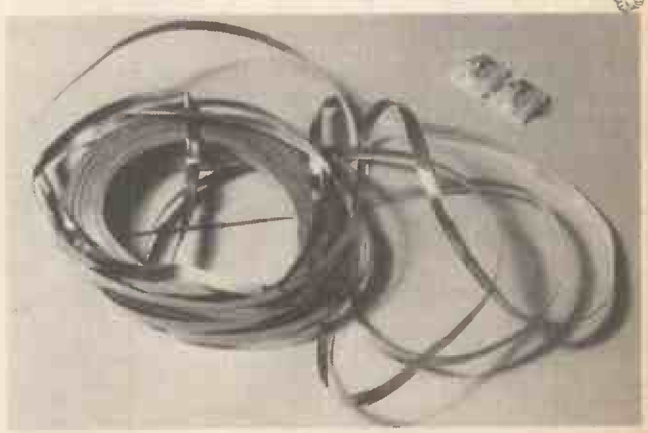


Fig 3. Self-adhesive window foil can be fixed to most types of glazing. It hooks into the security system via special connector blocks.

Fig 4. Pressure mats can be hidden under rugs and carpets.

be included in the owner's defence system. Invariably, the burglars first action on entering the property is to secure a rapid escape route, ie, to open the back door. He then starts hunting for stealable goodies.

TWO EXAMPLES.

Figure 1 shows two alternative ways of installing security defence systems in the ground floor of a medium-sized mid-terrace house. In both cases anti-thuggery protection has been obtained by installing a 'spy hole' device in the front door, and by fixing PANIC buttons at three likely attack points. The houses differ considerably, however, in their methods of burglary protection.

In the case of Fig 1a the owner has reasoned that a burglar is most likely to enter the house via the French windows of the lounge, or via the kitchen door or window. If he enters via the French windows he will be detected via a strategically placed pressure mat, but if he enters via the kitchen he will find nothing worth stealing so will open the kitchen door into the hall, where he will subsequently be detected via another pressure mat. In the unlikely event that the burglar enters the house from the front, he will eventually be detected via a pressure mat located in the hall, adjacent to the dining room door, or via a small pressure mat placed on the stairs. Note that this house owner has made no attempt to keep the burglar out of the house, but has used 'spot' defences to detect him once he has entered. This simple type of installation is highly cost-effective, and gives a reasonably high degree of protection.

By contrast, the house in Fig 1b uses an extensive perimeter and spot defence system. It's owner has decided to try to scare off potential burglars by fixing clearly visible window foil to selected areas of glazing at the front and rear of the house. Some of this foil is genuinely connected into the alarm system, and some is 'dummy'. All external and internal doors are protected by door switches, and two pressure mats are placed on the stairway. Additionally, baited traps are placed in the lounge and dining room. This house has excellent protection.

HINTS AND TIPS.

Pressure mats are excellent 'spot' defence devices, easily hidden under rugs and carpets. Both standard and stair types are available. Note, however, that they are fairly sensitive, and can easily be set off by large cats and dogs, and by very small elephants. If you own any of these creatures, make sure they are confined to sensible areas when the mats are enabled.

Window foil is an adhesive-backed aluminium strip that bonds to glazing. It couples into the alarm system via special connector blocks. The strip breaks when a window is shattered.

Door/window switches usually come in the form of a reed-relay/magnet combination. The magnet is installed in the door or the opening window, opposite the reed-relay that is installed in the frame. Most commercial units of this type have two sets of output wires in the reed-relay unit, one set giving normally-open operation, and the other giving normally-closed operation.

When you plan your installation, don't forget to make some provision for by-passing the front door protection system, so that you can re-enter the house without sounding the alarm: this facility is provided in the HE unit by the PY-PASS switch.

Don't forget to protect your shed and/or garage.

When you install your system, try to keep all wiring neat and concealed. Thoroughly test each section of the wiring as it is installed.

If possible, fit your system with both internal and external alarm bells or sirens. The external unit should be mounted in a prominent position at the front of the house, where it will act as an excellent burglar deterent. Special weather-proof housings are available.

Before you proceed with the installation, send off for at least one home-security catalogue. We recommend the one from STRATHAND, 44 St. Andrews Square, Glasgow G1 5PL, who supplied all the bits in the photo's. Their catalogue costs £1 plus P&P, and gives helpful installation notes.

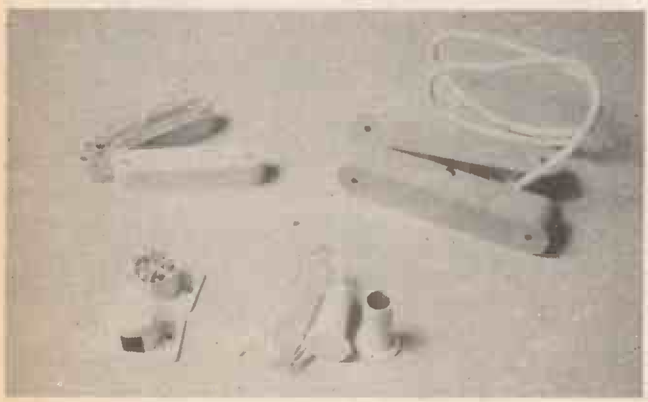


Fig 5. Reed-relay/magnet combinations, or door/window switches, are available in a variety of sizes. The smallest can be used on windows, the largest on garage doors.

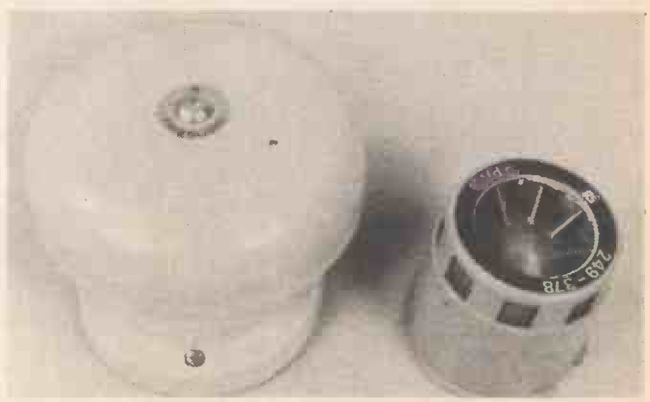


Fig 6. A powerful alarm bell or siren is an essential part of any home security system.

Variable Resistors

A Potted History

As promised Rick Maybury peers into the weird and wonderful world of the variable resistor, what they're made of and what they're good for.

ALL VARIABLE RESISTORS are transducers of one kind or another. The Potentiometer (pot) or Rheostat responds to a mechanical (rotational or linear) movement. The LDR (Light Dependant Resistor) to changes of light, the Thermistor and to a lesser degree the VDR (Voltage Dependent Resistor) to changes in temperature.

Most of us are familiar with the potentiometer, we've all twiddled those knobs that turn up the sound, volume etc but how often do we consider all the things that variable resistors do without any bidding from us. In many cases variable resistors are quietly going about their business looking after a multitude of electronic devices, controlling, adjusting and measuring, doing things that either we're too slow to do manually or would find impossible to do with our limited and insensitive senses. (Can you accurately measure temperature with your fingers?)

Of all the electronic components available to us, the

A small selection from our workshop, the slider in the foreground has become increasingly popular in recent years with manufacturers of H-Fi equipment.

amateurs, variable resistors constitute what must be the most diverse family. We will look at the four main types of variable resistor, namely the potentiometer, LDR, VDR and thermistor and consider what lurks beneath the skin of these rather versatile devices.

POTENTIOMETERS

If you take any kind of fixed resistor, expose the resistive element and move a third contact up and down its length you have a potentiometer or variable potential divider.

Up till only a few years ago many devices we now call 'pots' were called Rheostats, in fact the term rheostat is now only applied to two terminal devices, usually capable of dissipating quite considerable levels of power. These devices are unlikely to cross our paths very much these days so we'll stick to the good old pot found in countless radios, TVs etc. The pots we see on the fronts of most pieces of equipment often represent only a small fraction of pots that may be present in the circuit. The smaller brother of the Continuously Variable (CV) pot is the pre-set, usually considerably smaller and specifically designed to be used only once or twice during its life. Pre-sets are usually adjusted during the initial setting-up of a piece of equipment after manufacture. Design engineers often incorporate several pre-sets in a 'breadboard' design, finally settling upon fixed resistors, decided by the optimum setting of the pre-set in question. Pre-sets are often found in applications where some circuit parameter needs to be calibrated, or to trim the range of a CV pot. If you get the chance take a look into the back of a colour TV set and count how many pre-sets are lurking there, we would be surprised if there's less than forty.

Inside the potentiometer, note the metal wiper pressed on to the shaft, the resistive element (centre) is moulded on to a phenolic former.

MATERIALS

Most pots we're likely to come across will have their resistive element made from one of five types of material, they are: Carbon Composition, Carbon Film, Hot Moulded Carbon, germet and Wirewound.

Carbon Composition pots' elements are moulded from a mixture of carbon, ceramic dust and resin. A wiper, usually made from spring steel, constitutes the third contact. Composition pots tend to suffer quite badly from noise, usually after only limited use. As a consequence they are rarely found in Hi-Fi equipment, although in pre-sets form, where noise and excessive usage are not so much of a problem they are fairly widespread.

Carbon Film pots are manufactured by spraying or screening (you guessed it) a thin film of carbon onto a shaped phenolic former, again a metallic wiper is used. Noise proves to be less of a problem than with composition pots.

Hot Moulded Carbon next, the resistive element is moulded in one integral part containing the insulation and termination as well as the element itself. The wiper is usually made from carbon to minimise wear. Low noise levels and a high degree of conformity (they can make lots of them with identical characteristics) make them popular in so-called 'professional' or 'precision' pieces of equipment.

Cermet pots are a relative newcomer to the variable resistor field, the name cermet derives from ceramic-metal. The resistive element will stand considerable mechanical and electrical abuse and so have become quite popular with our friends the radio control enthusiasts in their servos as feedback pots. Again a metallic wiper is used, low noise levels and power disipation is directly comparable to Hot Moulded Carbon pots of similar size.

Inside a wire-round potentiometer, the windings are clearly visible inside the outer casing, a small tab of carbon is usually bonded to the underside of the wiper.

The Wirewound pot has got to be the daddy of them all, going back to the days when electronics as a science had not been thought of. The element is wound from resistance wire on an insulating former, a metallic or sometimes graphite wiper is employed in the contact department. Wirewound pots are usually only made in fairly low values, although they do have the advantage of being able to dissipate quite large levels of power. (Up to 200 watts is not an unrealistic figure. Unfortunately wirewounds are somewhat noisy in operation, the resistance also changes in 'steps' giving poor resolution, usually they are bulkier than other pots of equivalent value.

INS AND OUTS

As with fixed resistors, pots are specified by nominal resistance and power dissipation, unlike fixed resistors we have to state 'Law' and in some cases Resolution.

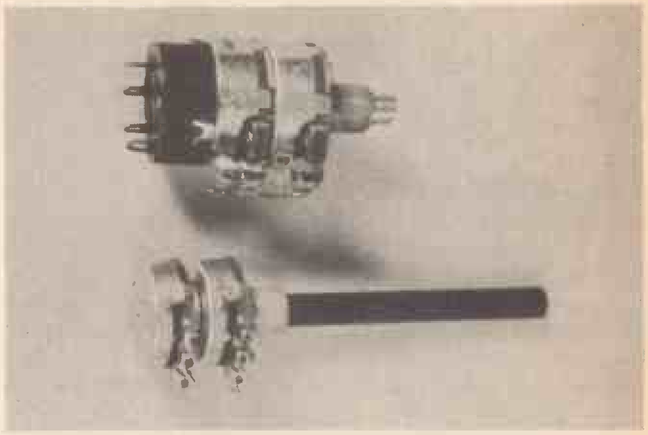
Law refers to how the resistance changes with respect to the position of the wiper. If the resistance varies in an equal amount over the whole length of the element we call it Linear or 'Lin' for short. This is not always convenient, we have another law called Logarithmic or 'Log' to accommodate such eventualities. (Just to be awkward we also have B-Law, Anti-log, Semi-log and for the really difficult ones among us, sine and co-sine. As we and you are very unlikely to come across such animals we'll save them for another day.)

If you're still with us, the Log pots change their resistance in a non-linear fashion or to put it another way, tend to be 'all up one end', the resistance changes gradually at first, perhaps over three-quarters of the track's length then suddenly increases (or decreases) in a small part of the track. Normally in any of our projects we will specify a 'Lin or Log' pot. Remeber that if you ever replace a pot whether it be CV or pre-set to make sure that the replacement has the same law.

Resolution of pots refers to the amount of resistance change that occurs for any given change of wiper position. Obviously the wirewound pot with its 'stepped' changes has a very poor resolution, the cermet pot however will show a change of resistance no matter how small the change in position might be.

STYLES

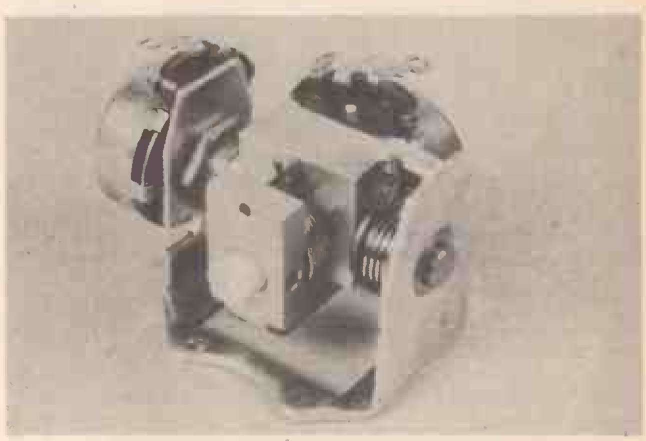
The two main styles of pot, the continuously variable and the pre-set are themselves available in a multitude of different shapes and sizes, appropriate to their function. Most rotary pots have a 270-280 degree limit, both CV and pre-set conform to this standard, with notable exceptions as we will see later. The second largest group of CV pots are the slider pots. Over the past few years they have become very popular with manufacturers of middle-of-the-road Hi-Fi equipment. In most cases they are purely cosmetic, however in certain applications, mixers, graphic equalisers etc, their readability and ease of multi or 'banked' operation are a definite advantage.



Ganged pots, the two separate pots are joined together by a single shaft, most often seen in stereo systems.

Pots with switches, the switch mechanism is connected to the shaft assembly.

A collection of pre-sets, the upper one is in fact a thumb-wheel pot, with switch, often found in cheap transistor radios, not dissimilar to the genuine pre-set immediately below.

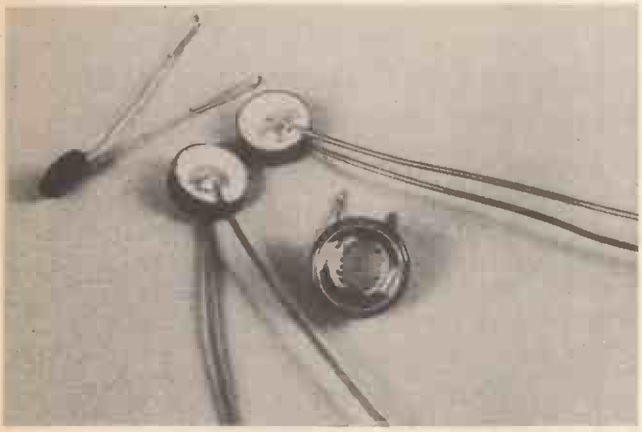


An unusual application for pots, this is a joystick (found in radio control systems, synthesisers etc) the mechanical linkage will allow both pots to move in an X Y axis.

In certain applications it's necessary to operate two or more pots simultaneously, stereo volume or balance for instance. In these cases the pots are joined together or 'ganged' on a common shaft or slider. The mechanical rotation of pots is carried out in a number of ways, most of the time a simple metallic or plastic shaft is sufficient, but in the case of pre-sets a slotted screwdriver notch is used instead of a shaft. Most oriental transistor radio manufacturers seem to favour the 'thumbwheel' pot, usually incorporating an on-off switch on the rear of the pot. Certain types of pre-sets use a hybrid method of construction. The multi-turn pre-sets found in many modern TV and Hi-Fi tuners have a linear track (as opposed to a rotary track) and a threaded screw supporting the wiper. Multi-turn pots have very good resolution factors, ideal for tuner application.

LDRs, VDRs and THERMISTORS

The last group of variable resistors we shall look at comprise the LDRs, VDRs and Thermistors, in the true sense of the word they are not resistors but semiconductors but the fact that their resistance does change under external influence makes them worth looking at.



A small selection of thermistors, VDRs and the LDR.

LDRs

The LDR utilises the photo-conductive properties of many semi-conductor materials such as selenium, cadmium phosphide, silicon and semi-conductor materials generally. As the light energy falling upon these materials increases the number of free electrons also increases, thus the resistance of the material will decrease. (Remember last month?) One of the most common materials used is Cadmium Sulphide (CdS). The resistance of CdS will fall to as little as 5 ohms in bright light and rise to several million ohms in total darkness. These figures are pretty generalised but a fair example is the ORP 12. It has a typical dark resistance of 10 M ohms to around 130 ohms in bright light (1000 Lux). To make the best use of the light available the resistive track of the LDR is 'spiralled' across the body of the cell.

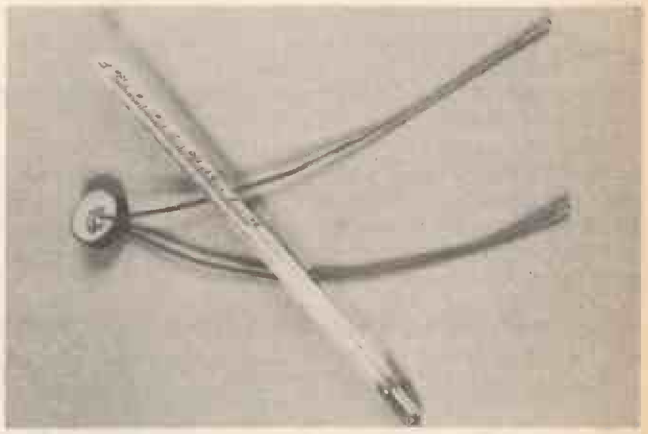
Close up of an LDR, note the track (silver) is cut across the face of the device to expose the maximum amount of resistive element to light.

LDRs are *not* to be confused with Solar Cells, they rely on the photo-voltaic effect, that is, they generate an EMF in the presençe of light. They are most familiar as the 'wings' that protrude from many of the spacecraft that we see and hear about, the wings are made up from thousands of such cells.

THERMISTORS AND VDRS

Again we have a bewildering choice of types, styles and applications to look at. Nearly all thermistors (and VDRs, more of that later) have either a Negative Temperature Coefficient (NTC) or a Positive Temperature Coefficient (PTC). In NTC types the resistance of the device will decrease with a rise of temperature, and vice-versa for PTC types.

As the thermistor will decrease (or increase) its resistance with temperature, we can use the self-heating effect of the thermistor to stabilise voltage. If a sufficiently large current is passed through the device it will heat up, if it is strategically placed within the circuit it will respond to any abnormal voltage. or current conditions by varying its resistance accordingly. In these circumstances its called a Voltage Dependant Resistor (VDR).



A thermistor, this style will be mostly found in circuits where a degree of thermal protection is required, note the size next to a medical thermometer.

The degree of resistance change can be tailored to suit the application, some will operate up to several hundred degrees centigrade or many degrees below zero. Many thermistors are specifically designed to be used for temperature measurement, as such they will ideally have as small a mass as possible to allow for measurement of rapid changes of temperature.

The encapsulation of thermistors is extremely important, glass is often favoured in cases where the thermistor is to be immersed in corrosive substances. Sizes of thermistors vary considerably, from almost microscopic bead thermistors to large carbon rod devices several inches long. Obviously for measurement purposes they need to be as small as possible. We've deliberately left the choice of materials to last, that's because it would be impossible to list the materials used, they will vary according to use. Generally though, most are based on one or more types of semi-conductor material or carbon. It's interesting to note that all conductive substances will change their resistances when heated or cooled.

Well that's about it for resistors, coming up soon we will be looking at some of the more exotic and specialised components some of which we have only briefly mentioned in the past. **HE**

Kit Review

Heathkit Car Clock Timer

Have you got around £40 and a couple of hours to spare? If so why not have a go at building this excellent car clock/timer from Heathkit, its worth every penny.

WELL, WHAT CAN WE SAY? We've seen quite a few kits in the past few months, some fair, one or two outstanding, but this one was superb. At £40 it may seem a bit expensive but just ask yourself, how much does a Rolls-Royce cost? This month's offering comes from *the* kitmakers, Heathkit. If you've been looking for a kit to build you can be sure that Heathkit can supply it. They may not be cheap, but consider how much you can end up spending on a kit that doesn't work.

The kit we received was a car clock/timer, the idea is, that it will give a constant readout of time, as well as providing an elapsed time function ideal for rallies and treasurehunts. We were surprised to see how small the device was, barely six inches across, the electronics however, fit very comfortably inside without any undue cramping. The clock is built on two glass-fibre PCBs, the main one is double sided, both are beautifully made and look strong enough to stand up to even the most cack-handed soldering.

All of the components come in neatly packaged envelopes, we always check the contents against the parts list, this also gets us familiar with some of the more obscure devices. The instruction manuals in many kits often prove to be a bit of a let down, not so with Heathkit, their manual would be better described as a book. Its good to see they've taken the trouble to include a very comprehensive section on faultfinding, not that you'll need it if you follow the instructions.

CHIPS WITH EVERYTHING

As you would expect the ubiquitous IC rears its many legged body into view. We have three such creatures in this kit. The two 40 pinners carry out the timing functions. It would be interesting to find out why Heathkit didn't use just one purpose-built device. As it turned out our only gripe with the kit arose from the fact that the spacing on the IC sockets was a little tight. Great

Below, the complelte kit spread out for inspection, absolutely nothing is missing or left to chance.

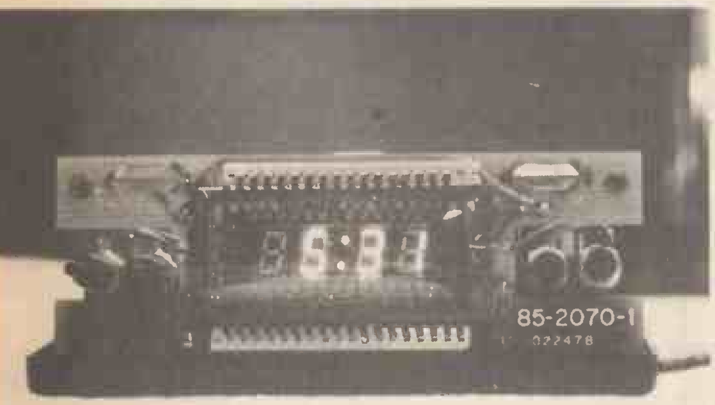
care should be taken when inserting the ICs. The rest of the parts consisted of a handful of resistors, a couple of capacitors, one transistor, six diodes, a crystal and four push button switches. On the display board two spring metal switches need to be soldered to the board, the contact plates were so small they nearly disappeared down one of the holes without trace.

Actual building time should take no more than a couple of hours or so, providing you follow the very comprehensive, step-by-step instructions. Each stage consisted of about half a dozen parts, after each component has been fitted it can be ticked off in the space provided. (See what we mean, its these little touches that can turn a quite ordinary kit into a real joy to build.)

A TESTING TIME

Providing all is well, nothing is left out, (theres always some strange object that doesn't seem to have a home), Heathkit suggest that before its fitted into its case some preliminary tests be carried out.

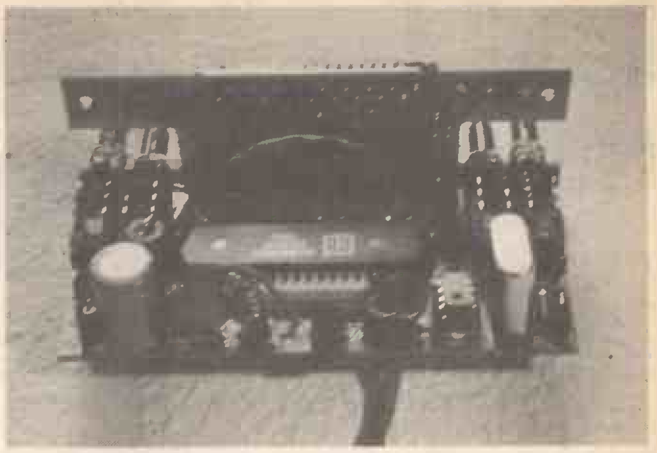
The clock was connected up to a power supply and with bated breath switched on. As usual nothing happened. Nothing wrong with the kit, just our myopic reviewer forgetting to connect up the green wire. The green wire is connected to the ignition side of the cars electrical system. It actually switches on the display so the clock will only appear to be operative when the engine is running. We say appear because it will be working all the time, the display is only blanked out to prevent excess current consumption. Both normal clock and timer functions will continue to operate when the ignition is switched off.



The completed clock before insertion into the case the two metal strips at the top right and left of the PCB are for time setting.

Besides ensuring the clocks are working we had to check out the LDR circuit that controls the brightness of the display, and very impressive it is too. The actual display is a four digit flourescent device (green), it has been readable even in bright sunlight, but this will depend to a large extent on where it is mounted.

All being well the electronics can be put into the rather neat looking two tone grey ABS case. Several options are available, we chose to mount the clock with its bracket on the top of the dash board of the editorial Viva. Apart from looking better it should be easier to read.



The main timing ICs are mounted top and bottom of the main PCB. The upper one is used for continuous timing functions.

ON THE ROAD

With every thing connected up and the clock firmly screwed down on top of the dash (and very good it looks too) we decided to check out its accuracy. The two main clock ICs run independently but from a single timing source. So far under quite variable weather conditions (temperature) and roads, (vibration etc) the main clock has lost five seconds in a week and the timer was accurate to within one second in a twenty four hour period. Both these results are very acceptable considering the adverse conditions and voltage variations of the average car.

The Heathkit car clock/timer installed on the top of the dashboard.

IN CONCLUSION

You may have noticed that this review has said very little about the kit itself. This is simply because the kit went together so easily, and worked first time. It's usually the faults or problems that we write about. As it is, it sounds like one long commercial for Heathkit (it's not actually).

In the past we've commented on a kit's worth as a learning aid, again full marks to Heathkit for their excellent technical explanations, full circuit diagram, soldering instructions, wiring diagrams, component identification etc. etc. We could go on. Let us just say, let all kits be judged by the standard of Heathkit (How about sending us something else Mr Heathkit, those Short Wave radios look rather interesting.) **HE**

LED Tachometer

The HE Tacho uses 21 LEDs to give a solid-state analogue RPM display. It's an ideal project for the motoring or motor-cycling enthusiast.

THE HE LED TACHO or 'Rev Counter' is an all solid-state project. It displays engine speed in analogue form (like a conventional tacho) as an illuminated section of a semicircle of 21 LEDs (light-emitting diodes). The length of the illuminated section is proportional to the engine speed, so that half of the semicircle is illuminated at half of full-scale speed, and the full semicircle is illuminated at full speed. In other words, the display is in 'bar' rather than 'dot' form.

The HE Tacho can be used with virtually any type of multi-cylinder petrol engine. It has two speed ranges, each of which can be calibrated via a pre-set pot to give any full-scale speed range required by the individual owner. Our prototype is calibrated to give full scale readings of 10000 RPM and 1000 RPM on a 4-cylinder 4-stroke engine. The lower range is of great value when adjusting the engine's ignition and carburation for recommended tick-over speeds.

The unit is designed for use only on vehicles fitted with 12 volt electrical systems. It can be used with conventional or CD (capacitor-discharge) ignition systems, and is wired into the vehicle via three connecting leads. It can be used on vehicles fitted with either negative or positive earth electrical systems.

CONSTRUCTION

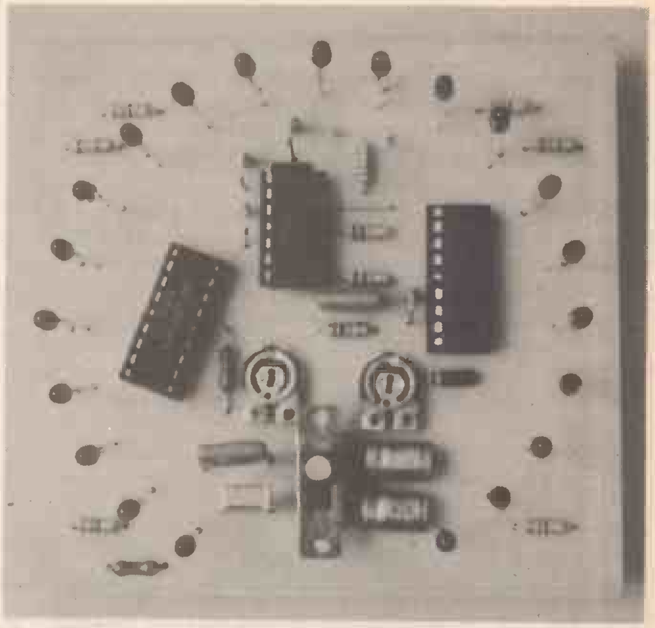
The complete unit, including the 21-LED display, is wired up on a single PCB. Take extra care over the construction, paying special attention to the following points.

(1). Confirm the polarity of each of the 21 LEDs, by connecting in series with a 1k0 resistor and testing across a 12 volt supply, before wiring into place on the PCB. Note that LED colours can be mixed, if required.

(2). Take care to connect all semiconductor devices and electrolytic capacitors into circuit as shown on the overlay. Note the orientation of the three ICs.

(3). Note that four LINK connections (using insulated wire) are used on the underside of the PCB: if in doubt about these connections, cross-check with the circuit diagram. Also note that the external connections to the unit (0 V, + ve, and CB) are made via solder terminals (Veropins).

(4). Note that the values of C2 and C3 must be chosen to suit the engine type and the full-scale RPM ranges required (see the conversion graph). Our prototype is calibrated to read 10 000 RPM and 1000 RPM on a 4-cylinder 4-stroke engine, and uses C2 and C3 values of 22n and 220n respectively.



The HE tachometer, make sure all polarised components are inserted the correct way round.

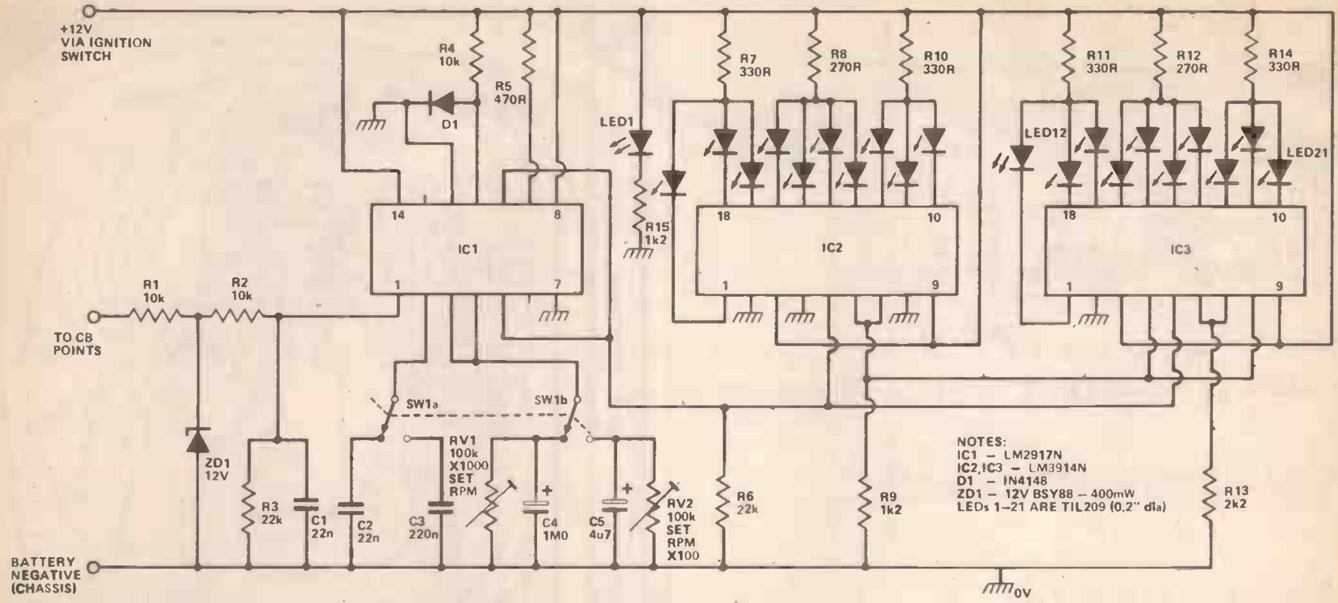
When the construction is complete, connect the unit to a 12 volt supply and check that only LED 1 illuminates: if all LEDs illuminate, suspect a fault in the IC1 wiring.

CALIBRATION

The unit can be calibrated against either a precision tachometer or against an accurate (2% or better) audio generator that gives a square wave output of at least 3 volts peak-to-peak. The method of calibration against an audio generator is as follows:

Connect the tacho to a 12 volt supply, and connect the square wave output of the audio generator between the 0V and CB terminals of the unit. Check against the conversion graph to find the frequency needed to give the required HIGH range full-scale RPM reading on the type of engine in question, and feed this frequency into the tacho input. Switch SW1 to it's HIGH range (10 000 RPM on our prototype) and adjust RV1 for full-scale reading.

Repeat the procedure on the LOW range of the tacho (1000 RPM on our prototype), adjusting RV2 for full-scale reading.



Circuit diagram of the LED Tacho, refer to the conversion graph for values of C2, C3.

How It Works

The ignition signal appearing on a vehicle's contact-breaker (CB) points terminal has a basic frequency that is directly proportional to the RPM of the engine. The HE LED Tacho works by picking up the CB signal, extracting its basic frequency, converting the frequency to a linerarly-related D.C. voltage, and displaying an analogue representation of this voltage (and thus the RPM) on a semicircular scale of 21 LED's (light-emitting diodes). The tacho can thus be broken down, for descriptive purposes, into an input signal conditioner section, a frequency-to-voltage converter section, and LED voltmeter display section.

The input signal conditioner section comprises R1-R2-R3-ZD1-C1. The CB signal of a conventional ignition system consists of a basic RPM-related rectangular waveform that switches alternately between zero and 12 volts, onto which various ringing waveforms with typical peak amplitudes of 250 volts and frequencies up to 10 kHz are superimposed. The purpose of the input signal conditioner is to cleanly filter out the basic rectangular waveform and pass it on to the frequency-to-voltage converter. It does this by first limiting the peak amplitude of the signal to 12 volts via R1 and zener diode ZD1, and then filtering out any remaining high frequency components via R2-R3-C1. The resulting 'clean' signal is passed on to input pin 1 of IC1.

IC1 is a frequency-to-voltage converter chip with a built-in supply-voltage regulator. The operating range of the IC is determined by the value of a capacitor connected to pin 2, and by a timing resistor and smoothing capacitor connected to pins 3-4. In our application, two switch-selected presettable ranges are provided. The D.C. output of the IC is made available across R6, and is passed on to the input terminals of the IC2-IC3- LED voltmeter.

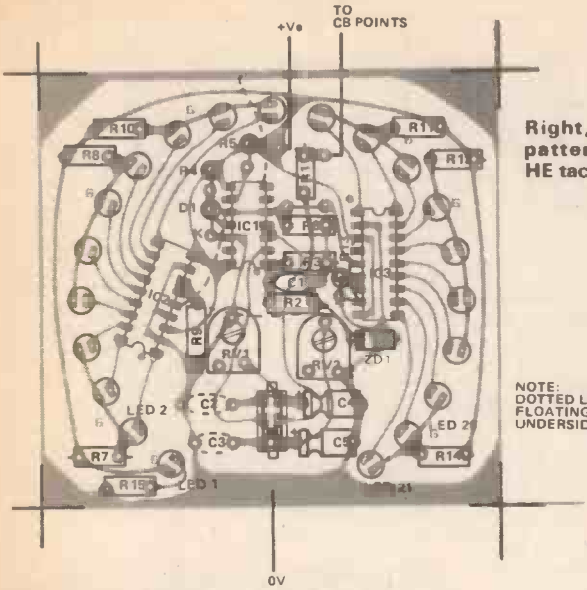
IC2 and IC3 are LED display drivers. Each IC can drive a chain of ten LED's the number of LED's illuminated being proportional to the magnitude of the IC's input signal. Put simply, the IC's act as LED voltmeters. In our application, the two IC's are cascaded in such a way that they perform as a single 20-LED voltmeter with a full scale range of about 2.4 volts: the configuration is such that the voltmeter gives a 'bar' display, in which the first 10 LED's are illiminated at full scale voltage. Resistors R7-R8-R10-R11-R12-R14 are wired in series with the display LED's to reduce the power dissipation of the two IC's. LED1 is permanently illuminated so that the RPM display does not blank out completely when the vehicle's engine is stationary with the ignition turned on.

INSTALLATION

The completed unit can either be mounted in a special cut out in the vehicles instrument panel, or (preferably) can be assembled in a home-made housing and clipped on top of the instrument panel. In either case, try to fit some kind of light shield to the face of the unit, so that the LEDs are shielded from direct sunlight.

To wire the unit into place, connect the supply leads to the tacho via the vehicles ignition switch, and connect the unit's CB terminal to the CB terminal in the vehicle's distributor. Note that the unit can be fitted to vehicles using either positive or negative earth systems.

The lower range of the tach (1000 RPM on our prototype) is of great value when adjusting the vehicles engine for correct tick-over: it is thus advantageous to arrange the tacho housing so that it can be easily dismounted from the vehicles instrument panel.



Component overlay for the HE Tacho.

NOTE:
DOTTED LINES SHOW
FLOATING LINKS MADE
UNDERSIDE OF PCB

Right, PCB foil pattern for the HE tachometer.

Parts List

RESISTORS
R1, R2, R4 10k
R3, R6 22k
R5 470R
R7, R10, R11, R14 330R
R8, R12 270R
R9, R15 1k2
R13 2k2

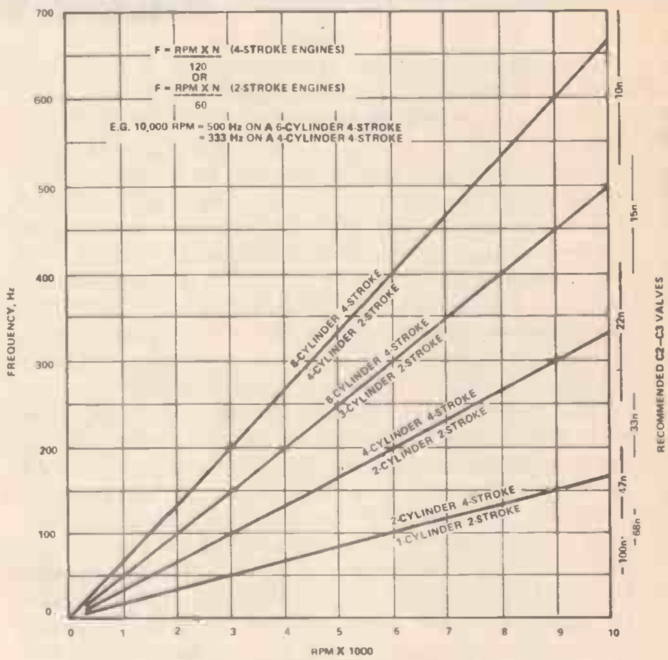
POTENTIOMETERS
RV1, RV2 100k Sub. min. preset

CAPACITORS
C1, C2* 22n polyester
C3* 220n polycarbonate
C4 1µ0 elect. 63V
C5 4µ7 elect. 63V
*=values used on prototype: see text

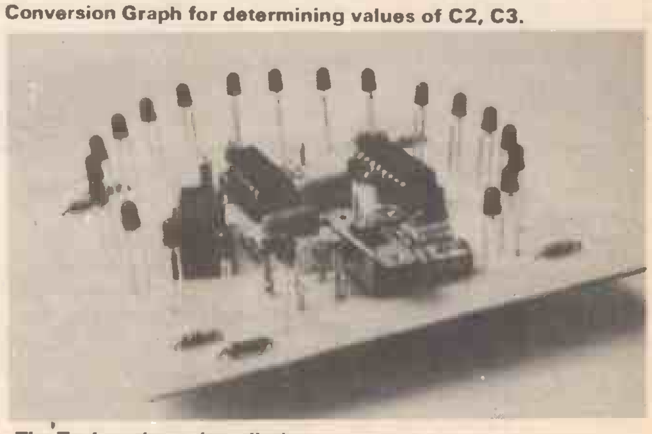
SEMICONDUCTORS
IC1 LM2917N
IC2, IC3 LM3914N
ZD1 12V @ 400mw
D1 IN4148
LEDS 1-21 are TIL209 0.2" dia.

MISCELLANEOUS
Miniature slide switch (two position double pole). PCB foil pattern.

Approximate cost £10.00.



Conversion Graph for determining values of C2, C3.



The Tacho prior to installation.

Buylines

The three ICs used in this project are fairly 'rare' types, particularly IC1. We obtained ours from Maplin, but they may also be available from other large stockists such as Marshalls, etc.

CITIZEN'S BAND SPECIAL

Picture from the film **Convoy' courtesy EMI Films Ltd.**

No-one could ever accuse HE of being slow to respond to public opinion. Since we carried our major feature 'Citizens Banned' in our June issue the national press, radio and television have all given CB tremendous coverage; obviously we wouldn't claim that HE was responsible but we would like to think we have made some people think about the possibilities of CB.

So for everyone even remotely interested in CB we have produced a 64 page special in record time; it will cover all aspects of CB both at home and abroad, a guide to the law relating to CB, technical information on aerials, the film Convoy etc, and views and opinions from the people who know what they're talking about, the R/C modellers the radio amateurs and the major organisations involved in the legislation of CB. PLUS the first English dictionary of CB slang and codes.

The special should be on your newsagents bookshelves by the second week in July, price 75 pence. If you have any difficulty in obtaining a copy write to us at our Charing Cross Road offices, enclosing a PO or cheque for £1.00 (inc P and P) and mark your envelope CB Special.

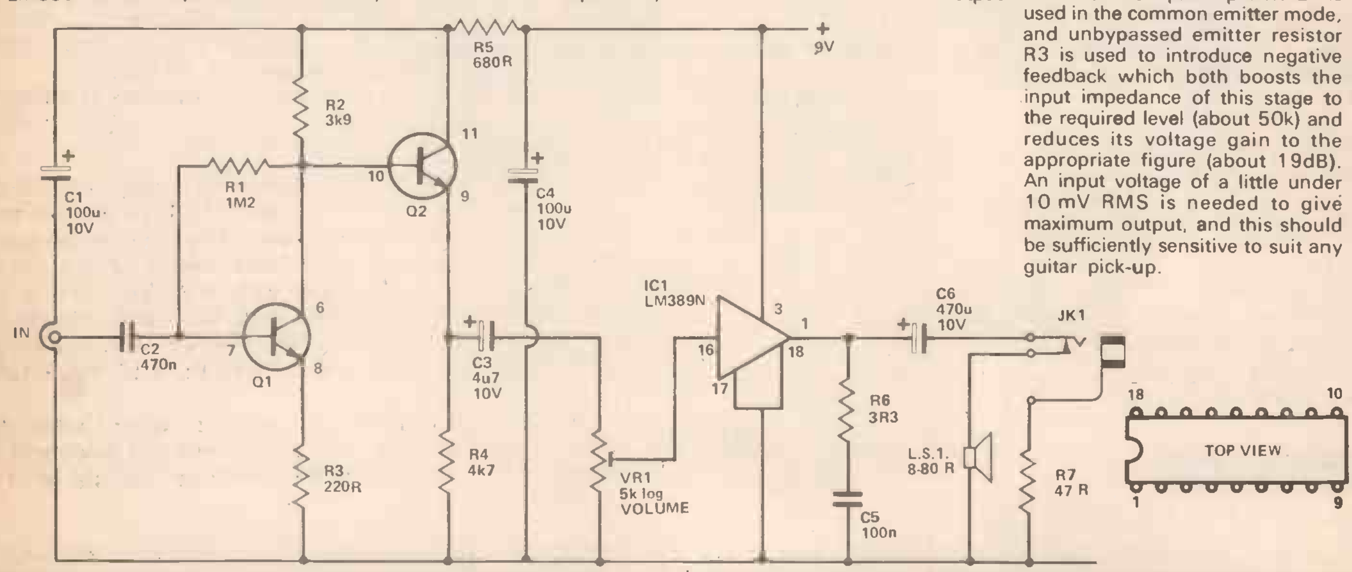
Short Circuit

GUITAR PRACTICE AMPLIFIER

This simple guitar amplifier provides an output that is suitable to drive any normal type of headphones (or earphone), and it permits one to practice without disturbing others, or to practice in a noisy environment where the noise excluding properties of the phones is of considerable benefit.

The circuit is based on an LM389N audio amplifier IC which contains a small class B power amplifier. The output of the amplifier is coupled to the speaker via DC blocking capacitor C6 and the break contact of headphone socket JK1. Automatic loudspeaker muting is provided by the latter when the headphones are connected to the amplifier. The output voltage swing is considerably in excess of that required by most phones, and so a degree of attenuation is provided by series resistor R7. R6 and C5 are a Zobel network which aid the stability of the circuit.

As the voltage gain of the amplifier is preset at about 26dB by an internal feedback network, an input level of over 100 mV RMS is required to produce full output. This is far more than the output level of the majority of guitars. Some form of preamplifier is therefore required. The LM389N has the unusual feature of containing three NPN transistors in addition to the power amplifier circuit. The terminals of these transistors are connected to individual pinouts of the device, and it is two of these devices that are used to form a suitable preamplifier. Q1 is used in the common emitter mode, and unbypassed emitter resistor R3 is used to introduce negative feedback which both boosts the input impedance of this stage to the required level (about 50k) and reduces its voltage gain to the appropriate figure (about 19dB). An input voltage of a little under 10 mV RMS is needed to give maximum output, and this should be sufficiently sensitive to suit any guitar pick-up.



Breaker One-Four

**Send any news, comments, or information you may have to:
Breaker One Four,
Hobby Electronics,
145 Charing Cross Road,
London WC2H 0EE.**

Several hundred letters and quite a few phone calls later we've come to the conclusion that the subject of CB is not going to be swept under the carpet any longer. In view of this we've decided to start a regular column covering as many aspects of CB as we are legally able. We believe we are the first UK magazine to do so, so who knows, we may even change the law.

THE LETTERS ARE STILL COMING IN concerning our feature 'Citizens Banned', many of them have expressed the wish to be better informed, so for the people who've asked for some kind of column here goes.

We must make a couple of important points first. Firstly we cannot supply any information regarding the availability of CB rigs, circuits etc. Secondly we cannot encourage the use of the 27 MHz system currently in operation, both would be incitement to commit a crime; we've no great desire to run foul of the gentlemen in blue (or any other colour uniform for that matter).

We'll start this month by taking a look back over the past couple of months since the article came out. At least five national dailies have run stories on the recent 'busts' that have been happening in the midlands; isn't it strange that so many articles have started appearing since we ran ours! Of course this is a good thing, the more it is brought to the public's attention, the more people will understand it and hopefully want to experience the delights of 'free speech' for themselves.

CLUBS, WHERE ARE YOU?

We're still waiting to hear from any clubs or organisations that are interested in legalising CB. So far the only club we've heard from is the 10-4 club, their membership is rapidly approaching 200, so keep your letters for them coming. Maybe we will adopt them (if they'll have us) and keep you informed as to their progress. Already they've had a visit from a member of the legal profession to explain the law relating to CB, they are also well in hand with plans to invite a local MP to a meeting to put their points to the people that matter. Meetings are now being held on a regular basis, so if you want to get in touch we'll forward any letters as they are still looking for a permanent address.

PETITION

The petition is doing better than we dared hope. No exact figures yet, but it's into the thousands, so keep them coming. We're having some problems with the post and with moving etc. Send them off as soon as possible and don't worry about not filling them all up. We'll let you know next month when we're handing them over.

CBA BANDSTAND

The CBA have contacted us, it seems someone is using their name to put adverts in the Exchange and Mart, they would like to point out it has absolutely nothing to do with them, so beware.

News of a newsletter on CB has just reached us, its called 'Bandstand' copies are free, enclose a large skinny SAE and write to: Bandstand, Flagstones, Westheath Lane, Sevenoaks, Kent.

LETTERS

The rest of the column we've set aside for interesting letters, if you think you've got something to say then drop us a line. After all we need to know what you're up to, to make this column as up to date as possible. Meanwhile we're toying with the idea of producing some stickers or badges, more about that next month.

Dear Sir,

I bought my first edition of HE and I have found it extremely interesting. However, concerning the article on CB radio, I must accuse you of writing a very biased article. You almost seemed to be trying to 'sell' the idea to your readers. You actually said, 'Hopefully it will be legalised'.

I have an active interest in amateur radio and can tell you that the amateur service has done a lot for science, in pioneering new ideas in radio telecommunications and electronics. The introduction of Citizens Band radio would bring the amateur service into disrepute.

Jonathon Hallewell
Manchester

No one is trying to take anything away from anybody, quite the opposite in fact. Before we get too many 'dog in the manger' type letters consider for a moment a physically disabled driver stuck on a lonely road, late at night and with no means of summoning assistant; the RAE for all its worth is not much use to that person. Have you heard how many lives are saved annually in the US? We could go on.

Many people either cannot, or do not want to take the RAE. Why should people be prevented from talking to one another without the aid of the Post Office?

All the high numbers, stay lucky and BREAKER BREAK. . . .

COMPETITION

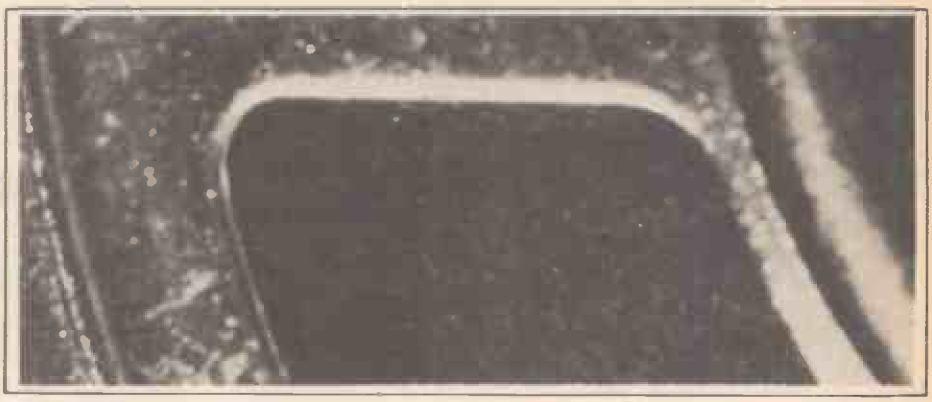
Each month we receive literally dozens of requests for projects, high on the list is an oscilloscope, as we've pointed out in the past its not really practical to build a scope, you simply can't build them as well and as cheaply as a commercial unit. So for all the frustrated scope builders we are giving two away this month as prizes in our first competition.

The first prize is the Calscope Super 10, it's a fine 10 MHz, dual trace instrument, costing £219.00 retail, it features many of the specifications found on instruments costing twice as much. Our second prize is the Calscope Super 6 MHz bandwidth, easy to use controls and perfect for TV servicing applications. It will cost you £162.00 at the moment so as you can see, we're not being mean with the prizes.

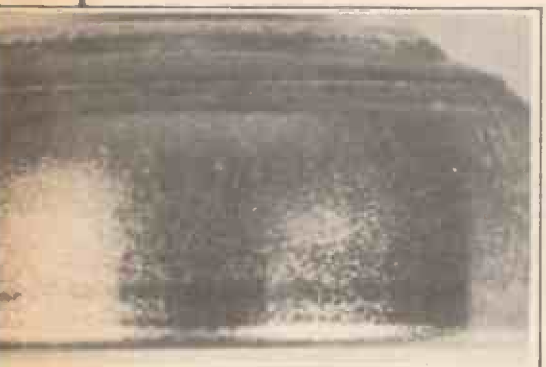
There will be 20 runners up prizes each receiving a HE Tee Shirt, send in your entry as soon as possible, closing date for entries will be the 20th August 1979.

The Editors decision will be final. No correspondance will be entered into regarding this competition.

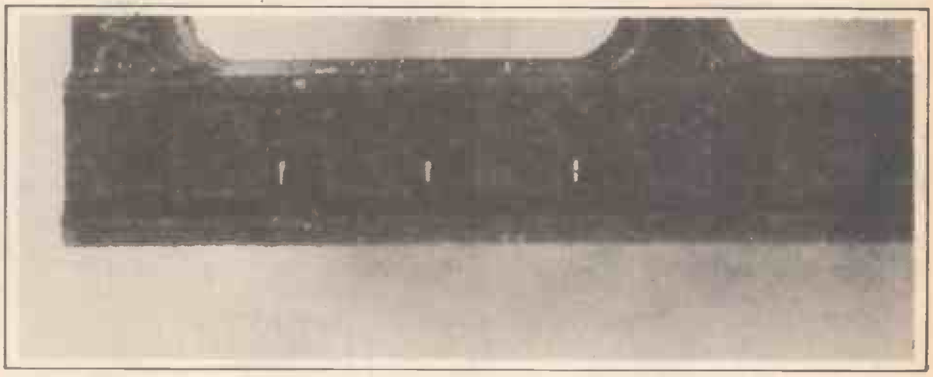
Socket to me? A



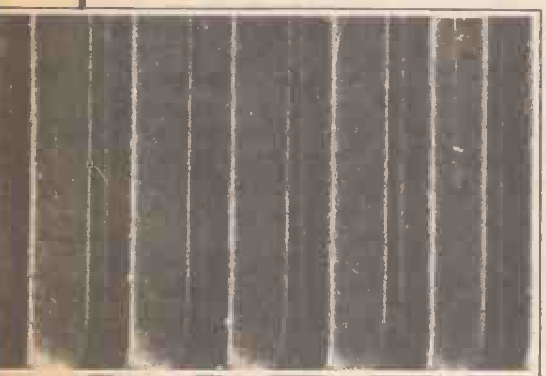
Big talker? B



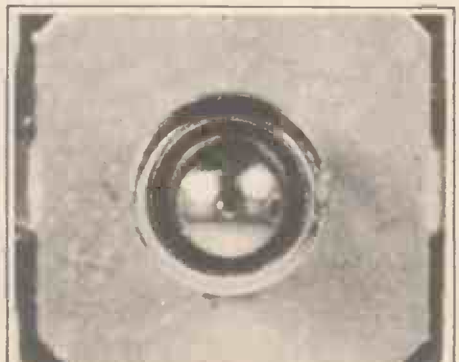
Watch out for this one! C



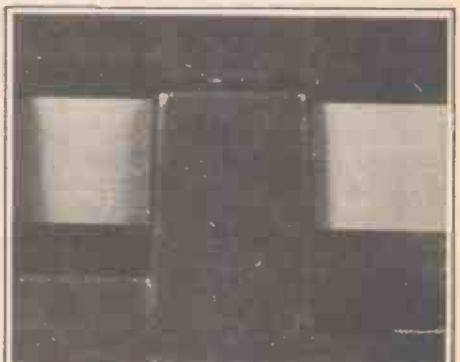
Caterpiller stand? D



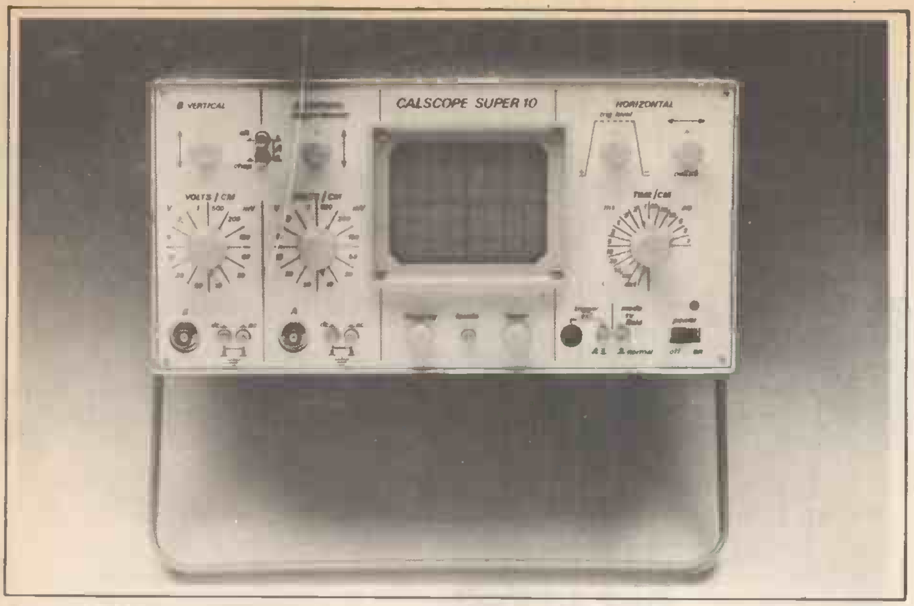
Hot stuff! E

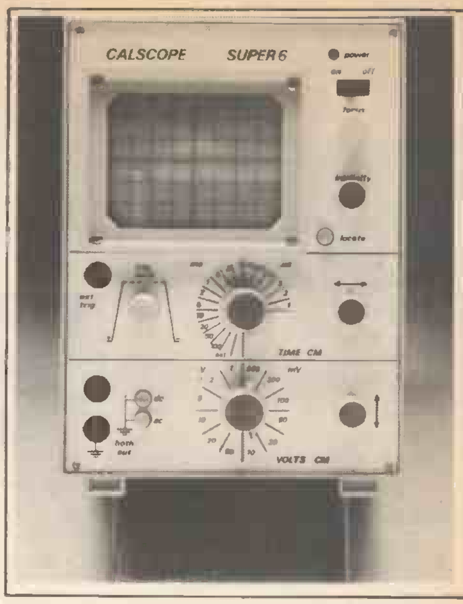


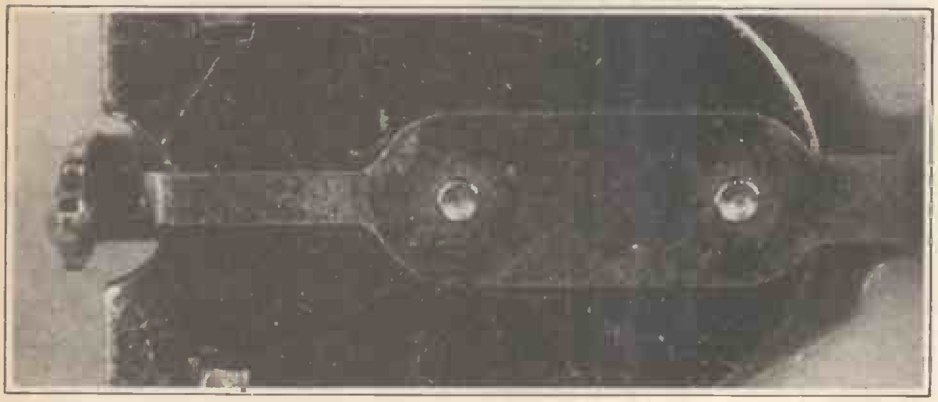
Turned on? F



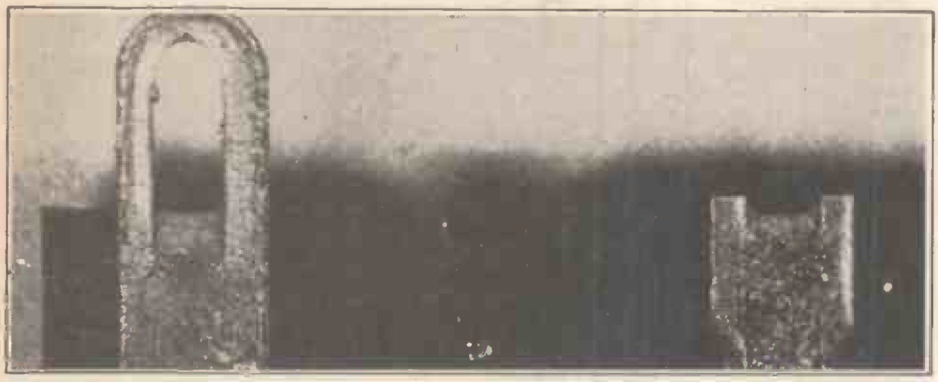
Off the record? G



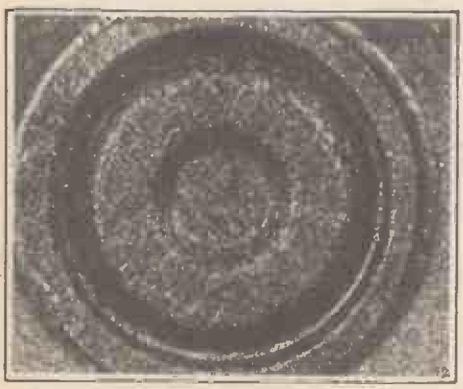




. . . any messages? H



HE . . . exposed? I



Ice cream? J

Jaws? K

As you can see the competition couldn't be easier. All you have to do is decide what each picture shows, they're all electronic components or hardware and we promise nothing obscure. Send you answers to:

Hobby Electronics Competiton
145 Charing Cross Road,
London WC2H 0EE

A. ....

B. ....

C. ....

D. ....

E. ....

F. ....

G. ....

H. ....

I. ....

J. ....

K. ....

Name ....

Address ....

....

....

Tee-Shirt size (S, M, L) ....

The winning entry will be drawn from the HE hat, all winners and runners up will be notified by post.

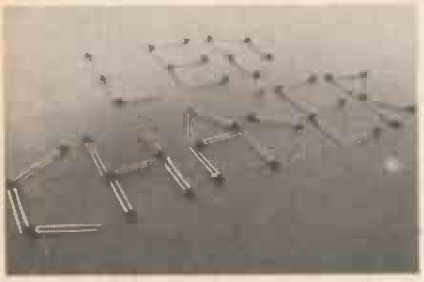
Next Month

Hobby Electronics

ELECTRONIC TIMEKEEPING

Nowadays we take it for granted that a wrist-watch costing little more than £5 will be accurate to within a few seconds a year. Electronic timekeeping as such has been with us for several years now. we have the atomic standard clocks accurate to within one second in a million years (even less in some recently developed machines), or even our own TIM. Look out next month for a detailed investigation into how these clocks (if we can call them that) operate and where future developments may be leading.

LED CHASER



You may be thinking we've got a thing about flashing light displays, you'd be right too. This month we have a go at a LED Chaser, watch the light appear to move, build several and have your name in lights, annoy the neighbours, it's all here. Easy to build too.

FET SPECIAL

What do you know about FETs? Next month, rather than bore you with a lot of graphs and theoretical circuits we're doing a large feature on FET projects, there's quite a few RF circuits (no not CB rigs) for you to build and experiment with, we always think it's a lot easier to learn about something by using it rather than reading about it.

ULTRASONIC REMOTE CONTROL

You can't see it but it's there. Amaze your friends, turn the light on and off, how about switching the telly on or even locking the cat flap? It can all be done with next month's high frequency ultrasonic remote control; popular with the dogs too.

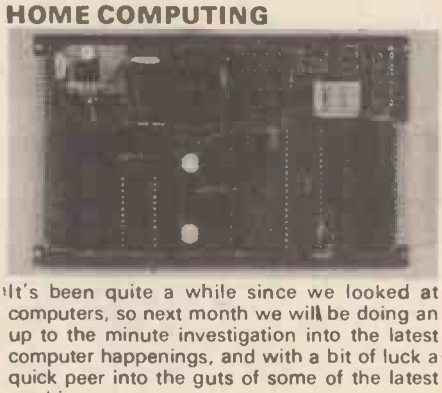
RADIO CONTROL

We're sorry to say that we upset some of our friends the radio control enthusiasts with our feature 'Citizens Banned' (Hope we're redeemed ourselves now?) So to redress the balance we've persuaded one of the country's leading experts to write a feature on the current R/C scene and what's going to be happening in the future of this fascinating hobby.

THYRISTORS

Have you ever wondered about Thyristors? These rather interesting semiconductor devices have made considerable inroads into the 'power handling' areas of electronics as well as carving out a whole new field for themselves in control applications. Look out next month for a detailed investigation into the application, characteristics and history of Thyristors.

HOME COMPUTING



It's been quite a while since we looked at computers, so next month we will be doing an up to the minute investigation into the latest computer happenings, and with a bit of luck a quick peer into the guts of some of the latest machines.

STEREO AMPLIFIER

At last, a true Hi-Fi, high power stereo amplifier. Not one of your common or garden 5 watt jobs, not even 10 watts per channel, its ...... Well, you'll have to wait until next month to find out. What we will say is, that it will hold its head up amongst the many amplifiers that are flooding our high streets, and its British folks, through and through (we think). It uses modular construction so no problems getting all the bits together, we think it's a winner.

LAMP DIMMER

Lamp Dimmers are always popular, it's good to have a really practical project, one that you'll use every day. And it should save you money too, a good non-nonsense easy to build project, fit to grace any living-room wall.

BREAKER ONE FOUR

Don't forget to 'eyeball' our new regular feature on CB next month, all the latest news, views and information.

The September issue will be on sale August 10th

The items mentioned here are those planned but circumstances may affect the actual contents

Tools

What can you never have enough of? The answer is tools, for those of you just starting out in our hobby Rick Maybury takes a look into the wonderful world of tools and points out some of the more obvious things to look out for when parting with your hard earned money.

IF YOU'RE ANYTHING LIKE US, you're entry into the wonderful world of electronics followed a pretty rough transition period. Like us you were probably fascinated by the apparent ease at which examples of high technology could be assembled by even the most dimwitted for just a few shillings. (Still can't get used to this new fangled money). All you needed was a soldering iron (or something that could be persuaded to heat up would do just as well) and a few of those little coloured tubes with a wire at each end and Bobs your uncle.

Your first project was probably far too ambitious and almost certainly didn't work. This is the critical point, most of us did not give up, (you wouldn't be reading this would you?). With luck and hindsight (and plenty of determination too) you're second or third project did work, (much to your surprise and delight) and you proceeded to be 'hooked', probably for life.

STARTING OUT

The point of all this, is that most first-timers can avoid many of these traumas when first embarking on electronics, simply by going into your new hobby well prepared. And this means having the right tools for the right job.

There is a common fallacy that the more you spend the better the quality of tool you will get. To an extent this is true, but there is a breakpoint after which you're money will be wasted. A better rule of thumb would be to ask. Ask people who know. Anyone who has worked in the electronics industry will have had all of their unfortunate experiences fairly early on in their careers so

Basic soldering equipment, don't forget a stand, preferably with a wiper sponge, a solder sucker too will save much heartache and many burnt fingers.

their toolkit will have evolved into a pretty sophisticated piece of equipment. After all no-one wants to make work for themselves, and every job will have a tool best suited to its speedy completion.

Some of the handiest tools are also the cheapest. Have you ever dropped a screw or nut into an inaccessible part of a radio cabinet? Next time try a small magnet on the end of a piece of string, or magnetise an old screwdriver rather than try to remove it by brute force.

Its obviously difficult to recommend specific makes of tools for your tool box but we can give you the benefit of some of our more disastrous (and rewarding experiences) to start you off. So lets assume you have nothing (not money, however, you'll need plenty of that) and want to start a tool kit.

A temperature controlled soldering iron, nice to have if you plan to leave it on for prolonged periods.

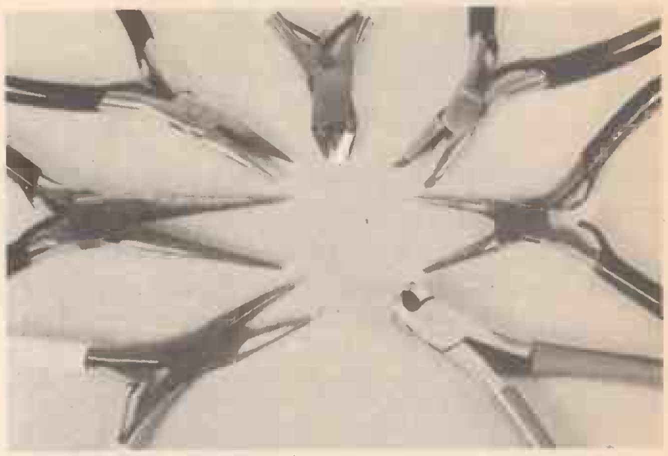
HOT STUFF

Number one tool has got to be the soldering iron. A quick poll around our office and workshop revealed only one thing, every one to their own! Everyone believes their own iron to be the best there is. When you come to think about it this is not altogether a bad thing, soldering irons are perhaps the most used of all tools, and certainly there is no lack of choice. There really are so many good soldering irons around these days there's no excuse whatsoever for not having two or even three, they'te not that expensive either.

Your first iron must be a good general purpose 25 watt model, choose one with an iron coated bit, make sure the bit is easily changed, its surprising how much gunge builds up around the bit after only a few hours use. This type of iron will be your main workhorse and will tackle 90% of all your soldering work. The dry joints and solder blobs come when you try to do those jobs a 25 watt iron is not designed for.

Very fine joints, especially those on closely grouped boards containing ICs or sub-miniature stuff need the fine tip and limited heating capacity of a precision 15 watt iron. Again look out for coated bits, easily interchangeable of course.

The big jobs, soldering chassis earths, tinplate screens etc can only be handled by a 50 or 100 watter. These days we have been blessed with the high capacity soldering guns. They heat up quickly and because of their weight can get a good thermal contact on the workpiece, no messing about.



Tools that grip, strip and cut, some of the many styles and sizes available.

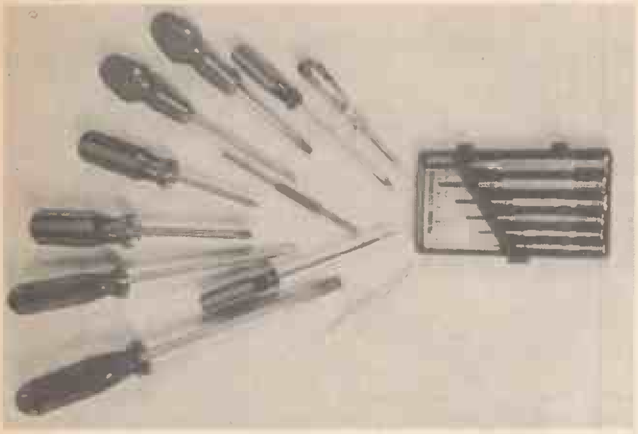
As with all tools there are countless variations on the soldering iron theme, everything from rechargeable to variable heat, these types are usually very good for one specific job, so no matter what the literature may say one soldering iron can never be all things to all joints. The right tool for the right job still holds true. Get the feel of one or two, ask around, and whatever you buy, make sure you get a stand with a wiper sponge or you will live to regret, it, and that's a promise.

A CUTTING REMARK

After you've soldered all your joints on your latest project you'll need to trim off all those surplus bits of wire. No, you don't use the kitchen scissors, you use sidecutters. This is the tool that will wear out most rapidly (apart from the soldering iron bit). You have two options here, buy a cheap pair and discard them when blunt or buy a good pair and hope they last longer, maybe even sharpen them. Whatever you do you will need a couple of sizes, a small one for the miniature work and a hefty pair for the bolt cropping (naughty) etc. It may even be a good idea to have a cheap pair for the rough stuff, see the table at the back for one or two suggestions.

A couple of things to look out for when buying sidecutters, hold them up to the light and make sure the cutting faces mate correctly, check the hinge, is it likely to wear out quickly? Finally look at the handle grips, is the insulation thick enough to prevent you getting a

More tools that cut, grip and strip, a good pair of wire strippers could save you a small fortune in dental bills.



Screwdrivers, you can never have enough, the jewellers sets are particularly useful when working on sub-miniature equipment.

shock if they should stray on to voltage carrying wires, you shouldn't be working on live equipment anyway, should you?

GETTING PINCHED

Pliers now, most of the time a good pair of long-nosed electrical pliers will be quite adequate, look at the tips are they likely to bend or crack?. They probably will if you try to use them for anything they were not designed to do.

A pair of conventional flat faced pliers will also be needed for those large jobs, look out for those handy snippers that are incorporated into some types, both in the jaws and sometimes on the hinge, very useful for cropping thin bolts.

Finally check that they're not going to pinch you if your fingers stray, nasty one that, it hurts for days.

SCREWDRIVERS

Screwdrivers, you can never have enough screwdrivers, start a collection and get as many different sizes as you can lay your hands on. Avoid at all cost those nasty combination sets of oriental origin that seem to appear from time to time. They are usually all packed neatly in a plastic box with an interchangeable handle or grip. This type is worse than useless. If the blades don't bend, the handles usually crack, one case where you do get what you pay for, about 50p usually.

Screwdrivers are probably the most used (and abused) of all tools so don't be mean, they rarely cost more than £1.00 each, for the larger ones. Don't forget the Phillips and Pozidrive styles, get a couple of sizes of each. Look around for some really miniature ones, they will prove invaluable for some of the imported pieces of equipment. Try to get hold of some plastic screwdrivers (or non-inductive) or trimming tools for variable capacitors coils etc. Finally, going back to the first couple of paragraphs, find a fairly old, long shafted screwdriver and magnetise it. (Strike a permanent magnet along its shaft in one direction only for a couple of minutes — make sure its steel first) this will save many hours of frustration trying to retrieve small screws lost down cracks, or starting off those small cross headed screws that seem to abound in oriental transistor radios.

Box spanners and spanners, again well worth thinking about.

If you're feeling rich why not invest in a set of box spanners? Stick to about half a dozen BA and metric sizes (2, 4, 6, 8 BA etc) should be enough. They're not tools you'll use a lot but may well get you out of plenty of trouble when you do need them. Its so much easier to do a nut up with one of these than a large pair of pliers, mercilessly thrashing about inside your latest project, decapitating luckless transistors.

TWISTING THE NIGHT AWAY

Assuming your projects will be housed in cases made from materials other than cardboard, (and they do use cardboard too, we know all about your nasty little habits!), you'll need some twist drills. To make life easy on yourself get hold of a drill to put them in. Two options here, power and hand drills, of course if funds will stretch get both. Whatever you do, you will need a hand drill, they don't cost much, make sure the one you end up with will tightly grip a 1 mm drill, take a pin or needle to the shop with you. Watch out for exposed gears, they bite, nearly as painfully as a large pair of pliers.

The power drill is very much a matter for personal choice, conscience and wallet. A large power drill will come in handy for all those DIY jobs around the house, (that's what you can tell the wife). Variable speed types are worth considering, as much of the time it will be used for drilling pot holes in fairly soft metal, failing that, why not build our HE drill speed controller?

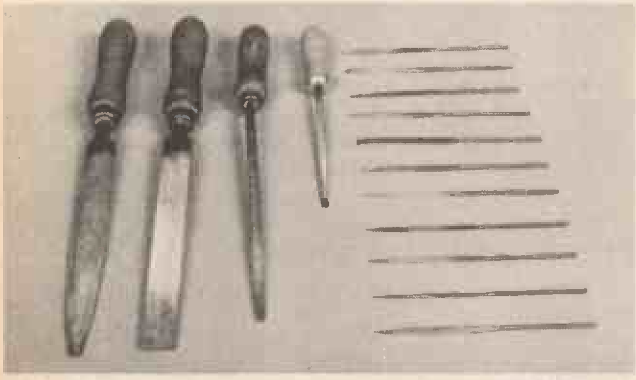
Before we leave drills, if you're going to do a lot of PCB work, it might be worth considering an electric PCB drill, they're small and light, and will slip through SRBP

Tools for cutting holes, countersinking etc. The purpose-designed PCB drill is well worth thinking about.

and glass fibre like the proverbial hot knife. As a final thought, when buying drills watch out for the twisted coat-hangers that were masquerading as twist drills a couple of years ago. Don't forget a rack, you'll go cross eyed trying to decipher the miniscule writing on the drill itself.

A HOLE IN ONE

These days making holes is quite a business, some holes you'll need to cut time and time again. A chassis cutter will be well worth having for all those 'pot holes and the larger type of switches. There really is only one type of chassis cutter to have, they're called Q-Max. You'll still need your drill to cut a pilot hole though. The two halves of the cutter are bolted onto either side of the workpiece



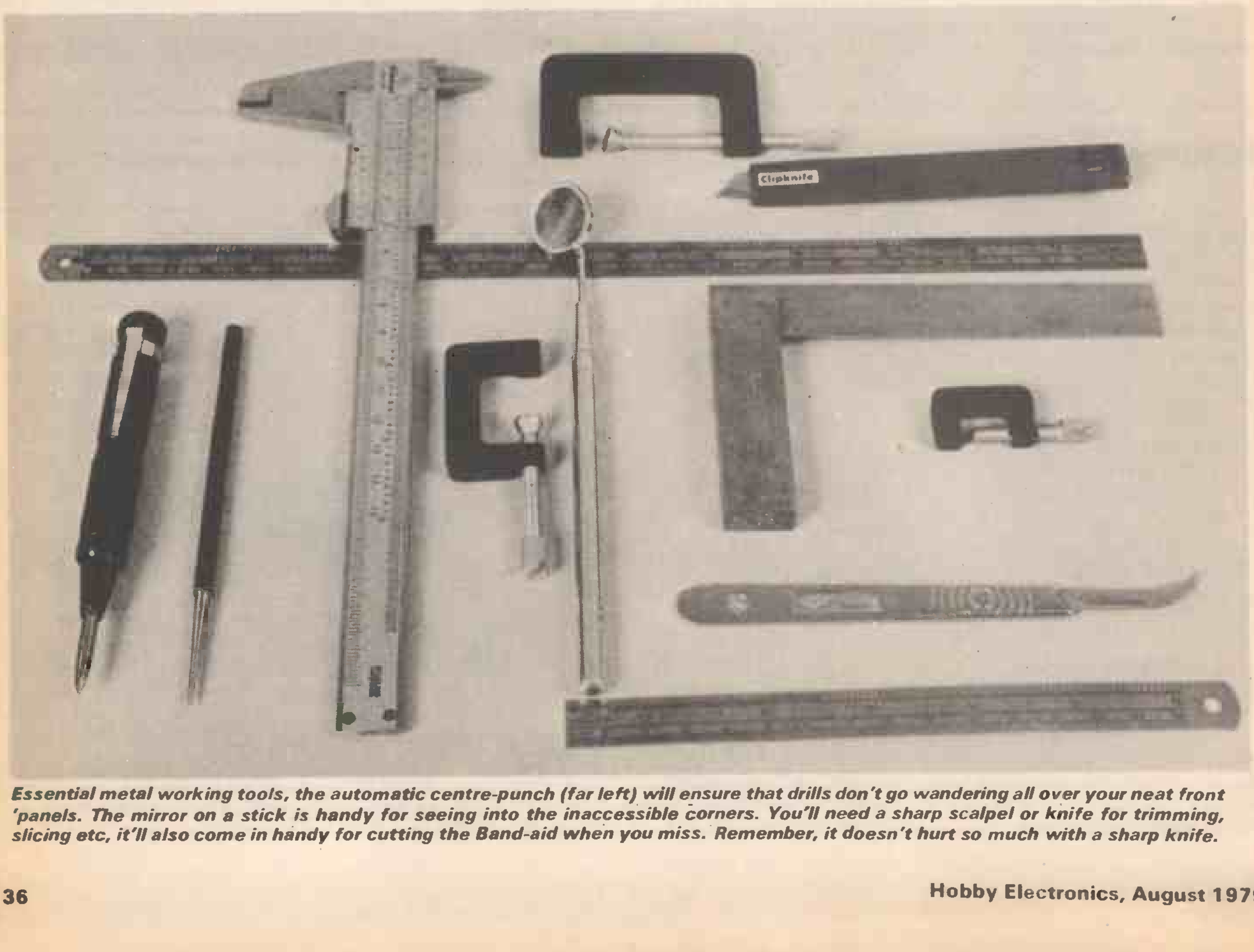
Files, just a small selection, however, sooner or later you'll need most of them.

Saws, the large hacksaw is a very worthwhile investment, you'll need the junior version in tight corners. The coping saw will enable you to cut any tricky shapes when housing your projects.

and with the aid of an Allen key the two halves are screwed together. A shearing action between the two parts leave a neat burr-free hole.

GETTING IT ON FILE

Just in case all those holes you've drilled aren't quite large enough or not quite the right shape buy a set of files. Only a small selection is needed. Don't forget a reasonably large, coarse one (Bastard) — yes they're really called that. A large and small round, small triangular, and a 'Rats Tail! they're usually about six inches long and taper to a sharp point, ideal for opening up small apertures.



Essential metal working tools, the automatic centre-punch (far left) will ensure that drills don't go wandering all over your neat front 'panels. The mirror on a stick is handy for seeing into the inaccessible corners. You'll need a sharp scalpel or knife for trimming, slicing etc, it'll also come in handy for cutting the Band-aid when you miss. Remember, it doesn't hurt so much with a sharp knife.

CUT IT FINE

So much for holes, how about cutting? The Hack-Saw will be the mainstay for all cutting work. Two types will be most useful. The Junior, about six inches long and a Standard hacksaw. Again don't be mean, lash out a few quid, they'll last a lifetime.

While you're at it get a few spare blades, from our experience blades always break on Sunday afternoons, about an hour after the only shop has closed, and its bank holiday Monday tomorrow. A couple of different grades wouldn't come amiss, you never know when the wife's going to insist you cut back a few branches off the tree.

ODDS AND ENDS

Of course we've only scratched at the surface of what is a vast subject. Let's look at a couple of things worth

Chassis cutters, very useful for large, often cut holes, eg pots and switches.

considering if you've got any money left.

Sooner or later you'll need some kind of de-soldering aid, if money is tight, you may get away with some De-Solder braid, it works by drawing the molten solder into itself by capillary action. A good quality solder pump is the ideal, however, be prepared to pay up to £10 for a decent one.

You may consider buying a PCB jig, they have a lockable action so the board can be moved into virtually any position, again not cheap, around £30-£40 for a pretty average example.

Nuts; don't forget the bolts, you'll need hundreds of them, try looking through the pages of Exchange and Mart for some bulk buys, avoid at all costs those little plastic bags with half a dozen nuts and bolts costing anything up to 50 pence.

Materials; if you're going to make your own PCBs you will need some copper-clad PCB material. We prefer glass fibre to SRBP, it's much stronger and it doesn't cost much more. For the etching get some Ferric Chloride, it's usually cheaper to get it from a chemist than buy those little bottles of acid that are sold for around 60 pence in some component shops.

TOOLING ALONG

Well, that's about it. As a rule sooner or later most of your tools will end up doing something they were not designed for, so bear that in mind, we're all guilty. Now for those of you that are just starting out, we'll take a look at what might be called an ideal tool box, don't be put off by the cost, you can buy them gradually. In the table we'll mention a few names of manufacturers that we have been pleased with in the past, but don't forget these are personal opinions, your own experience and those around you will be your best guide. **HE**

TOOLS	SIZE/MAKE	PRICE (APPROX)
Soldering irons		
15 W	Antex, Adcola etc	£2-£5
25 W	Antex, Adcola, Weller etc	£3-£10
50 + W	Weller etc	£8-£15
Screwdrivers	Broad Blade: large, medium, small	
	Flat blade: med, small, min.	Stanley, Spear etc
	Cross heads: Phillips, large small, Pozidrive	from 30p to £2.50
Pliers	Broad blade, long nosed	Linstrom, CK etc
Sidecutters	Small, med	from £4-£8
Drills (power)	Black and Decker, Stanley, Wolf etc	£8-£25
Drills (hand)	Spear and Jackson, Stanley	£5-£15
Drills (twist)	Dormer, Nos 60, 62, 125, 187, 250, 375	
Chassis cutters	Q-Max, ⅜", ½", ¾"	
Files	Spear and Jackson, Large coarse, round, large and small, needle file etc	50p-£3
De-soldering aids	Erem, Preh etc	£5-£12
Miscellaneous	Wire strippers, centre punch, Various, according Steel rule, set square, nuts, bolts (2, 4, 6, BA)	Varies according to supplier

A very brief outline of some of the basic tools you will need to get you started. Of course these are only suggestions, your experience will be your ultimate guide.

Power From Satellites

Solar power satellites could provide a real alternative to ground-based solar collector arrays as an infinitely renewable energy source.

Brian Dance studies the possibilities.

WORLD-WIDE DEMAND for energy is growing at around 5% per year. Although conventional power stations using fossil fuels (coal and oil) are now backed-up by nuclear power stations, both fossil fuels and our supplies of fissionable isotopes are being depleted. Some action must be taken to provide for our energy requirements during the next century. Fast breeder reactors have been suggested since they generate fissionable fuel, but some people think the associated environmental hazards are unacceptable.

Controlled nuclear fusion produces little radioactive waste and could use readily available hydrogen from the sea. This method is attractive in principle but despite twenty years' scientific study has not yet produced useful power.

SOLAR SATELLITES

Other sources of power such as the waves of the sea, geothermal sources, photoelectric converters, etc, have been suggested but the most ambitious proposal yet made is for a number of huge satellites (often called 'Powersats' or 'Sunsats') to be assembled in space. They would convert the energy of sunlight into electrical energy which would be sent to the earth as a microwave beam. At the receiving station the energy would be converted into power suitable for feeding to our electricity grid.

This solar power satellite idea is perhaps the most complex and expensive proposal yet made by our civilisation.

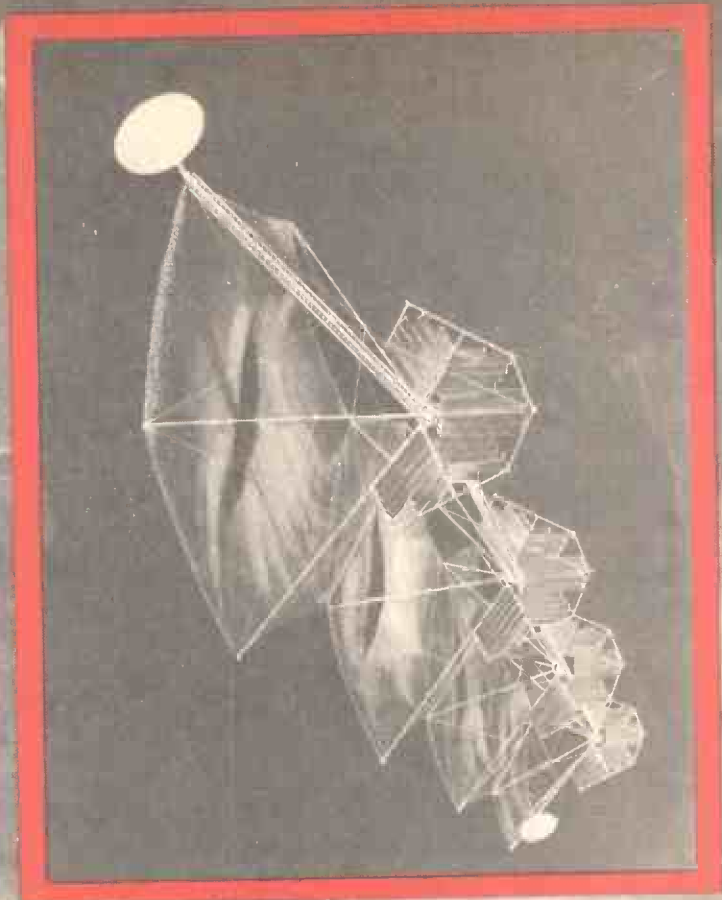
US WORK

Some immediately obvious difficulties include the problem of converting many megawatts of power into a focused microwave beam, the possible effects of the beam on people, animals and plants and its effect on the ionosphere and our weather. But the potential benefits are so great that the United States National Aeronautics and Space Administration (NASA) and the US Department of Energy have provisionally allocated 15.6 million dollars for work on the project up to 1980, at which time it will be compared in detail with other possible energy sources. Now a bill is being considered by Congress which would increase this amount by 25 million dollars for the fiscal year beginning in October 1979.

Boeing Aerospace, Varian Associates, the Jet Propulsion Laboratory of California and the Raytheon Company of Waltham, Massachusetts are some of the companies contracted to work on the project.

Although the US Department of Energy actually manage the funds for the Solar Power Satellite project, NASA is deeply involved with the development of new launch vehicles required for putting huge payloads into orbit. NASA has already established a Solar Power Satellite Office.

The idea of a solar power satellite was first proposed just over ten years ago by Dr Peter E. Glaser. His suggestion was not taken very seriously at first, but NASA investigations in 1971/72 showed that it would be a feasible project. At the present time there is enormous interest in the USA in solar power satellites and campaigns are being organised to encourage the Government to proceed with the work in great haste. Peter Glaser leads a group of industrialists known as the "Sunsat Energy Council", this Washington-based



Artists impression of a 'Rectenna' used to receive and convert the microwave energy from the power satellite, to usable electric power.

Council was formed on solar power satellites. Naturally US electronics manufacturers are well represented on this Council (including General Electric, RCA and Westinghouse), since such a project could bring a vast amount of work to the electronics industry.

CURRENT IDEAS

The proposals currently being considered are for a number of huge solar power satellites each providing a power level of some 10,000 megawatts and weighing some 10^8 kg (100,000 tonnes) with an area of about 100km^2.

In order to place such an amount of material in orbit, it has been estimated that one would require a few launchings per day of huge Space Shuttle type vehicles over a period of a year or so. Boeing Aerospace are studying the possible effects of such launchings on the environment which will far outweigh the flights of our own Concorde. Launch and recovery problems may be considerable and the choice of rocket fuel may be limited by considerations of the resultant atmospheric pollution.

A solar power satellite would operate in geosynchronous orbit: this means orbiting at a rate calculated to keep the satellite apparently stationary above a point on the earth's surface. The receiving station would always be in a direct line-of-sight from such a satellite which could supply microwave energy for over 99% of its operational life. The other part of the time is spent with the satellite in the shadow of the earth, so it cannot supply power at this time. However, such eclipses of a power satellite would occur only for short periods when it is late at night in the region of the earth being served when electricity demand would normally be quite low.

A satellite in geosynchronous orbit receives at least six times as much solar energy as a similar collector on earth (although a figure of nearly twenty times is more typical). A 10,000 MW (megawatt) solar power satellite could supply all the electricity requirements of New York City or London. About forty-five such satellites would be required to match the present electrical generating capacity of the USA. Smaller satellites providing outputs down to 2500 MW could be economical propositions for some areas.

If it is decided to proceed with the construction of one or more solar power satellites, hundreds or even thousands of people will be working in space on the project.

ENERGY CONVERSION SYSTEMS

A number of forms of energy conversion have been studied for possible use in a power satellite, but two

basic forms seem to be currently in favour. In the photovoltaic type of satellite, an array of perhaps 14 x 10^9 solar cells would be employed with a total area of about 24.8 km in length by 5.2 km in width (129 km^2). These cells would convert the energy radiated from the sun into a direct current.

Another possible system is known as the Brayton heat engine satellite; it would employ a series of four huge parabolic-dish reflectors, each about 5.6 km in diameter and similar to the reflectors used with conventional microwave aerials. The whole satellite would stretch some 23.7 km across space. The parabolic reflectors would collect the energy from the sun and would direct it into a 'solar furnace'. Each reflector would consist of thousands of steerable, extremely thin plastic reflectors which would direct the energy into a dome-like cavity absorber or solar furnace located near each dish.

Helium gas operating in a closed loop could be heated in the solar furnace cavity so that it passes through gas turbines and would then flow through a space radiator where the heat from the gas would be passed to the

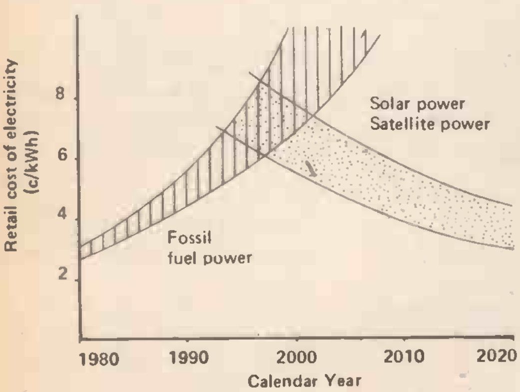
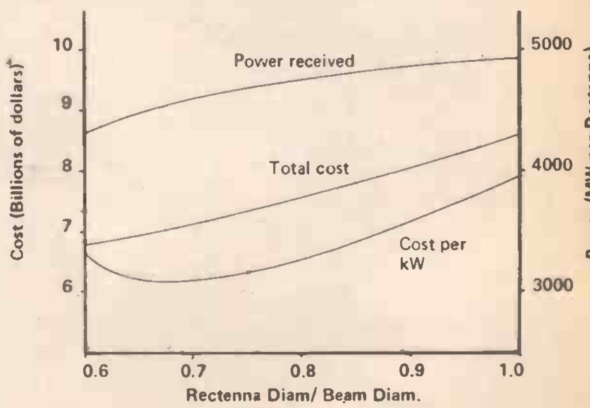
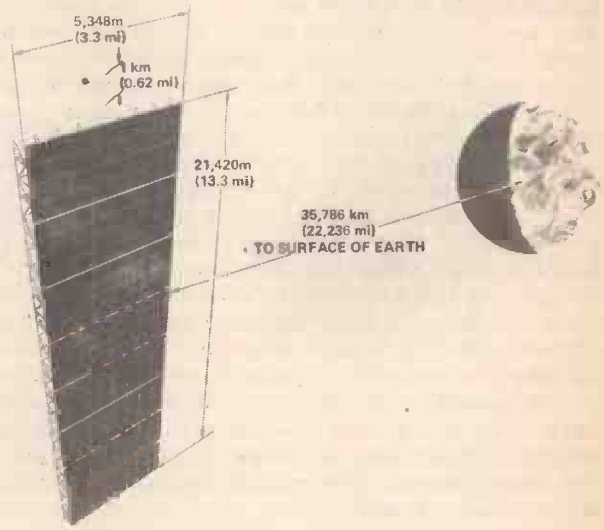


Fig. 1. The graph at left shows how the cost of electricity generated from the burning of fossil fuels (coal, oil) will increase over the next two decades. The cost of solar power derived from the proposed satellites is likely to become an economic alternative within 15 years.
The graph at right indicates how the cost of a solar power satellite system varies depending on the diameter of the receiving antenna (Rectenna) on earth. Optimum cost per kW is obtained from an antenna of about 700 m diameter.



Space Shuttle type vehicles may be used to ferry materials to a 'factory' in a near earth orbit constructing a power satellite, the completed structure being moved later to a geosynchronous orbit.



radiator for dispersion into space. The space radiator could employ a liquid metal loop with a helium/liquid metal heat exchanger. A liquid alkali metal such as potassium, would suffer little contamination in space. The gas turbines would drive a dynamo. As there would be no gravitational force in the region, the turbo-generators could be entirely supported by gas bearings.

Power satellites using other types of conversion are possible. The possibility of using thermionic electricity does not seem to be in the running at the moment owing to low efficiency, waste heat rejection and the cost of the materials.

Both the photovoltaic and heat engine systems seem to be possible, although each has its own advantages and disadvantages. In both systems the electricity produced would be beamed to the earth as microwaves. The Boeing study concluded that the weight of either type of satellite would be of the same order, namely 80,000 to 110,000 metric tonnes for a 10,000 MW satellite.

Although the photovoltaic system is less complex, the currently available solar cells are expensive to produce and are believed to be less efficient than thermal cycle engines. In addition, Brayton heat engines have already been operated very successfully on the earth using 7 metre diameter reflectors to generate large amounts of electrical energy.

At the present time it seems that a photovoltaic system using silicon cells is most in favour. Unfortunately they are subject to radiation degradation, but this can be corrected by suitable annealing. It seems likely that silicon solar cells which have spent much time in the region of the Van Allen radiation belt would require re-annealing before use in their geosynchronous orbit.

MICROWAVE POWER GENERATION

The conversion of some 10,000 MW of power fed in as a direct current into the required 2.45 GHz microwave beam is no easy task. Varian Associates are basing their plans on the use of 70 kW klystrons cooled by heat pipes for microwave power generation in the satellite. It has been estimated that each satellite transmitter would employ some 250,000 70 kW-klystons in its 1 km diameter transmitting array. However, Raytheon favour the use of 5 kW "amplitron" devices which are crossed field amplifiers of the magnetron type.

The power transmitter design is largely dictated by the fact that it has been decided to limit the maximum power intensity in the ionosphere to 230 W/m² (23 mW/cm²), since this is the best estimate of the limit below which localised heating of the ionosphere by the power beam can not exceed the heating occasionally produced by natural effects. Incidentally, the fraction of the complete atmosphere heated by the combined power beams of even a large number of solar power satellites will be extremely small.

THE MICROWAVE BEAM

It is intended that the microwave power beam from the satellite used to convey energy to earth would use a frequency of 2.45 GHz and would be focused on an array of receiving aerials on the earth over an elliptical area of some 12 km by 8 km in size. The receiving area would resemble a chain link fence mounted in stripes high enough above the ground to allow agriculture and animal grazing beneath the aerials.

It has been suggested by Ralph Chernoff of the Jet Propulsion Laboratory that a phased array of aerials on a satellite of a diameter of about 1 km could produce a suitable beam to the earth. Large phased transmitter arrays are required in order to produce a narrow beam which can be accurately directed. There may be two transmitters per satellite.

At the receiving station the microwave beam would be converted into direct current. A grid interface converter would then change this current into a high voltage alternating current of the mains frequency used in that region. It is probable that part of the power would be used to electrolyse water at the receiver site so as to generate the oxygen and hydrogen required for liquefaction for use as rocket fuel.

Earthbound experiments at the Jet Propulsion Laboratory have used a conventional communications receiver operating at 2.45 GHz as a beam source to direct power on to a tower at a distance of over 1.6km. A receiving antenna was mounted on the tower; it consisted of a phased array of dipoles with each dipole connected to a diode rectifier and smoothing capacitor, the output being connected to a direct current load. An efficiency of 82.5% was obtained at a level of over 30 kW, the efficiency being defined as the direct current power delivered divided by the RF power transmitted. These experiments, which were performed a few years ago, almost abolished any doubts about the feasibility of obtaining high efficiency power transfer through the use of a microwave beam.

A solar power satellite receiving station could also use a suitable array of dipoles and diode rectifiers; such a system is often referred to as a "rectenna" or "rectifying antenna".

Accurate direction of the power beam from the satellite is essential for optimum efficiency. An error of only 1 second of arc in the direction of the beam will produce an error of about 174 m at the ground from a satellite in a geosynchronous orbit at 36,000 km above the earth.

A "retrodirective" technique is employed oin which a signal transmitted from the ground station is used to measure and correct for any mechanical inaccuracies in the transmitting antenna. It is desirable that the wavefront emitted from the 1 km diameter transmitting antenna should be planar to within ±3 mm (±10° phase error) for optimum efficiency. It is probably impossible to obtain such mechanical perfection, but the phase front can be electronically controlled by distributing a reference phase synchronisation signal to all of the sub-arrays from a common source on the antenna and comparing this signal with the signal transmitted from the ground.

Rectenna costs have been found to be a major factor in the overall cost of transmitting the power from gthe satellite to the grid. Owing to the shape of the beam intensity pattern on the ground, one can reduce the size of the antenna array somewhat in order to reduce the

Rocket type	Time	Pounds (£s)/kgm	Typical load
Vanguard	late 1950's	0.6×10^6	9 to 14 kg
Thor	1960's	11×10^3	450 kg
Saturn	early 1970's	0.7×10^3	110,000 kg
Space Shuttle	1980's	165	
Heavy Lift Vehicle	?	10–15	500,000 kg

Approximate cost of lifting material into earth orbit at various times.

The 'Rectenna as seen from the air, it would measure 5 miles by 7½ miles. Microwave levels beneath the structure would allow grazing and farming.

cost per kW collected. In other words, the outer parts of the beam contain so relatively little energy that one cannot collect it economically. The graph on the right (Fig. 1) shows a definite minimum in the cost per kW of the collected power for various rectenna dimensions.

ASSEMBLY LOCATION

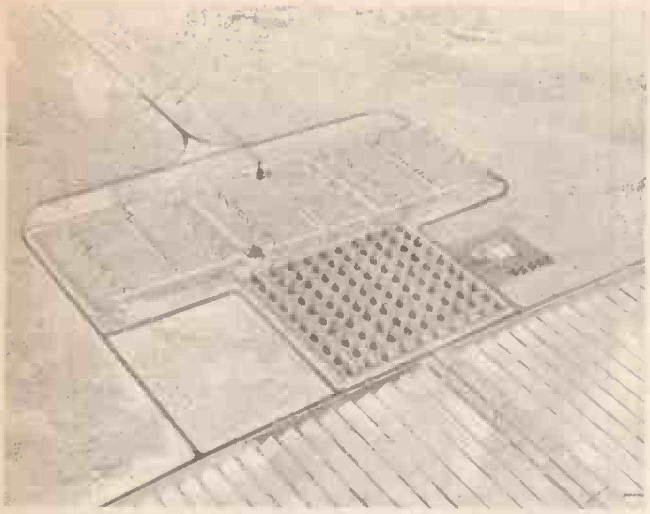
Boeing Aerospace have studied the possibility of assembling the parts of the solar power satellite in low earth orbit and then using the power available from the satellite itself to provide electric propulsion into a geosynchronous orbit. The main advantage of an assembly in low earth orbit is the reduction in rocket fuel requirements from 2.1 tons per ton delivered to a geosynchronous orbit to a mere 0.25 tons per ton. This greatly reduces the cost of launching the solar power satellites.

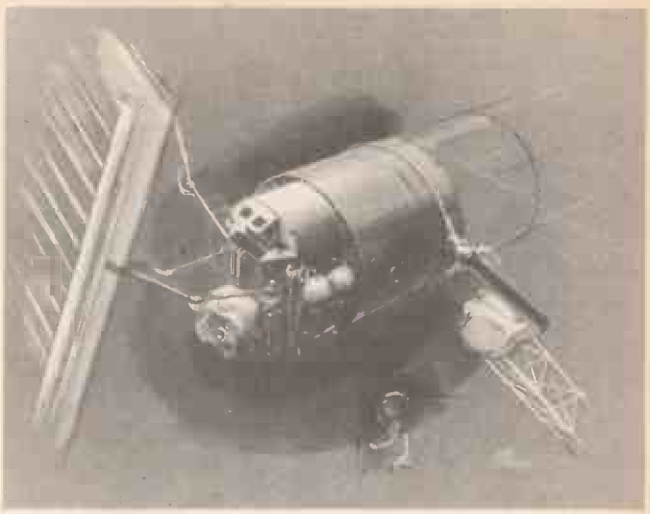
However, there are quite a number of disadvantages of assembly in low earth orbit, some of which are not easy to quantify. Boeing Aerospace feel the main disadvantage of low earth orbit assembly is the relatively long time (about 6 months) required for moving the satellite assembly from low earth orbit into geosynchronous orbit. This delay represents interest chargeable on the cost of the satellite assembly, etc and interest charges on such enormous amounts of money cannot be ignored. Nevertheless Boeing feel that the reduction in the rocket fuel costs make assembly in low earth orbit the best technique.

Other problems associated with assembly in low earth orbit include the radiation damage of the solar power satellite components and solar cells during the relatively long time they remain in the Van Allen radiation belts. The problem of converting the assembled satellite into an electrically propelled unit, the risk of collisions with man-made objects in the low earth orbit and during the relatively slow spiralling passage from low earth to geosynchronous orbit the upper atmosphere drag affecting the construction work.

HAZARDS

The proposed 10,000 MW beam directed on to the receiving antenna should produce an intensity of some


Switchyard which serve as the control point for 5 million kilowatts of electricity produced by the 'powers at' in earth orbit.


Construction workers would need unique tools to work in the vacuum of space, the drawing shows a one-man capsule manipulating a section of the satellite, below the astronaut in his shirt-sleeve environment.

230 W/m² (23 mW/cm²) at the centre of the rectenna and about 10 W/m² at the edge of the ellipse. It is rather surprising that the 230 W/m² level corresponds to about the level of natural radiation incident upon the ionosphere. Investigations have been made into techniques for reducing the amount of radiation in the side lobes by some 45 dB so that the intensity outside most of the main rectenna area is seldom more than 0.1 W/m². Offshore rectennas have been proposed for use in areas of high population density.

It is claimed that birds and aeroplane passengers would be able to pass directly though the main beam without any harm owing to the low beam intensity. Presumably aeroplane passengers would be fairly well screened from microwave radiation anyway by the metal body of the craft. Peter Glaser has commented: "I have made a standing offer to provide the wine and salad to anyone who promises to eat that duck that flies through the beam — cooked or not!'

Biological tests are to be conducted to ascertain if a microwave beam of 230 W/m² produces any effect on birds and flying insects at the 2.45 GHz frequency. Similar tests wil be performed at 10 W/m² on plants and animals. One wonders whether biological tests at much higher intensities have yet been performed.

Perhaps it is rather remarkable that the rectenna arrays wil be suitably elevated to permit frost-free farming or other re-use of the land area. The field strength below the rectenna shold be less than the currently recommended maximum US exposure level of 0.1 W/m².

Experiments are planned to test the effect of very high power microwave beams from the huge Arecibo antenna on the ionosphere. These experiments will be carried out with the express purpose of checking that the solar power satellite beam will not produce any detrimental environmental effects.

HEAVY LIFT VEHICLES

The cost of the launch vehicles for placing heavy parts in low earth orbit ready for assembly forms one of the major items of a solar power satellite budget. The Boeing study assumed that a new launcher known as the 'Heavy Lift Vehicle' will be developed which should be able to put material into earth orbit for a cost of about 20 dollars per kg. Without such a heavy lift vehicle the whole solar power satellite project would become economically impossible. The enormous fall in the cost of putting material into earth orbit is well illustrated by the table above.

The heavy lift vehicle could either have wings like the shuttle (in which case it could land on the ground like an aeroplane even without using any of its motors) or alternatively it could be a vehicle without wings rather like the Saturn rocket which would to return to earth by splashing down in the sea. It seems likely that the type of vehicle without wings will be favoured for heavy loads according to current ideas. The Boeing report shows a Saturn type vehicle 72.98 m in height and 32.68 m in diameter at its base.

THE EUROPEAN OUTLOOK

The energy requirements of Europe have been studied by the OECD and it is felt that about fifteen 10 000 MW solar power satellites could supply all of Europe's requirements for 1980. (The total number required for the world has been estimated as about sixty-nine.) The total *developmental* cost (not including operation) of a solar power satellite has been estimated as being of the same order as the total investment already made in North Sea oil by European nations.

The problems in Europe associated with a solar power satellite programme are not identical with those in the USA, largely owing to the different population densities. In the highly industrialised regions of Europe (where power consumption and population densities are greatest), there is normally little land to spare for the huge rectenna arrays together with any surrounding safety areas which may be desirable. The low electrical power demand in rural areas and the high cost of conveying power over large distances may render it uneconomic to place rectenna arrays in these rural areas, so some compromise must be sought in choosing the optimum regions for the siting of rectennas.

It is, perhaps, quite amazing that the USA has set a limit of 10 mW/cm² as the maximum safe exposure of people to microwave radiation, whereas the upper limit in the USSR is one thousand times smaller, namely 0.01

mW/cm². It is certainly true that exposure to intense, non-ionising radiation at radio frequencies can produce internal heating of biological tissue and this can produce damage if the heat cannot escape rapidly enough for a reasonable equilibrium temperature to be obtained. However, scientists are not yet certain whether other adverse effects than those due to mere heating are also present when personnel are exposed to intense microwave beams. In Western Europe the US standards are applied in radar stations, etc., but it would seem to be highly desirable that the biological effects of microwaves be more intensively investigated so that various countries no longer have a factor of one thousand differences in their safety standards.

INTERNATIONAL ENTERPRISE

Work on solar power satellites is one of those major technological enterprises which should stimulate international participation and co-operation. The microwave beams can be received in all countries with latitudes between about 65°N and 65°S without any great loss of efficiency. The beam is virtually unaffected by even the heavy rain clouds so often found over many parts of the earth.

One may feel that the use of solar power satellites would not be an economical proposition in countries where the population density is not very high. However, one should remember that once a number of solar power satellites have been placed in geosynchronous orbit, the cost of placing any other such satellites in orbit will be much reduced.

One must not forget the disadvantages of establishing a world-wide solar power satellite system. Such a system would inevitably cause interruption of communications on the 2.45 GHz frequency. However, the enormous power radiated from a power satellite would result in considerable interference not only in the 2.45 GHz band, but also in a relatively wide frequency band around this region and in frequencies which are harmonics of 2.45 GHz. Apart from this problem, increased radio frequency noise is likely to be produced by the microwave energy absorbed by the ionosphere which results in a raised electron temperature in this region. There would also be interruptions in the radio frequency communications links with aeroplanes or satellites whilst they cross the microwave beams from the power satellites, but doubtless other frequencies or laser beams could be used to overcome this problem.

It seems likely that the equivalent of 1000 or more Saturn V launches would be needed to place one solar power satellite into geosynchronous orbit. The total mass sent into space in a project of this type would easily exceed an astounding 10^6 tonnes/year!

OTHER REQUIREMENTS

A maintenance vehicle would be needed to maintain and re-supply solar power satellites in geosynchronous orbits — possibly a couple of journeys to each satellite per year. If many solar satellites were in use, a maintenance base in geosynchronous orbit would be justified — especially as it could be used to maintain communications satellites and other non-power craft.

During the construction phase of a solar power satellite (either in low earth orbit or in a geosynchronous orbit) living accommodation must be provided in space for the workers. As the cost of human labour in space will be exceedingly high, intensive studies are in progress to promote the automatic assembly of large structures in space.

CONCLUSIONS

The need for a non-depletable energy source for the next century is undisputed. Many scientists believe that if the necessary funds are made available quickly, energy could be provided by solar power satellites by about the mid-1990's. The estimated cost of solar satellite produced power is 1700 dollars/kW as against 1400 dollars/kW for power from conventional nuclear power generators. However, the effective cost of satellite generated power will decrease with time, since solar satellites require no fuel and relatively little maintenance. In addition, the cost of fossil fuels will doubtless continue to rise as sources are depleted. The trend of rising fuels costs and falling solar satellite power costs is illustrated in the graph, but obviously all cost estimates are subject to wide variations.

The construction, in space, of equipment the size of a city is quite beyond our present experience. It is not, however, so very far beyond the present state of our art as to be a practical impossibility. No new technological developments are required — only an expansion of current technologies. First of all we must break through the psychological barrier which has convinced us that it is virtually impossible to put a satellite the size of a city and the weight of a battleship into orbit.

If *you* had perhaps 500,000 million pounds to spend, would you choose to use it on a multi-solar satellite power project, relief for the underdeveloped countries, cancer work or perhaps some other project? Sooner or later decisions of this type must be made about the solar power satellite work. It seems likely that many vital decisions will be made in the USA when the results of the 1980 status report requested by NASA and the US Department of Energy are known.

The author is indebted to Mr William A. Rice of Boeing Aerospace, Seattle, for the information and photographs which he has kindly provided for this publication.

electronics today international

What to look for in the September Issue: On sale August 3rd

Made your contribution to Confuse-a-Car Week yet? Jog your jalopy's geriatric innards into thinking it's Christmas by giving it one of our car projects.

Now that the Great British Summer's here again, you'll need our heated rear window controller. Hit the button and the wonderful window warmer heats your hindsight for a respectable screen-clearing interval and then switches off again.

Or there's a warning lamp audible repeater. If you're in the habit of driving with your eyes closed (clunk click every trip) you won't see your oil or ignition warning lamps come on. With our repeater you'll hear them.

We're also planning an LED temperature gauge. Watch your radiator blow its top in full technicolour. . . . Next month in motoring ETI.

SATELLITE SPECIAL

The satellite age dawned in 1957 with Sputnik 1. Since then thousands of tons of hardware have been blasted into orbit around us.

The satellites we have now, a little more sophisticated than Sputnik, monitor our weather, let us look in on a foreign war or the American Open as it happens, take navigation out of the realms of sun and sextant and many more applications, including a few that are distinctly hush-hush.

Next month Ian Graham looks skywards and brings the eye-in-the-sky down to earth.

LM10? What In The Name Of ETI Is An LM10?

Until last month very few people had even heard of the LM10. In a few more months not having done so will be a bigger disgrace than supporting Chelsea. Ray Marston produces one of his special features to help you out of the second division next month, so don't miss it.

KEEP IT QUIET, DON'T HISS AND GET IT TAPED PROPERLY

No it's not Dolby. It is based on a brand new chip set from National. It has an amazing low component count. It turns in a very respectable 'sound' and is ideal for home usage. It is inexpensive and a very good reason to buy ETI next month.

ETI MA

CLOCK RADIO

You probably won't believe us as we're selling the goods but we're going to tell you anyway! We have *rejected* eight clock radios for Marketplace, they were all cheap enough but the quality was so poor that we couldn't have lent our name to them. However, we are now able to offer a portable LCD Clock Radio to you which meets our standards.

The clock is a 12-hour one with AM/PM indicated and a back light. The radio is Medium Wave and FM with very nice quality for a small speaker — for FM there's a telescopic aerial. The alarm can be either a 'beep-beep' type or the radio, there's also a snooze facility.

The case is sensibly rugged and is printed on the back with a World Time Zones map, a bit of a cheek really, especially as the time is relative to Japan!

We won't even mention the RRP — but just check on comparable prices — you'll find ours a bargain.

An example of this Clock Radio can be seen and examined at our Charing Cross Road offices.

£17.95

(Inclusive of 15% VAT and Postage).

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The Hanimex HC-1100 is designed for mains operation only (240V/50Hz) with a 12 hour display, AM/PM and Alarm Set indicators incorporated in the large display. A switch on the top controls a Dim/Bright display function.

Setting up both the time and alarm is simplicity itself as buttons are provided for both fast and slow setting and there's no problem about knocking these accidentally as a 'locking' switch is provided under the clock. A 9-minute 'snooze' switch is located at the top.

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We feel we've got to tell you carefully about this offer which we're introducing for the first time. Why? Because our price is so enormously lower than anywhere else you may suspect the quality.

The display is LCD and shows the seconds as well as the hours — and minutes — press a button and you'll get the date and the day of the week.

Press another button for a coujple of seconds and you have a highly accurate stopwatch with hundredths of a second displayed and giving the time up to an hour. There is a lap time facility as well — and of course a back light.

Our Chrono comes complete with a high grade adjustable metal strap and is fully guaranteed.

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ALARM-CHRONO LCD

This new addition to our unbeatable selection of bargains is no ordinary LCD watch. It's a slim, multi-function, dual time chronograph alarm watch, no less.

This model will show hours, minutes, seconds, date, day of the week, stop watch, split time, alarm and alternate dual time zone — not all at once, of course. There is also a night light.

Hours, minutes, seconds and day of the week are displayed continuously, while the date will appear at the touch of a button. The day of the week is indicated by a flag. When used as a stopwatch, the maximum count is 0.1secs. short of thirteen hours.

£19.95

(Inclusive of 15% VAT and Postage).

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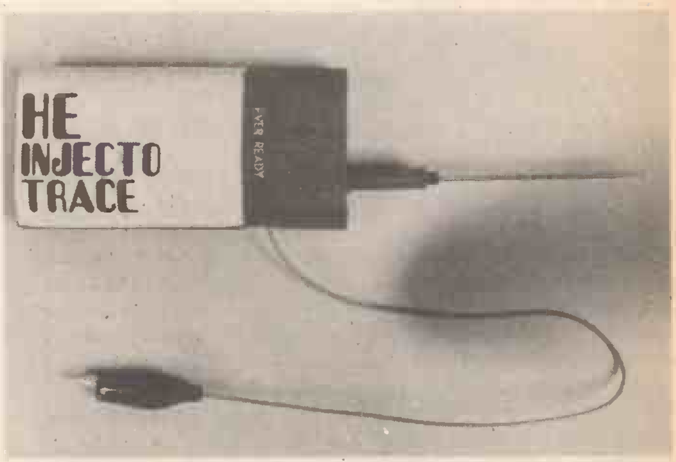
Please allow up to 28 days for delivery.

Injector/Tracer

An ultra-useful piece of low-cost test gear for the DIY electronics enthusiast.

ONE OF THE MOST USEFUL and inexpensive pieces of test gear that an electronics serviceman or constructor can own is a combined signal injector and signal tracer, or injecto-trace. This amazingly simple yet versatile little device is designed to rapidly and easily locate faults in many types of electronic equipment, including radios, TV's and audio systems.

The HE Injecto-trace generates a 1 kHz 'square' wave which produces harmonics up to 100 MHz or more when used in the INJECT mode, and these signals can be injected into a piece of equipment under test via a simple needle probe and a flying lead. In the TRACE mode the unit will detect AF and RF signals with amplitudes as low as a couple of hundred microvolts and produce the amplified AF or demodulated RF signals in a crystal earpiece. The unit is automatically switched from the INJECT to the TRACE mode when the crystal earpiece is plugged into its jack socket. The HE Injecto-trace measures a mere 3½ x 1¾ x ¾ inches, and is truly pocket sized.



The HE Injecto Trace in its torch case, note the flying lead and crocodile clip.

USING THE INJECTO-TRACE

The unit is used in fault-finding applications by systematically working through the defective equipment and appropriately injecting into, or tracing from, the circuit until the inoperative section of the equipment is located.

Take for example the case of a defective transistor radio in which the battery and the earphone switch (the two most common faults) are known to be good. You can

The Injecto-Trace being used on a 'dead' radio, by using logical fault finding procedures the faulty component is quickly traced.

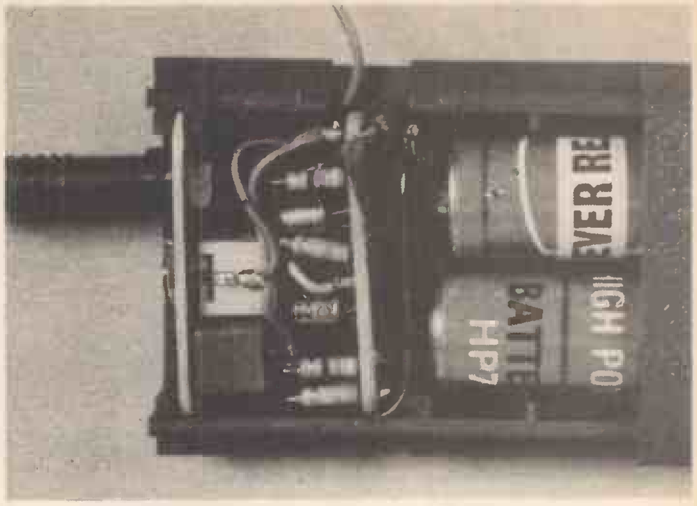
start fault-finding by injecting a signal at the slider of the volume control. If the resulting 1 kHz signal is heard in the set's speaker you'll know that the audio amplifier is OK, and the fault therefore lays further back, in the IF or RF sections of the receiver. If the signal is not heard, you'll know that the audio amplifier is defective. By systematically working either forwards or backwards through the circuit, injecting or tracing as appropriate, the fault area can be easily located.

CONSTRUCTION

The unit, complete with two HP7 batteries, is built inside a small Ever-Ready pocket torch case and, as can be seen from the photo's, presents a bit of a challenge from the constructional point of view, since the electronics have to be sub-miniaturised.

The PCB is designed specifically to slot into the bulb/reflector compartment of the Ever Ready torch shown in the photo's (it is available from most electrical shops). Note that all components must be mounted vertically on the PCB, with their leads as short as possible. Also note that C2 is mounted with one leg on the PCB and the other on jack socket SK1 (see the circuit diagram), and that the flexible or 'flying' probe lead (a length of lead with a crock clip on one end) passes from the PCB to the outside world via the original on/off switch slot in the side of the torch case. A piece of insulating tape should be fixed to the underside of the assembled PCB, to prevent it shorting against the battery terminals.

A small aluminium panel with the same dimensions as the PCB must be made up to slot into the front of the torch case and hold sub-miniature components SW1 and SK1: our prototype unit also holds a miniature 2 mm socket, into which the metal probe (made from a short length of knitting needle) clips. The interwiring between the PCB and the panel controls must be undertaken with some care, as considerable dexterity is called for in wielding the soldering iron in the limited space of the component assembly area. **HE**



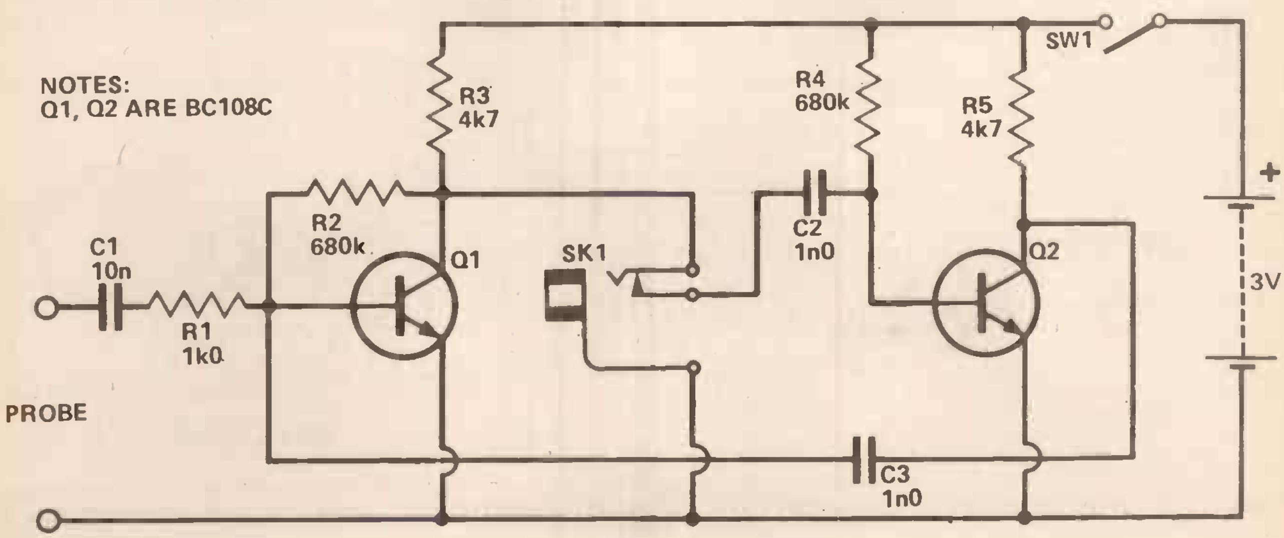
Inside the Injecto-Trace, using the Ever-Ready case results in a really small and compact piece of test gear.

How it Works

The operating theory of the circuit is very simple. Normally, when the earpiece is not plugged into SK1, C2 is connected directly between the collector of Q1 and the base of Q2, and in this mode Q1 and Q2 act as a modified astable multivibrator that generates an approximately square waveform at about 1 kHz. A distorted and harmonically rich part of this waveform is tapped off at the base of Q1 and can be injected into an external circuit via R1-C1 and the probes.

When the crystal earpiece is plugged into SK1 the earpiece is connected between Q1 collector and emitter, and the connection between Q1 collector and Q2 base is broken. In this case Q1 acts as a high-gain low-level wide-band amplifier, which is driven by signals picked up on the probe, and Q2 is inoperative. The Q1 circuit amplifies AF signals directly, and demodulates RF signals via its base-emitter junction and amplifies the resulting AF components.

Fig. 1. Circuit diagram for the HE Injecto/trace, use only sub-miniature components if the same case as our ptototype is to be used.



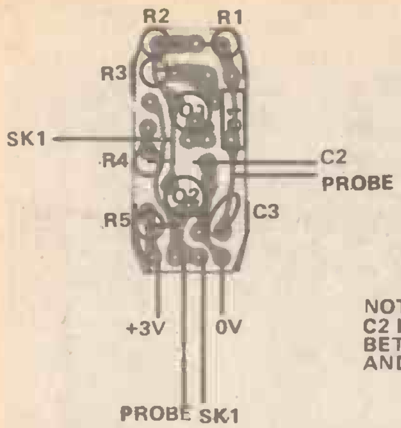
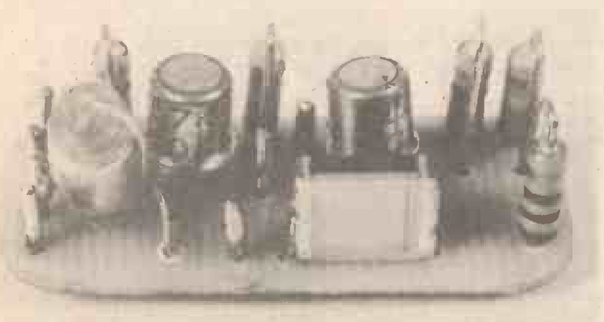


Fig. 3. PCB pattern, this may present some problems to the less experienced, why not try our Hobbyprint service for really first class results.

**NOTE:
C2 IS MOUNTED
BETWEEN THE PCB
AND SK1**

Fig. 2. Component overlay for the Injecto-Trace, keep the leads as short as possible to ensure everything fits in.



Close up of the circuit board, you can see how important it is to keep the component leads short.

Parts List

RESISTORS (A11 ¼W, 5%)

R1	1k0
R2, R4	680k
R3, R5	4k7

CAPACITORS (All sub-min types)

C1 10n	Polycarbonate
C2, C3 1n0	Ceramic

SEMICONDUCTORS

Q1, Q2	BC108C

MISCELLANEOUS
SW1 Sub-min slide switch (PCB type)
SK1 2.5mm Jack Socket
CRYSTAL EARPIECE
PCB
Ever Ready torch case

Approximate cost £3.50

Buylines

There should be no problems in finding the components for this project. Note, however, that SW1 and SK1 are sub-miniature components. The Ever Ready torch is available from most electrical shops.

Short Circuit

SCRATCH AND RUMBLE FILTER

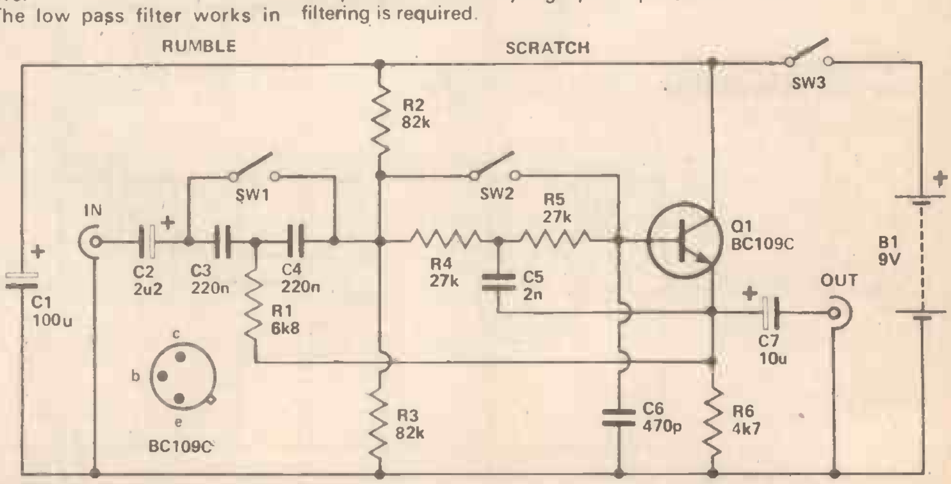
Scratch and rumble filtering is a valuable feature in a hi fi amplifier, but is one which is absent from many designs, or if this filtering is present it may well be in the form of a relatively ineffective 6 dB. per octave type filter. This circuit is a 12 dB per octave add-on scratch and rumble filter which can be connected into the 'tape monitor' or some similar facility of the amplifier.

This is a conventional second order filter circuit having passive high pass filter formed by the series capacitance C3 and C4, plus the parallel resistance of R2 and R3 (the latter also being used to bias emitter follower transistor Q1). A passive filter of this type gives only a very slow initial roll off, and an ultimate attenuation rate of only 6 dB per octave. A bootstrapping resistor is therefore used to improve performance. Above the cut-off frequency where the gain of the circuit would otherwise fall off somewhat, R1 has the effect of reinforcing the input signal from the output of the buffer amplifier based on Q1. Well below the cut off frequency, losses through C4 result in the signal level at Q1 emitter being well below that at the junction of C3 and C4. This results in some of the signal at the junction of C3 and C4 being tapped off through R1, with C3 and R1 effectively forming a second high pass filter network. This eliminates the slow initial roll off rate (in fact there is a small and insignificant peak of about 0.5 dB above the cut off frequency) and speeds up the attenuation rate to a nominal 12 dB per octave.

The low pass filter works in much the same way as the high pass one, except of course, the R and C filter elements have been transposed so as to give the correct filter action.

If only low pass filtering is required, SW1 can be used effectively to bypass the high pass filter components. C2 then maintains DC blocking at the input. SW2 can be used to bypass the low pass filter components when only high pass filtering is required.

With the specified component values the rumble filter response falls below unity at approximately 45 Hz, reaches the — 6 dB point just above 30 Hz, and then falls away at a nominal 12dB per octave. The scratch filter response crosses the unity gain point at about 6.5 kHz, reaches the —6 dB point at approximately 10 kHz, and then falls away at a nominal 12 dB per octave.



Hobby Chit-Chat

THE DEMISE OF THE DISCRETE TRANSISTOR

HE project editor and chief designer Ray Marston takes the second of his monthly series of looks at the hobby scene.

ONE OF THE FRINGE BENEFITS that I have through working for Hobby Electronics is ready access to all of the back issues of HE and its sister magazine Electronics Today International. The British version of ETI was first published in April 1972, a mere seven and a bit years ago. Looking through the back issues of ETI recently I was greatly impressed by the enormous technological changes that have taken place in the hobby electronics scene in that relatively short space of time.

Specifically, I was struck by the fact that most of the projects published in the early 1970s were based on discrete transistors, whereas most of today's projects are designed around integrated circuits. The discrete transistor has, it seems, become a near-obsolescent device in all except the most mundane or the most demanding applications within the past five years.

The transistor itself is, of course, alive and well, since all integrated circuits are based on transistor technology (either bipolar or FET). The reasons for the rise of the IC and the demise of the discrete transistor are primarily economic. An IC containing dozens of transistors usually costs only a fraction of the price, and occupies a fraction of the space, of its discrete transistor equivalent. An IC and its related external components can thus be built on a far smaller and less expensive PCB than an equivalent all-discrete circuit, so the IC user benefits in all ways.

The technological changes that have taken place in our hobby over the past five years have been slow and insidious, rather than sudden and dramatic ones. This process of gradual change will continue throughout the next five years, and beyond. As the years tick by you'll be almost unaware of the changes that are taking place as you effortlessly absorb an apparent trickle of new knowledge. But if, in the year 1984, you look back through your tattered 1979 copies of HE, you will probably be staggered at the total sum of all these gradual technological changes.

TOWARDS 1984

So what changes can you expect to see in the Hobby Electronics scene in the five years between now and 1984? Let's look first at passive components. In the past five years we've seen the demise of the multi-ganged tuning capacitor as it has gradually been replaced by the Varactor diode, or voltage-tuned solid-state capacitor. We've also seen the demise of the inductor in tuned circuits, as it has been replaced by gyrator circuits in low-frequency applications and by ceramic or crystal networks in high-frequency applications.

In the next five years we can similarly expect to see the demise of the multi-ganged pot or variable resistor as it is replaced by new integrated circuits that are presently under development. We will also see the multi-gang multi-way electro-mechanical switch virtually disappear in all except high-voltage and high-current applications by 1984: these switches are already on the way out, and are expected to be given a final 'heave' within the next two years.

On the digital electronics scene, CMOS ICs will remain strong and healthy over the next five years, but 'conventional' TTL will become obsolete and be replaced by low-power Schottky (LS) TTL: conventional TTL is in fact expected to be 'dead' by 1981.

The much-vaunted microprocessor will continue to become more sophisticated, and the capacities of digital memories will continue to grow. The real explosion in the microprocessor field will, however, come at the low end of the sophistication spectrum as a new generation of 'dedicated' and simplified control oriented processors (COPS) enter our lives. By 1984 the hobbyist will use a COP even more casually than he uses a digital clock chip or a TV games chip today. COPS are already here, but are not set to really take off until 1980-81.

Digital ICs are set to have a big impact on hobby activities such as radio control modelling and model railroading in the next five years. A complete low-cost 4-channel radio control coder/transmitter IC, and a matching receiver/decoder IC, is due to be announced at the end of this year. Hornby are also due to release their microprocessor-based model railway control system this year. Lots of other goodies are in the pipeline.

REVAMP OP-AMP

In the linear IC field, a brand new type of op-amp is due to be announced within the next couple of months, and could be quite revolutionary. Power ICs will be used increasingly in the output stages of high-power Hi-Fi amplifiers, following new advances in IC technology. Electronic delay lines, based on charge-coupled device (CCD) technology, will achieve vastly increased capacities, and will fall substantially in relative costs, in the next few years.

That, then, is an educated estimate of what is going to happen on our hobby scene over the next five years. If I'm right, we're all in for an interesting time. If I'm wrong, I'll apologise in 1984.

THE LM380 2-WATT AUDIO AMPLIFIER

If you saw last month's Baby Alarm project you'll have noticed that it was designed around the LM380 integrated circuit. The LM380 is one of those highly popular and useful ICs that every self-respecting electronics enthusiast should get to know about. It is an easy-to-use general-purpose audio power amplifier that can deliver 2 watts into an 8 ohm load with a typical distortion of only 0.2%, and can be used with any single-ended supply voltages in the range 8 V to 22 V. The device has an internally fixed voltage gain of 50 (34 dB), a power bandwidth of 100 kHz, and an output that is well protected with short circuit limiting and thermal shut-down circuitry.

For the benefit of voyeurs, figure I shows what the LM380 looks like with its clothes off. Q1 to Q4 form a PNP differential amplifier that has its input signals DC referenced to the ground line via R4 and R5, thus enabling input transducers to be directly connected between the ground and input lines if required. The output of the differential amplifier is coupled directly to the base of common emitter amplifier Q12, which uses Q11 as a constant current (high impedance) collector load, and the collector signal of Q12 is fed to the output terminals of the IC via the Q7-Q8-Q9 quasi-complementary emitter follower set of output transistors. The output currents of Q7 and Q8 are rated at 1.3 A peak.

The output stages of the IC are provided with biasing, plus a good degree of thermal and overload protection, via D1-D2-R6 and R7. Resistors R1 and R2 automatically set the output of the amplifier at a quiescent value of approximately half supply-line voltage, to enable the IC to provide the maximum possible output power with minimal distortion, and R2 and R3 provide the IC with its internally fixed voltage gain of 34 dB

HOW TO USE THE LM380

Figure 2 shows the outline and pin connections of the LM380, which is housed in a standard 14-pin dual-in-line plastic package. The package contains a copper lead frame that acts as a heat sink and is internally connected to the three centre pins on either side of the IC (pins 3, 4, 5, 10, 11, and 12). This frame enables the device to support 1.5W at 25°C ambient. The device dissipation can be increased to 3.7W at 25°C ambient by soldering the six heat sink pins into a PCB with 6 square inches (37.5 square cm) of standard copper foil.

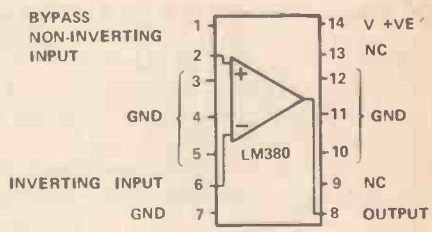


Fig. 2. Outline and pin connections of the standard 14 pin Dual-in-line (DIL) version of the LM380.

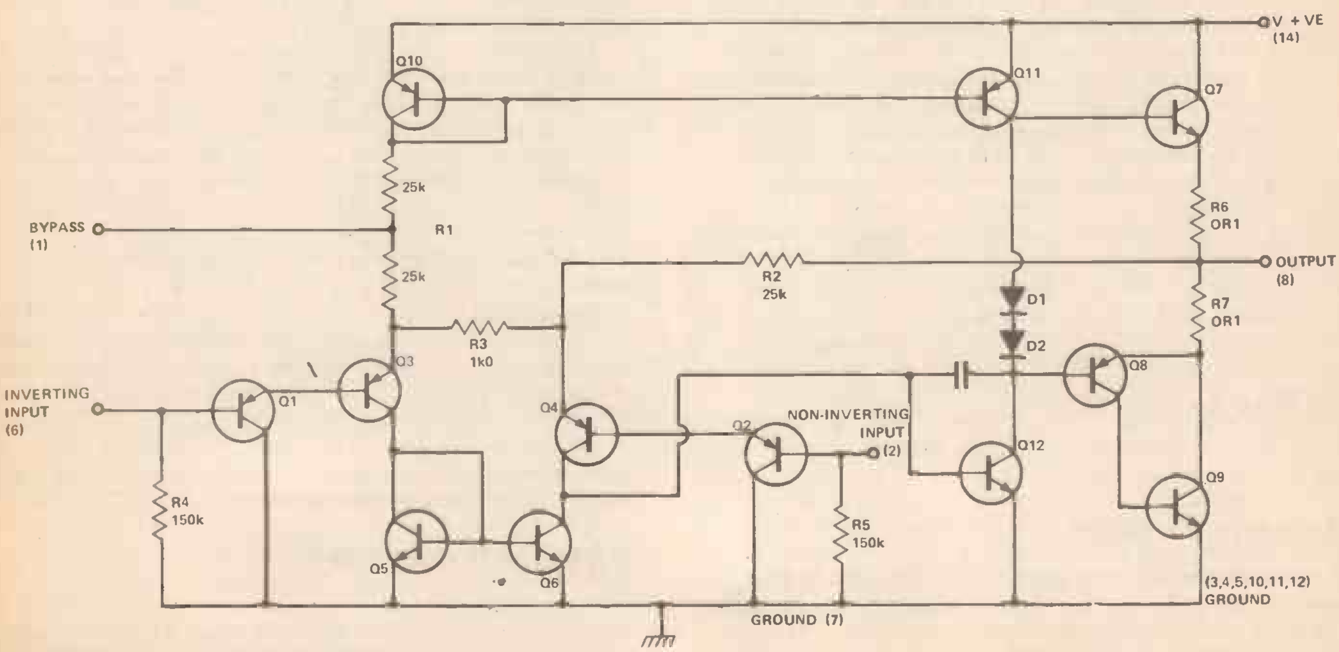


Fig. 1. The internal circuitry of the LM380 IC.

The LM380 is a very easy device to use. Input signals can be direct coupled to either the inverting (pin 6) or non-inverting (pin 2) input terminals, which have input impedances of about 150k. An unused input terminal can either be left floating, or can be shorted directly to ground, or can be tied to ground via a resistance. The output speaker load should be connected between the pin 8 output terminal and ground (pin 7) via a large-value electrolytic capacitor in most applications.

The LM380 can be used with any single-ended supply voltages in the range 8 to 22 volts. In all cases, the supply must be decoupled via a 47uF or larger capacitor located close to the IC, and a 100n ceramic capacitor must be wired as near as possible between pin 14 and the ground terminal of the IC as a precaution against parasitic oscillations. When the IC is used to drive speakers or other inductive loads, a Zobel network (comprising a 2R7 resistor and a 100n capacitor in series) must be wired between the output (pin 8) and ground terminals to protect the IC against high frequency oscillations. If the power supply lines to the IC have high ripple, a 10u or greater capacitor must be wired between the BYPASS (pin 1) and ground terminals to prevent the ripple reaching the speaker. The IC gives greater than 37 dB of ripple rejection at 50 Hz when fitted with this 10u bypass capacitor.

LM380 APPLICATIONS

The best way to get to know any IC is to put it on your workbench and experiment with it. Figures 3 to 10 show a variety of ways of using the LM380 in audio amplifier applications. Most readers should have little difficulty in wiring these circuits up (on Veroboard or microdeck, etc) straight from the diagrams.

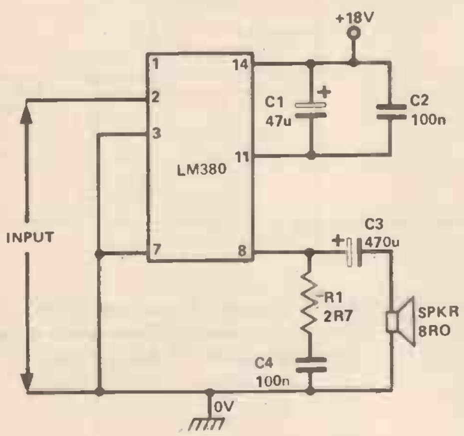


Fig. 3. A simple Non-Inverting 2 watt audio amplifier.

Fig 3 shows how to use the LM380 as a very simple non-inverting 2 W amplifier. The input signal is direct coupled between ground and the pin 2 non-inverting input terminal of the IC, which has an input impedance of about 150k. C1 and C2 are the supply decoupling and anti-parasitic capacitors respectively, and R1 and C4 form the Zobel network across the output of the IC.

Fig 4 shows how the IC can be used in the inverting mode by simply connecting the input signal directly to the pin 6 inverting input terminal and leaving the unused pin 2, non-inverting terminal floating. This diagram also shows how a potential divider volume control (RV1) can be added to the circuit, and how to improve supply-line ripple rejection by wiring C5 between by pass pin 1 and ground.

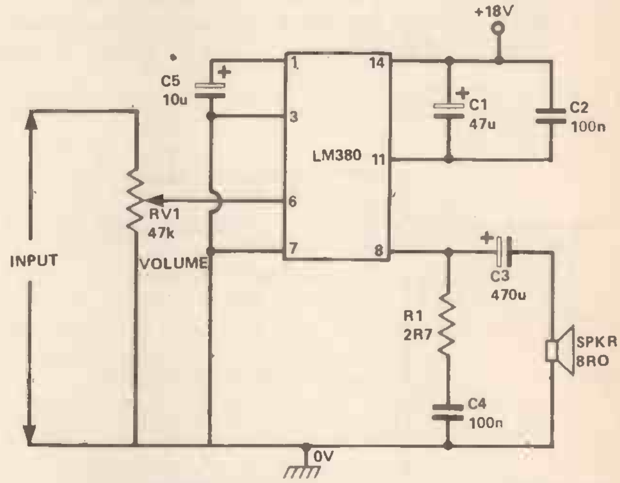


Fig. 4. A the LM380 connected as an inverting 2-watt audio amplifier with volume control and ripple rejection.

Figure 5 shows one way of using the LM380 as a simple non-inverting 2-watt phono amplifier that can be used with any ceramic or crystal pick-up cartridge. Here, RV1 and R2 act as a simple volume control, and C6 and RV2 act as a tone control that gives variable high-frequency roll-off. R2 is wired in series between the pick-up and the slider of RV1 to give the circuit a reasonably high input impedance. A minor disadvantage of the Fig 5 circuit is that, because of the presence of R2, signal attenuation occurs between the pick-up and the input pin of the LM380 at all settings of RV1.

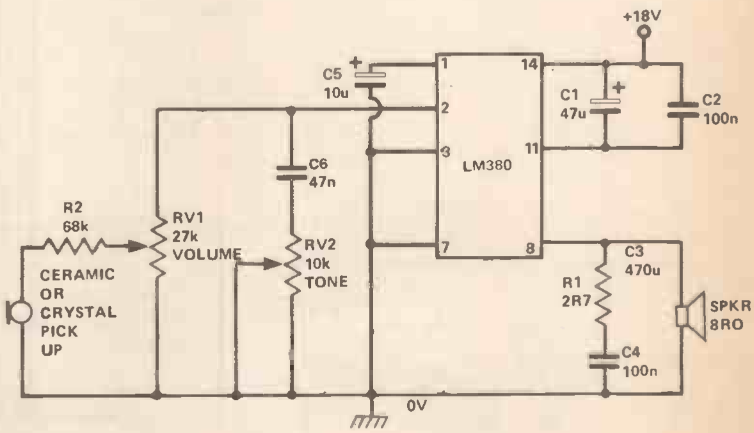


Fig. 5. A simple 2-watt phono amplifier.

Figure 6 shows an alternative, and possibly better, system of volume control that can be used with the LM380. Here, the input signal is fed directly to the pin-2 terminal of the IC's differential input amplifier, and is fed to the pin-6 input terminal via high value variable resistor RV1. When RV1 is set to zero resistance identical signals are fed to both of the input terminals of the IC, so the amplifier has zero gain and the IC gives zero output: the circuit exhibits an input impedance of about 75k under this condition. When RV1 is set to maximum value, a large signal is applied to pin 2 and a negligible signal is fed to pin 6, so the amplifier has a high gain and the IC gives a large output; the circuit exhibits an input impendance of about 150k under this condition.

The volume control system described above is known as a 'common mode' system, since it relies on the

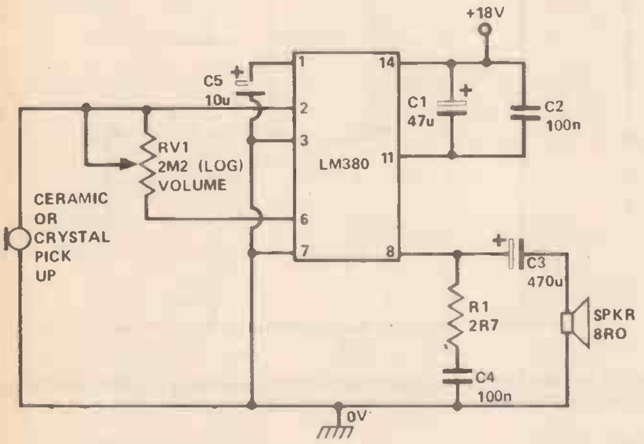


Fig. 6. A 2-watt audio amplifier with 'common mode' volume control.

differential action of the amplifier. It's major advantage is that it provides the circuit with a reasonably high input impedance. Figure 7 shows how a common mode variable tone control can be combined with the common

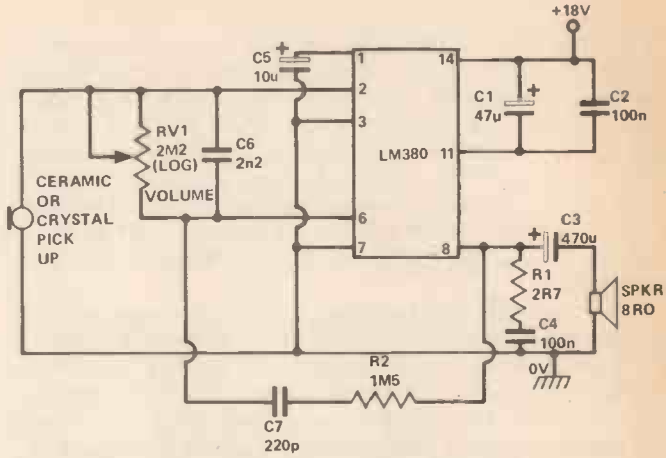


Fig. 8. A phono amplifier with RIAA equalisation.

mode volume control. Alternatively, figure 8 shows how a variable tone control can be dispensed with and replaced with a fixed RIAA equalisation network. Both of the above circuits make excellent low-cost phono amplifiers. They can be used in stereo systems by simply using an identical amplifier, but with ganged controls, in each channel.

The LM380 can be used in a wide variety of audio amplifier applications. Figure 9 shows how it can be used in conjunction with a field-effect transistor (FET) to make a high-input-impedance (10 megohms); 2-watt general-purpose or 'bench' amplifier. Q1 is the FET, and

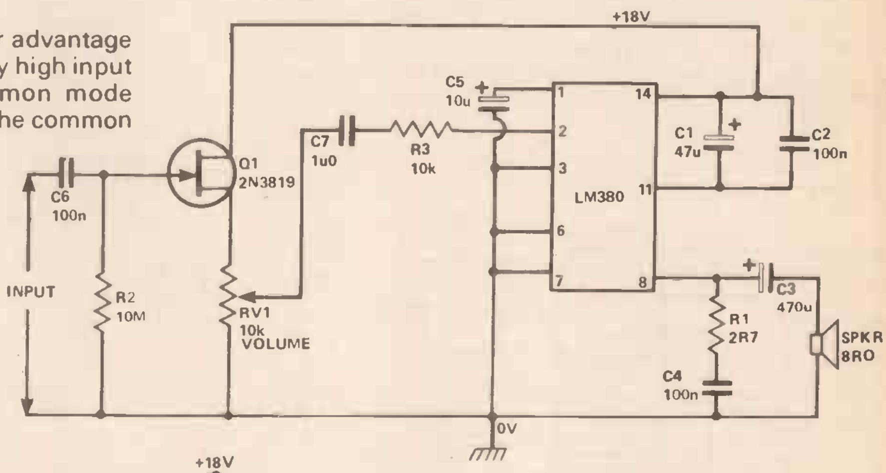


Fig 9. Above: A general purpose 2-watt audio amplifier with an input impedance of 10 Meg ohms.

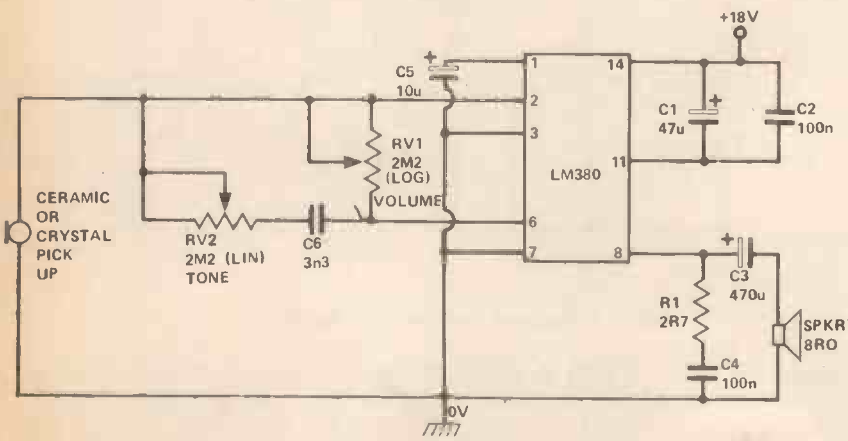


Fig. 7. A practical 2-watt phono amplifier with 'common mode' volume and tone controls.

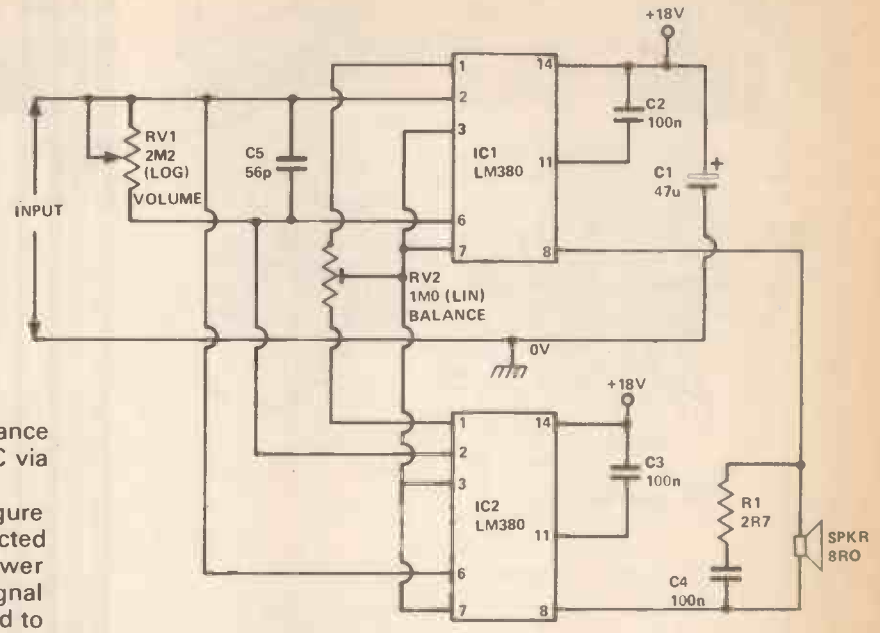


Fig. 10. A 4-watt amplifier using two LM380 ICs in a bridge configuration. The circuit uses common mode volume control.

is wired as a source follower, with its input impedance determined by R2, and has its output fed to the IC via volume control RV1 and limiting resistor R3.

Finally, to complete this month's 'Chit Chat', figure 10 shows how a pair of LM380s can be interconnected in a bridge configuration to give an output power roughly double that of a single IC. Here, the input signal is applied to the non-inverting terminal of one IC and to the inverting terminal of the other, thus producing anti-phase output signals from the two ICs and dividing the output power dissipation equally between the two devices. The Fig 10 circuit is shown with a common mode volume control, but the basic bridge configuaration can in fact be used with any type of volume control.

Note in the Fig 10 circuit that the speaker is wired directly between the output pins of the two ICs and that BALANCE control RV2 must be pre-set so that negligible current flows through the speaker under quiescent conditions. To make this adjustment, temporarily connect a DC current meter in series with the positive supply rail of the circuit (both ICs use the same supply rail) and then adjust RV2 for a minimum current reading with zero input signal applied. Once RV2 has been pre-set, it should require no further adjustment throughout the life of the amplifier. **HE**

Short Circuit

GAS AND SMOKE DETECTOR

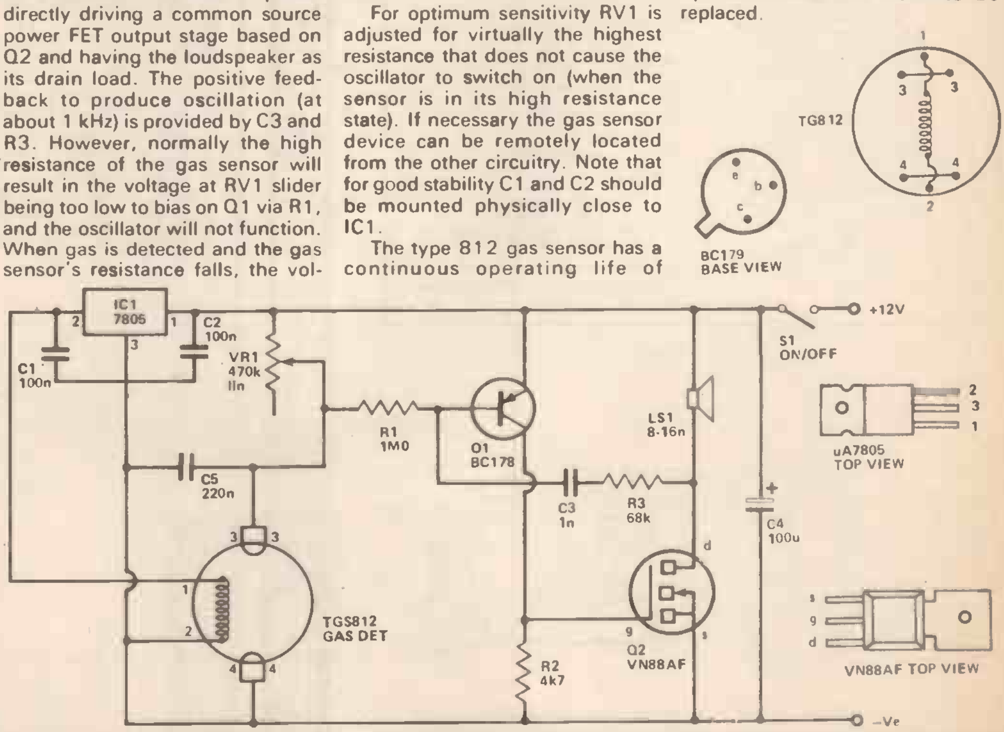
This circuit is primarily intended for use as a gas detector for a boat or caravan, and is designed to run from a 12 V battery supply. It could of course be run from a mains power supply unit if necessary. The quiescent current consumption of the unit is about 130 mA, rising to approximately double this figure when the alarm sounds. Apart from propane, butane, methane, etc., the unit will respond to most smoke, combustible vapours and even carbon monoxide. It will detect these at well below the minimum concentrations required to produce an explosion.

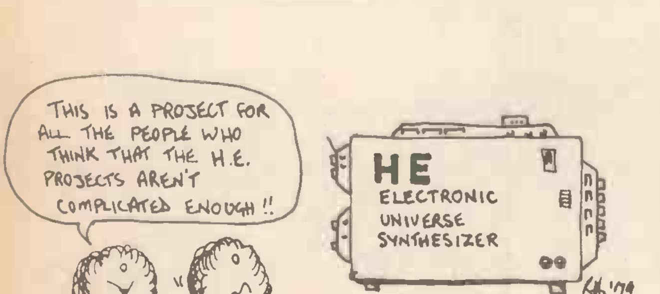
At the heart of the unit is a special sensor device which has a semiconductor section which is heated by a 5 V heating element. The latter is powered from the 12 V supply via a 5 V regulator device, IC1. The semiconductor sensor oxidizes when heated by the element, and exhibits a high resistance between two electrodes which are attached to it. Inflammable gasses, vapours, etc. have a deoxidizing (reducing) effect on the semiconductor material, causing its resistance to fall to only a fraction of its previous level.

The alarm signal is generated by a simple oscillator which uses Q1 as a common emitter amplifier directly driving a common source power FET output stage based on Q2 and having the loudspeaker as its drain load. The positive feedback to produce oscillation (at about 1 kHz) is provided by C3 and R3. However, normally the high resistance of the gas sensor will result in the voltage at RV1 slider being too low to bias on Q1 via R1, and the oscillator will not function. When gas is detected and the gas sensor's resistance falls, the voltage at RV1 slider increases and the oscillator is biased into operation.

For optimum sensitivity RV1 is adjusted for virtually the highest resistance that does not cause the oscillator to switch on (when the sensor is in its high resistance state). If necessary the gas sensor device can be remotely located from the other circuitry. Note that for good stability C1 and C2 should be mounted physically close to IC1.

The type 812 gas sensor has a continuous operating life of approximately two years, after which it will become rather slow in operation and will need to be replaced.




THIS IS A PROJECT FOR ALL THE PEOPLE WHO THINK THAT THE H.E. PROJECTS AREN'T COMPLICATED ENOUGH!!
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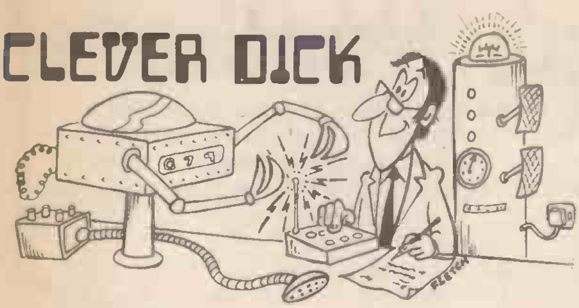
CLEVER DICK



We start our new feature Clever Dick with a look at some of the more frequently asked questions that arrive each day. Clever Dick will attempt to answer some of them, if you've got a problem why not drop us a line and we'll see what we can do.

MOST OF THE LETTERS we receive on Hobby Electronics are technical enquiries, providing they're accompanied by a SAE they receive a fairly speedy reply, unfortunately not all of them do have a SAE, so they usually get 'filed'. The purpose of this occasional feature is to answer some of the more frequently asked questions and if space and resources permit, matters not directly connected with HE.

Our first letter comes from Sandra Witter, (good to see the ladies taking an interest), in the past we've had one or two letters from Sandra (haven't we Sandra) as this one concerns the Digi-Bell (June HE)

Dear Dick

I've built the 'Digi-Bell' and have come to the conclusion it would be better described as the 'Relucta-Warble'.

The 'thing has been subjected to several 'pullings apart' and 'puttings back together'. I've replaced both ICs and changed a dodgy (wrong value) capacitor, re-soldered every joint on the board, checked it with a multi-meter, even my dad has had it on a 'scope, he reckons that the first stage is working all the time, so when we connect up the battery it keeps sounding. HELP.

Sandra Witter
Coventry.

Well, we must own up, we did omit a link on the PCB but we did admit to it in the June issue. The second point with the Digi-Bell was the high current consumption experienced by some people, this is easly recitified by connecting all the unused inputs of ICI to 0 V. Hope that answers all the questions on the Digi-Bell.

Another common question concerns the availability of PCBs and components, particularly, do we supply them? This letter from A. Atefi is fairly typical.

Dear Sir,

I am enquiring about the GSR Monitor in your June edition. Would you please tell me if it is possible for me to order the PCB and components from you. I would be grateful if you could mention the price so that I can send you a cheque.

A. Atefi
Birmingham

The answer, sadly is no. It would be very difficult for us to do so. Luckily companies like Tamtronik Ltd (see ad. in this issue) are only too happy to supply all the components, includig PCBs and hardware for all our projects.

We've had quite a few enquiries lately on our sound effects projects, the White Noise Effects Generator and the ADSR Envelope Generator. (Yes the PCB for the White Noise Generator was back to front, sorry again). They were developed as a matched pair but there's no reason whatsoever why other inputs cannot be connected to the ADSR, eg guitar organ etc.

Our third main topic this month concerns addresses, people seem to think that we are all-seeing, all-knowing, we must admit that would be nice but we're not. Its no good whatsoever asking us to recommend a decent lawnmower, people do too. If you stick to electronic matters then maybe we can help. M N H Christmas is in luck, he writes:

Dear Sir,

I have been fascinated by computers for many years. Last week I purchased your book Into Electronics Plus to read the feature Home Computers. I find that the cheaper ones, ie £200-£300 are within my price range. I would be grateful if you could supply me with any addresses from where I could obtain further information.

Mr N H Christmas
Middlesex

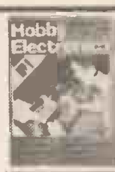
Nice easy one this, in London we are particularly fortunate, we have 'Eurocalc' and the 'Byte Shop' both in Tottenham Court Road, along with several other well known shops also in the same road. They can be found displaying some small micro systems, Nascom etc. All the addresses you may need can be found in our sister magazine Computing Today (plug plug). Look out for the Comp Computer Components Ltd ad there are several low to medium budget machines in their range. They can be found at: 14 Station Road, New Barnet, Herts.

Probably the most frequently asked question is, "Can you supply me with a circuit for . . . . ?1. Most of the time we can find something suitable in our back issues, don't forget ETI goes back seven years. Of course we have to make a small cahrge for photocopying. The trouble arises when we're asked to design circuits for people. Unfortunately or porject team is employed full time in designing our own projects, they just do not have the time or resources to undertake any private work. Sorry to those of you that want everything from multi-bank mixers to a circuit diagram for a BBC colour TV camera. Keep reading HE, you just never know.

Back Numbers

Shown here is a selection of past issues with their major features and projects. All are available (at the moment) for just 60 pence each, including post and packing. Send your order to:

Hobby Electronics
Backnumbers Dept.
145 Charing Cross Road
London, WC 2

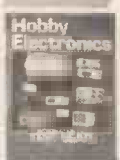


NOVEMBER 78
Projects: Stereo Amplifier, Digital Clock, Wah-Wah Pedal, Bedside Radio.
Features: The Edison Effect, Robots, Hi-F Specs, Kit Review, Transducers Metal Locators etc.

DECEMBER 78
Projects: Metronome, Photon Phone, Audio Mixer, Electronic Dice.
Features: Deep Space Communications, Understanding Bias, Lasers, Photocells, Calculators, The Tesla Controversy etc.

JANUARY 79
Projects: Graphic Equaliser, Touch Switch, Vari-Wiper, Flash Trigger.
Features: BASIC programming, Viewdata, Starship Daedalus, Pinball Machines etc.

FEBRUARY 79
Projects: Short Wave Radio, Sine/Square Generator, Scratch/Rumble Filter, Car Alarm Project.
Features: Video Tape Recorders, Radioactivity, CA 3130 Circuits, Computer Glossary etc.



MARCH 79
Projects: Light Chaser, Tone Controller, Photographic Timer, Cassanova's Candle.
Features: TV Signals, Test Gear, SW Aerials, Interfering Waves, Communications Satellites, etc.

APRIL 79
Projects: Model Train Controller, Cistern Alarm, Transistor Tester.
Features: The Telephone System, TV Aerials, Electronics in Warfare, Catalogue Survey etc.

MAY 79
Projects: Power Supply, Parking Meter Timer, Digibell, White Noise Effects.
Features: Feedback, Electronic Music, AB Circuits, 555 Circuits, Aerial Tuners, Varicap Diodes etc.

JUNE 79
Projects: GSR Monitor, Envelope Generator, Drill Speed Controller.
Features: Citizene Banned, Display Techniques, Moving Coil Meter, Electronics in Music Pt 2, etc.

JULY 79
Projects: Shark, Baby Alarm, Points Controller, Linear Scale Ohmmeter.
Features: Cassette Decks and Tapes, Binary Numbers, Fixed Resistors, Short Circuits Special, etc.

Constant Volume Amplifier

The uses of a Constant Volume Amplifier may at first seem somewhat limited, but any audio enthusiasts will immediately recognise it as a compressor, invaluable in high quality tape recording etc.

ANY ENTHUSIASTIC USER of a tape recorder, cassette or reel to reel, will appreciate that the recording of rapidly fluctuating sound levels such as the human voice or an orchestra for example, can often pose certain difficulties. If the level control is set on the recorder during a loud passage then when a quiet passage comes along, it can be almost inaudible. Likewise if the level is set on a quiet passage then the louder ones will be distorted.

What is needed is a piece of equipment which can strengthen the weak signals and lower the louder. Such a device is the HE Constant Volume Amplifier which attempts to give a relatively unchanging output level for a multitude of inputs.

The key word here, of course, is 'relatively' — we don't really want a *constant* volume level because we might not be able to tell if the orchestra was playing a crescendo or a quiet passage. The ideal device would simply reduce the volume range. In other words it compresses the volume, in fact equipment of this sort is

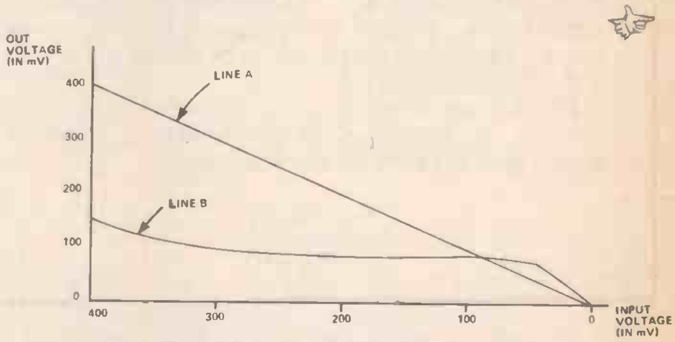
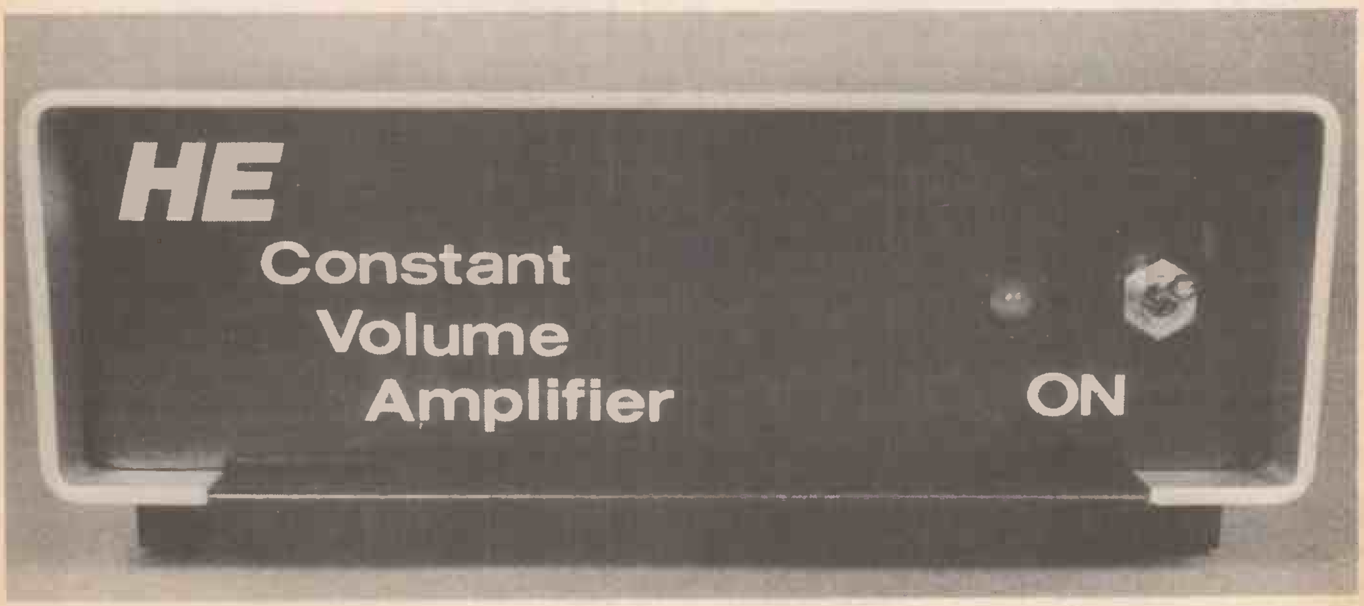


Figure 1. Graph of output vs. input voltage.



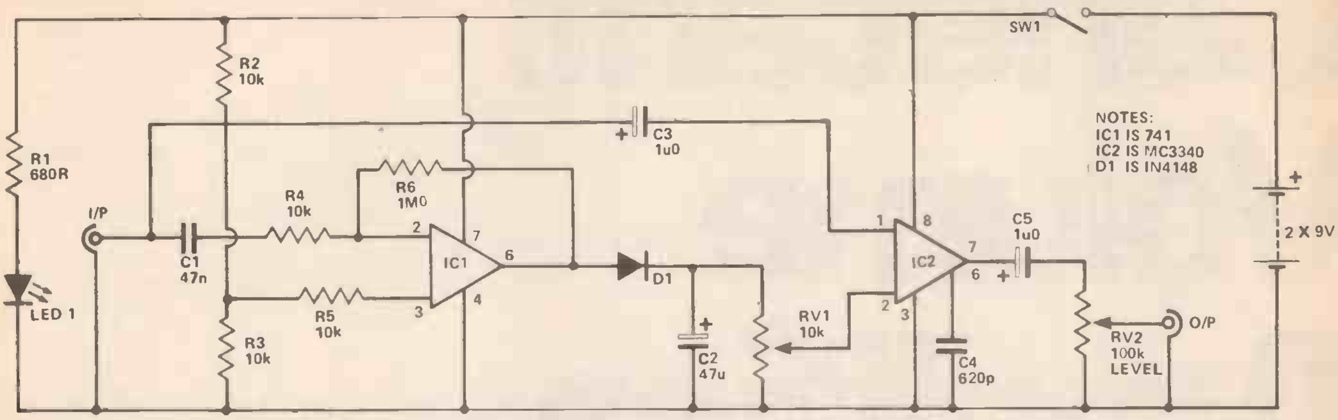


Figure 2. Circuit diagram of the HE Constant Volume Amplifier.

How It Works

IC 2 is a voltage controlled amplifier. That is, an amplifier whose gain is directly proportional to a DC control voltage present at pin 2. Following the circuit diagram, the signal can be seen to pass through coupling capacitor C3, to pin 1 of IC2, the input. The output from pin 7 is coupled via C5 to the preset RV2 which is set to give the required output amplitude. As the voltage on pin 2 alters, so does the gain of the amplifier. At 3.5 V the gain is at maximum, but at 6 V the output of the amp is virtually zero. At control voltages in between these two limits the o/p amplitude is between maximum and zero. (See figure 4.)

The circuit around IC 1 derives the control voltage. IC 1 is used as an inverting amplifier whose gain is given by the formula

$$\frac{\text{R feedback}}{\text{R input}}$$

according to figure 5. These two resistors correspond to R6 and R4 in the final circuit, giving a gain of 1M/10K = 100.

D1 half wave rectifies this amplified AC waveform which is then stored as a DC voltage on C4. The voltage should vary between about 8-14 volts, depending on the amplitude of the input signal. RV1 is used as a variable potential divider to drop this voltage to 3.5 to 6 V DC – used now for the necessary control voltage to pin 2 of IC2.

A compressor should ideally have a fast attack time, in the order of just a few milliseconds, so that any sharp loud note is acted upon quickly, but a relatively slow decay time of say 100 milliseconds – otherwise the effect described previously of a *constant* CVA would occur. These two times are inherent in the circuit as capacitor C4 charges quickly through D1, when a loud sound is present at the input, but it *discharges* at a much slower rate through RV1.

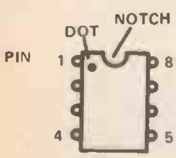


Figure 3. Showing an integrated circuit, viewed from above (with pins pointing away).

quite often referred to by people in the know as a compressor.

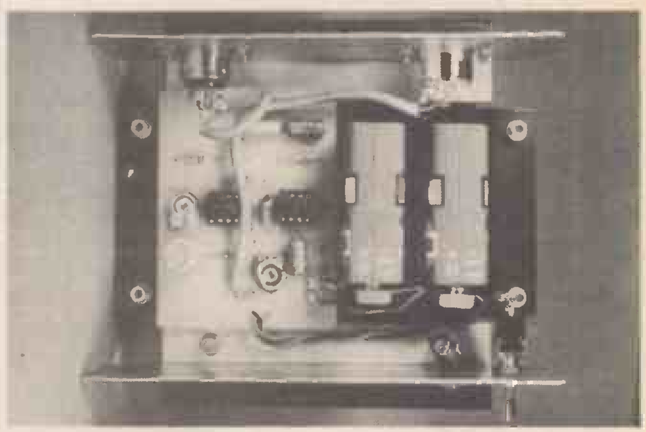
The graph in figure 1 displays the characteristics of the HE Constant Volume Amplifier showing output voltage vs input voltage. Line A is the graph obtained if the CVA is not used i.e. the output voltage is the same as that of the input (because there is nothing there to alter the input). However, with the CVA in use (line B) the output varies a greatly reduced amount as the input changes.

These results were obtained using the prototype constant volume amplifier and show how effective it functions as an audio compressor.

CONSTRUCTION

Make sure that IC1 and 2 are inserted correctly — note that pin 1 of both ICs is the top left hand pin when the locating notch or dot is on the top of the chip (see figure 3).

Some ICs have a dot used as a locator, some a notch and some have both. The printed circuit board has a dot



Note the position of the two nine volt batteries, make sure the metal cases of the batteries don't short against the switch or socket connections.

etched on it which corresponds to the correct placing of pin 1 for both ICs (see PCB pattern).

Looking at the inside photograph of the case shows the layout of wiring up, which is quite easy. Remember to use screened cable for input and output leads. The case ideally should be metal and earthed, to screen the circuit against mains hum. The earthing can take place at either input or output socket by connecting a short lead from tag 2 of the socket to the tag which is connected to the metal shield. The signal should come from tag 1 of the input socket and go to tag 3 of the output socket. (See figure 4).

The rest of the components should present no difficulties, the circuit being fairly straightforward.

SETTING UP

The procedure for setting up requires the use of the CVA in situ. Feed an input to the device and the output to an amplifier with the amplifier volume turned down. Set RV2 to mid-position and RV1 fully anti-clockwise then switch everything on. Turn the amplifier volume up till you hear the signal. Now turn RV1 clockwise until distinct distortion of the signal occurs, then turn it back until the distortion just disappears. Finally, adjust RV2 to give the required volume level. **HE**

Buylines

All components bar IC2 should be obtainable at any component stockist as they are common types. If IC2 can't be found locally then any of the larger mail order firms might be able to help. It is also available as an RS Components IC stock number 306-803.

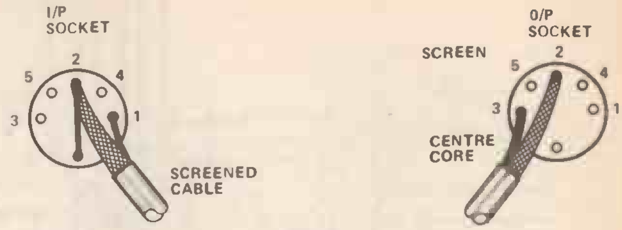


Figure 4. The connections to the input and output sockets.

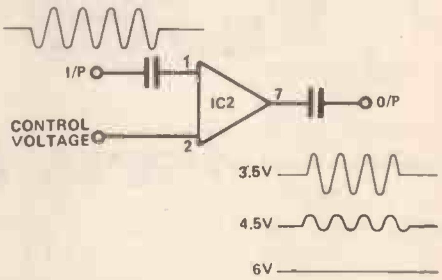


Figure 5. Showing the outputs obtained with various control voltages.

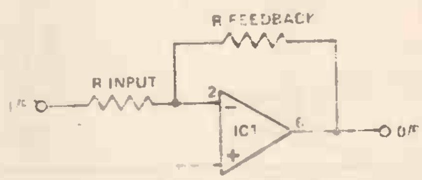
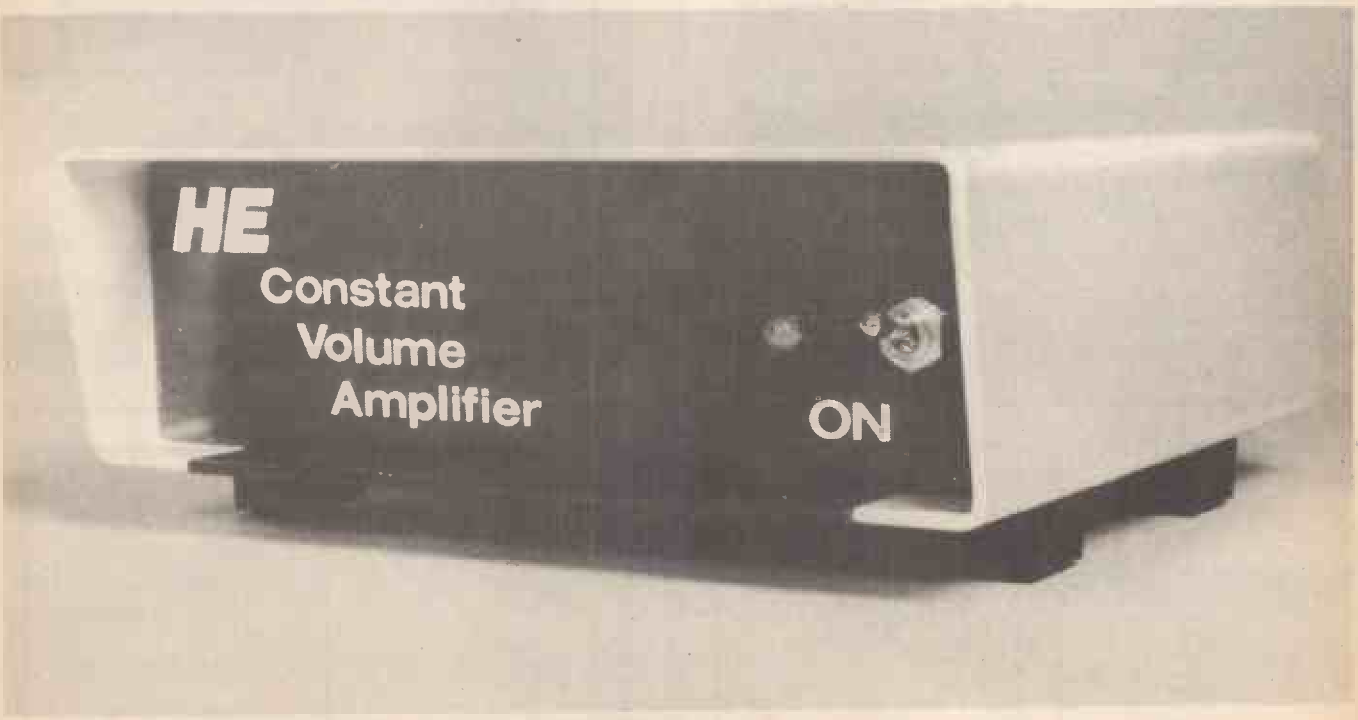
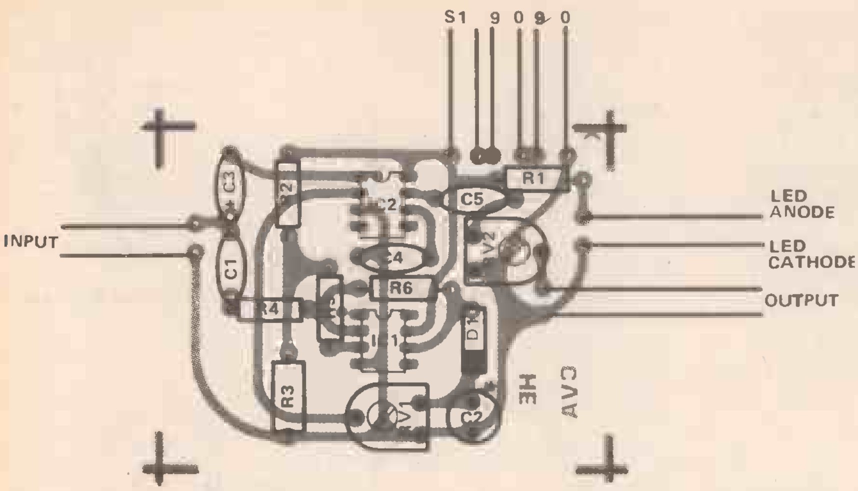


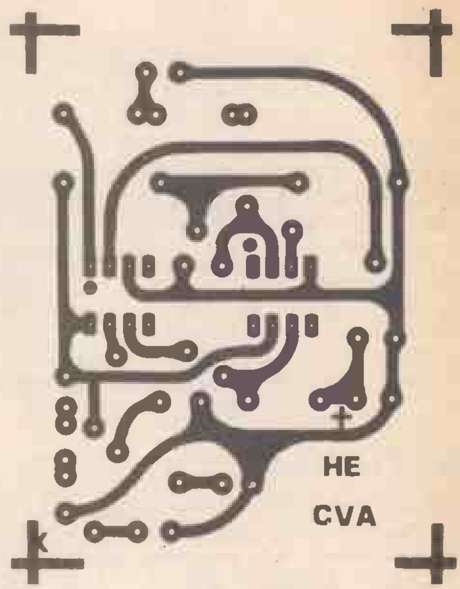
Figure 6. A straightforward operational amplifier circuit.



The on-off switch and LED keep the front panel neat and uncluttered.

Constant Volume Amplifier





Parts List

RESISTORS (All ¼W, 5%)
R1 680R
R2,3,4,5 10K
R6 1M

POTENTIOMETERS
RV1 10K Preset
RV2 100K Preset

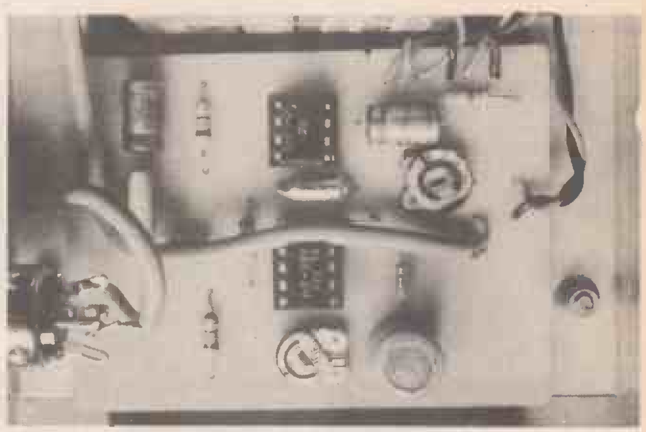
CAPACITORS
C1 47nF Polyester
C2 47uF Elect.
C3,5 1uF Elect
C4 620pF Polystyrene

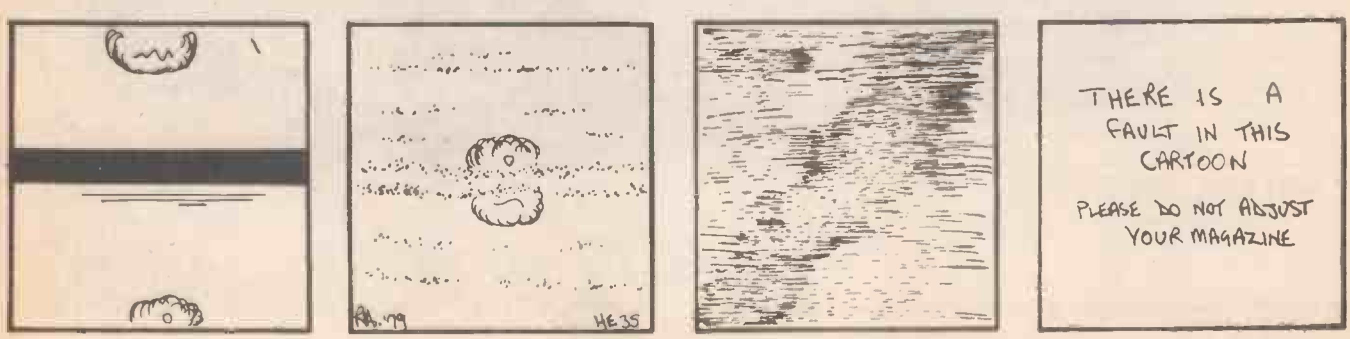
SEMICONDUCTORS
IC1 741
IC2 MC3340
D1 1N4148
LED 1 TIL 220 0.1'' LED

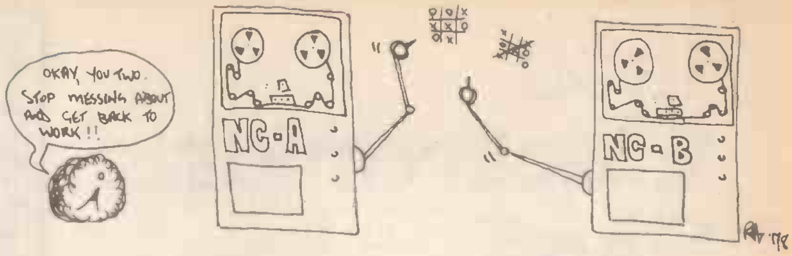
MISCELLANEOUS
Switch 2 x PP3 batteries and clips
Case to suit 2 x 3-pin Din Sockets

Approximate cost £9.00

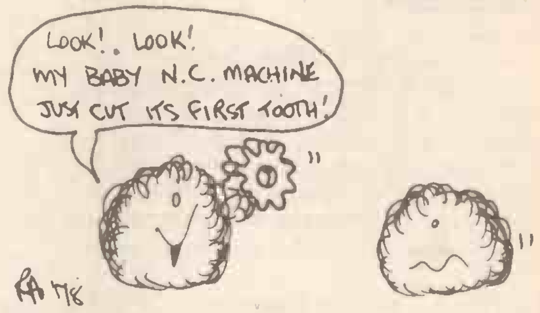
Top left. ***Overlay diagram for the Constant Volume Amplifier.***
Above. PCB foil pattern.
Below Right. Inside the cabinet, note the use of screened cable for signal wires.



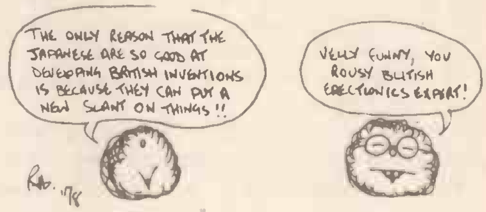




OKAY, YOU TWO. STOP MESSING ABOUT AND GET BACK TO WORK !!
NC-A
NC-B



LOOK! . LOOK! MY BABY N.C. MACHINE JUST CUT ITS FIRST TOOTH!



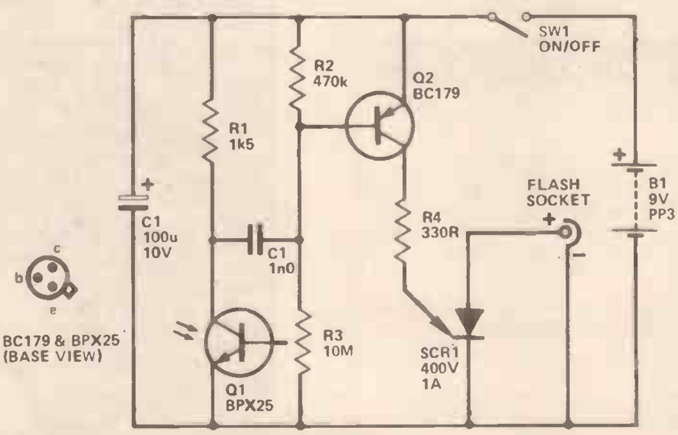
THE ONLY REASON THAT THE JAPANESE ARE SO GOOD AT DEVELOPING BRITISH INVENTIONS IS BECAUSE THEY CAN PUT A NEW SLANT ON THINGS !!
VELLY FUNNY, YOU LOUSY BLITISH ELECTLONICS EXPERT!

Short Circuit

FLASH SLAVE UNIT

The problem of harsh and unnatural shadows that occurs when taking flash photographs using a single flashgun can be overcome by the use of a second flashgun. A flash slave unit is then very useful as it enables the additional flashgun to be triggered by the light from the main gun, thus reducing the amount of interconnecting leads required. The flash slave circuit shown here is extremely sensitive and when used indoors it always seems to trigger reliably regardless of where the main flashgun and the slave unit are\ positioned. If used out of doors there is likely to be little reflected light to help trigger the slave unit and it may be necessary to have the photocell aimed towards the main flashgun in order to obtain reliable operation (this is common to all flash slave units). The circuit has excellent immunity to saturation by strong ambient lighting.

The photocell is a BPX 25 or similar silicon photo-transistor. The collector to emitter resistance of this component varies over a wide range from darkness to high lighting levels, with the latter giving the lowest resistance. The photocell is connected as part of a potential divider across the supplv rails and when the light from the flash unit is received, a negative output pulse is produced by this circuit. This pulse is coupled by way of C1 to the input of a common emitter amplifier based on Q2. C1 has been given a low value so that it only efficiently couples the fast pulse caused by the flashgun, and slow signals such as those caused by shadows crossing the photocell are blocked.



R2 and R3 forward bias Q2, but by an amount which is too small to produce a significant collector current. However, the negative input from the photocell causes Q2 to conduct heavily and feed a trigger current to SCR 1 gate via current limit resistor R4. SCR 1 then briefly switches on and fires the flash unit. The circuit operates extremely rapidly and there is no significant delay between the firing of the two flashguns. The unit has a current consumption of about 20 to 50uA in normal ambient lighting conditions, falling to less than a microamp if it is stored in darkness and it is therefore quite feasible to omit the on/off switch SW1.

Into Linear ICs

By Ian Sinclair Part 2

Part two already. This month Ian Sinclair digresses for a moment to take a look at the gentle art of PCB construction, soldering and layout before we get down to the real business of linear ICs.

IF YOU'VE JUST BECOME accustomed to laying out transistor circuits, then your first look at a circuit diagram for an IC project is a bit off-putting, mainly because so many connections have to be made to one small unit. Don't worry, it's not only easier than it looks, it's even easier than laying out transistor circuits, thanks to the use of DIL packages.

SPREADING THE BREAD

Any IC circuit can, of course, be soldered onto a specially prepared printed-circuit board (PCB), but for trying out circuits of all sorts, nothing beats a solderless breadboard for speed and ease of handling. The breadboard which is best suited for these circuits is the Euroboard, which has contacts arranged in groups of five, with 25 groups in a column, and four columns. Fig. 1 shows the arrangement — the groups are spaced out 2.5 mm apart on one column — so that the standard IC pin spacing of 2.5 mm can be accepted. The columns are arranged either 7.5 mm apart (A and B; C and D) or 15 mm apart (B and C) so that any of the normal IC's right up to the monster microprocessor can be fitted in. The size of the board is enough to permit assembling any of the circuits we shall use, but the price is as low as several much smaller and less suitable competitors.

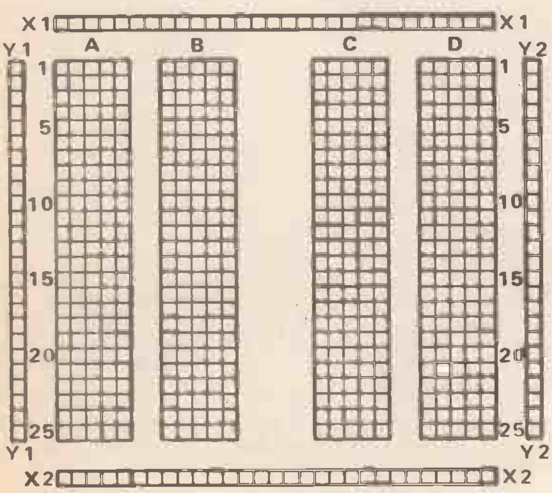


Fig. 1. The Eurobreadboard layout. Columns AB or CD are used for small ICs, the larger spacings between B and C can be used for the bigger ICs with 15 mm between lines.

The columns are lettered A, B, C, D, and the lines are numbered 1 to 25, so that we can indicate where a connection is made by using a letter and a number. For example A4 means *any* of the five contacts on the 4th line in column A. Contact is made by inserting a lead into a hole on the correct line, so that if one lead of a resistor is to be connected to A4, the wire end is simply pushed into one of the holes on this line — any one will do.

Now when we plug an IC into this breadboard, each of its pins will be on a different line, one side in one column and the other side in another column. You wouldn't, of course, ever plug an IC into the board so that two pins were on the same line. Each pin will therefore be on a line of its own which can be identified by a letter (for the column) and a number (for the row).

INSTANT CIRCUIT

This makes construction incredibly easy. Mark on the circuit diagram the letter and number for each pin of the IC. Because most IC's need only a few other components, very few other lines on the board need to be used, and we can use any spare convenient lines. Each circuit diagram (using IC's) in this series will show the Eurobreadboard layout in this way, so that you don't even have to be able to read the circuit diagram particu-

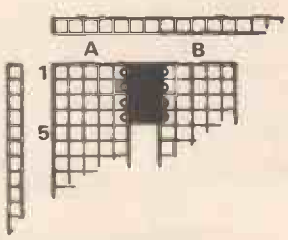


Fig. 2. How the small 8-pin IC fits on to the Eurobreadboard. This is the position which will be used in all the circuits in this series using these ICs.

larly well to be able to construct each circuit. At the same time, you'll gain valuable experience in laying out a circuit.

The Eurobreadboard also has four long lines of contacts arranged round the edges, and intended for power supplies.

We'll use these as the power supply points in all the circuits, using X1, for positive supply, X2 for negative (if needed) and Y1 for earth or zero voltage. As always, labelling X1 on a diagram means any contact hole on X1, usually the nearest one. Where a wire link has to be taken from one group of contacts to another, this is indicated on the diagrams by a thickened line.

SOLDERING IC's

A solderless breadboard is first-rate for testing-out circuits, particularly any circuits which have been modified a bit, but it's not the method we'd use for a permanent circuit — that's a soldering job. Now you've probably used a soldering iron already, but if your experience of soldering is only on transistor circuits, or possibly not at all, then perhaps a little bit of advice might be useful.

One essential point is to have a soldering iron which is suitable for working on ICs. Because of the 2.5 mm spacing between IC pins, an iron with a large bit is definitely out. Most modern soldering irons have replacable bits, so that it's possible to attach a very fine bit for soldering IC's and then change to a larger one for bigger stuff. A suitable power is around 15-25 watts. Much less than 15, and you find that the solder never readily melts properly, because the copper of the printed circuit board conducts too much heat away. Much more than 25W, and you find that you are overheating the tiny strips on the board, causing them to pull away. Make sure, too, that your iron can be earthed with an earth wire correctly fitted to a thre-pin plug. The circuits we're dealing with in this series *don't* need an earthed iron, but if you ever use the type of digital IC's called CMOS, or have to use FET's then you'll need an earthed iron — so why not start now?

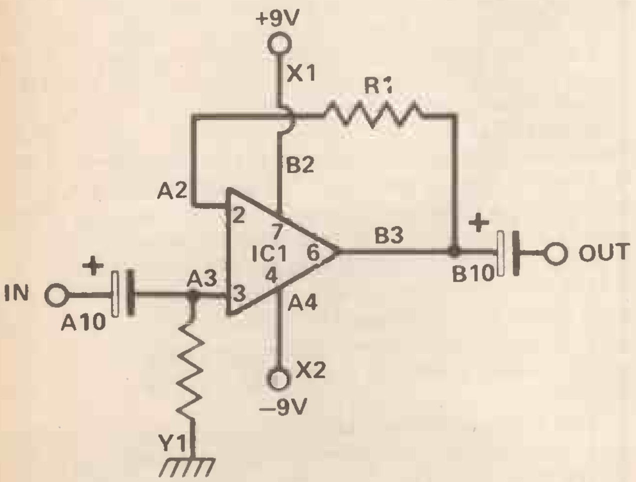


Fig. 3. Instant circuit! When the Eurobreadboard numbers are put on to the circuit, the few extra components that are needed go between these lines and earth or supply lines, or can be accommodated on spare lines.

The technique for soldering an IC goes something like this. First of all, you place the IC on the board, with its pins in the correct places — and then you *check*. Check that it's the correct IC for that part of the board (unless there's only one!), and that it's the correct type of IC — they look pretty much alike. Then locate pin 1 on the IC and check that it's placed in the hole that is intended for pin 1. On a small board, this is easy enough, but checking takes longer if you have a large board which takes twenty or more IC's. Use the small bit on the iron, and fine gauge resin-cored solder — Multicore size 10 (0.7 mm diameter) is ideal.

SOLDERING ON

Having checked, solder pin 1 onto its pad. Turn the board over so that it's resting on the IC, hold the tip of the bit of the soldering iron against the track pad just where the IC pin comes through, then touch this point with the end of the solder. When a small drop of solder flows on take the solder away, move the tip of the iron around the pin of the IC so that the solder forms a neat blob around the pin and the pad. At this point take the iron away and blow on the joint to cool it.

Most IC's are fairly heat-resistant, but if you have any doubts about how long it'll take to solder a pin into place, then protect the IC with a heat sink. This doesn't have to be anything elaborate, just a paper clamp of the Bulldog variety clipped onto the IC and touching the pins just where they are bent over at the sides of the casing (Fig. 4). Having soldered in pin 1, check again that you have the right IC, in the right place and the right way up. This may sound unnecessary, but at this point the IC can be removed very easily by heating the solder and pulling the IC out — after you've soldered in a few more pins, removal is a major operation! Having soldered in pin 1, now solder in the pin which is opposite, pin 5 on an 8-pin chip, pin 8 on a 14-pin chip, or pin 9 on a 16-pin chip. Check again — it's your last chance! If it still looks fine, solder in the rest of the pins, let them cool down, and then check that each pin is properly soldered, with no break in the solder around each pin and no little bridges of solder between one track and the next.

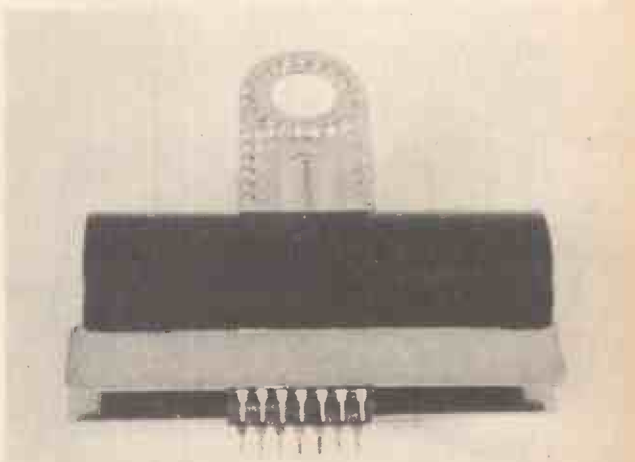


Fig. 4. Using an office paper clamp as a heat-sink. These clamps come in various sizes which are suitable for all the common linear ICs.

DE METHOD OF DESOLDERING

Even with all the care which you've taken (and you did, didn't you?) inevitably some day you will find that there's one IC in the wrong place, the wrong way up, or of the wrong type, and you have to remove it. If the IC has failed, and you're absolutely sure that it's failed — removal is easy. You simply cut through each pin at the body of the IC, using side-cutters, then take the pins out one by one, holding the remains of the pin in tweezers, and pulling the pin out as you melt the solder with the iron. If, however, there's nothing wrong with the IC and you want to use it again or in another part of the board, then gentler methods are called for.

Various desoldering tools can be bought, but unless you're going to do an awful lot of desoldering (it's cheaper to get the darn thing in the right place first time, folks), the cheapest and simplest method is to make use of copper braid, variously called solderwick or solder-braid. The idea behind this is that solder, like other molten metals, has a large amount of surface tension which pulls it into narrow tubes and small gaps. Copper braid is a mass of small gaps, so that molten solder runs into braid the way oil soaks into lampwick. To use desoldering braid, lay a clean piece of braid over the joint which you want to desolder. It helps if there's a faint coasting of flux on the braid — I keep an old tin of Fluxite (which I bought in 1949) handy. Then clean the solder from the bit of the iron by wiping it quickly with a damp cloth, and lay the hot bit on top of the braid so that the braid is sandwiched between the bit of the iron and the joint. Keep the iron in contact until you see the solder on the joint melt and run into the braid — then remove the iron and the braid together. You'll find that it helps to hold the braid with tweezers — it gets mighty hot during this operation. Don't leave the braid soldered to the joint!

This procedure should lap up all the solder from the joint, leaving only a very thin silvery film of solder. If it doesn't take all the solder first time (which means that you're putting too much solder on your joints), then cut off the piece of braid which is now stiff with solder, and try again with a fresh piece of braid. When all the solder has been removed from each pin of the IC, it should be possible to pull the IC away from the board without a struggle. With any reasonable luck, if you check each IC as you go, in the way we've described, you will never have to go through this procedure.

Fig. 5. Examples of Hobbyprints

BOARD STIFF?

That covers the jobs of soldering and de-soldering, but what about the circuit-boards themselves? What you use as a printed-circuit board (PCB) very much depends on what sort of project you are building. You may, for example, be constructing a project for which a ready-made board is available, in which case your only problem (apart from paying for it and getting it delivered in one piece) is to make sure that each component is soldered in the right place.

You can often save yourself a lot of time and money by etching your own boards — provided that you can get the pattern marked onto the board. For a project from your favourite magazine, you can buy the HOBBYPRINT transfers of instant dry transfer, and every major project in HE has a HOBBYPRINT to match. The laminate board (plastic coated with copper) is cleaned by rubbing the copper surface with fine sandpaper, and finished off by wiping over, using a clean rag moistened with a drop of lighter fuel or white spirit to remove any traces of grease. Once the laminate is completely dry, you then lay the HOBBYPRINT over the copper, with the backing surface of the HOBBYPRINT uppermost. Rub over the back of the HOBBYPRINT with a soft pencil, B, 2B or softer preferably, and make sure that you don't rub so hard that you pierce the paper. Make sure that you have rubbed thoroughly over all the parts where there is printing to be transferred. Then peel the backing-sheet off carefully. If you have been a bit careless, and you've missed a piece of track, or jabbed the pencil-point through, or lifted a piece of track, then panic not, the repair kit which comes with each HOBBYPRINT will attend to it. When the pattern is completely transferred, cover the surface with a piece of stiff paper or cardboard, and cut the laminate to size — I find a fretsaw is the handiest method of doing this. The transfer material is acid-resistant, so that you can now etch away the copper which is not covered by the printed lines.

COME AND SEE MY ETCHINGS

The etching material is ferric chloride (Iron (III) Chloride to you chemists). It's not very strongly acid, but don't splash it in your eyes (remedy: wash in plenty cold water, then in eyewash, and see a doctor just in case). It will also stain the fingers, so I always play safe and wear rubber gloves and goggles. Make up just what you need. I use a photographic developing tray which I bought from a junk-shop, and I measure out the solid ferric chloride into it, then pour on hot water and stir. When the solid has completely dissolved, put the board in, copper side up, and keep the solution hot from above by shining a desk lamp on to the copper from about six inches above the top — but don't take any risks, and make sure that the desk lamp is properly earthed in case it falls in. If you use a metal tray for etching, it can be kept warm on a hotplate, but I wouldn't be inclined to use the cooker for this job. Move the board around a bit, using tweezers, so that it's always in contact with fresh solution.

You will see the unwanted copper steadily etching away, and when its all gone, lift out the board and rinse it in warm water. Now use fine sandpaper or Vim to remove the transfer material — you'll have to scrub fairly hard. Dry the board, and drill through each solder-pad so that your components can be mounted. You can, if you like, drill before you scrub off the print.

You'll need a small drill-bit for this job and something suitable to use it in — it's not really suitable for a carpenter's brace. The used ferric chloride solution can be kept in a labelled and well-stoppered bottle until the next time, though it's best made up fresh unless you are etching again in a week's time or so.

Etching is done in exactly the same way, no matter how the board is printed; the important part of the process is cleaning the copper before applying the pattern. Any trace of dirt or grease on the copper (and that includes fingerprints) can cause faulty etching. If you're determined to keep costs low, or if you're building a project for which there is no HOBBYPRINT, you can apply your own pattern. One way is to use readymade shapes of instant transfer, another is to use etch-resist put on with a felt-tip pen. Some of the best PCB's I've seen were done with a drafting pen filled with waterproof Indian-ink; but your draftsmanship has to be good. All of these methods are particularly useful if you have to design a circuit layout for yourself, and if you have stencils for the IC mounting-pads. For HE projects, though, HOBBYPRINTS win every tine!

STRIP-TEASE

There are still a few methods left if you don't want to get involved with etching and marking-out copper laminate. These methods involve the use of stripboards — PC boards which have been machined or etched so as to have parallel strips of copper set at 2.5 mm apart so as to suit the pins of ICs. The original Veroboard consists of long strips made in this pattern and also drilled at 2.5 mm intervals. Other patterns are now available, with short tracks (something like the groups of contacts on the Eurobread-board in arrangement). If you use the long strips, you will have to cut the tracks, as shown in Fig. 6, so that the IC pins do not short to each other.

Stripboards can be used for any IC circuit, providing that they use 2.5 mm pitch strips. The circuits are laid out on the stripboard exactly as you would lay out a circuit on the Eurobreadboard. Unfortunately, most stripboards are not numbered nor lettered (don't ask me why, it can't be for lack of being asked!), so that you will have to do this for yourself unless you can get hold of ready-numbered material. One way is to stick some masking-tape at the end of the strips and write the strip numbers on it. Another method is to make use of the

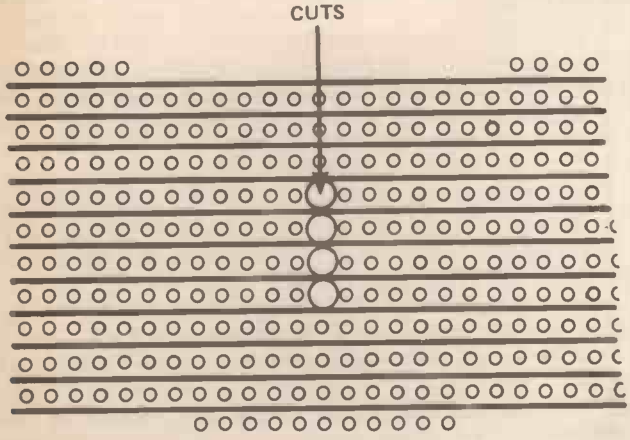


Fig. 6. Cutting 2.5 mm Veroboard to take an 8-pin IC.

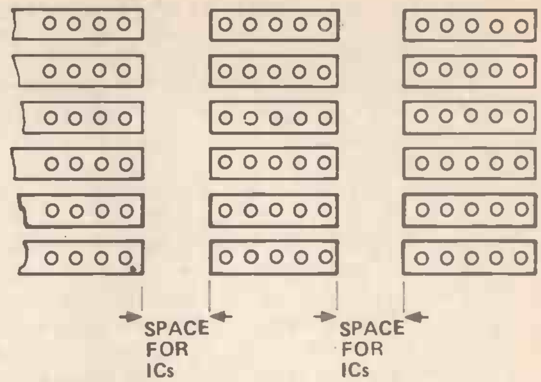


Fig. 7. The track pattern of DIL-board. Using this type of board saves on cutting.

white correcting fluid which is used by typists to cover mistakes (sold as Tippex fluid, Snopaque, etc.) and paint a stripe of this down one edge of the board. Let it dry for a minute (it's fast-drying) and then write the numbers in pen or pencil on it. Remember to number each side of the board, unless you are using single-sided board. Single-sided board is undrilled, so that the components are mounted on the same side as the copper tracks, with each leadout wire butted against the track and then soldered to the track. Circuit layout, circuit tracing, and troubleshooting are all much easier when this type of board is used, because you don't have to keep turning it over.

That's covered the possible constructional methods that you can use; but there's one important point to attend to before we start making linear IC circuits and getting them to work. It concerns power supplies — an important feature of all IC circuits.

VOLTS WITHOUT FAULTS

The small-scale circuits that we're going to feature can all be battery operated, though a few of the later circuits will take rather a lot of current from the batteries. If you don't have a mains power pack, or if you have a mains power supply which doesn't suit linear ICs, then the use of batteries is an attracitve proposition. All of the circuits have been designed to work from either single or twin 9 V batteries, such as the PP3 which seems to power so many small transistor radios. If you can spring a bit extra on the larger sizes, such as the PP6 or PP9, you'll find them better value for money, because their life is very much longer than that of the PP3's.

Some circuits specify dual supplies, meaning that

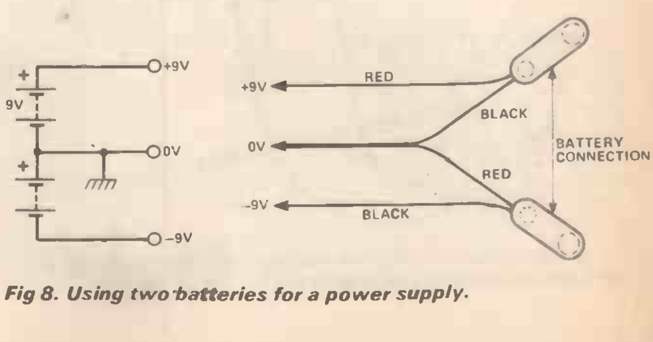


Fig 8. Using two batteries for a power supply.

there is a positive and a negative supply with a common earth return line. This is particularly easy to arrange when you see batteries, connecting two batteries as shown in Fig 8. A deluxe arrangement consists of the two batteries held in a plastic box, with their connectors wired to a miniature three-pin socket. The leads to the Eurobreadboard can then plug into this socket, which fits the plug one way only. If you don't feel like going to this much trouble, you will have to make sure that you have the supply leads right way round each time — one way is to solder the battery connectors to the leads, which are then plugged into the breadboard. If you see flexible leads, solder the ends lightly, because solderless breadboards don't take kindly to having stranded wire thrust into them — not all of the strands come out again! Generally, there's less of a problem in getting the leads the right way round when only a single 9 V supply is used, and there are only two leads.

MAINS SUPPLY

A mains-operated supply, is of course, very useful, particularly if you are interested in trying out IC amplifier circuits which operate loudspeakers. These circuits can flatten small batteries pretty quickly, so that extensive work of this kind really calls out for a mains supply. Building such a supply is not difficult (see HE for May, 1979), but you have to remember that the input to such a supply *is* 240 V mains, and you can't afford to take any risk with the high mains voltage which we use in this country. Building a mains supply is not a job for a beginner, and it demands as much care in mechanical details like shaping metalwork and mounting components as it does in electrical details like correct connections. The construction of a power supply won't be described here, because there are so many excellent designs and kits around. A kit, incidentally, is a very satisfactory way of building your first mains power supply.

Suppose you don't want to undertake the construction of a mains power pack, but you don't fancy using batteries? There are still a few ways out. One is to buy a power supply — a suitable unit would provide 9-0-9 volts of smooth DC at 0.5 A. This unit could be pricy, but it's certainly quick and safe. Another way is less costly and a bit unusual. Every motorist's accessory shop sells power supply units — called battery chargers. A lot of junk shops also sell them second-hand; there must be millions of them around, and they're only used in the winter. Now the output from these battery-chargers doesn't look much like DC, but if a smoothing capacitor of 5 000 µF, 35 V, is added, as shown in Fig. 9, they convert nicely into power supply units with an output of up to 18 V or so. Don't try to put the capacitor inside — there's seldom room, and you may disturb the wiring to the extent of causing a short circuit.

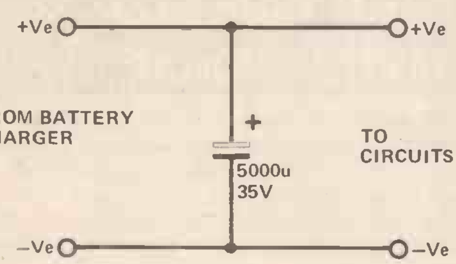
VARIABLE POWER

Fig. 10 shows how such a supply can be adapted to provide 9-0-9 V for the circuits which need a dual power supply. This circuit is also useful if you happen to have a power-pack which has an 18 V output and no negative output. The circuit consists of a 9V zener diode and a resistor, with the earth line taken from the place where the diode and the resistor connect. Even if the power supply doesn't deliver exactly 18 V, this version of a dual power supply works well enough for all the dual-supply projects in this series. Remember that dual-supply circuits use fewer components.

For circuits that use low currents (like many of the 741 and 555 circuits) the voltage across the zener diode in Fig. 10 can be used as a single supply, leaving the —9 V lead disconnected, but the higher-power circuits can't be operated in this way because the resistor in series with the zener diode won't pass enough current. Another solution will have to wait until Part 7: it's the use of a linear IC which acts as a voltage stabiliser.

The ultimate in power packs, of course, is a variable stablised mains unit, giving both positive and negative supplies and which can be set to any voltage required. Don't worry if you can't aspire to this, though, every circuit in this series can still be operated by the good old pair of PP3's.

HE



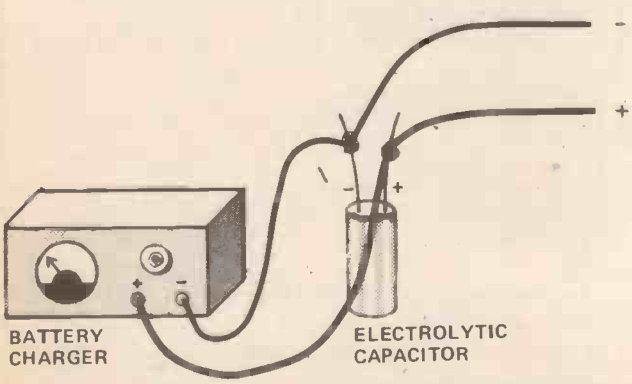


Fig. 9. Adding smoothing to a battery charger — a cheap way to get a single voltage supply suitable for many circuits.

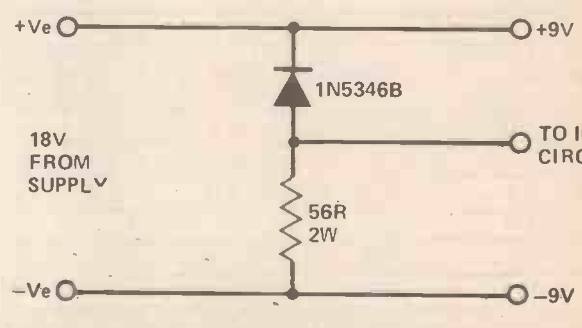


Fig. 10. Obtaining dual supplies from a single 18 V supply. The 1N5346B is a 9.1 V zener diode rated at 5 W and obtainable from RS Components stockists.

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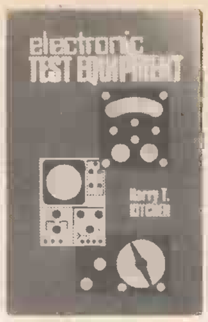

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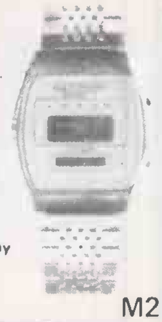

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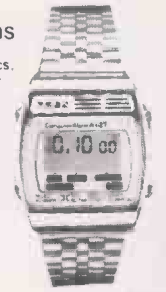

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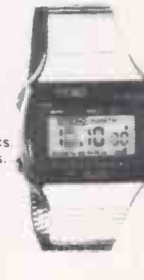

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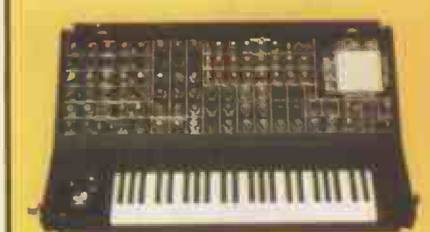

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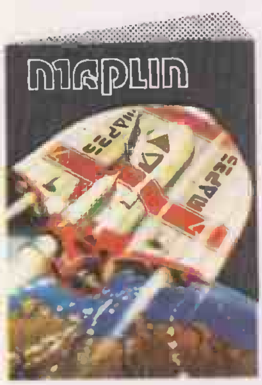

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